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MARINER JUPITER/SATURN 1977

SPACECRAFT FUNCTIONAL REQUIREMENTS BOOK

JET PROPULSION LABORATORY

CALIFORNIA INSTITUTE OF TECHNOLOGY

(Insert in 618-205, MJS77 Spacecraft Functional Requirements Book)

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JET PROPULSION LABORATORY

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FUNCTIONAL REQUIREMENT

MARINER JUPITER/SATURN 1977

SPACECRAFT REQUIREMENTS AND CONSTRAINTS

* Denotes change

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ILLUSTRATION

1.0 SCOPE

This document describes the Mariner Jupiter/Saturn 1977 (MJS77) Spacecraft System, defines the spacecraft subsystems, specifies the system level requirements for their performance and design, and delineates the constraints which are imposed on each subsystem by the system and by other subsystems. It is the controlling document for generation of the level 3 and 4 functional requirement documents contained in the MJS77 Spacecraft Functional Requirements Book, PD618-205.

2.0 APPLICABLE DOCUMENTS

The following documents form a part of this Functional Requirement.

DOCUMENTS

* Jet Propulsion Laboratory

PD618-51	Mariner Jupiter/Saturn 1977 Mission and Science Requirements Document
PD618-54	Mariner Jupiter/Saturn 1977 Project Safety Plan
PD618-59	Mariner Jupiter/Saturn 1977 Project/Launch Vehicle Systems Requirements
PD618-206	Mariner Jupiter/Saturn 1977 Support Equipment Functional Requirements Book
PD618-232	Mariner Jupiter/Saturn 1977 Spacecraft System Configuration Management Plan
PD618-257	Mariner Jupiter/Saturn 1977 Telecommunication Design Control Document
PD618-530	Mariner Jupiter/Saturn 1977 Spacecraft/Mission Operations System Interface Control Document

FUNCTIONAL REQUIREMENTS

Jet Propulsion Laboratory

MJS77-2-100	Functional Requirement, Mariner Jupiter/Saturn 1977 Spacecraft Design Criteria

MJS77-3-110	Functional Requirement, Mariner Jupiter/Saturn 1977 Functional Block Diagram and Interface Listings
MSJ77-3-120	Functional Requirement, Mariner Jupiter/Saturn 1977 Flight Sequence Implementation
MJS77-3-130	Functional Requirement, Mariner Jupiter/Saturn 1977 Standard Trajectories
MJS77-3-140	Functional Requirement, Mariner Jupiter/Saturn 1977 Nominal Aiming Point Selection
MJS77-3-150	Functional Requirement, Mariner Jupiter/Saturn 1977 Navigation Requirements
MJS77-3-170	Functional Requirement, Mariner Jupiter/Saturn 1977 Functional Accuracy and System Capabilities
MJS77-3-180	Functional Requirement, Mariner Jupiter/Saturn 1977 Configuration
MJS77-3-190	Functional Requirement, Mariner Jupiter/Saturn 1977 Structural Design Criteria
MJS77-3-200	Functional Requirement, Mariner Jupiter/Saturn 1977 Determination of Inertial Properties
MJS77-3-210	Functional Requirement, Mariner Jupiter/Saturn 1977 Design Criteria for Spacecraft Temperature Control
MJS77-3-220	Functional Requirement, Mariner Jupiter/Saturn 1977 Electronic Equipment Design
MJS77-3-230	Functional Requirement, Mariner Jupiter/Saturn 1977 Equipment List and Mass Allocation
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MJS77-3-250	Functional Requirement, Mariner Jupiter/Saturn 1977 Power Profile and Allocation

MJS77-3-260	Functional Requirement, Mariner Jupiter/Saturn 1977 Electrical Grounding and Interfacing
MJS77-3-270	Functional Requirement, Mariner Jupiter/Saturn 1977 Telemetry and Command Handling
MJS77-3-280	Functional Requirement, Mariner Jupiter/Saturn 1977 Telemetry Measurements and Data Formats
MJS77-3-290	Functional Requirement, Mariner Jupiter/Saturn 1977 Command Structure and Assignments
MJS77-3-300	Functional Requirement, Mariner Jupiter/Saturn 1977 Telecommunications
MJS77-3-310	Functional Requirement, Mariner Jupiter/Saturn 1977 Software Requirements

* OTHER DOCUMENTS

Military

AFETRM 127-1	Range Safety Manual

Thiokol Chemical Corporation

CP364-4	Contract End Item Detail Specification

DRAWING

* Jet Propulsion Laboratory

10073993	Science Calibration Target - Structural Interface

3.0 SYSTEM REQUIREMENTS

3.1 General

* a) The MJS77 Spacecraft system shall be compatible with the requirements specified in PD618-51, Mission and Science Requirements Document.

b) All elements of the spacecraft system shall comply with the design criteria specified in MJS77-2-100, Spacecraft Design Criteria.

c) All elements of the spacecraft system shall comply with the requirements of this functional requirement and all other applicable level 3 spacecraft functional requirements. In the case of conflict between this and any other level 3 spacecraft functional requirement, the requirements of this document shall prevail.

* d) Deviations from, and exceptions to, the contents of this document must be specifically waived. Waivers shall be in accordance with the waiver procedure contained in PD618-232, Spacecraft System Configuration Management Plan.

3.2 System Definition

The spacecraft system includes the spacecraft, the spacecraft adapter, the support equipment, and the spacecraft software.

* 3.2.1 Spacecraft

In addition to its scientific data gathering function, the MJS77 spacecraft also provides the final injection energy to place the spacecraft on the desired trajectory. The spacecraft is composed of a Propulsion Module (PM) and a Mission Module (MM). The PM is the portion of the spacecraft which provides the final injection and is separated from the MM once the injection has been achieved. The MM is the portion of the spacecraft which contains the science instruments and supports data gathering and transmission throughout the mission.

3.2.2 Spacecraft Adapter

The Spacecraft Adapter is composed of the transition structure and the associated equipment and cabling located between the field joint and the aft separation plane.

* 3.2.3 Support Equipment

The Support Equipment includes the System Test Complex, the Launch Complex Equipment, and all special test facilities required for testing of separate subsystems and the assembled spacecraft during system test and launch operations phases. Support Equipment shall be provided as required by PD618-206, Support Equipment Functional Requirements Book.

* 3.2.4 Spacecraft Software

Software for the MJS77 Spacecraft System is divided into three general categories

a) Flight software is defined as being on-board coding associated with the flight programs for the computer command subsystem, flight data subsystem, and the attitude and articulation control subsystem.

b) Flight support software is defined as that ground coding which is used directly to generate the flight coding, or is used to simulate the operation of flight hardware. It does not include that coding used to analyze and predict subsystem performance.

c) Support equipment software is defined as that ground coding which is utilized during the fabrication and test phases of the spacecraft system in the subsystem or system support equipment.

3.2.5 Subsystem Requirements

The spacecraft equipment shall be divided by function into a number of subsystems. Definitions of the subsystems, requirements placed upon them by other subsystems, and major system requirements on subsystems are established in Section 4.0 of this document and in other Level 3 functional requirement documents. Detailed functional requirements are established in the Level 4 Functional Requirement Documents.

3.2.6 Internal Electrical Interfaces

The internal electrical interfaces are defined to include all signals that are routed through system cabling. This includes intersubsystem signals and intrasubsystem signals when electronic packages of the same subsystem are not located in one bay. Internal electrical interfaces are defined in MJS77-3-110, Functional Block Diagram and Interface Listings.

3.2.7 External Interfaces

3.2.7.1 General. This paragraph specifies the requirements on the spacecraft system due to interfacing with other systems of the project which are: Mission Operations System (MOS), the Tracking and Data System (TDS), and the Launch Vehicle System (LVS).

* 3.2.7.2 Interface with the MOS. All elements of the spacecraft system shall meet the requirements of Spacecraft/MOS Interface Control Document PD618-530.

* 3.2.7.3 Interface with the TDS. All elements of the spacecraft system shall meet the requirements specified in the Telecommunications Design Control Document PD618-257.

* 3.2.7.4 Interface with the LVS. All elements of the spacecraft system shall meet the requirements of MJS77 Project Launch Vehicle System Requirements, PD618-59.

* 3.2.7.4.1 Separation Signal. The launch vehicle will provide a 28 Vdc level input to the spacecraft at Spacecraft/Launch Vehicle (LV) separation minus 7 s.

3.3 Design Characteristics

* 3.3.1 General

The MJS77 spacecraft shall be attitude stabilized in three axes using the Sun and a star as primary reference objects while maintaining communications with the Earth. The spacecraft shall have two-way communications equipment which permits the transmission of science data to the Earth, receipt of command transmission at the spacecraft, and two-way and one-way doppler tracking and range measurements. The spacecraft shall be capable of executing on-board stored sequences for trajectory correction and science instrument pointing maneuvers, antenna pointing, science instrument pointing, science and engineering data acquisition, and data formatting. The spacecraft shall derive its electrical power from solar independent sources.

* 3.3.2 Scientific Experiments.

The spacecraft with its scientific instruments will allow experiments to be performed during cruise phase between planets and in the vicinity of Jupiter and Saturn including selected satellites and Saturn's rings. In addition, it is expected that with these instruments an extended mission to investigate the region beyond Saturn could be performed until terminated by a depletion of expendables, inadequate performance capability or MM failure. The radio science experiment is accomplished with the MM telecommunications equipment. The science subsystems are listed below:

Cosmic Ray Subsystem	(CRS)
Planetary Radio Astronomy Subsystem	(PRA)
Plasma Wave Subsystem	(PWS)
Low Energy Charged Particle Subsystem	(LECP)
Photopolarimeter Subsystem	(PPS)
Plasma Subsystem	(PLS)
Ultraviolet Spectrometer Subsystem	(UVS)
Magnetometer Subsystem	(MAG)
Imaging Science Subsystem	(ISS)
Infrared Interferometer Spectrometer and Radiometer Subsystem	(IRIS)

* 3.3.3 Navigation

* 3.3.3.1 Trajectories

* 3.3.3.1.1 Interplanetary. All elements of the spacecraft shall be compatible with the set of trajectories represented in MJS77-3-130, Standard Trajectories.

✱ 3.3.3.1.2 Encounter. All elements of the spacecraft shall be compatible with the range of trajectories described in MJS77-3-140, Nominal Aiming Point Selection.

✱ 3.3.3.2 Trajectory Corrections. Requirements placed on the MM to support trajectory correction maneuvers are specified in MJS77-3-150, Navigation.

3.3.4 Spacecraft States

A set of state variables shall be defined for each spacecraft subsystem. Each allowable set of state variables constitutes a subsystem state. Each allowable set of subsystem states constitutes a system state.

✱ 3.3.4.1 Operating States. Operating states are defined to include the subset of system states identified by one or more of the following:

a) States which exist during the mission sequence specified in MJS77-3-120, Flight Sequence Implementation, as controlled by on-board switching or ground command.

b) The state is required to exist for verification of the spacecraft performance during system test.

✱ 3.3.4.2 Constraints

a) Each system operating state shall be uniquely identified via the spacecraft telemetry status registers and/or explicit telemetry measurements.

b) All system operating states shall be attainable by means of at least one of the following types of inputs:

1) On-board sensing and switching.

2) Computer command subsystem (CCS) discrete commands.

3) CCS coded commands.

CCS commands are listed and defined in MJS77-3-290, Command Structure and Assignments.

c) With the exception of unlatching and deployment functions, release of stored gas, propulsion operations, or failure mode switching it shall not be possible to place the spacecraft in a state such that exit from that state is impossible, nor shall it be possible to cycle the spacecraft through an operating state in such a manner that no means of returning from that state is possible.

d) No system state shall exist for the purpose of verification of S/C performance, if transition to a normal flight state cannot be achieved via spacecraft commands.

e) It shall be possible to condition the spacecraft to the launch state while on the launch pad using the radio link only except for the following umbilical functions:

1) External/internal power select

2) Standby to main inverter select

3) Solid rocket motor safe-arm

4) Flight data subsystem (FDS) memory load (the spacecraft supplies power to the FDS)

f) The design of the spacecraft shall be such that no single command can place the spacecraft in a state that violates the reliability criteria for a single failure as defined in MJS77-2-100.

g) At subsystem power turn-on, subsystems shall go to a specific predictable state. This requirement may be satisfied by power-on-reset logic or by remaining in the state that existed at power turn-off.

3.3.5 Communications

The spacecraft shall provide for communications to and from the earth for carrier tracking, ranging, telemetry and commanding. The spacecraft telecommunications design shall be a unified system such that all functions may be utilized simultaneously. The communications design of the spacecraft shall be compatible with the Deep Space Network and shall comply with PD618-257.

Functional requirements on the spacecraft telecommunications equipment are specified in MJS77-3-300, Telecommunications.

3.3.6 Attitude & Articulation Control

* 3.3.6.1 General. The spacecraft shall establish and maintain attitude orientation and stability about three orthogonal body axes during all phases of the mission following separation from the LV. The spacecraft shall use the sun as an attitude reference for its pitch and yaw axes, and a predetermined star (Canopus) for its roll attitude reference. The spacecraft shall control to inertial references for thrust vector control during injection, the MM shall control to inertial references during Trajectory Correction Maneuvers, Science Maneuvers and at those times when celestial reference signals are not available. The MM shall also be capable of articulating a science scan platform in two rotational degrees of freedom relative to the MM. Attitude and articulation control performance requirements are specified in MJS77-3-170, Functional Accuracies and System Capabilities.

* 3.3.6.2 Attitude Control Cruise Stability. During cruise, the MM angular rate shall be ≤ 8 μrad/s for each axis during undisturbed limit cycle operation.

* 3.3.6.3 Science Platform Articulation Control. The science scan platform coordinate system is defined in MJS77-3-180, Configuration. Pointing and settling requirements are with reference to the L vector relative to inertial space.

a) Articulation range of the science scan platform L vector shall conform to the requirements of MJS77-3-180.

b) The science platform shall be pointed within the accuracies specified in MJS77-3-170.

c) For 80% of the platform slews, the time from the end of the slew and the L vector excursions during a given time period relative to celestial space ($\Delta\theta/\Delta T$) shall be as follows:

Slew Rate	Time from end of slew	$\Delta\theta/\Delta T$
1.745 mr/s	30 s 300 s	20 mr/1 s 150 mr/10 s (100 mr/10 s)
17.45 mr/s	170 s	20 mr/1 s

* 3.3.6.4 Science Maneuver Turn Rate. Turns shall be performed about the MM roll and yaw or roll and pitch axes sequentially in clockwise or counterclockwise directions. The turn rate shall be 3.14 ±0.3 mrad/s.

* 3.3.6.5 High-Gain Antenna Pointing. After launch plus ≃80 days, the high-gain antenna shall be pointed at earth during cruise and encounter to the accuracies specified in MJS77-3-170.

* 3.3.6.5.1 Planet Limb Tracing. During earth occultation, the MM shall perform a series of preprogrammed pitch and yaw turns. These turns shall keep the high gain antenna pointed at the apparent closest limb of the planet to provide the highest probability of obtaining an RF signal path between earth and the spacecraft.

3.3.7 Data Handling

3.3.7.1 General. Data handling requirements are specified in MJS77-3-270, Telemetry and Command Handling.

* 3.3.7.2 Transition Density in Output Symbols. The transition density of ones and zeros in the spacecraft symbol stream shall be 6-2/3 percent or greater.

3.3.8 Temperature Control

* 3.3.8.1 Boost to Injection. Heat transfer through the nose fairing will be controlled in accordance with the requirements specified in PD618-59. After nose fairing ejection, the spacecraft will experience heating as a result of solar radiation, Earth radiation, and aerodynamic heating. The heat capacitance and thermal design of the spacecraft shall limit the temperature rise resulting from this heating to the limits specified in MJS77-3-210, Design Criteria for Spacecraft Temperature Control.

3.3.8.2 Post Injection. From injection to end-of-mission the temperature of all MM elements shall be maintained within the temperature ranges specified in MJS77-3-210.

3.3.9 Power

* 3.3.9.1 General. The internal sources of spacecraft power shall be radioisotope thermoelectric generators (RTG) and batteries. For ground test, provision shall be made to accept power from an external source that can simulate the RTGs. The batteries will provide power during injection and shall be jettisoned with the PM.

3.3.9.2 Allocations. Subsystem power demands shall be limited to the allocations contained in MJS77-3-250, Power Profile and Allocation.

3.3.10 Mass Properties

3.3.10.1 Spacecraft and Adapter Mass. The JPL supplied flight equipment, i.e.; the spacecraft and adapter, shall be compatible with the launch vehicle capability and mission requirements. PD618-51 specifies the maximum mass of the spacecraft and its adapter.

3.3.10.2 Inertial Properties. The mass, center of mass, and centroidal moments and products of inertia for the spacecraft and adapter shall be determined and controlled as specified in MJS77-3-200, Determination of Inertial Properties.

3.3.10.3 Subsystems. Spacecraft subsystem flight equipment shall meet the requirements of MJS77-3-230, Equipment List and Mass Allocation.

* 3.3.11 Packaging

Electronic packaging shall conform to the provisions of MJS77-3-220, Electronic Equipment Design.

3.3.12 Flight Software

The spacecraft shall be capable of performing certain functions in the Computer Command, Attitude and Articulation Control, and Flight Data Subsystems under on-board program control. These functions shall be programmable to the extent specified in MJS77-3-310, Software Requirements.

3.4 System Operations

* 3.4.1 Ground Handling and Flight Preparation

* 3.4.1.1 RTG Loading. The RTG output shall be shorted except as necessary during installation onto the MM. The transfer of the RTG output between loading connectors shall be completed in less than one hour to prevent RTG over heating.

* 3.4.1.2 PM Orientation. The serviced propulsion subsystem (PROP) shall be maintained with the propellant tank axis vertical, outlet down. Under no circumstances shall the tank outlet of the serviced subsystem be rotated more than 100 deg.

* 3.4.1.3 Telemetry Calibration. All PROP pressure transducers shall be calibrated through the flight data subsystem (FDS) prior to launch.

* 3.4.2 Prelaunch

* 3.4.2.1 General. Final assembly, checkout and other activities will be performed at Kennedy Space Center and the Air Force Eastern Test Range (AFETR).

* 3.4.2.2 Requirements

a) The PROP shall be loaded with hydrazine and pressurized in the Explosive Safe Facility (ESF) prior to being attached to the spacecraft structure.

b) The PROP, including the solid rocket motor, shall be attached to the spacecraft structure in the Spacecraft Assembly and Encapsulation Facility (SAEF).

c) Installation of pyrotechnic devices containing live ordnance (squibs) and installation of squibs in pyrotechnic devices attached to the spacecraft shall be accomplished in both the ESF and SAEF.

d) The fueled RTGs shall be attached to the spacecraft structure in the SAEF.

e) The spacecraft shall be encapsulated in the nose fairing at the SAEB.

f) No operations requiring physical access to the spacecraft shall be planned after spacecraft encapsulation.

g) Provision shall be made for S-band uplink and downlink while the spacecraft is on the launch pad.

* 3.4.2.3 Umbilical Link. The umbilical link shall provide the following:

a) Monitoring of spacecraft performance via the composite telemetry signal.

b) Capability to prepare the spacecraft for launch only where radio commands cannot do so. This includes the capability to arm the solid rocket motor and to load the FDS Memory.

c) Direct monitoring of subsystem functions related to safety where composite telemetry will not suffice. This includes the capability to monitor the Safe/Arm status of the Pyrotechnic Switching Unit (PSU) and solid rocket motor.

d) Capability to reset arming functions related to propulsion and pyrotechnics.

Detail umbilical interfaces are specified in MJS77-3-110.

* 3.4.2.4 Indefinite Hold Capability. There shall be capability during the coutdown of an indefinite hold, without the necessity of recycling. In the event of a scrub which does not require access to the spacecraft, the spacecraft shall be capable of being re-scheduled for a launch on the following day.

* 3.4.2.5 Encapsulation. The spacecraft shall have the capability of being encapsulated for up to a maximum of 30 days.

* 3.4.3 Flight Sequence

All spacecraft subsystems shall be compatible with the flight sequence described in MJS77-3-120 and the requirements listed in the following paragraphs.

* 3.4.3.1 Launch

* 3.4.3.1.1 Roll Rate. During launch, the LV may generate accelerations about the spacecraft roll axis. The maximum occurs at solid rocket motor separation when the acceleration may be $60°/s^2$ until a maximum rate of 15°/s is reached.

*3.4.3.1.2 Separation Rates. At spacecraft/LV separation the relative separation rate shall be 0.5 m/s. The post separation S/C rate shall be less than 26 mr/s. The Centaur residual rate prior to separation will be less than 3.5 mr/s.

At PM jettison, the realtive separation rate between the PM and MM shall be 0.66 m/s. The MM post jettison rates shall be less than 22 mr/s about the pitch axis and less than 45 mr/s about the yaw axis. The spacecraft residual rate prior to PM jettison shall be less than 1 mr/s about the pitch axis and less than 4 mr/s about the yaw axis.

*3.4.3.1.3 Operation During Vibration and Shock. During periods of vibration at launch and pyrotechnic shock, the DSS will be operated continuously at the 7.2 kbps tape speed.

*3.4.3.1.4 High Rate Telemetry. Engineering telemetry will be transmitted in real-time in the high rate engineering mode from prior to launch vehicle/spacecraft separation until sun acquisition.

*3.4.3.1.5 Pyrotechnic Safe/Arm. Pyrotechnic devices shall be safed by inhibiting the application of power to the firing circuits. Arming (application of power to the firing circuits) shall be accomplished after launch.

*3.4.3.1.6 Initiation of the Propulsion Module Sequence. After $MECO_2$, the LV will provide a 28-Vdc signal to the pyrotechnic subsystem (PYRO). Upon receipt of the 28-Vdc signal, PYRO shall arm the firing circuits and supply a switch closure to CCS for initiation of the PM sequence of events. The CCS shall not respond to a PYRO switch closure prior to launch plus T s, where T is a function of the launch trajectory.

*3.4.3.1.7 Orientation. To ensure compliance with constraints to keep the sun from entering the field-of-view (FOV) of the science instruments, the orientation of the spacecraft shall be controlled from spacecraft/LV separation to sun acquisition.

*3.4.3.1.8 Disturbance Torque During Injection. The placement, orientation, and alignment of all spacecraft elements that contribute to the generation of disturbance torques about the three spacecraft axes shall be controlled such that the maximum disturbance about the pitch or yaw axes shall be less than 533 n-m (393 ft-lb) (RSS) and about the roll axis shall be less than 22.5 n-m (16.6 ft-lb)(RSS).

*3.4.3.2 Cruise

*3.4.3.2.1 Thruster Operation. No mission sequence will require the simultaneous actuation of both active and redundant thrusters (i.e., thrusters providing the same control polarity about a given axis).

*3.4.3.2.2 Near Earth Antenna Pointing. In order to maximize the capability of the down link communications, prior to the time when the earth probe sun angle becomes less than the FOV of the cruise sun sensors, the cruise sun sensor shall be biased to point the MM roll axis as near the earth as possible within the sensor field of view constraints and MM thermal constraints.

* 3.4.3.2.3 Disturbance Torque. During cruise the MM shall be designed to accommodate solar and RTG generated torques with magnitudes $\leq 1.36 \times 10^{-5}$ n-m (10^{-5} ft-lb) about the pitch, yaw, or roll axis.

* 3.4.3.3 Trajectory Correction Maneuvers

* 3.4.3.3.1 Turn Duration and Direction. Temperature control of the MM imposes a constraint on the trajectory correction maneuver duration when the MM is within 2 AU of the sun. The detailed constraints are specified in MJS77-3-210.

* 3.4.3.3.2 Thrust Duration. The duration of the thrusting period shall be a time function controlled by the CCS. From 1 to 2 AU the following equation will be used to determine the maximum duration of a TCM burn, 1.0 hour x $(AU)^2$. After 2 AU the maximum TCM velocity increment the MM is capable of performing is 70 m/s, which corresponds to a maximum burn duration of 8-1/2 hours.

* 3.4.3.3.3 Telemetry. Engineering telemetry during Trajectory Correction Maneuvers will be recorded in the high rate engineering mode for later playback.

3.5 Operability

* 3.5.1 Reliability

All elements of the MJS77 Spacecraft System shall meet the reliability criteria defined in MJS77-2-100.

* 3.5.1.1 Redundancy. Where implementation of the redundancy requirements specified in MJS77-2-100 uses block redundancy, redundant elements at the provisioned spare level are specified in MJS77-3-230. Where standby redundancy is used, an additional requirement shall be that no single point failure in the switching shall prevent transfer to the standby unit.

Reliability may be enhanced by decreasing the size of the redundant blocks; therefore, redundant block size shall be determined on the basis of trade studies which consider improved reliability versus switching reliability, increased cross-strapping complexity, additional power dissipation, increased spacecraft mass, and expendature of project resources.

* 3.5.1.2 Fault Sensing and Correction Routines. The capability of on-board fault sensing and correction routines shall be limited to the minimum required to assure recovery from a failure with maximum use of ground station capability. As a minimum, on-board fault sensing and switching shall be provided to ensure a stable MM state (the MM is capable of remaining in this state until reception of ground commands) from which nominal performance can be restored via interaction with the ground stations. For example, the capability of the MM to respond to ground commands would be preserved

with the highest priority; the second priority may be to prevent loss of consumables; while the preservation of temperature control to the extent that temperatures may exceed design limits but not survival limits, may also compete for second priority. Retention of the capability to transmit engineering data without ground interaction shall be a goal.

* 3.5.1.3 Exemptions. In some cases where adequate design margin and derating have been employed, specific exemptions to the single failure criteria may be granted. Exemptions for the subsystem are listed in Section 4.0, Subsystem Requirements.

* 3.5.1.3.1 Cabling. Cabling shall be considered free of failure resulting in shorts.

* 3.5.1.4 Spacecraft/Launch Complex Interface. Techniques shall be employed in the design of the spacecraft/launch complex interface to meet the requirement that no single failure shall require the removal of the spacecraft from the launch vehicle in order to condition the spacecraft to the launch mode or to ascertain that it is in the launch mode.

3.5.2 Maintenance and Repair

3.5.2.1 Restrictions. Maintenance of the spacecraft during system level testing shall be restricted to the removal and replacement of equipment at the provisioned spares level.

3.5.2.2 System Trimming. System level electrical trimming, mechanical adjustment or alignment shall be such that these parameters are exactly and uniquely established in the event of subsystem disassembly and assembly of the spacecraft.

3.5.2.3 Subsystem Trimming. Subsystem or lower level electrical parameter trimming, mechanical adjustment, or alignment shall be performed prior to subsystem flight acceptance (FA) testing and shall not be subsequently changed.

3.5.2.4 Hardware Modifications. Modification to flight hardware after its shipment to AFETR shall be limited to those required to correct deficiencies or failures disclosed after shipment.

* 3.5.2.5 AFETR. Repairs to be effected at AFETR shall be limited to those failures which are discovered at AFETR. Failed assemblies shall be repaired in designated maintenance centers. Should repair be accomplished by replacement of assemblies, these assemblies shall have had an acceptable qualification test history. The test history shall include qualification in a fully assembled spacecraft as practical for the assembly type involved.

* 3.5.2.6 Flight. The MM shall be capable of maintaining a cruise phase operational state and attitude for at least 24 hours without ground intervention, except during the superior conjunction periods, when the requirement shall be for 10 days without ground intervention.

✱ 3.5.3 Lifetime

The MM equipment shall have operating and/or storage life, as applicable for a post launch flight duration as specified in MJS77-2-100, paragraph 6.2, and as modified by paragraph 3.12. The equipment jettisoned with the PM are exempt from the 4 year flight requirement. Total life-time of all spacecraft equipment shall accommodate a prelaunch system test program of one year in addition to the flight requirements.

3.5.4 Environments

The spacecraft shall be compatible with the requirements of MJS77-3-240, Environmental Design Requirements.

✱ 3.5.5 Safety

All spacecraft subsystems and support equipment shall incorporate protection for personnel and delicate hardware consistent with the procedures in PD618-54, Safety Plan. In order to protect delicate flight equipment, the handling and operational constraints of spacecraft subsystems, as specified in Section 8, Safety Considerations of each level 4 functional requirement, shall be strictly observed. The spacecraft design shall meet the intent of AFETRM 127-1, Range Safety Manual.

✱ 3.5.5.1 Solid Motor Safe/Arm. The safe/arm mechanical pin shall remain installed at all times from installation of igniter squibs until spacecraft encapsulation. Thereafter, the safe/arm status indicator shall be continuously monitored until liftoff. Electrical actuation of the safe/arm device shall occur just prior to liftoff.

3.6 Design and Construction

3.6.1 General

3.6.1.1 Interchangeability and Replacement. Flight spacecraft and adapters shall be interchangeable with one another with respect to mechanical, electrical and functional characteristics.

3.6.1.1.1 Mechanical. Mechanical interchangeability shall exist between the constituents or sets of like equipment at the assemblies, subassemblies, and replaceable parts level.

3.6.1.1.2 Electrical. Electrical interchangeability shall exist at the replaceable spare level between all sets of like equipment.

3.6.1.2 Electromagnetic Compatibility (EMC)

3.6.1.2.1 External Electromagnetic Interference (EMI). The design of the spacecraft shall be such that it is insensitive to the external electromagnetic environments specified in MJS77-3-240.

3.6.1.2.2 Internal EMI. The conducted and radiated electromagnetic interference generated by any of the spacecraft subsystems shall be suppressed such that it does not exceed the levels specified in MJS77-3-240. To satisfy the Magnetic Field restraints of MJS77-3-240, consideration shall be given to not using ferromagnetic material. Hard magnets may require the addition of similar magnets arranged to reduce the total field. Current loops which induce magnetic fields may require compensating loops.

3.6.1.2.3 Conducted Transient Susceptibility. Spacecraft signal input interface circuits shall be immune to the transient voltages or currents as specified in MJS77-3-240.

3.6.1.3 Equipment Identification and Marking

Assembly and subassembly reference numbers, where applicable, are established in MJS77-3-230.

3.6.2 Electrical Design Criteria

3.6.2.1 Electrical Interfacing and Grounding. The design of spacecraft system electrical interfacing and grounding shall meet the requirements specified in MJS77-3-260, Electrical Grounding and Interfacing.

* 3.6.2.1.1 Redundancy. Input or output end-circuits of parallel-connected redundant blocks including power supplies shall be designed for minimum probability of failing shorted.

* 3.6.2.2 High Voltages. The design of electrical circuits using voltage in excess of 250 V shall meet the requirements of MJS77-3-220, Electronic Equipment Design.

* 3.6.2.3 Electrical Loads. The spacecraft electrical equipment (with the exception of that equipment powered directly from the battery) shall meet the requirements listed below:

a) All loads shall be compatible with the power allocations specified in MJS77-3-250.

b) All loads shall operate within specifications throughout the type approval temperature range with the following variations in voltage at the user input:

	2.4 kHz (Vrms)	DC (Vdc)
Transient Maximum	53.5	31.5
Steady State Maximum	52.5	30.75
Design Value	50.0	30.0
Steady State Minimum	47.5	29.25
Transient Minimum	46.5	28.5

Duration of voltage excursions outside the steady state range shall not exceed 5 ms. Duration of voltage excursion outside the transient range shall not exceed 10 μs.

c) All loads shall be able to undergo input voltages ranging from zero volts to a maximum which exceeds the nominal by 15 percent for a maximum duration of 2 s, with reset to a predictable state and subsequent resumption of normal operation.

d) All loads shall be compatible with the grounding and interfacing requirements specified in MJS77-3-260.

e) Load changes for loads powered by the dc bus shall not exceed 100 W, and load changes for loads powered by the 2.4 kHz shall not exceed 50 W. Steady state loads and load transients are further subjected to the constraints of MJS77-3-250 with the exception that load changes controlled by the CCS shall be allowed a switching transient (excursion above steady state) with total energy of less than 4 Ws. Load changes shall not cause current rates to exceed 0.066 A/μs from the 2.4 kHz bus or 0.150 A/μs from the dc bus for more than 10 μs.

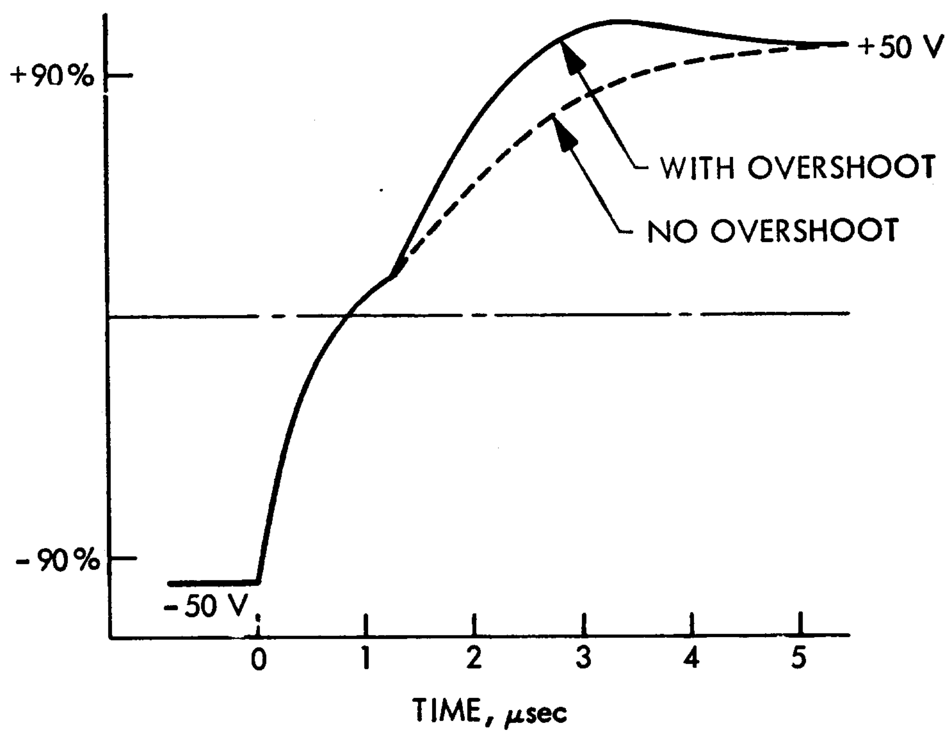
f) Power factor (ratio of average power per cycle to the product of rms voltage and current) shall be between 0.95 and unity for 2.4 kHz loads. Power factor correction capacitors, if used, shall not be placed directly across the ac buses.

g) No ac loads shall introduce more than 1.0 mA of direct current into the output of the inverter under normal operation or more than 10 mA with a single failure.

h) Loads powered from the dc source shall not introduce a ripple current (up to 50 kHz) whose peak-to-peak magnitude is greater than 1 percent of the average steady-state current when operating from a source with a dynamic impedance of less than 0.1 ohm.

i) All subsystems that use 2.4 kHz power shall operate within specification with frequency variation of ±0.002 percent of the nominal frequency throughout the type approval temperature range, and shall function to the extent that the capability of the spacecraft to receive and process ground commands is not impaired when the frequency is 2400 Hz ±6 percent. In addition, all subsystems shall have known operating characteristics over the ±6 percent frequency range and shall resume in specification operation when the frequency returns to 2400 ±0.002 percent.

j) AC loads shall operate within specification when the rise rate of the input waveform is not constant. A typical waveform is shown in Figure 1.



✱ Figure 1. 2.4 kHz Inverter Crossover Waveform (Typical)

* 3.6.2.4 Oscillator Synchronization. All oscillator circuits and all countdown circuits operating in the range of 10 Hz to 1.3 MHz shall be a harmonic of the 2.4 kHz power.

MM subsystems (except for MAG) shall avoid the use of the following frequencies (and their second harmonic): 12.600 kHz (25.200 kHz), 13.400 kHz (26.880 kHz), 15.120 kHz (30.240 kHz) and 16.128 kHz (32.256 kHz).

* 3.6.2.5 Continuity tests. When the capability to functionally verify the integrity of the cabling after final mating of a system connector does not exist, provisions shall be made to verify the continuity of each function used in the connector.

* 3.6.3 Mechanical Design Criteria

* 3.6.3.1 General. During all phases of the assembly, test, and flight preparation activities, handling equipment shall be provided (where required) to ensure that the spacecraft, MM, and components of the MM that are separated from the MM are not subjected to loads that exceed expected flight loads except during those tests specifically designed to support the environmental test program.

* 3.6.3.2 Deployable Elements. When deployable elements designed for deployment in a zero "g" field are deployed in a "1-g" field for testing, sufficient assembly, handling, and shipping equipment (AHSE) shall be provided to preclude damage and maintain stability.

Deployable elements include the science boom, science scan platform, RTG boom, magnetometer boom, and planetary radio astronomy antennas.

* 3.6.3.3 Propulsion

* 3.6.3.3.1 TCAPU Assembly. The TCAPU shall all be integrated together on its AHSE.

* 3.6.3.3.2 IPU Assembly. The IPU shall all be integrated together on its AHSE.

* 3.6.3.3.3 Propulsion Assembly. The TCAPU and the IPU are integrated with the required structure into a mechanically definable module. The spacecraft structure will allow the module to be removed from or installed on the spacecraft in either the dry or serviced condition.

* 3.6.3.4 Structural Design Criteria. All elements of the flight hardware shall meet the requirements of MJS77-3-190, Structural Design Criteria.

* 3.6.3.5 Temperature Control Design Criteria. All elements of the flight hardware shall meet the requirements of MJS77-3-210.

* 3.6.3.6 Configuration. The configuration shall meet the requirements specified in MJS77-3-180.

* 3.6.3.7 Alignments. Flight hardware shall be compatible with the mechanical alignment requirements specified in MJS77-3-170. Subsystems requiring boresight alignment shall be aligned at the subsystem level with respect to mechanical references. System level assembly will be restricted to alignment verification with respect to subsystem mounted reference mirrors and the science scan platform mirror. Field-of-view orientation checks are permissible, but alignment trimming shall not be performed at the system level.

* 3.6.3.7.1 Thrust Vector Alignment. The solid motor thrust vector final alignment for each spacecraft shall be accomplished after spacecraft assembly and center of mass determination.

3.7 Test Interfaces

The spacecraft and its test support equipment (SE) shall be capable of providing system and launch test evaluation through the following interfaces, further defined in PD618-206.

3.7.1 S-Band Interface

The ability to transmit and receive at S-band for the purpose of commanding the spacecraft, receiving telemetry, and ranging is required of the SE.

3.7.2 X-Band Interface

The ability to receive X-band for the purpose of receiving telemetry and ranging is required of the SE.

3.7.3 Stimulator/Sensor Interface

Stimulators, such as incandescent lamps, and sensors, such as gas jet detectors, will be mounted on or near the spacecraft.

* 3.7.4 Umbilical Interface

Monitoring of pyrotechnic subsystem status, and similar functions for other spacecraft subsystems are accomplished over the umbilical lines, in the final interval before committing to launch. These functions are also available in the system test configuration. The T-4 umbilical connector remains connected until 4 s before liftoff. The composite telemetry signal is included in this interface. Those functions which are required to safe the spacecraft after an abort shall be in the T-0 umbilical which remains connected until liftoff.

3.7.5 Direct Access Interface

Functions not available over other interfaces, which are necessary in the system test configuration shall be carried over the direct access interface lines. These lines connect each spacecraft subsystem with its associated SE.

3.7.6 Test Configuration

3.7.6.1 System Test Configuration. The spacecraft shall be testable as a system in the system test configuration. Each functioning subsystem shall be testable in this configuration when connected by direct access cables to test simulators, test sensors and associated subsystem SE. Flight subsystem associated SE will be augmented by other SE performing operational functions such as timing and data processing. SE design consideration shall be given to those physical and functional characteristics necessary for full support of the system test configuration. The test software shall be representative of flight software. It shall contain the same algorithms, utilize the same input and produce the same outputs as are required for flight. Timing relationships may vary to accommodate an efficient test schedule.

* 3.7.6.2 Launch Test Configuration. The spacecraft will be conditioned for launch and its launch readiness verified in the launch test configuration. There shall be no subsystem operation and verification carried out in this configuration except that which is required to support and operate the spacecraft during the launch phase. In this configuration, the only interface is via the umbilical (the direct access interface is not available). Umbilical functions are limited to those items required to support the launch preparations and launch and to monitor and/or control a few special items related to safety. Launch SE in the launch complex trailors and the system test SE in Building A0 participate jointly.

4.0 SUBSYSTEM REQUIREMENTS

The following paragraphs list the functions, single point failure criteria exemptions, and system level requirements and constraints for each subsystem. No attempt has been made to differentiate between requirements and constraints. In keeping with the guidelines that a requirement or constraint should be located in one place only, the requirement or constraint is listed for the subsystem that would be responsible for the implementation. The composition of each subsystem is specified in MJS77-3-230, and is not repeated here.

4.1 Structure Subsystem (STRU)

4.1.1 Function

The STRU provides

a) Mechanical support and alignment for all flight equipment

b) Meteoroid protection

c) Radiation protection

In addition, the structure becomes an integral part of the EMI control and provides means for handling the assembled spacecraft for flight qualification testing, transporting, and mating operations with the LV.

*4.1.2 Single Point Failure Exemption

The STRU, when designed to the requirement of MJS77-3-190 is specifically exempted from the single point failure criteria of MJS77-2-100, paragraph 4.4.

*4.1.3 Requirements and Constraints

a) The structure shall be compatible with the FOV requirements specified in MJS77-3-180.

b) Location of the science scan platform relative to the spacecraft center of mass shall be as specified in MJS77-3-180.

c) The science scan platform (including science instruments mounted on it) moment of inertia about its center of rotation shall be as specified in MJS77-3-200.

d) The science scan platform shall be designed such that the axis of rotation for both axes is coincident with the platform center of mass within ±3.8 cm (±1.5 in.).

e) Mounting and alignment provisions for the science subsystems shall be as defined in MJS77-3-170 and MJS77-3-180.

f) The structure shall provide a high gain antenna reflector with a diameter of 3.66 m, a F/D of 0.0338, and whose surface deviations from the specified surface shall not exceed 0.088 cm (0.035 in.) RMS.

g) The STRU shall provide an electrical load for use by the power subsystem to dissipate the excess power generated by the RTG. This load shall be capable of dissipating a maximum of 431 W. When located per MJS77-3-180, the assembly shall also provide a diffuse reflective surface for optical calibration of the science scan platform mounted instrument. The characteristics of the surface including dimensions, temperature and surface properties shall be as specified in ICD 10073993, Science Calibration Target-Structural Interface.

h) The structure shall provide a specular reflective surface for optical calibration of the IRIS interferometer. The mechanical and optical characteristics shall be as specified in ICD 10073993, Science Calibration Target-Structural Interface.

i) The science scan platform characteristics shall be as follows:

1) The bearing frictional torque shall be in the range from 0.3 to 0.5 ft-lb.

2) The ratio of running to static friction shall be greater than 0.8.

3) The angular stiffness in both azimuth and elevation shall be greater than 2000 ft-lb/rad.

4) The angular backlash shall be as specified in MJS77-3-170.

4.2 Radio Frequency Subsystem (RFS)

4.2.1 Function

The RFS shall perform the functions defined in MJS77-3-300.

✱4.2.2 Single Point Failure Exemptions

The RFS microwave components are specifically exempted from the single point failure criteria of MJS77-2-100, paragraph 4.4.

✱4.2.3 Requirements and Constraints

a) The RFS shall supply the composite command signal to each CDU over separate interface lines. The RFS/CDU interface shall be cross-strapped to allow either receiver to drive either CDU.

b) The RFS shall provide an indication of transmitter performance to the CCS via four level inputs. One will indicate a low S-band exciter power condition, one will indicate a low S-band TWTA power condition, one will indicate a low-X-band exciter power condition, and one will indicate a low X-band TWTA power condition.

c) The X-band and S-band TWTA shall not be simultaneously operated in their high power modes. At least one TWTA shall be operating at any time.

d) Other RFS requirements and constraints are specified in MJS77-3-300.

4.3 Modulation Demodulation Subsystem (MDS)

4.3.1 Function

The MDS shall perform the functions defined in MJS77-3-300.

4.3.2 Single Point Failure Exemptions

None

4.3.3 Requirements and Constraints

The MDS requirements and constraints are specified in MJS77-3-300.

4.4 Power Subsystem (PWR)

4.4.1 Function

The PWR shall provide a central supply of electrical power for the spacecraft. It also provides the switching and control function for the required distribution of power.

4.4.2 Single Point Failure Exemption

None

* 4.4.3 Requirements and Constraints

a) Three multi-hundred watt RTGs shall provide primary power. A battery shall supply additional power during the injection phase. After injection, capacitors supply power for transients that exceed the RTG capability.

b) In the absence of a synchronizing signal, the PWR 2.4 kHz inverter shall free run.

c) The PWR shall provide conditioned power to satisfy the requirements of MJS77-3-250, and paragraph 3.6.2.3 herein.

d) Decoding of coded commands from CCS as specified in MJS77-3-290 shall be provided for switching of spacecraft loads as specified in MJS77-3-250.

e) The PWR shall provide sufficient sensing and load switching to ensure that the dc power bus voltage does not remain more than 1 percent below the steady state minimum voltage for more than 0.5 s, or the ac power bus does not remain more than 2 percent below the steady state minimum voltage for more than 0.5 s. PWR shall supply two level inputs to CCS which will indicate that load switching has occurred and/or inverters have switched.

f) Power switching shall be interlocked to prohibit application of power to ISS when power is not applied to FDS.

g) The PWR shall provide for short circuiting the output of the RTGs during all ground operation periods when no spacecraft electrical loads are turned on or when external power is applied.

4.5 Computer Command Subsystem (CCS)

4.5.1 Function

The function of the CCS is to:

a) Decode ground commands.

b) Issue discrete and coded commands to user subsystems.

c) Issue a sequence of DC's and CC's according to the flight sequence.

d) Alter the sequence of events and CCS state in response to ground commands.

e) Respond to interrupts generated by the spacecraft or the CCS according to algorithms stored in the CCS.

4.5.2 Single Point Failure Exemptions

None

✱ 4.5.3 Requirements and Constraints

a) The CCS processors shall be capable of operation through either of the output units in the following three modes:

1) Individual - the two processors are working on separate events (or no events) which are issued independently.

2) Parallel - the two processors are both working on the same event which is issued independently.

3) Tandem - the two processors are both working on the same event which is issued only if they both agree.

b) The CCS memory shall be non-volatile.

c) CCS coded commands will be in the form of a 14-bit serial word. The CCS will supply a separate interface line for the command data, the strobe, and the enable pulse to each coded command user.

d) The CCS shall provide power management such that only one of the following loads is consuming power at any one time:

1) Scan Actuator Heater (on except when one of the other loads requires power.

2) The power required for the DSS turn-on transient in excess of the DSS steady state power.

3) One science scan platform actuator.

e) The CCS shall accept an input (switch closure) from PYRO to initiate the spacecraft/LV separation sequence.

4.6 Flight Data Subsystem (FDS)

4.6.1 Function

The function of the FDS is to:

a) Collect science data from the science instruments.

b) Collect engineering data from all spacecraft subsystems.

c) Formats the data under program control and send it either to the MDS for real-time transmission or to the DSS for storage, or both.

d) Control and sequence under program control the science instruments.

e) Provide the basic spacecraft clock.

✱ 4.6.2 Single Point Failure Exemptions

Although there are no exemptions to the single point failure criteria of MJS77-2-100, the requirements of paragraph 3.5.1.1 of this document are exempted to the extent that the FDS state vector control logic shall be designed such that a failure will result in all "A" units being selected.

✱ 4.6.3 Requirements and Constraints

a) The FDS shall process analog measurements, digital measurements and inputs indicative of discrete events. Analog data shall be converted to digital words. Discrete events shall be counted with provision made to identify their origin and time of occurrence.

b) All non-digital engineering data shall be digitized to 8-bit words.

c) The FDS shall provide the capability for 195 analog and 48 digital measurements. The input signal levels are specified in MJS77-3-270.

d) The FDS shall provide for Golay coding of non-imaging data. Use of coding to be optional.

e) The FDS basic timing shall have an accuracy of 0.002 percent.

f) The FDS shall provide sync pulses to PWR at a 4.8-kHz rate for synchronization of the 2.4 kHz inverters.

g) The FDS shall assure synchronization between 2.4 kHz inverter power cycles and ISS frames.

h) The FDS shall provide the data modes and rates specified in MJS77-3-270.

i) The FDS shall provide telemetry measurements and subcommutation consistent with MJS77-3-280, Telemetry Measurements and Data Formats.

j) The FDS shall provide control and sequencing for science subsystems consistent with MJS77-3-270.

k) The FDS shall provide the power required by temperature and pressure transducers which interface directly with the FDS.

l) The FDS shall provide an addressable digital data interface with the AACS.

m) The FDS shall provide the capability to control the DSS via coded commands. Commands to the DSS shall be 14-bit serial words identical in format to the coded commands issued by the CCS.

n) The FDS shall be standby redundant except for the state vector control logic.

4.7 Attitude and Articulation Control Subsystem (AACS)

4.7.1 Function

The AACS shall provide signals to establish and maintain spacecraft orientation and stability during the injection phase. The AACS shall control the attitude of the MM during cruise and encounter using the sun and a star (usually Canopus) as celestial reference objects and using gyro references when celestial references are not available. The AACS shall provide controlled turns about the MM reference axes for science and trajectory correction maneuvers. The AACS shall also control the attitude of the MM during the trajectory correction thrusting period. In addition, the AACS shall control the pointing of the science scan platform.

✱ 4.7.2 Single Point Failure Exemptions

The following AACS components are specifically exempted from the single point failure criteria of MJS77-2-100, paragraph 4.4.

a) IPU drivers.

b) Scan actuators.

c) Scan actuator drivers.

d) Scan actuator heater.

✱ 4.7.3 Requirements and Constraints

a) The AACS shall incorporate programmability to the extent specified by the software requirements of MJS77-3-310.

b) The AACS shall be capable of reducing the rate of the MM during undisturbed limit cycle operation to the requirements specified in paragraph 3.3.6.2.

c) The AACS shall provide limit cycle operations with deadbands programmable over the range from 0.87 to 175 mrad in 0.38 mrad steps.

d) The AACS shall provide an output signal to indicate the inadvertent loss of sun acquisition.

e) Except for trajectory correction maneuvers when five thrusters may be on simultaneously, the AACS shall supply heater power to the six active attitude propulsion thrusters and shall provide power management such that either the attitude propulsion thruster heaters or one attitude propulsion thruster is consuming power at any one time. (Mechanizations to provide both heater and thruster power simultaneously is not a requirement.)

f) The AACS control capability shall be compatible with spacecraft inertial properties specified in MJS77-3-200.

g) The AACS shall provide outputs indicative of the desired AACS power states. This output consisting of 6 signals (level interrupts) will be processed by the CCS to command the PWR to the required state.

h) In support of the fault sensing the correction routines specified in paragraph 3.5.1.2, the AACS shall provide the capability to reacquire the sun from any arbitrary orientation. In addition, the reacquisition process shall be constrained to minimize the probability of permanent solar energy induced damage to science instruments.

i) The AACS shall provide IPU and TCAPU valve open commands to PROP. The off time between adjacent commands to any valve shall be not less than 20 ms. Each open command to an IPU valve shall be 40 ms or greater in duration. Each open command to a TCAPU valve shall be 10 ms or greater.

j) The AACS shall provide failure sensing to command TCAPU isolation valves in the event of thruster malfunctions specified in MJS77-3-310.

k) The AACS power-on-reset shall provide three axis stabilization and on Earth pointing of the HGA.

4.8 Pyrotechnic Subsystem (PYRO)

4.8.1 Function

The PYRO actuates pyrotechnic devices.

4.8.2 Single Point Failure Exemptions

None.

* 4.8.3 Requirements and Constraints

a) The PYRO shall actuate squibs as shown in MJS77-3-120.

b) The PYRO shall be capable of simultaneously firing a minimum of 8 squib bridgewires as a single event.

c) The PYRO shall provide an input (switch closure) to the CCS for initiation of the spacecraft/launch vehicle separation sequence.

d) The PYRO shall perform voltage to frequency conversion for eight propulsion pressure measurements.

e) The PYRO shall be redundant except for the instrumentation power supply, PROP signal conditioning, and ISO valve position switches.

4.9 Cabling Subsystem (CABL)

4.9.1 Function

The CABL shall provide the necessary electrical inter-connections between all spacecraft subsystems, between equipment electrically connected through the system cabling harness, between subsystem electronic assemblies, and interfacing cabling from the spacecraft to the LV.

4.9.2 Single Point Failure Exemption.

Redundant wiring shall not be employed except as required to meet special reliability requirements and only after approval of the Spacecraft System Engineer.

✱4.9.3 Requirements and Constraints

a) Cabling shall be compatible with the functional requirements of all the connected equipment.

b) Access shall be provided that is adequate for necessary installation, testing, disassembly, and assembly.

c) Wire types shall be as few as practical.

d) Shielding shall be used as specified in MJS77-3-260.

e) Cabling connecting with articulating components shall be as flexible and compact as possible.

f) The loop resistance of each pyro-electronics to squib bridgewire cable (including connector pin resistance, but exclusing bridgewire resistance) shall not exceed 0.60 ohm over the expected operating temperature range.

g) Power distribution cabling shall not cause a voltage drop between the power distribution unit and the load that is greater than 0.5 percent of the distributed design value for loads as specified in MJS77-3-250.

h) Cabling to the science scan platform shall allow the platform to rotate. The maximum torque required to twist the cable through the scan range indicated below at 0°F shall be:

	Torque		Scan Range
	cm-N	(in-lb_f)	(degrees from center)
Azimuth axis	±112	(±10)	±180°
Elevation axis	±224	(±20)	±120°

i) Cables external to the bus and science scan platform enclosures shall be conductively isolated from support structure and radiatively insulated such that heat transfer to or from sensitive equipment via cabling is minimized.

4.10 Propulsion Subsystem (PROP)

4.10.1 Function

The PROP shall provide:

a) The final increment of injection energy to achieve the required interplanetary trajectory.

b) Impulse for post injection trajectory corrections.

c) Control torque to maintain spacecraft orientation and stability.

* 4.10.2 Single Point Failure Exemptions

The following PROP components are exempt from the single point failure criteria of MJS77-2-100, paragraph 4.4, and paragraph 3.5.1.2 of this document.

a) IPU engines.

b) Solid motor including the safe/arm device.

c) Propellant tank and lines.

d) P_c integrator output.

* 4.10.3 Requirements and Constraints

a) The solid rocket motor defined by Thiokol Chemical Corporation Specification CP364-4 shall be used to provide final impulse for injection.

b) The TCAPU shall provide thrust for thruster calibration and at least nine trajectory corrections. (The first trajectory correction may include multiple thrust periods.)

c) The PROP shall satisfy the trajectory correction velocity specified in MJS77-3-150.

d) Reaction control expendable mass shall be allocated sufficient to perform the mission events specified in MJS77-3-120 with the expendable mass allocated in MJS77-3-230.

e) The minimum thruster impulse bit for a TCAPU thruster shall be $\leq$ 0.0178 N-s (0.004 lbf-s) with minimum open command as specified in 4.7.3.i and with a duty cycle less than 0.01 percent.

f) The minimum thrust provided by any TCAPU thruster, after one second of firing, shall be 0.445 N (0.10 lbf).

g) TCAPU thruster pulse-to-pulse impulse bit variability under fixed conditions shall be $< \pm 15$ percent (3σ) for duty cycles less than 0.01 percent. Thruster-to-thruster steady state thrust variability shall be <5 percent (3σ).

h) TCAPU thruster impulse bit shall be predictable to $< \pm 50$ percent (3σ) for any operating condition.

i) TCAPU pulse response under any operating conditions shall be:

1) Maximum chamber pressure rise time
   Signal to 10 percent of pulse peak thrust - 30 ms
   Signal to 90 percent of pulse peak thrust - 80 ms
2) Maximum chamber pressure decay time
   Signal to 10 percent of pulse peak thrust - TBD

j) For a single trajectory correction maneuver the TCAPU shall provide a total impulse variable over the range 71.2 to 48,900 N-s (16 to 11,000 lbf-s).

k) Impulse prediction error during TCM shall be as specified in MJS77-3-170.

l) Each TCAPU thruster shall be capable of at least 400,000 actuations.

m) The maximum leakage force produced by a single thruster shall not exceed 22.2×10^{-8}N (5×10^{-8} lbf).

n) The thrust provided by an IPU A or B engine shall be $\geq$ 434 N (97.6 lbf).

o) The thrust provided by an IPU roll engine shall be $\geq$ 24 N (5.4 lbf).

p) Pulse response (after 1 s warm-up) for all IPU engines:

1) Maximum chamber pressure rise time:
   Signal to 10 percent of peak pulse thrust - 25 ms
   Signal to 90 percent of peak pulse thrust - 45 ms
2) Maximum chamber pressure decay time:
   Signal to 10 percent of peak pulse thrust - 35 ms

q) The minimum impulse bit for IPU engines after 1 s firing time shall be $\leq$ 13.3 N-s (3.0 lbf-s) for the A & B engines and $\leq$ 0.667 N-s (0.15 lbf-s) for the roll engine with minimum open commands as specified in 4.7.3.i.

4.11 Temperature Control Subsystem (TEMP)

* 4.11.1 Function

The function of the TEMP is to maintain the temperature throughout the spacecraft to within the limits specified in MJS77-3-210. In addition, micrometeoroid protection is provided by the TEMP.

* 4.11.2 Single Point Failure Exemptions

The following TEMP components are specific exemptions from the single point failure criteria of MJS77-2-100, paragraph 4.4.

a) Thermal blankets.

b) Thermal shields.

c) RHUs.

d) Micrometeoroid shields.

✱ 4.11.3 Requirements and Constraints

Hardware elements required for thermal control which are physically incorporated into other subsystems are considered to be part of the subsystem with which they are delivered to SAF and are therefore not part of the TEMP mass allocation. Examples of such items are paints, heaters, thermal isolation mounts, and some thermal shields.

4.12 Mechanical Devices Subsystem (DEV)

✱ 4.12.1 Function

The DEV shall provide latching, deployment, and damping. Specific functions performed are:

a) Deployment of the

1) RTG boom.

2) Science boom.

3) Magnetometer boom.

b) Latching of

1) Science Scan platform to PM.

2) RTG Boom to PM.

3) PM to MM.

4) PM to LV.

5) Magnetometer boom.

c) Separation of

1) Spacecraft from LV.

2) PM from MM.

✱4.12.2 Single Point Failure Exemptions

The magnetometer boom and the deployment mechanisms for the RTG boom and science boom are exempted from the single point failure criteria of MJS77-2-100, paragraph 4.4.

✱4.12.3 Requirements and Constraints

a) The RTG and science boom nominal deployment rate shall be 0.3 deg/s.

b) The magnetometer deployment rate shall be 0.125 m/s.

c) The outboard low field magnetometer shall be deployed 13 m from the intersection of the boom center line with its mounting plane, with the sensors located as specified in MJS77-3-180 and aligned as specified in MJS77-3-170.

d) RHUs shall be mounted to the support structure for the HFM magnetometer sensor. Thermally conductive paths into the magnetometer from the RHUs shall be provided.

e) A separation force shall be imparted to the MJS77 spacecraft sufficient to meet the requirements of paragraph 3.4.3.1.2. An impact-free (nominal) separation shall be achieved in the face of a Centaur residual rate specified in paragraph 3.4.3.1.2.

f) A separation force shall be sufficient to generate a relative separation rate between the MM and the PM as specified in paragraph 3.4.3.1.2. An impact free (nominal) separation and post jettison MM rates as specified in paragraph 3.4.3.1.2 shall be provided.

g) The DEV shall provide the capability to reduce the I_{yz} product of inertia to a nominal value of zero within the tolerances specified in MJS77-3-200.

h) Dampers shall be installed on the RTG Boom Locking Strut and Magnetometer Boom Assembly. The dampers shall provide damping of the form $e^{-2\pi yt}$ over the desired displacement range (x); where y is the product $[(c/c_c) \times (fn)]$.

For $c/c_c = 0.04$, the damping product (y) and displacement values are given below.

Boom	Damping Product (y)	Displacement Limits
RTG	0.091 Hz	$0.0005 \geq x \geq 0.0001$ in.
Mag.	0.0064 Hz	$0.00125 \geq x \geq 0.00025$ in.

4.13 Data Storage Subsystem (DSS)

4.13.1 Function

The DSS shall provide bulk storage of spacecraft digital data.

* 4.13.2 Single Point Failure Exemptions

The DSS is exempt from the single point failure criteria of MJS77-2-100, paragraph 4.4.

* 4.13.3 Requirements and Constraints

a) The DSS shall accept single stream data for storage at 115.2 or 7.2 kbps.

b) The DSS shall play back the stored data at 57.6, 33.6, 21.6 or 7.2 kbps in a time sequence that is the same as the recorded sequence.

c) The bit error rate at end of mission shall be less than 10^{-4} measured between input and output of the DSS for all playback rates.

d) With continuous input data, the storage capacity of the DSS shall be at least 5.36×10^{8} bits. The DSS shall provide the capability to store blocks of data of variable size. Storage capacity lost during starting and stopping to record a block of data shall not exceed 4×10^{5} and, 10^{4} bits for record rates of 115.2, and 7.2 kbps, respectively.

e) The DSS shall provide a slew mode for rapid access of a record or playback starting point.

f) The DSS shall provide the capability to start record or playback at any point on the tape. The DSS shall provide an output signal indicative of tape movement that will accommodate location of a specific point on the tape ±10 cm (4 in.).

g) The total tape travel across the DSS record/playback head shall not exceed 8.34 x 10^5 m.

h) The total number of passes across a head by any section of tape shall not exceed 6500.

i) The delay between the receipt of start record signal and when the DSS is ready to receive data shall be less than 4.5 s.

j) The DSS shall provide the capability to start and stop the DSS tape a minimum of 10^4 times.

k) The DSS shall provide a dedicated location on the magnetic tape to be used for storage at FDS programs. There shall be a minimum of eight segments of tape, each with a capacity greater than 150 k bits, certified by bit error tests to be error free.

l) The DSS shall provide a pulse output indicating when the tape has reached the beginning or end of the tape.

4.14 S/X Band Antenna Subsystem (SXA)

4.14.1 Function

The SXA shall perform the functions defined in MJS77-3-300.

*4.14.2 Single Point Failure Exemption

The SXA equipment shall be exempt from the single point failure criteria of MJS77-2-100, paragraph 4.4.

*4.14.3 Requirements and Constraints

The SXA requirements and constraints are specified in MJS77-3-300.

4.15 Cosmic Ray Subsystem (CRS)

4.15.1 Function

The CRS shall measure the energy and composition of cosmic ray nuclei from hydrogen to iron over the energy range from 1 to 500 MeV per nucleous. Electrons shall be measured over the range from 3 to 120 MeV. These measurements shall be made during both cruise and encounter phases of the mission.

4.15.2 Requirements and Constraints

a) The CRS shall be mounted to the spacecraft consistent with the requirements specified in MJS77-3-180.

b) The CRS shall not be exposed to relative humidity over 70 percent (50 percent when operating).

4.16 Planetary Radio Astronomy Subsystem (PRA)

4.16.1 Function

The PRA shall measure the strength and polarization of radio signals in the 20 kHz to 40.5 MHz range. These measurements shall be made during both cruise and encounter phases of the mission.

4.16.2 Single Point Failure Exemption

The PRA/PWS antenna is exempted from the single point failure criteria of MJS77-2-100, paragraph 4.4.

4.16.3 Requirements and Constraints

a) The spacecraft shall provide mounting for two, deployable, 10-m length, interlocking monopole antennas. Detailed mounting is specified in MJS77-3-180.

b) The PRA monopole antenna shall be designed to provide the following stability properties:

1) Bending stiffness EI $\geq$ 16.6 lb-ft^2.

2) Bending strength at antenna base $\geq$ 3.7 x 10^{-2} ft-lb.

3) Antenna element mass $\leq$ 0.5 lbm.

4.17 Plasma Wave Subsystem (PWS)

4.17.1 Function

The PWS shall make measurements of the electric fields of plasma waves both during cruise and at Jupiter and Saturn in the frequency range from 10 Hz to 56.2 kHz.

4.17.2 Requirements and Constraints

a) The PWS shall use the planetary radio astronomy antennas.

b) The PWS shall provide notch filtering to reject 2.4 and 7.2 kHz interference signals.

4.18 Low Energy Charged Particle Subsystem (LECP)

* 4.18.1 Function

The LECP measures the charge and energy distribution of nuclei over the energy range 0.04 to $\geq$ 30 MeV/nucleon, the energy distribution of electrons from 10 keV to 10 MeV and protons from 15 keV to 150 MeV.

* 4.18.2 Requirements and Constraints

a) The LECP shall be mounted to the spacecraft consistent with the requirements specified in MJS77-3-180.

b) Spacecraft will be rolled for calibration as specified in MJS77-3-120.

c) The LECP shall not induce into any MM axis a momentum increment greater than 7.5×10^{-2} kg-m^2/s.

d) The LECP shall not be exposed to humidity in excess of 50 percent.

4.19 Photopolarimeter Subsystem (PPS)

* 4.19.1 Function

The function of the PPS is to measure the intensity and polarization of light at eight wavelengths between 235 and 750 nanometer.

* 4.19.2 Requirements and Constraints

a) The PPS shall be mounted on the science scan platform and bore sighted with the ISS as specified in MJS77-3-180.

b) The PPS shall be compatible with pointing accuracies specified in MJS77-3-170.

c) Rotation of filter wheel and aperture/polarizer wheel shall not induce into any MM axis a momentum greater than 7.5×10^{-2} kg-m^2/s.

d) The spacecraft/science platform orientation shall be controlled such that the sun does not come within 0.349 rad of the PPS boresight.

e) The PPS shall provide a Brewster plate for polarization calibration. The plate shall be mounted per the requirements of MJS77-3-180 to the accuracies specified in MJS77-3-170.

f) The MM will provide for viewing of an MM mounted target and the Brewster plate for in-flight calibration of the PPS.

4.20 Plasma Subsystem (PLS)

4.20.1 Function

The PLS measures both solar wind electrons and solar wind ions with energies in the range of 10 to 5950 V.

* 4.20.2 Requirements and Constraints

a) The PLS shall be mounted to the spacecraft consistent with the requirements specified in MJS77-3-180.

b) Prior to and during instrument operation the relative humidity shall be maintained at 50 percent or less.

c) The PLS shall be compatible with the pointing accuracies specified in MJS77-3-170.

4.21 Ultraviolet Spectrometer Subsystem (UVS)

* 4.21.1 Function

The UVS measures ultraviolet emissions in the region 40 to 180 nm.

* 4.21.2 Requirements and Constraints

a) The UVS is mounted on the science scan platform and its airglow FOV boresighted with ISS as specified in MJS77-3-180, and aligned to the accuracies specified in MJS77-3-170.

b) The UVS occultation FOV shall be aligned compatible with the pointing accuracies specified in MJS77-3-170.

c) The requirements for science maneuvers are specified in MJS77-3-120.

d) Spacecraft orientation will be controlled such that the sun does not come within 20 deg of the UVS airglow bore boresight.

e) The MM will provide for viewing of a MM mounted target for in-flight calibration of the UVS.

f) During storage or ground operations the UVS will not be exposed to relative humidity greater than 15 percent.

4.22 Magnetometer Subsystem (MAG)

4.22.1 Function

The MAG measures the ambient magnetic fields over the range 10^{-11} to 2×10^{-3}T.

* 4.22.2 Requirements and Constraints

a) The MAG consists of two low field magnetometers (LFM) and two high field magnetometers (HFM) and shall be mounted on a deployable boom as specified in MJS77-3-180.

b) Two axes of each sensor shall be aligned transverse to the MM roll axis. The third sensor axis shall be aligned parallel to the MM roll axis. Alignment accuracies shall be as specified in MJS77-3-170.

c) The MM magnetic field shall not exceed 0.2 nT at the outboard LFM as established by analytical means.

d) The MAG sensors axis shall be aligned to mechanical reference marks compatible with paragraph 3.6.3.7 and MJS77-3-170.

e) The MM will provide rotation about the MM roll axis and separately about the yaw or pitch axis for in flight calibration as specified in MJS77-3-120.

f) RHUs will be accommodated by the support structure for the HFM sensors rather than by the sensors themselves. RHU attachment shall be accommodated by the LFM sensor base plates and shall be a part of the LFM sensors.

Thermally conductive paths into the sensitive elements of the magnetometer sensors from the RHUs shall be provided.

4.23 Imaging Science Subsystem (ISS)

4.23.1 Function

The ISS shall acquire image data of Jupiter and Saturn and many of their satellites.

* 4.23.2 Requirements and Constraints

a) The ISS shall consist of a two camera system, a narrow angle (1.5 m) and a separate wide angle (0.2 m).

b) The narrow angle and wide angle cameras shall be mounted on the science scan platform as specified in MJS77-3-180.

c) The ISS shall be mounted on the spacecraft and aligned as specified in MJS77-3-170.

d) The MM will provide for viewing of a MM mounted target for in-flight calibration of the ISS.

e) The ISS shall provide reseau marks such that the orientation of each image is unambiguously established.

4.24 Infrared Interferometer Spectrometer and Radiometer Subsystem (IRIS)

* 4.24.1 Function

The IRIS shall sense the infrared spectrum from 200 to 4000 cm^{-1}. Reflected solar energy between 5000 and 33000 cm^{-1} shall also be measured.

* 4.24.2 Requirements and Constraints

a) The IRIS shall be mounted on the science scan platform and boresighted with the ISS as specified in MJS77-3-180.

b) The MM will provide knowledge of the IRIS pointing direction. The IRIS shall be aligned to the accuracies specified in MJS77-3-170.

c) The IRIS shall not induce into any MM axis a momentum increment greater than 7.5×10^{-2} $kg\text{-}m^{-2}/s$.

d) The MM shall provide for viewing of a MM mounted target for in-flight calibration of the IRIS.

e) Relative humidity of optics module must be maintained below 30 percent during ground testing.

f) The IRIS shall be compatible with the data bit error rates specified in MJS77-3-270.

g) Vibration levels during IRIS operation must be less than 0.01 g peak in the frequency band from 5 to 640 Hz.

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FUNCTIONAL REQUIREMENT AMENDMENT

(Insert in 618-205, MJS77 Functional Requirements Book)

TITLE:	
MARINER JUPITER/SATURN 1977 FUNCTIONAL REQUIREMENT BOOK INTRODUCTION	FR No. MJS77-1-100A AMENDMENT No. 1 PAGE 1 OF 1 DATE: 20 October 1976 PER ECR No. 36366

DESCRIPTION OF CHANGE:

Paragraph 5.0, page 5, SUBSYSTEM REFERENCE NUMBERS, add the following subsystem reference number:

Ref. No.	Abbreviation	Subsystem
50	SFB	System Fasteners and Brackets

NOTE: This amendment is reissued to correct the referenced document page number and paragraph title, and supersedes the previously issued amendment dated 11 October 1976.

DISTRIBUTION:	REMARKS:
List 197	Referenced ECR Incorporated as Noted.
	APPROVED:

JPL 2030 (11-69)

(Insert in 618-205, MJS77 Functional
Requirements Book)

Custodian: E. L. Nave

APPROVED:

Spacecraft System Manager: R. L. Heacock

Spacecraft System Engineer: R. F. Draper

JET PROPULSION LABORATORY

No. MJS77-1-100A
5 June 1975
SUPERSEDES
MJS77-1-100
20 December 1974

MARINER JUPITER/SATURN 1977 FUNCTIONAL REQUIREMENTS BOOK

INTRODUCTION

✱ Denotes Change

1.0 PURPOSE AND SCOPE

1.1 Purpose

The purpose of the Mariner Jupiter/Saturn 1977 (MJS77) Functional Requirements Book is to provide the design criteria, the functional requirements and an accurate functional description of the MJS77 spacecraft at both the system and subsystem levels. The functional requirements herein will be used for the establishment of the subsystems and overall spacecraft system design.

1.2 Scope

The MJS77 Functional Requirements Book defines the spacecraft system and allocates system functions among the subsystems. This book contains information on the spacecraft system exclusive of the support equipment. This book is the controlling source of information on the spacecraft design; consequently conflicting statements, either written or oral, have no status until resolved and adopted by being included herein.

2.0 GENERAL

2.1 Responsibilities

The MJS77 Spacecraft System Engineer is responsible for the overall development of the MJS77 Functional Requirements Book and for insuring that the spacecraft system as defined in this book is consistent with the applicable documents as defined in MJS77-2-100, Spacecraft Design Criteria.

Generation and maintenance of complete, current, and accurate spacecraft information in the MJS77 Functional Requirements Book is the responsibility of the cognizant engineer (custodian) for that functional requirement.

2.2 Change Control

Change control of the MJS77 Functional Requirements Book shall be governed by the requirements of Project Document 618-232 (PD 618-232), Mariner Jupiter/Saturn 1977 Configuration Management Plan. This book will be revised by functional requirement amendments and revised functional requirements.

2.3 Limitations

The functional requirements will not contain any information on schedules, test plans, detail design, environmental qualification, quality control, or resource requirements.

3.0 DIVISION OF CONTENTS

3.1 General

This book consists of four principal sections:

a) Section 1: Introduction

b) Section 2: Spacecraft Design Criteria

c) Section 3: Spacecraft System Functional Requirements

d) Section 4: Spacecraft Subsystem Functional Requirements

3.2 Order of Precedence

With respect to technical content, the order of precedence is as follows:

a) Section 2

b) Section 3

c) Section 4

In the event of conflict between documents contained within the MJS77 Functional Requirements Book, this order of precedence shall prevail. Within each section; the order of precedence shall be determined by the MJS77 Spacecraft System Engineer as required.

3.3 Spacecraft Design Criteria (Section 2)

The functional requirement in this section is written to provide ground rules, guidelines, and a definition of the general design philosophy which will be used in the design of the MJS77 spacecraft. It also identifies mission requirements and constraints necessary for the successful accomplishment of the mission objectives.

3.3.1 Responsibilities

The functional requirement in this section is the responsibility of the Mariner Jupiter/Saturn 1977 Spacecraft System Manager and is approved by the Project Manager.

3.4 Spacecraft System Level Requirements (Level 3)

The functional requirements in this section state requirements which relate to the Spacecraft System, or requirements that involve more than one subsystem. The system level function requirements, as a group shall:

a) Set the requirements for those functions that the system shall perform and the sequences by which they shall be performed.

b) Delineate subsystem boundaries in sufficient detail so that identification with cognizant design groups can be made and interface control can be maintained.

c) Set limits or tolerances within which the system must perform.

d) Allocate units of variance for error sources.

e) Identify pertinent physical characteristics of the system.

3.4.1 Responsibilties

The functional requirements in this section are the responsibility of the MJS77 Spacecraft System Engineer and in certain specific cases may be assigned to cognizant engineers in other divisions. The Functional Requirements are approved by the MJS77 System Engineer and by persons designated by the divisions of the assigned engineer. The MJS77 Spacecraft System Manager will also approve MJS77-3-100, Spacecraft Requirements and Constraints.

3.5 Spacecraft Subsystem Level Requirements (Level 4)

The functional requirements in this section delineate the design of the individual subsystems. These requirements shall:

a) Define the functional requirements imposed upon the subsystem.

b) Define the boundaries of the subsystem.

c) Describe the functions that the subsystem shall perform and the sequence by which they shall be performed.

d) Set the limits and tolerances within which the subsystem must perform.

e) Identify the input and output interface elements.

f) Identify pertinent physical characteristics of the subsystem.

g) Identify special safety considerations dictated by the design relative to the safe handling and testing of the subsystem.

3.5.1 Responsibilities

Subsystem functional requirements are written by cognizant subsystem engineers and are approved by the MJS77 Spacecraft System Engineer, cognizant engineer, cognizant engineer's supervisor and division representative, and where applicable, by principal investigators.

4.0 FUNCTIONAL REQUIREMENT IDENTIFICATION

4.1 General

The Mariner Jupiter/Saturn 1977 Functional Requirements shall use a three-group coding in accordance with the following example:

Code Group	1	2	3
Requirement No.	MJS77	4	2005

4.1.1 Code Group 1

This code group identifies the spacecraft model. The MJS designates Mariner Jupiter/Saturn, and the 77 designates the year in which the spacecraft is to be launched. This will be common to all Functional Requirements in this book.

4.1.2 Code Group 2

This code group identifies the section into which the functional requirement will be inserted. In the example, the 4 indicates the spacecraft subsystem functional requirement section. This code group also indicates the functional requirement level number.

4.1.3 Code Group 3

This code group identifies the functional requirement within the section. In the example, the spacecraft flight equipment will be between 2000 and 2099 with the last two digits indicating the reference designation number of the subsystem to which the functional requirement applies. Therefore, the number 2005 indicates the functional requirement is for spacecraft flight equipment; in this case, the computer command subsystem.

5.0 SUBSYSTEM REFERENCE NUMBERS

The subsystem reference numbers assigned to the MJS77 System are as follows:

Ref. No.	Abbreviation	Subsystem
01	STRU	Structure subsystem
02	RFS	Radio frequency subsystem
03	MDS	Modulation demodulation subsystem
04	PWR	Power subsystem
05	CCS	Computer command subsystem
06	FDS	Flight data subsystem
07	AACS	Attitude and articulation control subsystem
08	PYRO	Pyrotechnic subsystem
09	CABL	Cabling subsystem
10	PROP	Propulsion subsystem
11	TEMP	Temperature control subsystem
12	DEV	Mechanical devices subsystem
16	DSS	Data storage subsystem
17	SXA	S/X-band antenna subsystem
21	CRS	Cosmic ray subsystem
22	PRA	Planetary radio astronomy subsystem
23	PWS	Plasma wave subsystem
25	LECP	Low energy charged particle subsystem
27	PPS	Photopolarimeter subsystem
32	PLS	Plasma subsystem
34	UVS	Ultraviolet spectrometer subsystem
35	MAG	Magnetometer subsystem
36	ISS	Imaging science subsystem
39	IRIS	Infrared interferometer spectrometer and radiometer subsystem
50	SFB	System Fasteners & Brackets

6.0 STRUCTURE AND CONTENT

6.1 Specific Guidelines

a) The only requirements which may be expressed in level 4 functional requirements are requirements on the subject subsystem covered by the functional requirement. These requirements shall be:

   1) Explicitly and concisely expressed.

   2) Recognizable through the presence of the verb, shall.

b) Requirements on other subsystems which impact the performance of the subject subsystem shall be incorporated as requirements in the appropriate level 3 functional requirement. Level 4 reference to these requirements are to be identified through the verb, will.

c) Names of subsystem shall not be capitalized.

d) Abbreviations used within the text shall be spelled out at their first usage.

e) Documents used within the text shall have number and title at their first usage, thereafter they shall be referenced by their number only.

f) Information which is not established, at the time of writing, shall be identified as a representative number whenever possible. These numbers shall be identified with a number sign (#) (denoted at the bottom of the same page as follows: # denotes representative number).

g) Information which is unavailable at the time of writing shall have a space reserved for it, and identified with a "TBD (To Be Determined).

h) Standard introduction of section 2 of level 4 functional requirements shall be provided to the authors by the MJS77 Spacecraft System Engineer.

i) All functional requirements shall list MJS77-3-100, Spacecraft Requirements and Constraints, in section 2. Inclusion of other level 3 functional requirements is required in section 2 if and only if they are referred to in the text subsequent to section 2.

6.2 Level 3 Functional Requirement Guidelines

Section	Content
1.0	SCOPE
	This section shall be a concise statement identifying the topic covered by this requirement and the use for which the document is intended.
2.0	APPLICABLE DOCUMENTS
	Supplementary and supporting documents shall be listed in this section and referred to in the subsequent text.

Subsequent sections shall follow the format specified below to the extent that they apply. When this is not the case, corresponding Mariner Mars 1971 (M71), Mariner Venus/Mercury 1973 (MVM73), and Viking Orbiter 1975 (VO75) documents should be used as guides.

3.0	SYSTEM REQUIREMENTS
	System-level requirements should appear in section 3.0. If appropriate, this section should include design philosophy, criteria and description at the system level.
4.0	SUBSYSTEM REQUIREMENTS
	This section is the subsystem-level counterpart of section 3.0.

6.3 Level 4 Functional Requirement Guidelines

Each level 4 (subsystem level) functional requirement shall consist of eight sections as described below. If one (or more) of these sections is not applicable to a particular Level 4 functional requirement, it should be so stated in that functional requirement.

Section	Content
1.0	SCOPE
	This section shall be a concise statement identifying the subsystem covered by this requirement and the use for which the subsystem is intended.
2.0	APPLICABLE DOCUMENTS
	Supplementary and supporting documents shall be listed in this section.

3.0 FUNCTIONAL REQUIREMENTS

This section shall contain a listing of each functional requirement which this subsystem must satisfy.

4.0 FUNCTIONAL DESCRIPTION

This section shall contain a description of the spacecraft subsystem. This description shall include a functional block diagram, a description of the operation of the major elements of the subsystem, and a state diagram. Operational sequences, flow diagrams and other tabular information may be included as required.

5.0 INTERFACE DEFINITION

This section shall contain a compilation of all system level interfaces, each described and each containing a listing of all applicable inputs and outputs including the respective source or destination. These interfaces are in the following typical categories:

a) Optical

b) Mechanical

c) Thermal

d) Electrical

e) Radio Frequency

f) Radioactive

Interfaces with systems other than the MJS77 spacecraft shall be called out and referenced to the applicable Interface Requirements Document.

6.0 PERFORMANCE PARAMETERS

This section shall state the required subsystem performance parameters (nominal and operating range) necessary to meet the functional requirements of this document, such as temperature, power, sensitivity frequency response, dynamic range resolution, signal-to-noise ratio, bit rates, etc.

7.0 PHYSICAL CHARACTERISTICS AND CONSTRAINTS

This section shall define physical characteristics such as mass, power, volume, environmental conditions, operations conditions, etc. Mass and power shall be stated in terms of a reference to the Equipment and Mass List (3-230) and the Power Profile and Allocations (3-250), respectively.

8.0 SAFETY CONSIDERATIONS

This section shall list the factors which must be considered in the formulation of operational procedures to ensure the safety of personnel, equipment and facilities.

9.0 SPECIAL REQUIREMENTS (SCIENCE SUBSYSTEMS ONLY)

This section shall list science instrument requirements not covered in a previous section. The requirements in this section shall include those which are necessary to more completely characterize a science instrument or its performance and shall be limited to the subsystem or system functional level.

7.0 ABBREVIATIONS AND ACRONYMS

The following are abbreviations or acronyms for words, phrases, quantities and measurements which may be used in the MJS77 Functional Requirements Book.

* 7.1 Words and Phrases

Abbreviations	Explanation
AACS	Attitude and articulation control subsystem
AAI	All-axes inertial
ACCEL	Accelerometer
ACIS	Antenna control and integration subassembly
ACQ	Acquisition
ACT	Actuator
A/D	Analog-to-digital
ADC	Analog-to-digital converter
AEC	Atomic Energy Commission
AFETR	Air Force Eastern Test Range
AFETRM	Air Force Eastern Test Range Manual
AGC	Automatic gain control
AGE	Aerospace ground equipment
AHSE	Assembly, handling and shipping equipment
AMPL	Amplifier
ANT	Antenna
ANTCAL	Antenna calibration link
AOS	Acquisition of signal
A/P	Autopilot
APC	Automatic phase control

Abbreviations	Explanation
A/PH	Analog-to-pulse height
A/PW	Analog-to-pulse width
Assy	Assembly
A.U.	Astronomical unit
AUTO	Automatic
AUX	Auxiliary
AVG	Average
AZ	Azimuth
BAT	Battery
BB	Beam blanking
BECO	Booster engine cut off
BER	Bit error rate
BOL	Beginning of life
BOM	Beginning of mission
BOT	Beginning of tape
BP	Bandpass
BR	Bandreject
BS	Bit sync
B/U	Backup
CA	Closest approach
CABL	Cabling subsystem
CALIB	Calibration
CAS	Command acquisition sequence
CB	Circuit breaker
CC	Coded commands
CCS	Computer command subsystem
CCSUP	Computer command subsystem update link
CDS	Circuit data sheet
CDU	Command detector unit
CG	Center-of-gravity
CH	Channel
CHRGR	Charger
CI	Control information
2CLGC	Two-color global coverage link
3CLGC	Three-color global coverage link
Clk	Clock
CM	Center-of-mass
CMD	Command
CMOS	Complementary metal oxide semiconductor
COND	Conditioner
CONT	Continuous
CONV	Converter
CP	Central Processor
CRS	Cosmic ray subsystem
CRT	Cathode ray tube
CS	Circulator switch
CSA	Celestial sensors assembly
CS/S	Cruise sun sensor

Abbreviations	Explanation
CSS	Centaur standard shroud
CST	Canopus star tracker
CTA 21	Compatibility Test Area
D	Disable
DAC	Digital-to-analog converter
DC	Discrete command
DCR	dc restoration
Depl	Deploy
DET	Detector
DEV	Mechanical devices subsystem
DIG	Digital
DIST	Distribution
DMA	Direct access to memory
DN	Data Number
DPE	Dynamic phase error
DRIRU	Dry Inertial Reference Unit
DRVID	Difference Range versus Integrated Doppler
DSIF	Deep Space Instrumentation Facility
DSN	Deep Space Network
DSS	Data storage subsystem
DSSE	Data storage subsystem electronics
DSS-(No.)	Deep Space Station - (number of station)
DSST	Data storage subsystem transport
DTM	Development test model
DTR	Digital Tape Recorder
E	Enable
E ± time	Encounter [time of closest approach (CA)] ± time from or to CA
EA	Electronic Assembly
ECI	Engineering Change Instruction
ECR	Engineering Change Requirement
EFF	Efficiency
EL	Elevation
EMC	Electromagnetic compatibility
EMI	Electromagnetic interference
ENC	Encounter
ENG	Engine
ENGR	Engineering
EOM	End-of-mission
EOT	End-of-tape
ERF	Erase/read frame rate
ERL	Erase/read line rate
ERTS	Earth Resources Technology Satellite
ESA	Explosive safe area
ESF	Explosive Safe Facility
ETL	Environmental Test Laboratory
EV	Engine valve
EXP	Exposure

Abbreviations	Explanation
F	Filament
FA	Flight acceptance
FCP	Flight control processor
FDS	Flight data subsystem
FDSUP	Flight data subsystem update link
Fe	Iron
FF	Focus field
F/F	Flip-flop
FIXLO	Fixed Frequency Low Bit Rate
FLTR	Filter
FOM	Figure-of-merit
FOV	Field-of-view
FR	Functional Requirement
FREQ	Frequency
FS	Factor of safety
FSE	Filter step enable
FSK	Frequency shift keyed
FSS	Frequency selective subreflector
FV	Fuel valve
FWHM	Full width - half maximum
G & C	Guidance and Control
GC	Golay Coded frames
GCF	Ground Communication Facility
GD/C	General Dynamics/Convair
GDS	Ground Data System
GFE	Government furnished equipment
GHE	Ground Handling Equipment
GMT	Greenwich Mean Time
GS&E	General Science and Engineering
GYCAL	Gyro calibration link
H	Hydrogen
HARAD	Harmonic Radiation
HED	High energy detector
HET	High energy telescope
HFB	Horizontal flyback
HFLC	High Frequency Log Compressor
HFM	High field magnetometer
HGA	High gain antenna
h_p	Periapsis altitude
HP/LP	High power/low power
HR	High rate
HSDL	High Speed Data Line
HTR	Heater
HVPS	High voltage power supply
HYBIC	Hybrid buffer interface circuit
HYPACE	Hybrid programmable attitude control electronics

Abbreviations	Explanation
NO	Normally open
NRT	Non-real time
NRZ	Non-return-to-zero
NRZ-L	Non-return-to-zero-level
NSW	Nonsolar wind
OBHFM	Outboard high field magnetometer
OBLFM	Outboard low field magnetometer
OC	Overcurrent
OCC	Occultation
OCCUL	Occultation link
OD	Orbit determination
O/L	Out of lock
Op-code	Operations code
OPSSG	Outer Planets Space Science Group
OSC	Oscillator
OU	Output unit
P	Pitch, parity bit, primary
PB	Playback
PC	Processor command
PCE	Power conditioning equipment
PCM	Pulse-code modulation
P/FR	Problem/Failure Report
Ph	Phase
PHA	Pulse height analysis
PI	Principal investigator
PIXEL	Picture element
PLAT	Platform
PLBK	Playback link
PLL	Phase-locked loop
PLS	Plasma subsystem
PM	Propulsion module
PMT	Photomultiplier tube
PN	Pseudo-noise
POLHI	Polarization High Bit Rate
POLLO	Polarization Low Bit Rate
POR	Power on reset
POS	Position
PPH	Pulse per hour
PPM	Pulse per minute
PPS	Pulse per second
PPS	Photopolarimeter subsystem
PQ	Planetary quarantine
PRA	Planetary radio astronomy subsystem
PRESS	Pressure
PROP	Propellant
PROP	Propulsion subsystem
PS	Pixel sync
PSK	Phase shift keying

Abbreviations	Explanation
PSL	Power source logic
PS&L	Power switching and logic
PSS	Power supply subassembly
PSU	Pyrotechnic switching unit
PTM	Proof test model
PTS	Position and turn subassembly
PWR	Power
PWR	Power subsystem
PWS	Plasma wave subsystem
PYRO	Pyrotechnic subsystem
QA	Quality assurance
QTY	Quantity
R	Roll
Rad	Radius
RAM	Random access memory
RASMA	Radio science maneuver link
RCVR	Receiver
RDM	Remote driver module
REA	Reaction engine assembly
REF	Reference
REG	Regulator
Repl	Replacement
RF	Radio frequency
RFS	Radio frequency subsystem
RHCP	Right hand circular polarization
RHU	Radioisotope heater unit
RI	Roll inertial
RIS	Remote input system
RJ	Jupiter radius
rms	root mean square
R/O	Readout
RS	Saturn radius
RSS	Radio science subsystem
rss	root sum square
RT	Real time
RTG	Radioisotope thermoelectric generator
RTLT	Round trip light time
RZ	Return-to-zero
S	Saturn
S	Separation (secondary)
S ± time	Time relative to separation
SAEF	Spacecraft Assembly and Encapsulation Facility
SAF	Spacecraft Assembly Facility
SC	Subcarrier
SCA	Scan control actuators
S/C	Spacecraft
SCAN	Science platform
SCI	Science

Abbreviations	Explanation
SE	Support equipment
SEP	Separation
S & H	Sample and hold
SFOF	Space Flight Operations Facility
SIG	Signal
SLC	Skip on line count
S/N	Serial number
SNR	Signal to noise ratio
SPCAL	Scan platform calibration link
SPE	Static phase error
SR	Status register
SS	Sun sensor, snapshot
S/S	Subsystem
STARAC	Star acquisition link
STC	System test complex
STCE	System test complex equipment
STDBY	Standby
STRU	Structure subsystem
SUNAC	Sun acquisition link
SW	Solar wind
SWR	Standing wave ratio
SXA	S/X-Band antenna subsystem
SYNC	Synchronization
SYS	System
Time (time)	Time relative to the LV-S/C launch sequence (stops during holds)
TA	Type approval
TBD	To be determined
TC	Temperature control
TCAPU	Trajectory correction attitude propulsion unit
TCM	Trajectory correction maneuver
TCP	Telemetry and Command Processor Assembly
TD	Tolerance detector
TDS	Tracking and data system
TEMP	Temperature
TEMP	Temperature control subsystem
TET	The Electron Telescope
TG	Timing generator
TLM	Telemetry
TMU	Telemetry-modulation unit
TOP	Test and Operations Plan
T/R	Transformer rectifier
TVC	Thrust vector control
TV-N	Narrow-angle television
TV-W	Wide-angle television
TWT	Traveling wave tube
TWTA	Traveling wave tube amplifier

Abbreviations	Explanation
UIS	Universal isolation switch
USO	Ultra stable oscillator
UV	Ultraviolet
UVS	Ultraviolet spectrometer subsystem
Val	Valve
VCO	Voltage controlled oscillator
Vdc	Volts direct current
VFB	Vertical flyback
VIB	Vertical integration building
VID	Vidicon
VLBI	Very long baseline interferometry
VLOBR	Very low bit rate
VO75	Viking Orbiter 1975
Vrms	Volts root mean square
VSWR	Voltage standing-wave ratio
WA	Wide angle
XFER	Transfer
XMIT	Transmit
Y	Yaw

7.2 Quantitative

Multiplier		Prefix		Symbol
10^{12}	=	tera	=	T
10^{9}	=	giga	=	G
10^{6}	=	mega	=	M
10^{3}	=	kilo	=	k
10^{2}	=	hecto	=	h
10	=	deka	=	da
10^{-1}	=	deci	=	d
10^{-2}	=	centi	=	c
10^{-3}	=	milli	=	m
10^{-6}	=	micro	=	μ
10^{-9}	=	nano	=	n
10^{-12}	=	pico	=	p
10^{-15}	=	femto	=	f
10^{-18}	=	atto	=	a

7.3 Measurement Abbreviations

Abbreviation	Unit
A	ampere
Å	angstrom
AC	alternating current
AU	astronomical unit
bps	bits per second
cm^3	cubic centimeters
cps	cycles per second
dc	direct current
deg	degree (of arc)
°C	degree celsius
C	coulomb
K	Kelvin
dia	diameter
F	farad
fps	feet per second
H	henry
h	hour
Hz	hertz (cps)
in.	inch
J	joule
kg	kilogram
lb	pound
lbf	pound force
lbm	pound mass
m	meter
min	minute
mps	meters per second
N	newton
Ω	ohm
pps	pulses per second
psia	pounds per square inch (absolute)
psig	pounds per square inch (gauge)
rad	radian
s	second
Sr	steradian
T	tesla
V	volts
W	watt
Wb	weber

REVISION PAGE

Revision	Date	ECR's Incorporated	Comments
Initial Release	12/20/74	N/A	
A	6/5/75	N/A	Additions to Abbreviations and Acronyms.

(Insert in 618-205, MJS77 Functional Requirements Book)

Custodian: E. L. Nave

APPROVED:

Project Manager: ______________

Spacecraft System Manager: ______________

JET PROPULSION LABORATORY

No. MJS77-2-100
20 December 1974

MARINER JUPITER/SATURN 1977

SPACECRAFT DESIGN CRITERIA

✱ Denotes Change

1.0 SCOPE

The purpose of this document is to define the criteria to be applied to the design and development of the Mariner Jupiter/Saturn 1977 (MJS77) Spacecraft. This document will provide the guidelines to be used by the Spacecraft System in implementing the requirements imposed by the MJS77 Project.

2.0 APPLICABLE DOCUMENTS

None

3.0 DESIGN APPROACH

3.1 The design philosophy adopted for the MJS77 Mission is to design a spacecraft based on the existing Mariner and Viking designs and experience. Viking Orbiter 1975 (VO75) inheritance will be utilized where cost effective.

New design approaches or changes will be utilized where necessary to:

a) Achieve mission objectives.

b) Accommodate Titan III E/Centaur D1-T launch vehicle.

c) Incorporate final injection capability.

d) Accommodate parts availability and reliability.

e) Meet MJS77 environmental requirements.

Other changes will be considered which:

f) Reduce cost.

g) Improve reliability.

h) Ensure safety.

i) Reduce mass and/or power.

3.2 Incorporation of design features to satisfy future requirements of similar missions will be permitted if these requirements are consistent with MJS77 Project requirements and constraints.

3.3 It is a design goal that the MJS77 Spacecraft shall be capable of performing operational sequences under control of on-board logic and measurement devices to the maximum extent consistent with project constraints.

3.4 Ground command capability shall be provided for:

a) Loading and updating of the computer flight sequences.

b) Initiating the trajectory correction maneuver sequences.

c) Backing-up critical on-board commands.

d) Loading and updating of the flight data handling programs.

e) Loading and parameter updating of the Attitude and Articulation Control program.

f) Switching to redundant elements.

3.5 All spacecrafts shall be identical with respect to electrical and mechanical configuration. The transmitted and received frequencies for each shall be different. This identicality shall not only yield the capability of launching any spacecraft initially but shall also possess the flexibility of targeting for any of the allowable aiming points. The capability shall also exist to modify the selected aiming point after launch.

3.6 The spacecraft design shall be based on the environments expected from the time of initial assembly in the JPL Spacecraft Assembly Facility (SAF) through ground test, transportation, launch, cruise, and encounter operations. The two flight spacecraft and their components will not be allowed to be subjected to environments beyond flight acceptance levels. Safeguards to prevent overtest levels shall be provided in the operations and ground facilities, and not put in the flight hardware. The proof test model (PTM) equipment will be refurbished where required after type approval level tests for flight spare use.

3.7 On-pad tests and operations shall be limited to the minimum required to turn the spacecraft on, ready it for launch, verify its launch phase readiness and recover from an abort. Only system level checks shall be performed after the spacecraft has left the final assembly area, and no operation shall be conducted on the pad, unless that operation has been previously checked out in SAF or Building AO at Air Force Eastern Test Range (AFETR) under comparable environments. No provisions shall be made for component or subsystem testing from the Launch Complex Equipment (LCE).

3.8 The spacecraft shall be instrumented, to the extent practical, to obtain diagnostic telemetry in the event of failures, whether the failures are caused by system malfunction or by the encountering of environments beyond those accounted for in the design.

* 3.9 The ability of the subsystems to meet the radiation environment shall be accomplished using the following priority:

a) Direct replacement of parts from the MJS77 parts lists.

b) Circuit redesign.

c) Radiation hardened parts, developed through the negotiation of special processes and screening.

d) Addition of shielding mass.

✱ 3.10 Subsystems meet the radiation requirements when:

a) Engineering and imaging subsystems have parts capability a factor of two above the expected internal parts environment for fluence.

b) Other science subsystems have parts capability equal to the expected internal parts environment for fluence.

c) Engineering subsystems have in specification functional performance capability a factor of two above the expected internal parts environment for flux.

d) All science subsystems have acceptable functional performance capability equal to the expected internal parts environment for flux.

✱ 3.11 All designs shall be subjected to type approval and flight acceptance testing except in those areas where it is cost and risk factor effective, to do verification by analysis. As a corollary to this requirement, development testing shall primarily be regarded as a tool for purpose of confirming the analysis rather than verification of the design.

✱ 3.12 The requirement for long spacecraft life to achieve mission success is recognized. No design decision shall be made which would preclude attainment of a 7-year mission lifetime without prior project office approval.

✱ 3.13 The spacecraft design shall include the capability of terminating and re-establishing RF transmission upon command.

4.0 RELIABILITY CRITERIA

4.1 The spacecraft design shall be governed by the policy that the requirement for reliable operation takes precedence over the requirements for additional capability/flexibility beyond that required to achieve the basic mission.

4.2 The design should take advantage of the Mariner Venus/Mercury 1973 (MVM73) and VO75 equipment and designs and of the experience gained in the previous Mariner and VO75 projects to the maximum feasible extent.

4.3 Where there are new designs or modifications to the previous Mariner or VO75 designs, care shall be taken in the choice and control of new fabrication techniques and operational procedures so that the probability of success will be enhanced over the previous Mariner or VO75 designs.

✱ 4.4 Within cost, mass, and schedule constraints; block, functional or alternate mode redundancy should be employed such that no single failure mode of any component (electronic, mechanical, pyrotechnic, electromechanical, or structural) could cause the loss of all data return from more than one science instrument or the loss of more than 50 percent of the engineering data. Acceptable single point failure risks shall be defined in MJS77-3-100, Spacecraft Requirements and Constraints.

✱ 4.5 Functional inter-dependency between subsystems shall be used only where such design contributes to the flexibility and/or the economy of the system without reducing the system reliability. It shall be a goal that a failure in dependent element or its interface shall cause only a graceful degradation of the system performance.

4.6 All scientific instruments shall be designed to be functionally independent of one another. The spacecraft shall be designed in such a manner that a failure in one instrument or in a non-science subsystem common to the support of several instruments will have a minimum effect on the total data received and other spacecraft functions.

✱ 4.7 Particular emphasis shall be placed upon proven designs plus new designs which contribute to the system's flexibility and/or economy without reducing the system's reliability along with a complete program of component, subsystem and system testing.

5.0 SCHEDULE CRITERIA

Since the mission objectives involve the 1977 Jupiter/Saturn opportunity, all designs, techniques and components must be compatible with the project development time schedule, including all intermediate milestone objectives leading up to the launchings.

6.0 SPACECRAFT LIMITATIONS

6.1 The launch mass of spacecraft and adapter shall be maintained compatible with the launch vehicle capability and mission requirements. Adequate margins shall be allocated to avoid conflicts late in the development schedule.

6.2 The defined mission lifetime to be used in the spacecraft design activity shall be interplanetary cruise to a total mission duration of four (4) years including eighty (80) days of planetary encounter at each planet (Jupiter and Saturn). The quantity of expendables shall meet the above requirement plus flight to a heliocentric range of 20 AU.

6.3 The power profile shall be compatible with the capability of the three MJS77 multihundred watt radioisotope thermoelectric generators.

7.0 COMPETING CHARACTERISTICS

In the event of design conflicts, where modest compromise is required, emphasis should be given the following functions in order listed while considering the cost effectiveness of each case:

a) Communication with and control of the Mission Module.

b) Acquisition and return of encounter science data.

c) Acquisition and return of interplanetary science data.

d) Acquisition and return of post Saturn interplanetary science data.

e) Compatibility of the design with later mission requirements.

NASA — JPL — Coml., L.A., Calif.

(Insert in 618-205, MJS77 Spacecraft Functional Requirements Book)

Custodian: C. Wertz

APPROVED:

Spacecraft System: R. L. Heacock

Spacecraft System Engineer: R. F. Draper

Spacecraft System Design: G. E. Cunningham

JET PROPULSION LABORATORY

No. MJS77-3-100
10 July 1975

FUNCTIONAL REQUIREMENT

MARINER JUPITER/SATURN 1977

SPACECRAFT REQUIREMENTS AND CONSTRAINTS

* Denotes change

CONTENTS

CONTENTS (Contd)

CONTENTS (Contd)

CONTENTS (Contd)

ILLUSTRATION

1.0 SCOPE

This document describes the Mariner Jupiter/Saturn 1977 (MJS77) Spacecraft System, defines the spacecraft subsystems, specifies the system level requirements for their performance and design, and delineates the constraints which are imposed on each subsystem by the system and by other subsystems. It is the controlling document for generation of the level 3 and 4 functional requirement documents contained in the MJS77 Spacecraft Functional Requirements Book, PD618-205.

2.0 APPLICABLE DOCUMENTS

The following documents form a part of this Functional Requirement.

* DOCUMENTS

Jet Propulsion Laboratory

PD618-51	Mariner Jupiter/Saturn 1977 Mission and Science Requirements Document
PD618-54	Mariner Jupiter/Saturn 1977 Project Safety Plan
PD618-59	Mariner Jupiter/Saturn 1977 Project/ Launch Vehicle Systems Requirements
PD618-206	Mariner Jupiter/Saturn 1977 Support Equipment Functional Requirements Book
PD618-232	Mariner Jupiter/Saturn 1977 Spacecraft System Configuration Management Plan
PD618-257	Mariner Jupiter/Saturn 1977 Telecommunication Design Control Document
PD618-530	Mariner Jupiter/Saturn 1977 Spacecraft/ Mission Operations System Interface Control Document

FUNCTIONAL REQUIREMENTS

Jet Propulsion Laboratory

MJS77-2-100	Functional Requirement, Mariner Jupiter/Saturn 1977 Spacecraft Design Criteria

MJS77-3-110	Functional Requirement, Mariner Jupiter/Saturn 1977 Functional Block Diagram and Interface Listings
MSJ77-3-120	Functional Requirement, Mariner Jupiter/Saturn 1977 Flight Sequence Implementation
MJS77-3-130	Functional Requirement, Mariner Jupiter/Saturn 1977 Standard Trajectories
MJS77-3-140	Functional Requirement, Mariner Jupiter/Saturn 1977 Nominal Aiming Point Selection
MJS77-3-150	Functional Requirement, Mariner Jupiter/Saturn 1977 Navigation Requirements
MJS77-3-170	Functional Requirement, Mariner Jupiter/Saturn 1977 Functional Accuracy and System Capabilities
MJS77-3-180	Functional Requirement, Mariner Jupiter/Saturn 1977 Configuration
MJS77-3-190	Functional Requirement, Mariner Jupiter/Saturn 1977 Structural Design Criteria
MJS77-3-200	Functional Requirement, Mariner Jupiter/Saturn 1977 Determination of Inertial Properties
MJS77-3-210	Functional Requirement, Mariner Jupiter/Saturn 1977 Design Criteria for Spacecraft Temperature Control
MJS77-3-220	Functional Requirement, Mariner Jupiter/Saturn 1977 Electronic Equipment Design
MJS77-3-230	Functional Requirement, Mariner Jupiter/Saturn 1977 Equipment List and Mass Allocation
MJS77-3-240	Functional Requirement, Mariner Jupiter/Saturn 1977 Environmental Design Requirements
MJS77-3-250	Functional Requirement, Mariner Jupiter/Saturn 1977 Power Profile and Allocation

MJS77-3-260	Functional Requirement, Mariner Jupiter/Saturn 1977 Electrical Grounding and Interfacing
MJS77-3-270	Functional Requirement, Mariner Jupiter/Saturn 1977 Telemetry and Command Handling
MJS77-3-280	Functional Requirement, Mariner Jupiter/Saturn 1977 Telemetry Measurements and Data Formats
MJS77-3-290	Functional Requirement, Mariner Jupiter/Saturn 1977 Command Structure and Assignments
MJS77-3-300	Functional Requirement, Mariner Jupiter/Saturn 1977 Telecommunications
MJS77-3-310	Functional Requirement, Mariner Jupiter/Saturn 1977 Software Requirements

* OTHER DOCUMENTS

Military

AFETRM 127-1	Range Safety Manual

Thiokol Chemical Corporation

CP364-4	Contract End Item Detail Specification

DRAWING

* Jet Propulsion Laboratory

10073993	Science Calibration Target - Structural Interface

3.0 SYSTEM REQUIREMENTS

3.1 General

* a) The MJS77 Spacecraft system shall be compatible with the requirements specified in PD618-51, Mission and Science Requirements Document.

b) All elements of the spacecraft system shall comply with the design criteria specified in MJS77-2-100, Spacecraft Design Criteria.

c) All elements of the spacecraft system shall comply with the requirements of this functional requirement and all other applicable level 3 spacecraft functional requirements. In the case of conflict between this and any other level 3 spacecraft functional requirement, the requirements of this document shall prevail.

* d) Deviations from, and exceptions to, the contents of this document must be specifically waived. Waivers shall be in accordance with the waiver procedure contained in PD618-232, Spacecraft System Configuration Management Plan.

3.2 System Definition

The spacecraft system includes the spacecraft, the spacecraft adapter, the support equipment, and the spacecraft software.

* 3.2.1 Spacecraft

In addition to its scientific data gathering function, the MJS77 spacecraft also provides the final injection energy to place the spacecraft on the desired trajectory. The spacecraft is composed of a Propulsion Module (PM) and a Mission Module (MM). The PM is the portion of the spacecraft which provides the final injection and is separated from the MM once the injection has been achieved. The MM is the portion of the spacecraft which contains the science instruments and supports data gathering and transmission throughout the mission.

3.2.2 Spacecraft Adapter

The Spacecraft Adapter is composed of the transition structure and the associated equipment and cabling located between the field joint and the aft separation plane.

* 3.2.3 Support Equipment

The Support Equipment includes the System Test Complex, the Launch Complex Equipment, and all special test facilities required for testing of separate subsystems and the assembled spacecraft during system test and launch operations phases. Support Equipment shall be provided as required by PD618-206, Support Equipment Functional Requirements Book.

* 3.2.4 Spacecraft Software

Software for the MJS77 Spacecraft System is divided into three general categories

a) Flight software is defined as being on-board coding associated with the flight programs for the computer command subsystem, flight data subsystem, and the attitude and articulation control subsystem.

b) Flight support software is defined as that ground coding which is used directly to generate the flight coding, or is used to simulate the operation of flight hardware. It does not include that coding used to analyze and predict subsystem performance.

c) Support equipment software is defined as that ground coding which is utilized during the fabrication and test phases of the spacecraft system in the subsystem or system support equipment.

3.2.5 Subsystem Requirements

The spacecraft equipment shall be divided by function into a number of subsystems. Definitions of the subsystems, requirements placed upon them by other subsystems, and major system requirements on subsystems are established in Section 4.0 of this document and in other Level 3 functional requirement documents. Detailed functional requirements are established in the Level 4 Functional Requirement Documents.

3.2.6 Internal Electrical Interfaces

The internal electrical interfaces are defined to include all signals that are routed through system cabling. This includes intersubsystem signals and intrasubsystem signals when electronic packages of the same subsystem are not located in one bay. Internal electrical interfaces are defined in MJS77-3-110, Functional Block Diagram and Interface Listings.

3.2.7 External Interfaces

3.2.7.1 General. This paragraph specifies the requirements on the spacecraft system due to interfacing with other systems of the project which are: Mission Operations System (MOS), the Tracking and Data System (TDS), and the Launch Vehicle System (LVS).

* 3.2.7.2 Interface with the MOS. All elements of the spacecraft system shall meet the requirements of Spacecraft/MOS Interface Control Document PD618-530.

* 3.2.7.3 Interface with the TDS. All elements of the spacecraft system shall meet the requirements specified in the Telecommunications Design Control Document PD618-257.

* 3.2.7.4 Interface with the LVS. All elements of the spacecraft system shall meet the requirements of MJS77 Project Launch Vehicle System Requirements, PD618-59.

* 3.2.7.4.1 Separation Signal. The launch vehicle will provide a 28 Vdc level input to the spacecraft at Spacecraft/Launch Vehicle (LV) separation minus 7 s.

3.3 Design Characteristics

✱ 3.3.1 General

The MJS77 spacecraft shall be attitude stabilized in three axes using the Sun and a star as primary reference objects while maintaining communications with the Earth. The spacecraft shall have two-way communications equipment which permits the transmission of science data to the Earth, receipt of command transmission at the spacecraft, and two-way and one-way doppler tracking and range measurements. The spacecraft shall be capable of executing on-board stored sequences for trajectory correction and science instrument pointing maneuvers, antenna pointing, science instrument pointing, science and engineering data acquisition, and data formatting. The spacecraft shall derive its electrical power from solar independent sources.

✱ 3.3.2 Scientific Experiments.

The spacecraft with its scientific instruments will allow experiments to be performed during cruise phase between planets and in the vicinity of Jupiter and Saturn including selected satellites and Saturn's rings. In addition, it is expected that with these instruments an extended mission to investigate the region beyond Saturn could be performed until terminated by a depletion of expendables, inadequate performance capability or MM failure. The radio science experiment is accomplished with the MM telecommunications equipment. The science subsystems are listed below:

Cosmic Ray Subsystem	(CRS)
Planetary Radio Astronomy Subsystem	(PRA)
Plasma Wave Subsystem	(PWS)
Low Energy Charged Particle Subsystem	(LECP)
Photopolarimeter Subsystem	(PPS)
Plasma Subsystem	(PLS)
Ultraviolet Spectrometer Subsystem	(UVS)
Magnetometer Subsystem	(MAG)
Imaging Science Subsystem	(ISS)
Infrared Interferometer Spectrometer and Radiometer Subsystem	(IRIS)

✱ 3.3.3 Navigation

✱ 3.3.3.1 Trajectories

✱ 3.3.3.1.1 Interplanetary. All elements of the spacecraft shall be compatible with the set of trajectories represented in MJS77-3-130, Standard Trajectories.

* 3.3.3.1.2 Encounter. All elements of the spacecraft shall be compatible with the range of trajectories described in MJS77-3-140, Nominal Aiming Point Selection.

* 3.3.3.2 Trajectory Corrections. Requirements placed on the MM to support trajectory correction maneuvers are specified in MJS77-3-150, Navigation.

3.3.4 Spacecraft States

A set of state variables shall be defined for each spacecraft subsystem. Each allowable set of state variables constitutes a subsystem state. Each allowable set of subsystem states constitutes a system state.

* 3.3.4.1 Operating States. Operating states are defined to include the subset of system states identified by one or more of the following:

a) States which exist during the mission sequence specified in MJS77-3-120, Flight Sequence Implementation, as controlled by on-board switching or ground command.

b) The state is required to exist for verification of the spacecraft performance during system test.

* 3.3.4.2 Constraints

a) Each system operating state shall be uniquely identified via the spacecraft telemetry status registers and/or explicit telemetry measurements.

b) All system operating states shall be attainable by means of at least one of the following types of inputs:

   1) On-board sensing and switching.

   2) Computer command subsystem (CCS) discrete commands.

   3) CCS coded commands.

   CCS commands are listed and defined in MJS77-3-290, Command Structure and Assignments.

c) With the exception of unlatching and deployment functions, release of stored gas, propulsion operations, or failure mode switching it shall not be possible to place the spacecraft in a state such that exit from that state is impossible, nor shall it be possible to cycle the spacecraft through an operating state in such a manner that no means of returning from that state is possible.

d) No system state shall exist for the purpose of verification of S/C performance, if transition to a normal flight state cannot be achieved via spacecraft commands.

e) It shall be possible to condition the spacecraft to the launch state while on the launch pad using the radio link only except for the following umbilical functions:

1) External/internal power select

2) Standby to main inverter select

3) Solid rocket motor safe-arm

4) Flight data subsystem (FDS) memory load (the spacecraft supplies power to the FDS)

f) The design of the spacecraft shall be such that no single command can place the spacecraft in a state that violates the reliability criteria for a single failure as defined in MJS77-2-100.

g) At subsystem power turn-on, subsystems shall go to a specific predictable state. This requirement may be satisfied by power-on-reset logic or by remaining in the state that existed at power turn-off.

3.3.5 Communications

The spacecraft shall provide for communications to and from the earth for carrier tracking, ranging, telemetry and commanding. The spacecraft telecommunications design shall be a unified system such that all functions may be utilized simultaneously. The communications design of the spacecraft shall be compatible with the Deep Space Network and shall comply with PD618-257.

Functional requirements on the spacecraft telecommunications equipment are specified in MJS77-3-300, Telecommunications.

3.3.6 Attitude & Articulation Control

* 3.3.6.1 General. The spacecraft shall establish and maintain attitude orientation and stability about three orthogonal body axes during all phases of the mission following separation from the LV. The spacecraft shall use the sun as an attitude reference for its pitch and yaw axes, and a predetermined star (Canopus) for its roll attitude reference. The spacecraft shall control to inertial references for thrust vector control during injection, the MM shall control to inertial references during Trajectory Correction Maneuvers, Science Maneuvers and at those times when celestial reference signals are not available. The MM shall also be capable of articulating a science scan platform in two rotational degrees of freedom relative to the MM. Attitude and articulation control performance requirements are specified in MJS77-3-170, Functional Accuracies and System Capabilities.

* 3.3.6.2 Attitude Control Cruise Stability. During cruise, the MM angular rate shall be $\leq$ 8 μrad/s for each axis during undisturbed limit cycle operation.

* 3.3.6.3 Science Platform Articulation Control. The science scan platform coordinate system is defined in MJS77-3-180, Configuration. Pointing and settling requirements are with reference to the L vector relative to inertial space.

a) Articulation range of the science scan platform L vector shall conform to the requirements of MJS77-3-180.

b) The science platform shall be pointed within the accuracies specified in MJS77-3-170.

c) For 80% of the platform slews, the time from the end of the slew and the L vector excursions during a given time period relative to celestial space ($\Delta\theta/\Delta T$) shall be as follows:

Slew Rate	Time from end of slew	$\Delta\theta/\Delta T$
1.745 mr/s	30 s 300 s	20 mr/1 s 150 mr/10 s (100 mr/10 s)
17.45 mr/s	170 s	20 mr/1 s

* 3.3.6.4 Science Maneuver Turn Rate. Turns shall be performed about the MM roll and yaw or roll and pitch axes sequentially in clockwise or counterclockwise directions. The turn rate shall be 3.14 ±0.3 mrad/s.

* 3.3.6.5 High-Gain Antenna Pointing. After launch plus ≃80 days, the high-gain antenna shall be pointed at earth during cruise and encounter to the accuracies specified in MJS77-3-170.

* 3.3.6.5.1 Planet Limb Tracing. During earth occultation, the MM shall perform a series of preprogrammed pitch and yaw turns. These turns shall keep the high gain antenna pointed at the apparent closest limb of the planet to provide the highest probability of obtaining an RF signal path between earth and the spacecraft.

3.3.7 Data Handling

3.3.7.1 General. Data handling requirements are specified in MJS77-3-270, Telemetry and Command Handling.

* 3.3.7.2 Transition Density in Output Symbols. The transition density of ones and zeros in the spacecraft symbol stream shall be 6-2/3 percent or greater.

3.3.8 Temperature Control

* 3.3.8.1 Boost to Injection. Heat transfer through the nose fairing will be controlled in accordance with the requirements specified in PD618-59. After nose fairing ejection, the spacecraft will experience heating as a result of solar radiation, Earth radiation, and aerodynamic heating. The heat capacitance and thermal design of the spacecraft shall limit the temperature rise resulting from this heating to the limits specified in MJS77-3-210, Design Criteria for Spacecraft Temperature Control.

3.3.8.2 Post Injection. From injection to end-of-mission the temperature of all MM elements shall be maintained within the temperature ranges specified in MJS77-3-210.

3.3.9 Power

* 3.3.9.1 General. The internal sources of spacecraft power shall be radioisotope thermoelectric generators (RTG) and batteries. For ground test, provision shall be made to accept power from an external source that can simulate the RTGs. The batteries will provide power during injection and shall be jettisoned with the PM.

3.3.9.2 Allocations. Subsystem power demands shall be limited to the allocations contained in MJS77-3-250, Power Profile and Allocation.

3.3.10 Mass Properties

3.3.10.1 Spacecraft and Adapter Mass. The JPL supplied flight equipment, i.e.; the spacecraft and adapter, shall be compatible with the launch vehicle capability and mission requirements. PD618-51 specifies the maximum mass of the spacecraft and its adapter.

3.3.10.2 Inertial Properties. The mass, center of mass, and centroidal moments and products of inertia for the spacecraft and adapter shall be determined and controlled as specified in MJS77-3-200, Determination of Inertial Properties.

3.3.10.3 Subsystems. Spacecraft subsystem flight equipment shall meet the requirements of MJS77-3-230, Equipment List and Mass Allocation.

* 3.3.11 Packaging

Electronic packaging shall conform to the provisions of MJS77-3-220, Electronic Equipment Design.

3.3.12 Flight Software

The spacecraft shall be capable of performing certain functions in the Computer Command, Attitude and Articulation Control, and Flight Data Subsystems under on-board program control. These functions shall be programmable to the extent specified in MJS77-3-310, Software Requirements.

3.4 System Operations

* 3.4.1 Ground Handling and Flight Preparation

* 3.4.1.1 RTG Loading. The RTG output shall be shorted except as necessary during installation onto the MM. The transfer of the RTG output between loading connectors shall be completed in less than one hour to prevent RTG over heating.

* 3.4.1.2 PM Orientation. The serviced propulsion subsystem (PROP) shall be maintained with the propellant tank axis vertical, outlet down. Under no circumstances shall the tank outlet of the serviced subsystem be rotated more than 100 deg.

* 3.4.1.3 Telemetry Calibration. All PROP pressure transducers shall be calibrated through the flight data subsystem (FDS) prior to launch.

* 3.4.2 Prelaunch

* 3.4.2.1 General. Final assembly, checkout and other activities will be performed at Kennedy Space Center and the Air Force Eastern Test Range (AFETR).

* 3.4.2.2 Requirements

a) The PROP shall be loaded with hydrazine and pressurized in the Explosive Safe Facility (ESF) prior to being attached to the spacecraft structure.

b) The PROP, including the solid rocket motor, shall be attached to the spacecraft structure in the Spacecraft Assembly and Encapsulation Facility (SAEF).

c) Installation of pyrotechnic devices containing live ordnance (squibs) and installation of squibs in pyrotechnic devices attached to the spacecraft shall be accomplished in both the ESF and SAEF.

d) The fueled RTGs shall be attached to the spacecraft structure in the SAEF.

e) The spacecraft shall be encapsulated in the nose fairing at the SAEB.

f) No operations requiring physical access to the spacecraft shall be planned after spacecraft encapsulation.

g) Provision shall be made for S-band uplink and downlink while the spacecraft is on the launch pad.

* 3.4.2.3 Umbilical Link. The umbilical link shall provide the following:

a) Monitoring of spacecraft performance via the composite telemetry signal.

b) Capability to prepare the spacecraft for launch only where radio commands cannot do so. This includes the capability to arm the solid rocket motor and to load the FDS Memory.

c) Direct monitoring of subsystem functions related to safety where composite telemetry will not suffice. This includes the capability to monitor the Safe/Arm status of the Pyrotechnic Switching Unit (PSU) and solid rocket motor.

d) Capability to reset arming functions related to propulsion and pyrotechnics.

Detail umbilical interfaces are specified in MJS77-3-110.

* 3.4.2.4 Indefinite Hold Capability. There shall be capability during the coutdown of an indefinite hold, without the necessity of recycling. In the event of a scrub which does not require access to the spacecraft, the spacecraft shall be capable of being re-scheduled for a launch on the following day.

* 3.4.2.5 Encapsulation. The spacecraft shall have the capability of being encapsulated for up to a maximum of 30 days.

* 3.4.3 Flight Sequence

All spacecraft subsystems shall be compatible with the flight sequence described in MJS77-3-120 and the requirements listed in the following paragraphs.

* 3.4.3.1 Launch

* 3.4.3.1.1 Roll Rate. During launch, the LV may generate accelerations about the spacecraft roll axis. The maximum occurs at solid rocket motor separation when the acceleration may be $60°/s^2$ until a maximum rate of 15°/s is reached.

✱3.4.3.1.2 Separation Rates. At spacecraft/LV separation the relative separation rate shall be 0.5 m/s. The post separation S/C rate shall be less than 26 mr/s. The Centaur residual rate prior to separation will be less than 3.5 mr/s.

At PM jettison, the realtive separation rate between the PM and MM shall be 0.66 m/s. The MM post jettison rates shall be less than 22 mr/s about the pitch axis and less than 45 mr/s about the yaw axis. The spacecraft residual rate prior to PM jettison shall be less than 1 mr/s about the pitch axis and less than 4 mr/s about the yaw axis.

✱3.4.3.1.3 Operation During Vibration and Shock. During periods of vibration at launch and pyrotechnic shock, the DSS will be operated continuously at the 7.2 kbps tape speed.

✱3.4.3.1.4 High Rate Telemetry. Engineering telemetry will be transmitted in real-time in the high rate engineering mode from prior to launch vehicle/spacecraft separation until sun acquisition.

✱3.4.3.1.5 Pyrotechnic Safe/Arm. Pyrotechnic devices shall be safed by inhibiting the application of power to the firing circuits. Arming (application of power to the firing circuits) shall be accomplished after launch.

✱3.4.3.1.6 Initiation of the Propulsion Module Sequence. After $MECO_2$, the LV will provide a 28-Vdc signal to the pyrotechnic subsystem (PYRO). Upon receipt of the 28-Vdc signal, PYRO shall arm the firing circuits and supply a switch closure to CCS for initiation of the PM sequence of events. The CCS shall not respond to a PYRO switch closure prior to launch plus T s, where T is a function of the launch trajectory.

✱3.4.3.1.7 Orientation. To ensure compliance with constraints to keep the sun from entering the field-of-view (FOV) of the science instruments, the orientation of the spacecraft shall be controlled from spacecraft/LV separation to sun acquisition.

✱3.4.3.1.8 Disturbance Torque During Injection. The placement, orientation, and alignment of all spacecraft elements that contribute to the generation of disturbance torques about the three spacecraft axes shall be controlled such that the maximum disturbance about the pitch or yaw axes shall be less than 533 n-m (393 ft-lb) (RSS) and about the roll axis shall be less than 22.5 n-m (16.6 ft-lb)(RSS).

✱3.4.3.2 Cruise

✱3.4.3.2.1 Thruster Operation. No mission sequence will require the simultaneous actuation of both active and redundant thrusters (i.e., thrusters providing the same control polarity about a given axis).

✱3.4.3.2.2 Near Earth Antenna Pointing. In order to maximize the capability of the down link communications, prior to the time when the earth probe sun angle becomes less than the FOV of the cruise sun sensors, the cruise sun sensor shall be biased to point the MM roll axis as near the earth as possible within the sensor field of view constraints and MM thermal constraints.

* 3.4.3.2.3 Disturbance Torque. During cruise the MM shall be designed to accommodate solar and RTG generated torques with magnitudes $\leq 1.36 \times 10^{-5}$ n-m (10^{-5} ft-lb) about the pitch, yaw, or roll axis.

* 3.4.3.3 Trajectory Correction Maneuvers

* 3.4.3.3.1 Turn Duration and Direction. Temperature control of the MM imposes a constraint on the trajectory correction maneuver duration when the MM is within 2 AU of the sun. The detailed constraints are specified in MJS77-3-210.

* 3.4.3.3.2 Thrust Duration. The duration of the thrusting period shall be a time function controlled by the CCS. From 1 to 2 AU the following equation will be used to determine the maximum duration of a TCM burn, 1.0 hour x $(AU)^2$. After 2 AU the maximum TCM velocity increment the MM is capable of performing is 70 m/s, which corresponds to a maximum burn duration of 8-1/2 hours.

* 3.4.3.3.3 Telemetry. Engineering telemetry during Trajectory Correction Maneuvers will be recorded in the high rate engineering mode for later playback.

3.5 Operability

* 3.5.1 Reliability

All elements of the MJS77 Spacecraft System shall meet the reliability criteria defined in MJS77-2-100.

* 3.5.1.1 Redundancy. Where implementation of the redundancy requirements specified in MJS77-2-100 uses block redundancy, redundant elements at the provisioned spare level are specified in MJS77-3-230. Where standby redundancy is used, an additional requirement shall be that no single point failure in the switching shall prevent transfer to the standby unit.

Reliability may be enhanced by decreasing the size of the redundant blocks; therefore, redundant block size shall be determined on the basis of trade studies which consider improved reliability versus switching reliability, increased cross-strapping complexity, additional power dissipation, increased spacecraft mass, and expendature of project resources.

* 3.5.1.2 Fault Sensing and Correction Routines. The capability of on-board fault sensing and correction routines shall be limited to the minimum required to assure recovery from a failure with maximum use of ground station capability. As a minimum, on-board fault sensing and switching shall be provided to ensure a stable MM state (the MM is capable of remaining in this state until reception of ground commands) from which nominal performance can be restored via interaction with the ground stations. For example, the capability of the MM to respond to ground commands would be preserved

with the highest priority; the second priority may be to prevent loss of consumables; while the preservation of temperature control to the extent that temperatures may exceed design limits but not survival limits, may also compete for second priority. Retention of the capability to transmit engineering data without ground interaction shall be a goal.

* 3.5.1.3 Exemptions. In some cases where adequate design margin and derating have been employed, specific exemptions to the single failure criteria may be granted. Exemptions for the subsystem are listed in Section 4.0, Subsystem Requirements.

* 3.5.1.3.1 Cabling. Cabling shall be considered free of failure resulting in shorts.

* 3.5.1.4 Spacecraft/Launch Complex Interface. Techniques shall be employed in the design of the spacecraft/launch complex interface to meet the requirement that no single failure shall require the removal of the spacecraft from the launch vehicle in order to condition the spacecraft to the launch mode or to ascertain that it is in the launch mode.

3.5.2 Maintenance and Repair

3.5.2.1 Restrictions. Maintenance of the spacecraft during system level testing shall be restricted to the removal and replacement of equipment at the provisioned spares level.

3.5.2.2 System Trimming. System level electrical trimming, mechanical adjustment or alignment shall be such that these parameters are exactly and uniquely established in the event of subsystem disassembly and assembly of the spacecraft.

3.5.2.3 Subsystem Trimming. Subsystem or lower level electrical parameter trimming, mechanical adjustment, or alignment shall be performed prior to subsystem flight acceptance (FA) testing and shall not be subsequently changed.

3.5.2.4 Hardware Modifications. Modification to flight hardware after its shipment to AFETR shall be limited to those required to correct deficiencies or failures disclosed after shipment.

* 3.5.2.5 AFETR. Repairs to be effected at AFETR shall be limited to those failures which are discovered at AFETR. Failed assemblies shall be repaired in designated maintenance centers. Should repair be accomplished by replacement of assemblies, these assemblies shall have had an acceptable qualification test history. The test history shall include qualification in a fully assembled spacecraft as practical for the assembly type involved.

* 3.5.2.6 Flight. The MM shall be capable of maintaining a cruise phase operational state and attitude for at least 24 hours without ground intervention, except during the superior conjunction periods, when the requirement shall be for 10 days without ground intervention.

✱ 3.5.3 Lifetime

The MM equipment shall have operating and/or storage life, as applicable for a post launch flight duration as specified in MJS77-2-100, paragraph 6.2, and as modified by paragraph 3.12. The equipment jettisoned with the PM are exempt from the 4 year flight requirement. Total life-time of all spacecraft equipment shall accommodate a prelaunch system test program of one year in addition to the flight requirements.

3.5.4 Environments

The spacecraft shall be compatible with the requirements of MJS77-3-240, Environmental Design Requirements.

✱ 3.5.5 Safety

All spacecraft subsystems and support equipment shall incorporate protection for personnel and delicate hardware consistent with the procedures in PD618-54, Safety Plan. In order to protect delicate flight equipment, the handling and operational constraints of spacecraft subsystems, as specified in Section 8, Safety Considerations of each level 4 functional requirement, shall be strictly observed. The spacecraft design shall meet the intent of AFETRM 127-1, Range Safety Manual.

✱ 3.5.5.1 Solid Motor Safe/Arm. The safe/arm mechanical pin shall remain installed at all times from installation of igniter squibs until spacecraft encapsulation. Thereafter, the safe/arm status indicator shall be continuously monitored until liftoff. Electrical actuation of the safe/arm device shall occur just prior to liftoff.

3.6 Design and Construction

3.6.1 General

3.6.1.1 Interchangeability and Replacement. Flight spacecraft and adapters shall be interchangeable with one another with respect to mechanical, electrical and functional characteristics.

3.6.1.1.1 Mechanical. Mechanical interchangeability shall exist between the constituents or sets of like equipment at the assemblies, subassemblies, and replaceable parts level.

3.6.1.1.2 Electrical. Electrical interchangeability shall exist at the replaceable spare level between all sets of like equipment.

3.6.1.2 Electromagnetic Compatibility (EMC)

3.6.1.2.1 External Electromagnetic Interference (EMI). The design of the spacecraft shall be such that it is insensitive to the external electromagnetic environments specified in MJS77-3-240.

3.6.1.2.2 Internal EMI. The conducted and radiated electromagnetic interference generated by any of the spacecraft subsystems shall be suppressed such that it does not exceed the levels specified in MJS77-3-240. To satisfy the Magnetic Field restraints of MJS77-3-240, consideration shall be given to not using ferromagnetic material. Hard magnets may require the addition of similar magnets arranged to reduce the total field. Current loops which induce magnetic fields may require compensating loops.

3.6.1.2.3 Conducted Transient Susceptibility. Spacecraft signal input interface circuits shall be immune to the transient voltages or currents as specified in MJS77-3-240.

3.6.1.3 Equipment Identification and Marking

Assembly and subassembly reference numbers, where applicable, are established in MJS77-3-230.

3.6.2 Electrical Design Criteria

3.6.2.1 Electrical Interfacing and Grounding. The design of spacecraft system electrical interfacing and grounding shall meet the requirements specified in MJS77-3-260, Electrical Grounding and Interfacing.

* 3.6.2.1.1 Redundancy. Input or output end-circuits of parallel-connected redundant blocks including power supplies shall be designed for minimum probability of failing shorted.

* 3.6.2.2 High Voltages. The design of electrical circuits using voltage in excess of 250 V shall meet the requirements of MJS77-3-220, Electronic Equipment Design.

* 3.6.2.3 Electrical Loads. The spacecraft electrical equipment (with the exception of that equipment powered directly from the battery) shall meet the requirements listed below:

a) All loads shall be compatible with the power allocations specified in MJS77-3-250.

b) All loads shall operate within specifications throughout the type approval temperature range with the following variations in voltage at the user input:

	2.4 kHz (Vrms)	DC (Vdc)
Transient Maximum	53.5	31.5
Steady State Maximum	52.5	30.75
Design Value	50.0	30.0
Steady State Minimum	47.5	29.25
Transient Minimum	46.5	28.5

Duration of voltage excursions outside the steady state range shall not exceed 5 ms. Duration of voltage excursion outside the transient range shall not exceed 10 μs.

c) All loads shall be able to undergo input voltages ranging from zero volts to a maximum which exceeds the nominal by 15 percent for a maximum duration of 2 s, with reset to a predictable state and subsequent resumption of normal operation.

d) All loads shall be compatible with the grounding and interfacing requirements specified in MJS77-3-260.

e) Load changes for loads powered by the dc bus shall not exceed 100 W, and load changes for loads powered by the 2.4 kHz shall not exceed 50 W. Steady state loads and load transients are further subjected to the constraints of MJS77-3-250 with the exception that load changes controlled by the CCS shall be allowed a switching transient (excursion above steady state) with total energy of less than 4 Ws. Load changes shall not cause current rates to exceed 0.066 A/μs from the 2.4 kHz bus or 0.150 A/μs from the dc bus for more than 10 μs.

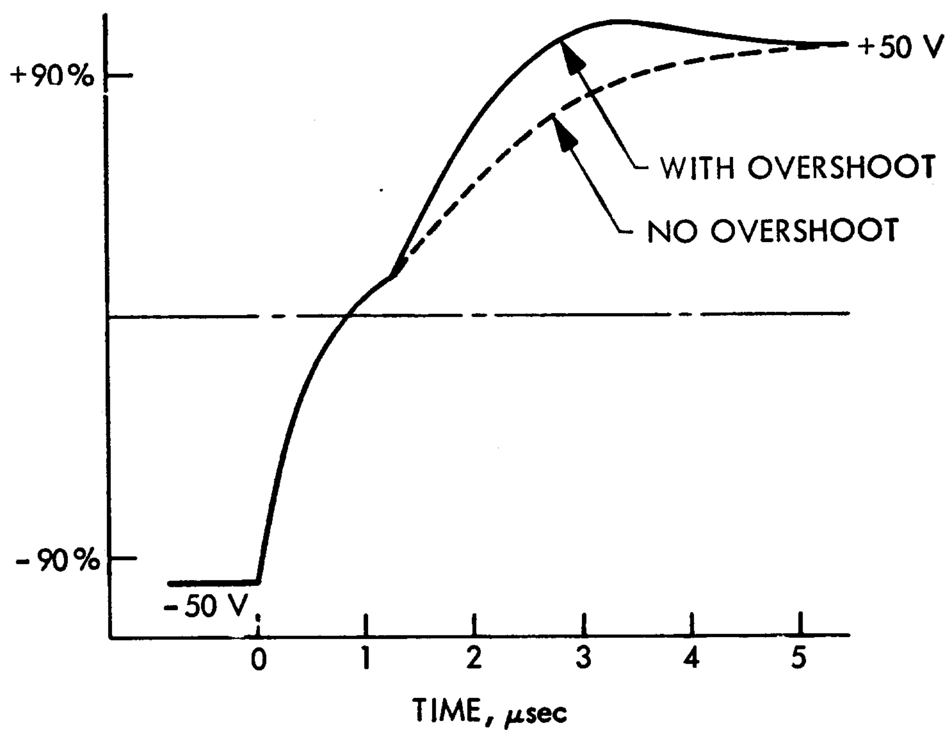
f) Power factor (ratio of average power per cycle to the product of rms voltage and current) shall be between 0.95 and unity for 2.4 kHz loads. Power factor correction capacitors, if used, shall not be placed directly across the ac buses.

g) No ac loads shall introduce more than 1.0 mA of direct current into the output of the inverter under normal operation or more than 10 mA with a single failure.

h) Loads powered from the dc source shall not introduce a ripple current (up to 50 kHz) whose peak-to-peak magnitude is greater than 1 percent of the average steady-state current when operating from a source with a dynamic impedance of less than 0.1 ohm.

i) All subsystems that use 2.4 kHz power shall operate within specification with frequency variation of ±0.002 percent of the nominal frequency throughout the type approval temperature range, and shall function to the extent that the capability of the spacecraft to receive and process ground commands is not impaired when the frequency is 2400 Hz ±6 percent. In addition, all subsystems shall have known operating characteristics over the ±6 percent frequency range and shall resume in specification operation when the frequency returns to 2400 ±0.002 percent.

j) AC loads shall operate within specification when the rise rate of the input waveform is not constant. A typical waveform is shown in Figure 1.



✱ Figure 1. 2.4 kHz Inverter Crossover Waveform (Typical)

✱ 3.6.2.4 Oscillator Synchronization. All oscillator circuits and all countdown circuits operating in the range of 10 Hz to 1.3 MHz shall be a harmonic of the 2.4 kHz power.

MM subsystems (except for MAG) shall avoid the use of the following frequencies (and their second harmonic): 12.600 kHz (25.200 kHz), 13.400 kHz (26.880 kHz), 15.120 kHz (30.240 kHz) and 16.128 kHz (32.256 kHz).

✱ 3.6.2.5 Continuity tests. When the capability to functionally verify the integrity of the cabling after final mating of a system connector does not exist, provisions shall be made to verify the continuity of each function used in the connector.

✱ 3.6.3 Mechanical Design Criteria

✱ 3.6.3.1 General. During all phases of the assembly, test, and flight preparation activities, handling equipment shall be provided (where required) to ensure that the spacecraft, MM, and components of the MM that are separated from the MM are not subjected to loads that exceed expected flight loads except during those tests specifically designed to support the environmental test program.

✱ 3.6.3.2 Deployable Elements. When deployable elements designed for deployment in a zero "g" field are deployed in a "1-g" field for testing, sufficient assembly, handling, and shipping equipment (AHSE) shall be provided to preclude damage and maintain stability.

Deployable elements include the science boom, science scan platform, RTG boom, magnetometer boom, and planetary radio astronomy antennas.

✱ 3.6.3.3 Propulsion

✱ 3.6.3.3.1 TCAPU Assembly. The TCAPU shall all be integrated together on its AHSE.

✱ 3.6.3.3.2 IPU Assembly. The IPU shall all be integrated together on its AHSE.

✱ 3.6.3.3.3 Propulsion Assembly. The TCAPU and the IPU are integrated with the required structure into a mechanically definable module. The spacecraft structure will allow the module to be removed from or installed on the spacecraft in either the dry or serviced condition.

✱ 3.6.3.4 Structural Design Criteria. All elements of the flight hardware shall meet the requirements of MJS77-3-190, Structural Design Criteria.

✱ 3.6.3.5 Temperature Control Design Criteria. All elements of the flight hardware shall meet the requirements of MJS77-3-210.

✱ 3.6.3.6 Configuration. The configuration shall meet the requirements specified in MJS77-3-180.

* 3.6.3.7 Alignments. Flight hardware shall be compatible with the mechanical alignment requirements specified in MJS77-3-170. Subsystems requiring boresight alignment shall be aligned at the subsystem level with respect to mechanical references. System level assembly will be restricted to alignment verification with respect to subsystem mounted reference mirrors and the science scan platform mirror. Field-of-view orientation checks are permissible, but alignment trimming shall not be performed at the system level.

* 3.6.3.7.1 Thrust Vector Alignment. The solid motor thrust vector final alignment for each spacecraft shall be accomplished after spacecraft assembly and center of mass determination.

3.7 Test Interfaces

The spacecraft and its test support equipment (SE) shall be capable of providing system and launch test evaluation through the following interfaces, further defined in PD618-206.

3.7.1 S-Band Interface

The ability to transmit and receive at S-band for the purpose of commanding the spacecraft, receiving telemetry, and ranging is required of the SE.

3.7.2 X-Band Interface

The ability to receive X-band for the purpose of receiving telemetry and ranging is required of the SE.

3.7.3 Stimulator/Sensor Interface

Stimulators, such as incandescent lamps, and sensors, such as gas jet detectors, will be mounted on or near the spacecraft.

* 3.7.4 Umbilical Interface

Monitoring of pyrotechnic subsystem status, and similar functions for other spacecraft subsystems are accomplished over the umbilical lines, in the final interval before committing to launch. These functions are also available in the system test configuration. The T-4 umbilical connector remains connected until 4 s before liftoff. The composite telemetry signal is included in this interface. Those functions which are required to safe the spacecraft after an abort shall be in the T-0 umbilical which remains connected until liftoff.

3.7.5 Direct Access Interface

Functions not available over other interfaces, which are necessary in the system test configuration shall be carried over the direct access interface lines. These lines connect each spacecraft subsystem with its associated SE.

3.7.6 Test Configuration

3.7.6.1 System Test Configuration. The spacecraft shall be testable as a system in the system test configuration. Each functioning subsystem shall be testable in this configuration when connected by direct access cables to test simulators, test sensors and associated subsystem SE. Flight subsystem associated SE will be augmented by other SE performing operational functions such as timing and data processing. SE design consideration shall be given to those physical and functional characteristics necessary for full support of the system test configuration. The test software shall be representative of flight software. It shall contain the same algorithms, utilize the same input and produce the same outputs as are required for flight. Timing relationships may vary to accommodate an efficient test schedule.

* 3.7.6.2 Launch Test Configuration. The spacecraft will be conditioned for launch and its launch readiness verified in the launch test configuration. There shall be no subsystem operation and verification carried out in this configuration except that which is required to support and operate the spacecraft during the launch phase. In this configuration, the only interface is via the umbilical (the direct access interface is not available). Umbilical functions are limited to those items required to support the launch preparations and launch and to monitor and/or control a few special items related to safety. Launch SE in the launch complex trailors and the system test SE in Building AO participate jointly.

4.0 SUBSYSTEM REQUIREMENTS

The following paragraphs list the functions, single point failure criteria exemptions, and system level requirements and constraints for each subsystem. No attempt has been made to differentiate between requirements and constraints. In keeping with the guidelines that a requirement or constraint should be located in one place only, the requirement or constraint is listed for the subsystem that would be responsible for the implementation. The composition of each subsystem is specified in MJS77-3-230, and is not repeated here.

4.1 Structure Subsystem (STRU)

4.1.1 Function

The STRU provides

a) Mechanical support and alignment for all flight equipment

b) Meteoroid protection

c) Radiation protection

In addition, the structure becomes an integral part of the EMI control and provides means for handling the assembled spacecraft for flight qualification testing, transporting, and mating operations with the LV.

✱4.1.2 Single Point Failure Exemption

The STRU, when designed to the requirement of MJS77-3-190 is specifically exempted from the single point failure criteria of MJS77-2-100, paragraph 4.4.

✱ 4.1.3 Requirements and Constraints

a) The structure shall be compatible with the FOV requirements specified in MJS77-3-180.

b) Location of the science scan platform relative to the spacecraft center of mass shall be as specified in MJS77-3-180.

c) The science scan platform (including science instruments mounted on it) moment of inertia about its center of rotation shall be as specified in MJS77-3-200.

d) The science scan platform shall be designed such that the axis of rotation for both axes is coincident with the platform center of mass within ±3.8 cm (±1.5 in.).

e) Mounting and alignment provisions for the science subsystems shall be as defined in MJS77-3-170 and MJS77-3-180.

f) The structure shall provide a high gain antenna reflector with a diameter of 3.66 m, a F/D of 0.0338, and whose surface deviations from the specified surface shall not exceed 0.088 cm (0.035 in.) RMS.

g) The STRU shall provide an electrical load for use by the power subsystem to dissipate the excess power generated by the RTG. This load shall be capable of dissipating a maximum of 431 W. When located per MJS77-3-180, the assembly shall also provide a diffuse reflective surface for optical calibration of the science scan platform mounted instrument. The characteristics of the surface including dimensions, temperature and surface properties shall be as specified in ICD 10073993, Science Calibration Target-Structural Interface.

h) The structure shall provide a specular reflective surface for optical calibration of the IRIS interferometer. The mechanical and optical characteristics shall be as specified in ICD 10073993, Science Calibration Target-Structural Interface.

i) The science scan platform characteristics shall be as follows:

1) The bearing frictional torque shall be in the range from 0.3 to 0.5 ft-lb.

2) The ratio of running to static friction shall be greater than 0.8.

3) The angular stiffness in both azimuth and elevation shall be greater than 2000 ft-lb/rad.

4) The angular backlash shall be as specified in MJS77-3-170.

4.2 Radio Frequency Subsystem (RFS)

4.2.1 Function

The RFS shall perform the functions defined in MJS77-3-300.

*4.2.2 Single Point Failure Exemptions

The RFS microwave components are specifically exempted from the single point failure criteria of MJS77-2-100, paragraph 4.4.

*4.2.3 Requirements and Constraints

a) The RFS shall supply the composite command signal to each CDU over separate interface lines. The RFS/CDU interface shall be cross-strapped to allow either receiver to drive either CDU.

b) The RFS shall provide an indication of transmitter performance to the CCS via four level inputs. One will indicate a low S-band exciter power condition, one will indicate a low S-band TWTA power condition, one will indicate a low-X-band exciter power condition, and one will indicate a low X-band TWTA power condition.

c) The X-band and S-band TWTA shall not be simultaneously operated in their high power modes. At least one TWTA shall be operating at any time.

d) Other RFS requirements and constraints are specified in MJS77-3-300.

4.3 Modulation Demodulation Subsystem (MDS)

4.3.1 Function

The MDS shall perform the functions defined in MJS77-3-300.

4.3.2 Single Point Failure Exemptions

None

4.3.3 Requirements and Constraints

The MDS requirements and constraints are specified in MJS77-3-300.

4.4 Power Subsystem (PWR)

4.4.1 Function

The PWR shall provide a central supply of electrical power for the spacecraft. It also provides the switching and control function for the required distribution of power.

4.4.2 Single Point Failure Exemption

None

* 4.4.3 Requirements and Constraints

a) Three multi-hundred watt RTGs shall provide primary power. A battery shall supply additional power during the injection phase. After injection, capacitors supply power for transients that exceed the RTG capability.

b) In the absence of a synchronizing signal, the PWR 2.4 kHz inverter shall free run.

c) The PWR shall provide conditioned power to satisfy the requirements of MJS77-3-250, and paragraph 3.6.2.3 herein.

d) Decoding of coded commands from CCS as specified in MJS77-3-290 shall be provided for switching of spacecraft loads as specified in MJS77-3-250.

e) The PWR shall provide sufficient sensing and load switching to ensure that the dc power bus voltage does not remain more than 1 percent below the steady state minimum voltage for more than 0.5 s, or the ac power bus does not remain more than 2 percent below the steady state minimum voltage for more than 0.5 s. PWR shall supply two level inputs to CCS which will indicate that load switching has occurred and/or inverters have switched.

f) Power switching shall be interlocked to prohibit application of power to ISS when power is not applied to FDS.

g) The PWR shall provide for short circuiting the output of the RTGs during all ground operation periods when no spacecraft electrical loads are turned on or when external power is applied.

4.5 Computer Command Subsystem (CCS)

4.5.1 Function

The function of the CCS is to:

a) Decode ground commands.

b) Issue discrete and coded commands to user subsystems.

c) Issue a sequence of DC's and CC's according to the flight sequence.

d) Alter the sequence of events and CCS state in response to ground commands.

e) Respond to interrupts generated by the spacecraft or the CCS according to algorithms stored in the CCS.

4.5.2 Single Point Failure Exemptions

None

* 4.5.3 Requirements and Constraints

a) The CCS processors shall be capable of operation through either of the output units in the following three modes:

1) Individual - the two processors are working on separate events (or no events) which are issued independently.

2) Parallel - the two processors are both working on the same event which is issued independently.

3) Tandem - the two processors are both working on the same event which is issued only if they both agree.

b) The CCS memory shall be non-volatile.

c) CCS coded commands will be in the form of a 14-bit serial word. The CCS will supply a separate interface line for the command data, the strobe, and the enable pulse to each coded command user.

d) The CCS shall provide power management such that only one of the following loads is consuming power at any one time:

1) Scan Actuator Heater (on except when one of the other loads requires power.

2) The power required for the DSS turn-on transient in excess of the DSS steady state power.

3) One science scan platform actuator.

e) The CCS shall accept an input (switch closure) from PYRO to initiate the spacecraft/LV separation sequence.

4.6 Flight Data Subsystem (FDS)

4.6.1 Function

The function of the FDS is to:

a) Collect science data from the science instruments.

b) Collect engineering data from all spacecraft subsystems.

c) Formats the data under program control and send it either to the MDS for real-time transmission or to the DSS for storage, or both.

d) Control and sequence under program control the science instruments.

e) Provide the basic spacecraft clock.

✻ 4.6.2 Single Point Failure Exemptions

Although there are no exemptions to the single point failure criteria of MJS77-2-100, the requirements of paragraph 3.5.1.1 of this document are exempted to the extent that the FDS state vector control logic shall be designed such that a failure will result in all "A" units being selected.

✻ 4.6.3 Requirements and Constraints

a) The FDS shall process analog measurements, digital measurements and inputs indicative of discrete events. Analog data shall be converted to digital words. Discrete events shall be counted with provision made to identify their origin and time of occurrence.

b) All non-digital engineering data shall be digitized to 8-bit words.

c) The FDS shall provide the capability for 195 analog and 48 digital measurements. The input signal levels are specified in MJS77-3-270.

d) The FDS shall provide for Golay coding of non-imaging data. Use of coding to be optional.

e) The FDS basic timing shall have an accuracy of 0.002 percent.

f) The FDS shall provide sync pulses to PWR at a 4.8-kHz rate for synchronization of the 2.4 kHz inverters.

g) The FDS shall assure synchronization between 2.4 kHz inverter power cycles and ISS frames.

h) The FDS shall provide the data modes and rates specified in MJS77-3-270.

i) The FDS shall provide telemetry measurements and subcommutation consistent with MJS77-3-280, Telemetry Measurements and Data Formats.

j) The FDS shall provide control and sequencing for science subsystems consistent with MJS77-3-270.

k) The FDS shall provide the power required by temperature and pressure transducers which interface directly with the FDS.

l) The FDS shall provide an addressable digital data interface with the AACS.

m) The FDS shall provide the capability to control the DSS via coded commands. Commands to the DSS shall be 14-bit serial words identical in format to the coded commands issued by the CCS.

n) The FDS shall be standby redundant except for the state vector control logic.

4.7 Attitude and Articulation Control Subsystem (AACS)

4.7.1 Function

The AACS shall provide signals to establish and maintain spacecraft orientation and stability during the injection phase. The AACS shall control the attitude of the MM during cruise and encounter using the sun and a star (usually Canopus) as celestial reference objects and using gyro references when celestial references are not available. The AACS shall provide controlled turns about the MM reference axes for science and trajectory correction maneuvers. The AACS shall also control the attitude of the MM during the trajectory correction thrusting period. In addition, the AACS shall control the pointing of the science scan platform.

✱4.7.2 Single Point Failure Exemptions

The following AACS components are specifically exempted from the single point failure criteria of MJS77-2-100, paragraph 4.4.

a) IPU drivers.

b) Scan actuators.

c) Scan actuator drivers.

d) Scan actuator heater.

✱4.7.3 Requirements and Constraints

a) The AACS shall incorporate programmability to the extent specified by the software requirements of MJS77-3-310.

b) The AACS shall be capable of reducing the rate of the MM during undisturbed limit cycle operation to the requirements specified in paragraph 3.3.6.2.

c) The AACS shall provide limit cycle operations with deadbands programmable over the range from 0.87 to 175 mrad in 0.38 mrad steps.

d) The AACS shall provide an output signal to indicate the inadvertent loss of sun acquisition.

e) Except for trajectory correction maneuvers when five thrusters may be on simultaneously, the AACS shall supply heater power to the six active attitude propulsion thrusters and shall provide power management such that either the attitude propulsion thruster heaters or one attitude propulsion thruster is consuming power at any one time. (Mechanizations to provide both heater and thruster power simultaneously is not a requirement.)

f) The AACS control capability shall be compatible with spacecraft inertial properties specified in MJS77-3-200.

g) The AACS shall provide outputs indicative of the desired AACS power states. This output consisting of 6 signals (level interrupts) will be processed by the CCS to command the PWR to the required state.

h) In support of the fault sensing the correction routines specified in paragraph 3.5.1.2, the AACS shall provide the capability to reacquire the sun from any arbitrary orientation. In addition, the reacquisition process shall be constrained to minimize the probability of permanent solar energy induced damage to science instruments.

i) The AACS shall provide IPU and TCAPU valve open commands to PROP. The off time between adjacent commands to any valve shall be not less than 20 ms. Each open command to an IPU valve shall be 40 ms or greater in duration. Each open command to a TCAPU valve shall be 10 ms or greater.

j) The AACS shall provide failure sensing to command TCAPU isolation valves in the event of thruster malfunctions specified in MJS77-3-310.

k) The AACS power-on-reset shall provide three axis stabilization and on Earth pointing of the HGA.

4.8 Pyrotechnic Subsystem (PYRO)

4.8.1 Function

The PYRO actuates pyrotechnic devices.

4.8.2 Single Point Failure Exemptions

None.

* 4.8.3 Requirements and Constraints

a) The PYRO shall actuate squibs as shown in MJS77-3-120.

b) The PYRO shall be capable of simultaneously firing a minimum of 8 squib bridgewires as a single event.

c) The PYRO shall provide an input (switch closure) to the CCS for initiation of the spacecraft/launch vehicle separation sequence.

d) The PYRO shall perform voltage to frequency conversion for eight propulsion pressure measurements.

e) The PYRO shall be redundant except for the instrumentation power supply, PROP signal conditioning, and ISO valve position switches.

4.9 Cabling Subsystem (CABL)

4.9.1 Function

The CABL shall provide the necessary electrical inter-connections between all spacecraft subsystems, between equipment electrically connected through the system cabling harness, between subsystem electronic assemblies, and interfacing cabling from the spacecraft to the LV.

4.9.2 Single Point Failure Exemption.

Redundant wiring shall not be employed except as required to meet special reliability requirements and only after approval of the Spacecraft System Engineer.

✱4.9.3 Requirements and Constraints

a) Cabling shall be compatible with the functional requirements of all the connected equipment.

b) Access shall be provided that is adequate for necessary installation, testing, disassembly, and assembly.

c) Wire types shall be as few as practical.

d) Shielding shall be used as specified in MJS77-3-260.

e) Cabling connecting with articulating components shall be as flexible and compact as possible.

f) The loop resistance of each pyro-electronics to squib bridgewire cable (including connector pin resistance, but exclusing bridgewire resistance) shall not exceed 0.60 ohm over the expected operating temperature range.

g) Power distribution cabling shall not cause a voltage drop between the power distribution unit and the load that is greater than 0.5 percent of the distributed design value for loads as specified in MJS77-3-250.

h) Cabling to the science scan platform shall allow the platform to rotate. The maximum torque required to twist the cable through the scan range indicated below at 0°F shall be:

	Torque		Scan Range
	cm-N	(in-lb$_f$)	(degrees from center)
Azimuth axis	±112	(±10)	±180°
Elevation axis	±224	(±20)	±120°

i) Cables external to the bus and science scan platform enclosures shall be conductively isolated from support structure and radiatively insulated such that heat transfer to or from sensitive equipment via cabling is minimized.

4.10 Propulsion Subsystem (PROP)

4.10.1 Function

The PROP shall provide:

a) The final increment of injection energy to achieve the required interplanetary trajectory.

b) Impulse for post injection trajectory corrections.

c) Control torque to maintain spacecraft orientation and stability.

* 4.10.2 Single Point Failure Exemptions

The following PROP components are exempt from the single point failure criteria of MJS77-2-100, paragraph 4.4, and paragraph 3.5.1.2 of this document.

a) IPU engines.

b) Solid motor including the safe/arm device.

c) Propellant tank and lines.

d) P_c integrator output.

* 4.10.3 Requirements and Constraints

a) The solid rocket motor defined by Thiokol Chemical Corporation Specification CP364-4 shall be used to provide final impulse for injection.

b) The TCAPU shall provide thrust for thruster calibration and at least nine trajectory corrections. (The first trajectory correction may include multiple thrust periods.)

c) The PROP shall satisfy the trajectory correction velocity specified in MJS77-3-150.

d) Reaction control expendable mass shall be allocated sufficient to perform the mission events specified in MJS77-3-120 with the expendable mass allocated in MJS77-3-230.

e) The minimum thruster impulse bit for a TCAPU thruster shall be $\leq$ 0.0178 N-s (0.004 lbf-s) with minimum open command as specified in 4.7.3.i and with a duty cycle less than 0.01 percent.

f) The minimum thrust provided by any TCAPU thruster, after one second of firing, shall be 0.445 N (0.10 lbf).

g) TCAPU thruster pulse-to-pulse impulse bit variability under fixed conditions shall be $< \pm 15$ percent (3σ) for duty cycles less than 0.01 percent. Thruster-to-thruster steady state thrust variability shall be <5 percent (3σ).

h) TCAPU thruster impulse bit shall be predictable to $< \pm 50$ percent (3σ) for any operating condition.

i) TCAPU pulse response under any operating conditions shall be:

1) Maximum chamber pressure rise time
   Signal to 10 percent of pulse peak thrust - 30 ms
   Signal to 90 percent of pulse peak thrust - 80 ms
2) Maximum chamber pressure decay time
   Signal to 10 percent of pulse peak thrust - TBD

j) For a single trajectory correction maneuver the TCAPU shall provide a total impulse variable over the range 71.2 to 48,900 N-s (16 to 11,000 lbf-s).

k) Impulse prediction error during TCM shall be as specified in MJS77-3-170.

l) Each TCAPU thruster shall be capable of at least 400,000 actuations.

m) The maximum leakage force produced by a single thruster shall not exceed 22.2×10^{-8}N (5×10^{-8} lbf).

n) The thrust provided by an IPU A or B engine shall be $\geq$ 434 N (97.6 lbf).

o) The thrust provided by an IPU roll engine shall be $\geq$ 24 N (5.4 lbf).

p) Pulse response (after 1 s warm-up) for all IPU engines:

1) Maximum chamber pressure rise time:
   Signal to 10 percent of peak pulse thrust - 25 ms
   Signal to 90 percent of peak pulse thrust - 45 ms
2) Maximum chamber pressure decay time:
   Signal to 10 percent of peak pulse thrust - 35 ms

q) The minimum impulse bit for IPU engines after 1 s firing time shall be $\leq$ 13.3 N-s (3.0 lbf-s) for the A & B engines and $\leq$ 0.667 N-s (0.15 lbf-s) for the roll engine with minimum open commands as specified in 4.7.3.i.

4.11 Temperature Control Subsystem (TEMP)

* 4.11.1 Function

The function of the TEMP is to maintain the temperature throughout the spacecraft to within the limits specified in MJS77-3-210. In addition, micrometeoroid protection is provided by the TEMP.

* 4.11.2 Single Point Failure Exemptions

The following TEMP components are specific exemptions from the single point failure criteria of MJS77-2-100, paragraph 4.4.

a) Thermal blankets.

b) Thermal shields.

c) RHUs.

d) Micrometeoroid shields.

✱ 4.11.3 Requirements and Constraints

Hardware elements required for thermal control which are physically incorporated into other subsystems are considered to be part of the subsystem with which they are delivered to SAF and are therefore not part of the TEMP mass allocation. Examples of such items are paints, heaters, thermal isolation mounts, and some thermal shields.

4.12 Mechanical Devices Subsystem (DEV)

✱ 4.12.1 Function

The DEV shall provide latching, deployment, and damping. Specific functions performed are:

a) Deployment of the

   1) RTG boom.

   2) Science boom.

   3) Magnetometer boom.

b) Latching of

   1) Science Scan platform to PM.

   2) RTG Boom to PM.

   3) PM to MM.

   4) PM to LV.

   5) Magnetometer boom.

c) Separation of

   1) Spacecraft from LV.

   2) PM from MM.

✱4.12.2 Single Point Failure Exemptions

The magnetometer boom and the deployment mechanisms for the RTG boom and science boom are exempted from the single point failure criteria of MJS77-2-100, paragraph 4.4.

✱4.12.3 Requirements and Constraints

a) The RTG and science boom nominal deployment rate shall be 0.3 deg/s.

b) The magnetometer deployment rate shall be 0.125 m/s.

c) The outboard low field magnetometer shall be deployed 13 m from the intersection of the boom center line with its mounting plane, with the sensors located as specified in MJS77-3-180 and aligned as specified in MJS77-3-170.

d) RHUs shall be mounted to the support structure for the HFM magnetometer sensor. Thermally conductive paths into the magnetometer from the RHUs shall be provided.

e) A separation force shall be imparted to the MJS77 spacecraft sufficient to meet the requirements of paragraph 3.4.3.1.2. An impact-free (nominal) separation shall be achieved in the face of a Centaur residual rate specified in paragraph 3.4.3.1.2.

f) A separation force shall be sufficient to generate a relative separation rate between the MM and the PM as specified in paragraph 3.4.3.1.2. An impact free (nominal) separation and post jettison MM rates as specified in paragraph 3.4.3.1.2 shall be provided.

g) The DEV shall provide the capability to reduce the I_{yz} product of inertia to a nominal value of zero within the tolerances specified in MJS77-3-200.

h) Dampers shall be installed on the RTG Boom Locking Strut and Magnetometer Boom Assembly. The dampers shall provide damping of the form $e^{-2\pi yt}$ over the desired displacement range (x); where y is the product $[(c/c_c) \times (fn)]$.

For $c/c_c = 0.04$, the damping product (y) and displacement values are given below.

Boom	Damping Product (y)	Displacement Limits
RTG	0.091 Hz	$0.0005 \geq x \geq 0.0001$ in.
Mag.	0.0064 Hz	$0.00125 \geq x \geq 0.00025$ in.

4.13 Data Storage Subsystem (DSS)

4.13.1 Function

The DSS shall provide bulk storage of spacecraft digital data.

* 4.13.2 Single Point Failure Exemptions

The DSS is exempt from the single point failure criteria of MJS77-2-100, paragraph 4.4.

* 4.13.3 Requirements and Constraints

a) The DSS shall accept single stream data for storage at 115.2 or 7.2 kbps.

b) The DSS shall play back the stored data at 57.6, 33.6, 21.6 or 7.2 kbps in a time sequence that is the same as the recorded sequence.

c) The bit error rate at end of mission shall be less than 10^{-4} measured between input and output of the DSS for all playback rates.

d) With continuous input data, the storage capacity of the DSS shall be at least 5.36×10^8 bits. The DSS shall provide the capability to store blocks of data of variable size. Storage capacity lost during starting and stopping to record a block of data shall not exceed 4×10^5 and, 10^4 bits for record rates of 115.2, and 7.2 kbps, respectively.

e) The DSS shall provide a slew mode for rapid access of a record or playback starting point.

f) The DSS shall provide the capability to start record or playback at any point on the tape. The DSS shall provide an output signal indicative of tape movement that will accommodate location of a specific point on the tape ±10 cm (4 in.).

g) The total tape travel across the DSS record/playback head shall not exceed 8.34×10^5 m.

h) The total number of passes across a head by any section of tape shall not exceed 6500.

i) The delay between the receipt of start record signal and when the DSS is ready to receive data shall be less than 4.5 s.

j) The DSS shall provide the capability to start and stop the DSS tape a minimum of 10^4 times.

k) The DSS shall provide a dedicated location on the magnetic tape to be used for storage at FDS programs. There shall be a minimum of eight segments of tape, each with a capacity greater than 150 k bits, certified by bit error tests to be error free.

l) The DSS shall provide a pulse output indicating when the tape has reached the beginning or end of the tape.

4.14 S/X Band Antenna Subsystem (SXA)

4.14.1 Function

The SXA shall perform the functions defined in MJS77-3-300.

*4.14.2 Single Point Failure Exemption

The SXA equipment shall be exempt from the single point failure criteria of MJS77-2-100, paragraph 4.4.

*4.14.3 Requirements and Constraints

The SXA requirements and constraints are specified in MJS77-3-300.

4.15 Cosmic Ray Subsystem (CRS)

4.15.1 Function

The CRS shall measure the energy and composition of cosmic ray nuclei from hydrogen to iron over the energy range from 1 to 500 MeV per nucleous. Electrons shall be measured over the range from 3 to 120 MeV. These measurements shall be made during both cruise and encounter phases of the mission.

4.15.2 Requirements and Constraints

a) The CRS shall be mounted to the spacecraft consistent with the requirements specified in MJS77-3-180.

b) The CRS shall not be exposed to relative humidity over 70 percent (50 percent when operating).

4.16 Planetary Radio Astronomy Subsystem (PRA)

4.16.1 Function

The PRA shall measure the strength and polarization of radio signals in the 20 kHz to 40.5 MHz range. These measurements shall be made during both cruise and encounter phases of the mission.

4.16.2 Single Point Failure Exemption

The PRA/PWS antenna is exempted from the single point failure criteria of MJS77-2-100, paragraph 4.4.

4.16.3 Requirements and Constraints

a) The spacecraft shall provide mounting for two, deployable, 10-m length, interlocking monopole antennas. Detailed mounting is specified in MJS77-3-180.

b) The PRA monopole antenna shall be designed to provide the following stability properties:

1) Bending stiffness EI $\geq$ 16.6 lb-ft^2.

2) Bending strength at antenna base $\geq 3.7 \times 10^{-2}$ ft-lb.

3) Antenna element mass $\leq$ 0.5 lbm.

4.17 Plasma Wave Subsystem (PWS)

4.17.1 Function

The PWS shall make measurements of the electric fields of plasma waves both during cruise and at Jupiter and Saturn in the frequency range from 10 Hz to 56.2 kHz.

4.17.2 Requirements and Constraints

a) The PWS shall use the planetary radio astronomy antennas.

b) The PWS shall provide notch filtering to reject 2.4 and 7.2 kHz interference signals.

4.18 Low Energy Charged Particle Subsystem (LECP)

* 4.18.1 Function

The LECP measures the charge and energy distribution of nuclei over the energy range 0.04 to $\geq$ 30 MeV/nucleon, the energy distribution of electrons from 10 keV to 10 MeV and protons from 15 keV to 150 MeV.

* 4.18.2 Requirements and Constraints

a) The LECP shall be mounted to the spacecraft consistent with the requirements specified in MJS77-3-180.

b) Spacecraft will be rolled for calibration as specified in MJS77-3-120.

c) The LECP shall not induce into any MM axis a momentum increment greater than 7.5×10^{-2} kg-m^2/s.

d) The LECP shall not be exposed to humidity in excess of 50 percent.

4.19 Photopolarimeter Subsystem (PPS)

* 4.19.1 Function

The function of the PPS is to measure the intensity and polarization of light at eight wavelengths between 235 and 750 nanometer.

* 4.19.2 Requirements and Constraints

a) The PPS shall be mounted on the science scan platform and bore sighted with the ISS as specified in MJS77-3-180.

b) The PPS shall be compatible with pointing accuracies specified in MJS77-3-170.

c) Rotation of filter wheel and aperture/polarizer wheel shall not induce into any MM axis a momentum greater than 7.5×10^{-2} kg-m^2/s.

d) The spacecraft/science platform orientation shall be controlled such that the sun does not come within 0.349 rad of the PPS boresight.

e) The PPS shall provide a Brewster plate for polarization calibration. The plate shall be mounted per the requirements of MJS77-3-180 to the accuracies specified in MJS77-3-170.

f) The MM will provide for viewing of an MM mounted target and the Brewster plate for in-flight calibration of the PPS.

4.20 Plasma Subsystem (PLS)

4.20.1 Function

The PLS measures both solar wind electrons and solar wind ions with energies in the range of 10 to 5950 V.

4.20.2 Requirements and Constraints

a) The PLS shall be mounted to the spacecraft consistent with the requirements specified in MJS77-3-180.

b) Prior to and during instrument operation the relative humidity shall be maintained at 50 percent or less.

c) The PLS shall be compatible with the pointing accuracies specified in MJS77-3-170.

4.21 Ultraviolet Spectrometer Subsystem (UVS)

4.21.1 Function

The UVS measures ultraviolet emissions in the region 40 to 180 nm.

4.21.2 Requirements and Constraints

a) The UVS is mounted on the science scan platform and its airglow FOV boresighted with ISS as specified in MJS77-3-180, and aligned to the accuracies specified in MJS77-3-170.

b) The UVS occultation FOV shall be aligned compatible with the pointing accuracies specified in MJS77-3-170.

c) The requirements for science maneuvers are specified in MJS77-3-120.

d) Spacecraft orientation will be controlled such that the sun does not come within 20 deg of the UVS airglow bore boresight.

e) The MM will provide for viewing of a MM mounted target for in-flight calibration of the UVS.

f) During storage or ground operations the UVS will not be exposed to relative humidity greater than 15 percent.

4.22 Magnetometer Subsystem (MAG)

4.22.1 Function

The MAG measures the ambient magnetic fields over the range 10^{-11} to 2×10^{-3}T.

* 4.22.2 Requirements and Constraints

a) The MAG consists of two low field magnetometers (LFM) and two high field magnetometers (HFM) and shall be mounted on a deployable boom as specified in MJS77-3-180.

b) Two axes of each sensor shall be aligned transverse to the MM roll axis. The third sensor axis shall be aligned parallel to the MM roll axis. Alignment accuracies shall be as specified in MJS77-3-170.

c) The MM magnetic field shall not exceed 0.2 nT at the outboard LFM as established by analytical means.

d) The MAG sensors axis shall be aligned to mechanical reference marks compatible with paragraph 3.6.3.7 and MJS77-3-170.

e) The MM will provide rotation about the MM roll axis and separately about the yaw or pitch axis for in flight calibration as specified in MJS77-3-120.

f) RHUs will be accommodated by the support structure for the HFM sensors rather than by the sensors themselves. RHU attachment shall be accommodated by the LFM sensor base plates and shall be a part of the LFM sensors.

Thermally conductive paths into the sensitive elements of the magnetometer sensors from the RHUs shall be provided.

4.23 Imaging Science Subsystem (ISS)

4.23.1 Function

The ISS shall acquire image data of Jupiter and Saturn and many of their satellites.

* 4.23.2 Requirements and Constraints

a) The ISS shall consist of a two camera system, a narrow angle (1.5 m) and a separate wide angle (0.2 m).

b) The narrow angle and wide angle cameras shall be mounted on the science scan platform as specified in MJS77-3-180.

c) The ISS shall be mounted on the spacecraft and aligned as specified in MJS77-3-170.

d) The MM will provide for viewing of a MM mounted target for in-flight calibration of the ISS.

e) The ISS shall provide reseau marks such that the orientation of each image is unambiguously established.

4.24 Infrared Interferometer Spectrometer and Radiometer Subsystem (IRIS)

* 4.24.1 Function

The IRIS shall sense the infrared spectrum from 200 to 4000 cm^{-1}. Reflected solar energy between 5000 and 33000 cm^{-1} shall also be measured.

* 4.24.2 Requirements and Constraints

a) The IRIS shall be mounted on the science scan platform and boresighted with the ISS as specified in MJS77-3-180.

b) The MM will provide knowledge of the IRIS pointing direction. The IRIS shall be aligned to the accuracies specified in MJS77-3-170.

c) The IRIS shall not induce into any MM axis a momentum increment greater than 7.5×10^{-2} $kg\text{-}m^{-2}/s$.

d) The MM shall provide for viewing of a MM mounted target for in-flight calibration of the IRIS.

e) Relative humidity of optics module must be maintained below 30 percent during ground testing.

f) The IRIS shall be compatible with the data bit error rates specified in MJS77-3-270.

g) Vibration levels during IRIS operation must be less than 0.01 g peak in the frequency band from 5 to 640 Hz.

FUNCTIONAL REQUIREMENT AMENDMENT

(Insert in 618-205, MJS77 Functional Requirements Book)

TITLE:

FUNCTIONAL REQUIREMENT
MARINER JUPITER/SATURN 1977
SPACECRAFT REQUIREMENTS AND CONSTRAINTS

FR No. MJS77-3-100
AMENDMENT No. 1
PAGE 1 **OF** 1
DATE: 9 October 1975
PER ECR No. 36072

DESCRIPTION OF CHANGE:

1. On page 40, paragraph 4.13.3, item d); line 5, change:

   From: 10^4 bits for record ...

   To: 1.5×10^4 bits for record ...

2. On page 13, paragraph 3.3.6.3, item c); last column of Table, change:

WAS	IS
20 mr/1 s	20 μr/1 s
150 mr/10 s (100 mr/10 s)	150 μr/10 s (100 μr/10 s)
20 mr/1 s	20 μr/1 s

3. On page 27, paragraph 4.1.3, item f), line 2, change:

   From: F/D of 0.0338, ...

   To: F/D of 0.338, ...

DISTRIBUTION:

List 197

REMARKS:

Item 1 per ECR 36072

Items 2 and 3 to correct typographical error in initial release

APPROVED:

[signatures]

SYSTEM

FUNCTIONAL REQUIREMENT AMENDMENT

(Insert in 618-205, MJS77 Functional Requirements Book)

TITLE: FUNCTIONAL REQUIREMENT MARINER JUPITER/SATURN 1977 SPACECRAFT REQUIREMENTS AND CONSTRAINTS	FR No. MJS77-3-100 AMENDMENT No. 2 PAGE 1 OF 2 DATE: 24 February 1976 PER ECR No. See Remarks

DESCRIPTION OF CHANGE:

1. Delete paragraph 4.12.3d, page 39 in its entirety.

2. Change paragraph 4.22.2f, page 45 as follows:

<u>IS:</u>

RHU holders for both the HFM and the LFM shall be provided by MAG. Thermally conductive paths into the sensitive elements of the magnetometer sensors from the RHUs shall be provided.

<u>WAS</u>

RHUs will be accommodated by the support structure for the HFM sensors rather than by the sensors themselves. RHU attachment shall be accommodated by the LFM sensor base plates and shall be a part of the LFM sensors.

Thermally conductive paths into the sensitive elements of the magnetometer sensors from the RHUs shall be provided.

3. Change paragraph 4.6.2, page 31, as follows:

<u>IS:</u>

Although there are no exemptions to the single point failure criteria of MJS77-2-100, the requirements of paragraph 3.5.1.1 of this document are exempted to the extent that a failure in the FDS state vector control logic shall be counted as <u>one</u> failure, e.g., failure modes in state vector control logic can preclude switching redundant units but a <u>second</u> failure is required before capability is lost.

<u>WAS:</u>

Although there are no exemptions to the single point failure criteria of MJS77-2-100, the requirements of paragraph 3.5.1.1 of this document are exempted to the extent that the FDS state vector control logic shall be designed such that a failure will result in all "A" units being selected.

DISTRIBUTION:	REMARKS:
List 197	Items 1 and 2 per ECR 36098 Items 3 per ECR 36172 Item 4 per ECR 36088A
	APPROVED: [signatures] SYSTEM

4. Change step q) of paragraph 4.10.3, page 37, as follows:

WAS:

q) The minimum impulse bit for IPU engines after 1 s firing time shall be $\leq$ 13.3 N-s (3.0 lbf-s) for the A & B engines and $\leq$ 0.667 N-s (0.15 lbf-s) for the roll engine with minimum open commands as specified in 4.7.3. i.

IS:

q) The minimum impulse bit for IPU engines after 1 s firing time shall be greater than 13.3 N-s (3.0 lbf-s) for the A & B engines and greater than 0.667 N-s (0.15 lbf-s) for the roll engine with minimum open commands as specified in 4.7.3. i.

FUNCTIONAL REQUIREMENT AMENDMENT

(Insert in 618-205, MJS77 Functional Requirements Book)

TITLE:

FUNCTIONAL REQUIREMENT
MARINER JUPITER/SATURN 1977
SPACECRAFT REQUIREMENTS AND CONSTRAINTS

FR No. MJS77-3-100

AMENDMENT No. 3

PAGE 1 **OF** 2

DATE: 22 April 1976

PER ECR No. See Remarks

DESCRIPTION OF CHANGE:

Change paragraph 3.4.3.1.2

IS: The relative separation rate between the PM and MM shall be 0.55 to 0.75 m/s.

WAS: The relative separation rate between the PM and MM shall be 0.66 m/s.

2. Add paragraph as follows:

4.7.3.1 The following sequences must be followed during all TCAPU thruster firings:

1. Open the hydrazine source isolation valve prior to energizing (opening) any thruster valve down stream of the isolation valve.
2. De-energize (close) all thruster valves prior to closing the hydrazine source isolation valve upstream of the thruster.

3. Change paragraph 3.3.4.2 g by adding the following sentence.

All subsystems shall document their power-on-reset (POR) state in their four-level FR and shall provide the system with POR trip point data.

4. Change paragraph 4.2.3 by adding the following:

e) A power-on-reset shall cause the RFS to return to its pre-power interrupted state.

DISTRIBUTION:

List No. 197

REMARKS: Item 1 per ECR 36079.
Item 2 per ECR 36188.
Items 3, 4, 5, 6, 7, and 8 per ECR 36201.
Item 9 per ECR 36233.

APPROVED: [signatures] Ronald F. Draper

SYSTEM

5. Change paragraph 4.3.3 by adding the following:

   a) MDS shall hardwire each TMU to the planetary encounter state.

   b) MDS shall trip at an input voltage less than 44.8 V for greater than 30 μsec including uncertainties.

6. Change paragraph 4.5.3 by adding the following:

   f) The CCS power-on-reset trip point range shall be 45.3 ±0.5 V for 20 ±10 μsec including uncertainties.

7. Change paragraph 4.6.3 by adding the following:

   o) The FDS power-on-reset shall trip at an input voltage less than 44.8 V for greater than 30 μsec including uncertainties.

   p) A power-on-reset shall cause the FDS to return to its pre-power interrupted state.

8. Change paragraph 4.7.3 by adding the following:

   l) The AACS power-on-reset shall trip at an input voltage less than 44.8 V for greater than 30 μsec including uncertainties.

9. Change paragraph 4.1.3 by deleting subparagraph h) in its entirety.

FUNCTIONAL REQUIREMENT AMENDMENT

(Insert in 618-205, MJS77 Functional Requirements Book)

TITLE:

FUNCTIONAL REQUIREMENT
MARINER JUPITER/SATURN 1977
SPACECRAFT REQUIREMENTS AND CONSTRAINTS

FR No. MJS77-3-100

AMENDMENT No. 4

PAGE 1 **OF** 2

DATE: 9 August 1976

PER ECR No. See Remarks

DESCRIPTION OF CHANGE:

1. Change paragraph 4.15.2, Item b, to read as follows:

   b) The CRS shall not be operated in any environment whose relative humidity exceeds 50 percent, and shall not be exposed for more than 24 hours to any nonoperating storage environment whose relative humidity is between 50 and 70 percent. The relative humidity shall never exceed 50 percent for at least 12 hours prior to CRS turn-on.

2. Change paragraph 4.10.3, p to read as follows:

   WAS: Pulse response (after 1 s warm-up) for all IPU engines:

   IS: Engines response for on-times greater than or equal to 40 ms and less than 500 ms for all IPU engines:

3. Change paragraph 4.10.3, p 2 to read as follows:

   WAS: Signal to 10 percent of peak pulse thrust - 35 ms

   IS: Signal to 15 percent of peak pulse thrust - 35 ms

4. Change paragraph 4.10.3, q to read as follows:

   WAS: The minimum impulse bit . . . with minimum open commands as specified in 4.7.3, i.

   IS: The minimum impulse bit . . . with open commands of 40 ms.

DISTRIBUTION:

List No. 197

REMARKS: Item 1 per ECR 36230.
Items 2 and 3 per ECR 36163
Items 4 and 5 per ECR 36241
Item 6 per ECR 36290

APPROVED:

FUNCTIONAL REQUIREMENT AMENDMENT

TITLE:	FR No. MJS77-3-100 AMENDMENT No. 4 PAGE 2 OF 2 DATE: PER ECR No.

DESCRIPTION OF CHANGE:

5. Change paragraph 4.7.3, i to read as follows:

   a) In fourth line of paragraph, change 40 ms to 20 ms.

   b) To end of paragraph, add the following sentence:

   The maximum load on the IPU battery shall be two IPUs A/B and two IPU roll REAs.

6. Change paragraph 4.13.3, d to read as follows:

   In the fifth line:

   WAS: data shall not exceed 4×10^5 and, 10^4 bits for record rates

   IS: data shall not exceed 5.1×10^5 and, 3×10^4 bits for record rates

DISTRIBUTION:	REMARKS:
	APPROVED:

FUNCTIONAL REQUIREMENT AMENDMENT

TITLE:

FUNCTIONAL REQUIREMENT
MARINER JUPITER/SATURN 1977
SPACECRAFT REQUIREMENTS AND CONSTRAINTS

FR No. MJS77-3-100

AMENDMENT No. 5

PAGE 1 **OF** 1

DATE: 11 October 1976

PER ECR No. 36391

DESCRIPTION OF CHANGE:

Add new paragraph per ECR 36391, to read as follows:

3.4.3.4 Encounters. In order to protect science platform instruments from the Saturn E Ring environment (based on 1976 ring model), during passage through E ring the science platform shall be positioned with the L vector (instrument look direction) at least 80 degrees from the direction of the incoming particles to prevent damage to the optical instruments. (Refer to 618-505, Vol. IV; Section II, Rule No. FR07B12.)

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List 197

REMARKS:

APPROVED:

JPL 2030 (11-69)

nc

FUNCTIONAL REQUIREMENT AMENDMENT

(Insert in 618-205, MJS77 Functional Requirements Book)

TITLE:

FUNCTIONAL REQUIREMENT
MARINER JUPITER/SATURN 1977
SPACECRAFT REQUIREMENTS AND CONSTRAINTS

FR No. MJS77-3-100

AMENDMENT No. 6

PAGE 1 **OF** 1

DATE: 3 January 1977

PER ECR No. 36543

DESCRIPTION OF CHANGE:

Add to paragraph 3.4.3.4 the following:

In order to protect the LECP detectors from the Saturn E Ring environment (based on 1976 ring model) during passage through the E Ring, the LECP telescopes shall be positioned such that their 0° - 180° axis be maintained as close to perpendicular as is possible to the direction of the incoming particles. This may be accomplished by appropriate positioning of the LECP stepper motor.

DISTRIBUTION:

List 197

REMARKS:

APPROVED: A. E. Cunningham R. F. Draper R. V. Heacock

A-C

FUNCTIONAL REQUIREMENT AMENDMENT

(Insert in 618-205, MJS77 Functional Requirements Book)

TITLE:

FUNCTIONAL REQUIREMENT
MARINER JUPITER/SATURN 1977
SPACECRAFT REQUIREMENTS AND CONSTRAINTS

FR No. MJS77-3-100

AMENDMENT No. 7

PAGE 1 **OF** 3

DATE: 8 March 1977

PER ECR No. See Remarks

DESCRIPTION OF CHANGE:

1. Change paragraph 4.10.3, e), page 36, to read as follows:
The impulse bit delivered by a TCAPU thruster when commanded open for 10 ms with a duty cycle less than 0.01 percent when the N_2H_4 inlet pressure is 350 psia at 70°F, shall be 0.223 N-s (0.005 lbf-s), maximum. The pulse-to-pulse variability shall be less than ±15 percent for duty cycles less than 0.01 percent.

2. Change paragraph 4.10.3, f), page 36, to read as follows:
The thrust delivered by the 0.2 lbf thrusters during a steady-state firing shall be within ±5 percent of the mean thrust from thruster to thruster as follows:

Maximum:	1.024 N (0.23 lbf) at 350 psia N_2H_4, pressure and 70°F
FA Maximum:	0.356 N (0.08 lbf) at 150 psia N_2H_4, pressure and 70°F
TA Maximum:	0.325 N (0.07 lbf) at 150 psia N_2H_4, pressure and 70°F

3. Delete paragraphs 4.10.3, g) and 4.10.3, h), page 36, in their entirety.

4. Change paragraph 4.10.3, i), page 37, to read as follows:
TCAPU pulse response under any operating conditions shall be:
   1) For FA testing:
      a. Maximum chamber pressure rise time:
      Signal to 10 percent of pulse peak thrust - 25 ms.
      Signal to 90 percent of pulse peak thrust - 80 ms.
      b. Maximum chamber pressure decay time:
      Signal to 10 percent of pulse peak thrust - 200 ms.

DISTRIBUTION:

List 197

REMARKS: Items 1 through 4 per ECR 36624
Items 5 and 6 per ECR 36647
Item 7 per ECR 36646
Item 8 per ECR 36704

APPROVED: A. S. Cunningham   Ronald F. Draper   R. L. Heacock

JPL 3930 (11-69)

4. (contd)

2) For TA testing:

a. Maximum chamber pressure rise time:

Signal to 10 percent of pulse peak thrust - 35 ms.

Signal to 90 percent of pulse peak thrust - 140 ms.

b. Maximum chamber pressure decay time:

Signal to 10 percent of pulse peak thrust - 1.2 s

5. Change paragraph 4.10.3, n), page 37, to read as follows:
The thrust provided by an IPU A or B engine shall be $\geq$ 434 N (97.6 lbf) with an REA inlet pressure greater than 2.413×10^6 N/m^2 (350 psia).

6. Change paragraph 4.10.3, o), page 37, to read as follows:
The thrust provided by an IPU roll engine shall be $\geq$ 24 N (5.4 lbf) with an REA inlet pressure greater than 2.413×10^6 N/m^2 (350 psia).

7. Change paragraph 4.10.3, p), page 37, to read as follows:

1) Pulse response (after 1 s warm-up) for IPU A or B engines:

a. Maximum chamber pressure rise time:

Signal to 10 percent of peak pulse thrust - 30 ms for REA inlet pressures greater than 2.413×10^6 N/m^2 (350 psia).

Signal to 10 percent of peak pulse thrust - 35 ms for REA inlet pressures less than 2.413×10^6 N/m^2 (350 psia).

Signal to 90 percent of peak pulse thrust - 50 ms for REA inlet pressures greater than 2.413×10^6 N/m^2 (350 psia).

Signal to 90 percent of peak pulse thrust - 55 ms for REA inlet pressures less than 2.413×10^6 N/m^2 (350 psia).

b. Maximum chamber pressure decay time:

Signal to 15 percent of peak pulse thrust - 55 ms for REA inlet pressures greater than 2.413×10^6 N/m^2 (350 psia).

Signal to 15 percent of peak pulse thrust - 90 ms for REA inlet pressures less than 2.413×10^6 N/m^2 (350 psia).

7. (contd)

2) Pulse response (after 1 s warm-up) for Roll engines:

a. Maximum chamber pressure rise time:
Signal to 10 percent of peak pulse thrust - 25 ms for REA inlet pressures greater than 1.724×10^6 N/m^2 (250 psia).

Signal to 90 percent of peak pulse thrust - 35 ms for REA inlet pressures greater than 2.413×10^6 N/m^2 (350 psia).

Signal to 90 percent of peak pulse thrust - 40 ms for REA inlet pressures less than 2.413×10^6 N/m^2 (350 psia).

b. Maximum chamber pressure decay time:
Signal to 15 percent of peak pulse thrust - 40 ms for REA inlet pressures greater than 2.413×10^6 N/m^2 (350 psia).

Signal to 15 percent of peak pulse thrust - 55 ms for REA inlet pressures less than 2.413×10^6 N/m^2 (350 psia).

8. Change paragraph 4.12.3, b), page 39, to read as follows:
The magnetometer boom deployment rate shall be within the range 0.13 m/s to 0.037 m/s.

FUNCTIONAL REQUIREMENT AMENDMENT

(Insert in 618-205, MJS77 Functional Requirements Book)

TITLE:

Function Requirement
Mariner Jupiter/Saturn 1977
Spacecraft Requirements and Constraints

FR No. MJS77-3-100

AMENDMENT No. 8

PAGE 1 OF 1

DATE: 24 June 1977

PER ECR No. See Remarks

DESCRIPTION OF CHANGE:

1. In paragraph 4.2.3 change "TWTA" to "transmitter" in four places.

2. In paragraph 4.2.3 c) add the following after the first sentence: "(The alternate X-band transmitter does not have a low power mode.)"

3. Add to item h) to paragraph 4.1.3 as follows:

   "Areas of the MM that may be viewed by the IRIS 2.5° straylight FOV during the performance of blocks SS2 (Science Target Calibration) and SS3 (Brewster Plate Calibration) are to be made non-reflective in such a way that there will not be, effectively, more than 0.4 cm^2 of totally reflective surface in the FOV at any time. The areas are shown in Figure 28 of MJS77-3-180B."

4. In paragraph 4.19.2d) change "0.349" to read "0.263."

5. In paragraph 4.1.3a) 1) change "0.5 ft-lb" to "0.75 ft-lb."

6. Add new paragraph 4.1.3j as follows: "j) The structure shall provide for installation of the Voyager Record."

DISTRIBUTION:

List #197

REMARKS: 36574A, 36603, 36725, 36774, 36802, 36852

APPROVED:

M. Landano

SYSTEM

JPL 3930 (11-69)

jpl # FUNCTIONAL REQUIREMENT AMENDMENT

(Insert in 618-205, MJS77 Functional Requirements Book)

TITLE:	
FUNCTIONAL REQUIREMENT MARINER JUPITER/SATURN 1977 SPACECRAFT REQUIREMENTS AND CONSTRAINTS	**FR No.** MJS77-3-100 **AMENDMENT No.** 9 **PAGE** 1 **OF** 1 **DATE:** 14 February 1979 **PER ECR No.** N/A

DESCRIPTION OF CHANGE:

A. This document has been removed from control and placed in a non-maintenance category.

B. Changes authorized by the following ECRs will not be incorporated into this document:

36949

37069

DISTRIBUTION:	**REMARKS:**
Distribution list attached	**APPROVED:** [signature] SYSTEM

(Insert in 618-205, MJS77 Functional Requirements Book)

Custodian: L. L. Holmes

APPROVED:

System: G. E. Cunningham

M. R. Landano

L. L. Holmes

JET PROPULSION LABORATORY

No. MJS77-3-110C
29 July 1977
Supersedes
MJS77-3-110B
17 June 1976

FUNCTIONAL REQUIREMENT
MARINER JUPITER/SATURN 1977 FLIGHT EQUIPMENT
FUNCTIONAL BLOCK DIAGRAM AND INTERFACE LISTINGS

* Denote changes from previous issue.

1.0 SCOPE

This document establishes the system level electrical interface circuits between:

a) Two different spacecraft subsystems.

b) Two electronic packages of the same spacecraft subsystem which are not contained within the same bay.

c) A spacecraft subsystem and the Centaur.

d) A spacecraft subsystem and the launch complex equipment, through the umbilical connectors.

Direct access circuits and non-flight circuits are not contained in this document. These circuits are defined or referenced in MJS77-3-1110, Support Equipment Functional Block Diagram.

2.0 APPLICABLE DOCUMENTS

The following documents form a part of this Functional Requirement:

NOTE

MJS77-3-100, Spacecraft Requirements and Constraints, applies to this document. Requirements of other MJS77 level 3 documents may also be applicable. It is the responsibility of the user to adequately acquaint himself with the organization and pertinent content of the level 3 documents, as well as with the material contained herein.

REQUIREMENTS

Jet Propulsion Laboratory

MJS77-1-100	Introduction
MJS77-2-100	Spacecraft Design Criteria
MJS77-3-100	Functional Requirement, Mariner Jupiter/Saturn 1977 Spacecraft Requirements and Constraints
MJS77-3-260	Functional Requirement, Mariner Jupiter/Saturn 1977 Electrical Grounding and Interfacing
MJS77-3-290	Functional Requirement, Mariner Jupiter/Saturn 1977 Command Structure and Assignments
MJS77-3-1110	Functional Requirement, Mariner Jupiter/Saturn 1977 Support Equipment Functional Block Diagrams and Interface Listings

OTHER DOCUMENTS

Jet Propulsion Laboratory

618-217	Spacecraft to Launch Vehicle System, Interface Control Document
618-232	Mariner Jupiter/Saturn 1977 Spacecraft System Configuration Management Plan

DRAWING

Jet Propulsion Laboratory

10063288	Circuit Data Sheet Index and Guide

3.0 FUNCTIONAL DESCRIPTION

3.1 General

This functional requirement is the defining document for all system level interface circuits. Only those system level interface circuits identified in this document shall be mechanized in the system cabling.

The circuit name used in this document is the approved circuit identifier and is the only name by which the circuit is to be referenced on schematics, circuit data sheets and all other MJS77 Project documentation.

The basic interfaces are as indicated in Figure 1. This diagram does not identify the specific circuits in all of the interfaces. For the complete definition, the interface listing presented in Table 1 should be consulted.

3.2 Nomenclature

3.2.1 Circuit Name

Each circuit is assigned a name descriptive of the circuit function within the spacecraft. The length shall not exceed 32 characters and spaces. Spacecraft command circuits are identified by their command name as defined in MJS77-3-290, Command Structure and Assignments. No two circuits shall have the same name unless they are the same function.

3.2.2 Circuit Number

Each circuit is uniquely numbered with a circuit number. The circuit number is created by attaching to the interface number an alphanumeric suffix, as follows:

002-003-B 02

Interface Number (002-003)

Alpha character, having the following significance: (B)

a) If not present, denotes that the circuit is to be described in a regular circuit data sheet.

b) If a letter other than X, indicates circuit is described in a multi-circuit data sheet.

c) If the letter is X, indicates that the circuit will NOT be described in circuit data sheets.

Circuit number in the interface. (02)

In this case, the second circuit in the 002-003 interface.

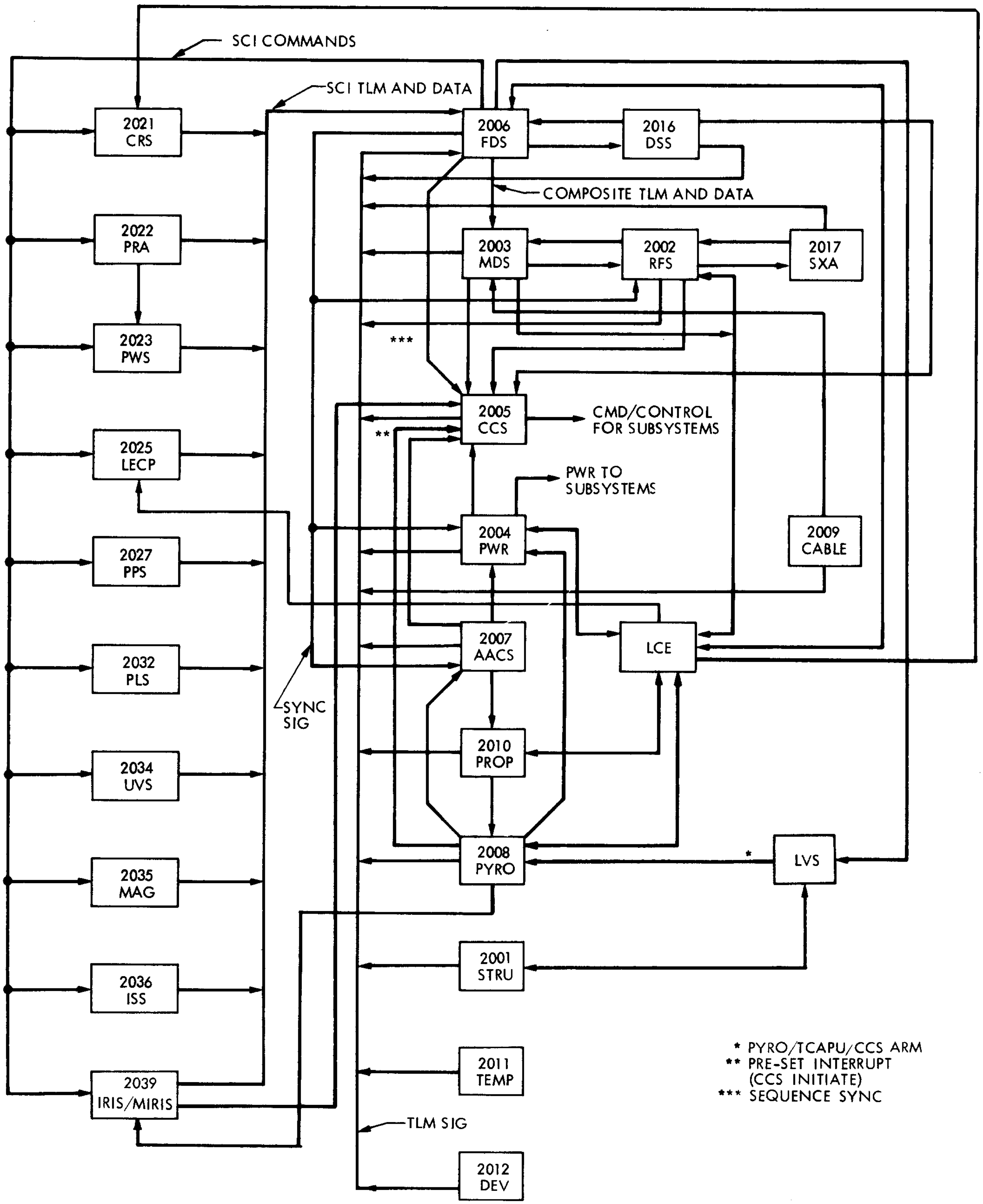

Figure 1. MJS77 Intersubsystem Functional Block Diagram

3.2.2.1 Interface Number. The interfaces are numbered in ascending numerical order, in accordance with the following code:

Example 002 - 003

Subsystem number of one of the interconnected subsystems, in this case, the radio frequency subsystem (Number is shortened from 2002) → 002

Number of the other subsystem. (Number is shortened from 2003) → 003

The subsystem number of lower numerical rank is always placed first. Thus, the numbering is 002 - 003, not 003 - 002. The end equipment determines the addressing, not in-line equipment such as junction boxes which merely feed through the signal.

3.2.2.1.1 Subsystem Number. Subsystem numbers are defined in MJS77-1-100, Introduction, and are partially reproduced below:

Number	Subsystem	Abbreviation
2001	Structure	STRU
2002	Radio frequency	RFS
2003	Modulation demodulation	MDS
2004	Power	PWR
2005	Computer command	CCS
2006	Flight data	FDS
2007	Attitude and articulation control	AACS
2008	Pyrotechnic	PYRO
2009	Cabling	CABL
2010	Propulsion	PROP
2011	Temperature control	TEMP
2012	Mechanical devices	DEV
2016	Data storage	DSS
2017	S/X band antenna	SXA
2021	Cosmic ray	CRS
2022	Planetary radio astronomy	PRA
2023	Plasma wave	PWS
2025	Low energy charged particle	LECP
2027	Photopolarimeter	PPS
2032	Plasma	PLS
2034	Ultraviolet spectrometer	UVS
2035	Magnetometer	MAG
2036	Imaging science	ISS
2039	Infrared Interferometer Spectrometer and Radiometer	IRIS
	Modified Infrared Interferometer and Radiometer	MIRIS
22XX*	(Applicable subsystem LCE)	XXX LCE

*"2" in the second position (e.g., 2207) denotes launch complex equipment (LCE). In the example shown, 2207 denotes AACS-LCE.

3.3 Interface Listing

All circuits are specified in Table 1. Each interface is identified with a heading, e.g., PWR - PYRO, followed by a listing of all circuits making up the interface.

a) The circuits identified herein support the requirements of MJS77-2-100, Spacecraft Design Criteria, and MJS77-3-100, Spacecraft Requirements and Constraints.

b) Basic requirements for electrical interface circuits are contained ln MJS77-3-260, Electrical Grounding and Interfacing.

c) Specific system level requirements for MJS77 system electrical interface circuits are contained in the applicable circuit data sheets. See JPL Drawing 10063288, Circuit Data Sheet Index and Guide.

d) Specific system level requirements for inter-system electrical interface circuits are contained in 618-217, Mariner Jupiter/Saturn 1977 Spacecraft to Launch Vehicle System, lnterface Control Document.

e) System circuit redundancy is specified at the end of the circuit name in Table 1 with the characters; XR. This shall be included in the 32 character limit for each circuit name.

3.3.1 Item

All entries are numbered sequentially for quick reference. Note that additions or deletions to the list result in item number changes for all subsequent listings.

3.3.2 Flow

> Signal Flow is to the right, relative to the Interface Number (Sub - Sub).

< Signal Flow is to the left.

- Signal Flow may be in either direction

Example:

004-005 < From 005 to 004
004-005 > From 004 to 005

3.3.3 Using the Interface Listing

The method of using the table is illustrated by an example: To locate the listing of circuits between the radio frequency subsystem and the power subsystem:

a) Determine from the list in paragraph 3.2.2.1.1 that the reference number of the radio subsystem is 002 and that the reference number of the power subsystem is 004.

b) Recalling that the organization is numerical, find the 002-004 interface (RFS-PWR) wherein all circuits forming this interface are listed.

TABLE 1. ELECTRICAL INTERFACE CIRCUITS MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	STRU - STRU		
	ITEM NUMBERS 1 THRU 6 LISTED BELOW ARE CIRCUITS CONNECTING ACCEL IN ADAPTER (LEFT COLUMN) TO ACCEL AMP IN ADAPTER (RIGHT COLUMN)		
1.	001-001-W01	>	ACCEL 1 OUTPUT
2.	001-001-W02	>	ACCEL 2 OUTPUT
3.	001-001-W03	>	ACCEL 3 OUTPUT
4.	001-001-W04	>	ACCEL 4 OUTPUT
5.	001-001-W05	>	ACCEL 5 OUTPUT
6.	001-001-W06	>	ACCEL 6 OUTPUT
	ITEM NUMBER 7 LISTED BELOW IS A CIRCUIT CONNECTIMG ACCEL IN MM (LEFT COLUMN) AND ACCEL AMP IN ADAPTER (RIGHT COLUMN).		
7.	001-001-W07	>	ACCEL 7 OUTPUT
	STRU - PWR		
8.	001-004-U03	<	30VDC SCAN PLATFORM SUPP HTR
9.	001-004-U31	<	2.4KHZ PWR TO BAY 1 HTR
10.	001-004-U32	<	2.4KHZ PWR TO BAY 2 HTR
11.	001-004-U33	<	2.4KHZ PWR TO BAY 6 A HTR
12.	001-004-U34	<	2.4KHZ PWR TO BAY 6 B HTR
13.	001-004-Q22	<	30VDC PWR TO MAG CAL COIL

*Revised in its entirety.

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	STRU -		FDS
14.	001-006- 01	>	TLM BAY 1 TEMP
15.	001-006- 02	>	TLM BAY 3 TEMP
16.	001-006- 03	>	TLM BAY 5 TEMP
17.	001-006- 04	>	TLM BAY 7 TEMP
18.	001-006- 05	>	TLM BAY 9 TEMP
19.	001-006- 06	>	TLM BAY 2 TEMP
20.	001-006- 07	>	TLM BAY 4 TEMP
21.	001-006- 08	>	TLM BAY 6 TEMP
22.	001-006- 09	>	TLM BAY 8 TEMP
23.	001-006- 10	>	TLM BAY 10 TEMP
	STRU -		LVS
24.	001-LVS-W01	>	ACCEL AMP 1 OUTPUT
25.	001-LVS-W02	>	ACCEL AMP 2 OUTPUT
26.	001-LVS-W03	>	ACCEL AMP 3 OUTPUT
27.	001-LVS-W04	>	ACCEL AMP 4 OUTPUT
28.	001-LVS-W05	>	ACCEL AMP 5 OUTPUT
29.	001-LVS-W06	>	ACCEL AMP 6 OUTPUT
30.	001-LVS-W07	>	ACCEL AMP 7 OUTPUT
31.	001-LVS-W11	<	ACCEL AMP 1 PWR
32.	001-LVS-W12	<	ACCEL AMP 2 PWR

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	STRU - LVS		
33.	001-LVS-W13	<	ACCEL AMP 3 PWR
34.	001-LVS-W14	<	ACCEL AMP 4 PWR
35.	001-LVS-W15	<	ACCEL AMP 5 PWR
36.	001-LVS-W16	<	ACCEL AMP 6 PWR
37.	001-LVS-W17	<	ACCEL AMP 7 PWR
	RFS - RFS		
	ITEM NUMBERS 38 THRU 75 LISTED BELOW ARE CIRCUITS CONNECTING XPONDER BAY 9(LEFT COLUMN) AND TWTA BAY 1 (RIGHT COLUMN) WITH THE RFS UNITS DENOTED IN THE CIRCUIT NAME.		
38.	002-002- 01	>	RCVR CS3 CW, CS4 CCW DR;XR
39.	002-002- 02	>	RCVR CS3 CCW, CS4 CW DR;XR
40.	002-002- 03	>	CS5 CW DR;XR
41.	002-002- 04	>	XMTR SW CS1 CW, CS2 CCW DR;XR
42.	002-002- 05	>	XMTR SW CS1 CCW, CS2 CW DR;XR
43.	002-002- 06	<	S-TWTA 1 XMTR SW DR
44.	002-002- 07	<	S-BAND SSA 2 XMTR SW DR
45.	002-002- 08	<	S-TWTA 1 ON STAT
46.	002-002- 09	<	S-BAND SSA 2 ON STAT
47.	002-002- 10	<	X-TWTA 1 ON STAT
48.	002-002- 11	<	X-TWTA 2 ON STAT

TABLE 1. ELECTRICAL INTERFACE CIRCUITS MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	RFS	-	RFS
49.	002-002- 12	<	S-TWTA/SSA HI/LO PWR STAT
50.	002-002- 14	<	X-TWTA HI/LO PWR STAT
51.	002-002- 16	<	S-TWTA 1 BASE TEMP
52.	002-002- 17	<	S-BAND SSA 2 BASE TEMP
53.	002-002- 18	<	X-TWTA 1 BASE TEMP
54.	002-002- 19	<	X-TWTA 2 BASE TEMP
55.	002-002- 20	<	X-TWTA 1 RF MONITOR TEMP
56.	002-002- 21	<	X-TWTA 2 RF MONITOR TEMP
57.	002-002- 22	<	S-TWTA 1 TEMP SW DR
58.	002-002- 23	<	S-BAND SSA TEMP SW DR
59.	002-002- 24	<	X-TWTA 1 TEMP SW DR
60.	002-002- 25	<	X-TWTA 2 TEMP SW DR
61.	002-002- 26	<	S-TWTA 1 INTERRUPT PWR ENABLE 1
62.	002-002- 27	<	S-BAND SSA INTERRUPT PWR ENABLE 1
63.	002-002- 28	<	S-TWTA 1 RF LEVEL
64.	002-002- 29	<	S-TWTA 2 RF LEVEL
65.	002-002- 30	<	S-EX RF LEVEL
66.	002-002- 31	<	S-TWTA RF DR MONITOR
67.	002-002- 32	<	S-LGA RF DR MONITOR
68.	002-002- 33	<	S-HGA RF DR MONITOR
69.	002-002-X35	>	S-EX 1 RF TO FILTER HYBRID

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	RFS - RFS		
70.	002-002-X36	>	S-EX 2 RF TO FILTER HYBRID
71.	002-002-X37	>	X-HYBRID TO X-BAND TWTA 1
72.	002-002-X38	>	X-HYBRID TO X-BAND TWTA 2
73.	002-002-X39	<	RF SW TO RCVR 1, UPLINK SIG
74.	002-002-X40	<	RF SW TO RCVR 2, UPLINK SIG
	RFS - MDS		
75.	002-003- 01	>	CMPST CMD, RCVR1 TO CDU-A
76.	002-003- 02	>	CMPST CMD, RCVR1 TO CDU-B
77.	002-003- 03	>	CMPST CMD, RCVR2 TO CDU-A
78.	002-003- 04	>	CMPST CMD, RCVR2 TO CDU-B
79.	002-003- 05	<	CMPST TLM, TMU-A TO S-BAND EX 1
80.	002-003- 06	<	CMPST TLM, TMU-B TO S-BAND EX 1
81.	002-003- 07	<	CMPST TLM, TMU-A TO S-BAND EX 2
82.	002-003- 08	<	CMPST TLM, TMU-B TO S-BAND EX 2
83.	002-003- 09	<	CMPST TLM, TMU-A TO X-BAND EX1
84.	002-003- 10	<	CMPST TLM, TMU-B TO X-BAND EX1
85.	002-003- 11	<	CMPST TLM, TMU-A TO X-BAND EX2
86.	002-003- 12	<	CMPST TLM, TMU-B TO X-BAND EX2
	RFS - PWR		
87.	002-004-001	<	30VDC UNSWITCHED PWR TO ACIS

TABLE 1. ELECTRICAL INTERFACE CIRCUITS MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	RFS	-	PWR
88.	002-004-002	<	30VDC PWR TO RCVR 1
89.	002-004-003	<	30VDC PWR TO RCVR 2
90.	002-004-004	<	30VDC PWR TO S-BAND EX 1
91.	002-004-005	<	30VDC PWR TO S-BAND EX 2
92.	002-004-006	<	30VDC PWR TO X-BAND EX 1
93.	002-004-007	<	30VDC PWR TO X-BAND EX 2
94.	002-004-008	<	30VDC PWR TO X-BAND TWTA 1
95.	002-004-009	<	30VDC PWR TO X-BAND TWTA 2
96.	002-004-010	<	30VDC PWR TO S-BAND TWTA 1
97.	002-004-011	<	30VDC PWR TO S-BAND SSA 2
	RFS	-	CCS
98.	002-005- 01	<	S-BAND TWT/SSA HI PWR,OU1;XR
99.	002-005- 02	<	S-BAND TWT/SSA HI PWR,OU2;XR
100.	002-005- 03	<	S-BAND TWT/SSA LO PWR,OU1;XR
101.	002-005- 04	<	S-BAND TWT/SSA LO PWR,OU2;XR
102.	002-005- 05	<	X-BAND TWT HI PWR,OU1;XR
103.	002-005- 06	<	X-BAND TWT HI PWR,OU2;XR
104.	002-005- 07	<	X-BAND TWT LO PWR,OU1;XR
105.	002-005- 08	<	X-BAND TWT LO PWR,OU2;XR
106.	002-005- 09	>	S-EX PWR OUTPUT INTERRUPT,XR

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	RFS -	CCS	
107.	002-005- 10	>	X-EX PWR OUTPUT INTERRUPT,XR
108.	002-005- 11	>	S-TWTA PWR OUTPUT INTERRUPT,XR
109.	002-005- 12	>	X-TWTA PWR OUTPUT INTERRUPT,XR
110.	002-005- 13	<	HGA SELECT,OU1;XR
111.	002-005- 14	<	HGA SELECT,OU2;XR
112.	002-005- 15	<	LGA SELECT,OU1;XR
113.	002-005- 16	<	LGA SELECT,OU2;XR
114.	002-005- 17	<	USO ON,OU1;XR
115.	002-005- 18	<	USO ON,OU2;XR
116.	002-005- 19	<	USO OFF,OU1;XR
117.	002-005- 20	<	USO OFF,OU2;XR
118.	002-005- 21	<	TWO-WAY NON-COHERENT ON,OU1;XR
119.	002-005- 22	<	TWO-WAY NON-COHERENT ON,OU2;XR
120.	002-005- 23	<	TWO-WAY NON-COHERENT OFF,OU1;XR
121.	002-005- 24	<	TWO-WAY NON-COHERENT OFF,OU2;XR
122.	002-005- 25	<	S-BAND RANGING ON,OU1;XR
123.	002-005- 26	<	S-BAND RANGING ON,OU2;XR
124.	002-005- 27	<	S-BAND RANGING OFF,OU1;XR
125.	002-005- 28	<	S-BAND RANGING OFF,OU2;XR
126.	002-005- 29	<	X-BAND RANGING ON,OU1;XR
127.	002-005- 30	<	X-BAND RANGING ON,OU2;XR

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	RFS -		CCS
128.	002-005- 31	<	X-BAND RANGING OFF,OU1;XR
129.	002-005- 32	<	X-BAND RANGING OFF,OU2;XR
	RFS -		FDS
130.	002-006- 01	<	14.4KHZ, S&X BAND TWTA/SSA
131.	002-006- 02	>	TLM X-BAND TWT CATHODE CUR
132.	002-006- 03	>	TLM X-BAND TWT REG V
133.	002-006- 04	>	TLM X-BAND HGA DR
134.	002-006- 05	>	TLM X-BAND TWT HELIX CUR
135.	002-006- 06	>	TLM S-TWT CATHODE/SSA INPUT CUR
136.	002-006- 07	>	TLM S-BAND TWT/SSA REG V
137.	002-006- 08	>	TLM S-BAND TWT HELIX CUR
138.	002-006- 09	<	50.4KHZ, SEX-1, XEX-1, & RCVR 1
139.	002-006- 10	<	50.4KHZ, SEX-2, XEX-2, & RCVR 2
140.	002-006- 11	>	14.4KHZ STATUS SHIFT CLOCK
141.	002-006- 12	<	RFS STATUS 1 WORD GATE
142.	002-006- 13	<	RFS STATUS 2 WORD GATE
143.	002-006- 14	>	TLM RFS STATUS 1 OUTPUT
144.	002-006- 15	>	TLM RFS STATUS 2 OUTPUT
145.	002-006- 16	>	TLM X-BAND HYBRID TEMP
146.	002-006- 17	>	TLM RCVR VCO TEMP

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	RFS -		FDS
147.	002-006- 18	>	TLM AUX OSC TEMP
148.	002-006- 19	>	TLM X-BAND EX TEMP
149.	002-006- 20	>	TLM S-BAND TWT/SSA BASE TEMP
150.	002-006- 21	>	TLM X-BAND TWT BASE TEMP
151.	002-006- 22	>	TLM X-BAND RF MONITOR TEMP
152.	002-006- 23	>	TLM X-BAND EX CUR
153.	002-006- 24	>	TLM RCVR LO DR
154.	002-006- 25	>	TLM RCVR 1 AGC;XR
155.	002-006- 26	>	TLM RCVR 1 OR 2 VCO V COARSE
156.	002-006- 27	>	TLM S-BAND EX CUR
157.	002-006- 28	>	TLM RCVR 2 AGC;XR
158.	002-006- 29	>	TLM RCVR RANGING AGC V
159.	002-006- 30	>	TLM RCVR 1 OR 2 VCO V FINE
160.	002-006- 31	>	TLM RCVR CUR
161.	002-006- 32	>	TLM S-BAND HGA DRIVE
162.	002-006- 33	>	TLM X-BAND TWT DRIVE
163.	002-006- 34	>	TLM S-BAND TWT DR
164.	002-006- 35	>	TLM LGA DR
165.	002-006- 36	>	TLM USO INNER OVEN CUR
166.	002-006- 37	>	TLM S-BAND HYBRID TEMP
167.	002-006- 38	>	TLM XMTR RF SW TEMP

TABLE 1. ELECTRICAL INTERFACE CIRCUITS MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	RFS	-	SXA
168.	002-017-X01	-	LGA S-BAND SIGNAL
169.	002-017-X02	-	HGA S-BAND SIGNAL
170.	002-017-X03	>	HGA X-BAND TWTA 1
171.	002-017-X04	>	HGA X-BAND TWTA 2
	RFS	-	RFS LCE
172.	002-202-X01	-	LGA PREC COUPLER S-BAND
173.	002-202-X02	-	HGA PREC COUPLER S-BAND
	MDS	-	PWR
174.	003-004-D01	<	2.4KHZ PWR TO TMU-A
175.	003-004-D02	<	2.4KHZ PWR TO TMU-B
176.	003-004-D03	<	2.4KHZ PWR TO CDU-A
177.	003-004-D04	<	2.4KHZ PWR TO CDU-B
	MDS	-	CCS
178.	003-005- 01	>	CDU-A COMMAND DATA,XR
179.	003-005- 02	>	CDU-A BIT TIMING,XR
180.	003-005- 03	>	CDU-A LOCK INDICATION,XR
181.	003-005- 04	>	CDU-B COMMAND DATA,XR
182.	003-005- 05	>	CDU-B BIT TIMING,XR
183.	003-005- 06	>	CDU-B LOCK INDICATION,XR

TABLE 1. ELECTRICAL INTERFACE CIRCUITS MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	MDS -		CCS
184.	003-005- 07	<	CC ENABLE TO TMU:XR
185.	003-005- 08	<	CC STROBE TO TMU:XR
186.	003-005- 09	<	CC DATA TO TMU;XR
	MDS -		FDS
187.	003-006- 01	<	TMU-A SYMBOL SYNC
188.	003-006- 02	<	HIGH RATE CHANNEL DATA TO TMU-A
189.	003-006- 03	<	LOW RATE CHANNEL DATA TO TMU-A
190.	003-006- 04	<	TMU-A 14.4KHZ SHIFT CLOCK
191.	003-006- 05	<	TMU-A STATUS WORD GATE 1
192.	003-006- 06	<	TMU-A STATUS WORD GATE 2
193.	003-006- 07	>	TMU-A STATUS DATA
194.	003-006- 08	<	TMU-B SYMBOL SYNC
195.	003-006- 09	<	HIGH RATE CHANNEL DATA TO TMU-B
196.	003-006- 10	<	LOW RATE CHANNEL DATA TO TMU-B
197.	003-006- 11	<	TMU-B 14.4KHZ SHIFT CLOCK
198.	003-006- 12	<	TMU-B STATUS WORD GATE 1
199.	003-006- 13	<	TMU-B STATUS WORD GATE 2
200.	003-006- 14	>	TMU-B STATUS DATA
201.	003-006- 15	>	TMU-B ACTIVE UNIT IND
202.	003-006- 16	>	CDU-A SUBCARRIER LOCK

TABLE 1. ELECTRICAL INTERFACE CIRCUITS MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	MDS -		FDS
203.	003-006- 17	>	CDU-A BIT SYNC LOCK
204.	003-006- 18	>	CDU-A OSC MONITOR
205.	003-006- 19	>	CDU-A SNR DATA
206.	003-006- 20	>	CDU-A SNR ALERT PULSE
207.	003-006- 21	>	CDU-A SNR CLOCK
208.	003-006- 22	>	CDU-B SUBCARRIER LOCK
209.	003-006- 23	>	CDU-B BIT SYNC LOCK
210.	003-006- 24	>	CDU-B OSC MONITOR
211.	003-006- 25	>	CDU-B SNR DATA
212.	003-006- 26	>	CDU-B SNR CLOCK
213.	003-006- 27	>	CDU-B SNR ALERT PULSE
214.	003-006- 28	>	CDU-B ACTIVE UNIT IND
	MDS -		CABL
215.	003-009- 01	<	TMU-A X-BAND UMB AMP CONTROL
216.	003-009- 02	<	TMU-B X-BAND UMB AMP CONTROL
	MDS -		MDS LCE
217.	003-203-C01	>	COMPOSITE TLM SIGNAL

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	PWR	-	PWR

ITEM NUMBERS 218 THRU 230 LISTED BELOW ARE CIRCUITS CONNECTING THE SHUNT RADIATOR (LEFT) TO THE SHUNT REGULATOR SUBASSEMBLY IN THE POWER BAY

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
218.	004-004- 01	>	SHUNT REG SEQ A COLLECTOR
219.	004-004- 02	>	SHUNT REG SEQ A EMITTER
220.	004-004- 03	>	SHUNT REG SEQ B COLLECTOR
221.	004-004- 04	>	SHUNT REG SEQ B EMITTER
222.	004-004- 05	>	SHUNT REG SEQ C COLLECTOR
223.	004-004- 06	>	SHUNT REG SEQ C EMITTER
224.	004-004- 07	>	SHUNT REG SEQ D COLLECTOR
225.	004-004- 08	>	SHUNT REG SEQ D EMITTER
226.	004-004- 09	<	SHUNT REG SEQ A EMITTER SENSE
227.	004-004- 10	<	SHUNT REG SEQ B EMITTER SENSE
228.	004-004- 11	<	SHUNT REG SEQ C EMITTER SENSE
229.	004-004- 12	<	SHUNT REG SEQ D EMITTER SENSE
230.	004-004- 13	>	SHUNT RADIATOR INTERLOCK

ITEM NUMBERS 231 THRU 233 LISTED BELOW ARE CIRCUITS CONNECTING THE RTG'S (LEFT) TO THE POWER CONTROL SUBASSEMBLY IN THE POWER BAY

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
231.	004-004- 14	>	RTG 1 PWR
232.	004-004- 15	>	RTG 2 PWR

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	PWR - PWR		
233.	004-004- 16	>	RTG 3 PWR
	PWR - CCS		
234.	004-005-D05	>	2.4KHZ PWR TO CCS A
235.	004-005-D06	>	2.4KHZ PWR TO CCS B
236.	004-005- 01	>	UNDERVOLTAGE TRIP INDICATION,XR
237.	004-005- 02	<	CC ENABLE TO PWR DIST;XR
238.	004-005- 03	<	CC STROBE TO PWR DIST;XR
239.	004-005- 04	<	CC DATA TO PWR DIST;XR
240.	004-005- 05	>	INV SWITCH (MAIN-TO-STANDBY)
	PWR - FDS		
241.	004-006-D07	>	2.4KHZ PWR TO CONV A
242.	004-006-D08	>	2.4KHZ PWR TO CONV B
243.	004-006-D12	>	30VDC FDS MEMORY PWR
244.	004-006- 01	<	4.8KHZ REFERENCE FREQ
245.	004-006- 02	>	TLM RTG 1 CASE TEMP 2
246.	004-006- 03	>	TLM RTG 1 CASE TEMP 3
247.	004-006- 04	>	TLM RTG 2 CASE TEMP 1
248.	004-006- 05	>	TLM RTG 2 CASE TEMP 3
249.	004-006- 06	>	TLM RTG 3 CASE TEMP 1
250.	004-006- 07	>	TLM RTG 3 CASE TEMP 2

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	PWR	-	FDS
251.	004-006- 08	>	TLM SHUNT RADIATOR TEMP 1
252.	004-006- 09	>	TLM SHUNT RADIATOR TEMP 2
253.	004-006- 10	>	TLM BATTERY TEMP
254.	004-006- 11	>	TLM SHUNT REG TEMP
255.	004-006- 12	>	TLM RTG 1 OUTPUT V
256.	004-006- 13	>	TLM RTG 2 OUTPUT V
257.	004-006- 14	>	TLM RTG 3 OUTPUT V
258.	004-006- 15	>	TLM RTG 1 OUTPUT I
259.	004-006- 16	>	TLM RTG 2 OUTPUT I
260.	004-006- 17	>	TLM RTG 3 OUTPUT I
261.	004-006- 18	>	TLM DC BUS VOLTAGE
262.	004-006- 19	>	TLM RDM VOLTAGE
263.	004-006- 20	>	TLM SHUNT REGULATOR INPUT I
264.	004-006- 21	>	TLM 2.4KHZ INV. INPUT I
265.	004-006- 22	>	TLM 2.4KHZ INV. OUTPUT I
266.	004-006- 23	>	TLM 2.4KHZ INV. OUTPUT V
267.	004-006- 24	>	TLM DC BUS I
268.	004-006- 25	>	TLM 2.4KHZ INV STATUS
	PWR	-	AACS
269.	004-007- 01	>	BAT A UNREG PWR TO RDM

TABLE 1. ELECTRICAL INTERFACE CIRCUITS MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	PWR - AACS		
270.	004-007- 02	>	BAT B UNREG PWR TO PDM
271.	004-007- 03	<	RDM VOLTAGE MONITOR
272.	004-007- 04	>	SOURCE 00 TO MAM RELAY 1 SET
273.	004-007- 05	>	SOURCE 01 TO MAM RELAY 1 RESET
274.	004-007- 06	>	SOURCE 02 TO MAM RELAY 2 SET
275.	004-007- 07	>	SOURCE 03 TO MAM RELAY 2 RESET
276.	004-007- 08	>	SINK 00 TO MAM RELAYS 1, 2
277.	004-007-D11	>	2.4KHZ PWR TO HYP 1 P
278.	004-007-D12	>	2.4KHZ PWR TO HYP 2 P
279.	004-007-D13	>	2.4KHZ PWR TO HYP 1 J
280.	004-007-D14	>	2.4KHZ PWR TO HYP 2 J
281.	004-007-D15	>	2.4KHZ PWR TO CST 1
282.	004-007-D16	>	2.4KHZ PWR TO CST 2
283.	004-007-D17	>	2.4KHZ PWR TO SUN SHUTTERS
284.	004-007-Q13	>	30VDC ISO VALVE 1 PWR
285.	004-007-Q14	>	30VDC ISO VALVE 2 PWR
286.	004-007-Q15	>	30VDC PWR TO A GYRO
287.	004-007-Q16	>	30VDC PWR TO B GYRO
288.	004-007-Q17	>	30VDC PWR TO C GYRO
289.	004-007-U02	>	30VDC PWR TO SCAN AZ HTR
290.	004-007-U23	>	30VDC PWR TO SUN SENSOR HTR A

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	PWR -		AACS
291.	004-007-U24	>	30VDC PWR TO SUN SENSOR HTR B
292.	004-007-P36	>	2.4KHZ H1P PWR TO MAM SWITCH
293.	004-007-P37	>	2.4KHZ H2P PWR TO MAM SWITCH
294.	004-007-P38	>	2.4KHZ PWR TO MAM
	PWR -		PYRO
295.	004-008- 01	<	ACTIVATE BATT A AND B:XR
296.	004-008- 02	<	ACTIVATE BATT A AND B:XR
297.	004-008-P18	>	2.4KHZ PWR TO PSU A
298.	004-008-P19	>	2.4KHZ PWR TO PSU B
299.	004-008-P20	>	2.4KHZ PWR TO PSU INSTM
	PWR -		PROP
300.	004-010-U25	>	30VDC PWR AP BR1 HTRS
301.	004-010-U26	>	30VDC PWR AP BR2 HTRS
302.	004-010-U27	>	30VDC PWR TO TCM HTRS
303.	004-010-U28	>	30VDC PWR TO IPU VALVE HTRS
304.	004-010-U29	>	30VDC PWR TO RED IPU VALVE HTRS
305.	004-010-U30	>	30VDC PWR TO IPU THRUSTER HTRS
306.	004-010-U35	>	2.4KHZ PWR TO TCM LINE+BKT HTRS

TABLE 1. ELECTRICAL INTERFACE CIRCUITS MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	PWR	-	DSS
307.	004-016-U01	>	2.4KHZ PWR TO DSS REPL HTR
308.	004-016-D21	>	2.4KHZ PWR TO DSS
	PWR	-	CRS
309.	004-021-Q18	>	30VDC PWR TO CRS
310.	004-021-U04	>	30VDC PWR TO CRS REPL HTR
311.	004-021-U05	>	30VDC PWR TO CRS SUPPL HTR
	PWR	-	PRA
312.	004-022-D22	>	2.4KHZ PWR TO PRA
313.	004-022-Q19	>	30VDC PWR FOR PRA ANT DEPLOY
	PWR	-	PWS
314.	004-023-D23	>	2.4KHZ PWR TO PWS
	PWR	-	LECP
315.	004-025-D24	>	2.4KHZ PWR TO LECP
316.	004-025-Q20	>	30VDC PWR TO LECP STEPPER MOTOR
317.	004-025-U06	>	30VDC PWR TO LECP REPL HTR
318.	004-025-U07	>	30VDC PWR TO LECP MAIN SUPP HTR
319.	004-025-U08	>	30VDC PWR TO LECP LEPT SUPP HTR

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	PWR	-	PPS
320.	004-027-D21	>	30VDC PWR TO PPS
321.	004-027-U09	>	30VDC PWR TO PPS SUPPL HTR
	PWR	-	PLS
322.	004-032-D25	>	2.4KHZ PWR TO PLS
323.	004-032-U10	>	30VDC PWR TO PLS SUPPL HTR
324.	004-032-U11	>	30VDC PWR TO PLS REPL HTR
	PWR	-	UVS
325.	004-034-D26	>	2.4KHZ PWR TO UVS
326.	004-034-U12	>	30VDC PWR TO UVS REPL HTR
	PWR	-	MAG
327.	004-035-D27	>	2.4KHZ PWR TO MAG
328.	004-035-D28	>	2.4KHZ STANBY PWR TO MAG
329.	004-035-D29	>	2.4KHZ IBLFM FWD FLIPPER PWR
330.	004-035-D30	>	2.4KHZ IBLFM REV FLIPPER PWR
331.	004-035-D31	>	2.4KHZ OBLFM FWD FLIPPER PWR
332.	004-035-D32	>	2.4KHZ OBLFM REV FLIPPER PWR
333.	004-035-U13	>	2.4KHZ MAG SENSOR HTRS
	PWR	-	ISS
334.	004-036-D09	>	ISS-NA 2.4KHZ PWR

TABLE 1. ELECTRICAL INTERFACE CIRCUITS MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	PWR - ISS		
335.	004-036-D10	>	ISS-WA 2.4KHZ PWR
336.	004-036-U15	>	ISS-NA 30VDC OPTICS HTR PWR
337.	004-036-U16	>	ISS-NA 30VDC VID REPL HTR PWR
338.	004-036-U17	>	ISS-WA 30VDC VID REPL HTR PWR
339.	004-036-U18	>	ISS-WA 30VDC ELEC REPL HTR PWR
340.	004-036-U19	>	ISS-NA 30VDC ELEC REPL HTR PWR

PWR - MIRIS

ITEM NUMBERS 341 THRU 345 LISTED BELOW ARE CIRCUITS BETWEEN THE POWER SUBSYSTEM AND THE IRIS OR MIRIS SUBSYSTEM. IRIS AND MIRIS HAVE THE SAME INTERFACE LISTING AND HAVE THE SAME SUBSYSTEM NUMBER.

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
341.	004-039-D33	>	2.4KHZ PRIMARY PWR TO MIRIS
342.	004-039-D34	>	2.4KHZ STBY PWR TO MIRIS SUPPLY A
343.	004-039-D35	>	2.4KHZ STBY PWR TO MIRIS SUPPLY B
344.	004-039-U20	>	30VDC PWR TO MIRIS FLASHOFF HTR
345.	004-039-U21	>	30VDC PWR TO MIRIS REPL HTRS
	PWR - PWR LCE		
346.	004-204-D01	<	RTG SHORT COMMAND
347.	004-204-D02	<	RTG UNSHORT COMMAND
348.	004-204-D03	<	RTG BYPASS RELAY RESET

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	PWR -		PWR LCE
349.	004-204-004	<	MAIN INVERTER SELECT
350.	004-204-006	<	SHUNT RADIATOR INTERLOCK
351.	004-204-007	<	EXT PWR
352.	004-204-008	>	INVERTER SELECT STATUS
353.	004-204-009	>	DC BUS VOLTAGE MONITOR
354.	004-204-010	>	RTG 1 SHORT CKT CUR
355.	004-204-011	>	RTG 2 SHORT CKT CUR
356.	004-204-012	>	RTG 3 SHORT CKT CUR
357.	004-204-013	>	RTG 1 CASE TEMP 1
358.	004-204-014	>	RTG 2 CASE TEMP 2
359.	004-204-015	>	RTG 3 CASE TEMP 3
360.	004-204-016	>	BATT ACTIVATE IND
361.	004-204-017	<	BATTERY HTR 1 PWR
362.	004-204-018	<	BATTERY HTR 2 PWR
363.	004-204-019	>	BATTERY TEMP
	CCS -		FDS
364.	005-006- 01	>	CC STROBE,XR
365.	005-006- 02	>	CC DATA,XR
366.	005-006- 03	>	CC ENABLE,XR
367.	005-006- 04	>	TLM CCS OUT 1

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	CCS -		FDS
368.	005-006- 05	>	TLM CCS OUT 2
369.	005-006- 06	<	CCS BIT SYNC 1
370.	005-006- 07	<	CCS BIT SYNC 2
371.	005-006- 08	<	CCS ALERT 1
372.	005-006- 09	<	CCS ALERT 2
373.	005-006- 10	<	FDS SEQUENCE SYNC 1;XR
374.	005-006- 11	<	FDS SEQUENCE SYNC 2;XR
375.	005-006- 12	<	FDS LO RATE DATA;XR
376.	005-006- 13	<	FDS LO RATE BIT SYNC;XR
	CCS -		AACS
377.	005-007- 01	>	CC DATA TO AACS,XR
378.	005-007- 02	>	CC STROBE TO AACS,XR
379.	005-007- 03	>	CC ENABLE TO AACS,XR
380.	005-007- 04	<	POWER CODE A,XR
381.	005-007- 05	<	POWER CODE B,XR
382.	005-007- 06	<	POWER CODE C,XR
383.	005-007- 07	<	POWER CODE D,XR
384.	005-007- 08	<	POWER CODE E,XR
385.	005-007- 09	<	POWER CODE F,XR
386.	005-007- 10	>	AACS SELF-TEST CMD;XR

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	CCS -		AACS
387.	005-007- 11	>	CC DATA TO MAM;XR
388.	005-007- 12	>	CC ENABLE TO MAM;XR
389.	005-007- 13	>	MAM SHORTING SWITCH ON CMD;XR
390.	005-007- 14	>	MAM SHORTING SWITCH OFF CMD;XR
	CCS -		PYRO
391.	005-008- 01	>	S/C-LV SEPARATION A;XR
392.	005-008- 02	>	S/C-LV SEPARATION B;XR
393.	005-008- 03	>	ACTIVATE BATT A AND B TO PSU A
394.	005-008- 04	>	ACTIVATE BATT A AND B TO PSU B
395.	005-008- 05	>	START SOLID MOTOR TO PSU A
396.	005-008- 06	>	START SOLID MOTOR TO PSU B
397.	005-008- 07	>	RELEASE MAG BOOM TO PSU A
398.	005-008- 08	>	RELEASE MAG BOOM TO PSU B
399.	005-008- 09	>	RELEASE RTG BOOM,SET 1 TO PSU A
400.	005-008- 10	>	RELEASE RTG BOOM,SET 1 TO PSU B
401.	005-008- 11	>	RELEASE RTG BOOM,SET 2 TO PSU A
402.	005-008- 12	>	RELEASE RTG BOOM,SET 2 TO PSU B
403.	005-008- 13	>	CLOSE IPU-REA ISO VALVE TO PSU A
404.	005-008- 14	>	CLOSE IPU-REA ISO VALVE TO PSU B
405.	005-008- 15	>	JETTISION PROPULSION MODULE;XR

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	CCS -		PYRO
406.	005-008- 16	>	RELEASE SCI BOOM TO PSU A
407.	005-008- 17	>	RELEASE SCI BOOM TO PSU B
408.	005-008- 18	<	PRE-SEPARATION INTERRUPT!XR
409.	005-008- 19	>	RELEASE MIRIS DUST COVER TO PSU A
410.	005-008- 20	>	RELEASE MIRIS DUST COVER TO PSU B
411.	005-008- 21	>	PYRO SPARE 1 TO PSU A
412.	005-008- 22	>	PYRO SPARE 1 TO PSU B
	CCS -		DSS
413.	005-016- 01	<	BOT/EOT•XR
414.	005-016- 02	<	TAPE INDEX INCREMENT•XR
415.	005-016- 03	<	TAPE INDEX DECREMENT•XR
416.	005-016- 04	>	CC DATA•XR
417.	005-016- 05	>	CC STROBE•XR
418.	005-016- 06	>	CC ENABLE•XR
	CCS -		MIRIS

ITEM NUMBER 419 LISTED BELOW IS A CIRCUIT BETWEEN THE CCS SUBSYSTEM AND THE IRIS OR MIRIS SUBSYSTEM. IRIS AND MIRIS HAVE THE SAME INTERFACE LISTING AND HAVE THE SAME SUBSYSTEM NUMBER.

419.	005-039- 01	<	MIRIS STBY SUPP VOLT INTERRUPT!XR

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	FDS -		AACS
420.	006-007- 01	>	AACS ADDRESS DATA A;XR
421.	006-007- 02	>	AACS ADDRESS WORD GATE A;XR
422.	006-007- 03	>	AACS 14.4KHZ SHIFT CLOCK A;XR
423.	006-007- 04	>	AACS DATA WORD GATE A;XR
424.	006-007- 05	<	AACS DATA 1;XR
425.	006-007- 06	>	AACS ADDRESS DATA B;XR
426.	006-007- 07	>	AACS ADDRESS WORD GATE B;XR
427.	006-007- 08	>	AACS 14.4KHZ SHIFT CLOCK B;XR
428.	006-007- 09	>	AACS DATA WORD GATE B;XR
429.	006-007- 10	<	AACS DATA 2;XR
430.	006-007- 11	<	TLM CST 1 TEMP
431.	006-007- 12	<	TLM CST 2 TEMP
432.	006-007- 13	<	TLM SUN SENSOR TEMP
433.	006-007- 14	<	TLM SCAN AZ TEMP
434.	006-007- 15	<	TLM A GYRO TEMP
435.	006-007- 16	<	TLM B GYRO TEMP
436.	006-007- 17	<	TLM C GYRO TEMP
437.	006-007- 18	>	MAM 14.4KHZ SHIFT CLOCK A
438.	006-007- 19	>	MAM DATA WORD GATE A
439.	006-007- 20	<	MAM DATA A

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	FDS -		PYRO
440.	006-008- 01	<	+P THRUST 1/+A ENG 1 CHAMBER PRES
441.	006-008- 02	<	-P THRUST 1/-A ENG 1 CHAMBER PRES
442.	006-008- 03	<	+Y THRUST 1/+B ENG 2 CHAMBER PRES
443.	006-008- 04	<	+R THRUST 1/-B ENG 2 CHAMBER PRES
444.	006-008- 05	<	TLM CAP BANK A VOLTS
445.	006-008- 06	<	TLM CAP BANK B VOLTS
446.	006-008- 07	<	TLM PYRO AMP IND A
447.	006-008- 08	<	TLM PYRO AMP IND B
448.	006-008- 09	<	TLM ISO VALVE POSITION BR1
449.	006-008- 10	<	TLM ISO VALVE POSITION BR2
	FDS -		CABL
450.	006-009- 01	<	S/C-LV SEPARATION INDICATION
451.	006-009- 02	<	PM-MM SEPARATION INDICATION
	FDS -		PROP
452.	006-010- 01	<	TLM IPU SOLID MOTOR TEMP 1
453.	006-010- 02	<	TLM IPU SOLID MOTOR TEMP 2
454.	006-010- 05	<	TLM IPU LINE TEMP 1
455.	006-010- 06	<	TLM IPU LINE TEMP 2
456.	006-010- 07	<	TLM IPU +ROLL ENGINE 1 TEMP
457.	006-010- 08	<	TLM IPU +ROLL ENGINE 2 TEMP

TABLE 1. ELECTRICAL INTERFACE CIRCUITS MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	FDS	-	PROP
458.	006-010- 09	<	TLM IPU -ROLL ENGINE 1 TEMP
459.	006-010- 10	<	TLM IPU -ROLL ENGINE 2 TEMP
460.	006-010- 11	<	TLM TCAPU TANK TEMP 1
461.	006-010- 12	<	TLM TCAPU TANK TEMP 2
462.	006-010- 13	<	TLM TCAPU FEED SYSTEM TEMP 1
463.	006-010- 14	<	TLM TCAPU FEED SYSTEM TEMP 2
464.	006-010- 15	<	TLM TCAPU SURFACE TEMP 1
465.	006-010- 16	<	TLM TCAPU SURFACE TEMP 2
466.	006-010- 17	<	TLM TCAPU +PITCH THR 2 TEMP
467.	006-010- 18	<	TLM TCAPU -PITCH THR 2 TEMP
468.	006-010- 19	<	TLM TCAPU +YAW THR 2 TEMP
469.	006-010- 20	<	TLM TCAPU -YAW THR 1 TEMP
470.	006-010- 21	<	TLM TCAPU -YAW THR 2 TEMP
471.	006-010- 22	<	TLM TCAPU -ROLL THR 1 TEMP
472.	006-010- 23	<	TLM TCAPU +ROLL THR 2 TEMP
473.	006-010- 24	<	TLM TCAPU -ROLL THR 2 TEMP
474.	006-010- 25	<	TLM IPU SOLID MOTOR CHMBR PRESIXR
475.	006-010- 26	<	TLM TCAPU N2H4 PRESSURE 1
476.	006-010- 27	<	TLM TCAPU HE PRESSURE
477.	006-010- 28	<	TLM TCAPU +PITCH TCM THR CH PRES
478.	006-010- 29	<	TLM TCAPU -PITCH TCM THR CH PRES

TABLE 1. ELECTRICAL INTERFACE CIRCUITS MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	FDS	-	PROP
479.	006-010- 30	<	TLM TCAPU +YAW TCM THR CH PRES
480.	006-010- 31	<	TLM TCAPU -YAW TCM THR CH PRES
	FDS	-	TEMP
481.	006-011- 01	<	TLM SCI PLUME SHIELD TEMP 1
482.	006-011- 02	<	TLM SCI PLUME SHIELD TEMP 2
	FDS	-	DEV
483.	006-012- 02	<	TLM RTG BOOM DEPLOY STATUS
484.	006-012- 04	<	TLM SCI BOOM DEPLOY STATUS
485.	006-012- 05	<	TLM MAG BOOM DEPLOY STATUS
486.	006-012- 06	<	TLM MAG BOOM RELEASE STATUS
487.	006-012- 07	<	TLM SCIENCE LATCH PRESSURE
	FDS	-	DSS
488.	006-016- 01	>	CC DATA 2
489.	006-016- 02	>	CC STROBE 2
490.	006-016- 03	>	RECORD DATA
491.	006-016- 04	>	DSS STATUS BIT SYNC
492.	006-016- 05	>	DSS MODE STATUS ALERT
493.	006-016- 06	>	DSS PLAYBACK STATUS ALERT
494.	006-016- 07	>	RECORD BIT SYNC

TABLE 1. ELECTRICAL INTERFACE CIRCUITS MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	FDS -		DSS
495.	006-016- 08	>	PLAYBACK BIT SYNC
496.	006-016- 09	>	CC ENABLE 2
497.	006-016- 10	>	2.4192 MHZ REFERENCE
498.	006-016- 11	<	PLAYBACK DATA
499.	006-016- 12	<	TLM DSS STATUS
500.	006-016- 13	<	TLM DSS MOTOR V
501.	006-016- 14	<	TLM DSS TRANSPORT PRESSURE
	FDS -		SXA
502.	006-017- 01	<	TLM HGA MAIN REFLECTOR TEMP
503.	006-017- 02	<	TLM HGA S-BAND FEED TEMP
504.	006-017- 03	<	TLM X-BAND FEED HORN TEMP
505.	006-017- 04	<	TLM LGA BODY TEMP
	FDS -		CRS
506.	006-021- 01	>	CRS 14.4KHZ SHIFT CLOCK A
507.	006-021- 02	>	CRS 14.4KHZ SHIFT CLOCK B
508.	006-021- 03	>	CRS CMD WG
509.	006-021- 04	>	CRS CMD WORD
510.	006-021- 05	>	CRS HV ON
511.	006-021- 06	>	CRS PHA DATA WG A
512.	006-021- 07	>	CRS PHA DATA WG B

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	FDS -		CRS
513.	006-021- 08	>	CRS RATE DATA WG A
514.	006-021- 09	>	CRS RATE DATA WG B
515.	006-021- 10	>	CRS DIG STATUS WG
516.	006-021- 11	>	CRS SYNC
517.	006-021- 12	>	CRS ANALOG MUX RESET
518.	006-021- 13	>	CRS ANALOG MUX STEP
519.	006-021- 14	>	CRS CALIB START
520.	006-021- 15	>	CRS REDUNDANCY SELECT
521.	006-021- 16	<	CRS DIG DATA A
522.	006-021- 17	<	CRS DIG DATA B
523.	006-021- 18	<	CRS ANALOG DATA
524.	006-021- 19	<	CRS TELESCOPE TEMP
525.	006-021- 20	<	CRS ELECTRONICS TEMP
	FDS -		PRA
526.	006-022- 01	>	PRA ADC BIT SYNC
527.	006-022- 02	>	PRA ADC START
528.	006-022- 03	>	PRA STATUS WG
529.	006-022- 04	>	PRA 76.8KHZ CLOCK
530.	006-022- 05	>	PRA MUX STEP
531.	006-022- 06	>	PRA MUX RESET

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	FDS - PRA		
532.	006-022- 07	>	PRA CMD WG
533.	006-022- 08	>	PRA CMD WORD
534.	006-022- 09	>	PRA 14.4KHZ SHIFT CLOCK
535.	006-022- 10	<	PRA ADC DATA
536.	006-022- 11	<	PRA DIG STATUS DATA
537.	006-022- 12	<	PRA ANALOG MUX DATA
538.	006-022- 13	<	PRA ELECTRONIC TEMP
539.	006-022- 14	<	PRA B ANT DEPLOY
540.	006-022- 15	<	PRA A ANT DEPLOY
	FDS - PWS		
541.	006-023- 01	>	PWS FREQ STEP
542.	006-023- 02	>	PWS CLOCK RESET
543.	006-023- 04	>	PWS INPUT RANGE CONTROL
544.	006-023- 05	<	PWS INPUT RANGE STATE
545.	006-023- 07	<	PWS TEMP
546.	006-023- 08	<	PWS ANALOG OUTPUT A
547.	006-023- 09	<	PWS ANALOG OUTPUT B
548.	006-023- 10	<	PWS PWR SUPPLY VOLTAGE
549.	006-023- 11	<	PWS WAVEFORM DATA
550.	006-023- 12	>	PWS ADC BIT SYNC

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	FDS	-	PWS
551.	006-023- 13	>	PWS ADC START
552.	006-023- 14	>	PWS WAVEFORM PWR
	FDS	-	LECP
553.	006-025- 01	>	LECP 14.4KHZ SHIFT CLOCK A
554.	006-025- 02	>	LECP 14.4KHZ SHIFT CLOCK B
555.	006-025- 03	>	LECP CMD WORD A
556.	006-025- 04	>	LECP CMD WORD B
557.	006-025- 05	>	LECP CMD WG A
558.	006-025- 06	>	LECP CMD WG B
559.	006-025- 07	>	LECP PHA WG A
560.	006-025- 08	>	LECP PHA WG B
561.	006-025- 09	>	LECP REDUNDANCY SELECT
562.	006-025- 10	>	LECP RATE CMD WG
563.	006-025- 11	>	LECP RATE/STATUS WG A
564.	006-025- 12	>	LECP RATE/STATUS WG B
565.	006-025- 13	>	LECP MOTOR STEP
566.	006-025- 14	>	LECP MUX STEP
567.	006-025- 15	>	LECP MUX RESET
568.	006-025- 16	>	LECP ADC CLOCK
569.	006-025- 17	<	LECP DATA A

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	FDS	-	LECP
570.	006-025- 18	<	LECP DATA B
571.	006-025- 19	<	LECP ANALOG ENGR DATA
572.	006-025- 20	<	LECP LEMPA TEL TEMP
573.	006-025- 21	<	LECP LEPT TEL TEMP
574.	006-025- 22	<	LECP ANALOG CAL DATA
	FDS	-	PPS
575.	006-027- 01	>	PPS 14.4 KHZ SHIFT CLOCK
576.	006-027- 02	>	PPS COMMAND WORD GATE
577.	006-027- 03	>	PPS COMMAND WORD
578.	006-027- 04	>	PPS DATA/COUNT CONTROL
579.	006-027- 06	<	PPS DIGITAL SCIENCE DATA
580.	006-027- 07	<	PPS LVPS MON
581.	006-027- 08	<	PPS HVPS MON
582.	006-027- 09	<	PPS SOLAR SENSOR
583.	006-027- 10	<	PPS FILTER POSITION
584.	006-027- 11	<	PPS ANALYZER POSITION
585.	006-027- 12	<	PPS APERTURE POSITION
586.	006-027- 13	<	PPS OPTICS TEMP
587.	006-027- 14	<	PPS ELECTRONICS TEMP XDUCER

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	FDS - PLS		
588.	006-032- 01	>	PLS 14.4KHZ SHIFT CLOCK
589.	006-032- 02	>	PLS MUX RESET
590.	006-032- 03	>	PLS SAMPLE CLOCK
591.	006-032- 04	>	PLS DATA WG
592.	006-032- 05	>	PLS CMD WG
593.	006-032- 06	>	PLS CMD WORD
594.	006-032- 07	>	PLS MUX STEP
595.	006-032- 08	>	PLS ADC CLOCK
596.	006-032- 09	<	PLS DIG DATA
597.	006-032- 10	<	PLS ANALOG MUX OUT
598.	006-032- 11	<	PLS SENSOR TEMP
599.	006-032- 12	<	PLS ELECTRONICS TEMP
600.	006-032- 13	<	PLS MODULATOR TEMP
	FDS - UVS		
601.	006-034- 01	>	UVS 14.4KHZ SHIFT CLOCK
602.	006-034- 02	>	UVS REGISTER LOAD GATE
603.	006-034- 03	>	UVS WORD ADDRESS RESET
604.	006-034- 04	>	UVS MODE CONTROL
605.	006-034- 05	>	UVS HV CONTROL 1
606.	006-034- 06	>	UVS HV CONTROL 2

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	FDS -		UVS
607.	006-034- 07	>	UVS HV CONTROL 3
608.	006-034- 08	<	UVS HV MONITOR
609.	006-034- 09	<	UVS SCIENCE DATA 1
610.	006-034- 10	<	UVS SCIENCE DATA 2
611.	006-034- 11	<	UVS TEMP
	FDS -		MAG
612.	006-035- 01	>	MAG 14.4KHZ SHIFT CLOCK A
613.	006-035- 02	>	MAG 14.4KHZ SHIFT CLOCK B
614.	006-035- 03	>	MAG CMD WG A
615.	006-035- 04	>	MAG CMD WG B
616.	006-035- 05	>	MAG CMD WORD A
617.	006-035- 06	>	MAG CMD WORD B
618.	006-035- 07	>	MAG SAMPLE A
619.	006-035- 08	>	MAG SAMPLE B
620.	006-035- 09	>	MAG RESET A
621.	006-035- 10	>	MAG RESET B
622.	006-035- 11	>	MAG STATUS WG A
623.	006-035- 12	>	MAG STATUS WG B
624.	006-035- 13	>	MAG SCI DATA WG A
625.	006-035- 14	>	MAG SCI DATA WG B

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	FDS -		MAG
626.	006-035- 15	>	MAG IBHFM CLOCK(50.400KHZ)
627.	006-035- 16	>	MAG OBHFM CLOCK(53.760KHZ)
628.	006-035- 17	>	MAG IBLFM CLOCK A(60.480KHZ)
629.	006-035- 18	>	MAG IBLFM CLOCK B(60.480KHZ)
630.	006-035- 19	>	MAG OBLFM CLOCK A(64.512KHZ)
631.	006-035- 20	>	MAG OBLFM CLOCK B(64.512KHZ)
632.	006-035- 22	>	MAG MUX STEP
633.	006-035- 23	>	MAG MUX RESET
634.	006-035- 24	<	MAG DIG DATA A
635.	006-035- 25	<	MAG DIG DATA B
636.	006-035- 26	<	MAG ANALOG MUX OUT
637.	006-035- 27	<	MAG IBHFM SENSOR TEMP
638.	006-035- 28	<	MAG OBHFM SENSOR TEMP
639.	006-035- 29	<	MAG IBLFM SENSOR TEMP
640.	006-035- 30	<	MAG OBLFM SENSOR TEMP
	FDS -		ISS
641.	006-036- 01	>	ISS-NA FRAME GATE
642.	006-036- 02	>	ISS-NA LIGHT FLOOD CONTROL
643.	006-036- 03	>	ISS-NA FRAME ERASE GATE
644.	006-036- 04	>	ISS-NA LINE CONTROL GATE

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	FDS -		ISS
645.	006-036- 05	>	ISS-NA G1 V/GAIN CMD WORD
646.	006-036- 06	>	ISS-NA G1 V/GAIN CMD WORD GATE
647.	006-036- 07	>	ISS-NA SHUTTER RESET
648.	006-036- 08	>	ISS-NA SHUTTER CLOSE
649.	006-036- 09	>	ISS-NA SHUTTER OPEN
650.	006-036- 10	>	ISS-NA FILTER STEP
651.	006-036- 11	>	ISS-NA FILTER READ/MUX RESET
652.	006-036- 12	>	ISS-NA 14.4KHZ SHIFT CLOCK
653.	006-036- 13	>	ISS-NA MUX STEP
654.	006-036- 14	>	ISS-NA BEAM ON
655.	006-036- 15	>	ISS-NA ELECTRONICS CALIBRATE
656.	006-036- 16	>	ISS-NA OPTICS CALIBRATE
657.	006-036- 17	>	ISS-WA BEAM ON
658.	006-036- 18	>	ISS-WA ELECTRONICS CALIBRATE
659.	006-036- 19	>	ISS-WA FRAME GATE
660.	006-036- 20	>	ISS-WA LIGHT FLOOD CONTROL
661.	006-036- 21	>	ISS-WA FRAME ERASE GATE
662.	006-036- 22	>	ISS-WA LINE CONTROL GATE
663.	006-036- 23	>	ISS-WA G1 V/GAIN CMD WORD
664.	006-036- 24	>	ISS-WA G1 V/GAIN CMD WORD GATE
665.	006-036- 25	>	ISS-WA SHUTTER RESET

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	FDS -		ISS
666.	006-036- 26	>	ISS-WA SHUTTER CLOSE
667.	006-036- 27	>	ISS-WA SHUTTER OPEN
668.	006-036- 28	>	ISS-WA FILTER STEP
669.	006-036- 29	>	ISS-WA FILTER READ/MUX RESET
670.	006-036- 30	>	ISS-WA 14.4KHZ SHIFT CLOCK
671.	006-036- 31	>	ISS-WA MUX STEP
672.	006-036- 32	>	ISS-NA ADC BIT SYNC
673.	006-036- 33	>	ISS-WA ADC BIT SYNC
674.	006-036- 34	>	ISS-NA ADC START
675.	006-036- 35	>	ISS-WA ADC START
676.	006-036- 36	<	ISS-NA ADC VIDEO DATA
677.	006-036- 37	<	ISS-WA ADC VIDEO DATA
678.	006-036- 38	<	ISS-NA FILTER POSITION
679.	006-036- 39	<	ISS-WA FILTER POSITION
680.	006-036- 40	<	ISS-NA REAR OPTICS TEMP
681.	006-036- 41	<	ISS-WA OPTICS TEMP
682.	006-036- 42	<	ISS-NA FRONT OPTICS TEMP
683.	006-036- 43	<	ISS-NA VIDICON TEMP
684.	006-036- 44	<	ISS-WA VIDICON TEMP
685.	006-036- 45	<	ISS-NA POWER SUPPLY TEMP
686.	006-036- 46	<	ISS-WA POWER SUPPLY TEMP

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	FDS	-	ISS
687.	006-036- 47	<	ISS-NA ANALOG ENGR TLM
688.	006-036- 48	<	ISS-WA ANALOG ENGR TLM
	FDS	-	MIRIS

ITEM NUMBERS 689 THRU 706 LISTED BELOW ARE CIRCUITS BETWEEN THE FDS AND THE IRIS/MIRIS SUBSYSTEM. THE IRIS AND THE MIRIS HAVE THE SAME INTER- FACE LISTING. CIRCUITS 17 AND 18 WILL BE IN SYSTEM CABLING AT ALL TIMES BUT WILL BE USED ONLY FOR THE MIRIS SUBSYSTEM.

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
689.	006-039- 01	>	MIRIS 14.4KHZ SHIFT CLOCK
690.	006-039- 02	>	MIRIS FRAME START
691.	006-039- 03	>	FDS 480HZ NEON REF FREQ
692.	006-039- 04	<	MIRIS SCIENCE DATA
693.	006-039- 05	>	MIRIS PLL CARRIER
694.	006-039- 06	<	MIRIS RAD SURFACE TEMP
695.	006-039- 07	<	MIRIS PRI MIRROR TEMP
696.	006-039- 08	<	MIRIS SEC MIRROR TEMP
697.	006-039- 09	<	MIRIS ELECTRONICS TEMP
698.	006-039- 10	<	MIRIS RADIOMETER HIGH GAIN ANALOG
699.	006-039- 11	<	MIRIS RADIOMETER ANALOG
700.	006-039- 12	<	MIRIS NEON ANALOG
701.	006-039- 13	<	MIRIS RAD SURFACE HTR ANALOG

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	FDS - MIRIS		
702.	006-039- 14	<	MIRIS PRI MIRROR HTR ANALOG
703.	006-039- 15	<	MIRIS SEC MIRROR HTR ANALOG
704.	006-039- 16	<	MIRIS STANDBY SUPPLY STATUS
705.	006-039- 17	>	MIRIS CMD WORD GATE
706.	006-039- 18	>	MIRIS CMD WORD
	FDS - FDS LCE		
707.	006-206-F01	<	+10VDC PWR FROM LCE
708.	006-206-F02	<	+5VDC PWR FROM LCE
709.	006-206-F03	<	-5VDC PWR FROM LCE
710.	006-206-F04	<	CC DATA FROM LCE
711.	006-206-F05	<	CC ENABLE FROM LCE
712.	006-206-F06	<	CC STROBE FROM LCE
713.	006-206-F07	>	2.4KHZ CC SYNC SIGNAL
	FDS - LVS		
714.	006-LVS-	>	MJS ENGINEERING DATA
	AACS - AACS		
	ITEM NUMBERS 715 THRU 802 LISTED BELOW ARE CIRCUITS CONNECTING HYPACE (LEFT) WITH THE AACS UNITS DENOTED IN THE CIRCUIT NAME.		
715.	007-007-01	>	CST1 CONE ANGLE CMD A

TABLE 1. ELECTRICAL INTERFACE CIRCUITS MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	AACS	-	AACS
716.	007-007-02	>	CST1 CONE ANGLE CMD B
717.	007-007-03	>	CST1 CONE ANGLE CMD C
718.	007-007- 04	>	CST1 DEMOD INHIBIT
719.	007-007- 05	>	CST1 SEARCH BIAS INHIBIT
720.	007-007- 06	>	CST1 FLYBACK
721.	007-007- 07	>	CST1 ROLL OVERRIDE
722.	007-007- 08	<	CST1 STAR INTENSITY
723.	007-007- 09	<	CST1 ROLL POSN
724.	007-007- 10	<	CST1 CONE ANGLE POSN
725.	007-007- 11	<	DA CST 1 STAR INTENSITY
726.	007-007- 12	<	PITCH SS 1 POSN
727.	007-007- 13	>	PITCH SS 1 BIAS
728.	007-007- 14	<	YAW SS 1 POSN
729.	007-007- 15	>	YAW SS 1 BIAS
730.	007-007- 16	>	15V SS 1 PWR
731.	007-007- 17	<	SS 1 SUN INTENSITY
732.	007-007- 19	>	SS 1 SYNC
733.	007-007- 20	>	SCAN AZ DRIVE
734.	007-007- 21	<	SCAN AZ POSN 1, COARSE
735.	007-007- 22	<	SCAN AZ POSN 1, FINE A
736.	007-007- 23	<	SCAN AZ POSN 1, FINE B

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	AACS	-	AACS
737.	007-007- 24	<	SCAN EL POSN 1, COARSE
738.	007-007- 25	<	SCAN EL POSN 1, FINE A
739.	007-007- 26	<	SCAN EL POSN 1, FINE B
740.	007-007- 27	>	POS IPU ROLL VALVE 1,PREDRIVE
741.	007-007- 28	>	NEG IPU ROLL VALVE 1,PREDRIVE
742.	007-007- 29	>	POS IPU A VALVE 1 PREDRIVE
743.	007-007- 30	>	NEG IPU A VALVE 1 PREDRIVE
744.	007-007- 31	>	POS IPU ROLL VALVE 2,PREDRIVE
745.	007-007- 32	>	NEG IPU ROLL VALVE 2,PREDRIVE
746.	007-007- 33	>	POS IPU B VALVE 2 PREDRIVE
747.	007-007- 34	>	NEG IPU B VALVE 2 PREDRIVE
748.	007-007- 35	>	CST2 CONE ANGLE CMD A
749.	007-007- 36	>	CST2 CONE ANGLE CMD B
750.	007-007- 37	>	CST2 CONE ANGLE CMD C
751.	007-007- 38	>	CST2 DEMOD INHIBIT
752.	007-007- 39	>	CST2 SEARCH BIAS INHIBIT
753.	007-007- 40	>	CST2 FLYBACK
754.	007-007- 41	>	CST2 ROLL OVERRIDE
755.	007-007- 42	<	CST2 STAR INTENSITY
756.	007-007- 43	<	CST2 ROLL POSN
757.	007-007- 44	<	CST2 CONE ANGLE POSN

TABLE 1. ELECTRICAL INTERFACE CIRCUITS MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	AACS	-	AACS
758.	007-007- 45	<	DA CST 2 STAR INTENSITY
759.	007-007- 46	<	PITCH SS 2 POSN
760.	007-007- 47	>	PITCH SS 2 BIAS
761.	007-007- 48	<	YAW SS 2 POSN
762.	007-007- 49	>	YAW SS 2 BIAS
763.	007-007- 50	>	15V SS 2 PWR
764.	007-007- 51	<	SS 2 SUN INTENSITY
765.	007-007- 53	>	SS 2 SYNC
766.	007-007- 54	>	SCAN EL DRIVE
767.	007-007- 55	<	SCAN AZ POSN 2, COARSE
768.	007-007- 56	<	SCAN AZ POSN 2, FINE A
769.	007-007- 57	<	SCAN AZ POSN 2, FINE B
770.	007-007- 58	<	SCAN EL POSN 2, COARSE
771.	007-007- 59	<	SCAN EL POSN 2, FINE A
772.	007-007- 60	<	SCAN FL POSN 2, FINE B
773.	007-007- 61	>	GYRO RATE CMD 1;XR
774.	007-007- 62	>	GYRO RATE CMD 2;XR
775.	007-007- 63	>	GYRO STROBE 1
776.	007-007- 64	>	GYRO STROBE 2
777.	007-007- 65	<	A GYRO SHIFT CLOCK 1
778.	007-007- 66	<	B GYRO SHIFT CLOCK 1

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	AACS	-	AACS
779.	007-007- 67	<	C GYRO SHIFT CLOCK 1
780.	007-007- 68	<	A GYRO SHIFT CLOCK 2
781.	007-007- 69	<	B GYRO SHIFT CLOCK 2
782.	007-007- 70	<	C GYRO SHIFT CLOCK 2
783.	007-007- 71	<	A GYRO DATA 1
784.	007-007- 72	<	B GYRO DATA 1
785.	007-007- 73	<	C GYRO DATA 1
786.	007-007- 74	<	A GYRO DATA 2
787.	007-007- 75	<	B GYRO DATA 2
788.	007-007- 76	<	C GYRO DATA 2
789.	007-007- 77	<	PITCH BIAS 1
790.	007-007- 78	<	YAW BIAS 1
791.	007-007- 79	>	+5VDC N 1
792.	007-007- 80	>	+5VDC N 1 MON
793.	007-007- 81	<	+5VDC J 1
794.	007-007- 82	<	+30VDC J 1
795.	007-007- 83	<	+/-15VDC J 1
796.	007-007- 84	<	PITCH BIAS 2
797.	007-007- 85	<	YAW BIAS 2
798.	007-007- 86	>	+5VDC N 2
799.	007-007- 87	>	+5VDC N 2 MON

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	AACS - AACS		
800.	007-007- 88	<	+5VDC J 2
801.	007-007- 89	<	+30VDC J 2
802.	007-007- 90	<	+/-15VDC J 2
803.	007-007- 91	<	MAM CLAMP, PR1
804.	007-007- 92	<	OBIN A, PR1
805.	007-007- 93	<	MAM CONTROL 1, PR1
806.	007-007- 94	<	MAM CONTROL 2, PR1
807.	007-007- 95	<	MAM DATA TO PR1
808.	007-007- 96	<	MAM ADDRESS TO PR1
809.	007-007- 97	>	DATA TO MAM, PR1
810.	007-007- 98	>	-15VDC P1 TO MAM
811.	007-007- 99	<	-15VDC P1 TO HYBIC 2
812.	007-007-100	<	-15VDC P1 TO HYBIC 1
813.	007-007-101	<	MAM HYBIC 1 CLK INHIBIT, PR1
814.	007-007-102	<	MAM CLAMP, PR2
815.	007-007-103	<	OBIN B, PR2
816.	007-007-104	<	MAM CONTROL 1, PR2
817.	007-007-105	<	MAM CONTROL 2, PR2
818.	007-007-106	<	MAM DATA TO PR2
819.	007-007-107	<	MAM ADDRESS TO PR2
820.	007-007-108	>	DATA TO MAM, PR2

TABLE 1. ELECTRICAL INTERFACE CIRCUITS MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
AACS - AACS			
821.	007-007-109	>	-15VDC P2 TO MAM
822.	007-007-110	<	-15VDC P2 TO HYBIC 1
823.	007-007-111	<	-15VDC P2 TO HYBIC 2
824.	007-007-112	<	MAM HYBIC 2 CLK INHIBIT, PR2
AACS - PYRO			
825.	007-008- 01	<	TCAPU ARM ENABLE;XR
AACS - PROP			
826.	007-010- 01	>	POS IPU ROLL VALVE 1 DRIVE
827.	007-010- 02	>	NEG IPU ROLL VALVE 1 DRIVE
828.	007-010- 03	>	POS IPU A VALVE 1 DRIVE
829.	007-010- 04	>	NEG IPU A VALVE 1 DRIVE
830.	007-010- 05	>	POS IPU ROLL VALVE 2 DRIVE
831.	007-010- 06	>	NEG IPU ROLL VALVE 2 DRIVE
832.	007-010- 07	>	POS IPU B VALVE 2 DRIVE
833.	007-010- 08	>	NEG IPU B VALVE 2 DRIVE
834.	007-010- 09	>	POS AP PITCH VALVE 1 DRIVE
835.	007-010- 10	>	NEG AP PITCH VALVE 1 DRIVE
836.	007-010- 11	>	POS AP YAW VALVE 1 DRIVE
837.	007-010- 12	>	NEG AP YAW VALVE 1 DRIVE
838.	007-010- 13	>	POS AP ROLL VALVE 1 DRIVE

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	AACS	-	PROP
839.	007-010- 14	>	NEG AP ROLL VALVE 1 DRIVE
840.	007-010- 15	>	AP P/Y THRUSTER 1 HTR PWR
841.	007-010- 16	>	AP R THRUSTER 1 HTR PWR
842.	007-010- 17	>	POS TCM PITCH VALVE 1 DRIVE
843.	007-010- 18	>	NEG TCM PITCH VALVE 1 DRIVE
844.	007-010- 19	>	AP P/Y ISO VALVE 1 OPEN CMD
845.	007-010- 20	>	AP P/Y ISO VALVE 1 CLOSE CMD
846.	007-010- 21	>	AP R ISO VALVE 1 OPEN CMD
847.	007-010- 22	>	AP R ISO VALVE 1 CLOSE CMD
848.	007-010- 23	>	TCM P ISO VALVE 1 OPEN CMD
849.	007-010- 24	>	TCM P ISO VALVE 1 CLOSE CMD
850.	007-010- 25	>	POS AP PITCH VALVE 2 DRIVE
851.	007-010- 26	>	NEG AP PITCH VALVE 2 DRIVE
852.	007-010- 27	>	POS AP YAW VALVE 2 DRIVE
853.	007-010- 28	>	NEG AP YAW VALVE 2 DRIVE
854.	007-010- 29	>	POS AP ROLL VALVE 2 DRIVE
855.	007-010- 30	>	NEG AP ROLL VALVE 2 DRIVE
856.	007-010- 31	>	AP P/Y THRUSTER 2 HTR PWR
857.	007-010- 32	>	AP R THRUSTER 2 HTR PWR
858.	007-010- 33	>	POS TCM YAW VALVE 2 DRIVE
859.	007-010- 34	>	NEG TCM YAW VALVE 2 DRIVE

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	AACS -		PROP
860.	007-010- 35	>	AP P/Y ISO VALVE 2 OPEN CMD
861.	007-010- 36	>	AP P/Y ISO VALVE 2 CLOSE CMD
862.	007-010- 37	>	AP R ISO VALVE 2 OPEN CMD
863.	007-010- 38	>	AP R ISO VALVE 2 CLOSE CMD
864.	007-010- 39	>	TCM Y ISO VALVE 2 OPEN CMD
865.	007-010- 40	>	TCM Y ISO VALVE 2 CLOSE CMD
	PYRO -		PYRO
			ITEM NUMBERS 866 THRU 895 LISTED BELOW ARE CIRCUITS CONNECTING THE PSU (LEFT) TO SQUIBS DENOTED IN THE CIRCUIT NAME.
866.	008-008- 01	>	S/C SEP A, 8SB1, 8SQ1
867.	008-008- 02	>	S/C SEP A, 8SB1, 8SQ2
868.	008-008- 03	>	SOLID MOTOR SQUIB 8IG1
869.	008-008- 04	>	RTG BOOM SQUIB,12PP3,8SQ1
870.	008-008- 05	>	RTG BOOM SQUIB,12PP4,8SQ1
871.	008-008- 06	>	RTG BOOM SQUIB,12PP5,8SQ1
872.	008-008- 07	>	RTG BOOM SQUIB,12PP6,8SQ1
873.	008-008- 08	>	SCI BOOM SQUIB 8SSI-A
874.	008-008- 09	>	PYRO ISO VALVE 1, 8PSI1-A
875.	008-008- 10	>	PYRO ISO VALVE 2, 8PSI2-A
876.	008-008- 11	>	JETTISON PM,12RD1, 8SQ1

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
PYRO	-		PYRO
877.	008-008- 12	>	JETTISON PM,12RD2, 8SQ1
878.	008-008- 13	>	JETTISON PM,12RD3, 8SQ1
879.	008-008- 14	>	JETTISON PM,12RD4, 8SQ1
880.	008-008- 15	>	MAG BOOM, 12PP1, 8SQ1
881.	008-008- 17	>	S/C SEP B, 8SB1, 8SQ3
882.	008-008- 18	>	S/C SEP B, 8SB1, 8SQ4
883.	008-008- 19	>	SOLID MOTOR SQUIB 8IG2
884.	008-008- 20	>	RTG BOOM SQUIB,12PP3,8SQ2
885.	008-008- 21	>	RTG BOOM SQUIB,12PP4,8SQ2
886.	008-008- 22	>	RTG BOOM SQUIB,12PP5,8SQ2
887.	008-008- 23	>	RTG BOOM SQUIB,12PP6,8SQ2
888.	008-008- 24	>	SCI BOOM SQUIB 8SSI-C
889.	008-008- 25	>	PYRO ISO VALVE 1, 8PSI1-C
890.	008-008- 26	>	PYRO ISO VALVE 2, 8PSI2-C
891.	008-008- 27	>	JETTISON PM,12RD1, 8SQ2
892.	008-008- 28	>	JETTISON PM,12RD2, 8SQ2
893.	008-008- 29	>	JETTISON PM,12RD3, 8SQ2
894.	008-008- 30	>	JETTISON PM,12RD4, 8SQ2
895.	008-008- 31	>	MAG BOOM, 12PP1, 8SQ2

TABLE 1. ELECTRICAL INTERFACE CIRCUITS MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
PYRO	-	PROP	
896.	008-010- 01	<	+A ENGINE 1 CHAMBER PRES
897.	008-010- 02	<	-A ENGINE 1 CHAMBER PRES
898.	008-010- 03	<	+B ENGINE 2 CHAMBER PRES
899.	008-010- 04	<	-B ENGINE 2 CHAMBER PRES
900.	008-010- 05	<	+P THRUST 1 CHAMBER PRES
901.	008-010- 06	<	-P THRUST 1 CHAMBER PRES
902.	008-010- 07	<	+Y THRUST 1 CHAMBER PRES
903.	008-010- 08	<	+R THRUST 1 CHAMBER PRES
904.	008-010- 09	<	ISO VALVE POSITION BP1
905.	008-010- 10	<	ISO VALVE POSITION BP2
PYRO	-	MIRIS	
906.	008-039- 01	>	MIRIS DUST COVER SQUIB,A
907.	008-039- 02	>	MIRIS DUST COVER SQUIB,B
PYRO	-	PYRO LCE	
908.	008-208-H01	>	PYRO/TCAPU/CCS ARM STATUS
909.	008-208-H02	<	PYRO/TCAPU/CCS ARM OFF
PYRO	-	LVS	
910.	008-LVS-W01	<	PYRO/TCAPU/CCS ARM A
911.	008-LVS-W02	<	PYRO/TCAPU/CCS ARM B

TABLE 1. ELECTRICAL INTERFACE CIRCUITS MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	PROP - PROP LCE		
912.	010-210-J01	<	SOLID MOTOR SAFE CMD
913.	010-210-J02	<	SOLID MOTOR ARM CMD
914.	010-210-J03	>	SOLID MOTOR SAFE MONITOR
915.	010-210-J04	>	SOLID MOTOR ARM MONITOR
916.	010-210-J05	<	PROP TANK HTR 1 PWR
917.	010-210-J06	<	PROP TANK HTR 2 PWR
918.	010-210-J07	>	PROP TANK TEMP
919.	010-210-J08	>	IPU SOLID MOTOR TEMP 3
920.	010-210-J09	>	IPU SOLID MOTOR TEMP 4
	CRS - CRS LCE		
921.	021-221-U01	<	CRS DETECTOR BIAS POWER
	PRA - PWS		
922.	022-023- 01	>	PRA B ANT SIGNAL
923.	022-023- 02	>	PRA A ANT SIGNAL
	LECP - LECP LCE		
924.	025-225-U02	<	LECP DETECTOR BIAS

TABLE 1. ELECTRICAL INTERFACE CIRCUITS MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	MAG - MAG		
	ITEM NUMBERS 925 THRU 962 LISTED BELOW ARE CIRCUITS CONNECTING THE MAG BUS ELECTRONICS (LEFT) WITH THE MAG SENSORS DENOTED IN THE CIRCUIT NAME.		
925.	035-035- 01	>	OBLFM X DRIVE FREQ (16.128KHZ)
926.	035-035- 02	>	OBLFM Y DRIVE FREQ (16.128KHZ)
927.	035-035- 03	>	OBLFM Z DRIVE FREQ (16.128KHZ)
928.	035-035- 04	<	OBLFM Z OUT (COAX)
929.	035-035- 05	<	OBLFM Y OUT (COAX)
930.	035-035- 06	<	OBLFM X OUT (COAX)
931.	035-035- 07	<	OBLFM ZERO DEGREE POSITION
932.	035-035- 08	<	OBLFM ONE EIGHTY DEGREE POSITION
933.	035-035- 09	>	OBLFM 2.4KHZ FWD FLIPPER PWR
934.	035-035- 10	>	OBLFM 2.4KHZ REV FLIPPER PWR
935.	035-035- 11	>	OBLFM 2.4KHZ SENSOR HTR
936.	035-035- 12	<	OBLFM SENSOR TEMP
937.	035-035- 13	>	IBLFM X DRIVE FREQ (15.120KHZ)
938.	035-035- 14	>	IBLFM Y DRIVE FREQ (15.120KHZ)
939.	035-035- 15	>	IBLFM Z DRIVE FREQ (15.120KHZ)
940.	035-035- 16	<	IBLFM Z OUT (COAX)
941.	035-035- 17	<	IBLFM Y OUT (COAX)
942.	035-035- 18	<	IBLFM X OUT (COAX)

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	MAG - MAG		
943.	035-035- 19	<	IBLFM ZERO DEGREE POSITION
944.	035-035- 20	<	IBLFM ONE EIGHTY DEGREE POSITION
945.	035-035- 21	>	IBLFM 2.4KHZ FWD FLIPPER PWR
946.	035-035- 22	>	IBLFM 2.4KHZ REV FLIPPER PWR
947.	035-035- 23	>	IBLFM 2.4KHZ SENSOR HTR
948.	035-035- 24	<	IBLFM SENSOR TEMP
949.	035-035- 25	>	OBHFM X DRIVE FREQ (13.440KHZ)
950.	035-035- 26	>	OBHFM Y DRIVE FREQ (13.440KHZ)
951.	035-035- 27	>	OBHFM Z DRIVE FREQ (13.440KHZ)
952.	035-035- 28	<	OBHFM Z OUT (COAX)
953.	035-035- 29	<	OBHFM Y OUT (COAX)
954.	035-035- 30	<	OBHFM X OUT (COAX)
955.	035-035- 31	>	IBHFM X DRIVE FREQ (12.600KHZ)
956.	035-035- 32	>	IBHFM Y DRIVE FREQ (12.600KHZ)
957.	035-035- 33	>	IBHFM Z DRIVE FREQ (12.600KHZ)
958.	035-035- 34	<	IBHFM Z OUT (COAX)
959.	035-035- 35	<	IBHFM Y OUT (COAX)
960.	035-035- 36	<	IBHFM X OUT (COAX)
961.	035-035- 37	<	OBHFM SENSOR TEMP
962.	035-035- 38	<	IBHFM SENSOR TEMP

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	ISS	-	ISS
			ITEM NUMBERS 963 THRU 992 LISTED BELOW ARE CIRCUITS CONNECTING THE WA AND NA PWR SUPPLY SUBASSYS (LEFT COLUMN) WITH THE WA AND NA CAMERA HEAD SUBASSYS (RIGHT COLUMN)
963.	036-036- 01	>	NA G1 VOLTAGE
964.	036-036- 02	>	NA VIDICON FILAMENT SUPPLY
965.	036-036- 03	>	NA CAMERA HEAD REPL HTR
966.	036-036- 04	<	NA VIDICON TEMP
967.	036-036- 05	<	NA CATHODE 1 ETM
968.	036-036- 06	<	NA CATHODE 2 ETM
969.	036-036- 09	<	NA FOCUS CURRENT ETM
970.	036-036- 10	<	NA G2 ETM
971.	036-036- 11	>	NA ALIGNMENT CURRENT SUPPLY
972.	036-036- 12	>	NA FOCUS CURRENT SUPPLY
973.	036-036- 13	>	NA GAIN SWITCH
974.	036-036- 14	>	NA +15V SIGNAL CHAIN SUPPLY
975.	036-036- 15	>	NA -15V SIGNAL CHAIN SUPPLY
976.	036-036- 16	>	NA +50V SUPPLY
977.	036-036- 17	>	NA +50V HVM SUPPLY
978.	036-036- 43	>	WA G1 VOLTAGE
979.	036-036- 44	>	WA VIDICON FILAMENT SUPPLY
980.	036-036- 45	>	WA CAMERA HEAD REPL HTR

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	ISS - ISS		
981.	036-036- 46	<	WA VIDICON TEMP
982.	036-036- 47	<	WA CATHODE 1 ETM
983.	036-036- 48	<	WA CATHODE 2 ETM
984.	036-036- 51	<	WA FOCUS CURRENT ETM
985.	036-036- 52	<	WA G2 ETM
986.	036-036- 53	>	WA ALIGNMENT CURRENT SUPPLY
987.	036-036- 54	>	WA FOCUS CURRENT SUPPLY
988.	036-036- 55	>	WA GAIN SWITCH
989.	036-036- 56	>	WA +15V SIGNAL CHAIN SUPPLY
990.	036-036- 57	>	WA -15V SIGNAL CHAIN SUPPLY
991.	036-036- 58	>	WA +50V SUPPLY
992.	036-036- 59	>	WA +50V HVM SUPPLY

ITEM NUMBERS 993 THRU 006 LISTED BELOW ARE CIRCUITS CONNECTING THE WA AND NA PWR SUPPLY SUBASSYS (LEFT COLUMN) WITH THE WA AND NA FILTER WHEELS/SHUTTER SUBASSYS (RIGHT COLUMN)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
993.	036-036- 18	>	NA SHUTTER 1 OPEN DRIVE
994.	036-036- 19	>	NA SHUTTER 1 RESET DRIVE
995.	036-036- 20	>	NA SHUTTER 2 CLOSE DRIVE
996.	036-036- 21	>	NA SHUTTER 2 RESET DRIVE
997.	036-036- 22	>	NA FILTER WHEEL DRIVE

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB ISS - SUB ISS NO	FLOW	CIRCUIT NAME
998.	036-036- 26	>	NA FLOOD LAMP DRIVE
999.	036-036- 29	>	NA +15V FW SUPPLY
1000.	036-036- 60	>	WA SHUTTER 1 OPEN DRIVE
1001.	036-036- 61	>	WA SHUTTER 1 RESET DRIVE
1002.	036-036- 62	>	WA SHUTTER 2 CLOSE DRIVE
1003.	036-036- 63	>	WA SHUTTER 2 RESET DRIVE
1004.	036-036- 64	>	WA FILTER WHEEL DRIVE
1005.	036-036- 66	>	WA FLOOD LAMP DRIVE
1006.	036-036- 68	>	WA +15V FW SUPPLY
	ITEM NUMBERS 007 THRU 014 LISTED BELOW ARE CIRCUITS CONNECTING THE WA AND NA PWR SUPPLY SUBASSYS (LEFT COLUMN) WITH THE WA AND NA OPTICS SUBASSYS (RIGHT COLUMN)		
1007.	036-036- 23	>	NA OPTICS HTR
1008.	036-036- 24	<	NA REAR OPTICS TEMP
1009.	036-036- 25	<	NA FRONT OPTICS TEMP
1010.	036-036- 27	>	NA OPTICS CALIB DRIVE
1011.	036-036- 49	>	WA OPTICS CALIB DRIVE
1012.	036-036- 28	<	NA INTERLOCK
1013.	036-036- 65	<	WA REAR OPTICS TEMP
1014.	036-036- 67	<	WA INTERLOCK

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	ISS - ISS		
	ITEM NUMBERS 015 THRU 024 LISTED BELOW ARE CIRCUITS CONNECTING THE WA AND NA SUPPORT ELECTRONICS SUBASSYS (LEFT COLUMN) WITH THE WA AND NA FILTER WHEEL/SHUTTER SUBASSYS (RIGHT COLUMN)		
1015.	036-036- 30	>	NA FWID WRITE
1016.	036-036- 31	<	NA FWID-A
1017.	036-036- 32	<	NA FWID-B
1018.	036-036- 33	<	NA FWID-C
1019.	036-036- 34	<	NA FWID-D
1020.	036-036- 69	>	WA FWID WRITE
1021.	036-036- 70	<	WA FWID-A
1022.	036-036- 71	<	WA FWID-B
1023.	036-036- 72	<	WA FWID-C
1024.	036-036- 73	<	WA FWID-D
	ITEM NUMBERS 025 THRU 040 LISTED BELOW ARE CIRCUITS CONNECTING THE WA AND NA SUPPORT ELECTRONICS SUBASSYS (LEFT COLUMN) WITH THE WA AND NA CAMERA HEAD SUBASSYS(RIGHT COLUMN)		
1025.	036-036- 35	>	NA FRAME YOKE DRIVE
1026.	036-036- 36	>	NA LINE YOKE DRIVE
1027.	036-036- 37	>	NA HVM SYNC
1028.	036-036- 38	>	NA BEON

TABLE 1. ELECTRICAL INTERFACE CIRCUITS
MJS77 (CONT)

ITEM	SUB SUB NO	FLOW	CIRCUIT NAME
	ISS -	ISS	
029.	036-036- 39	>	NA FEG (C/H)
030.	036-036- 40	>	NA CALIBRATE
031.	036-036- 41	<	NA CAMERA HEAD VIDEO
032.	036-036- 42	<	NA INTERLOCK
033.	036-036- 74	>	WA FRAME YOKE DRIVE
034.	036-036- 75	>	WA LINE YOKE DRIVE
035.	036-036- 76	>	WA HVM SYNC
036.	036-036- 77	>	WA BEON
037.	036-036- 78	>	WA FEG (C/H)
038.	036-036- 79	>	WA CALIBRATE
039.	036-036- 80	<	WA CAMERA HEAD VIDEO
040.	036-036- 81	<	WA INTERLOCK

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REVISION PAGE

Revision	Date	ECR's Incorporated	Comments
Initial Release	11 April 75	N/A	—
A	17 Feb 1976	36028, 36032 36033, 36034 36043, 36045 36046, 36053 36054, 36059 36069, 36077 36107, 36120 36129, 36143 36146, 36170 36086	Table 1 and Figure 1 - Electrical Interface Circuits Revised per ECRs Listed
B	17 June 1976	36085, 36153 36191, 36212 36222, 36288 36280	Table 1 and Figure 1 - Electrical Interface Circuits Revised per ECRs Listed
C	29 July 1977	36353, 36196, 36416, 36464, 36453, 36480, 36524, 36574, 36701, 36705, 36770, 36792, 36858, 36917	Table 1 - Electrical Interface Circuits Revised per ECRs Listed.

FUNCTIONAL REQUIREMENT AMENDMENT

(Insert in 618-205, MJS77 Functional Requirements Book)

TITLE:	
FUNCTIONAL REQUIREMENT MARINER JUPITER / SATURN 1977 SPACECRAFT FLIGHT SEQUENCE IMPLEMENTATION	FR No. MJS77-3-120B AMENDMENT No. 2 PAGE 1 OF 24 DATE: 25 April 1978 PER ECR No. See Remarks below

DESCRIPTION OF CHANGE:

1. Remove and replace Table 3, pages 12 through 30, with the revised version.
2. Insert new Tables, 3a and 3b, immediately following Table 3 per ECR 36920.

DISTRIBUTION:	REMARKS:
List 197	ECRs incorporated: 36687, 36901, 36920, 36932, 36953, 36955, 36957, 36965, 36969
	APPROVED: David M. Dunham R. L. Stoller SYSTEM

JPL 3930 (11-69)

FUNCTIONAL REQUIREMENT AMENDMENT

(Insert in Book 618-205, MJS77 Functional Requirements Book)

TITLE:

FUNCTIONAL REQUIREMENT
MARINER JUPITER/SATURN 1977
SPACECRAFT FLIGHT SEQUENCE IMPLEMENTATION

FR No. MJS77-3-120B

AMENDMENT No. 1

PAGE 1 **OF** 1

DATE: 2 August 1977

PER ECR No. 36847

DESCRIPTION OF CHANGE:

Add to Table 2, page 5, item 2. "Data Handling Blocks," the following:

Number	Name	Description
2.10	Periodic Engineering and science calibration	Provides for periodic engineering commutator format changes to obtain engineering and science (PRA, LECP, MAG) calibration data.

DISTRIBUTION:

List 197

REMARKS:

APPROVED:

Om Denham 7/16/77 — SUBSYSTEM
M. Landano 7/21/77 — SUBSYSTEM
[signature] — SYSTEM

(Insert in 618-205, MJS77 Functional Requirements Book)

Custodian: D. M. Durham

APPROVED:

System: R. F. Draper

R. L. Stoller

D. M. Durham

JET PROPULSION LABORATORY

No. MJS77-3-120B

12 May 1977

Supersedes MJS77-3-120A 16 Sept 1976

FUNCTIONAL REQUIREMENT

MARINER JUPITER/SATURN 1977

SPACECRAFT FLIGHT SEQUENCE IMPLEMENTATION

* Denotes changes from previous issue.

1.0 SCOPE

This document describes the implementation of spacecraft (S/C) capabilities to carry out the operations required for the baseline Jupiter-Saturn-Titan (JST) and Jupiter-Saturn-Optional (JSX) Flight Sequences. The JSX Flight Sequence shall have the option of an extended mission to Uranus dependent on the performance of both mission modules. The Block concept is described and the current Block list is maintained in this document.

2.0 APPLICABLE DOCUMENTS

The following documents form a part of this functional requirement.

NOTE

MJS77-3-100, Spacecraft Requirements and Constraints, apply to this document. Requirements of other Mariner Jupiter/Saturn 1977 (MJS77) level three documents may also be applicable. It is the responsibility of the user to adequately acquaint himself with the organization and pertinent content of the level three documents, as well as with the material contained herein.

REQUIREMENTS

Jet Propulsion Laboratory

MJS77-1-100	Mariner Jupiter/Saturn 1977 Functional Requirements Book Introduction
MJS77-3-100	Functional Requirement, Mariner Jupiter/Saturn 1977 Spacecraft Requirements and Constraints
MJS77-3-290	Functional Requirement, Mariner Jupiter/Saturn 1977 Command Structure and Assignments
MJS77-3-310	Functional Requirement, Mariner Jupiter/Saturn 1977 Software Requirements

OTHER DOCUMENTS

Jet Propulsion Laboratory

618-51, Rev. C	Mariner Jupiter/Saturn 1977 Mission and Science Requirements Document
618-53, Rev. B	Mariner Jupiter/Saturn 1977 Mission Plan
618-212	Mariner Jupiter/Saturn 1977 Spacecraft Block Dictionary

3.0 INTRODUCTION

3.1 Abbreviations

The abbreviations found in the tables and figures of this document are defined in MJS77-1-100.

3.2 Flight Sequences

As a minimum, the MJS77 S/C shall be capable of performing the blocks defined in Section 4.0. The S/C design shall as a minimum also permit accomplishing the flight sequence summarized in Section 5.0.

3.3 Implementation

The flight sequence is responsive to the mission requirements specified in the Mission Requirements Document 618-51, Rev. C and to the Mission Plan Document 618-53, Rev. B which provides example mission profiles that implement those mission requirements. Its structure shall be such that it can be described wholly in terms of single commands/events and blocks.

4.0 DEFINITION OF SPACECRAFT CAPABILITIES

4.1 Single Commands/Events

Single commands are those individual commands generated by the computer command subsystem (CCS), which are defined in MJS77-3-290, Command Structure and Assignments. Single events are those subsystem-to-subsystem signals or control words which are generated by means other than the CCS.

4.2 Blocks

4.2.1 Definition

A block is defined as a sequence of CCS commands and/or spacecraft events, with a well defined time interrelationship, that performs some spacecraft function. Blocks are used to implement "normal" flight sequences and do not consider failure modes of operation.

4.2.2 Block Description

A block will be determined by the specification of all of the requirements to be satisfied by the block and describes the block sequence of events at a functional level including a start time, a set of time variables, and a set of S/C parameters.

The MJS77 Spacecraft Block Dictionary, 618-212, contains a description of each block, listing the required inputs, S/C initial conditions, S/C final conditions, and any constraint applicable to the implementation of the defined sequence. The blocks are classified according to the type of function they are satisfying. These classes are identified in Table 1.

Table 1. Block Classification

Class	Block Type
1	Telecommunication
2	Data Handling
3	Attitude Control
4	Data Storage
5	Science Scan Platform
6	Science
7	Engineering Sequence
8	Science Sequence

Table 2 is the controlling list of Blocks. The detailed block design shall be consistent with the spacecraft software specified in MJS77-3-310, Software Requirements.

5.0 REQUIRED SPACECRAFT OPERATIONS

5.1 Description

The required S/C operations are defined here as those functions necessary to meet the requirements set forth in 618-51, Rev. C, Mission and Science Requirements Document. The operations described herein are categorized by mission phase and are consistent with the mission implementation described in 618-53, Rev. B.

5.2 Mission Phases

* 5.2.1 Launch Phase

The launch phase is defined as the time period between CCS initialization and Canopus acquisition. This phase is characterized by the launch phase sequence shown in Figure 1. The detailed launch sequence, including pre-lift off activities, S/C launch events, and initial science instrument turn on events, are listed in Table 3.

NOTE

Time of events relative to "L-time" and "T-time" presented in Figure 1 and Table 3 are launch day/arrival day and trajectory dependent. Events initiated after the parking orbit coast, due to coast time variance, may vary in real time as much as 5 minutes over the launch period for a particular launch day. The relative time of occurrence between events after the parking orbit coast, however, will remain the same.

* Table 2. Blocks

Number	Name	Description
	1. Telecommunication Blocks	
1.1	HGA Pointing With Sun Sensors	With the Sun and Canopus acquired the AACS sun sensors are biased so as to provide the desired HGA pointing direction.
1.2	Telecommunications Configuration	RFS, MDS, and SXA are configured to meet a specific set of downlink requirements.
	2. Data Handling Blocks	
2.1	FDS Readout	A partial or complete readout of the FDS memories is performed.
2.2	AACS Readout	A partial or complete readout of the AACS memories is performed.
2.3	CCS Readout	A partial or complete readout of the CCS memories is performed.
2.4	FDS-ISS Parameter Table Switching	Switches set of ISS parameter tables within FDS
2.5	FDS Memory Load	Performs a software (write protect override) load of the secondary FDS memory.
2.6	FDS Memory Control Transfer	Performs a synchronous FDS memory configuration change.
2.9	FDS Memory Copy	Copies FDS primary memory to FDS secondary memory.
	3. Attitude Control Blocks	
* 3.1	Sun Acquisition	(Deleted)
3.2	Star Acquisition	A roll maneuver is executed by the MM to search for and acquire a reference star by the CST.
3.3	Commanded Turn	Provides capability to turn MM at a rate of π mrad/sec around any one of its three axes.
* 3.4	Inertial Reference Calibration	(Deleted)
3.5	AACS Memory Load	An AACS memory load is performed.

* Table 2. Blocks (cont'd)

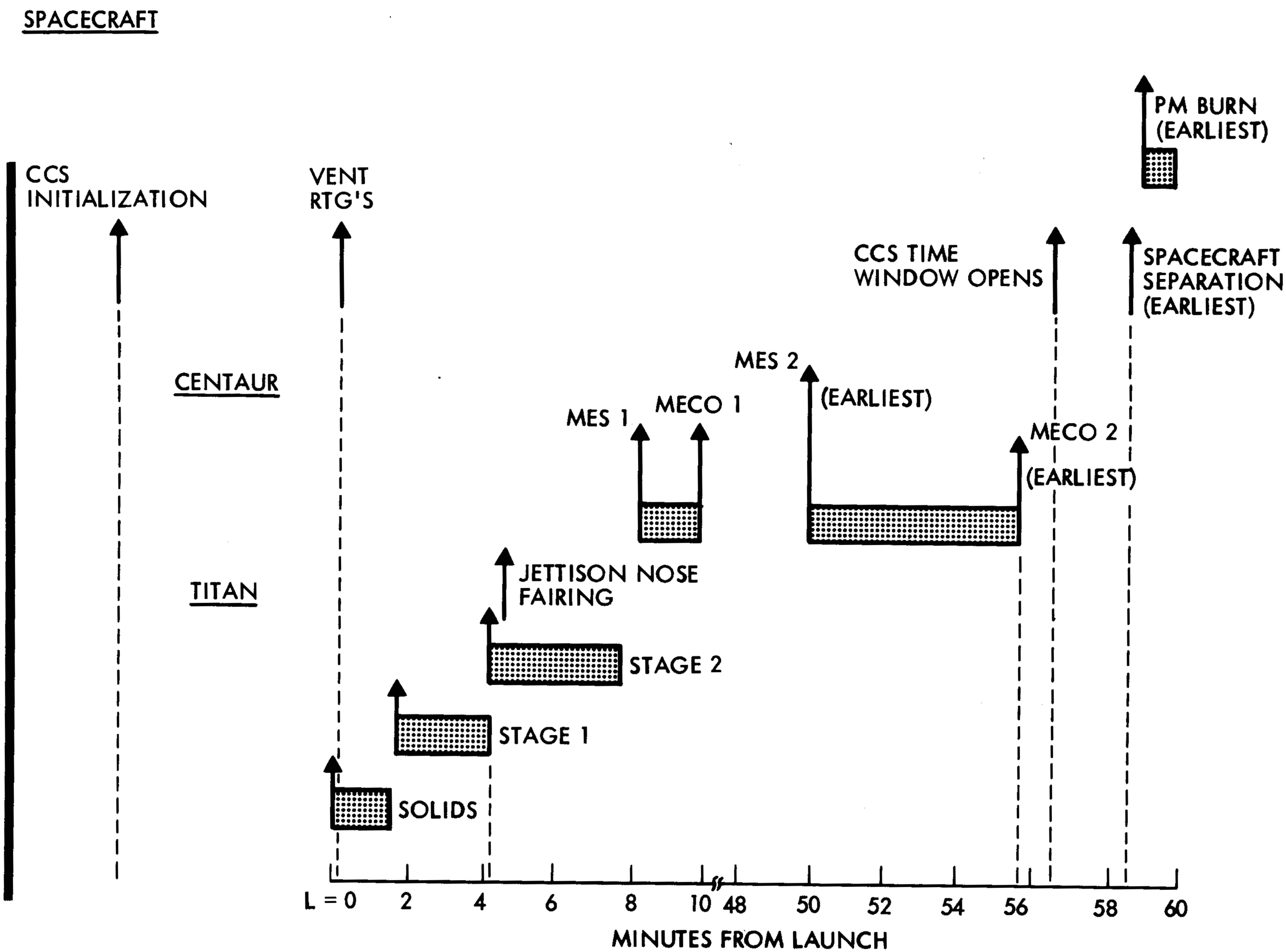
Number	Name	Description
	4. Data Storage Blocks	
4.1	Tape Positioning	The DSS tape is positioned to a given location prior to recording or playback.
4.2	Playback	Recorded data is played back from the DSS.
4.3	Record	Data is recorded on the DSS tape under control of the CCS.
	5. Science Scan Platform Blocks	
5.1	Platform Position	Science scan platform is positioned in azimuth and/or elevation.
5.2	Platform Scan	Provides for a series of platform movements along a single strip with options of periodic departures from that strip.
5.3	Platform Mosaic	Provides for a series of parallel platform movements.
	6. Science Blocks	
6.1	N-Picture Imaging	Accomplishes a planned shuttering/readout sequence for N images
* 6.2	MAG In-Flight Calibration	Shall perform an in-flight calibration of the magnetometer or perform a boom alignment calibration.
6.3	ISS Long Exposure	The FDS is configured to permit long exposure times for imaging.
6.4	ISS Optical Calibration	NA and WA cameras are calibrated using the calibration lamps.
6.5	PLS In-Flight Calibration	Allow for in-flight calibration of the PLS.

* Table 2. Blocks (cont'd)

Number	Name	Description
	7. Engineering Sequence Blocks	
* ES1	SS-HGA Calibration	The sun sensors and HGA are calibrated by stepping the sun sensor bias or updating the gyro drift and observing the resulting change in downlink X-band signal strength.
* ES2	Platform Calibration	(Deleted)
* ES3	Trajectory Correction Maneuver	A propulsive maneuver is performed.
* ES4	Optical Navigation Imaging	(Deleted)
* ES5	Canopus Tracker Calibration	(Deleted)
* ES6	Real-Time Engineering Data Acquisition	(Deleted)
* ES7	TCM Thruster-Earth Line Calibration	(See Blk ES3)
	8. Science Sequence Blocks	
SS1	Cruise Science Maneuver	A non-propulsive maneuver is performed for science observations and calibrations.
SS2	Science Target Calibration	A non-propulsive maneuver is performed for optical science intrument calibration.
SS3	PPS-Brewster Plate Calibration	The MM is maneuvered to allow the PPS to observe the Brewster plate for calibration purposes.
SS4	Radio Science Maneuver	During Earth occultation at Jupiter and Saturn, the virtual image of the Earth on the planets limb is tracked. UVS solar occultation is also observed.
* SS5	Radio Tracking	(Deleted)
* SS6	Integrated Science Scan	(Deleted)
* SS7	Integrated Science Mosaic	(Deleted)
* SS8	Data Acquisition	(Deleted)
* SS9	Recorded Data Acquisition	(Deleted)

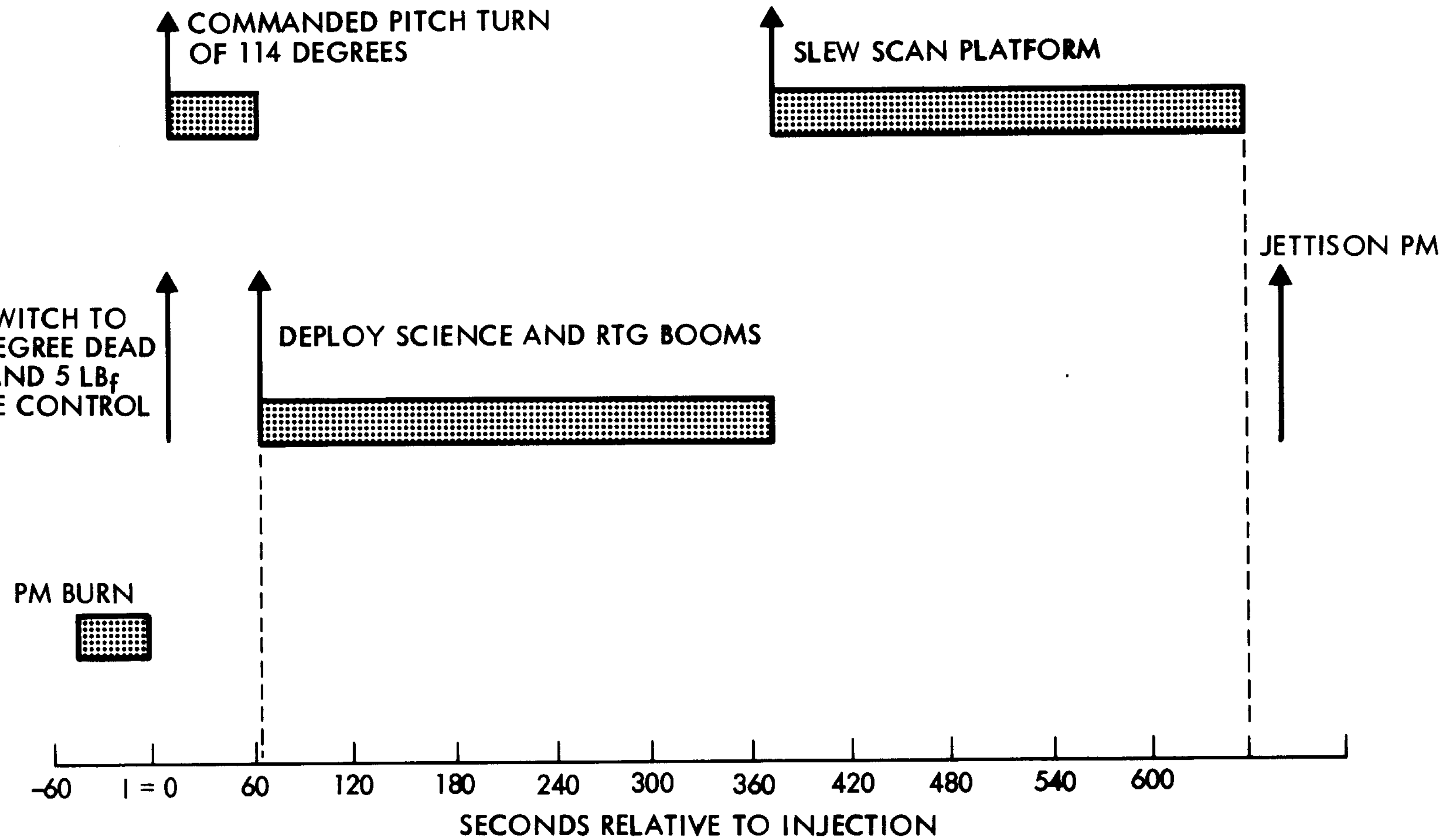
*Table 2. Blocks (contd)

	Number	Name	Description
		8. Science Sequence Blocks (contd)	
*	SS10	Sequence Cyclic	Allows a group of blocks and/or individual commands to be identified as a cyclic.
*	SS11	MAG In-Flight Calibration	(See Blk 6.2)
*	SS12	ISS Optical Lamp Calibration	(See Blk 6.4)
	SS13	Cruise Science Instrument Calibration	Allows for general science instrument calibrations.
*	SS14	PLS Calibration	(See Blk 6.5)
*	SS15	UVS Slit Alignment	(Deleted)
	SS16	PPS/MIRIS In-Flight Calibration	Allows for in-flight calibration of the PPS and MIRIS Science instruments.
*	SS17	Simultaneous Alternating with NA Imaging	(Deleted)



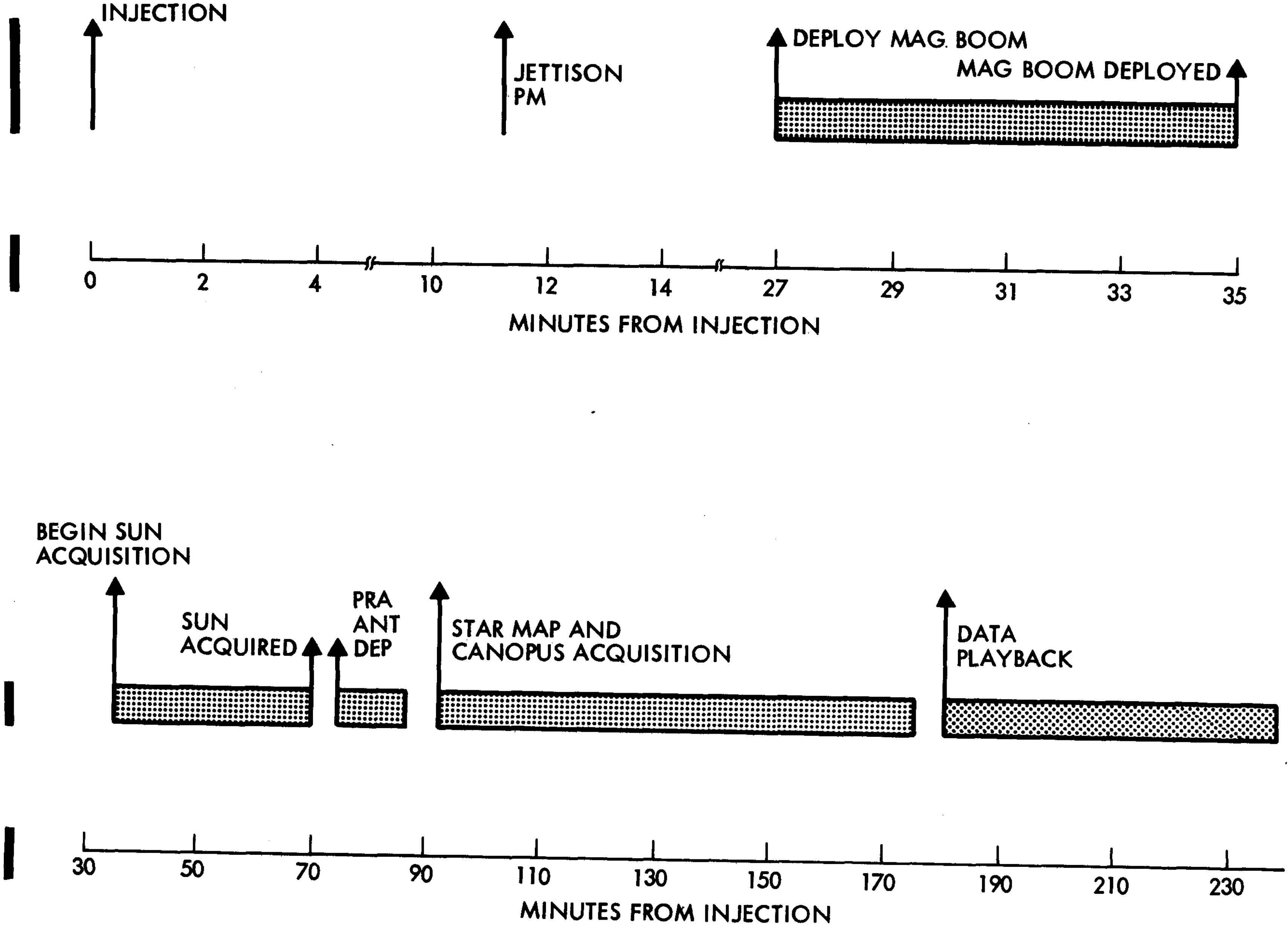
* Figure 1. Launch Phase

MJS77-3-120B



MJS77-3-120B

* Figure 1. Launch Phase (cont'd)



* Figure 1. Launch Phase (cont'd)

Backup page only
No change

* Table 3. MJS77 Launch Sequence of Events

*KEY: The following sequence shall be considered as the Project's baseline launch sequence. The event times were derived for an August 20, 1977 launch with a Jupiter arrival date of mid July 1979. Between events 52.0 through 158.5, all CCS events are issued in parallel except for events 108.5, 149.1, 149.2, and 162.1, which are issued by CCS processor A only. T-time is time from lift off but includes 2 scheduled holds of 1 hour and of 10 minutes durations. L-time is essentially real time from lift off and has no scheduled holds. To illustrate the difference between 'L-time' and 'T-time', these are used in the sequence prior to CCS reset (Event No. 52.0) at which time succeeding events will generally be given relative to injection (hr:min:sec). *Times scheduled before the 60 minute hold (Event No. 32.0) are representative only.* (Do not have to be aberrantly held.) Supplemental Tables 3a and 3b follow Table 3 and describe launch dependent variables and updates to the FCP initialization table, respectively.

Event No.	Source	Via	Desti-nation	Command ID	Command/Event	T-Time	Relative Time	Comments
0.0								The AACS and CCS launch loads must be loaded prior to launch day
* 0.5	LCE	RF	PWR		Relay configuration routine			SC configuration will be performed prior to SC turn off on day before liftoff; sets secondary switches; resets primary switches; selects primary units except for AACS proc/mem 2, S-band transmitter 2, and X-band transmitter 2, PWR-PYRO-FDS-MDS-DSS-RFS-AACS command enables; S- and X-band TWTA low power; 2-way non-coherent off (enables VCO); LGA selected; FDS power on/ISS power enabled.
1.0	LCE	UMB	PROP		Hydrazine tank HTRS on			Turned on as soon as S/C is on pad; go off when T-4 sec umbilical is pulled
					I. S/C turn on: telemetry configuration			
2.0	LCE	UMB	PWR		IPU battery HTRS on	T-22:50:00	L-24:00:00	Go off when T-4 sec UMB is pulled
3.0	LCE	UMB	PWR		Switch to main inverter	T-6:50:10	L-8:00:10	
* 4.0	LCE	UMB	PWR		Unshort RTGs	T-6:50:00	L-8:00:00	S/C power on; As SC power comes up, the CCS will perform PWRCHK and automatically start sending the following commands in 4 seconds and on 200 ms centers: S-band ranging off (DC 2AR) X-band XMTR off (CC2GRP) S-band XMTR of (CC2KRP) S-band exciter off (CC2MRP) X-band ranging off (DC2NR) 2-Way Non-coherent off (DC2PR) TMU off (CC3BRP) PRA/PWS antenna deploy motor off (CC22BRP) NOP Enable and check power codes: After a 10 minute delay (nominal value), the following 4 commands will be sent on 1 second centers: UV trip reset (CC4A) TMU on (CC3BP) S-band XMTR on (CC2KP) S-band exciter on (CC2MP).
* 6.0	LCE	CCS	PWR	CC4A	Undervoltage trip reset	T-6:49:00	L-7:59:00	
8.0	LCE	UMB	FDS	CC06A	Set FDS state vector			5 CMDS: (CC06AA; CC06AB; CC06AC; CC06AD; CC06AE)
9.0	LCE	UMB	FDS		Start loading FDS memory	T-6:47:30	L-7:57:30	Loading takes approx. 3 min; load in LN-12 mode and launch tables

* Table 3. MJS77 Launch Sequence of Events (cont'd)

Event No.	Source	Via	Desti-nation	Command ID	Command/Event	T-Time	Relative Time	Comments
* 10.0	LCE	CCS/ PWR	MDS	CC3BP	TMU power on	T-6:47:00	L-7:57:00	Switches 2.4 kHz power to TMUs during FDS load
* 11.0	LCE	CCS	MDS	CC3A 39111	TMU state select			S-band high rate data channel and low frequency subcarrier state (Driver 1 active only)
* 11.5	LCE	CCS	MDS	CC3A 47120	TMU state select			X-band high frequency subcarrier state (Driver 1 active only)
12.0					FDS load in by this time	T-6:44:30	L-7:54:30	FDS in LN-12 mode (1200 bps high rate engr data)
13.0	LCE	RF	CCS		Launch day CCS and AACS updates			Follows FDS configuration; only performed for launch day tweaks if needed.
* 15.0	LCE	CCS/ PWR	RFS	CC2MP	S-band exciter power on			30 Vdc to S-band exciter
* 16.0	LCE	CCS/ PWR	RFS	CC2KP	S-band transmitter power on			30 Vdc to S-band transmitter
								Events 8, 9, 11 and 11.5 will be redone if needed following the PWRCHK routine.
* 19.0	LCE	CCS	FDS		Verify FDS load			By way of checksum, Follows FDS load
* 20.0	LCE		CCS		Checksum of CCS load			Done automatically on request
* 21.0	LCE	CCS/ PWR	AACS	CC7H1P	HYBIC 1 major PWR supply on	T-4:02:00	L-5:12:00	With HYBIC turn on the following are turned on: ISO valve power on; 2 of 6 ISO valves are opened (after ISO valves open ISO valve power off); CST sun shutter on DRIRU to low rate Gyros B and C on Sun sensor power on
* 22.0	LCE	CCS	FDS	SC06BB 160041	FDS mode select	T-4:01:00	L-5:11:00	AA-12 (high rate AACS telemetry); triggers AACS memory dump
* 23.0	LCE	CCS	AACS	AC7MLD 0000	PROC/MEM 2 readout (start)	T-4:00:00	L-5:10:00	Takes approx. 6 to 6.5 minutes
* 24.0	LCE	CCS	AACS		PROC/MEM 2 readout (stop)	T-3:53:30	L-5:03:30	

* Table 3. MJS77 Launch Sequence of Events (cont'd)

Event No.	Source	Via	Destination	Command ID	Command/Event	T-Time	Relative Time	Comments
* 25.0	LCE	CCS/ PWR	AACS	CC7MMP	PROC/MEM 1 select	T-3:53:00	L-5:03:00	Follows PROC/MEM 2 readout
* 26.0	LCE	CCS	AACS	AC7MLD 0000	PROC/MEM 1 readout (start)	T-3:52:45	L-5:02:45	
* 27.0	LCE	CCS	AACS		PROC/MEM 1 readout (stop)			
* 28.0	LCE	CCS	FDS	SC06BB 160040	FDS mode select	T-3:46:00	L-4:56:00	Select LN-12 data mode at end of readout
					II. Pre-lift off: lift off			
* 29.0	LCE	CCS/ PWR	DSS	CC16AP	DSS on	T-2:08:00	L-3:18:00	
* 30.0	LCE	CCS	DSS	CC16C 2710	Slew to EOT	T-2:07:50	L-3:17:50	Balance heavy damper on left reel by having tape on right reel
31.0					DSS at EOT	T-1:58:00	L-3:08:00	DSS to ready mode: maximum time for DSS to reach EOT.
32.0					Scheduled T-Time hold (60 minutes long)	T-1:55:00	L-3:05:00	Begin countdown test sequence (T-10 to T=0). Send CMDs to initialize S/C to T-10; send SC06BB 320040 (LN-40 mode); send CC3A 28101 (low frequency, low data rate); send simulated arm CMDs; initiate CCS Launch Hold/Reset routine; verify CCS event counter; hydrazine tank and battery heaters OFF; abort LH/R routine; begin pad evacuation 30 minutes into hold; reconfigure S/C to T-1:55:00.
33.0					T-Time count resumes	T-1:55:00	L-2:05:00	
34.0	LCE	UMB	PROP		Check SRM safe and arm	T-1:50:00	L-2:00:00	Tankage begins after safe and arm
* 40.5	LCE	CCS	AACS	CC7GY 3	Initialize AACS position	T-1:00:00	L-1:10:00	Permits earth rate observations
* 41.0	LCE	CCS	AACS	CC7GY 4	Gyro fault test start	T-0:55:00	L-1:05:00	Compares common axis
* 42.0	LCE	CCS/ PWR	PYRO	CC8D	PSU instrumentation on	T-0:54:00	L-1:04:00	Switches 2.4 kHz power to PSU instrumentation

* Table 3. MJS77 Launch Sequence of Events (cont'd)

Event No.	Source	Via	Desti-nation	Command ID	Command/Event	T-Time	Relative Time	Comments
* 43.0	LCE	CCS/ PWR	PROP	CC10F	IPU valve HTRS on			Also provides heat to TCAPU line and hydrazine disconnect (HD)
* 44.0	LCE	CCS/ PWR	PROP	CC10H	IPU redundant valve HTRS on			Also provides heat to TCAPU line and HD
45.0	LCE	CCS/ PWR	PROP	CC10G	IPU thruster HTRS on			
* 45.5	LCE	CCS	MDS	CC3A 28101	TMU state select	T-0:45:00	L-0:55:00	S-band low rate data channel and low subcarrier frequency (Driver 1 active only)
* 46.0	LCE	CCS	FDS	SC06BB 320040	FDS mode select			LN-40 mode
* 47.0	LCE	CCS	PWR	CC4K	RTG 1 diode bypass on	T-0:40:00	L-0:50:00	Shorts out RTG isolation diode
* 48.0	LCE	CCS	PWR	CC4L	RTG 2 diode bypass on			
* 49.0	LCE	CCS	PWR	CC4M	RTG 3 diode bypass on			
* 49.5	LCE	RF	CCS		CCS Initialization	T-0:35:00	L-0:45:00	Generates checksum of CCS
* 49.6	LCE	RF	CCS	DC5A	Sets Tolerance Detector Override	T-0:35:00	L-0:45:00	Sets indicator in CCS status
50.0					Scheduled T-Time hold (10 minutes long)	T-0:10:00	L-0:20:00	Final planned LV update occurs within this hold
50.5	LCE	RF	CCS/ AACS	CC7GY 5	Gyro Fault Test Stop	T-0:10:00	L-0:20:00	For second launch only
51.0	LCE	UMB	PROP		Solid propellant motor arm	T-0:09:00	L-0:09:00	
* 52.0	LCE	RF	CCS		Initiate CCS Launch Hold/ Reset Routine	T-0:08:30	L-0:08:30	CCS clocks initialized; CCS in seconds mode with time window opening approx. T+55M; PYRO, RFS and MAM commands inhibited; DSS state select (record 7.2 kbps; reverse: Track 6); no data being sent by FDS for recording. In the event of an unexpected hold ground CMD of DSS to ready mode may be necessary; Initialize AACS position to observed lift-off rates and initiate heatbeat algorithm; (equivalent to the following 3 CMDs are stored in the heartbeat failure table: CC7CT 05; AC7DDB 2000; AC7MDP 1); Start CCS fast clock test; Send CMD DC5AR to reset tolerance detector override. Maximum hold the S/C can tolerate before resetting CCS is 40 minutes (27 minutes for second launch)

✱ Table 3. MJS77 Launch Sequence of Events (cont'd)

* S/C Status at T - 8m 30s (after CCS Initialization Routine)

Subsystem	Function	Status
RFS	Receiver	1
	Antenna	LGA
	USO	Off
	2-Way non-coherent mode	Off
	Downlink frequency source	VCO
	S-band	
	Exciter select	1
	Transmitter select	2
	Power on/off	On
	Power mode select	Low
	Ranging	Off
	X-band	
	Exciter select	1
	Transmitter select	2
	Power on/off	Off
	Power mode select	Low
	Ranging	Off
MDS	CDU select	A
	TMU select	A
	TMU power	On
	S-band	
	Mod. index	28_{10}
	Driver select	1 On, 2 Off
	Subcarrier	Low subcarrier frequency
	Data channel	Low rate
	X-band	
	Mod. index	47_{10}
	Driver select	1 On, 2 Off
	Subcarrier	High subcarrier frequency
PWR	Batteries A, B	Off
	RTG diode bypass	On
	2.4 kHz inverter	Main
	RTG short relay	Unshorted
	Battery heaters	On
CCS	Internal interrupts	Unmasked
	Lock indicator (P and S)	Unmasked
	Bit timing (P and S)	Unmasked
	CCS mode	Seconds, Parallel
	Command inhibited to	RFS, PYRO MAM
*	All automatic routines except RF loss, MIRIS switch and CCS tolerance detector	Enabled
* FDS	Basic mode	EL (40 bps)
*	Engineering mode	Launch
	FDS processor	A

* Table 3. MJS77 Launch Sequence of Events (contd)

S/C Status at T - 8m 30s (after CCS Initialization Routine)

Subsystem	Function	Status
FDS (contd)	FDS primary memory	A
	AACS data	Data 1 (Two for VGR77-2)
	* AACS TLM mode	TLM readout
	FDS timing chain	A
	FDS power converter	A
	FDS transducer power	On
	FDS MDS I/O logic	A
	CRS I/O logic	A
	LECP I/O logic	A (B for 2nd launch)
	* LECP mode	Far encounter
	MAG I/O logic	A
	FDS P and S memory protect	On
	* Primary Memory	
	lower half	location 0-OBFF
	upper half	location 1000-IDFF
	* Secondary memory	
	lower half	location 0-OBFF
	upper half	location 1000-IDFF
AACS	FCP/MEM in use	1 (Two for VGR77-2)
	AACS mode	Launch (matches FDS tree switch ID C1)
	FDS channel select	A
	HYBIC/sun sensors (SS)	1 (Two for VGR77-2)
	SS gates (V_{SS} = volts at SS)	
	High	9.6 V_{SS} Typical
	Low	8.4 V_{SS} Typical
	SS heaters	A & B off
	Sun point	Enabled
	SS bias	
	pitch	-11°
	yaw	+11°
	CST power	Disabled
	Cone angle position (CST)	C5 (Good for 8/20 through 8/30/77; See Table 3A(I) for other info)
	CST gate (V_T = volts at tracker)	HG = 7.5 V_T LG = 8.6 V_T H = 0.4 V_T LG4= 11.6 V_T Typical
	CST sun shutter	On
	Canopus search	Disabled
	* DRIRU capture rate	Low
	Gyros powered	B and C On, A Off

Table 3. MJS77 Launch Sequence of Events (contd)

S/C Status at T - 8m 30s (after CCS Initialization Routine)

Subsystem	Function	Status
AACS (contd)	Gyro usage pattern	
	pitch	B
	yaw	C
	roll	C
	DRIRU drift update	0.0° P, Y, R
	AACS deadband	1.0° P, Y, R
	Scan position	AZ = 180.0° EL = 10.5° Typical
	AZ scan actuator heater	Off
	AZ scan actuator coil heater	Off
	ISO valve status	
	power	Off
	AP P/Y ISO valve (Branch 1)	Open
	AP roll ISO valve (Branch 1)	Open
	TCM P ISO valve (Branch 1)	Closed
	AP P/Y ISO valve (Branch 2)	Closed
	AP roll ISO valve (Branch 2)	Closed
	TCM Y ISO valve (Branch 2)	Closed
	TCAPU fault test	Disabled
	Rate TLM scaling	Shift right 4 (P, Y, R)
PYRO	Instrumentation	On
	PSU A, B	Off
	PYRO/TCAPU/CCS State	Safe
	Capacitor bank A, B	Discharged (1.5 volts)
PROP	Solid rocket motor	Arm
	IPU-REA ISO valves	Open
	IPU valve heaters	On
*	IPU redundant valve heaters	On
	IPU thruster heaters	On
*	AP BR 1 & 2 Heaters	Off
	Hydrazine tank heaters	On
	TCM heaters	Off
	Hydrazine tank Temp	95-100°F
	AP P & Y BR 1 ISO valve	Open
	AP R BR 1 ISO valve	Open
	TCM ISO valves	Closed
	AP BR 2 ISO valves	Closed
*	TCM line and Bracket HTR	Off
DEV	Magnetometer boom	Stowed/Latched
	Science boom	Stowed/Latched
	RTG boom	Stowed/Latched

Table 3. MJS77 Launch Sequence of Events (contd)

S/C Status at T - 8m 30s (after CCS Initialization Routine)

	Subsystem	Function	Status
	DEV (contd)	S/C Separation	Not separated
		PM Jettison	Not separated
	DSS	DTR - 2.4 kHz power	On
		Mode	Record
		Rate	7.2 kbps
		Position	EOT
		Direction	Reverse
		Track	6
		Replacement heater	Off
*	CRS	30 Vdc CRS power	Off (Low voltage mode if instrument turns on)
		30 Vdc CRS replacement heater	Off
		30 Vdc CRS supplemental heater	Off
		High Voltage	Off
	PRA	Antenna	Stowed
		2.4 kHz PRA power	Off
		30 Vdc antenna deploy motor	Off
	PWS	2.4 kHz PWS power	Off
*	LECP	2.4 kHz LECP power	Off (Low voltage mode if instrument turns on)
		30 Vdc stepper motor power	Off
		30 Vdc LECP replacement heater	Off
*		30 Vdc LECP main supplemental heater	Off
*		30 Vdc LECP LEPT supplemental heater	Off
		Mode	MOSTO
	PPS	30 Vdc PPS power	Off (High voltage mode if intrument turns on)
		30 Vdc replacement heater	Off
		Filter wheel position	Filter 5
		Aperture wheel position	Aperture 4 (1/16° FOV)
		Polarization analyzer wheel positon	Analyzer 4 (Dark slide)

Table 3. MJS77 Launch Sequence of Events (contd)

S/C Status at T - 8m 30s (after CCS Initialization Routine)

	Subsystem	Function	Status
	PLS	2.4 kHz PLS power	Off (Low voltage mode if instrument turns on)
		30 Vdc supplemental heater	Off
		30 Vdc replacement heater	Off
*	UVS	2.4 kHz UVS power	Off (Low voltage mode if instrument turns on)
		30 Vdc replacement heater	Off
		High voltage mode	Off
	MAG	2.4 kHz MAG power	Off
		2.4 kHz Standby power	Off
		2.4 kHz flipper power	Off
		2.4 kHz MAG sensor heater	Off
*		MAG coil current	Off
	ISS	2.4 kHz ISS power	Off (High voltage mode if instrument turns on)
*		NA filter position	0 (clear)
		WA filter position	2 (clear)
*		NA optics heater	Off
*		NA VID REPL heater	Off
*		NA ELEC REPL heater	Off
*		WA VID REPL heater	Off
*		WA ELEC REPL heater	Off
		Shuttering	Inhibited
		Filter wheel stepping	Inhibited
	IRIS	2.4 kHz IRIS power	Off
		2.4 kHz IRIS standby power	Off
		IRIS dust cover	Latched
*		Flashoff heater	Off
*		REPL heater	Off
*	STRU	Bay 1 & Bay 8/9 HTR	Off
*		Bay 2 HTR	Off
*		Bay 6 HTR A	Off
*		Bay 6 HTR B	Off
*		SCNPLT SUP HTRS	Off

✱Table 3. MJS77 Launch Sequence of Events (cont'd)

	Event No.	Source	Via	Desti-nation	Command ID	Command/Event	T-Time	Relative Time	Comments
*									Succeeding events are issued at the denoted times relative to PM burn out (injection)
	52.5	CCS		Ground		CCS Readiness verification	T-0:05:30		Event counter & status TLM verifies readiness for launch.
*	52.7	LCE	MDS	CCS		Drop uplink	T-0:04:00		CDU subcarrier lock dropped.
	53.0	LCE		PROP		Hydrazine tank and battery HTRS off	T-0:00:04		HTRS off as a result of T-4 sec UMB pulled
	54.0					State 0 ignition	T-0:00:00.2		T = 0 UMB pulled
	55.0					Lift off	T-0:00:00		
						III. Post Lift-off to MES2			
	56.0					Vent RTGs	T+0:00:10		Pressure release device actuates when the pressure differential from inside the device to the external environment is 10 psi (Approximately 20,000 ft.)
	57.0					Stage 0 shutdown	T+0:01:49		
	58.0					Stage 1 ignition	T+0:01:51		
*	59.0					Stage 0 separation	T+0:02:02		
*	60.0					Stage 1 shutdown	T+0:04:20		
*	61.0					Stage I/II separation Stage II ignition	T+0:04:21		
*	62.0					Centaur standard shroud jettison	T+0:04:31		
*	63.0					Stage II shutdown	T+0:07:51		
*	64.0					Stage II/Centaur separation	T+0:07:57		
*	65.0					MES1	T+0:08:08		
*	66.0					MEC01/begin PO coast	T+0:09:50		
	67.0					Minimum RTG power after vent	T+0:20:00		
	67.5	CCS		AACS	CC7GY 4	Gyro fault test start	T+0:37:00		For second launch only
*	68.0					Enter earth shadow	T+0:40:00		Shadow entry varies between T+0:37:30 and T+0:51:08 over the launch period
*	69.0	CCS		AACS	CC7GY 5	Gyro fault test stop	T+0:41:00		Occurs before MES2; occurs at T+0:47:00 for second launch only

* Table 3. MJS77 Launch Sequence of Events (cont'd)

Event No.	Source	Via	Destination	Command ID	Command/Event	T-Time	Relative Time	Comments
* 69.5					CCS separation window opens	T+0:51:00		This time is launch day independent.
* 70.0					MES2	T+0:52:45		MES2 can vary between T+0:47:30 and T+0:56:30
					IV. MES2 to separation			
* 71.0					Earliest MEC02	T+0:55:47		For 20 August 1977 launch
* 72.0					MEC02/post MEC02 coast	T+0:58:30		Earliest MEC02 vary between T+0:53:30 and T+1:02:30 for launch period; post MEC02 coast time is 185 seconds up through Sept 12 launches and 85 seconds thereafter.
* 73.0	Centaur	PYRO	PYRO/ PROP/ CCS		PYRO/TCAPU/CCS Arm A on PYRO/TCAPU/CCS Arm B on	T+1:00:11	I-0:02:09	Signal from Centaur; separation occurs 69 seconds after signal is detected
* 74.0	CCS		MDS	CC3A 39111	TMU state select		I-0:02:09	Occurs immediately after Centaur signal; S-band high rate data channel and low subcarrier frequency state (Driver 1 active only)
75.0	CCS		FDS	SC06BB 160040	FDS mode select		I-0:02:09	LN-12 data mode
* 75.5	CCS		CCS		Processor CMD		I-0:01:15	CCS updates the FCP Initialization Table: Disable Heartbeat failure response. All updates during launch sequence to the FCP initialization table are located in Table 3b.
76.0	CCS		CCS	DC8X	PYRO command enable		I-0:01:09	
77.0	CCS CCS	PWR PWR	PYRO PYRO	CC8A CC8B	PSU A on PSU B on		I-0:01:08 I-0:01:08	PSU A on and PSU B on are within 100 ms of each other from CCS output units 1
* 78.0	CCS	PWR	PROP	CC10FR	IPU valve HTRS off		I-0:01:07	Turn off IPU valve and thruster heaters at this time.
* 79.0	CCS	PWR	PROP	CC10HR	IPU redundant valve HTRS off		I-0:01:07	
80.0	CCS	PWR	PROP	CC10GR	IPU thruster HTRS off		I-0:01:07	
81.0	CCS	PYRO	PWR	DC4T	Activate batteries A and B		I-0:01:04	Issued within 100 ms of each other from CCS output units 1 and 2

* Table 3. MJS77 Launch Sequence of Events (cont'd)

Event No.	Source	Via	Destination	Command ID	Command/Event	T-Time	Relative Time	Comments
82.0	CCS		AACS	CC7GY 2	DRIRU to high rate mode		I-0:01:02	
83.0	CCS		AACS	CC7GY 3	Initialize AACS position		I-0:01:01	
84.0	Centaur	PYRO	PYRO/ PROP/ CCS		PYRO/TCAPU/CCS Arm A off PYRO/TCAPU/CCS Arm B off		I-0:01:01	
85.0	CCS	PYRO	DEV	DC12A1	S/C-LV separation A		I-0:01:00	Separation occurs 15 sec before propulsion module ignition; the sending of the DC12A1 CMD must precede the DC12A2 CMD by at least 200 ms.
* 86.0	CCS	PYRO	DEV	DC12A2	S/C-LV separation B		I-0:00:59	
					V. Separation to PM jettison			
* 87.0	CCS		AACS	AC7MDP 8	Pre-burn mode/5-lbf engine control		I-0:00:57	5-lbf engines enabled (P, Y, R) limit cycle plus or minus 1.0 degree
88.0	CCS		AACS	AC7DDB 001920	AACS deadband update		I-0:00:54	Deadband to plus or minus 0.2 degrees (P; Y; R)
89.0	CCS		AACS	AC7PAR 6742 022600	Parameter load		I-0:00:54	Positive roll deadband to 1.0 degree
* 90.0	CCS		AACS	AC7PAR 6746 755200	Parameter load		I-0:00:54	Negative roll deadband to 1.0 degree
91.0	CCS		AACS	AC7MDP 2	AACS burn mode		I-0:00:50	100-lbf engines enabled for P & Y control; 5-lbf engines for roll
92.0	CCS	PWR	AACS	AC7PCG 22	CST sun shutter off		I-0:00:47	
93.0	CCS	PYRO	PROP	DC10A	Start solid motor		I-0:00:45	Propulsion module ignition; timed from Centaur signal
* 94.0	Centaur	PYRO	PYRO/ PROP/ CCS		PYRO/TCAPU/CCS Arm A on PYRO/TCAPU/CCS Arm B on	T+1:01:40	I-0:00:40	Backup signal sent by Centaur

* Table 3. MJS77 Launch Sequence of Events (cont'd)

Event No.	Source	Via	Desti-nation	Command ID	Command/Event	T-Time	Relative Time	Comments
* 95.0					Propulsion module burn out		I-0:00:00	PMBO (Injection) may occur as early as 57.5 min after launch or as late as 66 min after launch throughout the launch period.
* 95.5	CCS		CCS		Processor CMD		I+0:00:04	CCS updates the following CMDs in the FCP Initialization Table: Enables Heartbeat failure Response, AC7DDB 9600, AC7MDP 3, CC7GY 2, and CC7GY 4.
* 96.0	CCS		AACS	AC7DDB 009600	AACS deadband update		I+0:00:05	P; Y; R; deadband to plus or minus 1.0 degrees.
* 97.0	CCS		AACS	AC7MDP 3	Post burn mode/5-lbf engine control		I+0:00:05	Turns off 100-lbf engines CST sun shutter on
98.0	CCS		AACS	CC7GY 4	Gyro fault test start		I+0:00:11	
* 99.0	CCS	PWR	PROP	CC10F	IPU valve HTRS on		I+0:00:12 -	
100.0	CCS		AACS	AC7TCD 111 000658	Command turn		I+0:00:15	Commanded pitch turn of 114 degrees at 2.88 deg/sec.
* 101.0	CCS	PWR	PROP	CC10H	IPU redundant valve HTRS on		I+0:00:16	
* 102.0	CCS	PWR	PROP	CC10D	AP BR 1 HTRS on		I+0:00:20	TCAPU Branch 1 redundant HTRS
104.0	CCS	PYRO	DEV	DC12B2	Release RTG boom: set 2		I+0:01:02	
105.0	CCS	PYRO	DEV	DC12D	Release science boom		I+0:01:07	
106.0	CCS	PYRO	DEV	DC12B1	Release RTG boom: set 1		I+0:01:12	
* 106.5					End commanded turn		I+0:02:00	Includes 60 seconds settling time
* 106.8					Exit earth shadow	T+1:05:44		Shadow exit varies between T+1:03:08 and T+1:14:50.
107.0					Booms deployed		I+0:06:12	
* 108.0	CCS		AACS	AC7SPM 1012114103	Slew scan platform (EL)		I+0:06:12	Slew to point at calibration target (AZ 9 deg 26 min; EL 109 deg 26 min); not necessary to be completed by earth shadow exit; Parameters given for the slew CMDs are for the VGR-B S/C only; VGR-A S/C parameters are located in Table 3a(II), these commands are S/C independent. Coil heater on after first slew.
	CCS		AACS	AC7SPK 2011017099	Slew scan platform (AZ)			
* 108.3	CCS	PWR	PROP	CC10DR	AP BR 1 HTR off		I+0:07:20	TCAPU Branch 1 redundant heaters off

* Table 3. MJS77 Launch Sequence of Events (cont'd)

Event No.	Source	Via	Desti-nation	Command ID	Command/Event	T-Time	Relative Time	Comments
* 108.5	CCS		FDS	SC06AJ 800	FDS initialization		I+0:10:35	Sets FDS line count to 800; CCS hours and seconds clocks reset at next frame start. Not a parallel CMD.
* 108.6	CCS		CCS		Processor CMD		I+0:10:35	Reset CCS clock.
* 108.7	CCS		FDS	SC06AH 0	Set SCT 60 count		I+0:10:35	Sets SCT 60 count to a known position; follows FDS initialization; also unmasks cruise interrupts (e.g., DTR); stop CCS fast clock test.
* 108.8	CCS		CCS		Enables DTR tic interrupts		I+0:10:35	DTR tic count initialized as soon as tape hits BOT or EOT
* 109.0	CCS	PWR	PROP	CC10FR	IPU valve HTRS off		I+0:11:05	
* 110.0	CCS	PWR	PROP	CC10HR	IPU redundant valve HTRS off		I+0:11:09	
* 111.0	CCS		PYRO	DC10B	Actuate IPU-REA ISO valves		I+0:11:12	Seals off PM and opens compliance device
112.0	CCS		PYRO	DC12E	Jettison propulsion module		I+0:11:17	
					VI. PM jettison to first cruise			
* 112.5	CCS		CCS		Processor CMD		I+0:11:17	CCS updates the following CMDs in the FCP Initialization Table: AC7DDB 4800 and AC7MDP 6, and CC7ML 09.
* 113.0	CCS	AACS	PROP	AC7MDP 6	Mode control		I+0:11:18	All axes inertial mode; TCAPU engine control; DRIRUs remain at high rate. TCAPU primary thruster heaters on; sets TCAPU MOT to 60 ms.
* 113.2	CCS		AACS	AC7PAR 7301 673000	AACS Parameter Update		I+0:11:18	Events 113.2, 113.3, 113.4 updates the S/C rate TLM scale factor for the MM attitude control modes.
* 113.3	CCS		AACS	AC7PAR 7311 673100	AACS Parameter Update		I+0:11:18	
* 113.4	CCS		AACS	AC7PAR 7321 673200	AACS Parameter Update		I+0:11:18	

* Table 3. MJS77 Launch Sequence of Event (cont'd)

Event No.	Source	Via	Destination	Command ID	Command/Event	T-Time	Relative Time	Comments
114.0	CCS		AACS	AC7RCB 1	Register Control CMD		I+0:11:18	Assures ISO valves in correct state. Delete for 2nd launch.
115.0	CCS		PWR	CC4A	Undervoltage trip reset		I+0:11:19	Redundant CMDs in case of undervoltage trip at jettison.
115.5	CCS		RFS	DC2X	RFS command enable		I+0:11:20	Enables CCS outputs to RFS
* 116.0	CCS	PWR	RFS	CC2MP	S-band exciter on		I+0:11:21	CMD in case turned off during PM jettison.
* 116.2	CCS	PWR	MDS	CC3BP	TMU power on		I+0:11:21	CMD in case turned off during PM jettison.
* 116.3	CCS		MDS	CC3A 28101	TMU state select		I+0:11:21	S-band low rate data channel and low subcarrier frequency state (Driver 1 active only) Delete for 2nd launch.
116.4	CCS		FDS	SC06BB 051040	FDS mode select		I+0:11:21	GS-3 mode: LECP near encounter, Eng launch (40 bps downlink - record GS-3 data) Delete for 2nd launch.
* 116.5	CCS		RFS	DC2DR	S-band transmitter low power		I+0:11:22	CMD in case turned off during PM jettison
* 117.0	CCS	PWR	RFS	CC2KP	S-band transmitter power on		I+0:11:23	CMD in case turned off during PM jettison
* 120.3	CCS	PWR	PROP	CC10F	IPU valve HTRS on		I+0:11:26	IPU valve HTRS circuit on to warm TCAPU line and HD (hydrazine disconnect).
* 120.4	CCS	PWR	PROP	CC10H	IPU redundant valve HTRS on		I+0:11:26	IPU valve HTRS circuit on to warm TCAPU line and HD.
* 120.8	CCS		AACS	CC7ML 09	TCAPU fault test enabled		I+0:11:27	For 2nd launch delayed to I+0:14:27
121.0	CCS		AACS	AC7DDB 004800	AACS deadband update		I+0:11:27	Deadband to plus or minus 0.5 degrees
* 121.5	CCS		RFS	DC2A	S-band Ranging on		I+0:16:00	
* 121.7	CCS		FDS	SC06BB 050040	FDS mode select		I+0:20:20	GS-3 mode; LECP far encounter launch format (7.2 kbps on downlink and recorded) for 2nd launch only.
* 122.0	CCS		MDS	CC3A 41131	TMU state select		I+0:21:00	S-band high rate data channel and high subcarrier frequency state (Driver 1 active only). This CMD allows the general science data to be on the downlink (7.2 kbps).
* 123.0	CCS	PWR	PWS	CC23A	PWS on		I+0:21:52	Instrument turn on state determined by FDS launch load (SC23AD 1).

* Table 3. MJS77 Launch Sequence of Events (cont'd)

	Event No.	Source	Via	Destination	Command ID	Command/Event	T-Time	Relative Time	Comments
*	124.0	CCS	PWR	CRS	CC21B	CRS Replacement HTR on		I+0:22:00	
*									
*	125.5	CCS	PWR	LECP	CC25E	LECP LEPT supplemental HTR on		I+0:22:00	Thermostatically controlled.
*	126.0	CCS	PWR	LECP	CC25A	LECP on		I+0:22:09	Four LECP CMD words are sent to put the LECP in its stowed state. The first CMD is stored in the FDS launch load (SC25AH 0000) and is sent on the first FDS frame start following instrument turn on. The three additional CMD words follow on 48 s centers. (Next frame start at I+0:22:11).
*	127.0	CCS	FDS	LECP	SC25AH 2576	Load LECP CMD register		I+0:22:13	
*									
*	129.0	CCS	PWR	PLS	CC32C	PLS replacement HTR on		I+0:22:40	
*	131.0	CCS		CCS		Processor CMD		I+0:23:00	Disable launch option/enables cruise option in PWRCHK routine.
*	132.0	CCS	FDS	LECP	SC25AH 6001	Load LECP CMD register		I+0:23:01	
*	133.0	CCS	PWR	MAG	CC35A	MAG on		I+0:23:28	Instrument turn on state determined by FDS launch load (SC35AI 010002 and SC35AO 010002).
*	134.5	CCS	FDS	LECP	SC25AH 4237	Load LECP CMD register		I+0:23:49	
*	134.6	Deleted							
*	134.7	Deleted							
*	135.0	CCS	PYRO	DEV	DC12C	Release MAG boom		I+0:27:00	
*	136.0	CCS		AACS	AC7RCB 1	Register Control CMD		I+0:27:01	Assures iso valves are in the correct state
*	136.5	CCS		CCS		Processor CMD		I+0:34:59	CCS updates the following CMDs in the FCP Initialization Table: CC7GY 1 and CC7SS 1; and sets time delay to 30 minutes
*	137.0					MAG boom deployed		I+0:35:00	Worst case deployment time
*	138.0	CCS		AACS	CC7GY 1	DRIRU control		I+0:35:00	Capture rate-low

* Table 3. MJS77 Launch Sequence of Event (cont'd)

Event No.	Source	Via	Destination	Command ID	Command/Event	T-Time	Relative Time	Comments
* 139.0	CCS		AACS	AC7TCD 321 001339	CMDed turn to sun point (roll, -14.5 degrees)		I+0:35:00	Turn rate at 3.14 mrad/sec; launch day dependent; at end of sun turns TCAPU MOT is 10 ms in "share mode," Turn angles good for five consecutive launch days (Sun angles change at a rate of 2°/day). Implement using commanded turn block. See Table 3a(III) for subsequent launch days.
* 140.0	CCS		AACS	AC7TCD 221 004737	CMDed turn to sun point (yaw, -51.3 degrees)		I+0:40:00	Implement using commanded turn block. See Table 3a(III) for subsequent launch days. Between launch days of 9/21/77 and 9/23/77 relative time is I+0:40:15.
* 140.2	CCS	FDS	MAG	SC35AI 030001	MAG configuration CMD		I+0:37:00	Automatic range mode
* 140.3	CCS	FDS	MAG	SC35AO 030001	MAG configuration CMD		I+0:37:00	Automatic range mode
* 140.5	CCS		FDS	SC06BB 051070	FDS mode select		I+0:40:20	GS-3 mode, LECP near encounter, Eng cruise
* 140.9	Centaur	PYRO	PYRO/ PROP/ CCS		PYRO/TCAPU/CCS arm A off PYRO/TCAPU/CCS arm B off		I+0:59:20	Backup arm signal off
* 141.0	CCS		AACS	CC7SS 1	Initiate sun acquisition		I+1:05:00	
* 141.5	CCS		FDS	ST06PY 19 2E01	FDS commutator change		I+1:06:00	PRA MUX measurement to position 145.
* 141.6	CCS		FDS	ST06PY 26 E63E	FDS commutator change		I+1:06:00	PPS analyze measurement to position 210.
* 142.0					Sun acquired		I+1:10:00	Roll inertial mode and sun shutter power off automatic.
* 143.0	CCS	FDS	LECP	SC25AH 4220	Start LECP scan		I+1:10:09	Normal scan; fast stepping, SC25AH 4020 for 2nd launch.
* 144.0	CCS	PWR	LECP	CC25B	LECP stepper motor on		I+1:10:10	
* 144.3	CCS	FDS	LECP	SC25AH 1777	Load LECP CMD register		I+1:10:57	
* 145.0	CCS	PWR	PRA	CC22A	PRA on		I+1:11:20	

* Table 3. MJS77 Launch Sequence of Events (cont'd)

	Event No.	Source	Via	Destination	Command ID	Command/Event	T-Time	Relative Time	Comments
*	146.0	CCS	FDS	PRA	SC22AF 5147	PRA configuration CMD		I+1:11:35	CMD to select attenuators
*	147.0	CCS	FDS	LECP	SC25AH 2417	Load LECP CMD register		I+1:11:45	
*	148.0	CCS	PWR	PRA	CC22BP	PRA/PWS antenna deploy motor on		I+1:12:15	
*	149.0	CCS	FDS	LECP	SC25AH 6032	Load LECP CMD register		I+1:12:33	
	149.1	Ground	CCS/ FDS	LECP	SC25AH 7032	Load LECP and register		I+1:12:38	Not parallel command; SC25AH 7072 for 2nd launch
	149.2	Ground	CCS	FDS	SC06BB 050070	FDS mode select		I+1:13:22	Selects LECP far encounter; not parallel command
*	150.0					PRA/PWS antenna deployed		I+1:22:15	
*	150.5	Ground	CCS	RFS	DC2A	S-band ranging on		I+1:24:00	Redundant CMD to test uplink capability.
*	151.0	CCS	PWR	PRA	CC22BRP	PRA/PWS antenna deploy motor off		I+1:27:15	
*	151.5	CCS		FDS	ST06PY 19 3E01	FDS commutator change		I+1:27:15	PPS analyze measurement to position 145.
*	152.0	CCS		FDS	ST06PY 26 E62E	FDS commutator change		I+1:27:15	PRA MUX measurement to position 210.
*	153.0	CCS	PWR	PPS	CC27A	PPS on		I+1:27:15	Instrument turn on state determined by FDS launch load (SC27AE 000 and SC27AF 0001).
*	154.0	CCS	PWR	UVS	CC34B	UVS REPL Htr on		I+1:28:30	
	154.5	CCS	PWR	ISS	CC36JP	ISS NA ELEC REPL Htr on		I+1:28:40	
	154.6	CCS	PWR	ISS	CC36H	ISS WA ELEC REPL Htr on		I+1:28:50	
*	155.0	CCS	PWR	MIRIS	CC39F	MIRIS standby supply on		I+1:29:00	Switches power to MIRIS standby supply A.
	156.0	CCW	PWR	AACS	CC7ML 05	CST power enable		I+1:29:40	
*	157.0	CCS		AACS	AC7TCD 311 058172	CST star map/CMDed turn (roll, +630 degrees)		I+1:32:00	One roll revolution (positive roll) plus angle to vicinity of Canopus. Implement using commanded turn block, see Table 3a(III) for subsequent launch days.

*Table 3. MJS77 Launch Sequence of Events (contd)

	Event No.	Source	Via	Desti- nation	Command ID	Command/Event	T-Time	Relative Time	Comments
*	157.6	CCS	FDS	PPS	SC27AF 0000	PPS configuration CMG		I+2:23:57	Enters PPS table.
*	157.7					Star map/CMDed turn complete		I+2:30:54	Predicted turn end plus 60 sec settling.
*	157.8	Ground	RFS/ CCS	AACS	AC7TCD 321 000923	CMD turn to Canopus (roll)		I+2:45:00	Small turn (nominally, ~10 degrees) to Canopus, determined from star map.
*	158.0	Ground	RFS/ CCS	AACS	CC7CT 07	Canopus acquisition (Flyback and sweep)		I+2:50:00	Canopus acquire within 1 minute, sun sensors biases in within 8 min, gyros off and celestial cruise immediately after biases in, after bias angle insertion the SC position is -11 degrees pitch and +11 degrees yaw.
*	158.1	Ground		CCS		CMD to enable continuance of sequence			To be sent prior to I+2:54:15; nominally at time I+2:50:00.
*	158.2	CCS		CCS		Processor CMD		I+2:54:15	Disable automatic power fail restart sequence
*	158.3	CCS		CCS		Processor CMD		I+2:54:15	Enable RF LOSS routine
*	158.4	CCS		CCS		Processor CMD		I+2:54:15	Enables IRSPWR routine
*	158.5	CCS		CCS		Processor CMD		I+2:54:15	CCS updates the following CMDs in the FCP Initialization Table; CC7ML 05, CC7CT 05, and CC7CT 09.
*	158.6					CCS in individual mode		I+2:54:15	CMDS no longer sent by both processors.
*	158.7	CCS		CCS		Processor CMD		I+2:54:15	Checks for ground enable CMD. If ground enable CMD has not been received, the sequence will stop.
*	158.9	CCS		RFS	DC2D	S-band transmitter high power		I+2:55:00	
*	159.0	CCS		DSS	CC16C 7000	DSS state change		I+2:55:00	Ready mode
*	159.2	CCS		DSS		Slew to TIC 2884		I+2:55:03	Slew time will be less than 6 minutes. Implement tape positioning block.
*	159.5	CCS	PWR	ISS	CC36CP	ISS NA Optics HTR on		I+2:56:00	
*	161.0	CCS		MDS	CC3A 47131	TMU state select		I+3:01:00	S-band high rate data channel and high subcarrier frequency state (Driver 1 active only) (Mod indice change only)

Table 3. MJS77 Launch Sequence of Events (cont'd)

Event No.	Source	Via	Destination	Command ID	Command/Event	T-Time	Relative Time	Comments
* 162.0	CCS		FDS	SC06BB 018070	FDS mode select		I+3:01:00	PB2 data mode (44.8 kbps)
162.1	Ground	CCS	FDS	SC06BB 080070	FDS mode select		I+3:01:06	Not parallel command
* 163.0	CCS		DSS	CC16C 1426	DSS state change		I+3:03:41	Playback launch data; track 6, 33.6 kbps reverse direction. Implement using playback block.
* 164.0	CCS		DSS	CC16C 7000	DSS state change		I+3:58:41	Ready mode; time determined by amount of data recorded.
* 164.1	CCS		DSS		Slew to EOT		I+4:00:00	Implement tape positioning block.
* 164.4	CCS		MDS	CC3A 39131	TMU state select		I+4:10:45	S-band high rate data channel and high subcarrier frequency.
* 164.5	CCS		FDS	SC06BB 501070	FDS mode select		I+4:11:00	CR-2 data mode. Note: The CMD ID parameter contains a known error, but does not affect the sequence (see MJS77-3-290)

*The PLS and CRS shall not be turned on prior to one and two days respectively. This is to prevent corona problems which could damage the instruments. The MIRIS dust cover shall not be released until launch plus 43 hours.

Table 3a. Launch Day Dependent Updates

I. AACS Canopus Cone Angle: C5 for 8/20/77 through 8/30/77 Launches
C4 for 8/31/77 through 9/23/77 Launches

II. AACS Safing Slew Command Parameters:

VGR-A: 1012115103 (EL)
2011017100 (AZ)

VGR-B: 1012114103 (EL)
2011017099 (AZ)

III. Launch Day Dependent Commanded Turn Angles and Command Parameters

Trajectory	Launch Days	Sun Acquisition Turns				Canopus Acquisition Turns	
		Roll		Yaw			
		Angle	CMD Parameters	Angle	CMD Parameters	Angle	CMD Parameters
JSX	8/20/77 - 8/30/77	-14.5	321 001339	-51.3	221 004737	+630	311 058172
JSX	8/31/77 - 9/9/77	+7.4	311 000683	-44.4	221 004100	+625	311 057710
JSX	9/10/77 - 9/20/77	+32.6	311 003010	-37.7	221 003481	+605	311 055863
JSX	9/21/77 - 9/23/77	+44.1	311 004072	-41.7	221 003851	+590	311 054478
JST	8/31/77 - 9/11/77	-0.0	321 000000	-32.9	221 003038	+635	311 058633
JST	9/12/77 - 9/19/77	+29.5	311 002724	-32.9	221 003038	+610	311 056325

Table 3b. FCP Initialization Table Updates

Event	Prelaunch	Preseparation	Burnout	Jettison	Sun Acquisition	Cruise
Table Update Time:		I-00:01:15	I+00:00:04†	I+00:11:17	I+00:34:59	I+2:54:15
FCP/MEM Swap	Enabled	Disabled*	Enabled*	Enabled	Enabled	Enabled
Gyro Rate	--	--	7GY 2*	7GY 2	7GY 1*	7GY 1
AACS Mode	--	--	7MDP 3*	7MDP 6*	7MDP 6	7 MDP 6
Deadband	--	--	7DDB 009600*	7DDB 004800*	7DDB 004800	7DDB 004800
Gyro Fault Test	--	--	7GY 4*	7GY 4	7GY 4	7GY 4
TCAPU Fault Test	--	--	--	7ML 09*	7ML 09	7ML 09
CST Cone Angle	--	--	--	--	--	7CT 05 (1st Launch)* 7CT 04 (2nd Launch)
CST Power	--	--	--	--	--	7ML 05*
Time Delay	--	--	--	--	delay 30 min*	delay 30 min
Sun Search	--	--	--	--	7SS 1*	7SS 1
Canopus Search	--	--	--	--	--	7CT 09*

*Identifies new update to FCP initialization table.
†This time is I+00:00:09 in the A1019 Launch Load.

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168-300

*5.2.2 SAMPLER Phase

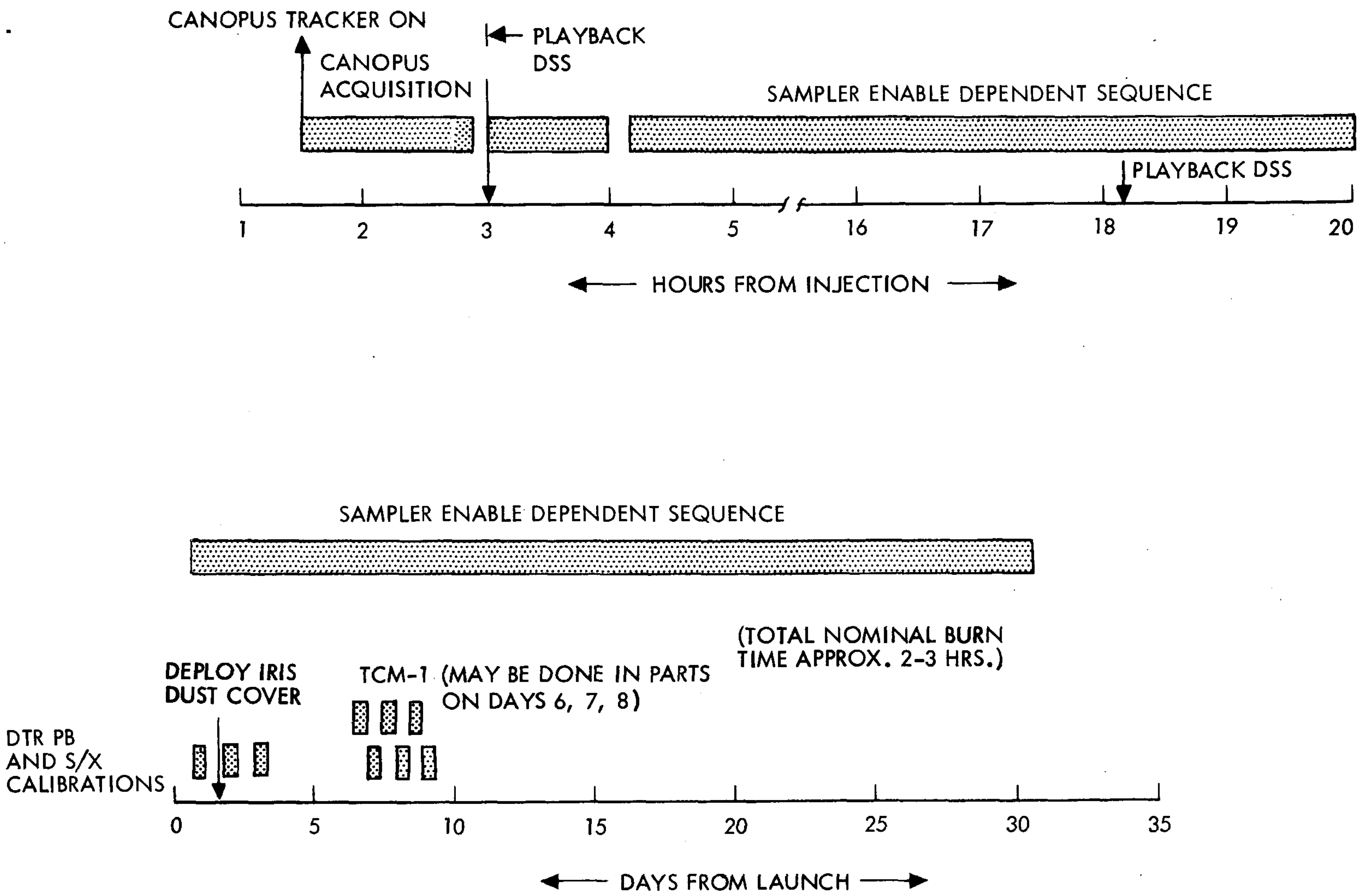
The SAMPLER phase is defined as that part of the mission beginning after celestial references are acquired and ending at launch plus 30 days. In addition to the necessary engineering events, this phase includes engineering and science events supporting a near-Earth science sequence. This near-Earth science sequence shall only be performed if a successful nominal launch has occurred and implemented by a series of CCS load updates. Telecommunications shall be maintained through the LGA. DTR playbacks will be performed using the HGA by maneuvering the spacecraft to Earth point, except for the first couple of playbacks which will be done over the LGA. In general, the SAMPLER phase will include approximately six CCS updates, S/X radiometric calibrations, a rough scan platform calibration, a TCM, which will be performed in parts to satisfy an off-sun orientation thermal constraint, science instrument calibrations, and optical observations of the Earth, moon, and selected stars by the optical instruments. A general timeline of the SAMPLER phase is shown in Figure 2.

*5.2.3 Cruise Early Phase

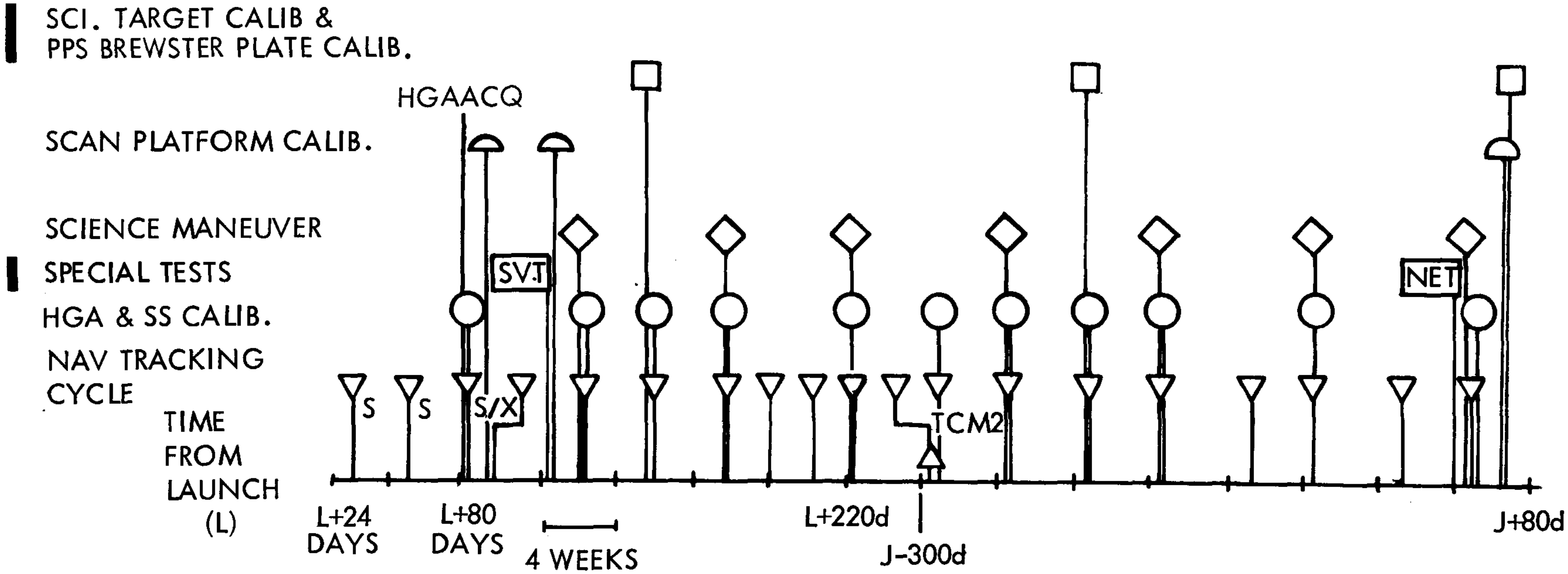
The period from the end of SAMPLER (L+30 days) to L+99 days, (HGA acquisition may be performed prior to L+99 days) shall be known as Cruise Early Phase (CRE). This phase shall maintain the spacecraft in a relatively quiescent state with only necessary engineering and science events being performed. These events include engineering and science calibrations, a clean-up TCM at about L+55 days, to correct injection and TCM-1 errors, an S/X radiometric calibration at about L+56 days and DTR playbacks. There shall be one CCS update planned for CRE.

*5.2.4 Earth-Jupiter Cruise Phase

The Earth-Jupiter Cruise Phase (CR) spans the time from L+99 days and the start of the Jupiter encounter phase. MM activities on each MM during CR include cruise science maneuvers, occurring every eight weeks, scan platform and science instrument calibrations, Canopus star tracker cone angle updates, sun sensor bias updates, sun sensor and HGA calibrations, and TCM-2. Additionally, navigation tracking cycles are performed every four weeks. A science verification test (SVT) will be performed during the first or second CCS load of CR to gain specific performance data for later use in detailed instrument sequence design (e.g., platform slewing/settling, interference effects, FOV alignment, etc.). Also, just prior to Jupiter encounter phase, a near encounter test (NET) shall be performed to check out personnel, procedures, MOS software, and MM on-board programming and sequence of operations. A timeline of CR is shown in Figure 3. A detailed timeline of events for a nominal cruise science maneuver is given in Figure 4.



* Figure 2. SAMPLER Phase

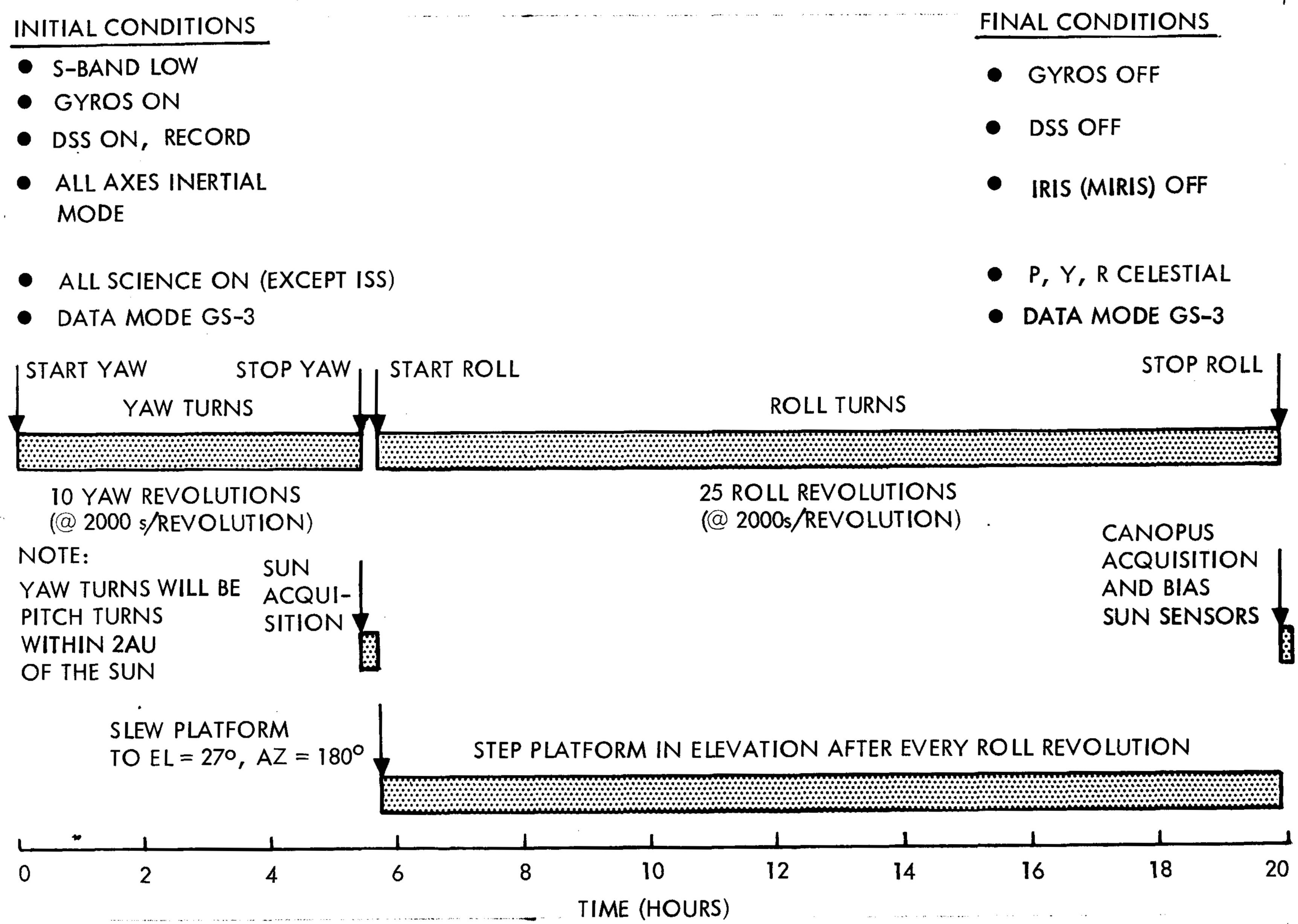


ASSUMPTIONS:

1) TIMING OF EVENTS CONSISTENT WITH MISSION REQUIREMENT DOCUMENT (PD 618-51).
2) CCS UPDATES OCCUR NOMINALLY EVERY FOUR WEEKS.
3) A SCAN PLATFORM CALIBRATION MUST OCCUR PRIOR TO THE FIRST SCIENCE TARGET CALIBRATION.
4) THE FIRST CRUISE SCIENCE MANEUVER OCCURS AFTER SCIENCE TARGET CALIBRATION.
5) FOUR FDS UPDATES OCCUR DURING EARTH-JUPITER CRUISE.
6) THERE ARE TWO NAVIGATION TRACKING CYCLES BEFORE AND AFTER THE SECOND TCM.
7) SS BIAS ANGLES AND CANOPUS TRACKER CONE ANGLE UPDATES WILL BE DONE AS NECESSARY TO MAINTAIN EARTH POINTING AFTER HGA IS ACQUIRED.
8) SS CALIBRATIONS SHALL BE DONE EVERY 14 DAYS FROM L+80 TO L+250 DAYS AND EVERY 28 DAYS FROM L+250 TO J-80 DAYS.

* Figure 3. Earth-Jupiter Cruise Phase (Typical)

MJS77-3-120 B



* Figure 4. MJS77 Cruise Science Maneuver (Every 2 Months)

* 5.2.5 Jupiter Encounter Phase

The Jupiter encounter phase spans the time between J-80 and J+40 days. This phaseis described in terms of five subphases. Figure 5 shows a representative Jupiter encounter phase. Table 4 defines the less commonly known acronyms used in Figures 5 and 7.

* 5.2.5.1 Jupiter Observatory Subphase. Jupiter Observatory subphase (OB) starts at best quoted Earth-based resolution of Jupiter and ends at the start of Jupiter Movie subphase. Times generally associated with the above subphase definitions are J-80 days to J-34 days for JST and J-80 days to J-45 days for JSX. OB provide observance of periodic Jupiter atmospheric phenomena. High rate science data are returned in non-real time. Optical navigation and imaging frames are recorded on the DTR and played back periodically. There will be four CCS updates for JST and three CCS updates for JSX during OB. SS-HGA calibrations, S/X tracking cycles and TCM-3 (for JST) are engineering events that will occur in Jupiter OB.

* 5.2.5.2 Jupiter Movie Subphase. The Movie subphase will occur at J-34 days to J-30 days for JST and J-45 days to J-41 days for JSX. This four day interval is place at a time to provide highest resolution of the fall Jupiter disk with the NA camera's field-of-view. The imaging data will be received in real-time. There shall be no other engineering or science activities, excluding nominal occurring activities, during the Movie subphase.

* 5.2.5.3 Jupiter Far Encounter Subphase. Typically Jupiter Far Encounter subphase (FE) is defined as J-30 days (JST) and J-41 days (JSX) to J-1 day (JST and JSX). During this phase there is a fourth TCM (for JST), TCM-3 and TCM-4 for JSX, CCS updates (will include 9 for JST and 10 for JSX), and more SS-HGA calibrations. S/X doppler and ranging activities are essentially continuous as is real-time science data acquisition. S/X tracking cycles become more frequent. Science and engineering calibrations are performed in a manner to provide optimum performance and data return during the Near Encounter phase which follows.

* 5.2.5.4 Jupiter Near Encounter Subphase. The Near Encounter Subphase is defined between J-1 day and J+1 day. Science data acquisition is most active during closest approach. Earth occultation radio science limb tracking, Io flux tube passage (JST)or Ganymede wake passage (JSX), close observations, phase angle observations, and the UVS solar occultation experiment are prime science events during this subphase. Table 5 shows a representative sequence of MM events required during the occultation period. Data taken during Earth occultation are recorded for later playback. Two CCS updates are planned before closest approach.

* 5.2.5.5 Jupiter Post-Encounter Subphase. Jupiter Post-Encounter subphase (PE) begins at J+1 day and ends at J+35 days for JST and at J+40 days for JSX. End time correspond to latest departure of bow shock crossing events. PE includes Callisto encounter (JST),

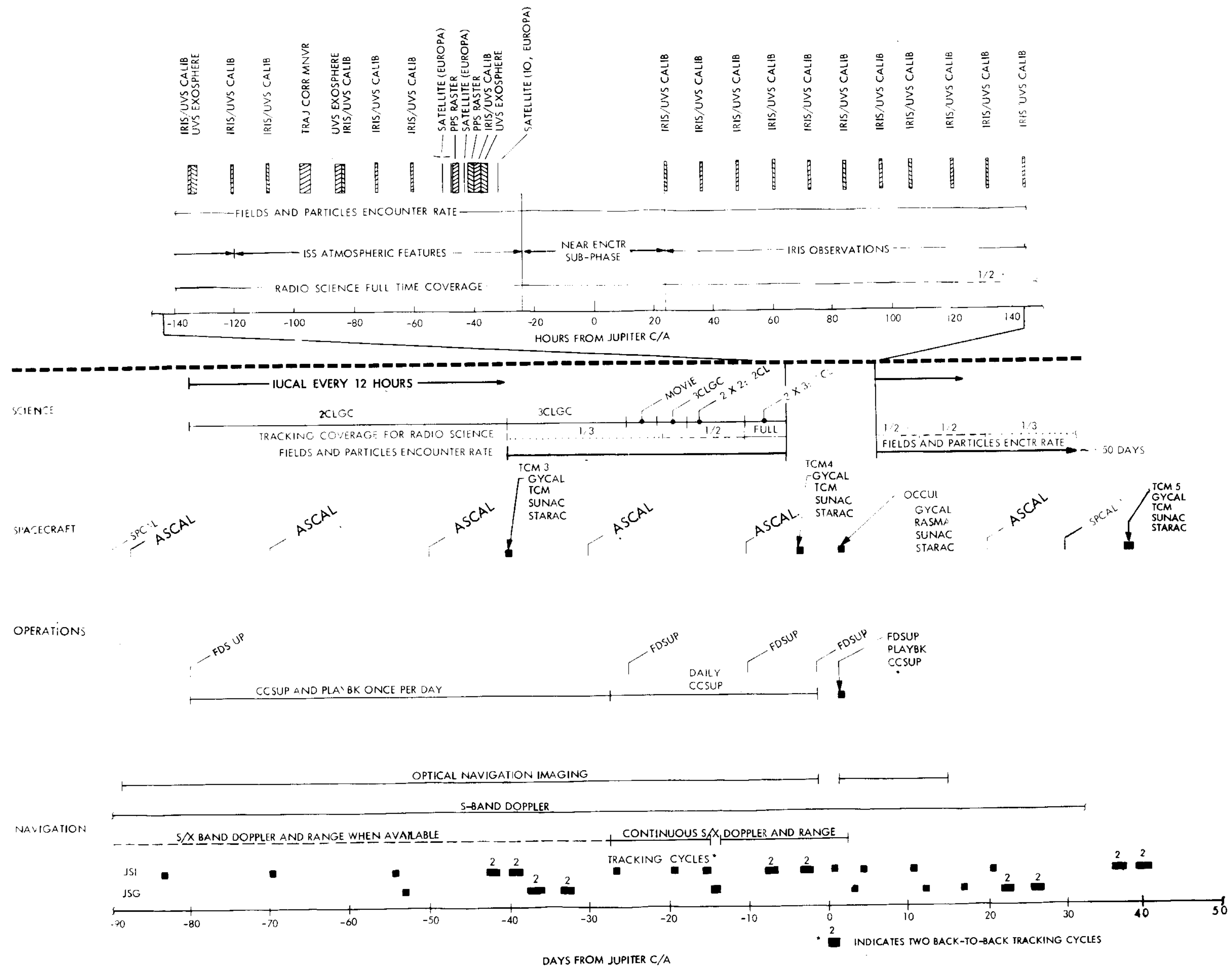


Figure 5. Jupiter Encounter Phase (Representative)

Table 4. Encounter Acronyms Defined

Acronym	Definition
ACSCAL	HGA - Celestial sensor calibration
CCSUP	CCS update
FDSUP	FDS update
GYCAL	Gyro calibration
IUCAL	IRIS/UVS calibration
PLAYBK	Playback
RASMA	Radio science maneuver
SPCAL	Scan platform calibration
STARAC	Star acquisition
SUNAC	Sun acquisition
2CLGC	Imaging two color global circulation observations
3CLGC	Imaging three color global circulation observations

Table 5. Typical UVS/RSS Occultation Sequence (Jupiter)

Event	**Time Relative to Earth Occultation (Hr : Min)
Point of Jupiter Closest Approach	EOI-3:45
Set Up MM Initial Conditions	
FDS Data Mode to GS-3 (Only for Saturn)	
X-band TWT Low Power (Only for Saturn)	EOI-1:00
Begin Uplink Sweep for MM Receiver Acquisition	EOI+0:02-RTLT
Initiate S- and X-band Range Code Transmission	EOI+0.10-RTLT
FDS Data Mode to GS-3 (Only for Jupiter)	EOI-TBD
Start DTR; Record at 7.2 kbps	EOI-0:16
Non-Coherent Two-Way On	EOI-0:15
Begin Requisition of Downlink	EOI-0:15
S- and X-band Telementry Modulation Off	EOI-0:07
S- and X-band Ranging Modulation Off	EOI-0:05
Begin Limb Tracking Maneuver	EOI-0:01.5
Earth Immersion	
Stop Limb Tracking Maneuver (Set Up for UVS Roll)	EOI-0:00
Roll for UVS Solar Ingress Alignment (Trajectory Dependent)	EOI+TBD
Start UVS Solar Observations (GS3)	
FDS Data Mode to OC-1	
Solar Ingress Occurs	
FDS to General Science Data Mode (GS3)	

**EOI = Earth Occultation Immersion (Geometrical)
EOE = Earth Occultation Emersion (Geometrical)

Table 5. Typical UVS/RSS Occultation Sequence (Jupiter) (cont'd)

Event	**Time Relative to Earth Occultation (Hr : Min)
End UVS Solar Observations	
Resume Limb Tracking Maneuver	EOE-TBD
Earth Emersion	EOE-0:00
End Limb Tracking Maneuver	EOE+0:01.5
S- and X-band Ranging Modulation On	EOE+0:05
S- and X-band Telemetry Modulation On	EOE+0:07
Roll for UVS Solar Egress Alignment	
Non-Coherent Two-Way Off	EOE+0:15
FDS Data Mode to OC-1	
Start UVS Solar Observations	
Solar Egress Occurs	
End UVS Solar Observations	
MM to Final Configuration	
SUNAC	
STARAC	
Gyros Off	
DTR Off	
X-band High Power (Saturn)	
FDS Data Mode go GS-3	

**EOI = Earth Occultation Immersion (Geometrical)
EOE = Earth Occultation Emersion (Geometrical)

E/S occultation (JSX) and IRIS/UVS Jupiter darkside observations. TCM-5 will be performed during this subphase and S/X tracking cycles return to their once-per-month frequency after J+10 days.

* 5.2.6 Jupiter-Saturn Cruise Phase

The Jupiter-Saturn cruise phase is defined between J+40 and S-80 days. Mission module activities during this phase includes SS-HGA calibrations (every 56 days), navigation tracking cycles (every four weeks), science maneuvers (every eight weeks), two scan platform calibrations and science instrument calibrations. TCM-6, CST cone angle updates, and sun sensor bias updates will also occur in this phase of the mission. A timeline for this phase is shown in Figure 6.

* 5.2.7 Saturn Encounter Phase

The Saturn encounter phase spans the time between S-80 and S+30 days. This phase has the same basic structure as the Jupiter encounter phase, being divided into four subphases. A representative Saturn encounter is shown in Figure 7 of a JSG encounter sequence.

* 5.2.7.1 Saturn Observatory Subphase. Between S-80 and S-30 days, high rate science data are returned in non-real time. Optical navigation and ISS imaging are recorded on the DSS and played back daily. CCS updates also occur once per week. SS-HGA calibrations and tracking cycles continue to occur periodically. The seventh TCM is executed near the end of this phase.

* 5.2.7.2 Saturn Far Encounter Subphase. The Far Encounter subphase is defined as S-30 to S-1 day. During this phase, the last (eighth) TCM is performed. Frequent CCS and FDS updates are required to support near continuous real-time data acquisition. S/X doppler and ranging are essentially continuous throughout the phase and tracking cycle frequency increases.

* 5.2.7.3 Saturn Near Encounter Subphase. The Near Encounter subphase is defined between S-1 and S+1 day. The spacecraft may be in the roll inertial mode throughout this phase. Data acquired during this period are primarily in real time, with selected imaging and the occultation data being recorded. UVS and radio science occultation data are acquired but without limb tracking for RSS at Titan. At Saturn, the occultations are similar to those at Jupiter.

* 5.2.7.4 Saturn Post-Encounter Subphase. From S+1 to S+30 days, science data are periodically returned in real time. Tracking cycles continue as required.

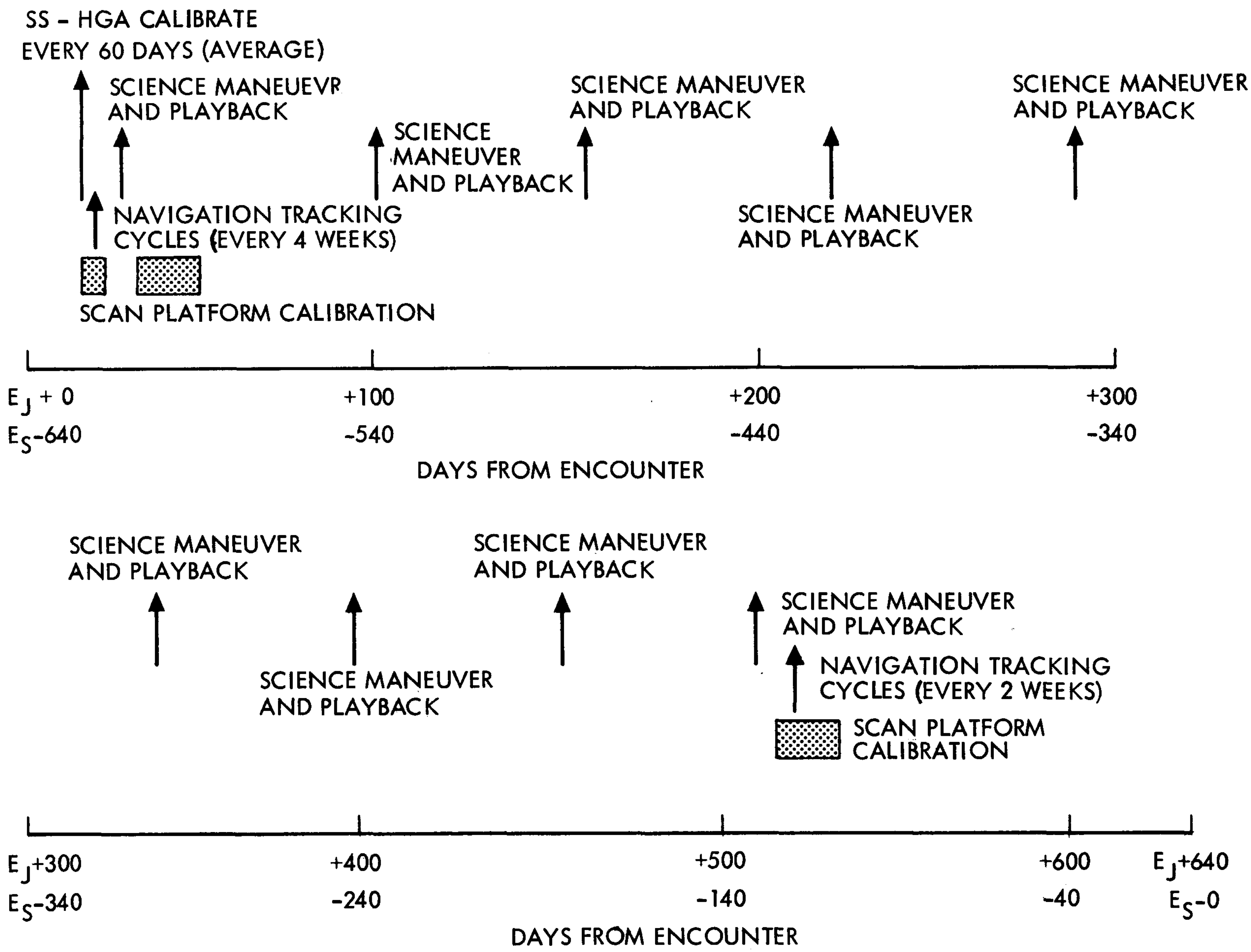


Figure 6. Jupiter-Saturn Cruise Phase

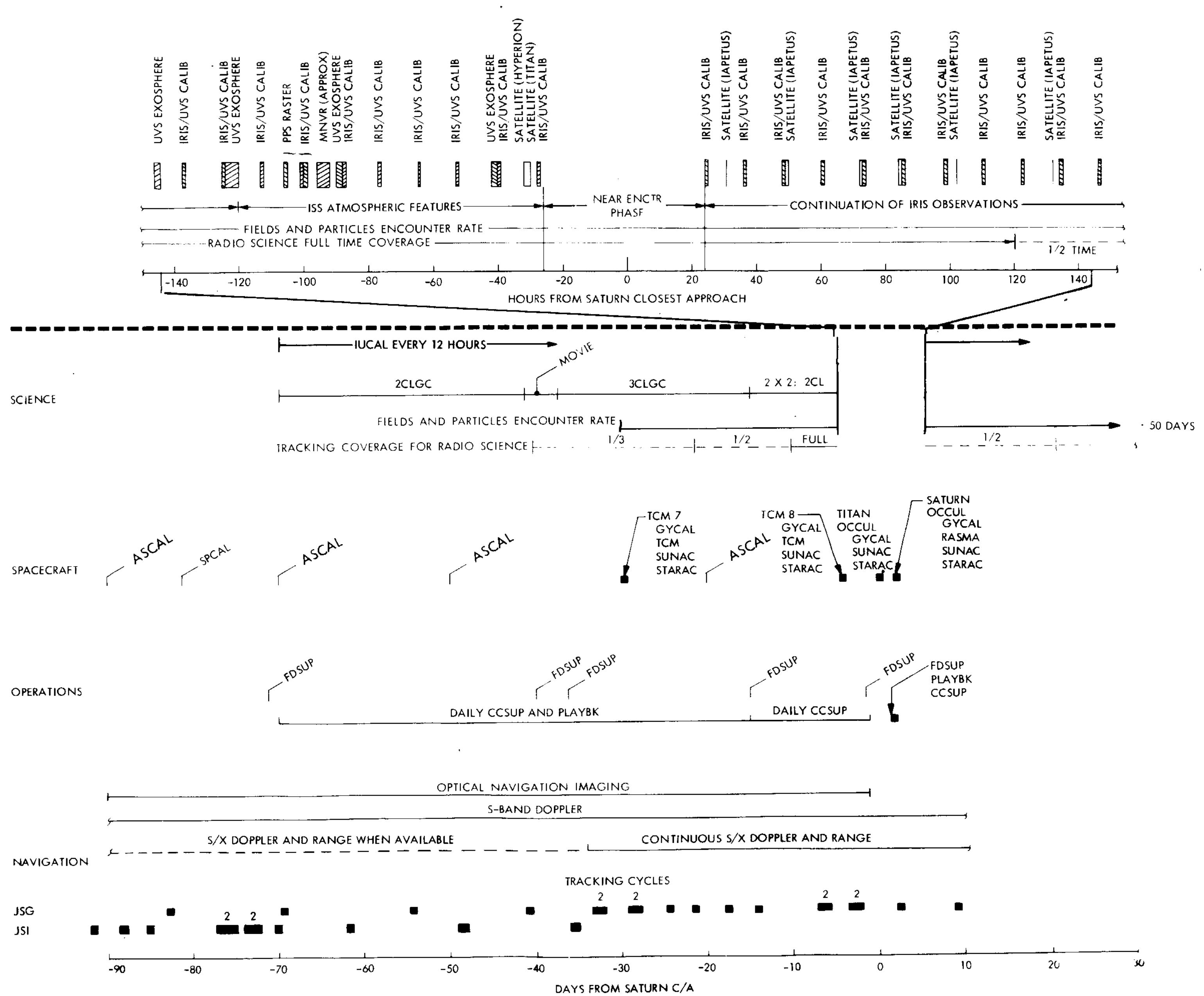


Figure 7. Saturn Encounter Phase (Representative)

* 5.2.8 Post-Saturn Cruise

Although a post-Saturn mission is presently not part of the MJS77 mission and is not being funded, the standard mission is required to be consistent with a possible post-Saturn mission. Depending on the state of the MMs, there is a possibility of obtaining useful data as far out as 20 AU with the X-band telemetry link.

Activities during post-Saturn cruise phase would be similar to those described for the previous cruise phases and would emphasize investigations of field and particles. Science maneuvers would be reduced to every 1 AU from the sun.

* 5.2.9 Uranus Option Encounter Phase

The Uranus option encounter phase is defined in a manner similar to that of Saturn, except a single MM is involved. If a nominal mission has occurred prior to Saturn encounter for both MMs, the MM on a JSX trajectory will be targeted for a Uranus encounter.

REVISION PAGE

Revision	Date	ECRs Incorporated	Comment
Initial Release	22 April 1975		
A	15 Sept 1976	36043, 36054 36086, 36120 36209, 36212 36399	Incorporated in Table 3 Updates Initial Release of of this document
B	12 May 1977	36565, 36621, 36701, 36721, 36773 36797	Updates document per ECRs listed Updates Revision A of this document

(Insert in 618-205, MJS77 Spacecraft Functional Requirements Book)

Custodian: J. G. Beerer

APPROVED:

System: R. F. Draper

F. M. Sturms

J. G. Beerer

JET PROPULSION LABORATORY

No. MJS77-3-130
12 March 1975

FUNCTIONAL REQUIREMENT

MARINER JUPITER/SATURN 1977

STANDARD TRAJECTORIES

✱ Denotes Change

1.0 SCOPE

This document defines the Earth-Jupiter-Saturn heliocentric and near-Earth trajectory space which the spacecraft design must accommodate. The Jupiter and Saturn-centered trajectory space is defined by the aiming point region boundaries set forth in MJS77-3-140, Nominal Aiming Point Selection. Additional data on trajectory parameter ranges may be found in other documents listed in Section 2.0.

2.0 APPLICABLE DOCUMENTS

Except as noted herein, all parts of the following documents of the latest available issue are applicable to this Functional Requirement.

NOTE

MJS77-3-100, Spacecraft Requirements and Constraints, applies to this document. Requirements of other MJS77 level 3 documents may also be applicable. It is the responsibility of the user to adequately acquaint himself with the organization and pertinent content of the level 3 documents, as well as with the material contained herein.

REQUIREMENTS

Jet Propulsion Laboratory

MJS77-3-100	Spacecraft Requirements and Constraints
MJS77-3-140	Functional Requirement, Mariner Jupiter/Saturn 1977 Nominal Aiming Point Selection

OTHER DOCUMENTS

Jet Propulsion Laboratory

618-16	Mariner Jupiter/Saturn 1977 Preliminary Trajectory Characteristics
618-113	Mariner Jupiter/Saturn 1977 Standard Trajectories

3.0 TRAJECTORY CHARACTERISTICS

The trajectory of the mission module (MM) may be divided into six periods: Near-Earth, heliocentric Earth-Jupiter, near-Jupiter, heliocentric Jupiter-Saturn, near-Saturn, and post-Saturn heliocentric. This document is pertinent to all but the near-Jupiter, near-Saturn and post-Saturn periods.

The characteristics of the near-Earth trajectory are determined by the launch date, Jupiter arrival date, and launch azimuth. Specification of launch date and Jupiter arrival date defines the required energy and asymptote direction of the departure geocentric hyperbola.

The MM trajectory characteristics during the heliocentric periods are defined by the launch date and the planet arrival dates. The varying launch times on any given day produce a negligible effect on the characteristics of the heliocentric trajectory.

The trajectory characteristics for the near-planet periods and post-Saturn period are determined by the launch and arrival dates and by the aiming points. The requirements on aiming point selection are specified in MJS77-3-140, Nominal Aiming Point Selection.

4.0 TRAJECTORY REQUIREMENTS

✱ 4.1 General

Two MMs are to be launched in 1977 on trajectories arriving at Jupiter and Saturn in 1979 and 1980/81, respectively. The launch will be conducted from Complex 41 at AFETR. The Titan IIIE/ Centaur D-1 T launch vehicles will be flown in a parking orbit mode in order to place the MJS77 spacecraft on Type-I heliocentric transfer trajectories to Jupiter. The current standard trajectories are defined in 618-113, Standard Trajectories.

4.2 Heliocentric Trajectory

Type I trajectories (those which have heliocentric transfer angles less than 180 deg) which lie nearly in the ecliptic will be used. Figure 1 shows a heliocentric plan view of two trajectories with an 25 August 1977, launch date. For further description of heliocentric trajectories refer to 618-16, Section VI, Preliminary Trajectory Characteristics.

4.3 Ascent Mode

The ascent from launch to injection shall be by way of a 166.8 km (90 nautical mile) parking orbit. Following the second Centaur cutoff the Propulsion Module solid motor will provide the final impulse necessary to achieve the injection velocity.

4.4 Launch Azimuth

Launch azimuths shall be restricted to lie between 80 and 108 deg east of north. As a result yaw steering during the second Centaur burn will be required on some trajectories to achieve the higher asymptote declinations.

✱ 4.5 Launch Dates

The spacecraft design shall be capable of supporting any of the available launch dates. The available launch dates will depend on the launch vehicle performance capability, spacecraft mass and trajectory energy and asymptote declination requirements. The trajectory requirements are given in Figures 3-1 and 3-2 of 618-16. Current launch vehicle performance estimates indicate that a launch opportunity exists from 17 August to 17 September 1977 for a MM mass of 767 kg., assuming a latest Saturn arrival date of 1 June 1981.

4.6 Launch Windows

Daily launch windows shall have a nominal duration of one hour. The nominal window open and closing times are set forth in Near-Earth Tracking Data System Supplementary View Periods and Related Data Documents. Typical window opening times are 1200 to 1500 hours GMT (8:00 to 11:00 EDT).

✱ 4.7 Planetary Arrival Dates

The MM design shall be capable of supporting any Jupiter arrival date from 7 March 1979 through 26 July 1979. The corresponding Saturn arrival dates are 21 November 1980 through 28 September 1981. 7 March 1979 is the earliest Jupiter arrival date that will permit a Jovian passage wherein the 3 MeV equivalent electron fluence level is $\leq 1 \times 10^{13}$ electrons/cm^2 (according to the currently accepted radiation model). Trajectories with Jupiter arrival dates after 26 July 1979 place the MM too near the Solar conjunction at both planetary encounters.

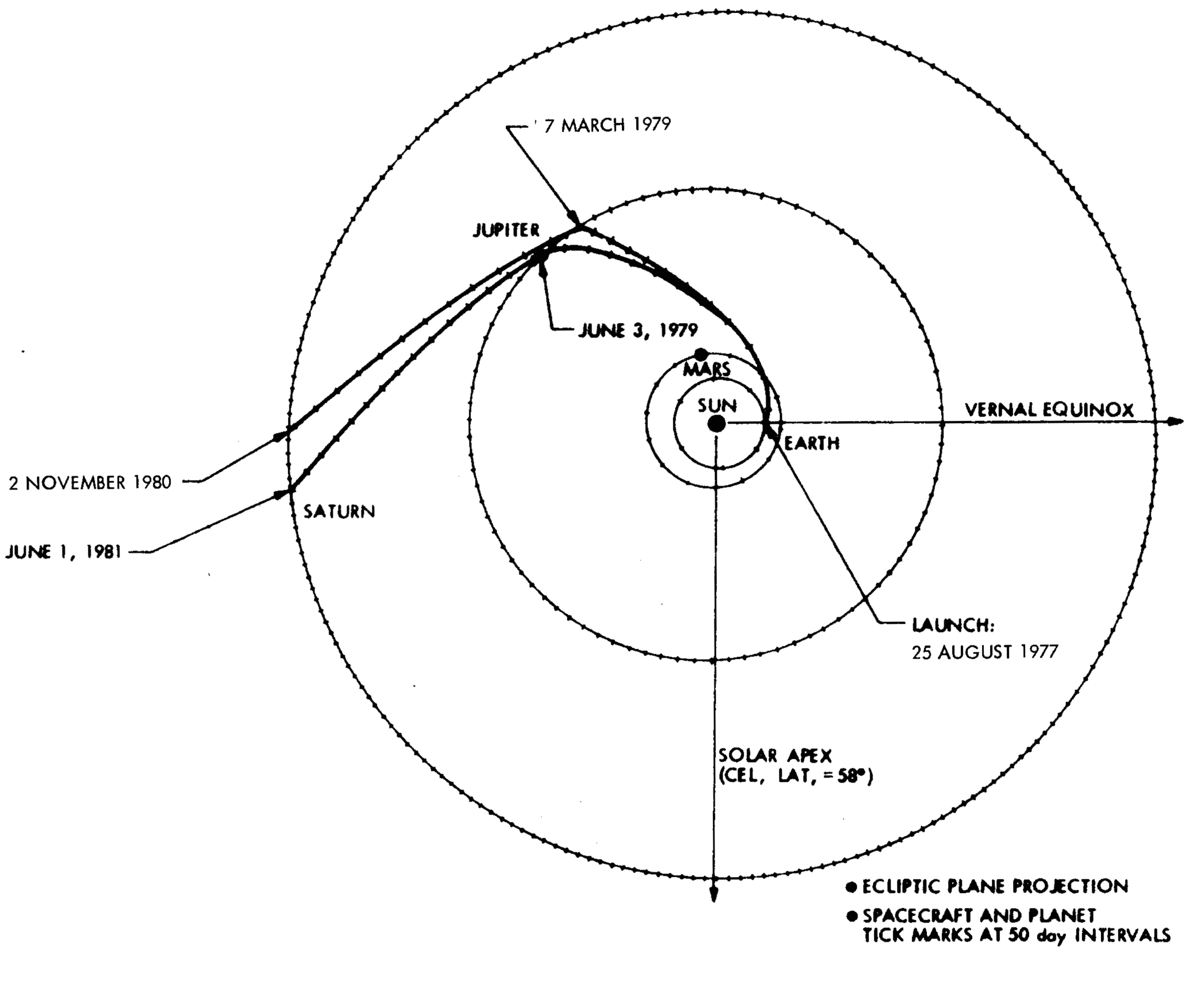


Figure 1. Heliocentric Plan View of Typical Transfer Trajectories

NASA — JPL — Coml., L.A., Calif.

(Insert in 618-205, MJS77 Spacecraft Functional Requirements Book)

Custodian: R. A. Wallace

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JET PROPULSION LABORATORY

No. MJS77-3-140
13 March 1975

FUNCTIONAL REQUIREMENT

MARINER JUPITER/SATURN 1977

NOMINAL AIMING POINT SELECTION

✱ Denotes Change

1.0 SCOPE

This document defines constraints which shall be met in establishing nominal trajectory aiming points Trajectory aiming points and times of closest approach to Jupiter and Saturn are established.

2.0 APPLICABLE DOCUMENTS

Except as noted herein, all parts of the following documents of the latest available issue are applicable to this Functional Requirement.

NOTE

MJS77-3-100, Spacecraft Requirements and Constraints, applies to this document. Requirements of other MJS77 level 3 documents may also be applicable. It is the responsibility of the user to adequately acquaint himself with the organization and pertinent content of the level 3 documents, as well as with the material contained herein.

REQUIREMENTS

Jet Propulsion Laboratory

MJS77-3-100	Spacecraft Requirements and constraints
MJS77-3-240	Functional Requirement, Mariner Jupiter/Saturn 1977 Environmental Design Requirements

* OTHER DOCUMENTS

Jet Propulsion Laboratory

618-16	Mariner Jupiter/Saturn 1977 Preliminary Trajectory Characteristics
618-113	Mariner Jupiter/Saturn 1977 Standard Trajectories

3.0 AIMING POINT DESCRIPTION

3.1 The aiming point can be specified by two components of the impact parameter vector $\overline{B}$ ($\overline{B} \cdot T$ and $\overline{B} \cdot R$) or by the magnitude $\overline{B}$ and its angular orientation, θ. Figure 1 shows the aiming plane definition.

3.2 Encounter (the time of arrival) is defined as the time of closest approach to the planet.

4.0 AIMING ZONE BOUNDARIES

* 4.1 The aiming points at Jupiter shall be selected so that:

a) A trajectory which reaches Saturn is achieved with only small departures from the ballistic path.

b) Closest approach to Jupiter does not violate the radiation constraints specified in MJS77-3-240, Environmental Design Requirements.

*4.2 The aiming points at Saturn shall be selected so that the flyby trajectories satisfy the following requirements:

a) The Mission Module shall not impact Saturn or its rings.

b) Earth and Sun occultation of Saturn shall be achieved on both trajectories. Earth and Sun occultation of Titan shall be achieved on one trajectory. Earth occultation of the rings shall be achieved on one trajectory.

c) Saturn closest approach shall not exceed 10 Saturn radii.

d) Saturn aiming points shall lie off the right side of the aiming plane to assure solar system escape.

5.0 NOMINAL AIMING POINTS

*5.1 Jupiter aiming points for the MJS77 trajectory space are given on Figure 4.7 (Jupiter arrival date), 4.8 (Jupiter periapsis radius) and 4.9 (Jupiter theta) of 618-16, Trajectory Characteristics, as a function of Launch Date and Saturn Arrival Date. A typical Jupiter aiming plane and aiming point which satisfies 4.1a is shown in Figure 2. Jupiter and Saturn aiming points given below are taken from 618-113, Standard Trajectories.

5.1.1 Jupiter aiming points selected for the two reference trajectories are:

a) JSG: $\overline{B} \cdot \overline{T}$ = 1167628 km, $\overline{B} \cdot \overline{R}$ = 77999 km, Jupiter arrival date 4-7-79, 11:27:50 GMT (launch 8-19-77, 15:15 GMT; Saturn arrival date 1-31-81, 16:09:28 GMT).

b) JSI: $\overline{B} \cdot \overline{T}$ = 954420 km, $\overline{B} \cdot \overline{R}$ = 59639 km, Jupiter arrival date 3-7-79, 06:11:15 GMT (launch 8-30-77, 12:45 GMT; Saturn arrival date 11-21-80, 14:26:00 GMT).

*5.2 Saturn aiming points for the MJS77 trajectory space which satisfy the requirements in 4.2 lie in a bounded region in the B-plane and are shown on Figures 5-25, 5-26, and 5-27 of 618-16 for Saturn arrival dates which bound the MJS77 trajectory space. A typical example is shown in Figure 3. Also shown are aiming point loci for close flyby of the satellite Titan.

*5.2.1 Saturn aiming points selected for the two standard trajectories are:

a) JSG: $\overline{B} \cdot \overline{T}$ = 99293 km, $\overline{B} \cdot \overline{R}$ = 276570 km, Saturn arrival date 1-31-81, 16:09:28 GMT (launch 8-19-77, 15:15 GMT; Jupiter arrival date 4-7-79, 11:27:50 GMT).

b) JSI: $\overline{B} \cdot \overline{T}$ = 193954 km, $\overline{B} \cdot \overline{R}$ = 133291 km, Saturn arrival date 11-21-80, 14:26:00 GMT (Launch 8-30-77, 12:45 GMT; Jupiter arrival date 3-7-79, 06:11:15 GMT).

Note: These aiming points are those used for trajectory targetting; close satellite perturbations may slightly alter the values at actual planet closest approach.

6.0 BIASING OF AIMING POINTS FOR PLANETARY QUARANTINE (PQ)

✱ 6.1 Preliminary studies indicate that, for the current standard trajectory design, no biasing of planetary aiming points is necessary to satisfy planetary or satellite quarantine constraints. However, a decision to retarget JSI to Titan during the early part of the Jupiter to Saturn cruise could require biasing for Titan quarantine at a ΔV cost of ≤ 5 m/sec.

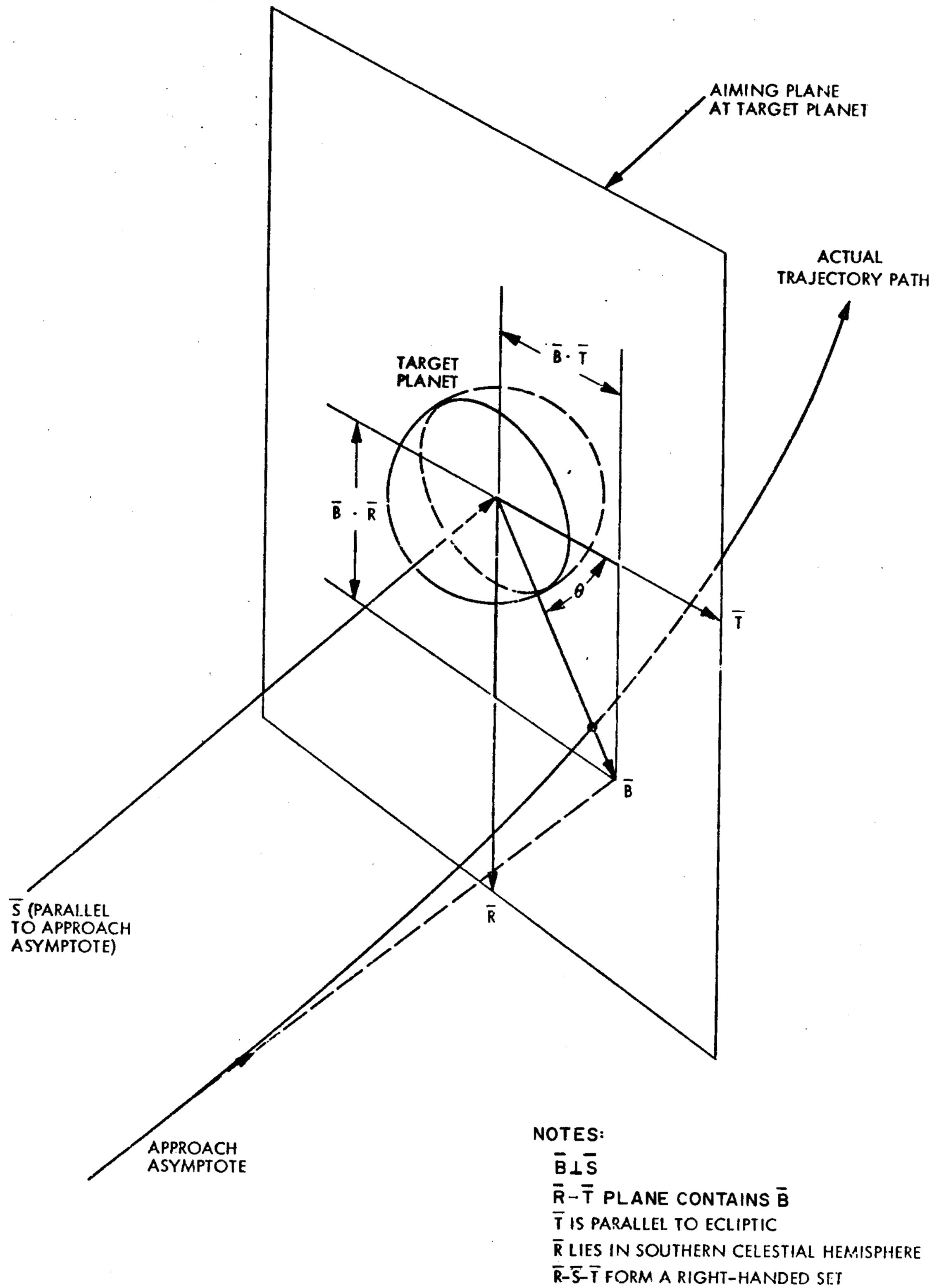


Figure 1. Definition of Target Aiming Plane

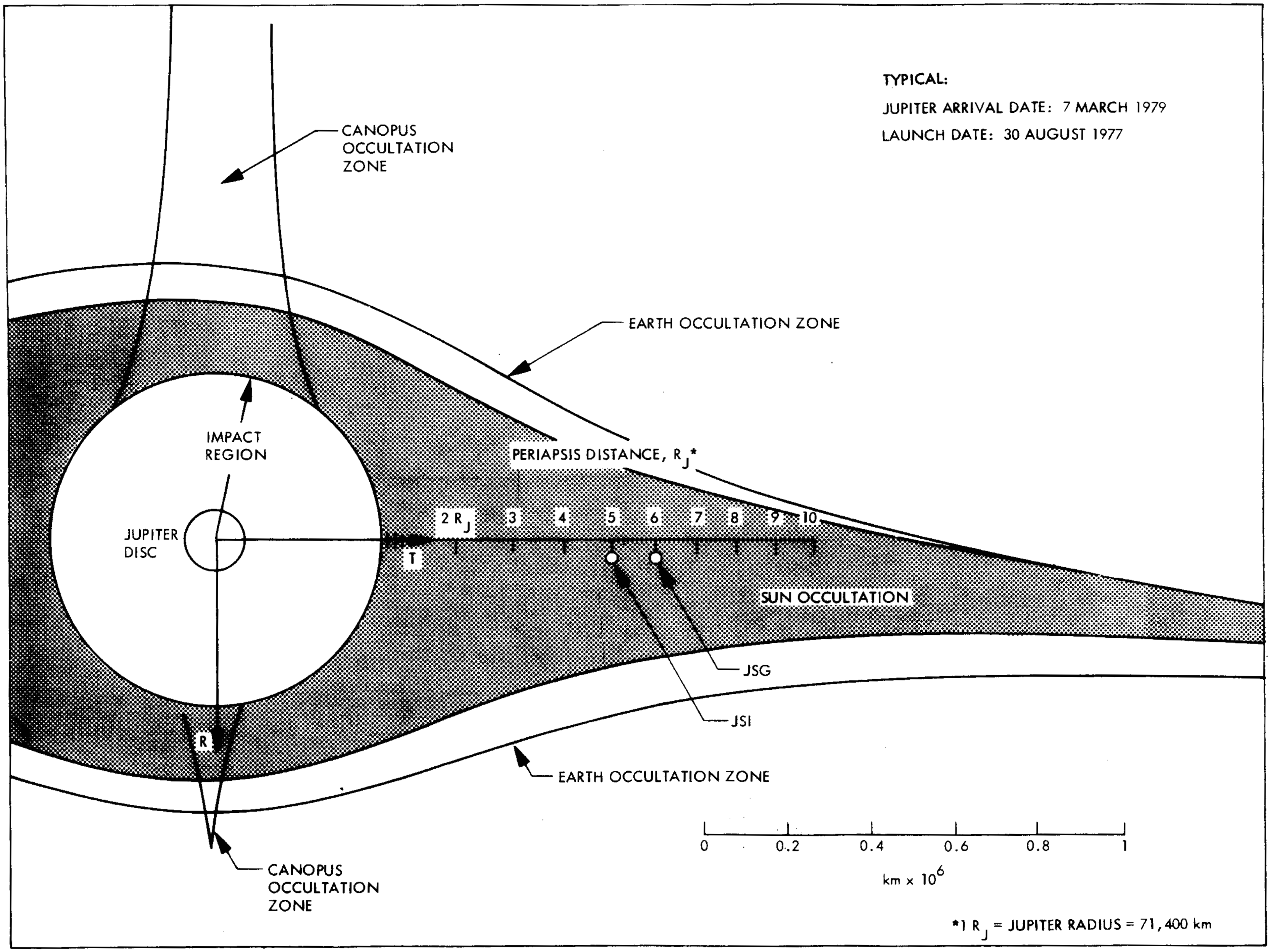
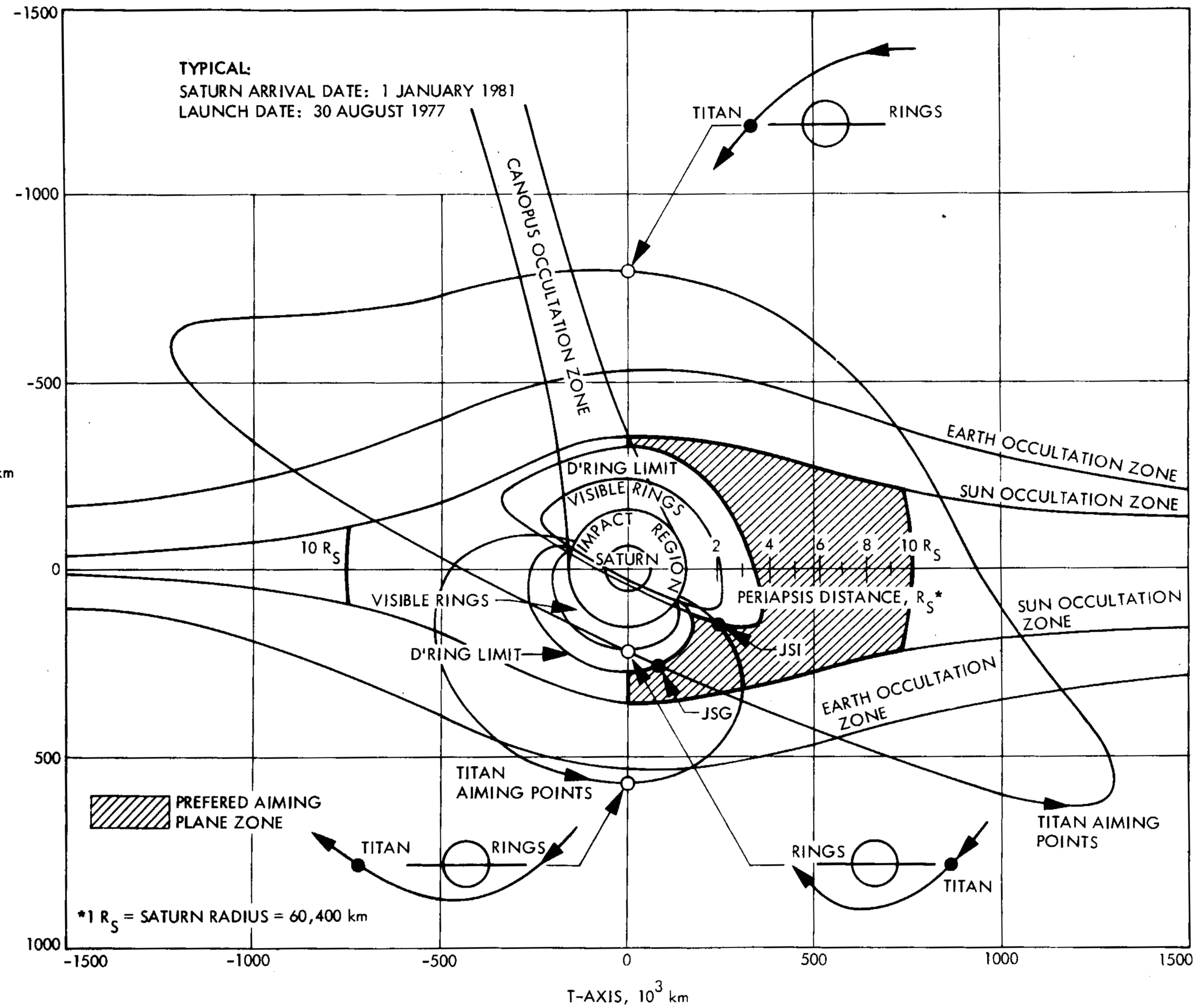


Figure 2. Jupiter Aiming Plane with Constraints

MJS77-3-140



✱ Figure 3. Saturn Aiming Plane with Constraints

NASA — JPL — Coml., L.A., Calif.

(Insert in 618-205, MJS77 Spacecraft Functional Requirements Book)

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System: R. F. Draper

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JET PROPULSION LABORATORY

No. MJS77-3-150
3 April 1975

FUNCTIONAL REQUIREMENT
MARINER JUPITER/SATURN 1977
NAVIGATION

✱ Denotes Change

1.0 SCOPE

This document establishes the requirements on the Mariner Jupiter/Saturn 1977 (MJS77) Spacecraft necessary to conduct the navigation for the MJS77 mission to the accuracies, and within the constraints specified by MJS77 Project Documents 618-51, Mission and Science Requirements Document, Volumes I and II, and 618-114, Planetary Quarantine Plan.

2.0 APPLICABLE DOCUMENTS

Except as noted herein, all parts of the following documents of the latest available issue are applicable to this Functional Requirement.

NOTE

MJS77-3-100, Spacecraft Requirements and Constraints, applies to this document. Requirements of other MJS77 level 3 documents may also be applicable. It is the responsibility of the user to adequately acquaint himself with the organization and pertinent content of the level 3 documents, as well as with the material contained herein.

FUNCTIONAL REQUIREMENTS

Jet Propulsion Laboratory

MJS77-3-100	Functional Requirement, Mariner Jupiter/Saturn 1977 Spacecraft Requirements and Constraints
MJS77-3-140	Functional Requirement, Mariner Jupiter/Saturn 1977 Nominal Aiming Point Selection
MJS77-3-170	Functional Requirement, Mariner Jupiter/Saturn 1977 Functional Accuracies and System Capabilities
MJS77-3-180	Functional Requirement, Mariner Jupiter/Saturn 1977 Configuration
MJS77-3-200	Functional Requirement, Mariner Jupiter/Saturn 1977 Inertial Properties
MJS77-3-300	Functional Requirements, Mariner Jupiter/Saturn 1977 Telecommunications

* OTHER DOCUMENTS

Jet Propulsion Laboratory

PD618-51	Mariner Jupiter/Saturn 1977 Mission and Science Requirements Document, Volumes I and II.
PD618-114	Mariner Jupiter/Saturn 1977 Planetary Quarantine Plan
PD618-115	Mariner Jupiter/Saturn 1977 Navigation Plan

3.0 FUNCTIONAL DESCRIPTION

The purpose of the MJS77 Navigation System is to navigate the Mission Module (MM) from the point of interplanetary injection at Earth to encounters with Jupiter, Saturn, and their natural satellites per the requirements of MJS77-3-140, Nominal Aiming Point Selection. This task shall be performed to a level of precision which will:

a) Meet the accuracy requirements of the science experiments given by PD618-51, MJS77 Mission and Science Requirements Document, Volume II, Science Requirements;

b) Satisfy the planetary and satellite quarantine constraints given by PD618-114, MJS77 Planetary Quarantine Plan;

c) Conform to mission operational constraints.

As a general rule, it is convenient to speak of two basic functions the navigation system performs:

a) <u>Control</u>. With a combination of orbit determination and trajectory correction maneuvers, deliver the MM to a desired target relative trajectory.

b) <u>Knowledge</u>. After the trajectory correction maneuver prior to each planetary encounter has been performed, determine the achieved trajectory to enable delivering the scientific instrument field-of-views to the desired target or aid in the interpretation of scientific data received.

These functions are used in various combinations to perform the three main navigation tasks as shown on Figure 1. They are:

a) <u>Global Trajectory Control</u>. This task consists of a series of Control functions and enables the MM to proceed from the Earth, to Jupiter, and to Saturn, with encounters of selected natural satellites at each planet.

b) <u>Local Trajectory Control and Instrument Pointing</u>. This task consists of a combination of Control and Knowledge functions, and is for the purpose of obtaining the full complement of science data at each immediate target.

c) <u>Post-Flight Trajectory Reconstruction</u>. This task consists of refining the Knowledge of the entire trajectory for the purpose of aiding the interpretation of the science data.

Figure 1 gives specific examples under each of these tasks and indicates the navigation scheme being pursued to accomplish them with a reliability consistent with the impact each task has on the entire mission.

MJS77 NAVIGATION TASKS

	GLOBAL TRAJECTORY CONTROL	LOCAL TRAJECTORY AND INSTRUMENT POINTING CONTROL	POST-FLIGHT TRAJECTORY RECONSTRUCTION
EXAMPLES	JUPITER SATELLITE DELIVERY ACCURACY TO BOUND POST-JUPITER ΔV REQUIREMENT, SWINGBY TO SATURN, RETARGET TO TITAN, PLANETARY QUARANTINE.	SATELLITE DELIVERY CONTROL FOR BEST OCCULTATION, KNOWLEDGE ACCURACY FOR INSTRUMENT POINTING	PRECISE NEAR-ENCOUNTER TRAJECTORY SO OCCULTATION DATA CAN AID IN DETERMINING FIGURE OF PLANETS, SATELLITES.
NAVIGATION PHILOSOPHY	RADIO-PRIME OPTICAL-VERIFICATION	OPTICAL/RADIO-PRIME	ALL DATA RESOURCES AVAILABLE

Figure 1. Navigation Tasks

MJS77-3-150

In order to accomplish the navigation tasks, requirements must be placed on the MM which affect the following:

a) Trajectory correction velocity capability and accuracy.

b) Optical data in the form of images from the Imaging Science Subsystem.

c) Radiometric data - S and X band doppler and range.

4.0 REQUIREMENTS

4.1 Statistical Interpretation and Design Goals

Numerical requirements are stated either in terms of a 99 percent or a 3σ value, depending on which method is thought more appropriate. Using the former method, if the error source identified has an unbiased, univariant normal distribution, the specification is equivalent to identifying the 2.57 standard deviation (σ) value. The 3σ method is used primarily in conjunction with specifying data system performance. In general, 3σ should be interpreted as an upper bound, but when the distribution of the error source is known to be nearly normal, the interpretation can be the literal one - 3 times the rms error. In certain cases a design goal (stated in parenthesis) is also identified. The requirements are necessary to meet mission requirements. Although only the requirements are binding, the design goals are identified to call attention to areas where superior performance could significantly enhance either mission return or reliability.

✱ 4.2 Injection Accuracy

The figure-of-merit (FOM) for injection accuracy is defined as the square root of the trace of the trajectory correction velocity covariance matrix for miss plus time-of-flight, calculated at the time of the first maneuver (L + 10 days). The FOM shall be based upon correcting the "total" error due to all hardware and software error sources from liftoff through Propulsion Module/Mission Module (PM/MM) separation. FOM shall not exceed 21.0 meters-per-second (m/s) (15 m/s) for all launch days except the opening and closing days due to the burn short injection philosophy. The opening and closing day FOM will be the 21.0 m/s with a correction for burn short injection.

✱ 4.3 Propulsion Module/Mission Module Separation ΔV

At the time of the PM/MM separation, the relative separation velocity shall not exceed 1 m/s.

4.4 Maneuver Orientation

The MM shall be capable of performing a trajectory correction maneuver in any arbitrary inertial direction from launch plus 1 day to Saturn encounter minus 2 days.

✱ 4.5 Maneuver Velocity Increment

The MM shall be capable of delivering a total velocity increment for trajectory correction maneuvers of 155 m/s (164 m/s).

✱ 4.6 Minimum and Maximum Maneuver Velocity Increment

The MM shall be capable of applying a velocity increment of between 0.1 m/s and 70 m/s.

✱ 4.7 Number of Maneuvers

The MM shall be capable of performing at least 9 trajectory correction maneuvers. The near Earth maneuver (TCM No. 1) can be performed in segments not to exceed 25 m/s each, if required to maintain temperature control within acceptable limits. In addition, the MM shall be capable of performing small (0.25 to 0.5 m/s) earth line calibration maneuvers, one prior to TCM No. 1 and possibly one prior to TCM No. 5 to reduce maneuver execution errors.

4.8 Maneuver Spacing

The MM shall be capable of performing trajectory correction maneuvers at any time after injection plus six* hours with a minimum separation of 1 day and a maximum separation of 640 (670) days.

4.9 Maneuver Execution Accuracy

The maneuver execution errors shall not exceed the values specified in Table 1.

✱ Table 1. Maneuver Execution Errors (3σ)

ΔV Magnitude		Per-Axis Pointing	
Proportional (%)	Fixed (m/s)	Proportional (mr)	Fixed (m/s)
9.0** 6.0***	0.2	20	0.2
**Without Calibration Maneuver ***With Calibration Maneuver			

*Representative value.

✱ 4.10 Maneuver Profile

A representative MJS77 Maneuver Scenario is given by Table 2. The MM will be required to perform a maneuver sequence approximating that given by the table. However, entries in Table 2 can change (in some cases, dramatically) with mission profile so that the entries should be used in light of the mission profile being considered. (See PD618-115, MJS77 Navigation Plan for more detail.)

✱ Table 2. Representative MJS77 Maneuver Profile

Maneuver	Epoch	Mean ΔV, m/s	ΔV_{99}, m/s
1	Injection +10d	18.6	40.3
2	Jupiter -300d	2.1	6.8
3	Jupiter -30d	1.6	5.9
4	Jupiter -4d	1.7	4.1
5	Jupiter +40d	36.8	47.7
6	Saturn -300d	2.4	7.1
7	Saturn -30d	1.6	3.2
8	Saturn -4d	3.3	7.0
Mission Total		68.2	104.0
Retarget to Titan*		25.0	25.0
Total with Retarget		93.2	129.0

*This item reflects an interest in being able to re-target a MM from its primary aimpoint to a Titan encounter aimpoint. It is an allocation, not a requirement. (See PD618-115 for more detail.)

4.11 Mission Module Mass

The MM mass shall be determined to an accuracy consistent with MJS77-3-200, prior to launch and recalibration prior to each trajectory correction maneuver to an accuracy of 0.5 percent 3σ.

4.12 Mission Module Maneuver Reliability

The MM shall have a reliability of at least 0.99 of being able to perform a trajectory correction maneuver for the period from launch to launch plus 20 days.

The MM shall have a reliability of at least 0.99 of being able to perform a trajectory correction maneuver within 30 days of a previously executed trajectory correction maneuver, or within the period to Saturn encounter following a previously executed maneuver, whichever is less.

The MM shall have a reliability of at least 0.90 of being able to perform a trajectory correction maneuver within 300 days of a previously executed trajectory correction maneuver, or within the period to Saturn encounter following the previously executed maneuver, whichever is less.

✱4.13 Spacecraft Effective Areas

The MM effective areas are defined in terms of the accelerations induced by solar radiation on the MM. With the following parameter definitions:

C_1 = solar constant

M = MM mass,

R = Sun to MM distance,

$\bar{a}$ = MM acceleration due to solar radiation,

$\hat{X}, \hat{Y}, \hat{Z}$ = unit vectors along the primary MM axes, per MJS77-3-180, Configuration,

A_x, A_y, A_z = effective areas for each MM axis, the acceleration is given by:

C = speed of light

$$\bar{a} = \frac{C_1}{CMR^2} \left[A_x\hat{X} + A_y\hat{Y} + A_z\hat{Z} \right].$$

The effective areas of the MM shall be determined to an accuracy of 10 percent of:,

$$\sqrt{A_x^2 + A_y^2 + A_z^2}.$$

4.14 Short Term Impulse Uncertainties

A short term impulse event is any activity, excluding trajectory correction maneuvers, which imparts a translational velocity increment to the MM within a short interval of time. Examples include science maneuvers and attitude control thrust.

Events, with the exception of those scheduled between Injection and Injection plus 1 day, shall, to the extent possible, be scheduled to occur during periods when simultaneous doppler tracking data are being obtained.

The a-priori uncertainty of all short term impulse events shall not exceed those values given by Table 3.

Table 3. Allowable A-priori Uncertainty in Short Term Impulse Events

Mission Phase		Impulse Uncertainty m/s/Week
From	To	
Injection	Injection +10d	0.050
Injection +10d	Jupiter -310d	0.017
Jupiter -310d	Jupiter -100d	0.010
Jupiter -100d	Jupiter -40d	0.170
Jupiter -40d	Jupiter -7d	0.070
Jupiter -7d	Jupiter +2d	0.145
Jupiter +2d	Saturn -310d	0.013
Saturn -310d	Saturn -100d	0.010
Saturn -100d	Saturn -40d	0.170
Saturn -40d	Saturn -7d	0.070
Saturn -7d	Saturn	0.145

4.15 Indigenous Non-Gravitational Accelerations

Accelerations which are effectively constant, or modeled temporally over a two-year period, shall be uncertain to no greater than 1.5×10^{-11} km/s^2 per MM axis.

Accelerations, which are effectively constant or modeled temporally over the 30-day period prior to each planet encounter, and which were not constant or predictable over a two-year period, shall be uncertain to no greater than 3×10^{-12} km/s^2 per MM axis.

Accelerations which are unpredictable in time shall be uncertain to no greater than 3×10^{-12} km/s^2 (3×10^{-13} km/s^2) per MM axis.

During the 30 days prior to Jupiter and Saturn encounter, the changes in the Z-axis component of the MM acceleration resulting from changing Earth-probe-Sun geometry shall be predictable to 10 percent (0.99 probability level) of the acceleration at the start of the subject 30-day period.

4.16 Radiometric Tracking Data

The MM shall be capable of receiving an S-band radio signal, modulated with an appropriate ranging code as required, and transponding the carrier and code at S and/or X band. The accuracy of this process shall be consistent with the requirements set forth by PD618-51, Rev. A, Mariner Jupiter/Saturn 1977 Mission and Science Requirements Document, Vol. I, Tables 5.8.2 through 5.8.6. The requirements on the MM radio frequency subsystem shall be as included in MJS77-3-300, Telecommunications.

* 4.17 Optical Data

Accurate and timely determination of the position of natural satellites relative to background stars is required for Local Trajectory Control and Knowledge and for Post-flight Trajectory Reconstruction. The narrow angle camera of the imaging science subsystem (ISS) shall be used to acquire imaging frames, referred to as "navigation exposures", for this purpose. The natural satellites imaged with background stars will include Io, Europa, Ganymede, and Callisto at Jupiter, and Mimas, Tethys, Rhea, Titan, and Hyperion at Saturn. (Referred to as "Navigation Satellites".)

The MM shall:

a) Be capable of obtaining navigation exposures, approximately 15 or fewer per day, during the period from 90 days before to 30 days after each Jupiter or Saturn encounter.

b) Be capable of pointing the narrow angle camera to an arbitrary inertial direction within the scan limits as specified in MJS77-3-180, Configuration, and to the accuracy as specified in MJS77-3-170, Functional Accuracies and System Capabilities. The image drift (L vector position relative to inertial space for 80 percent of the navigation exposures) shall not exceed 150 μrad in 10 s (100 μrad in 10 s).

The ISS performance shall be such that stars of magnitude 9 (spectral class A through K) shall be detectable with limited real-time data processing. The vidicon reseau pattern (fiducial marks) shall be detectable in all navigation exposures.

Imaging data quality for navigation exposures shall be consistent with the requirements as specified in PD618-51, Vol. 1.

(Insert in 618-205, MJS77 Functional Requirements Book)

Custodian: G. Cunningham

APPROVED:

System: R. F. Draper

G. Jaivin

T. Assefi

G. Cunningham

F. Locatell

JET PROPULSION LABORATORY

No. MJS77-3-170A
22 July 1977

Supersedes
8 July 1975

FUNCTIONAL REQUIREMENT

MARINER JUPITER/SATURN 1977

FUNCTIONAL ACCURACIES AND SYSTEM CAPABILITIES

*Denotes Change from previous issue

1.0 SCOPE

This document establishes the functional accuracies for the Mariner Jupiter/Saturn 1977 (MJS77) flight equipment, defines the maneuver and articulation accuracy capabilities and provides the corresponding statistical error budgets. As such, it specifies the accuracies and capabilities for the following:

a) Execution of trajectory correction maneuvers.

b) Pointing of antennas.

c) Pointing of science instruments.

d) Non-gravitational acceleration magnitude.

e) Execution of launch injection.

2.0 APPLICABLE DOCUMENTS

The following documents form a part of this Functional Requirement.

NOTE

MJS77-3-100, Spacecraft Requirements and Constraints, applies to this document. Requirements of other MJS77 level 3 documents may also be applicable. It is the responsibility of the user to adequately acquaint himself with the organization and pertinent content of the level 3 documents, as well as with the material contained herein.

REQUIREMENTS

Jet Propulsion Laboratory

MJS77-3-100	Functional Requirement, Mariner Jupiter/Saturn 1977 Spacecraft Requirements and Constraints
MJS77-3-150	Functional Requirement, Mariner Jupiter/Saturn 1977 Navigation
MJS77-3-180	Functional Requirement, Mariner Jupiter/Saturn 1977 Flight Equipment, Configuration
MJS77-3-200	Functional Requirement, Mariner Jupiter/Saturn 1977 Inertial Properties

3.0 SPACECRAFT SYSTEM FUNCTIONAL ACCURACY REQUIREMENTS

3.1 General

Mission related functional accuracies determine overall system performance. As a minimum design requirement, the following mission critical spacecraft (S/C) system accuracies (3σ values unless otherwise stated) shall apply. These accuracies are given in terms of control (limits of design uncertainty) and knowledge (limits of measurement uncertainty) and are referenced to the spacecraft coordinate system defined in MJS77-3-180, Configuration.

3.1.1 Trajectory Correction Maneuver Accuracy

Delta V magnitude and pointing errors for trajectory correction maneuvers shall be in accordance with the requirements specified in MJS77-3-150, Navigation. Mission Module (MM) capability is as described in paragraph 5.1 of this document.

3.1.2 High Gain Antenna (HGA) Electrical Boresight Pointing Accuracy

The following HGA electrical boresight pointing accuracies with respect to S/C coordinates shall be achieved. The MM's capability to meet these requirements is described in paragraph 5.2 (Total of both axes).

3.1.2.1 Telemetry Pointing Requirements (Control only)

X-band	S-band
2.5 mrad (0.143°)	15.0 mrad (0.86°)

3.1.2.2 Radio Navigation Pointing Requirements (Control only)

X-band
5.76 mrad (0.33°)

3.1.3 Pointing Accuracy for Scan Platform

To meet the accuracies specified below, the imaging science subsystem (ISS) narrow angle camera pointing shall be calibrated with respect to S/C coordinates in flight with an associated calibration accuracy of 0.58 mrad (0.033°). Paragraph 5.3 of this document analyzes the error allocations related to this requirement. All numbers are per axis and apply only to MM performance (trajectory uncertainties are not included).

Control	Knowledge
2.5 mrad (0.143°)	1.5 mrad (0.086°)

3.1.4 Science Instrument Alignment Accuracies

3.1.4.1 Scan Platform Science Instrument Alignments

* 3.1.4.1.1 Optical Boresight Alignments. The alignment of the scan platform-mounted science instruments shall be as specified below. The alignments provide nesting of the various fields-of-view (FOV), and 64 percent FOV overlap of the infrared interferometer spectrometer and radiometer subsystem (IRIS) FOV and the photopolarimeter subsystem (PPS) FOV. The alignments of the IRIS, PPS, imaging science subsystem wide angle camera (ISSWA), and ultraviolet spectrometer subsystem (UVS) are expressed in terms of their boresight offsets with respect to the boresight of the imaging science subsystem narrow angle camera (ISSNA).

Boresight to Boresight Misalignment with
Respect to ISSNA

Science Instrument	Elevation (mrad)		Cross Elevation (mrad)		Boresight To Boresight (mrad)		Nested Within ISSNA
	Control	Knowledge	Control	Knowledge	Control	Knowledge	
ISSWA	2.47 (0.141°)	0.43 (0.025°)	2.47 (0.141°)	0.43 (0.025°)	3.49 (0.200°)	0.61 (0.035°)	N/A
IRIS/* MIRIS	0.84 (0.048°)	0.28 (0.016°)	0.79 (0.045°)	0.28 (0.016°)	1.15 (0.066°)	0.40 (0.023°)	Yes
UVS	0.91 (0.052°)	0.30 (0.017°)	4.39 (0.252°)	0.56 (0.032°)	Must fall within elevation cross elevation rectangle		Yes
PPS*	0.92 (0.053°)	0.28 (0.016°)	0.85 (0.049°)	0.28 (0.016°)	1.25 (0.072°)	0.40 (0.023°)	Yes

*IRIS-PPS Overlap = 64 percent

* 3.1.4.2 Bus Mounted Science Instrument Alignments.

a) The planetary radio subsystem (PRA) shall be aligned to the MM axes (per axis): within ±8.7 mrad (0.5°).

b) The plasma wave subsystem (PWS) shall be aligned to the MM axis (per axis): within ±8.7 mrad (0.5°).

c) Photopolarimeter subsystem (PPS) polarimetric calibration plate (Brewster Plate): ±5.0 mrad (0.29°).

3.1.4.3 Magnetometer Boom Mounted Instrument Alignment. Instruments mounted on the Magnetometer Boom shall be aligned to the spacecraft (S/C) or other instruments:

a) Each Low Field Magnetometer (LFM) instrument mounting surface to S/C coordinate axes (per axis).

Control	Knowledge
17.45 mrad (1.0°)	12.22 mrad (0.7°)

b) Each LFM instrument mounting surface to its companion LFM instrument mounting surface (per axis).

Control	Knowledge
6.98 mrad (0.40°)	6.98 mrad (0.40°) @ Earth*
	4.36 mrad (0.25°) @ Jupiter and Saturn

c) Each High Field Magnetometer (HFM) instrument mounting surface to S/C coordinate axes (per axis).

Control	Knowledge
6.98 mrad (0.4°)	3.49 mrad (0.2°)

d) Each HFM instrument mounting surface to its companion HFM instrument mounting surface (per axis).

Control	Knowledge
3.49 mrad (0.2°)	1.75 mrad (0.1°)

✻ 3.1.4.4 Science Boom Mounted Instruments. Instruments mounted on the Science Boom shall be aligned to Inertial Space as specified below:

	Control	Knowledge
a) Low Energy Charged Particle Subsystem (LECP)	34.91 mrad (2.0°)	TBD

*4.36 mrad (0.25°) shall be a design goal.

		Control	Knowledge
b)	Cosmic Ray Subsystem (CRS)	34.91 mrad (2.0°)	34.91 mrad (2.0°)
c)	Plasma Subsystem (PLS)	34.91 mrad (2.0°)	4.36 mrad (0.25°)

✱ 3.1.4.5 Science Calibration Surfaces. Science calibration surfaces shall be aligned to the S/C axes as follows:

		Control	Knowledge
a)	Brewster plate (per axis)	±8.7 mrad (0.5°)	±4.3 mrad (0.25°)
b)	Calibration target (per axis)	±8.7 mrad (0.5°)	±8.7 mrad (0.5°)

3.1.5 Non-gravitational Acceleration Magnitude Requirements

The indigenous non-gravitational acceleration requirements shall not exceed the allocation specified in MJS77-3-150. The interpretation of these requirements and an analysis of the MM's capabilities toward meeting these requirements are contained in paragraph 5.4 of this document.

3.1.6 Propulsion Module Figure-of-Merit

The PM figure-of-merit (FOM) is defined in MJS77-3-150. Paragraph 5.5 of this document analyzes the error sources contributing to the FOM.

a) S/C center of mass (CM) - The S/C CM shall be aligned with the S/C coordinate system as defined in MJS77-3-200, Inertial Properties.

b) Variations in the S/C CM subsequent to mass properties verification shall be controlled as defined in MJS77-3-200.

c) The S/C Z axis shall be perpendicular to the launch vehicle interface plane within 2 mrad (0.11°).

4.0 SUBSYSTEM FUNCTIONAL ACCURACIES

4.1 General

The subsystem functional accuracies required to achieve the system accuracies of paragraph 3.1 are specified in the following paragraphs. For convenience, they are grouped according to the responsible subsystem and elements therein. Directional control and knowledge of the S/C's electrical and optical lines of sight are determined using the accuracies specified herein. All accuracies specified are 3σ values unless otherwise noted.

These functional accuracies are mechanical, electrical, and optical in nature.

a) Mechanical functional accuracies consist of alignment tolerances of mounting surfaces and mechanical backlash and mechanical stability.

b) Electrical functional accuracies consist of pointing accuracies of antenna patterns, timing quantization and control accuracies of electronic circuits, electrical null offsets and scale-factor, noise and drift errors.

c) Optical functional accuracies consist of alignment tolerances of sensor optics.

Spacecraft reference planes, cartesian coordinates, spherical coordinates (aximuth/elevation) and the elevation/cross-elevation angles on the scan platform are the four basic means for defining points, lines or positions on the S/C. These coordinate systems are defined in MJS77-3-180.

4.2 Accuracies Provided by the Structure Subsystem

4.2.1 Spacecraft

a) Misalignment of PM coordinate axes with S/C axes.

a) X and Y Axes	±0.5 mrad (0.03°)
b) Z Axis	±0.33 mrad (0.02°)

b) Contribution of MM truss mounting hole patterns (MM and PM interfaces) to radial offset of PM coordinate axes from S/C axes (X and Y axes only)	±0.381 mm (0.015 in.)

4.2.2 Science Platform

a) Scan Platform Gimbal

1) Azimuth axis normal to elevation axis.	2.5 mrad (0.14°)

2)	Azimuth actuator case pin offset angle to boom interface plane.	2.5 mrad (0.14°)
3)	Elevation actuator case pin offset angle with L vector.	2.5 mrad (0.14°)
4)	Misalignment of azimuth actuator drive shaft slot with elevation drive axis.	6.9 mrad (0.39°)
5)	Misalignment of elevation actuator drive shaft slot with the azimuth drive axis.	7.0 mrad (0.40°)

b) Platform Mounting Surface.

1)	L-vector perpendicularity to elevation axis.	2.0 mrad (0.11°)

c) Bus Structure Related Errors.

1)	Azimuth axis angular misalignment to reference plane A.	17.45 mrad (1.0°)
2)	100 day stability of Item 1) at Jupiter/Saturn.	0.33 mrad (0.02°)
3)	Misalignment of azimuth actuator case pin to S/C X axis.	9.0 mrad (0.52°)
4)	100 day stability of Item 3 at Jupiter/Saturn.	0.33 mrad (0.02°)

4.2.3 Structural Alignment Accuracies of Attitude and Articulation Control (AACS) Equipment

4.2.3.1 Dry Inertial Reference Unit (DRIRU) Sensor Subassembly. The inertial sensors subsystem (ISS) package shall be aligned to the S/C coordinate axes within:

a)	X and Z axes.	2.0 mrad (0.115°)
b)	Y axis.	1.4 mrad (0.08°)

4.2.3.2 Canopus Star Trackers

a)	Line across the outboard edge of the alignment pins (parallel to reference plane A) and inclined 35 deg to the MM X-axis (clock error).	2.0 mrad (0.11°)
b)	Canopus star trackers mounting surfaces parallel to reference plane A (cone error).	5.0 mrad (0.29°)
c)	Canopus star trackers mounted surfaces parallel to reference plane A (FOV rotation error).	5.0 mrad (0.29°)

4.2.3.3 Sun Sensors

a)	Angular alignment between the projection of a line normal to the mounting surface onto the pitch plane (Y-Z) and a line normal to reference plane A.	2.2 mrad (0.13°)
b)	Angular alignment between the projection of a line normal to the mounting surface onto the yaw plane (X-Z) and a line normal to reference plane A (rotated 104.7 mrad (6°) about the Yaw axis).	4.1 mrad (0.23°)

4.2.3.4 Scan Platform Azimuth and Elevation Actuators Alignment

a)	Actuator/drive axis interface backlash.	0.50 mrad (0.03°)
b)	Actuator/drive axis windup error for maximum stick friction.	0.7 mrad (0.04°)
c)	Drive axis bearing clearance.	0.0

4.2.4 Structural Alignment Accuracies of Propulsion Equipment

* 4.2.4.1 Propulsion Module (incl IPU) (PM)

a) Each IPU engine (pitch/yaw and roll) mounting hole pattern shall be located in reference to the PM coordinate axes within 1.524 mm (0.060 in.) radius.

b) Each IPU engine (pitch/yaw and roll) mounting surface shall be aligned with the PM coordinate axes within 4.4 mrad (0.25°).

c)	Solid motor bolt circle radial offset from PM coordinate system (in X-Y plane).	±0.038 mm (0.015 in.)
d)	Pointing tolerance of SRM ring centerline with nominal center of mass post-injected S/C. (This is a radial offset uncertainty.)	
e)	S/C (P/M, MM and MM Truss) reassembly alignment tolerance (per axis).	±0.178 mm (0.007 in.)

✱ 4.2.4.2 TCAPU (MM)

a)	Radial offset of hydrazine tank ℄ to S/C Z axis.	±1.27 mm (0.050 in.)
b)	Centroid of hydrazine propellant lines relative to S/C axes.	±6.35 mm (0.25 in.)
c)	Radial offset of TCAPU attitude thruster mounting surface to S/C coordinate system.	±1.524 mm (0.060 in.)
d)	Angular misalignment of TCAPU attitude thruster mounting surface to S/C coordinate system.	±4.36 mrad (0.25°)
e)	Radial offset of trajectory correction thruster support bracket to S/C coordinate system.	0.445 mm (0.0175 in.) Radius
f)	Angular misalignment of trajectory correction thruster support bracket mounting surface to S/C coordinate system.	4.0 mrad (0.23°)

4.2.5 Structural Alignment Accuracies of Mechanical Devices Equipment

4.2.5.1 Magnetometer Boom. Structural and mechanical devices contributions to alignment accuracy of the magnetometer instruments and S/C coordinates or instrument to instrument alignments are presented in the accompanying table. Alignment accuracies of the MM Bus, MAG Boom Outrigger, MAG Boom Support Structure, MAG Boom Damper, AstroMast and Instrument Mounts have been combined into the data of this table. Those combinations for which no knowledge data is shown are not measured subsequent to installation of the instruments. The only contributor to differences between control and knowledge is thermal distortion of the astro mast.

Instrument/ System	Knowledge (mrad)			Control (mrad)		
	X	Y	Z	X	Y	Z
OBLFM-S/C Coord.						
Near Earth	9.93 (0.57°)	8.51 (0.49°)	8.51 (0.49°)	25.39 (1.45°)	15.24 (0.87°)	14.48 (0.83°)
Near Jupiter	6.59 (0.38°)	5.68 (0.33°)	5.68 (0.33°)	12.37 (0.71°)	8.02 (0.46°)	7.78 (0.45°)
Near Saturn	6.04 (0.35°)	5.18 (0.30°)	5.18 (0.30°)	9.48 (0.54°)	6.50 (0.37°)	6.86 (0.39°)
IBLFM-S/C Coord.						
Near Earth	7.33 (0.42°)	4.93 (0.28°)	4.93 (0.28°)	15.59 (0.89°)	5.03 (0.29°)	5.80 (0.33°)
Near Jupiter	5.88 (0.33°)	4.75 (0.27°)	4.75 (0.27°)	8.49 (0.49°)	4.76 (0.27°)	4.96 (0.28°)
Near Saturn	5.69 (0.33°)	4.72 (0.27°)	4.72 (0.27°)	7.20 (0.41°)	4.73 (0.27°)	4.82 (0.28°)
OBLFM-IBLFM						
Near Earth	4.05 (0.23°)	6.67 (0.38°)	6.67 (0.38°)	10.43 (0.60°)	13.48 (0.77°)	10.73 (0.61°)
Near Jupiter	2.66 (0.15°)	3.56 (0.20°)	3.56 (0.20°)	5.01 (0.29°)	6.30 (0.36°)	5.19 (0.30°)
Near Saturn	2.46 (0.14°)	2.97 (0.17°)	2.97 (0.17°)	3.97 (0.23°)	4.74 (0.27°)	3.97 (0.23°)
IBHFM-S/C Coord.	NA	NA	NA	2.58 (0.15°)	2.99 (0.17°)	2.99 (0.17°)
OBHFM-S/C Coord.	NA	NA	NA	2.75 (0.16°)	3.09 (0.18°)	3.09 (0.18°)
IBHFM-OBHFM	NA	NA	NA	1.72 (0.10°)	1.57 (0.09°)	1.57 (0.09°)

4.2.5.2 RTG Boom

a) RTG boom deployment angle inclination to S/C Y axis. ±17.5 mrad (1.0°)

b) RTG boom deployment axis inclination to S/C X axis. 5 mrad (0.29°)

4.2.6 Structural Alignment Accuracies of Antennas

a) Mechanical boresight misalignment and stability of the low gain antenna perpendicular to reference plane A. — 1.1 mrad (0.06°)

b) Mechanical boresight misalignment and stability of the high gain antenna in cone angle to reference plane A. — 1.1 mrad (0.06°)

c) 100 day structural stability of the high gain antenna in cone angle to reference plane A. — 0.25 mrad (0.014°)

4.2.7 Structural Alignment Accuracies of Non-Platform Mounted Science Instruments

a) Cosmic ray subsystem (CRS) mounting surface to S/C coordinates — 17.5 mrad (1.0°) Cone; 17.5 mrad (1.0°) Clock

b) Planetary radio astronomy subsystem (PRA) mounting surface misalignment to plane A. — 2.0 mrad (0.11°) Cone

c) PRA mounting surface misalignment to S/C coordinates. — 4.0 mrad (0.23°) Clock

d) Low energy charged particle subsystem (LECP) mounting surface to S/C coordinates. — 17.5 mrad (1.0°) Cone; 17.5 mrad (1.0°) Clock

e) Plasma subsystem (PLS) mounting surface to S/C coordinates. — 8.7 mrad (0.5°) Cone; 8.7 mrad (0.5°) Clock

f) MAG boom mounting surface
- X Axis — 2.5 mrad (0.14°)
- Y and Z Axes. Per Axis — 3.0 mrad (0.17°)

*4.2.8 Structural Alignment Accuracies of Science Calibration Surfaces

Mounting planes of the science calibration surfaces shall be aligned to S/C coordinates as stated below:

a) Brewster plate angular (per axis) — ±4.3 mrad (0.25°)

b) Calibration target aligned to the S/C X-Z Plane — ±4.3 mrad (0.25°)

*4.2.9 Structural Alignment Accuracies of Scan Platform Mounted Science Instruments

The scan platform instrument mounting surfaces shall be parallel or perpendicular to the ISSNA reference surface as described below.

Instrument Mounting Surface	Reference Surface	Elevation (mrad)		Cross Elevation (mrad)	
		Control	Knowledge	Control	Knowledge
ISSWA	ISSNA	0.6 (0.034°)	0.40 (0.023°)	0.6 (0.034°)	0.40 (0.023°)
IRIS/ MIRIS	ISSNA	0.6 (0.034°)	0.40 (0.023°)	0.53 (0.030°)	0.37 (0.021°)
PPS	ISSNA	0.7 (0.040°)	0.45 (0.026°)	0.6 (0.034°)	0.40 (0.023°)
UVS	ISSNA	0.6 (0.034°)	0.40 (0.023°)	2.45 (0.140°)	0.48 (0.028°)

4.3 Accuracies Provided by the Computer Command Subsystem (CCS)

a) Roll, yaw, and pitch turn duration resolution error (±5 ms). 8.7 ms

b) Max TCAPU shutdown command delay. 5 ms

4.4 Accuracies Provided by the Flight Data Subsystem (FDS)

Measurement uncertainty. ±1/2 DN

4.5 Accuracies Provided by the AACS

* 4.5.1 Celestial Sensor Accuracies

a) Error voltage electronics scale factor stability is: ±7%

b) Null offset tolerance at room temperature, for sun distances between 1.5 and 10 AU, and no light stress* is: 8.73 mrad (0.5°)

c) Null offset stability for all expected mission conditions within the temperature range of 22.5°C to -7.5°C, within the sun distance range of 1 AU to 10 AU, and for the expected light exposure time and angular distributions is: 26.18 mrad (1.5°)

d) Zero error voltage stability for all expected mission conditions within the temperature range of 22.5°C to -7.5°C, within the sun distance range of 1 AU to 10 AU, for the expected light exposure time and angular distributions shall have the following tolerances over the full FOV for the specified sun distance ranges and light exposure times:

1) 1.0 to 1.5 AU and 9 days of light exposure:	7.68 mrad (0.44°)
2) 1.5 to 10 AU and 3 days of light exposure:	2.0 mrad (0.12°)
3) 1.5 to 10 AU and 0.5 days of light exposure:	0.593 mrad (0.034°)

e) Electronic noise: 0.05 volts peak-to-peak

4.5.2 <u>HYPACE Accuracies</u>

a) Sun sensor bias command resolution (1 bit).	0.70 mrad (0.04°)
b) 100 day sun sensor bias calibration accuracy and drift error (per axis).	0.349 mrad (0.02°)
c) 5 year sun sensor bias calibration accuracy and drift error (per axis).	0.87 mrad (0.05°)
d) Limit cycle switching quantization (1 bit).	0.052 mrad (0.003°)
e) Attitude position estimation error (2 bit)	0.105 mrad (0.006°)
f) Attitude position signal quantization error (1 bit).	0.052 mrad (0.003°)
g) Limit cycle null offset due to electronics (per axis).	1.75 mrad (0.1°)
h) Deadband vaiation due to electronics.	±2%

* 4.5.3 <u>DRIRU Accuracies</u>

a) Uncalibrated gyro and integrator drift rate uncertainty (per axis).	9.42 mrad (0.54°)/hr
b) Calibrated gyro and integrator drift rate uncertainty (per axis).	
1) 24 hour duration	3.14 mrad/hr (0.18°)/hr

c)	Gyro sensitive misalignment about each of two orthogonal axes.	1.73 mrad (0.10°)
d)	Command turn rate calibration error per axis.	26.18 mrad/hr (1.5°)/hr
e)	Gyro g sensitive drift rate.	±60.39 mrad/(3.46°)/hr/g

✱ 4.5.4 Articulation Control Accuracies

a)	Scan actuator step resolution.	0.52 mrad (0.03°)
b)	Feedback potentiometer non-linearity.	0.26 mrad (0.015°)
c)	Feedback calibration error.	0.52 mrad (0.03°)
d)	Control loop noise and drift.	10 mV

4.6 Accuracies Provided By The Propulsion Subsystem

4.6.1 Propulsion Module Accuracies

a) IPU Engine Performance.

1) Engine to engine thrust variation (per axis). ±5%

b) Alignment.

1) Thrust vector to nozzle centerline.

(a) Radial offset. ±1.27 mm (0.05 in.)*

(b) Angular misalignment. ±8.73 mrad (0.50°)*

c) Mounting.

1) Radial offset of nozzle centerline relative to outrigger structural mounting hole pattern (5-lb engine) ±0.76 mm (0.030 in.)

* Measured at nozzle throat

2)	Radial offset of nozzle centerline relative to outrigger structural mounting hole pattern (100 lb engine).	±1.27 mm (0.050 in.)
3)	Angular misalignment of nozzle centerline relative to outrigger structural mounting plane. (100 lb engine)	±4.36 mrad (0.25°)
4)	Angular misalignment of nozzle centerline relative to outrigger structural mounting plane. (100 lb engine)	±8.73 mrad (0.50°)

* 4.6.2 Solid Rocket Motor

a) Performance.

1)	Total impulse uncertainty.	±0.75%
2)	Lateral force (measure at nozzle exit).	177.92 n (40 lbf)
3)	Radial offset of thrust vector to nozzle ℄.	1.26 mm (0.05 in.)

b) Alignment.

1)	Radial offset of nozzle ℄ to motor case ℄.	±0.18 mm (0.007 in.)
2)	Angular misalignment of nozzle ℄ to motor case ℄.	0.35 mrad (0.02°)
3)	Misalignment of thrust ℄ and nozzle ℄ (angular and radial).	Included in a)2) above

c) Mounting

1)	Radial offset of motor case ℄ to motor attachment flange (bolt circle - case eccentricity).	±0.25 mm (0.010 in.)
2)	Angular misalignment between motor case ℄ and attachment flange.	0.11 mrad (0.0064°)

d) Center of mass.

1)	Radial offset prior to ignition.	±0.43 mm (0.017 in.)
2)	Radial offset during burn	±0.76 mm (0.030 in.)
3)	Radial offset post-burn	±0.86 mm (0.034 in.)
4)	Radial offset during burn (result of temperature gradient - worst case at end of burn.)	±4.07 mm (0.16 in.)

5) Axial offset before ignition. ±1.78 cm (0.70 in.)

6) Axial offset at end of burn. ±1.78 cm (0.70 in.)

4.6.3 TCAPU Accuracies

4.6.3.1 Thrusters

a) Performance.

1) Thruster to thruster thrust variation. ±5%

2) Pulse impulse predictability.

(a) During cruise. ±20%

(b) During high rate slews. ±50%

3) TCM impulse error (4 thrusters) ±4.82%*

b) Alignment.

1) Thrust vector to nozzle ℄.

(a) Radial offset. ±0.25 mm (0.010 in.)

(b) Angular misalignment. 8.73 mrad (0.50°)

c) Mounting.

1) Radial offset of nozzle ℄ relative to MM mounting surface. ±1.78 mm (0.070 in.)

2) Angular misalignment of nozzle ℄ relative to MM mounting surface. 8.7 mrad (0.50°)

* 4.6.3.2 Liquid Propellant System

a) Center of mass (CM) - propellant in tank relative to propellant tank center.

1) Radial offset at SRM ignition. ±22.86 mm (0.90 in.)

2) Axial offset at SRM ignition. ±5.08 mm (0.20 in.)

* ±2.0% following a 0.2 to 0.5 m/s Earthline Calibration Maneuver.

3) Radial offset at end of SRM burn.	±5.08 mm (0.20 in.)
4) Axial offset at end of SRM burn.	±20.32 mm (0.80 in.)
b) CM of propellant in propellant lines (radial offset).	±6.35 mm (0.25 in.)

4.7 Accuracies Provided by the S/X-Band Antenna Subsystem

4.7.1 High Gain Antenna

Misalignment between the mechanical boresight and electrical boresight. (5 year stability).

a)	S-band (per axis).	0.87 mrad (0.05°)
b)	X-band (per axis).	0.87 mrad (0.05°)
c)	100 day electrical stability of HGA (per axis).	0.18 mrad (0.01°)

4.7.2 Low Gain Antenna

Misalignment between the mechanical boresight and electrical boresight. (5-year stability).

a)	S-band (per axis)	1.75 mrad (0.10°)
b)	100 day electrical stability (per axis)	0.18 mrad (0.01°)

4.8 Alignment Accuracies Provided by Science Instruments

4.8.1 Alignment Accuracies of Non-Platform Instruments

4.8.1.1	Magnetometer (MAG). Misalignment of the MAG sensor coils and the sensor mounting surface (Knowledge) (per axis).	±3.5 mrad (0.20°)
4.8.1.2	Low Energy Charged Particles Subsystem (LECP). Alignment of the centerline of the telescope look angle to the instrument mounting surfaces.	±17.48 mrad (1.0°)
4.8.1.3	Cosmic Ray Subsystem (CRS). Misalignment of the sensor boresight to the instrument mounting surface (per axis).	4.36 mrad (0.25°)
* 4.8.1.4	Plasma Subsystem (PLS). Alignment of the instrument boresight to instrument alignment mirror cube (per axis).	±0.87 mrad (0.05°)
4.8.1.5	Planetary Radio Astronomy Subsystem (PRA). Misalignment of the PRA antenna and the sensor mounting surface (per axis)	4.36 mrad (0.25°)

* 4.8.2 Alignment Accuracies of Scan Platform Instruments

Each scan platform mounted instrument boresight shall be aligned with respect to its own mounting feet as specified below.

Instrument	Boresight to Mounting Feet Alignment				Raster Alignment*
	Elevation		Cross-Elevation		
	Control (mrad)	Knowledge (mrad)	Control (mrad)	Knowledge (mrad)	Knowledge
ISSNA	0.58 (0.03°)	0.145 (0.008°)	0.58 (0.033°)	0.145 (0.008°)	TBD
ISSWA	2.32 (0.13°)	0.323 (0.019°)	2.32 (0.133°)	0.323 (0.019°)	TBD
IRIS	0.1 (0.0057°)	0.01 (0.0006°)	0.1 (0.0057°)	0.01 (0.0006°)	TBD
MIRIS	0.12 (0.00686°)	0.01 (0.0006°)	0.12 (0.00686°)	0.01 (0.0006°)	TBD
UVS	0.35 (0.02°)	0.1 (0.0057°)	0.87 (0.050°)	0.25 (0.014°)	TBD
PPS	0.16 (0.009°)	0.05 (0.0028°)	0.16 (0.009°)	0.05 (0.0028°)	TBD

*Raster alignment refers to the orientation of the central scan line, the scan direction, or the field of view axis of symmetry as appropriate.

* 4.8.3 Scan Platform Alignment Mirror Accuracies

The alignment of the normal to the alignment mirror with respect to the boresight of each scan platform instrument shall be known in elevation and cross-elevation to the accuracies specified below.

Science Instrument	Knowledge (mrad)
ISSNA	0.495 (0.028°)
ISSWA	0.495 (0.028°)
IRIS/MIRIS	0.049 (0.0028°)
UVS	0.262 (0.015°)
PPS	N.A.

The alignment of the normal to the platform alignment mirror with respect to the platform L-vector shall be known in elevation and cross-elevation to within 0.0175 mrad (0.001°).

* 4.8.4 Science Calibration Surfaces

The calibration surface of the Brewster plate and calibration target shall be aligned to their respective mounting planes as specified below.

a) Brewster plate. ±4.3 mrad (0.25°)

b) Calibration target. ±4.3 mrad (0.25°)

5.0 SYSTEM CAPABILITIES

The analysis below describes how the subsystem functional accuracies of Section 4.0 compare to the system accuracy requirements of Section 3.0. Specifically, data is presented for:

a) Maneuver execution.

b) HGA pointing.

c) Science platform pointing.

d) Non-gravitational acceleration magnitude.

e) Launch injection execution.

5.1 Maneuver Execution Accuracy

5.1.1 Interpretation of Maneuver Execution Accuracy Requirements

Maneuver execution accuracy is defined by error in direction and error in magnitude of the ΔV vector. Errors in direction are referred to as "pointing" errors and errors in magnitude are referred to as "ΔV magnitude" errors.

Mission requirements are stated, for maneuver pointing accuracy and maneuver ΔV error. The effects of error sources are expressed in units corresponding to the mission requirements. Values given in radians for pointing accuracy may be re-expressed as the equivalent side velocity by multiplying by its corresponding value of ΔV.

* 5.1.2 Pointing Error

Table 1 shows the MM 3σ total pointing error. The first two columns show the contribution in mrad to the maneuver pointing error and the percent of the variance that contributes to the mission requirement. Pointing error coefficients averaged over all possible pointing directions were used to compute the maneuver pointing error. A Canopus cone angle of 83 deg was assumed for these computations. The total mission requirement value shown is $\sqrt{2}$ times the per-axis value specified in MJS77-3-150.

5.1.3 ΔV Magnitude Errors

Table 2 provides statistical error budgets for the ΔV error sources and lists the resulting ΔV magnitude errors. The errors listed in Table 2 and the mission requirement shown in Table 2 are both expressed as a percentage of the ΔV magnitude. The column titled "% of M/R" gives the percent of the variance of the mission requirement contributed by each error source.

*Table 1. Mission Module Pointing Error

Error Source		3 σ Value	Error (mrad)	% of M/R
1.	Roll Gyro Drift Uncertainty	9.42 mrad (0.54°)/hr		
2.	Yaw Gyro Drift Uncertainty	9.42 mrad (0.54°)/hr	16.42 (0.94°)	33.71
3.	Pitch Gyro Drift Uncertainty	9.42 mrad (0.54°)/hr		
4.	Misalignment of Yaw Gyro About Roll Axis	2.64 mrad		
5.	Misalignment of Yaw Gyro About Pitch Axis	2.23 mrad		
6.	Misalignment of Roll Gyro About Yaw Axis	2.23 mrad	4.82 (0.28°)	2.90
7.	Misalignment of Roll Gyro About Pitch Axis	2.64 mrad		
8.	Misalignment of Pitch Gyro About Yaw Axis	2.64 mrad		
9.	Misalignment of Pitch Gyro About Roll Axis	2.64 mrad		
10.	Roll DRIRU Scale Factor Error	0.5%		
11.	Roll DRIRU Resolution Error	$5.2 \times 10^{-5°}$		
12.	Pitch DRIRU Scale Factor Error	0.5%	9.33 (0.53°)	10.88
13.	Pitch DRIRU Resolution Error	$5.2 \times 10^{-5°}$		
14.	Yaw DRIRU Scale Factor Error	0.5%		
15.	Yaw DRIRU Resolution Error	$5.2 \times 10^{-5°}$		
16.	CST Null Offset	2.2 mrad	1.87 (0.11°)	0.44
17.	CST Non-perpendicularity	5.0 mrad		
18.	Pitch Sun Sensor Null Offset	8.19 mrad	9.67 (0.56°)	11.69
19.	Yaw Sun Sensor Null Offset	8.89 mrad		

*Table 1. Mission Module Pointing Error (contd)

Error Source	3 σ Value	Error (mrad)	% of M/R
20. Pitch Sun Sensor Ground Calibration	0.21 mrad	0.24 (0.01°)	0.01
21. Yaw Sun Sensor Ground Calibration	0.21 mrad		
22. Pitch Sun Sensor Stability	0.70 mrad	0.81 (0.05°)	0.08
23. Yaw Sun Sensor Stability	0.70 mrad		
24. HYPACE Roll Error	0.22 mrad	1.26 (0.07°)	0.20
25. HYPACE Pitch Error	1.08 mrad		
26. HYPACE Yaw Error	1.08 mrad		
27. Roll Limit Cycle Magnitude Error	0.05 mrad	0.07 (4×10^{-3}°)	0.00
28. Pitch Limit Cycle Magnitude Error	0.05 mrad		
29. Yaw Limit Cycle Magnitude Error	0.05 mrad		
30. Limit Cycle Turn Error	1.51 mrad	3.07 (0.19°)	1.18
31. Autopilot Error	---------	6.30 (0.36°)	4.96
Total 3 σ Pointing Error		22.98 (1.32)	66.0
Mission Requirement		28.28 (1.62°)	

✻ Table 2. TCM ΔV Error*

Error Source	3σ Estimate	Error (%)	% of M/R
1. Thrust Errors			
a. Thruster Acceptance Test Error	3.20%		
b. Effects of long term storage and thruster life	2.0%	4.82*	28.7
c. Tank pressure uncertainty	3.0%		
2. Duty Cycle			
a. CG offset	2.54 mm (0.1 in.)		
b. Thrust vector angular misalignment	12.98 mrad (0.74°)	1.23	10.7
c. Thrust mismatch	5.0%		
d. Thruster location	1.78 mm (0.07 in.)		
3. Proportional Timer Uncertainty	0.01%	0.01	0.0
4. Mass Uncertainty	0.25%	0.25	0.1
Total 3σ TCM ΔV Error		4.98*	39.6
Mission Requirement		9.0*	

*Reduce to 2, 2.4, and 6 percent, respectively, following an earthline calibration maneuver of 0.25 to 0.5 mps.

5.1.4 Maneuver Execution Capability

The MJS77 MM meets the mission requirement for maneuver pointing accuracy and maneuver ΔV accuracy.

* 5.2 High-Gain Antenna Pointing Control Accuracy

The antenna pointing control accuracy requirement is interpreted as one which may not be exceeded at any time in mission due to limit cycle motion.

* 5.2.1 Operational Conditions

For the purpose of this document it is assumed that the sun sensor will be electrically biased to compensate for the net mean offset of all control error sources. These include the expected value of noise, ground-calibrated biases and in-flight calibrated offsets.

5.2.2 Calibration Requirements

5.2.2.1 System-Level Ground Calibration. Ground calibration at the system level shall be required to meet the error budgets listed in Table 3.

* 5.2.2.2 In-Flight Calibration. In-flight calibration of the sun sensors (pitch and yaw) shall be performed as required so that along with HGA calibrations and a sun sensor analytical model the error allocations in Table 3 are met. These calibrations are expected to be performed every 20 ±10 days.

* 5.2.3 Pointing Control Error

Table 3 lists the values of the pointing control error sources for X-band, S-band, and Navigation Tracking modes. For the S-band and the Navigation Tracking modes the worst case limit cycle size is combined with the 3σ value representing the contribution of the remaining error sources. For the X-band mode the pointing control error was estimated by means of a Monte Carlo technique. The statistical results obtained from 10,000 samples indicates pointing control requirement is met.

The columns entitled "Relative % of M/R" show percent of mission requirement contributed by each error source.

5.2.4 High-Gain Antenna Pointing Control Capability

The MJS77 MM meets the mission requirements for the high-gain antenna pointing control accuracy.

✻ Table 3. High Gain Antenna Pointing Control

Error Sources	Values	X-Band		S-Band		Navigation Tracking	
		Contribution to Pointing Error (mrad)	Relative % of M/R (in terms of variance)	Contribution to Pointing Error (mrad)	Relative % of M/R	Contribution to Pointing Error (mrad)	Relative % of M/R
1. Attitude Control Limit Cycle Deadband							
a) X-band	±0.87 (0.05°)	1.51 (0.086°)	65.8	---	---	---	---
b) S-band	±8.36 (0.48°)	---	---	11.82 (0.677°)	78.8	---	---
c) Nav. Track.	±2.81 (0.16°)	---	---	---	---	3.97 (0.227°)	68.9
2. Attitude Control Limit Cycle Size Variation							
a) X-band	±17.1%	0.26 (0.015°)	1.9	---	---	---	---
b) S-band	±10%	---	---	1.45 (0.083°)	5.9	---	---
c) Nav. Track.	±17.1%	---	---	---	---	0.83 (0.048°)	8.8

✻ Table 3. High Gain Antenna Pointing Control (contd)

Error Sources	Values	X-Band		S-Band		Navigation Tracking	
		Contribution to Pointing Error (mrad)	Relative % of M/R (in terms of variance)	Contribution to Pointing Error (mrad)	Relative % of M/R	Contribution to Pointing Error (mrad)	Relative % of M/R
3. Sun Sensor Bias Command Resolution	±0.35 mrad (0.02°)	0.60 (0.034°)	10.7	0.60 (0.034°)	1.0	0.60 (0.034°)	4.6
4. Limit Cycle Switching Point Quantization	0.052 mrad (0.003°)	0.052 (0.003°)	0.0	0.052 (0.003°)	0.0	0.052 (0.003°)	0.0
5. Attitude Position Signal Quantization Error	0.052 mrad (0.003°)	0.052 (0.003°)	0.0	0.052 (0.003°)	0.0	0.052 (0.003°)	0.0
6. Attitude Position Estimation Error	0.105 mrad (0.006°)	0.105 (0.006°)	0.3	0.105 (0.006°)	0.0	0.105 (0.006°)	0.2
7. Sun Sensor Bias Command Calibration Accuracy and Drift Error							
a) X-band	0.349 mrad (0.02°)	0.349 (0.02°)	3.5	---	---	---	---
b) S-band	0.873 mrad (0.05°)	---	---	0.873 (0.05°)	2.2	---	---
c) Nav. Track.	0.873 mrad (0.05°)	---	---	---	---	0.873 (0.05°)	9.7

* Table 3. High Gain Antenna Pointing Control (contd)

Error Sources	Values	X-Band		S-Band		Navigation Tracking	
		Contribution to Pointing Error (mrad)	Relative % of M/R (in terms of variance)	Contribution to Pointing Error (mrad)	Relative % of M/R	Contribution to Pointing Error (mrad)	Relative % of M/R
8. Sun Sensor Performance Prediction Accuracy							
a) X-Band/NAV, Track	0.593 mrad (0.034°)	0.593 (0.034°)	10.3	---	---	0.593 (0.034°)	4.5
b) S-Band	2.0 mrad (0.115°)	---	---	2.0 (0.115°)	11.4	---	---
9. Residual Inflight Calibration Accuracy	±0.510 mrad (0.029°)	0.510 (0.029°)	7.5	0.510 (0.029°)	0.7	0.510 (0.029°)	3.3
Total Pointing Error		2.5 mrad (0.143°)	100.0	15 (0.86°)	100.0	5.76 (0.33°)	100.0
Mission Requirement		2.5 mrad (0.143°)		15 (0.86°)		5.76 (0.33°)	

5.3 Scan Platform Pointing Accuracy

5.3.1 Operational Conditions

For the purposes of this section, it is assumed that the attitude is controlled by celestial sensors. It is assumed that the net offset of all position control error sources will be compensated by in-flight biasing of the scan platform position. This includes the expected values of backlash, electro-mechanical offsets and celestial control bias errors. After disturbances affecting the spacecraft attitude, a settling time sufficiently long to reduce the attitude error to within the limit cycle deadband has been assumed.

5.3.2 Calibration Requirements

5.3.2.1 System-Level Ground Calibration. Ground calibration at the system and subsystem levels shall be required to meet the error budgets in Tables 3 and 4.

5.3.2.2 In-Flight Calibration. In-flight calibration shall be capable of realizing a residual in-flight calibration accuracy of 0.58 mrad 3σ value per axis at the scan platform. In-flight calibration sufficient to achieve this residual shall have been completed 30 days prior to the first encounter phase. The ground calibration error budget of Table 5 must be met in order to achieve the in-flight calibration accuracy. In-flight calibration of the sun sensors (pitch and yaw) shall be performed as required so that along with HGA calibrations and a sun sensor analytical model the error allocations in Tables 3 and 4 are met. These calibrations are expected to be performed every 20 ±10 days.

5.3.3 Pointing Accuracy

5.3.3.1 Pointing Control. Table 4 lists the values of the pointing control error sources and gives the 3σ pointing accuracy expressed in mrad corresponding to each error source. The total per axis 3σ pointing control accuracy is given and the column entitled "% of M/R" shows the percent of the variance of the mission requirement provided by each error source. The values shown correspond to the worst scan platform axis after in-flight calibration.

5.3.3.2 Pointing Knowledge. Table 5 provides statistical error budgets for the pointing knowledge error sources. The column entitled "3σ Error" gives the statistical value, expressed in mrad, for each error source. The values are applicable only after ground and in-flight calibration of the scan platform. The total per axis 3σ pointing knowledge accuracy is given and the column entitled "% of M/R" shows the percent of variance of mission requirement provided by each error source. The values shown correspond to the worst scan platform axis. It is assumed that, at the time of the science measurement, sufficient engineering telemetry will be avail able to accurately model the attitude of the MM and platform.

✻ Table 4. Scan Platform Pointing Control

Error Source	Value	3σ Contribution to Control (mrad)	% of M/R
1. Attitude Control Limit Cycle Deadband	±0.87 mrad (0.05°)	1.5 (0.086°)	36.0
2. Attitude Control Limit Cycle Size Variation	±17.1%	0.26 (0.015°)	1.1
3. Limit Cycle Switching Point Quantizitation	0.052 mrad (0.003°)	0.052 (0.003°)	0.0
4. Attitude Position Signal Quantizitation	0.052 mrad (0.003°)	0.052 (0.003°)	0.0
5. Attitude Position Estimation Error	0.105 mrad (0.006°)	0.105 (0.006°)	0.2
6. Sun Sensor Bias Command Calibration and Drift Error (100 days)	0.349 mrad (0.02°)	0.349 (0.020°)	1.9
7. Celestial Sensor Performance Prediction Accuracy	0.593 mrad (0.034°)	0.593 (0.034°)	5.6
8. Sun Sensor Bias Command Resolution	0.698 mrad (0.04°)	0.60 (0.034°)	5.7
9. Scan Actuator Step Resolution	0.524 mrad (0.03°)	0.453 (0.026°)	3.3
10. Feedback Calibration Accuracy	0.524 mrad (0.03°)	0.524 (0.030°)	4.4
11. Scan Control Loop Noise and Drift	10 mV	0.128 (0.007°)	0.3
12. Closed Loop Controller Accuracy	0.50 mrad (0.029°)	0.50 (0.029°)	4.0

✱ Table 4. Scan Platform Pointing Control (contd)

Error Source	Value	3σ Contribution to Control (mrad)	% of M/R
13. Structural Unrelieved Windup Error	0.70 mrad (0.040°)	0.70 (0.040°)	7.8
14. Drive Axis Bearing Clearance	0.0 mm (0.0 in.)	0.0 (0.00)	0.0
15. Scan Actuator/Drive Axis Interface Backlash	0.5 mrad (0.029°)	0.50 (0.029°)	4.0
16. Scan Platform Residual Inflight Calibration Accuracy	0.58 mrad (0.033°)	0.58 (0.033°)	5.4
17. Structure 100 Day Stability	0.33 mrad (0.019°)	0.33 (0.019°)	1.8
Total 3σ Scan Platform Pointing Accuracy (per axis)		2.26 (0.129))	81.5
Mission Requirement (M/R)		2.50 (0.143)	

5.4 Non-Gravitational Acceleration

5.4.1 Interpretation of Non-Gravitational Acceleration Requirements

Solar and RTG radiation interactions with the MM produce accelerations which are effectively constant (or otherwise modeled temporally) over a two-year time span. TCAPU thruster leakage and propulsion system leakage produce accelerations which are effectively constant (or otherwise modeled temporally) over the 30 day period prior to each planet encounter. Angular and translational misalignments of the thrusters, center of gravity migration, thruster firing differences due to TCAPU plume impingement, and unbalanced side forces produce accelerations which are unpredictable with time. Mission requirements are specified for the 3σ per axis uncertainties associated with each of these three MM non-gravitational acceleration modes. The units of acceleration are expressed in km/s^2.

*Table 5. Scan Platform Pointing Knowledge

Error Source	Value	3σ Contribution to Knowledge (mrad)	% of M/R
1. Attitude Control Limit Cycle Telemetry Resolution	0.122 mrad (0.007°)	0.106 (0.006°)	0.5
2. Attitude Control Limit Cycle Telemetry Calibration Accuracy and Drift Error	0.061 mrad (0.0035°)	0.061 (0.0035°)	0.2
3. Attitude Control Limit Cycle Motion (20 μrad/sec, 12 sec* between measurements)	0.120 mrad (0.0069°)	0.120 (0.0069°)	0.6
4. Sun Sensor Bias Command Calibration and Drift Error (100 days)	0.349 mrad (0.02°)	0.349 (0.020°)	5.4
5. Celestial Sensor Performance Prediction Accuracy	0.593 mrad (0.034°)	0.593 (0.034°)	15.6
6. Scan Actuator Step Resolution	0.524 mrad (0.03°)	0.453 (0.026°)	9.1
7. Feedback Calibration Accuracy	0.524 mrad (0.03°)	0.524 (0.030°)	12.2
8. Scan Control Loop Noise and Drift	10 mv	0.128 (0.0073°)	0.7
9. Structural Unrelieved Windup Error	0.70 mrad (0.040°)	0.70 (0.040°)	21.8
10. Drive Axis Bearing Clearance	0.0 mm (0.0 in.)	0.0 (0.00°)	0.0
11. Scan Actuator/Drive Axis Interface Backlash	0.5 mrad (0.029°)	0.5 (0.029°)	11.1

✱ Table 5. Scan Platform Pointing Knowledge (contd)

Error Source	Value	3σ Contribution to Knowledge (mrad)	% of M/R
12. Scan Platform Residual Inflight Calibration Accuracy	0.58 mrad (0.033°)	0.58 (0.033°)	15.0
13. Structure 100 Day Stability	0.33 mrad (0.019°)	0.33 (0.019°)	4.8
Total 3σ Scan Platform Pointing Knowledge Accuracy (per axis)		1.48 (0.084°)	97.0
Mission Requirement (M/R)		1.5 (0.086°)	

5.4.2 Non-Gravitational Acceleration

Except as noted Table 6 shows the Z-axis non-gravitational acceleration uncertainties associated with the MM. The Z-axis was chosen because, except for the encounters, it represents the worst case results of the analysis. Note that the results shown herein pertain to the thrust configuration consisting of eight thrusters parallel to the X-axis providing roll and yaw moments and four thrusters in the Y-Z plane providing pitch moments. Table 7 illustrates the relative contributions of various sources of unpredictable non-gravitational acceleration to the composite total. The relative contributions of the various sources vary considerably from axis to axis and therefore the results shown are not typical of all axes.

✱ 5.4.3 Design Capability

The MJS77 MM meets the mission requirement for the uncertainty of the constant acceleration (over two years) after launch plus 150 days. The mission requirement for the uncertainty of the constant acceleration (30 days prior to encounter) is met. The mission requirement for the uncertainty in the acceleration which is unpredictable in time is met only in the E-5 to E+3 day time period.

5.5 Propulsion Module Figure-of-Merit

5.5.1 Interpretation of the Propulsion Module Figure-of-Merit (FOM)

A measure of launch vehicle injection accuracy is the FOM which is defined as the square root of the trace of velocity covariance matrix for the first trajectory correction maneuver (TCM). The

Table 6. Mission Module Non-gravitational Acceleration

A. Uncertainty in acceleration which is effectively constant over a two year period	
Mission Requirement	1.5×10^{-11} km/s^2 (3σ) (per MM axis)
System Capability	$<4.4 \times 10^{-11}$ km/s^2 (3σ) for all time L + 150 days $<1.5 \times 10^{-11}$ km/s^2 (3σ) for all time L +150 days
B. Uncertainty in acceleration which is effectively constant over the 30 day period prior to encounter	
Mission Requirement	3×10^{-12} km/s^2 (3σ) (per MM axis)
System Capability	3×10^{-13} km/s^2 (3σ)
C. Uncertainty in acceleration which is unpredictable in time	
Mission Requirement	From E-4 to E+4 3×10^{-11} km/s^2 (3σ) (Z Axis) All other time periods 3×10^{-12} km/s^2 (3σ) (Z Axis)
System Capability	Cruise (0.5° deadband) 5×10^{-13} km/s^2 (3σ) Cruise (0.17° deadband) 4.7×10^{-13} km/s^2 (3σ)

Encounter (km/s^2, 3)

Time Period	X Axis	Y Axis	Z Axis
E-10 days to E-8 days	2.7×10^{-12}	3.6×10^{-11}	1.3×10^{-11}
E-8 days to E-5 days	1.1×10^{-12}	1.0×10^{-11}	4.4×10^{-11}
E-5 days to E+1 days	2.5×10^{-12}	3.2×10^{-11}	1.2×10^{-11}
E+1 days to E+3 days	1.5×10^{-12}	1.7×10^{-11}	6.6×10^{-11}
E+3 days to E+10 days	1.0×10^{-12}	8.4×10^{-11}	3.6×10^{-11}

*A detailed breakdown of error sources is shown in Table 7.

*Table 7. Detailed Breakdown of Unpredictable Non-gravitational Acceleration (E-4 to E+4 Period, 2 Axis)

Source	Magnitude	Non-gravitational Acceleration (km/s^2) (Z-Axis)	Percent of Variance
1. Angular Misalignment			
a) Misalignment between actual thrust vector and geometric centerline of thruster	8.73 mrad (0.50°)	4.30×10^{-12}	19.9
b) Misalignment between thruster mounting surface and bus mounting surface	8.73 mrad (0.50°)	4.30×10^{-12}	19.9
c) Misalignment between bus mounting surface and bus reference plane	4.94 mrad (0.283°)	2.44×10^{-12}	6.4
2. Thrust vector translational offset	2.54 mm (0.1 in.)	7.17×10^{-13}	0.6
3. Unbalanced side force	±0.873 mrad (0.05°)	6.55×10^{-13}	0.5
4. Thruster firing differential caused by pitch TCAPU plume impingement		7.01×10^{-12}	52.7
	RSS Total	9.65×10^{-12}	100.0

first TCM is nominally at launch plus six days. FOM is expressed in units of meters per seconds (m/s).

✻ 5.5.2 Figure of Merit

Calculation of the FOM is based on the most recent launch vehicle guidance analysis performed for MJS77. (GD/C analysis dated 17 May 1976, reference 667-5-76-053). This analysis utilized four trajectories representing different launch days. A "worst case" trajectory was chosen from which to derive the Centaur performance and FOM sensitivity coefficients for propulsion module pointing errors and velocity shutoff error. Utilizing these coefficients, the effect of pointing accuracy and velocity shutoff accuracy on the FOM was determined. Table 8 indicates the error sources, their 1σ value, the resulting FOM, and the percent contribution of the variance of the mission requirement FOM.

✻ 5.5.3 Propulsion Module Capability

The PM currently meets the injection accuracy FOM mission requirement.

✻ Table 8. Propulsion Module Figure of Merit

	Error Source	1σ Value	FOM m/s	% of M/R
1.	Centaur Performance		6.65	10.02
2.	Centaur Reference Attitude	6.45 mrad (0.370°)	14.71	49.06
3.	Misalignment to Centaur Reference	0.88 mrad (0.050°)	0.79	2.00
4.	Thrust Vector Misalignment	1.05 mrad (0.060°)	1.13	2.39
5.	Gyro Drift	3.14 mrad/ Hr (0.18°)/ Hr	0.07	0.0
6.	Gyro g Sensitive Drift	34.87 mrad/ Hr/g (2.0°)/ Hr/g	2.58	1.50
7.	Autopilot Deadband	2.0 mrad (0.115°)	4.56	4.56
8.	Solid Impulse Uncertainty	0.25%	8.56	16.61
9.	Spacecraft Weight Uncertainty	0.1%	2.40	1.30
10.	Expended Inerts Uncertainty	5%	0.57	0.07
11.	Solid Motor Temperature Uncertainty	0.37°C (0.67°F)	0.11	0.0
12.	TVC Propellant Usage Uncertainty	2.13 kg (4.7 lb)	7.45	12.58
13.	TVC Specific Impulse	5.0%	1.10	0.27
14.	Solid Engine Cant Angle		0.0	0.0
15.	TVC Engines Cant Angle		0.03	0.0
	Total FOM		20.63	98.38
	Mission Requirement		21.0	

REVISION PAGE

Revision	Date	ECRs Incorporated	Comments
Original	8 July 1975		
A	22 July 1977	36094, 36231, 36334, 36397, 36433, 36468, 36565, 36591	Updates data and analysis

FUNCTIONAL REQUIREMENT AMENDMENT

(Insert in 618-205, MJS77 Functional Requirements Book)

TITLE:	
FUNCTIONAL REQUIREMENT MARINER JUPITER/SATURN 1977 FUNCTIONAL ACCURACIES AND SYSTEM CAPABILITIES	FR No. MJS77-3-170A AMENDMENT No. 1 PAGE 1 OF 1 DATE: 14 February 1979 PER ECR No. N/A

DESCRIPTION OF CHANGE:

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JET PROPULSION LABORATORY

No. MJS77-3-180C
1 February 1979

Supersedes
MJS77-3-180B
13 June 1977

FUNCTIONAL REQUIREMENT

MARINER JUPITER/SATURN 1977 FLIGHT EQUIPMENT CONFIGURATION

* Denotes Changes from previous issue

Section		Page

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FIGURES

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CONTENTS (contd)

TABLES

DISTRIBUTION

1.0 SCOPE

This document defines the Mariner Jupiter/Saturn 1977 (MJS77) Spacecraft Configuration and establishes the functional requirements to which the configuration is designed. These requirements include those imposed by the spacecraft system, subsystem, launch vehicle, system tests and operations.

2.0 APPLICABLE DOCUMENTS

The following documents form a part of this Functional Requirement.

NOTE

MJS77-3-100, Spacecraft Requirements and Constraints, applies to this document. Requirements of other MJS77 level 3 documents may also be applicable. It is the responsibility of the user to adequately acquaint himself with the organization and pertinent content of the level 3 documents, as well as with the material contained herein.

FUNCTIONAL REQUIREMENTS

<u>Jet Propulsion Laboratory</u>

MJS77-3-100	Mariner Jupiter/Saturn 1977 Spacecraft Requirements and Constraints
MJS77-3-170	Mariner Jupiter/Saturn 1977 Functional Accuracies and System Capabilities
MJS77-3-200	Mariner Jupiter/Saturn 1977 Inertial Properties
MJS77-3-210	Mariner Jupiter/Saturn 1977 Design Criteria for Spacecraft Temperature Control
MJS77-3-220	Mariner Jupiter/Saturn 1977 Electronic Equipment Design
MJS77-3-240	Mariner Jupiter/Saturn 1977 Environmental Design Requirements

OTHER DOCUMENTS

<u>Jet Propulsion Laboratory</u>

PD 618-217	Mariner Jupiter/Saturn 1977 Spacecraft/ Launch Vehicle Systems Requirements and Integration

DRAWINGS

<u>Jet Propulsion Laboratory</u>

10047158	Articulation Actuator Assembly Interface Control Drawing

10062348	Modified Infrared Interferometer Spectrometer and Radiometer Power Supply and Electronics Interface Control Drawing
10062351	Cosmic Ray Subsystem Interface Control Drawing
10062352	Planetary Radio Astronomy Subsystem Interface Control Drawing
10062355	Low Energy Charged Particle Subsystem Interface Control Drawing
10062357	Photopolarimeter Subsystem Interface Control Drawing
10062360	Imaging Science Subsystem Electronics Assembly Interface Control Drawing
10062362	Plasma Subsystem Interface Control Drawing
10062364	Ultraviolet Spectrometer Subsystem Interface Control Drawing
10062365	Magnetometer Subsystem Interface Control Drawing
10062366	Imaging Science Subsystem Wide Angle Television Camera Assembly Interface Control Drawing
10062367	Imaging Science Subsystem Narrow Angle Television Camera Assembly Interface Control Drawing
10062369	Infrared Interferometer Spectrometer and Radiometer Subsystem Interface Control Drawing
10062371	Modified Infrared Interferometer Spectrometer and Radiometer Subsystem Interface Control Drawing
10062372	Infrared Interferometer Spectrometer and Radiometer Subsystem Power Supply and Electronics Interface Control Drawing

10062373	Plasma Wave Subsystem Interface Control Drawing
10062445	Electronic Equipment Arrangement Drawing
10065262	Sun Sensor Assembly Interface Control Drawing
10065263	Canopus Star Tracker Interface Control Drawing
10070962	Mariner Jupiter/Saturn 1977 Spacecraft Mechanical Configuration

Lewis Research Center

CR 600458	Mariner Jupiter/Saturn 1977 Spacecraft-to-Launch Vehicle System Mechanical Interface Control Drawing General Arrangement
CR 600459	Mariner Jupiter/Saturn 1977 Spacecraft-to-Launch Vehicle System Mechanical Interface Control Drawing Mechanical Details

3.0 CONFIGURATION

3.1 Configuration Definition

The configuration design serves to establish the mechanical relationship between the various subsystems, subsystem components, and Launch Vehicle (LV) in a manner which most nearly satisfies the system and subsystem level requirements. Where requirements cannot be specifically met, the configuration provides a negotiated alternative position within which the subsystem can satisfactorily perform its designated function.

The configuration also establishes coordinate systems, reference planes, and their interrelationships such that subsystem-to-spacecraft and inter-subsystem interfaces and relationships may be conveniently and precisely negotiated and defined.

The spacecraft (S/C) configuration is described by:

a) The MJS77 Spacecraft Mechanical Configuration Drawing (Figure 1),

b) The MJS77 Electronic Equipment Arrangement Drawing (Figure 2),

c) The MJS77 Spacecraft-to-Launch Vehicle System Interface Control Drawing (Figures 3 and 4), and

d) The coordinate system definitions and their interrelationships (Figures 5 through 11).

3.2 Spacecraft Mechanical Configuration

JPL Drawing 10070962 (Figure 1) defines the mechanical configuration of the MJS77 spacecraft.

3.3 Electronic Equipment Arrangement

JPL Drawing 10062445 (Figure 2) shows the electronic equipment arrangement for the MJS77 spacecraft.

3.4 Launch Vehicle Interface

LeRC Drawings CR 600458 and CR 600459 (Figures 3 and 4) define the mechanical interface with the Titan IIIE/Centaur D-IT LV.

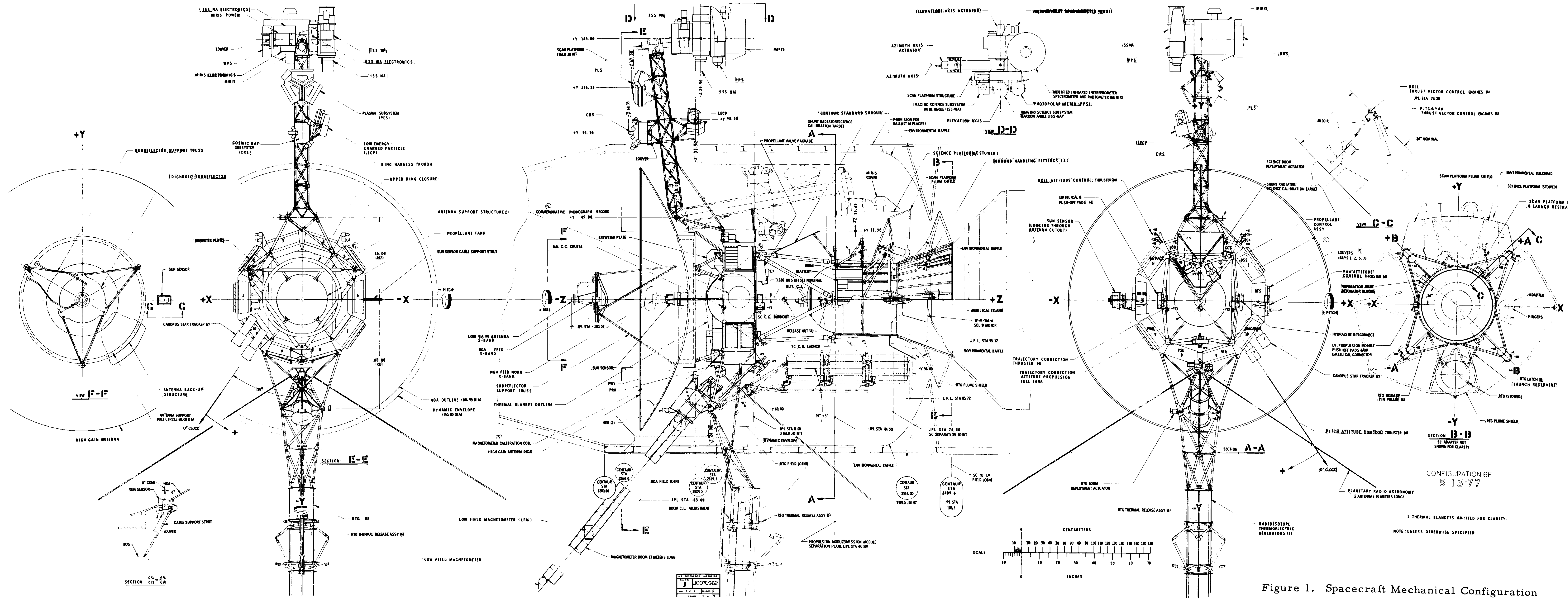


Figure 1. Spacecraft Mechanical Configuration

NOTE: Thermal blankets are not shown but may increase S/C dimensions by as much as 1 inch on each edge.

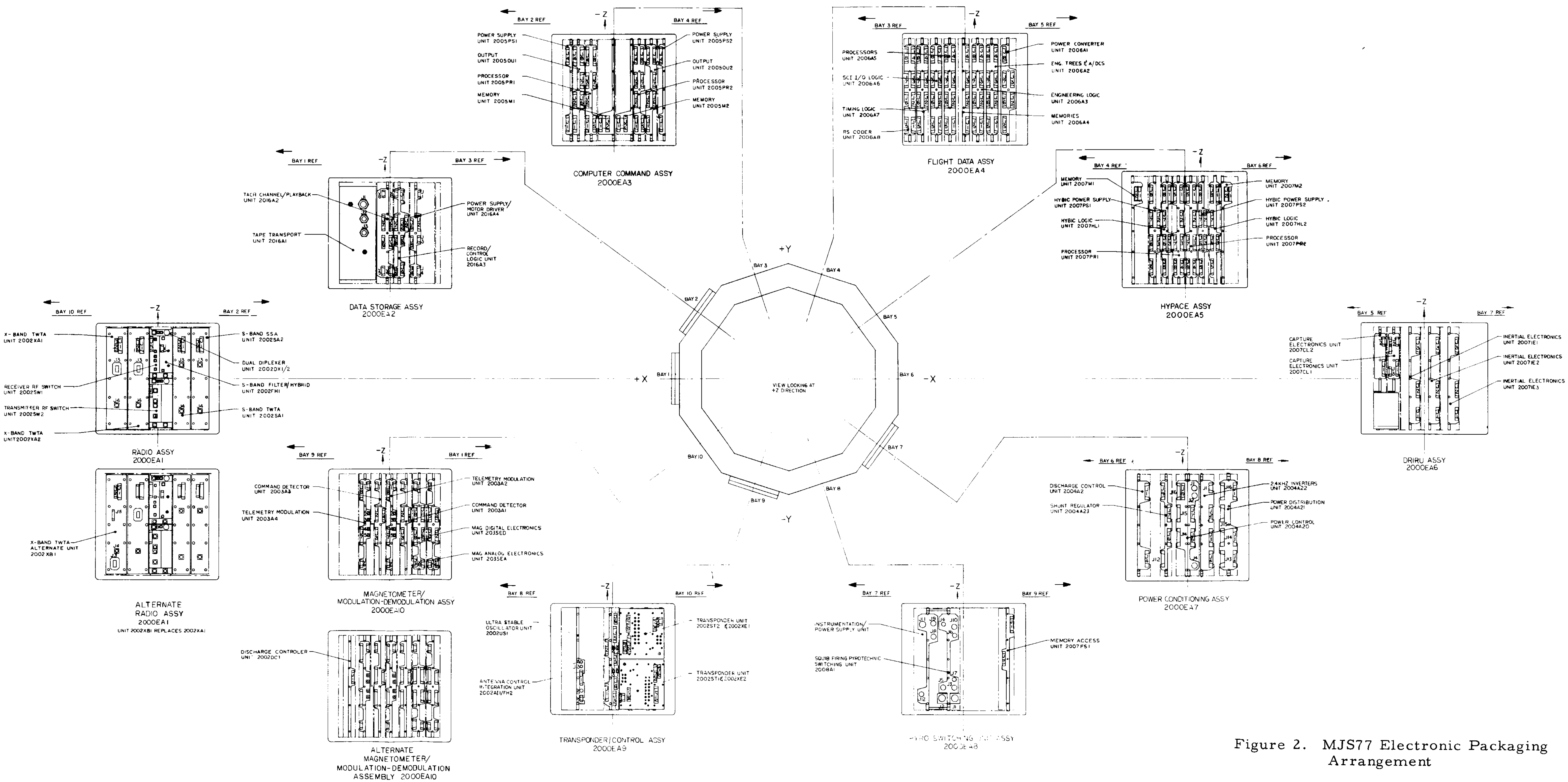
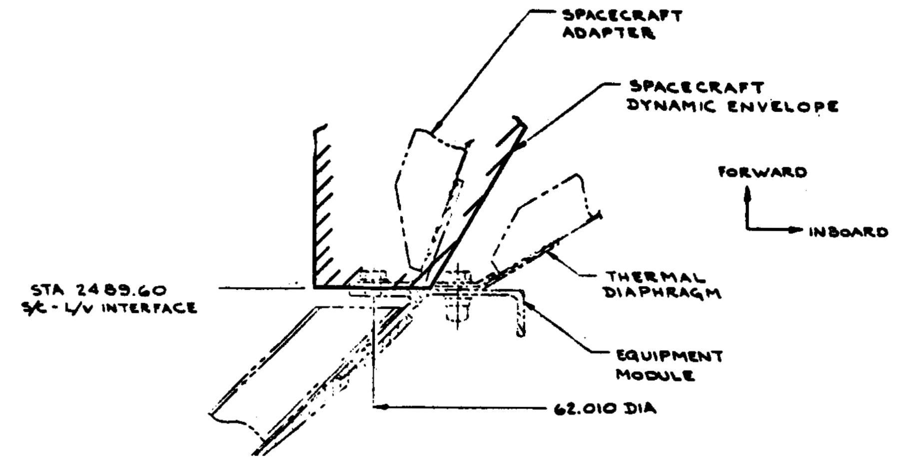


Figure 2. MJS77 Electronic Packaging Arrangement

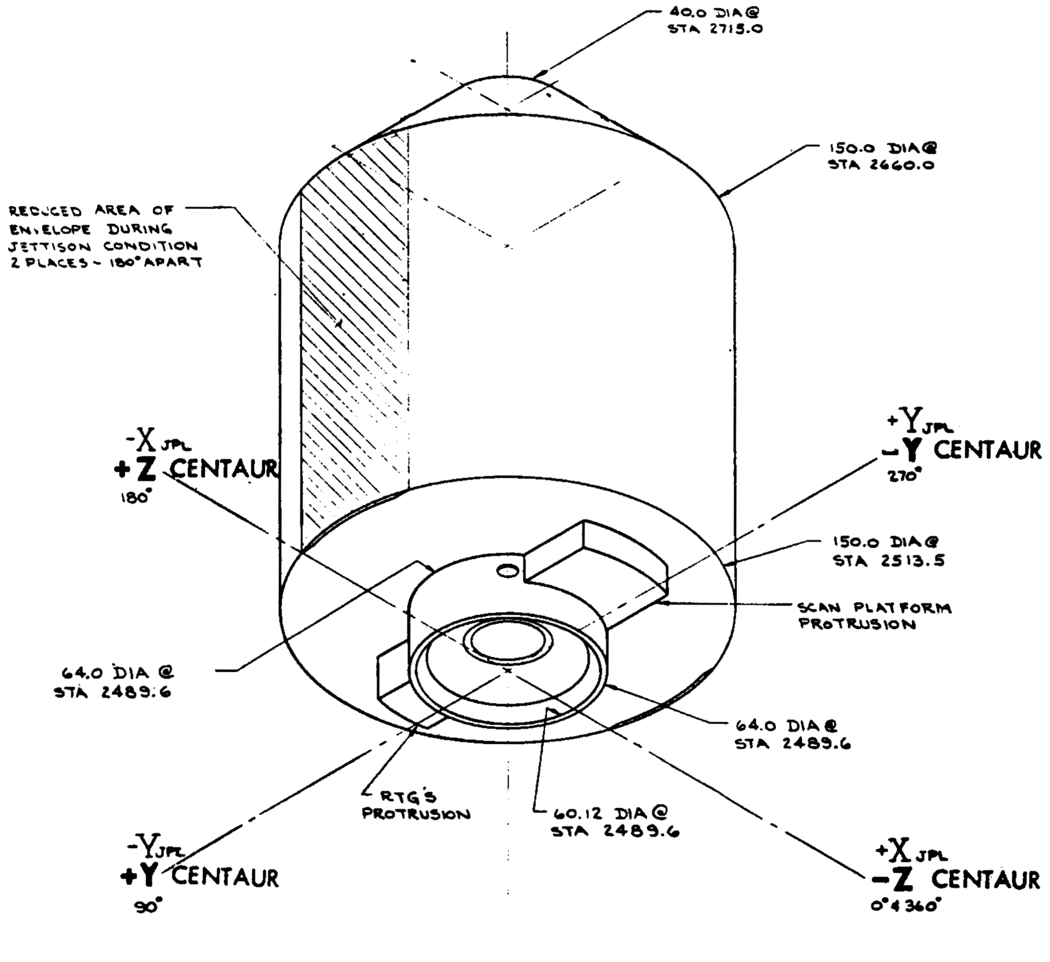
NOTE: Thermal blankets are not shown but may increase S/C dimensions by as much as 1 inch on each edge.

FOR REFERENCE ONLY.
WILL NOT BE UPDATED.

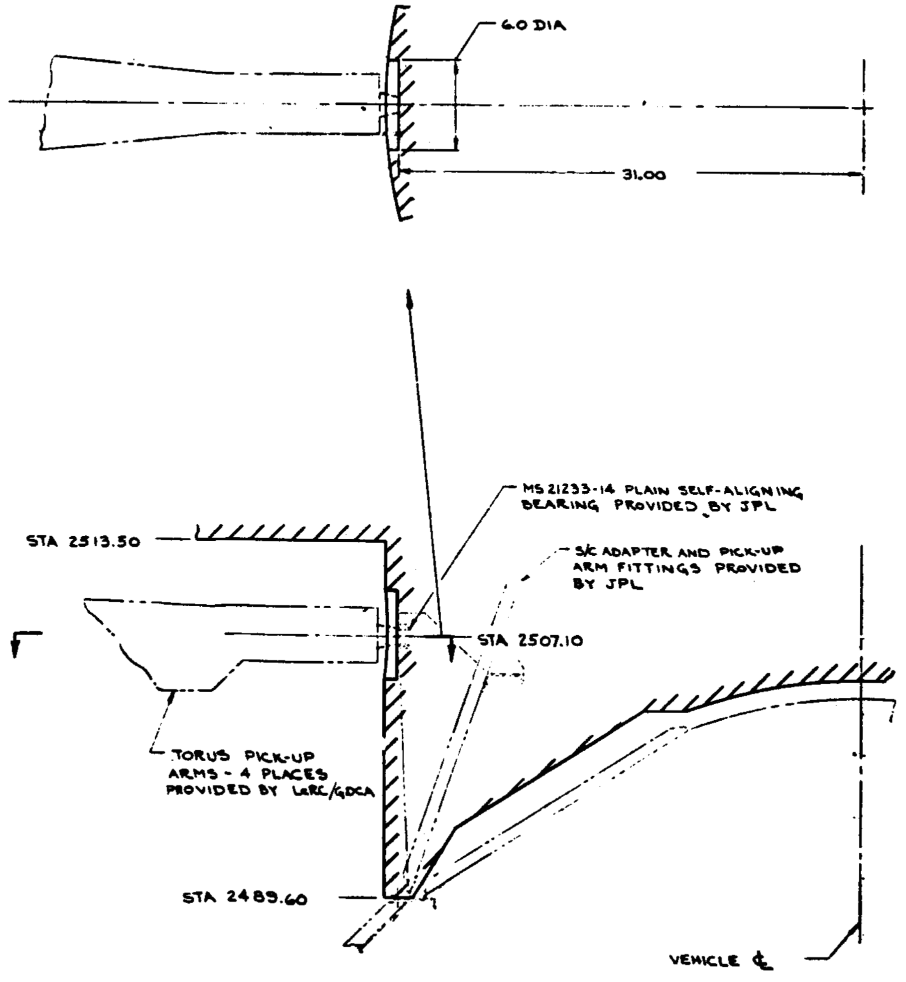
Figure 3. MJS77 Spacecraft-to-Launch Vehicle System Mechanical Interface Control Drawing – General Arrangement



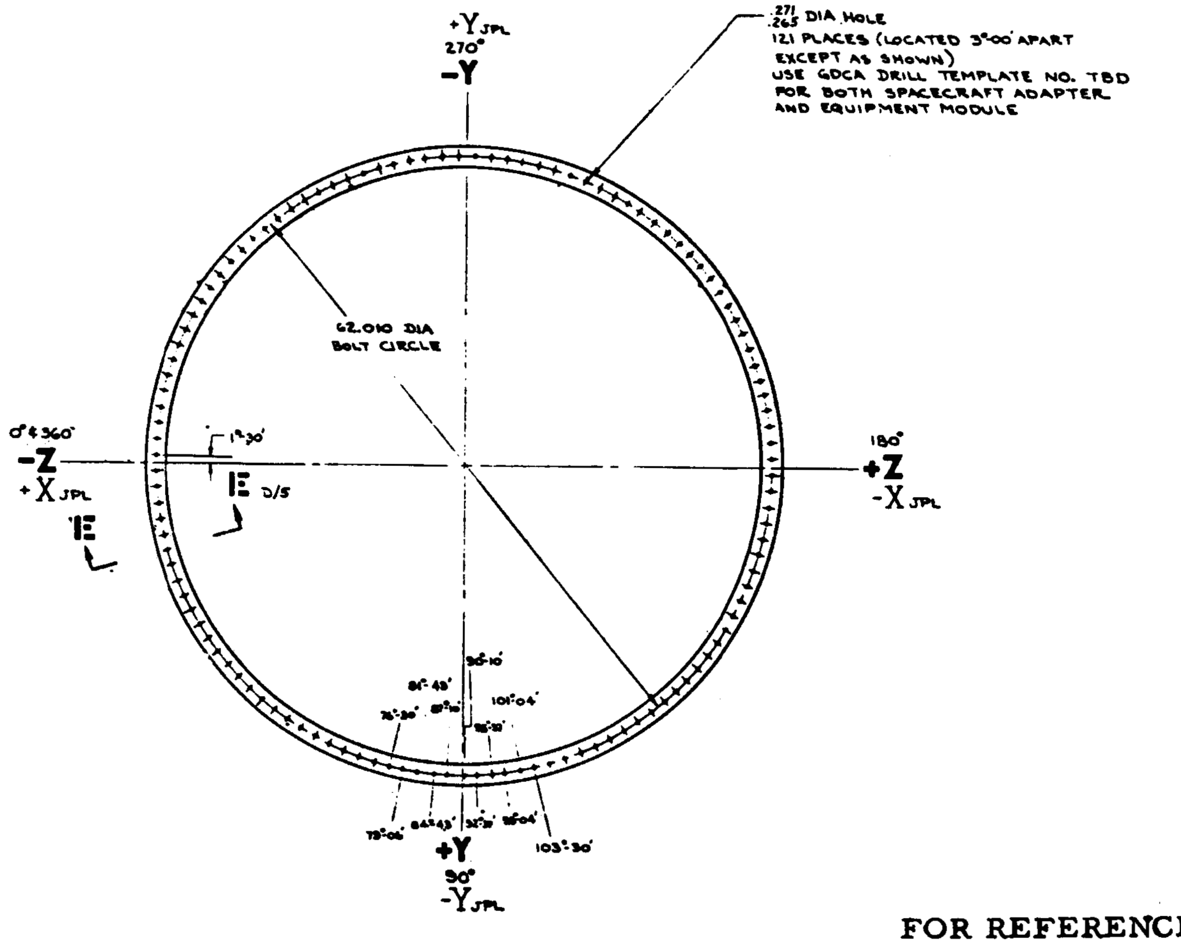
SECTION E-E B/4
SCALE - FULL SIZE



S/C DYNAMIC ENVELOPE
ISOMETRIC
NO SCALE



SECTION D-D CR600 458 A/4
TYPICAL 4 PLACES
SCALE - 1/4
ROTATED CW 45°



SECTION C-C CR600 458 B/5
LOOKING AFT
SCALE - 1/6

NOTE: Thermal blankets are not shown but may increase S/C dimensions by as much as 1 inch on each edge.

FOR REFERENCE ONLY.
WILL NOT BE UPDATED.

Figure 4. MJS77 Spacecraft-to-Launch Vehicle System Mechanical Interface Control Drawing – Mechanical Details

3.5 Coordinate Systems

This section describes the S/C, scan platform and LV coordinate systems. Also defined are the reference locations on which the coordinate systems are based and appropriate interrelationships.

3.5.1 Celestial Clock/Cone Coordinates

The cone angle of a celestial body is defined as the angle, β (where $0 \leq \beta \leq 180$ deg), from the S/C - primary reference body line to the S/C - object line. The clock angle of a celestial body is defined as the angle, α (where $0 \leq \alpha \leq 360$ deg), between a plane containing the primary reference body, the S/C and Canopus and a plane containing the primary reference body, the S/C and the object. It is measured from the primary reference body - S/C - Canopus plane and is defined as positive, in the clockwise direction, when looking toward the primary reference body from the S/C.

NOTE

The primary reference body may be either the earth or the sun depending on mission phase. Thus, the qualifier "earth or sun" should be used when specifying clock/cone coordinates (i.e., "earth clock/cone" or "sun clock/cone").

3.5.2 Spacecraft Clock/Cone Coordinates

All pointing vectors may be uniquely defined in a S/C fixed spherical clock and cone coordinate system. The cone angle of a pointing vector is defined as the angle, β'(where $0 \leq \beta' \leq 180$ deg), from the high gain antenna (HGA) boresight vector to the specified pointing vector. The clock angle of a pointing vector is defined as the angle, α' (where $0 \leq \alpha' \leq 360$ deg), between a plane containing the HGA boresight vector and the Canopus Star tracker optical axis and a plane containing the HGA boresight vector and the specified pointing vector. It is measured from the HGA boresight - Canopus Star tracker plane and is defined as positive, in the clockwise direction, when looking out along the HGA boresight vector.

NOTE

The S/C clock/cone coordinates move with S/C as it turns, whereas the celestial clock/cone coordinates are fixed. Thus, the S/C clock/cone and celestial clock/cone coordinates will only coincide when all angular offsets and biases are zero.

3.5.3 Scan Platform Azimuth/Elevation Coordinates

A pointing vector may also be defined uniquely in the Scan Platform Azimuth/Elevation coordinate system. The Azimuth angle of a pointing vector is defined as the angle, Υ (where $0 \leq \Upsilon \leq 360$ deg) between a plane containing the -Y/+Z axes and the specified pointing vector. It is measured from the -Y direction positively in the clockwise direction when looking toward earth. The Elevation angle of a vector is defined as the angle, δ(where $-10 \leq \delta \leq 200$ deg) in the constant Azimuth plane containing the specified pointing vector. Zero degrees elevation lies along the azimuth axis in the earthward hemisphere and 180 deg elevation lies along the opposite end of the azimuth axis in the anti-earthward hemisphere. Elevation values $-10 \leq \delta \leq 0$ and $180 \leq \delta \leq 200$ deg represent second solution values for a specified pointing vector resulting from a platform elevation gimbal over-travel capability at a given azimuth angle.

3.5.4 Spacecraft (and MM) Cartesian Coordinates

The S/C cartesian coordinate system (Figure 5) consists of three mutually perpendicular axes; X (pitch), Y (yaw), and Z (roll). The Z-axis is parallel to the HGA boresight vector and passes through the center of the S/C with +Z directed opposite to the antenna boresight direction. +Y is normal to Z and is directed toward the scan platform.

The X-axis is normal to the Y and Z axes. Pitch, yaw, and roll polarity is measured positively clockwise when facing in the plus direction along each axis. S/C and MM cartesian coordinates are coincident and may be used interchangeably.

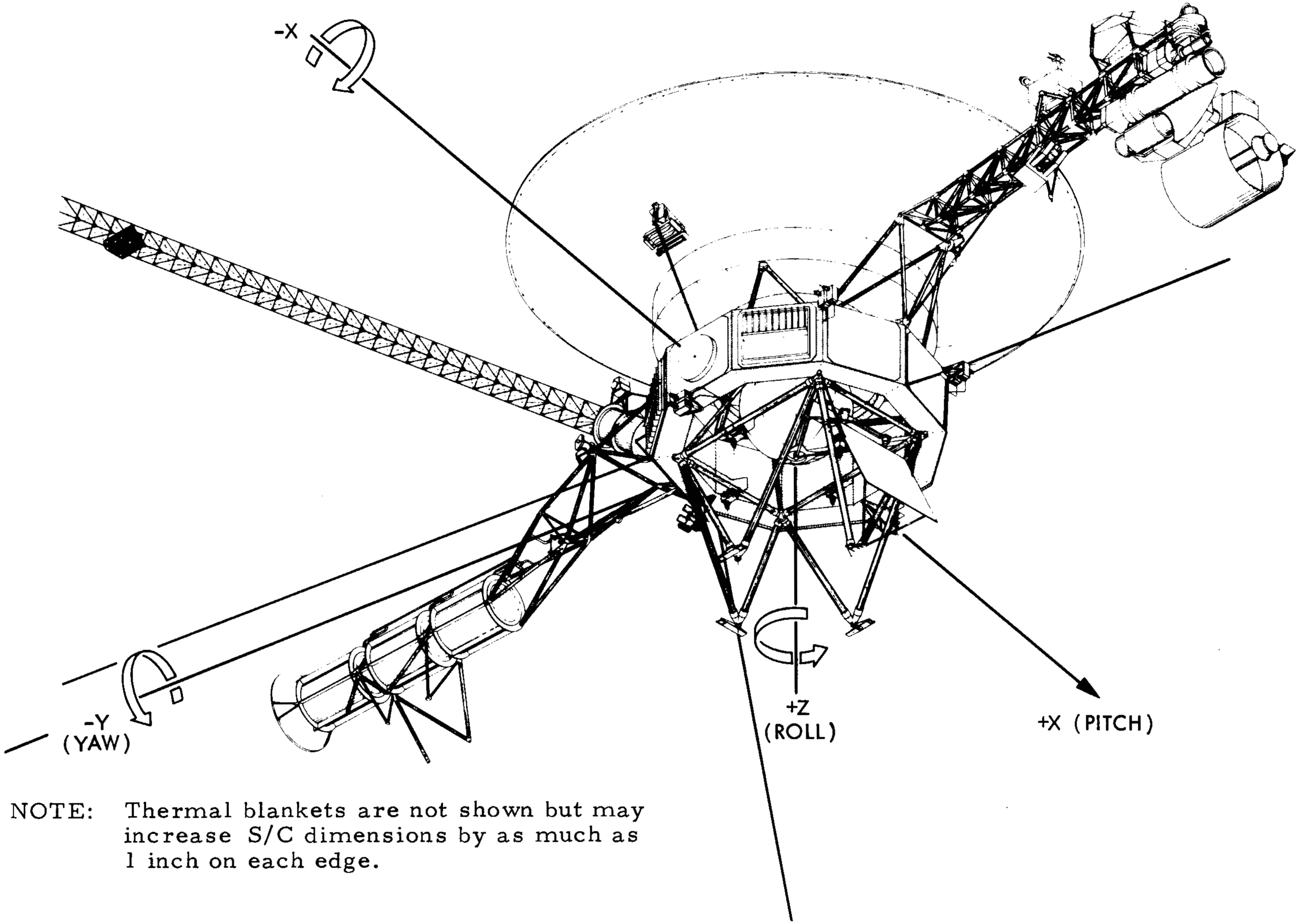
3.5.5 Propulsion Module Cartesian Coordinates

The three mutually perpendicular Propulsion Module (PM) cartesian coordinate axes X_p, Y_p and Z_p are nominally parallel to the S/C X, Y and Z axes respectively (Figure 6). Polarity and sign convention of the PM coordinates duplicates that of the S/C system.

A secondary set of PM cartesian coordinates axes, A and B, have been established to provide for thrust vector control motion definitions. The A and B axes lie in a plane parallel to the X_p - Y_p plane. The axes are rotated 45 deg to the X_p and Y_p axes such that +A lies between +X and +Y, and +B lies between +Y and -X. The Z_p axis serves as the third control axis. Rotations about A, B and Z_p are measured positively clockwise when looking in the plus direction along each axis.

3.5.6 Scan Platform Cartesian Coordinates

A right-handed, orthogonal coordinate system ($\overline{L}$, $\overline{M}$, $\overline{N}$) (Figure 7), is used to relate the location and pointing direction of instruments located on the science scan platform. The platform has a primary mounting plane which is established by three points on the platform. Two reference pins (pin 1 and pin 2) are installed on the primary mounting plane to establish platform alignment. The origin of the coordinate system lies at the intersection of the centerline of pin 1 and the primary mounting plane. The coordinate axis $\overline{L}$ defining platform look direction is parallel to the Narrow Angle Camera nominal boresight vector, lies in the primary mounting plane and



NOTE: Thermal blankets are not shown but may increase S/C dimensions by as much as 1 inch on each edge.

Figure 5. Spacecraft Cartesian Coordinates

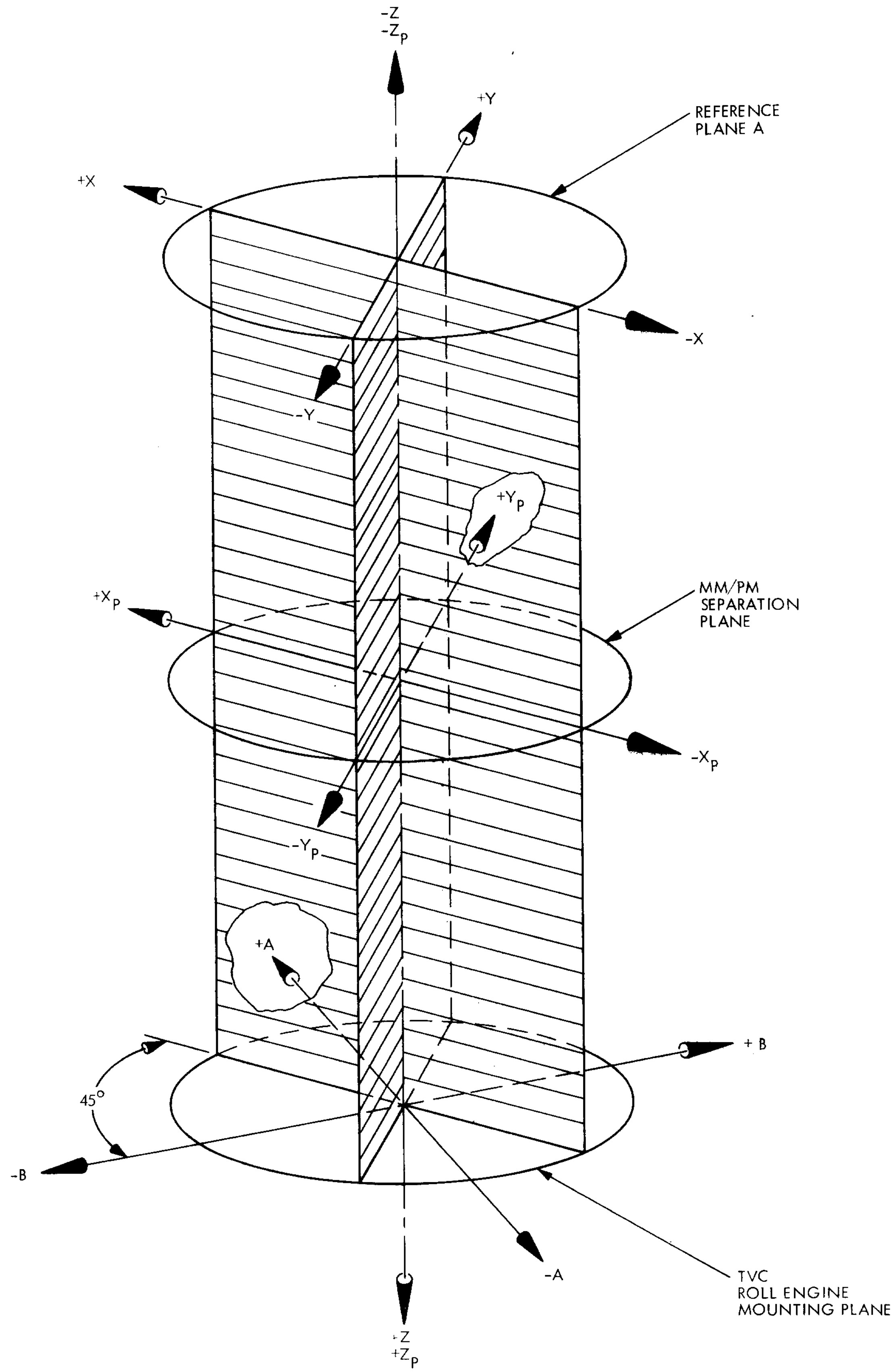


Figure 6. Propulsion Module Coordinate Systems

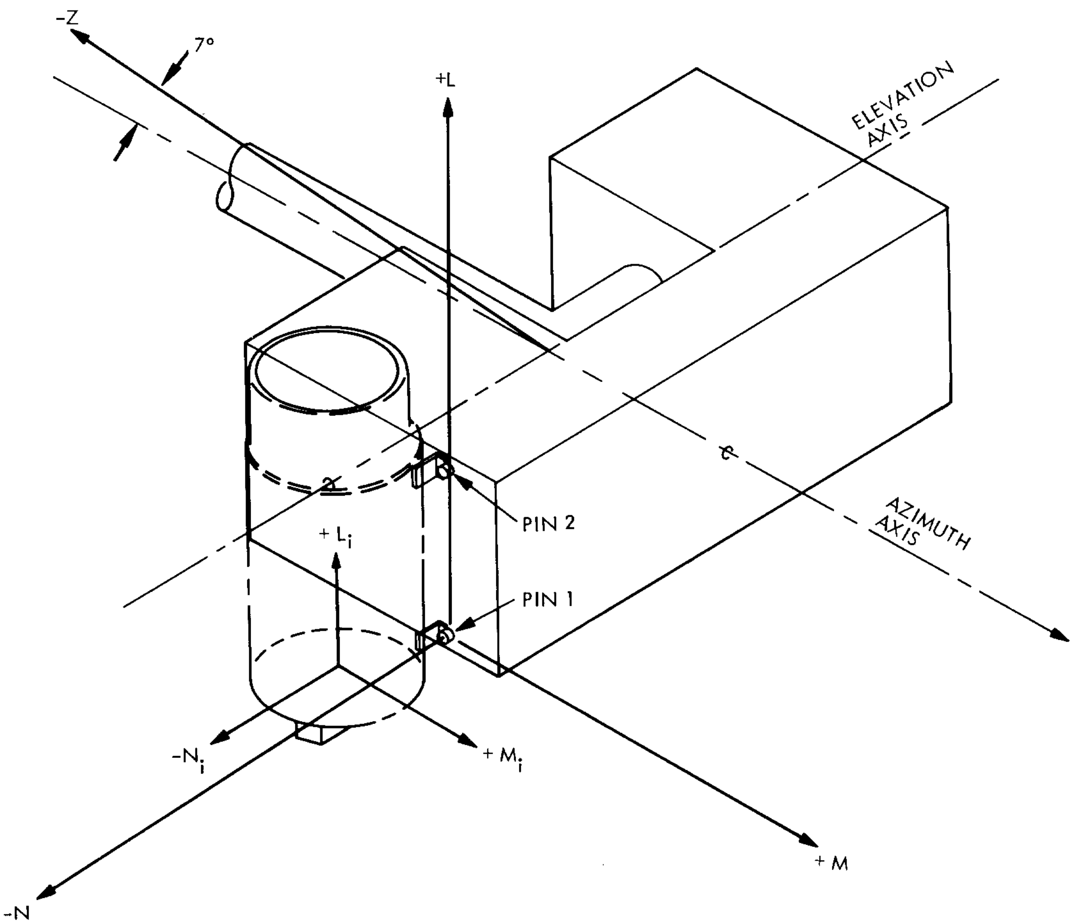
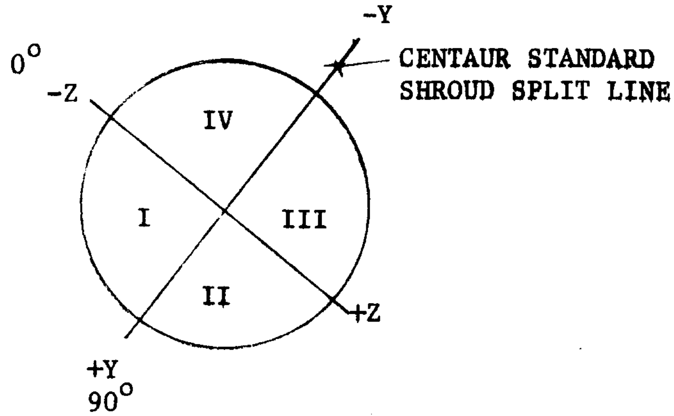
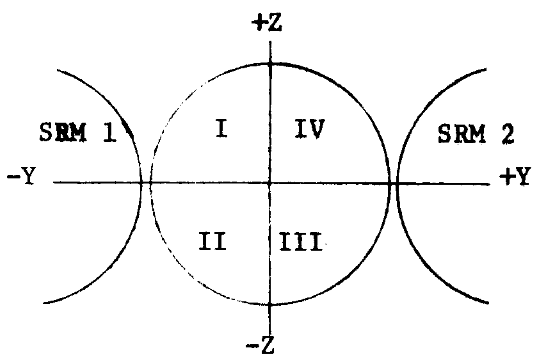


Figure 7. Scan Platform Cartesian Coordinates

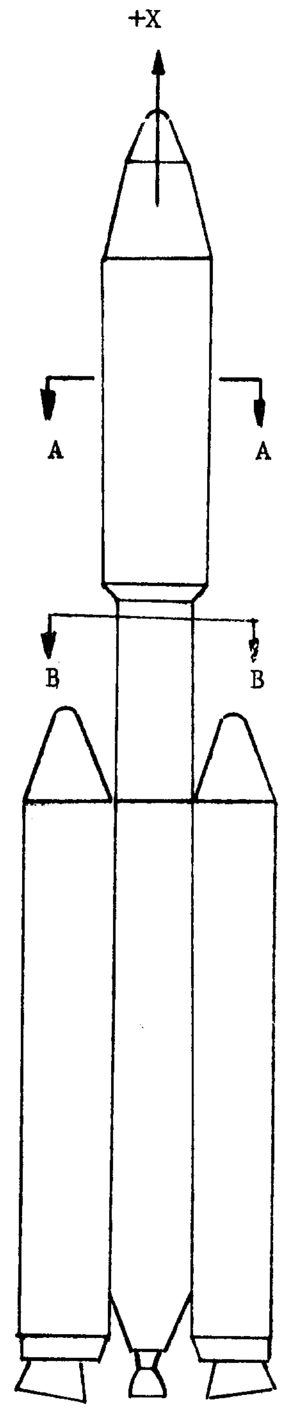


SECT A-A
CENTAUR
VIEW AFT



LC 41
UMBILICAL MAST

SECT B-B
TITAN
VIEW AFT



TITAN IIIE/CENTAUR D1-T

NOTE: CENTAUR Y-Y AXIS IS LOCATED 128.5° CLOCKWISE WITH RESPECT TO TITAN Y-Y AXIS (LOOKING AFT).

Figure 8. Launch Vehicle Coordinates

passes through the centerline of pins 1 and 2. Coordinate axis $\overline{M}$ lies in the primary mounting plane and is perpendicular to $\overline{L}$, passing through the origin. The coordinate axis $\overline{N}$ is mutually perpendicular to $\overline{L}$ and $\overline{M}$ such that $\overline{L} = \overline{M} \times \overline{N}$. Individual instruments have a subscripted $\overline{L}_i$, $\overline{M}_i$, $\overline{N}_i$ coordinate system such that an instrument pointing vector is specified by the direction cosines of its coordinate axes, $\overline{L}_i$, $\overline{M}_i$, $\overline{N}_i$ with respect to the platform coordinates $\overline{L}$, $\overline{M}$, $\overline{N}$.

3.5.7 Launch Vehicle Coordinates

The Titan IIIE and Centaur D1-T LV stage cartesian coordinate systems (Figure 8) are standard right-handed three axis system (X, Y, and Z); in which the X-axis is the longitudinal axis with +X up for launch for both stages. The Titan Y-axis is normal to the X-axis and passes through the two solid motors. The Z-axis is normal to X and Y. The Centaur Y and Z axes are rotated 128.5 deg clockwise with respect to the corresponding Titan axes. The shroud split line lies along the Centaur Y-axis.

3.5.8 Spacecraft Reference Systems

3.5.8.1 Bay Numbering

a) The electronic equipment bays within the bus are labeled numerically from 1 through 10 in a counterclockwise direction as viewed from the LV, or +Z side of the S/C (Figure 9). Bay 1 is defined as being on the +X axis.

b) The structual longerons which separate each equipment bay are labeled A through K, less I, in the same sequence as the bay convention. Longeron A is located between Bays 1 and 10.

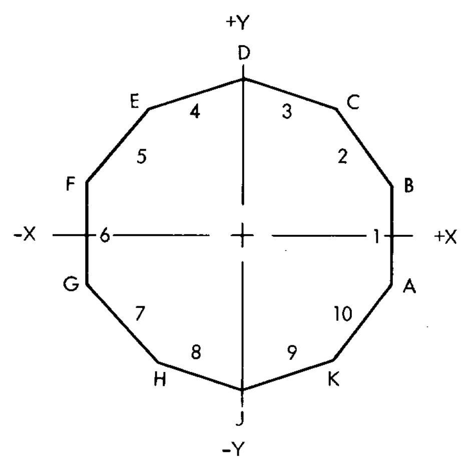


Figure 9. Bay Numbers and Longeron Letters

3.5.8.2 Primary Reference Plane (A). The primary reference plane (A) is defined as the plane of the mating surface of the lower ring at longerons C, E, and K and the eight-member PM truss interface (i.e., PM/MM field joint).

3.5.9 Coordinate Relationships

3.5.9.1 Spacecraft and Mission Module Cartesian-to-Reference Systems. The origin of the MM and S/C cartesian coordinate system lies in reference plane (A) 1.120 in. from the center of the PM/MM field joint bolt circle in the base of longerons C, E and K. Note: The center of the bus (and field joint bolt circle) is offset from the origin of the coordinate system by 1.120 in. in the +Y direction. The X- and Y-axes lie in reference plane (A). The X-axis is parallel to the centerline through the holes in longerons C and E. The Y- and Z-axes emanate from the origin and are mutually perpendicular to the X-axis. The S/C cartesian coordinate system is identical to and coincident, with the MM coordinate system.

3.5.9.2 Propulsion Module Cartesian-to-S/C Cartesian. The origin of the PM cartesian coordinate system lies in the PM-MM separation plane at the center of the PM-MM joint explosive bolt circle. The X_p-axis is through the centerline of the two explosive bolt holes which lie nominally in the X-Z plane. The Yp and Zp axis emanate from the origin and are mutually perpendicular to the X_p-axis.

The A and B axes lie in a plane which is parallel to, and 29.70 inches below, the X_p - Y_p plane. The A-B plane contains the center of rotation of the Thrust Vector Control Engines (i.e., the intersection of the thrust vector and a radial vector 40.0 inches long). The origin of the A and B axes is at the point where the Z_p axis pierces the A-B plane.

3.5.9.3 Clock/Cone-to-Spacecraft Cartesian. The S/C clock plane lies in the S/C X-Y plane with its origin at the cartesian coordinate system origin (Figure 10). Clock is measured positively from 0 to 360 deg clockwise when looking in the -Z direction. 0 deg clock (established by the Canopus Star Tracker pointing vector) is 35 deg counterclockwise from the -Y axis (looking in the -Z direction). The -Z and +Z axis directions are coincident with 0 deg cone and 180 deg cone, respectively. Reference: Cautionary notes in paragraphs 3.5.1 and 3.5.2).

3.5.9.4 Azimuth/Elevation-to-Spacecraft Cartesian and Clock/Cone. The S/C azimuth/elevation coordinates result from tilting the primary axis of rotation of the scan platform 7 deg with respect to S/C clock axis. The azimuth axis zenith and nadir are at 35 deg clock 7 deg cone and 215 deg clock 173 deg cone respectively. The azimuth plane is normal to the azimuth axis and intersects the S/C clock plane along the X-axis. 0 deg azimuth is defined as the intersection of the -Y/+Z plane and the azimuth plane (See Figure 10). Azimuth is measured positively from 0 to 360 deg clockwise when looking in the -Z direction. Elevation angles are measured positively from 0 to 200 deg from Zenith to 20 deg beyond the Nadir at all azimuth angles. Note: A scan platform overtravel capability of 10 deg at the zenith results in negative elevation values. For a given azimuth value, elevation may range from -10 thru 0 to +200 deg.

3.5.9.5 Scan Platform-to-Spacecraft Coordinate Relationships. The scan platform coordinates, L, M and N, relate to the S/C coordinate system as shown in Figure 11. The $\overline{L}$ vector of the platform is located in S/C clock and cone by α and β, respectively. When the S/C is in Earth-Canopus lock, α and β are also the earth celestial clock and cone of the platform $\overline{L}$ vector. The $\overline{L}$ vector may also be identified by the platform gimbal axes position angles Azimuth (γ) and Elevation (δ).

Instrument pointing directions or lines-of-sight ($\overline{P}$ in Figure 11) are specified with respect to scan platform coordinates by a cone offset angle (ψ) and cross-cone offset angle (χ). Cone offset is defined as the angle measured from L to the projection of $\overline{P}$ onto the $\overline{L}$-$\overline{M}$ plane. Positive cone offset is toward positive $\overline{M}$. Cross-cone offset is defined as the angle of inclination of $\overline{P}$ from the $\overline{L}$-$\overline{M}$ plane. Positive cross-cone is measured toward positive $\overline{N}$.

3.5.9.6 Spacecraft Cartesian-to-Launch Vehicle Cartesian. Figure 12 depicts the relationship between the S/C and LV cartesian coordinate systems. Also depicted are certain other indexing features relating the spacecraft to LV and launch complex interfaces.

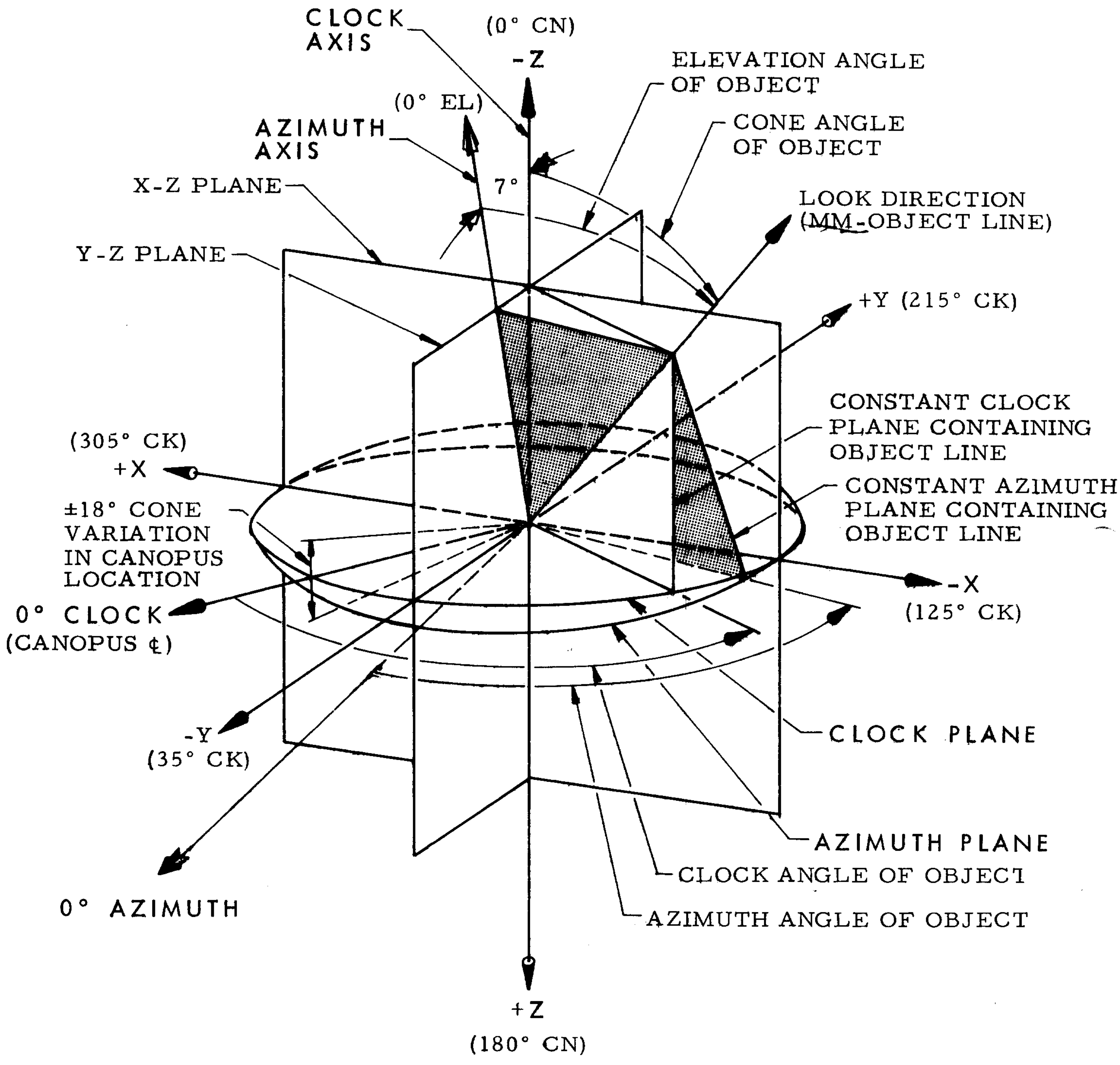


Figure 10. Spacecraft Clock/Cone-Azimuth/Elevation Coordinate Systems

$\overline{G}$ = AZIMUTH AXIS (0° ELEVATION)

$\overline{L}$ = PLATFORM POINTING DIRECTION

$\overline{N} = \dfrac{\overline{G} \times \overline{L}}{|\overline{G} \times \overline{L}|}$

$\overline{M} = \overline{N} \times \overline{L}$

α' = SPACECRAFT CLOCK ANGLE TO $\overline{L}$

β' = SPACECRAFT CONE ANGLE TO $\overline{L}$

γ = AZIMUTH ANGLE TO $\overline{L}$

δ = ELEVATION ANGLE TO $\overline{L}$

$\overline{P}$ = INSTRUMENT POINING DIRECTION

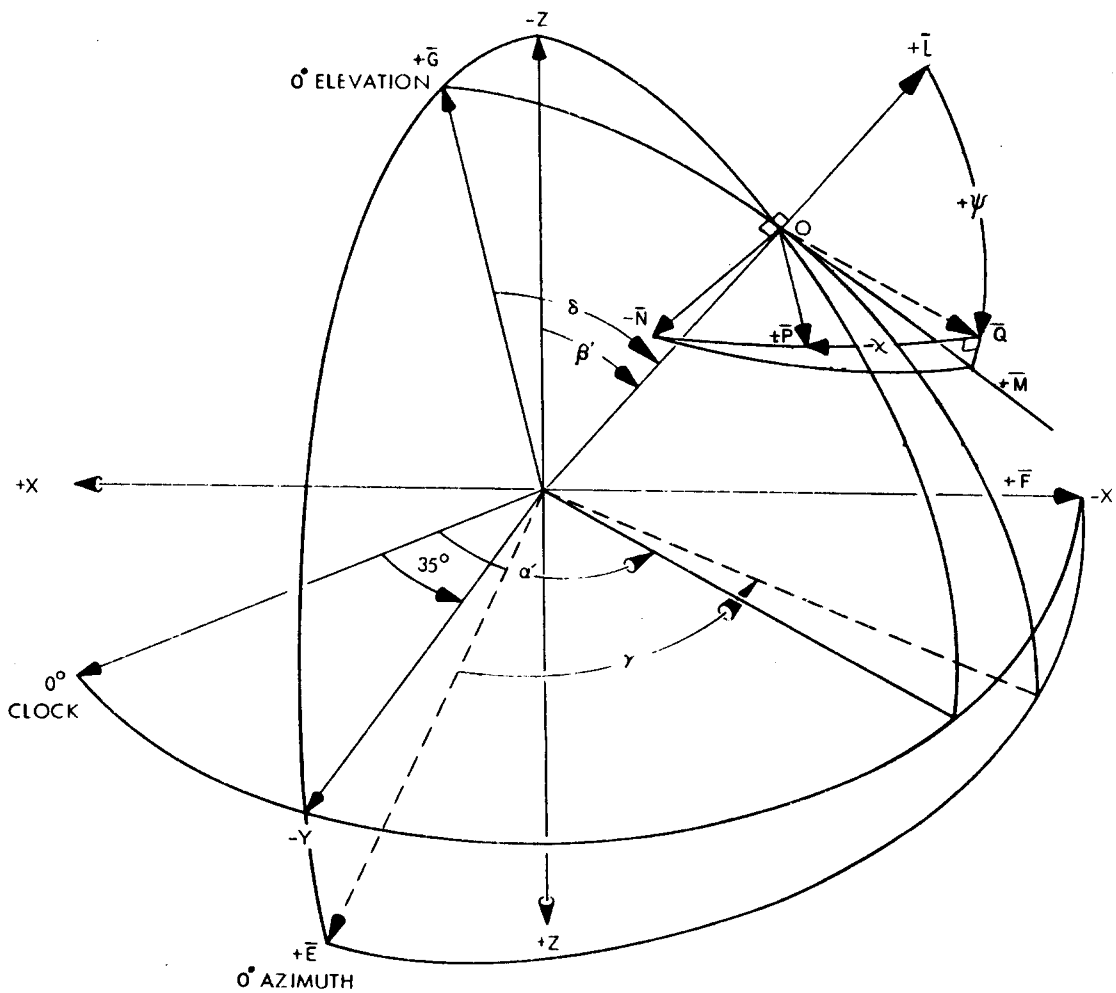
$\overline{Q}$ = $\overline{P}$ PROJECTED ONTO THE $\overline{L}$ - $\overline{M}$ PLANE

$\overline{M}$ - $\overline{L}$ PLANE = $\overline{G}$ - $\overline{L}$ PLANE

$\overline{P}$ - $\overline{Q}$ PLANE = $\overline{L}$ - $\overline{M}$ PLANE

ψ = ELEVATION OFFSET ANGLE OF $\overline{P} = \measuredangle LOQ$ IN THE $\overline{L}$ - $\overline{M}$ PLANE. POSITIVE ANGLE MEASURED FROM $\overline{L}$ TOWARD $+\overline{M}$.

χ = CROSS-ELEVATION OFFSET ANGLE OF $\overline{P}$ = ANGLE OF INCLINATION OF $\overline{P}$ TO THE $\overline{L}$ - $\overline{M}$ PLANE. POSITIVE INCLINATION MEASURED TOWARD $+\overline{N}$.



* Figure 11. Scan Platform/Spacecraft Coordinate Relationship

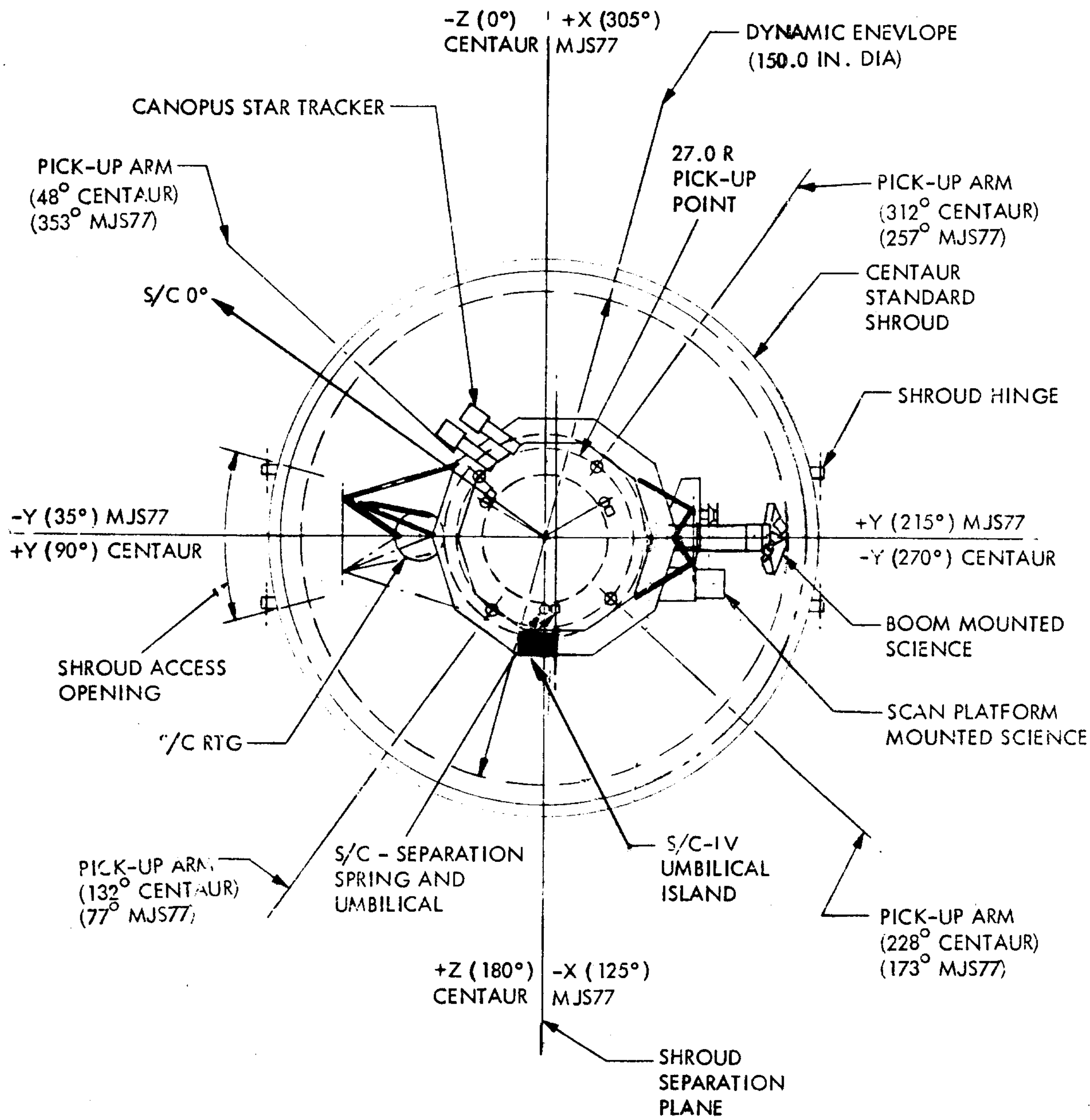


Figure 12. S/C - LV Interface Relationship

4.0 FUNCTIONAL REQUIREMENTS

Functional requirements which determine the S/C configuration design fall into four categories: system level (including LV integration, system testing, and operations); bay mounted electronic equipment; mechanical; and science. Paragraphs 4.1 through 4.4 detail requirements in those categories.

NOTE

> Where requirements cannot be specifically met because of inter- or intra-subsystem conflict, an alternative condition has been negotiated within which the subsystems can satisfactorily perform their designated function. Both "REQUIREMENTS" and "NEGOTIATED EXCEPTIONS" are presented in the following paragraphs.

4.1 System Level Requirements

The configuration design shall:

a) Be compatible with the LV according to the interface requirements defined in: PD 618-217, Spacecraft/Launch Vehicle System Requirements; LeRC Drawing CR 600459, Mechanical ICD - Mechanical Details; LeRC Drawing CR 600458, Mechanical ICD - General Arrangement; and GDC Drawing EICD 623-2-3, Electrical Systems ICD.

b) Permit 180 deg rotation of the "all-up", unfueled S/C in the launch configuration with the S/C Z-axis vertical.

c) Permit 180 deg rotation of the MM, less appendages and HGA, with the Z-axis vertical.

d) Not require lifting the S/C with the HGA installed.

e) Provide for access to install test cables without removal of flight equipment.

f) Provide for system test stimuli, handling equipment, and protective device installation and removal in a manner precluding interference with flight equipment.

g) Provide for access to, and installation or removal, of any flight equipment with minimal impact to or removal of other flight equipment.

h) Provide for modular installation and removal of the Trajectory Correction and Attitude Propulsion Unit (TCAPU) and the Injection Propulsion Unit (IPU) with a minimum complexity and number of affected mechanical and electrical interfaces.

i) Allow for separate determination of the MM launch and cruise mass properties; PM mass properties; and S/C mass properties per the requirements of MJS77-3-200, Inertial Properties.

j) Provide for installation of the PM such that the individual thrust vectors of the IPU and the TCAPU are aligned with respect to the launch and cruise centers-of-mass respectively, according to the requirements of MJS77-3-200, and MJS77-3-170, Functional Accuracies and System Capabilities.

k) Provide that nominal cross products of inertia in X-Y and X-Z shall be nominally near zero according to the requirements of MJS77-3-200.

l) Provide for adjustment of the deployed Radioisotope Thermoelectric Generator (RTG) location to reduce the cross products of inertia value in the Y-Z plane to a nominal of zero according to the requirements of MJS77-3-200.

m) Provide that the cruise location and orientation of the deployed RTG's shall be such that the radiation levels established in MJS77-3-240, Environmental Design Requirements, for electronics assemblies is not exceeded.

n) Provide for final installation of the S/X-band antenna subsystem, with cruise sun sensor attached, to the fueled spacecraft with a minimum of mechanical and electrical interfaces.

o) Provide for efficient and safe installation of the RTG assembly to the fueled S/C just prior to encapsulation.

p) Provide for electrical and mechanical separation of the S/C from the LV.

q) Provide for release and deployment of the scan platform and RTG's.

r) Provide for the electrical, mechanical and hydraulic release and separation of the PM from the MM.

s) Be compatible with requirements for micrometeroid protection.

4.2 Electronic Equipment Arrangement Requirements

The configuration shall define an Electronic Packaging Arrangement (Figure 2) such that the electronic subassemblies designed in accordance with the requirements of MJS77-3-220, Electronic Equipment Design, shall be contained within bays in the bus structure unless otherwise specified. Wherever possible, all the subassemblies for a given subsystem shall be located within one bay as an Electronic Assembly (EA). The arrangement shall also take into consideration such factors as: subsystem functional interfaces with other subsystems, cabling, temperature control, mass distribution, radiation, magnetic moment and EMI shielding. The Electronic Equipment Arrangement shown in Figure 2 represents the configuration which most nearly satisfies the subsystem requirements delineated in the following paragraphs.

4.2.1 Radio Frequency Subsystem (RFS)

Two bays of volume shall be provided for the RFS electronic equipment. For temperature stability, the EA containing the TWTA's shall be one bay removed from the EA containing the S/X transponders. The bay between the two EA's shall contain an assembly of low or constant power dissipation.

4.2.2 Modulation Demodulation Subsystem (MDS)

Approximately 1/2 bay of volume shall be provided for the MDS electronic equipment. The MDS shall be located as close to the RFS S/X transponder as is practical.

4.2.3 Power Subsystem (PWR)

One bay of volume shall be provided for the PWR electronic equipment. The EA shall be located as close to the RTG's as is practical.

4.2.4 Computer Command Subsystem (CCS)

Approximately one bay of volume shall be provided for the CCS electronic equipment. The CCS shall be as centrally located with respect to its interfaces as is practical.

4.2.5 Flight Data Subsystem (FDS)

Approximately one bay of volume shall be provided for the FDS electronic equipment. The FDS shall be located as close to the science instruments as is practical.

4.2.6 Data Storage Subsystem (DSS)

Approximately one bay of volume shall be provided for the DSS electronic equipment. The DSS shall be located as close to the FDS as is practical, and adjacent to a high power dissipation bay.

4.2.7 Hybrid Programmable Attitude Control Electronics (HYPACE)

Approximately one bay of volume shall be provided for the HYPACE electronic equipment. The HYPACE shall be located as close to the scan actuators, TCAPU thrusters, Sun sensors, Canopus Star Trackers (CST) and the Dry Inertial Reference Units (DRIRU's) as is practical.

4.2.8 Dry Inertial Reference Units (DRIRUs)

Approximately 1/2 bay of volume shall be provided for the DRIRU subassemblies. The DRIRU's shall be located on a reference axis and as close to the HYPACE as is practical.

4.2.9 Pyrotechnic Switching Unit (PSU)

Approximately 1/4 bay of volume shall be provided for the PSU electronic equipment. The PSU shall be located as closely to its interfaces as is practical.

4.2.10 Magnetometer Subsystem Electronics (MAG)

Approximately 1/4 bay of volume shall be provided for the MAG electronic equipment. The MAG electronics shall be located as close to the magnetometer boom and FDS bay as is practical.

4.3 Mechanical Requirements

Functional requirements imposed by the various subsystems on the MJS77 Spacecraft Mechanical Configuration are listed by subsystem in the following paragraphs.

4.3.1 Structure Subsystem (STRU)

The configuration shall define a generalized structural arrangement such that:

a) Efficient structural support of the spacecraft, all subsystems and subsystem components can be provided,

b) Alignment accuracies as defined in MJS77-3-170 can be achieved,

c) Deployable elements of the S/C can be adequately supported in both the stowed and cruise configuration,

d) Deployment paths are unimpaired,

e) Spacecraft mass properties and thrust vector alignment can be achieved by adjustment of the PM thrust vector and/or the RTG location,

f) Adequate electronic packaging volume is provided within the bus structure according to the requirements listed in paragraph 4.2,

g) Radiation and micrometeroid protection for flight equipment can be efficiently provided,

h) A two-degree-of-freedom scan platform with maximum practical rotational freedom about both axes can be provided (see paragraph 4.5 for scan platform requirements),

i) A S/C-to-LV adapter and LV interface of minimum complexity can be defined.

4.3.2 Power Subsystem (PWR)

4.3.2.1 RTG Assembly. The configuration design shall:

a) Provide for three RTG's to be mounted in line on a deployable structure, such that the separation between the inboard RTG and the nearest electronics assembly is compatible with the allowable radiation levels specified in MJS77-3-240.

b) Provide that the longitudinal centerline of the deployed RTG's, when projected through the bus, shall intersect the deployed cruise science instruments in the vicinity of the most radiation sensitive instrument.

c) Provide for adequate radiation and/or thermal protection for the RTG assembly and nearby S/C equipment in the launch configuration.

d) Provide for minimal exposure of personnel to the radiation and thermal environment of the RTG's during the installation of:

   1) Interconnect structure,

   2) RTG cabling,

   3) Boom structure, and

   4) Launch restraint latching and release devices.

e) Provide for minimal exposure of personnel to the hazardous radiation and thermal environments of the RTG's during installation and removal of the RTG assembly from the launch ready S/C.

4.3.2.2 Shunt Radiator. The configuration shall provide for a shunt radiator capable of dissipating as heat, part or all of the electrical power generated by the RTG's. The radiator shall be positioned to have a clear view of space and be in the HGA solar shadow during cruise.

4.3.2.3 Battery. The configuration shall provide for installation of a battery on the PM in a location compatible with temperature control requirements of MJS77-3-210, Design Criteria for Spacecraft Temperature Control.

4.3.3 Attitude and Articulation Control Subsystem (AACS)

4.3.3.1 Sun Sensor (ICD No. 10065262). The configuration shall provide the Sun Sensor an unobstructed rectangular field-of-view (FOV) of ±25 deg in pitch and +19 to -31 deg in yaw, and, a rectangular stray light FOV of ±40 deg in pitch and +34 to -46 deg in yaw.

4.3.3.2 Canopus Star Tracker (CST) (ICD No. 10065263). The configuration shall provide an unobstructed rectangular FOV of ±5 deg in clock and ±18 deg in cone, centered at clock and cone angles of 0 and 90 deg respectively; and a stray light FOV of ±15 deg in clock and ±33 deg in cone. The CST shall be located in the +X/-Y quadrant 35 deg from the -Y axis.

4.3.3.3 Articulation Actuators (ICD No. 10047158). The configuration design shall provide a scan platform and science assembly with minimal center-of-mass offsets from the center of rotation of the platform in azimuth and elevation, and rotational moments of inertia minimized to the extent possible commensurate with instrument viewing requirements. Scan platform inertial properties and center-of-mass offset shall be in accordance with MJS77-3-200.

4.3.4 Pyrotechnic Subsystem (PYRO)

The configuration shall provide:

a) For pyrotechnic actuation of functions to include, but not be limited to:

1) Launch vehicle/spacecraft separation,

2) Solid motor ignition,

3) Thrust vector control fuel line isolation,

4) RTG launch restraint release,

5) Scan platform launch restraint release,

6) PM jettison, and

7) Magnetometer boom deployment.

b) For installation of all squibs with the S/C in a near flight condition, during the final assembly sequence, in the Explosive Safe Facility (ESF);

c) For installation of the super zip primer cord and actuation hardware, with the S/C in a near flight ready condition, during the final assembly sequency at the ESF;

d) Access to the PSU with direct access cabling, with the S/C in a near launch ready condition, for final safety and circuit continuity verification.

4.3.5 Cabling Subsystem (CABL)

The configuration shall:

a) Provide for minimal system and subsystem cable length commensurate with resolution of other requirements;

b) Provide for pathways and structural support of system and subsystem cabling;

c) Allow access for installation and removal of electrical connectors required during system testing.

4.3.6 Propulsion Subsystem (PROP)

The PROP consists of the IPU and the TCAPU.

The configuration design shall:

a) Provide a field joint at the base of the bus for final installation of the near flight ready MM (less RTG's, HGA and MM Adapter Truss) to the near flight ready PROP (with the Adapter Truss attached);

b) Provide that the solid motor, thrust vector control thrusters and TCAPU thrusters are oriented and aligned with respect to the S/C and/or MM centers-of-mass in accordance with the requirements of MJS77-3-170;

c) Locate and orient the thrust vector control roll engine on the P/M A and B axes 40.0 inches radially outboard from the S/C Z-axis such that when fired in opposing pairs they will produce S/C roll control torque;

d) Locate and orient the remaining four thrust vector control engines on the P/M A and B axes (at JPL Station 74.20) angled 24 deg from the vertical as shown in Figure 1, View C-C;

e) Locate and orient the TCAPU thrusters relative to the nominal center-of-mass such that the primary control torque moment arms are 38.62* ±1.0 in. in pitch, 21.60* ±1.0 in. in yaw and 40.32* ±1.0 in. in roll;

f) Provide that propulsion exhaust plume impingement shall not damage, nor degrade the operation of, other S/C equipment.

4.3.7 Temperature Control Subsystem (TEMP)

The configuration design shall be such that the S/C temperature can be maintained according to the requirements of MJS77-3-210.

Additionally, the configuration shall:

a) Provide a thermally clean S/C exterior, minimizing heat leaks;

b) Provide for adequate thermal protection of the RTG assembly and nearby S/C equipment during launch and cruise;

c) Provide for the directed flow of conditioned air over components and subassemblies during the period of encapsulation, as necessary, to meet the requirements of MJS77-3-210.

* The nominal center-of-mass is located at X = +0.13; Y = -4.51 and Z = -16.91. The ±1.0 inch tolerance in moment arm length represents an uncertainty in the center-of-mass location.

d) Provide for installation and support of thermal blankets and sunshades;

e) Provide for installation and support of Radioisotope Heater Units per MJS77-3-210.

f) Modulate temperature excursions of bay-mounted electronics in bays 1, 2, 6, 7, and 9 through the use of externally-mounted louver assemblies.

4.3.8 Mechanical Devices Subsystem (DEV)

The configuration design shall make provisions for the installation and effective utilization of mechanical devices to perform the following functions:

a) Latch and restrain the scan platform and science boom for launch,

b) Latch and restrain the RTG assembly during launch,

c) Support and align the two MAG High Field Sensors,

d) Deploy, support and align the two MAG Low Field Sensors,

e) Latch and restrain the magnetometer boom during launch,

f) Separate the S/C from the LV,

g) Release and deploy the RTG's and boom assembly,

h) Release and deploy the scan platform and boom assembly,

i) Release and extend the magnetometer boom,

j) Release and separate the PM from the MM,

k) Provide active shock isolation or attenuation where required by scan platform instruments.

l) Provide active shock isolation or attenuation for the magnetometer boom.

m) Provide active shock isolation or attenuation for the RTG boom.

4.3.9 S/X-band Antenna Subsystem (SXA)

The configuration design shall:

a) Provide for support and alignment of a circular, parabolic, 3.66 m (12 ft) diameter, S/X-band, antenna reflector with a focal length-to-diameter ratio of 0.3376;

b) Provide for support and alignment of an X-band feed horn to be located in the center of the parabolic reflector;

c) Provide for support and alignment of a hyperbolic dichroic (frequency selective) subreflector directly above the X-band feed horn;

d) Provide for support and alignment of a pair of back-to-back S-band antenna feed horns - one to serve as the S-band HGA feed, the other to serve as Low Gain Antenna (LGA);

e) Provide the HGA with an unobstructed 5 deg half-cone angle FOV centered on, and aligned parallel with the S/C -Z-axis, and emanating from the periphery of the primary reflector surface;

f) Provide for a minimum length wave guide and/or coax path from the RFS transmitter bay to the X-band HGA feed, the S-band HGA feed and the S-band LGA;

g) Provide for cruise sun sensor support, alignment and FOV requirements when mounted on the rear face of the parabolic reflector;

h) Provide for modular final installation of the HGA assembly with feeds, sun sensors and cabling in place.

4.4 Science Requirements

The science payload may be grouped in three categories:

a) Body Fixed Science - That science which is attached directly to the MM bus. The planetary radio astronomy, plasma wave, and magnetometer subsystems have bus mounted electronic packages extendable antennas and an extendable boom respectively. These instruments are sensitive to MM electromagnetic interference and magnetic fields respectively. The instrument locations and orientation shall be chosen to minimize those instrument environments to the greatest degree practical, commensurate with other spacecraft requirements.

b) Boom Mounted Science - Three science instruments are affixed to the science boom to continuously monitor the interplanetary space media in general, and energetic particle medium in particular. The cosmic ray, low energy charged particle and plasma subsystems are sensitive to their celestial orientation and the MM induced radiation environment.

c) Scan Science - The wide angle (WA) and narrow angle (NA) imaging science cameras, photopolarimeter, infrared interferometer spectrometer and radiometer and ultraviolet spectrometer are mounted on the scan platform. Since they are optical in nature, they are sensitive to stray light, require protection from direct exposure to the Sun, and desire an unobstructed view of the celestial sphere.

Certain MJS77 limitations and constraints preclude satisfaction of all science requirements and objectives per se. However, within the limitations of the S/C capabilities, alternative solutions have been negotiated which result in realization of the objectives of each experiment without undue compromise.

The following paragraphs present the stated "REQUIREMENTS" and the "NEGOTIATED EXCEPTIONS" (where applicable) for each of the instruments in the scientific payload.

4.4.1 Planetary Radio Astronomy Subsystem (PRA) (ICD No. 10062352)

The PRA consists of an electronics package to which are attached two deployable 10 m long antennas.

The configuration shall:

a) Provide an external bus mounted location from which the antennas may be deployed without interference with other flight equipment;

b) Provide for structural support and launch restraint;

c) Provide a deployed orientation such that the antennas are normal to each other in a plane perpendicular to the MAG boom and centered about the Y-axis;

d) Provide for centerline clearance between antennas and RTG outrigger of 76 cm (3.0 in.) to the upper outrigger members and 127 cm (5.0 in) to lower members.

4.4.2 Plasma Wave Subsystem (PWS) (ICD No. 10062373)

The PWS consists of an electronics package which in conjunction with the PRA shares the two 10 m PRA antennas.

The configuration shall provide an external bus mounted location for the PWS electronics as near the PRA antennas as is practical.

4.4.3 Magnetometer Subsystem (MAG) (ICD No. 10062365)

The MAG instrument consists of two bay mounted electronics subassemblies, two Low Field Magnetometer (LFM) sensor packages mounted on a 13 m deployable boom, and two High Field Magnetometer (HFM) sensor packages which are attached to MM structure.

The configuration shall:

a) Provide for LFM sensor orientation on the boom such that the longitudinal axis of the outboard sensor is parallel to the X-axis, the inboard sensor longitudinal axis is parallel to the Y-axis and both sensor axes are normal to the Z-axis.

b) Provide for mounting one LFM sensor package at the boom tip and a second between 7.8 and 10.4 m from the base of the boom;

c) Provide for mounting of the two HFM sensor packages near the base of the boom approximately one meter apart.

4.4.4 Cosmic Ray Subsystem (CRS) (ICD No. 10062351)

The CRS consists of a sensor array mounted on an electronics package. The sensor array, in turn, consists of:

a) Two High Energy Telescopes (HET) with 50 deg conical FOV's emanating from each end;

b) Four Low Energy Telescopes (LET) with 90 deg conical FOV's; and

c) The Electron Telescope (TET) with a 90 deg conical FOV.

The configuration shall:

a) Position the instrument on the MM near the projection of the RTG centerline such that maximum utilization of the radiation shielding effect of the bus structure and the bay mounted electronics assemblies can be realized consistent with other S/C requirements;

b) Provide an unobstructed FOV for the four LET's and the TET; and both ends of the two HET's.

c) Orient the HET's such that their boresight vectors are normal to each other and one lies in the plane of the Ecliptic at 9 AU;

d) Provide a second position for mounting one HET, such that the above conditions are met;

e) Orient three of the LET's such that their boresight centerlines are orthogonal, and the fourth such that it is coaxial with, but directed opposite from, any one of the other LET's;

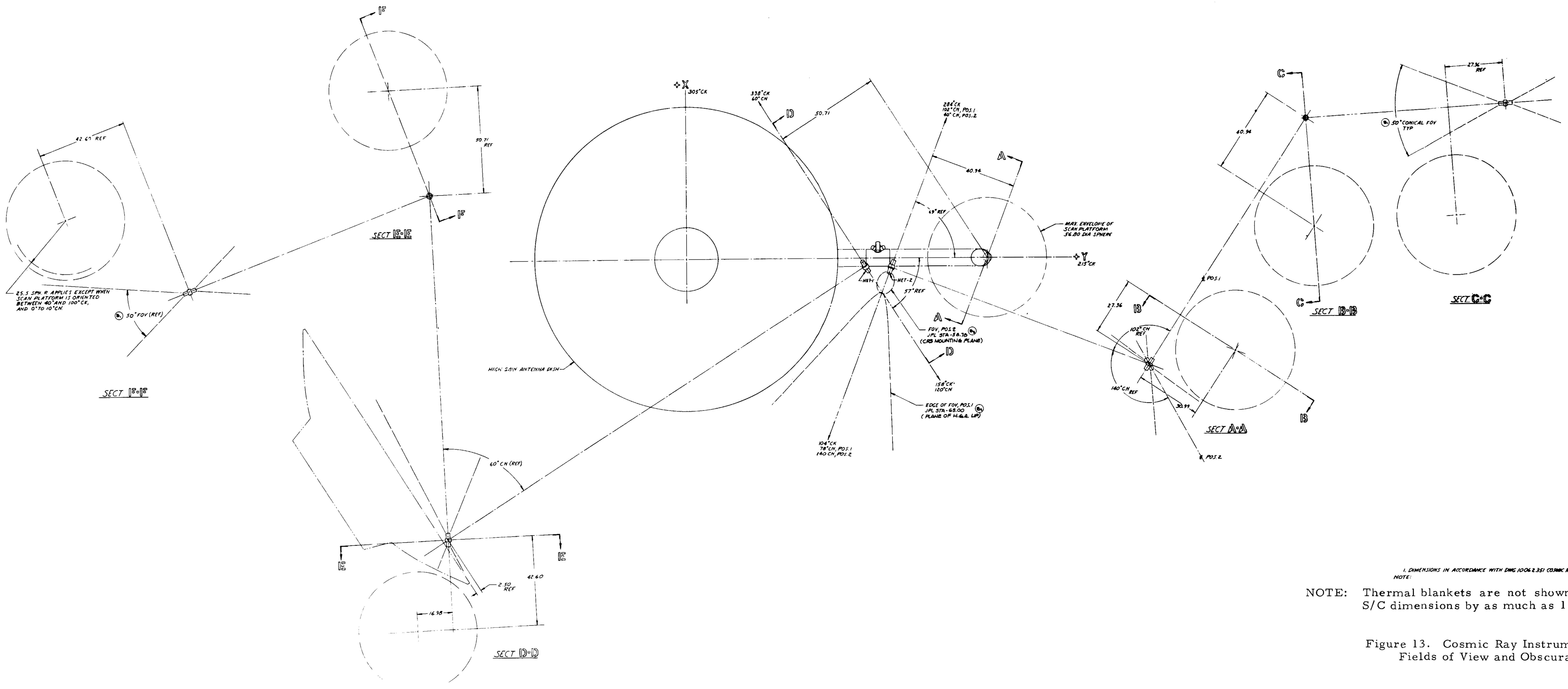
f) Orient the TET boresight parallel to any LET pointing direction.

NEGOTIATED EXCEPTIONS:

HET pointing requirements have been relaxed such that their boresight directions are oriented as near to c) and d) above as possible while maintaining FOV's which are unobscured and do not overlap. Table 1 lists HET and LET boresight orientation, FOV status and percentage of FOV obscuration. A graphic representation is presented in Figures 13 and 14.

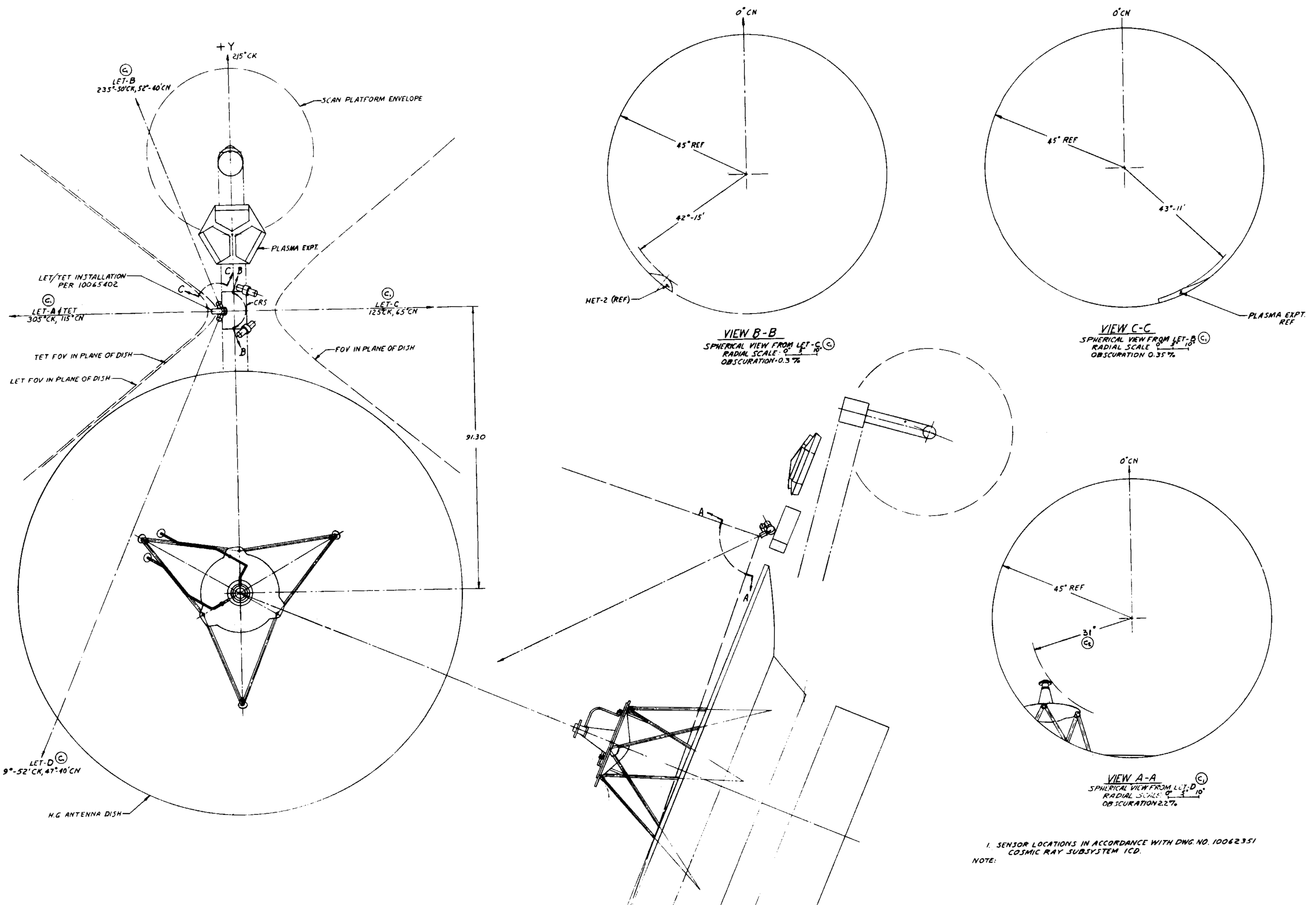
Table 1. CRS Sensor Boresight Vectors

SENSOR	BORESIGHT VECTOR		ANGLE BETWEEN SENSORS and PERCENT OBSCURATION
	Clock (deg)	Cone (deg)	
LET A	305	115	90 deg to B and D, 180 deg to C
B	236	53	90 deg to A, C and D (1 percent obs.)
C	125	65	90 deg to B and D, 180 deg to A (1 percent obs.)
D	10	48	90 deg to A, B and C (2 percent obs.)
TET	305	115	Parallel to C
HET 1	338 158	60 120	
HET 2 Pos. 1	104 284	78 102	67 deg to HET C
HET 2 Pos. 2	104 284	140 40	45 deg to HET C



NOTE: Thermal blankets are not shown but may increase S/C dimensions by as much as 1 inch on each edge.

Figure 13. Cosmic Ray Instrument HET Fields of View and Obscuration



NOTE: Thermal blankets are not shown but may increase S/C dimensions by as much as 1 inch on each edge.

Figure 14. Cosmic Ray Instrument LET/TET Fields of View and Obscuration

4.4.5 Low Energy Charged Particle Subsystem (LECP) (ICD No. 10062355)

The LECP consists of a series of sensors in a pair of rotating telescopes. The Low Energy Magnetospheric Particle Analyzer (LEMPA) and the Low Energy Particle Telescope (LEPT) are mounted on a rotating platform which is, in turn, mounted on an electronics package. The LEPT telescope has a 55 deg conical FOV emanating from each end. The LEMPA has 45 deg and 95 deg conical FOV's emanating from opposite ends. A β' sensor views space from the side of the LEMPA, from the plane of rotation to nearly the axis of rotation sequentially through a series of seven equal solid angle ports in a hemispherical shield. The entire sensor package rotates plus and minus 360 deg in 45 deg steps. Each sensor samples at each of the 45 deg positions.

The configuration shall:

a) Locate the instrument near the projection of the RTG centerline in a manner which maximizes the radiation shielding effect of the bus structure and bay mounted electronics assemblies consistent with other spacecraft requirements;

b) Orient the plane of rotation of the telescopes as nearly parallel to the ecliptic plane during post-Saturn cruise as possible;

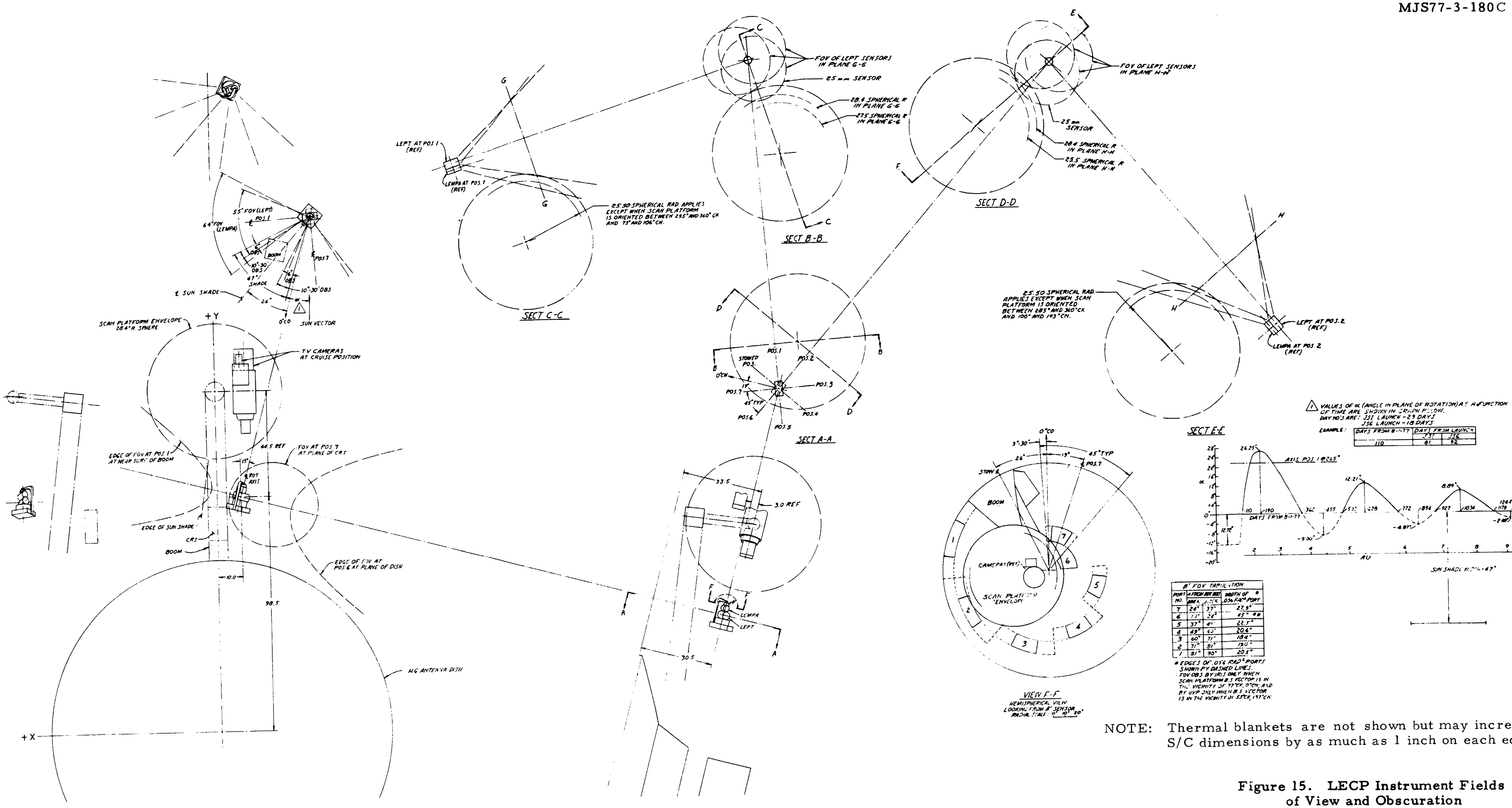
c) Provide for unobstructed fields-of-view for all sensors in each of the eight platform sampling positions (except as noted in d) below);

d) Provide for one platform position (stowed), in which a sun shade completely covers the β' sensor and the ports on one end of each telescope (LEPT and LEMPA);

e) Provide that all MM induced obscuration occur within the angle subtended by the sun shade.

NEGOTIATED EXCEPTION:

The LECP has been oriented such that the axis of rotation is aligned with a 200 deg clock 90 deg cone vector to provide the sensors with unobscured 55 deg conical fields-of-view at all platform boresight positions. This orientation results in an obscured 47 deg conical region centered at 290 deg clock, 26 deg cone. Seven orientations for ports in the β' shield have been selected which provide coverage of all angles between the plane of rotation and 9 deg of the projected axis of rotation. Table 2 lists the LECP FOV boresight orientation. A graphic representation is presented in Figure 15.



NOTE: Thermal blankets are not shown but may increase S/C dimensions by as much as 1 inch on each edge.

Figure 15. LECP Instrument Fields of View and Obscuration

Table 2. LECP Sensor Boresight Vectors

PLATFORM POSITION	BORESIGHT VECTOR		
	LEPT (LEMPA)		β' POINTING VECTOR
	CLOCK (deg)	CONE (deg)	(NOM ∠ TO AXIS)
0 (Stowed)	290	26	—
1	290	71	85.5
2	290	116	76.0
3	290	161	65.5
4	110	154	54.5
5	110	109	43.0
6	110	64	17.0
7	110	19	33.5

4.4.6 Plasma Subsystem (PLS) (ICD No. 10062362)

Three pentagon-shaped sensor packages are joined to each other to form an array with 90 deg primary, and 180 deg secondary, conical FOV's centered on the axis of symmetry of the array. A fourth, cylindrical, sensor is boresighted normal to axis of symmetry and has a 120 deg conical FOV centered on its boresight. The sensors and a supporting electronics package constitute the PLS instrument.

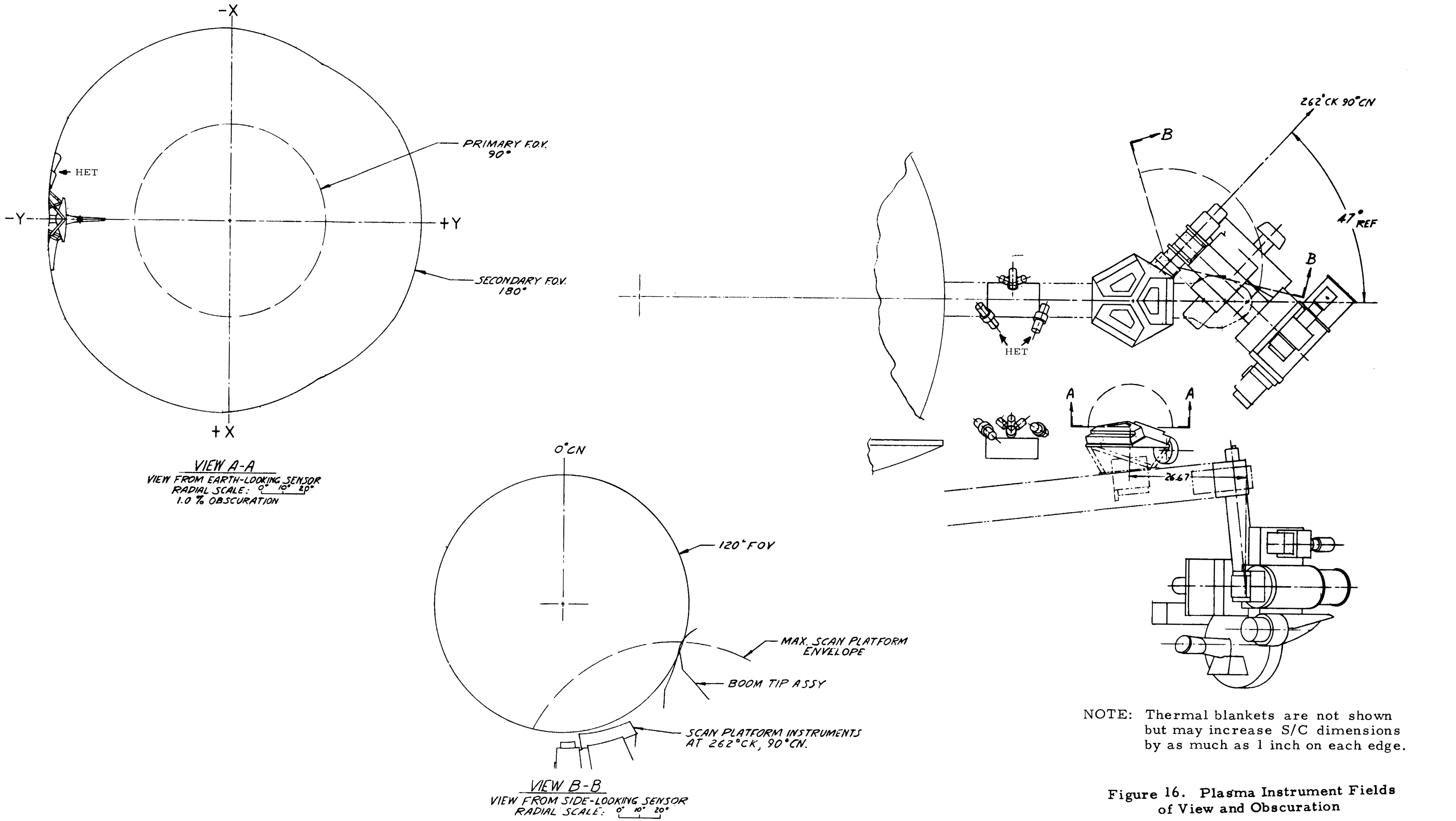
The configuration shall:

a) Provide an unobstructed, 90 deg conical , primary FOV centered on the nominal MM-Earth vector;

b) Provide a nearly unobstructed, hemispherical, secondary, FOV centered on the nominal MM-Earth vector;

c) Provide an unobstructed, 120 deg conical, FOV for the lateral sensor, centered normal to MM-Earth vector and boresighted at 262 deg clock, 90 deg cone.

The FOV requirements are met as depicted graphically in Figure 16.



NOTE: Thermal blankets are not shown but may increase S/C dimensions by as much as 1 inch on each edge.

Figure 16. Plasma Instrument Fields of View and Obscuration

NEGOTIATED EXCEPTIONS:

The instrument position and orientation selected provides totally unobscured primary FOV. Two CRS telescopes, the HGA feed, and the Mag Boom protrude into the 180 deg secondary FOV producing an obscuration of approximately 1.0 percent of the total field. The FOV of the side mounted sensor is unobscured by the scan platform when the platform is boresighted at 262 deg clock 90 deg cone, however, other platform positions may result in obscuration.

4.4.7 Imaging Science Subsystem (ISS) (ICD's No. 10062360, 10062366 and 10062367)

The ISS consists of: a 1.5 m focal length, NA camera (ISS NA), with 0.6 deg conical, optical FOV and 11 deg conical stray light FOV; a 0.2 m focal length, WA camera with a 4.6 deg conical, optical FOV and a 15 deg stray light FOV; and two identical electronic packages.

The configuration shall:

a) Provide for installation and alignment of the ISS NA and ISS WA cameras on the scan platform in a manner which relates their boresight vectors with the platform $\bar{L}$ vector according to the requirements of MJS77-3-170,

b) Provide unobstructed fields-of-view of 0.6 deg for the ISS NA and 4.6 deg for the ISS WA cameras,

c) Provide that no flight equipment be within the 11 deg NA or 15 deg WA stray light FOV when that equipment is illuminated;

d) Provide for installation of two electronics packages on the scan platform;

e) Provide for radiation shielding of the electronics packages per the requirement s of MJS77-3-240.

4.4.8 Photopolarimeter Subsystem (PPS) (ICD No. 10062357)

The PPS instrument consists of electronics, sensors, filter wheels, optics and Sun shade integrated into a single package. The PPS has four conical FOV's boresighted along the centerline of the instrument. The largest of the FOV's is 3-1/2 deg.

The configuration shall:

a) Provide for installation of the PPS instrument on the scan platform such that its boresight vector is aligned with the platform $\bar{L}$ vector according to the requirements of MJS77-3-170,

b) Provide an unobstructed 3-1/2 deg., conical FOV, centered on the instrument boresight vector;

c) Provide a 20 deg conical stray light FOV centered on the instrument boresight vector;

d) Provide that no illuminated flight equipment shall see the inner surface of the Sun shade;

e) Provide that the sun shall not see the inner surface of the sun shade when the scan platform is at cone angles of 20 deg or greater.

4.4.9 <u>Ultraviolet Spectrometer Subsystem (UVS) (ICD No. 10062364)</u>

The UVS instrument consists of electronics, sensors and optics contained within a single package. The instrument has a rectangular 1.0 x 0.2 deg Airglow FOV centered parallel to its longitudinal axis and a 0.6 x 0.6 deg Occultation FOV centered on a vector 20 deg off the Airglow boresight vector.

The configuration shall:

a) Provide for installation of the UVS instrument on the scan platform such that its boresight vector is aligned with the platform $\bar{L}$ vector according to the requirements of MJS77-3-170.

b) Provide an unobstructed 1 x 0.2 deg rectangular FOV and Stray light FOV of 10 x 2 deg centered on the instrument boresight;

c) Provide an unobstructed 0.6 x 0.6 deg square FOV and stray light FOV of 10 x 1 deg boresighted at ψ = 20 deg, χ = 0 deg for observation of solar occultation. (Ref. Fig. 11) (e.g., the occultation port boresight elevation angle equals the the airglow elevation angle less 20°.)

4.4.10 <u>Infrared Interferometer Spectrometer and Radiometer Subsystem (IRIS) (ICD's No. 10062369 and 10062372)</u>

The IRIS instrument consists primarily of a cassegrain telescope, an optical conditioning assembly, a power supply, and an electronics package. The IRIS electronics package and power supply are mounted separately on the platform. The instrument has a 1/4 deg conical FOV emanating from the periphery of the 51 cm diameter primary reflector.

The configuration shall:

a) Provide for installation of the IRIS instrument on the scan platform such that its boresight vector is aligned with the platform $\bar{L}$ vector according to the requirements of MJS77-3-170;

b) Provide for installation of the IRIS electronics package and power supply on the scan platform;

c) Provide an unobstructed 1/4 deg conical FOV centered on the primary mirror centerline;

d) Provide that no illuminated flight equipment shall be within the 2.5 deg conical stray light FOV during slewing of the Science platform to view the calibration target and brewster plate. Special care shall be taken to have all flight equipment surfaces glint free in the areas shaded in Figure 28.

e) Provide that the optical surface of the IRIS beam splitter shall be vertical +10 deg for launch (i.e., the instrument boresight vector shall be in the X-Y plane ±10 deg);

f) Provide an unobscured 12 mrad conical FOV for the solar calibration mirror boresighted at $\psi=20°$, $X=0°$ (refer to Figure 11) (e.g., the mirror boresight elevation angle equals the instrument elevation angle less 20 percent.

✱ 4.4.11 Modified Interferometer Spectrometer and Radiometer Subsystem (MIRIS) (ICDs No. 10062348 and 10062371).

Deleted

4.5 Scan Platform Pointing Requirements

The configuration design shall:

a) Provide for a two-deg-of freedom scan platform;

b) Provide an unobstructed 4π steradian FOV for all platform mounted instruments;

c) Provide rotational freedom in the gimbal axes such that the platform can be pointed at any object in the MM centered celestial sphere;

d) Orient gimbal axes to minimize slewing time during periods of highest platform utilization; and

e) Provide maximum flexibility for the accommodation of changes to the mission sequence and/or trajectory flown.

f) Provide rotational capability to align the UVS occultation FOV long axis (10 deg) tangent to the edge of the planet at immergence and emergence to sun occultation (while satisfying radio science HGA pointing during Earth occultation).

NEGOTIATED EXCEPTION:

The scan platform provided in the MJS77 configuration has rotational freedom in Azimuth and Elevation. Azimuth rotation is limited to ±180 deg about Azimuth position 167.5 deg. An overtravel capability in Elevation provides 210 deg of rotational freedom. The platform may be rotated in elevation 10 deg beyond the zenith (0 deg El) and 20 deg beyond the nadir (180 deg El) at all available Azimuth angles. Figure 17 depicts the platform rotational freedom and limits.

* Certain platform pointing directions result in instrument obscuration by MM hardware. The obscuration for each platform mounted instrument is different. In addition there is an operational restriction imposed by the PPS instrument. The PPS constrains the scan platform from pointing within 20 deg of the Sun before 5 AU. After 5 AU, the platform shall not point within 15 deg (but only with PPS analyzer wheel in the "dark" or "cal slide" position when inside 20 deg). Figures 18 through 33 depict individually each instrument's pointing capability and limitation. (Obscurations shown are hardware tangent to that instrument's largest FOV.)

4.6 Scan Science Calibration Target Requirements

The configuration shall provide for a science calibration target such that:

a) The target shall be in the shade of the HGA during the normal cruise mode;

b) The target can be illuminated by the sun when the MM is properly oriented by pitch, yaw, and/or roll turns;

c) The scan platform can point the instrument (IRIS, PPS, ISSNA and ISSWA) at the target;

d) The instrument boresight may be aligned normal ±10 deg to the surface of the target during observations;

e) The target is larger than corresponding instrument FOV by at least 10 percent;

f) There is no illuminated object other than the target within the stray light FOV.

Target orientation, instrument pointing vectors and FOV information is presented graphically in Figure 28.

4.7 PPS Brewster Plate Calibration Target Requirements

The configuration shall provide for a PPS polarimetric calibration target such that:

a) The target shall be in the shade of the HGA during the normal cruise mode;

b) The target can be illuminated by a steller or planetary source when the MM is properly oriented by pitch, yaw, and/or roll turns;

c) The target mounting allows the PPS to view it with a nominal angle of 57 deg between the target normal and the target-PPS line, and;

d) The target mounting accuracy shall be as specified in MJS77-3-170.

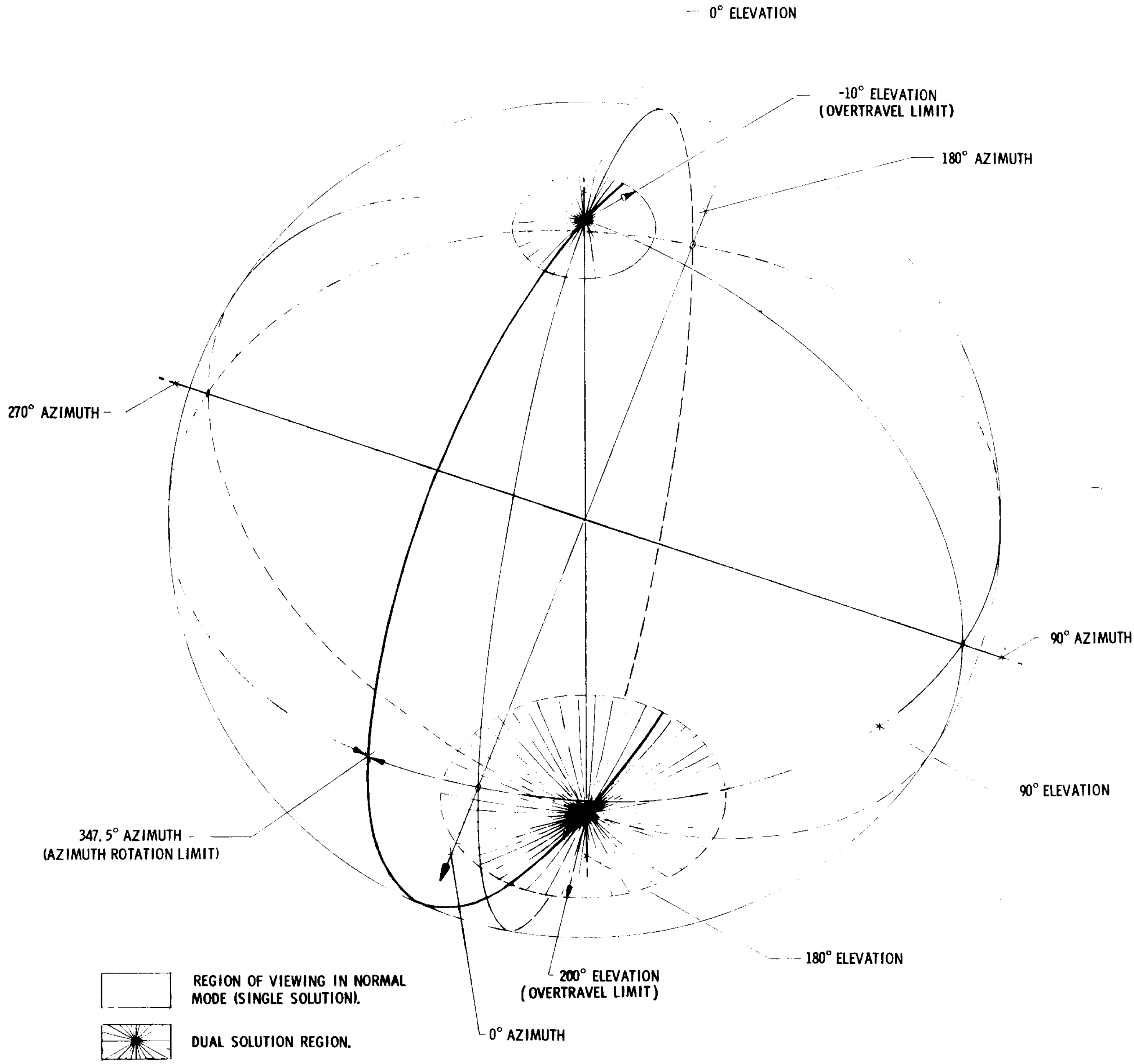
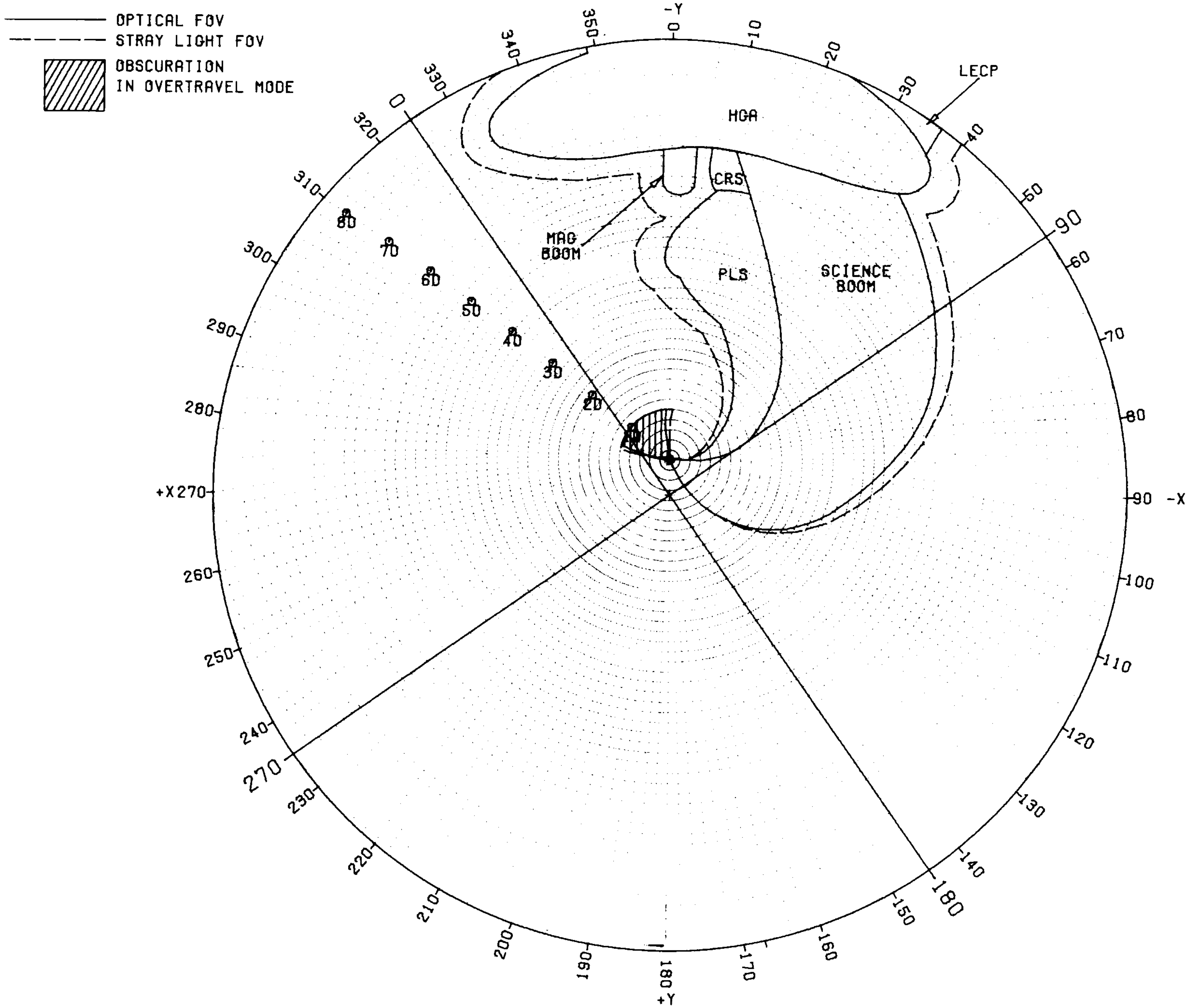
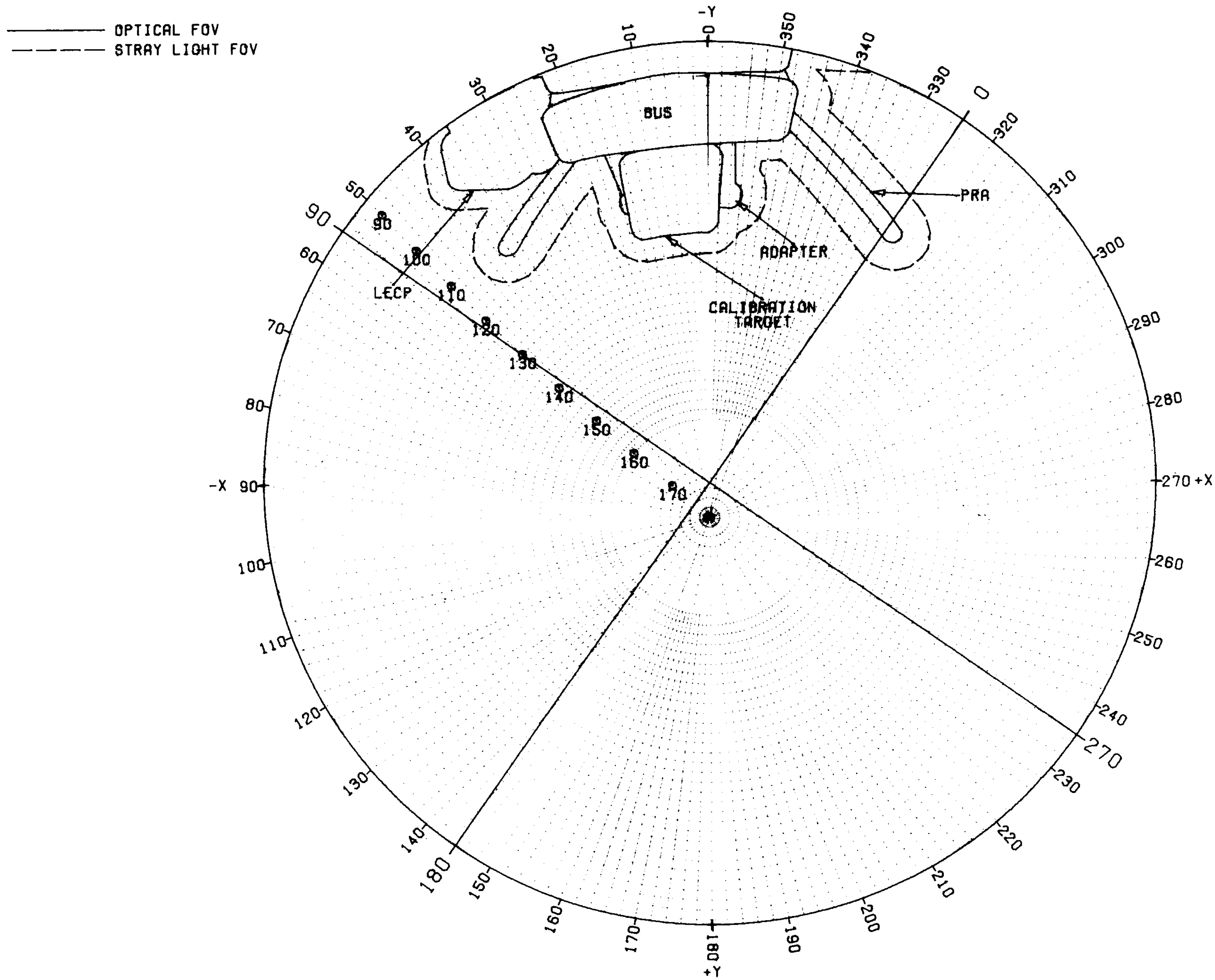


Figure 17. Scan Platform Limit and Capabilities



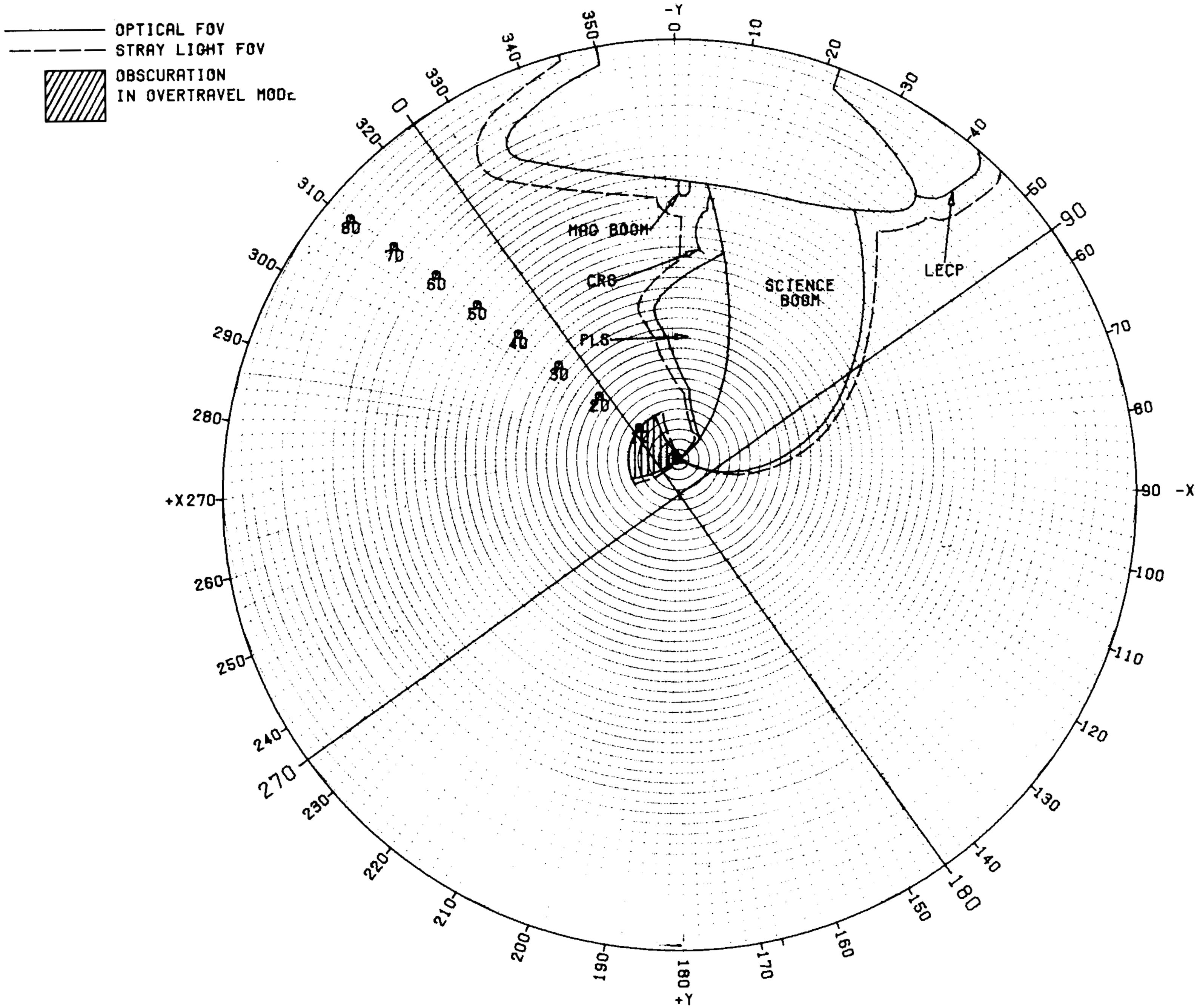
* Figure 18. ISS WA Obscuration, Earthward Hemisphere

MJS77-3-180C

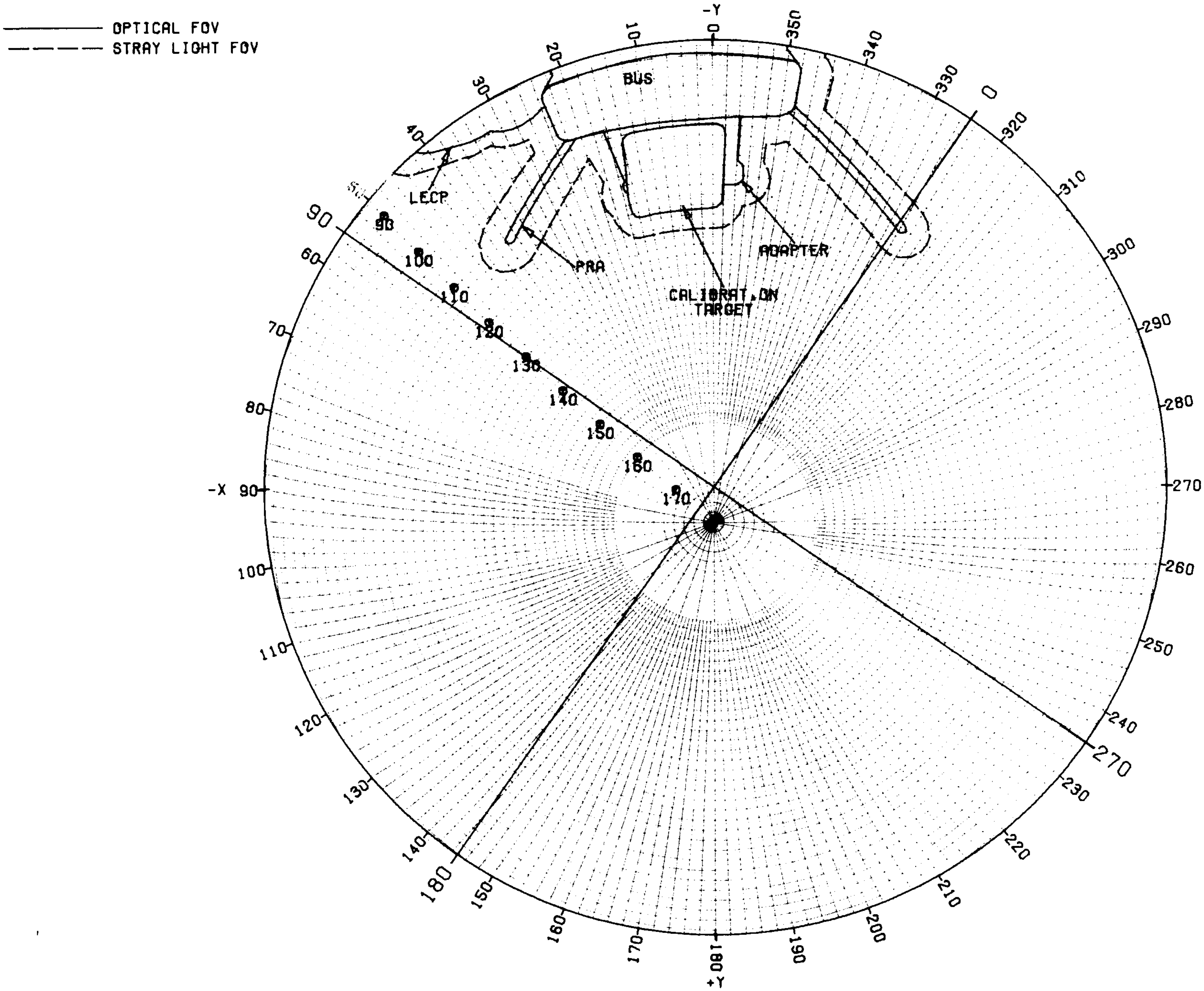


✱ Figure 19. ISS WA Obscuration. Anti-Earthward Hemisphere

MJS77-3-180C

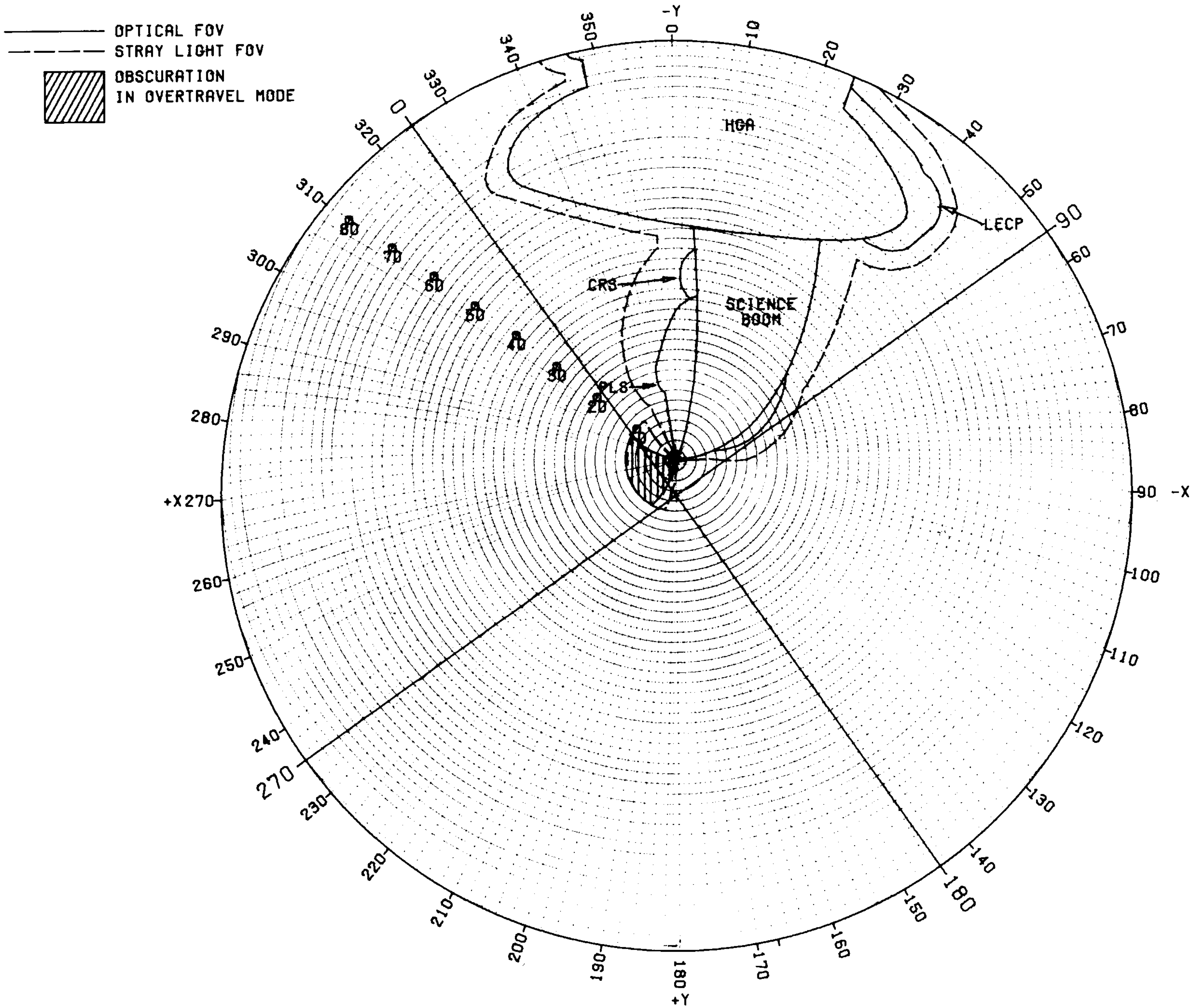


✱ Figure 20. ISS NA Obscuration, Earthward Hemisphere

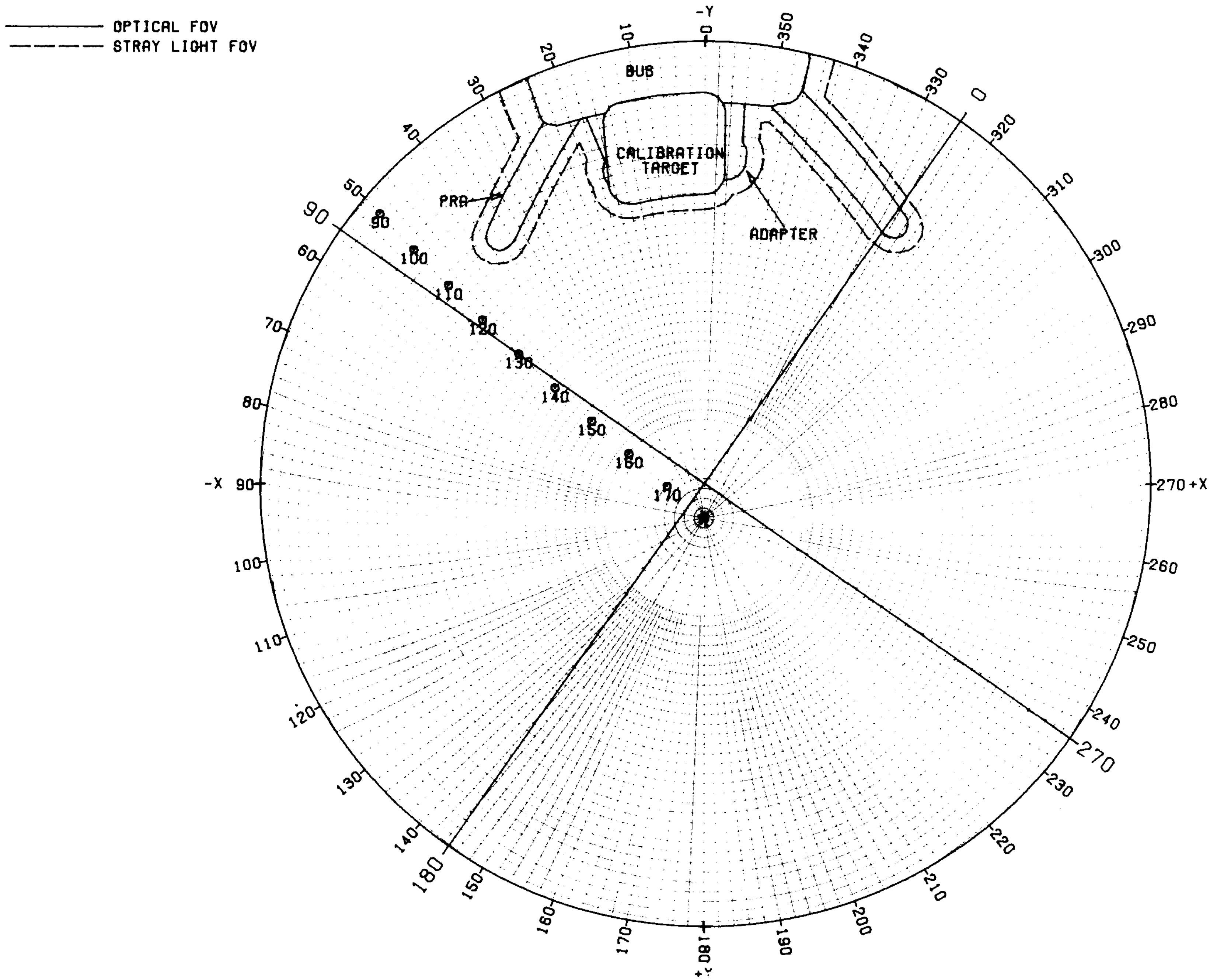


MJS77-3-180C

✱ Figure 21. ISS NA Obscuration, Anti-Earthward Hemisphere

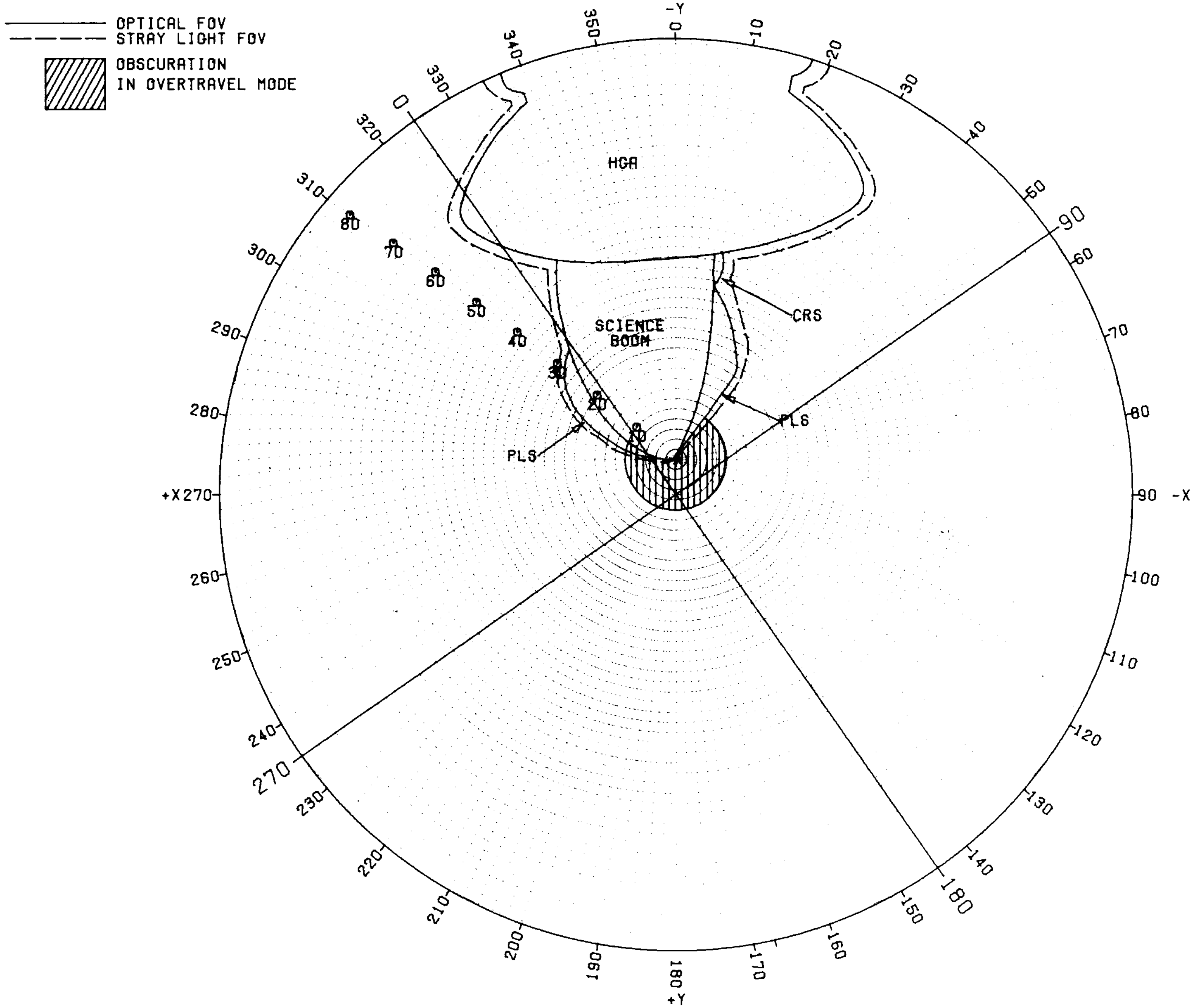


* Figure 22. PPS Obscuration, Earthward Hemisphere



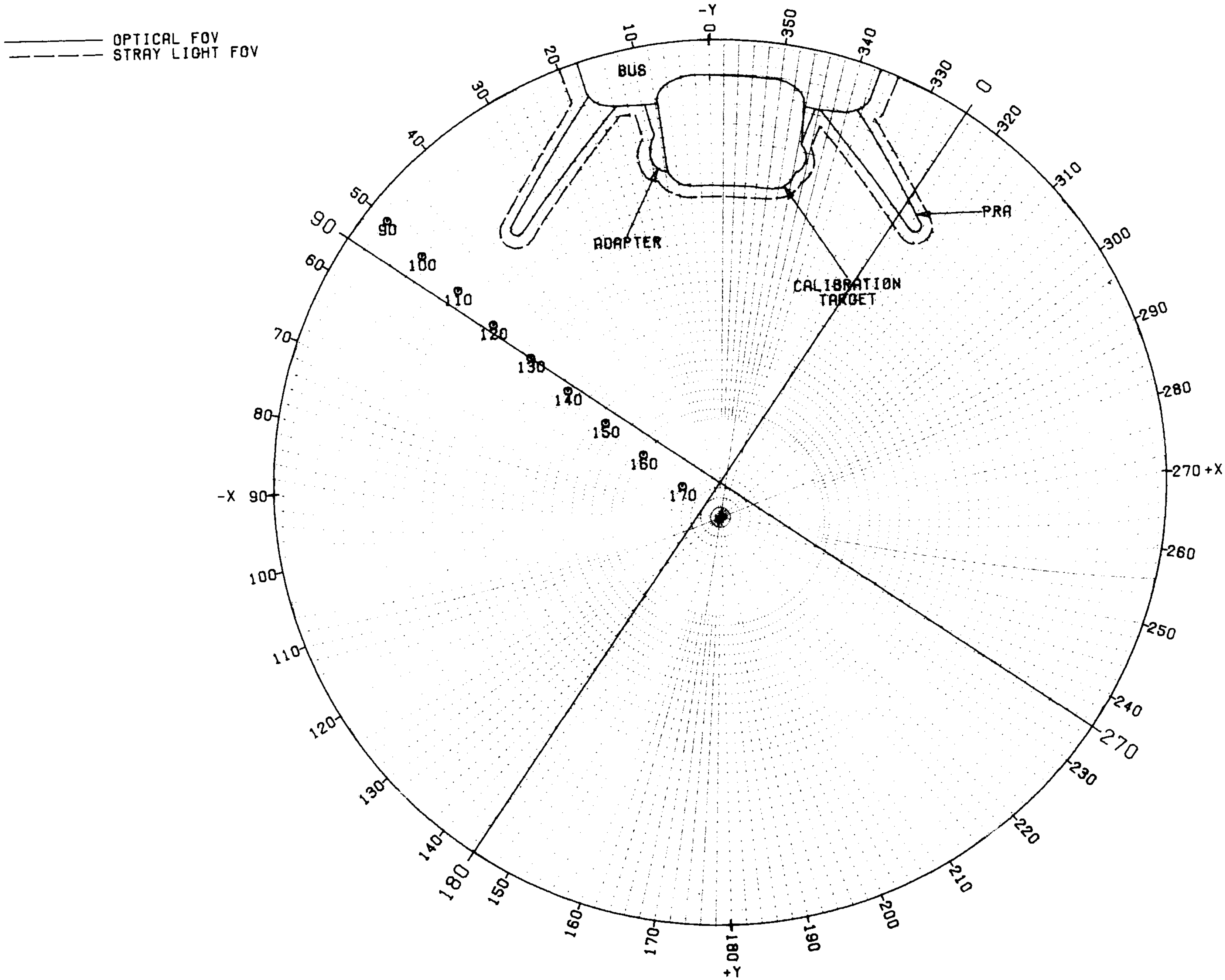
✱ Figure 23. PPS Obscuration, Anti-Earthward Hemisphere

MJS77-3-180C



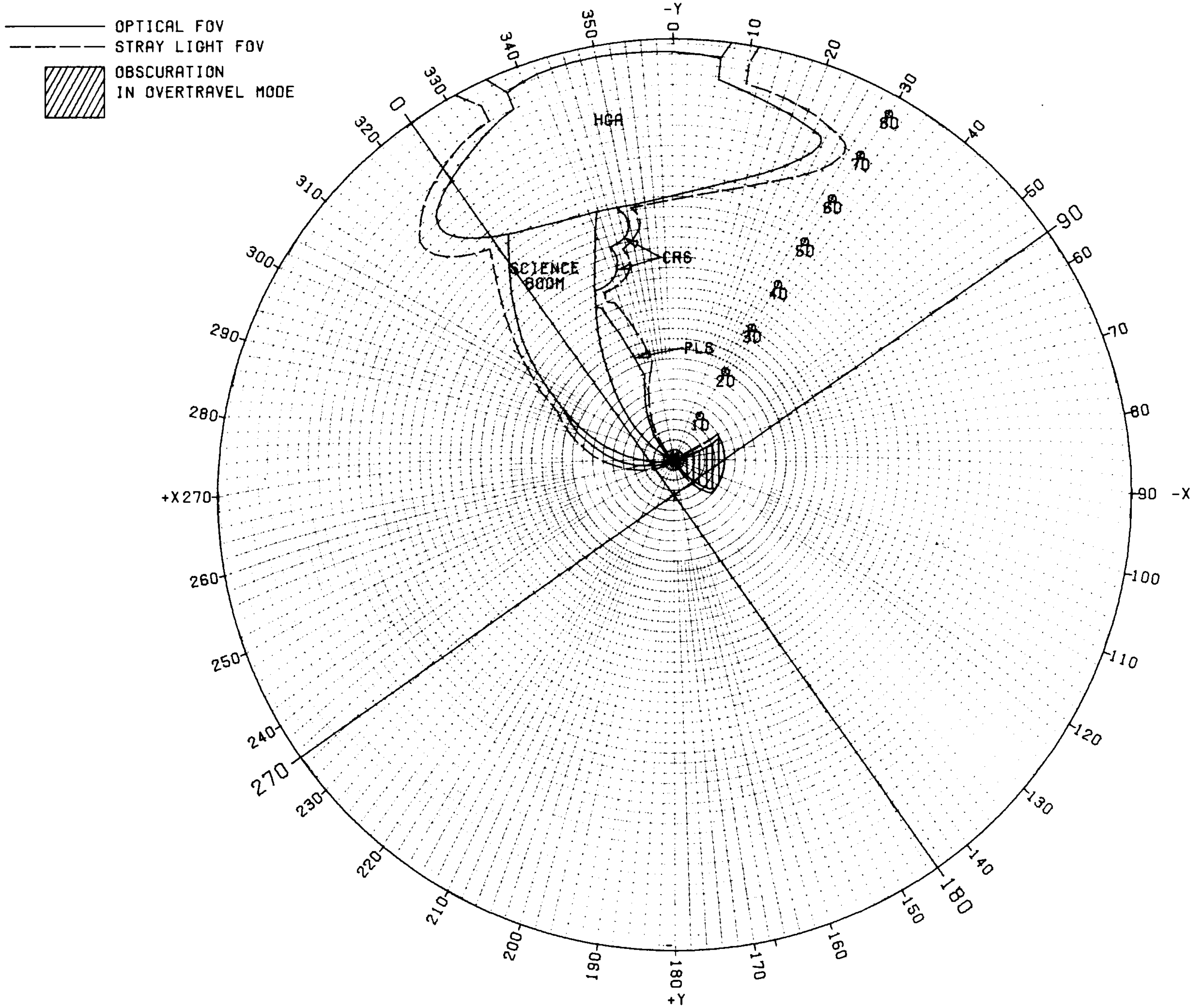
✱ Figure 24. IRIS Obscuration, Earthward Hemisphere

MJS77-3-180C

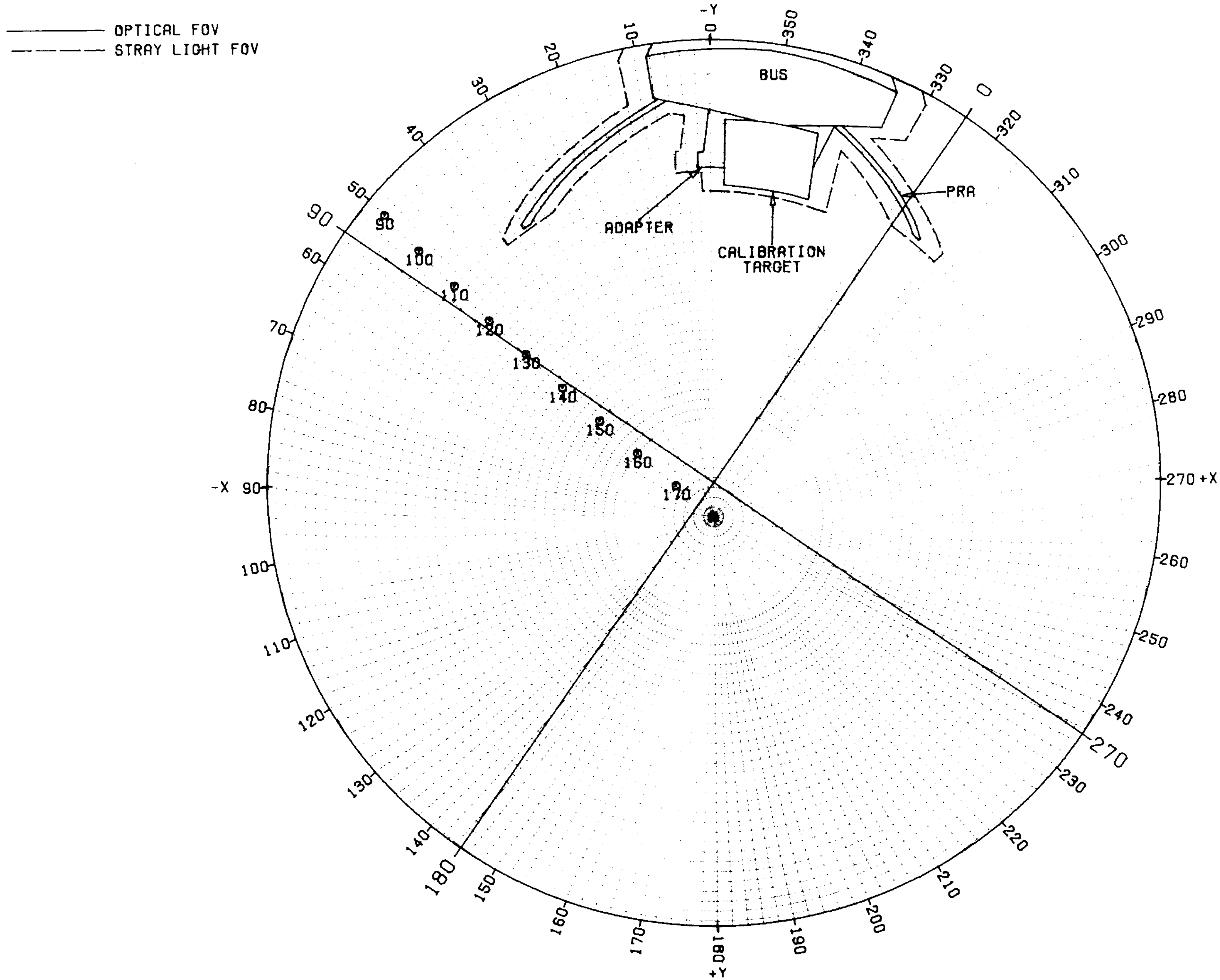


MJS77-3-180C

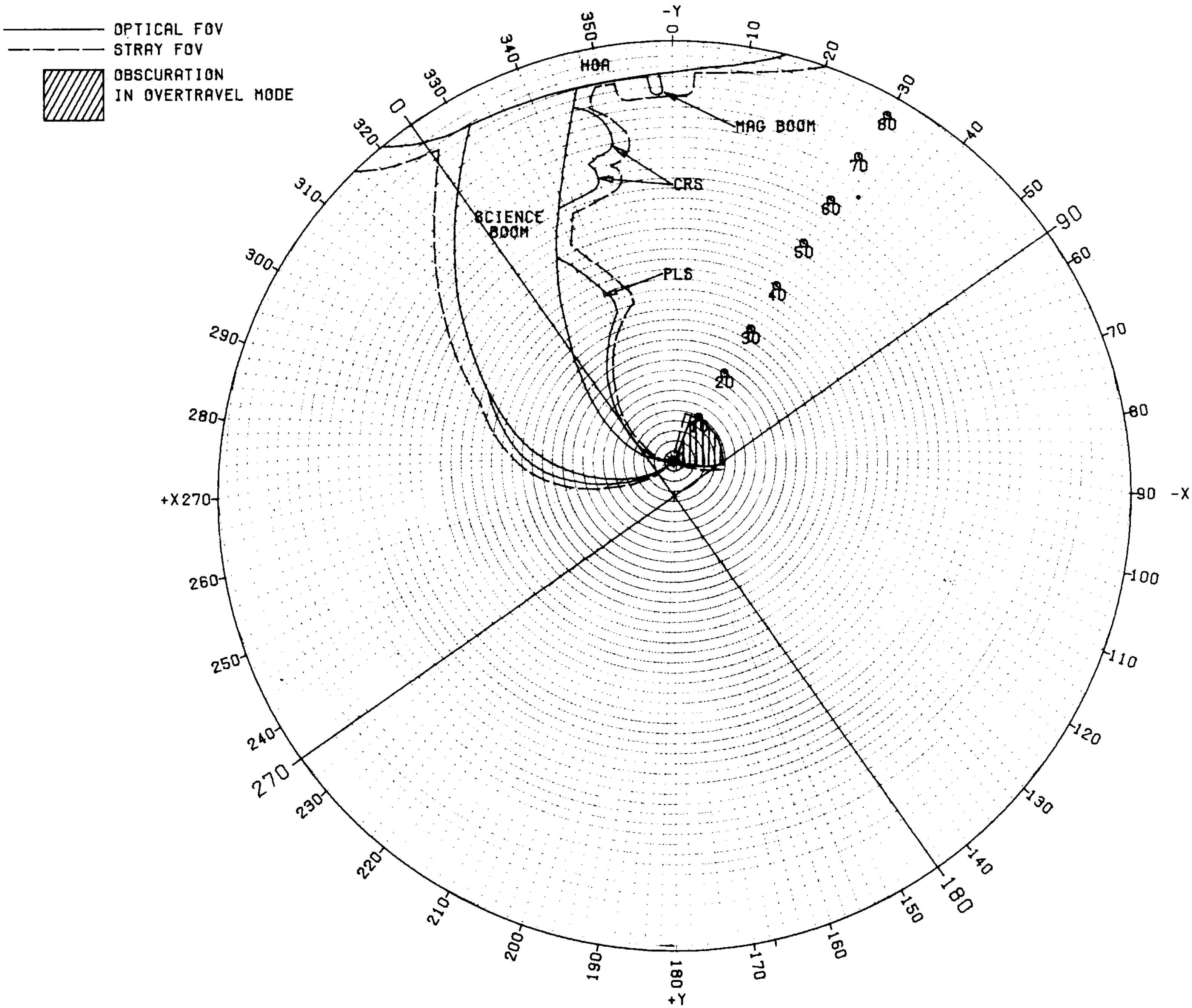
✱ Figure 25. IRIS Obscuration, Anti-Earthward Hemisphere



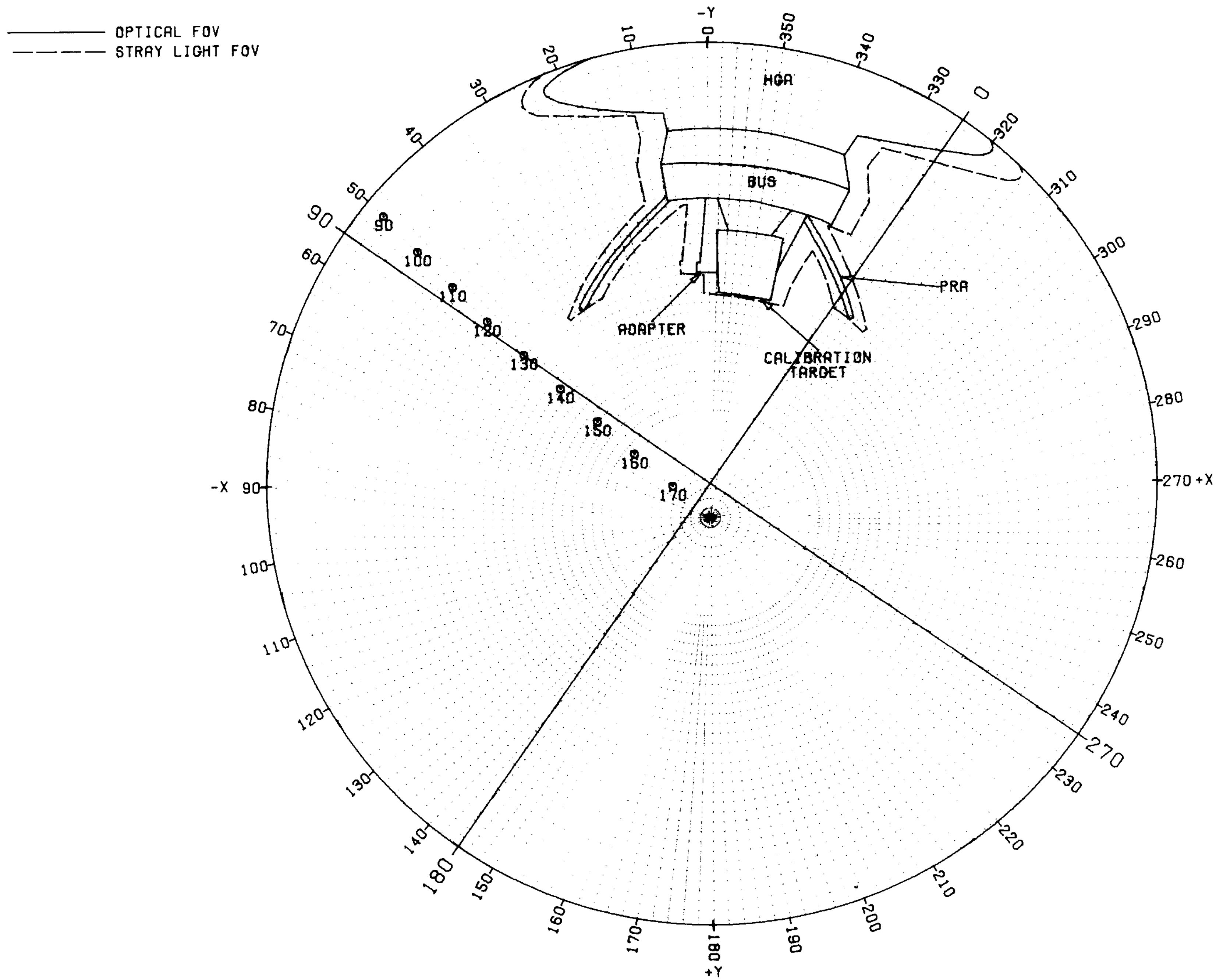
✱ Figure 26. UVS Air-Glow Obscuration Earthward Hemisphere



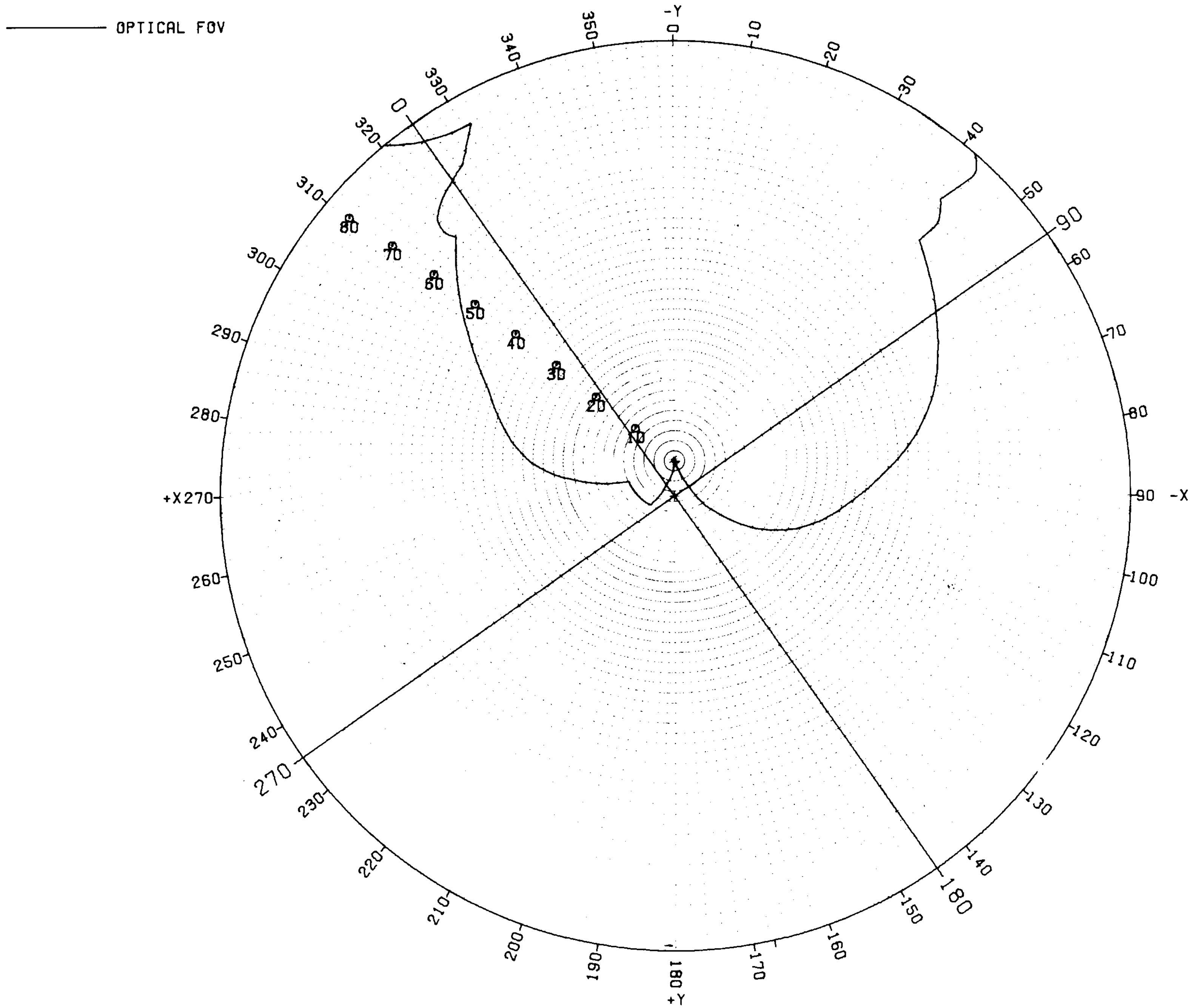
✱ Figure 27. UVS Air-Glow Obscuration Anti-Earthward Hemisphere



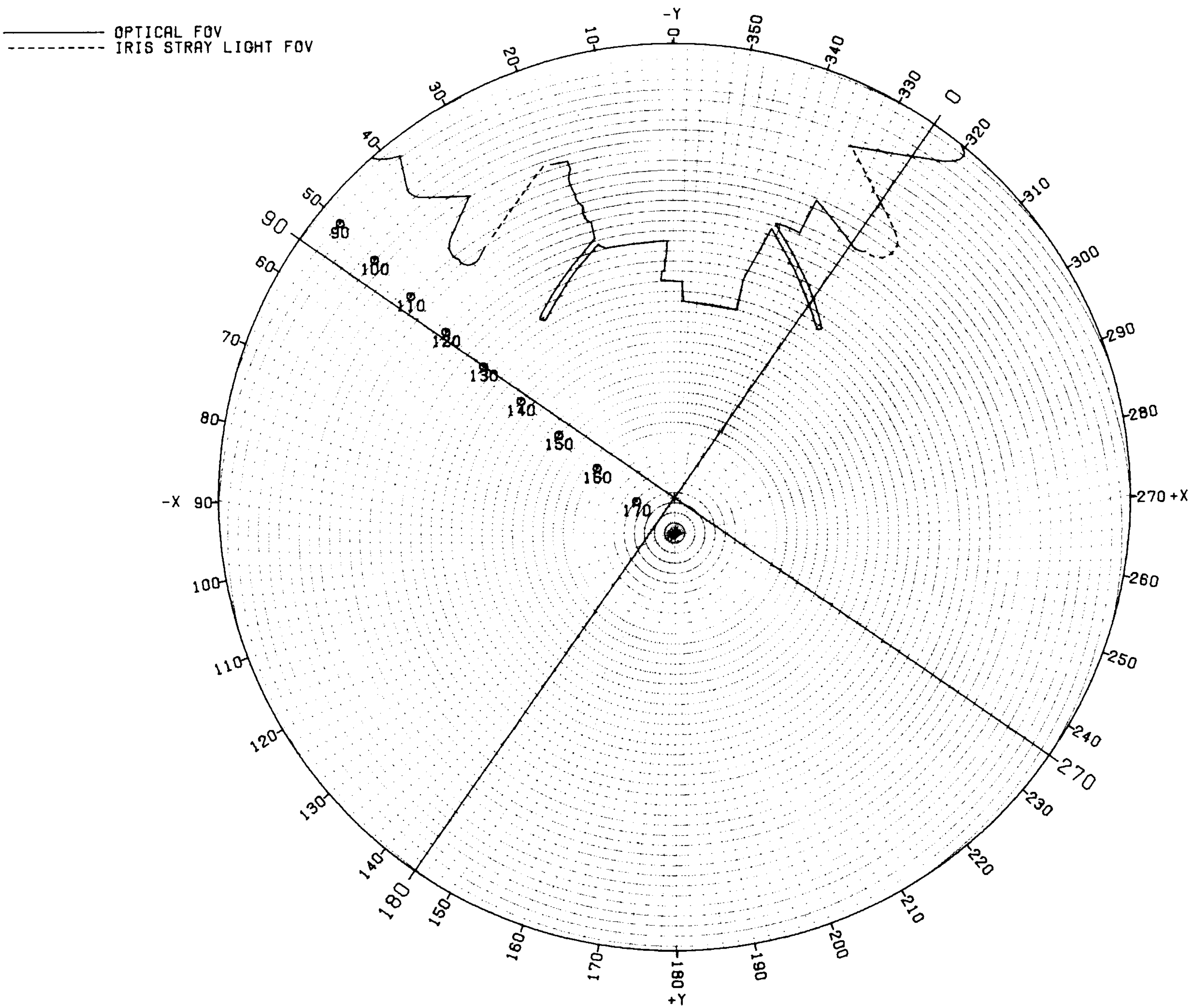
* Figure 28. UVS Occultation Obscuration Earthward Hemisphere



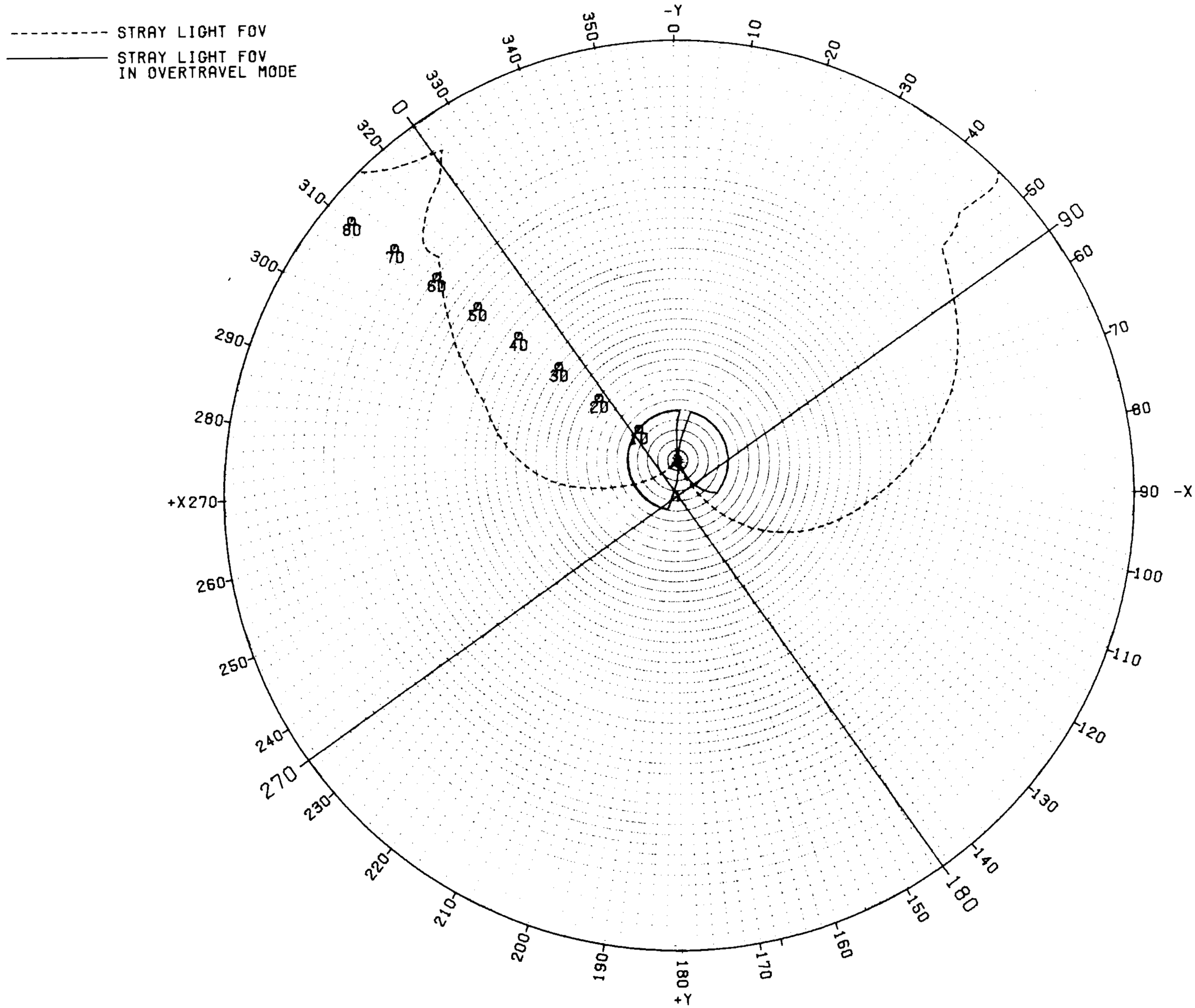
* Figure 29. UVS Occultation Obscuration Anti-Earthward Hemisphere



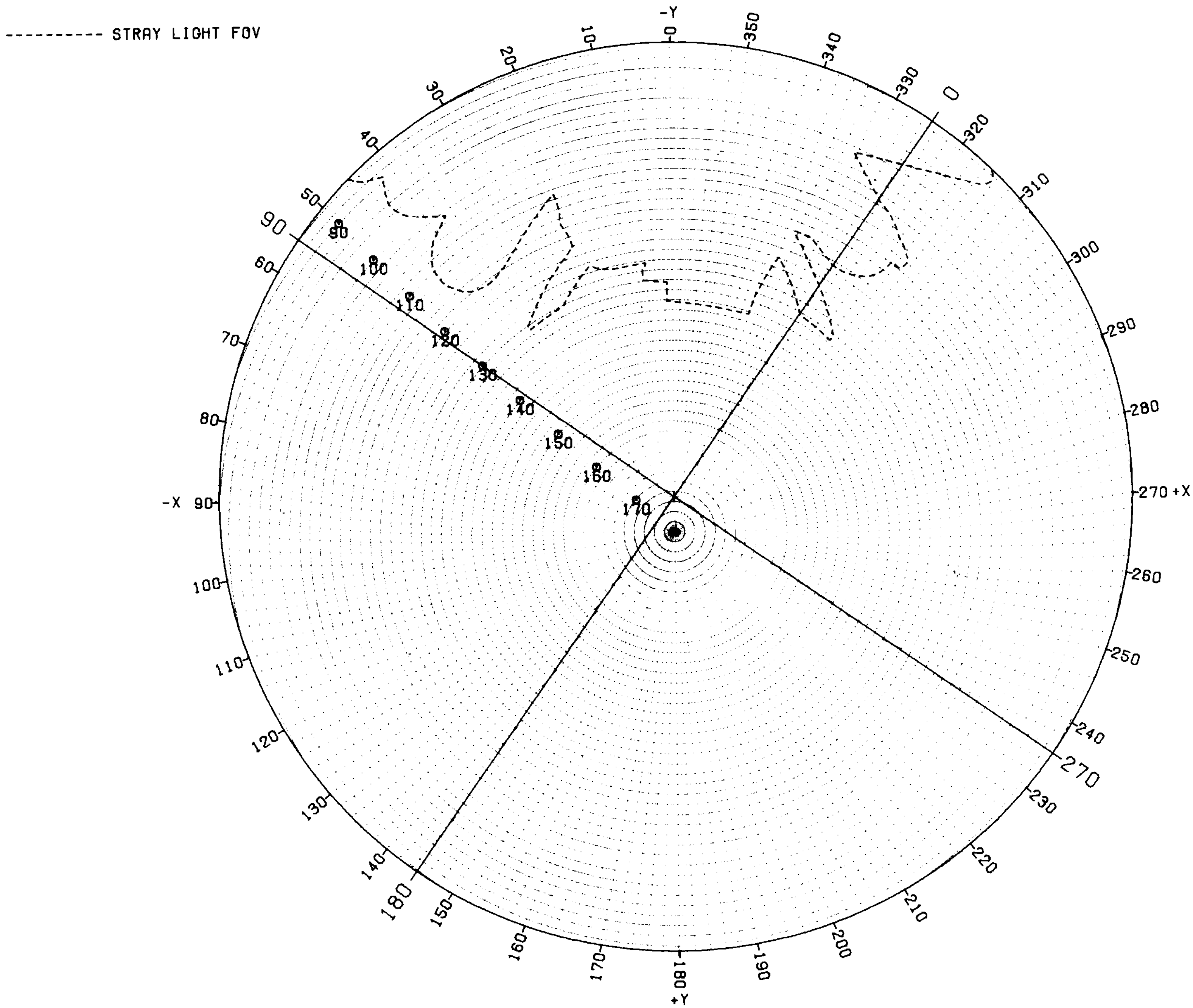
* Figure 30. Platform Slew Stray Light Limits Earthward Hemisphere



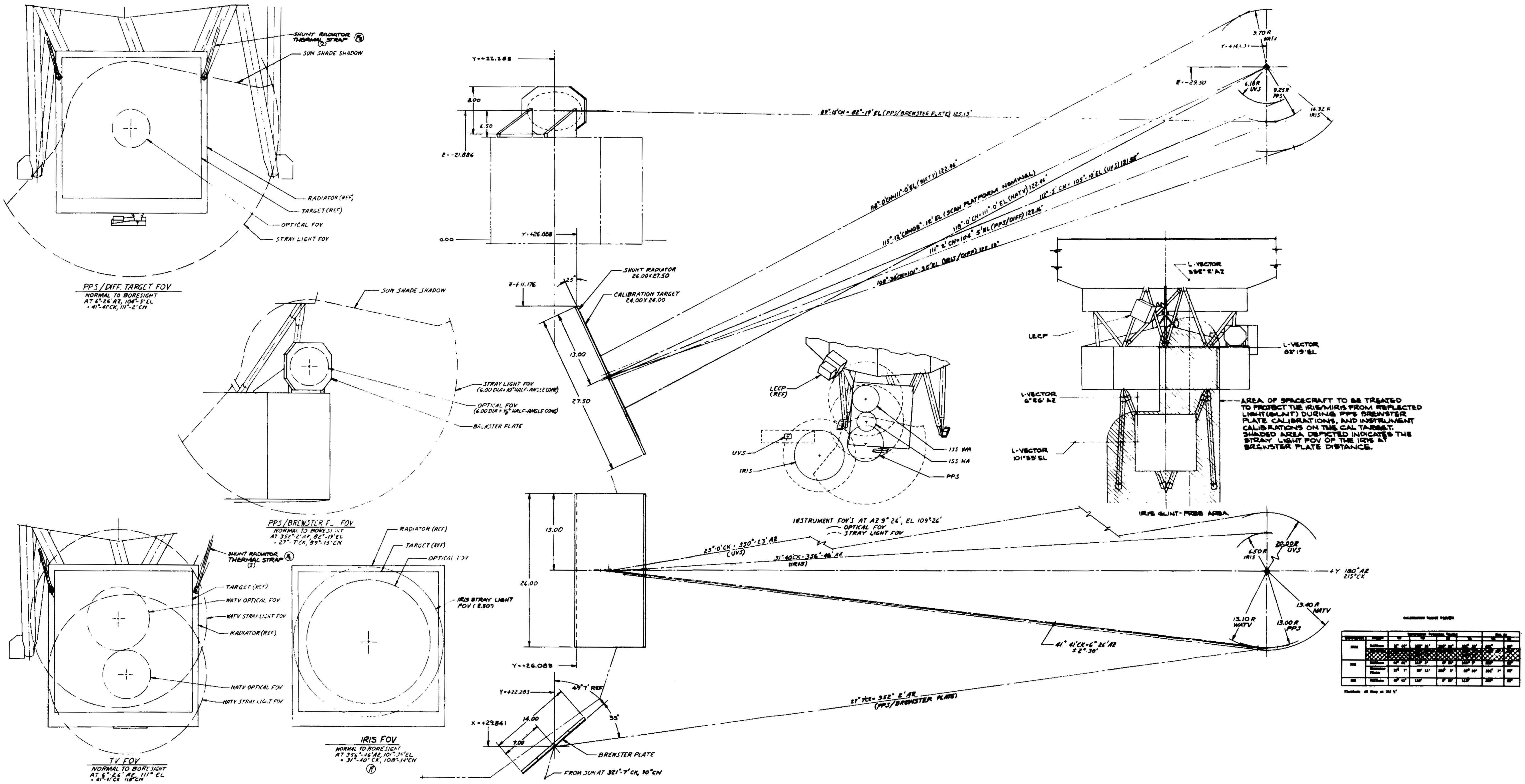
* Figure 31. Platform Slew Stray Light Limits Anti-Earthward Hemisphere



* Figure 32. Platform Science Stray Light FOV Limits Earthward Hemisphere



✱ Figure 33. Platform Science Stray Light FOV Limits Anti-Earthward Hemisphere



NOTE: Thermal blankets are not shown but may increase S/C dimensions by as much as 1 inch on each edge.

Figure 34. Scan Platform Calibration Targets, MJS77 Configuration 6

REVISION PAGE

Revision	Date	ECR's Incorporated	Comments
Original	18 April 1975		
A	2 June 1976	36043 36125 36161 36231 36233	Figures 1, 2, 5, 6, 11, 12 Figures 15, 16, through 29 Update Configuration
B	13 June 1977	36329, 36333, 36370, 36374, 36446, 36486, 36574, 36603, 36660, 36671, 36701, 36725, 36774, 36781, 36852, 36787	Updates document per ECRs listed.
C	1 February 1979	36949, 36991, 37069	Updates Paragraph 4.5 Negotiated Exception. Revises Figures 18 - 27. Adds new Figures 28 and 29. Original Figure 28 is now Figure 34 to show platforms pointing in "SAFE" position.

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FUNCTIONAL REQUIREMENT AMENDMENT

(Insert in 618-205, MJS77 Functional Requirements Book)

TITLE:

FUNCTIONAL REQUIREMENT
MARINER JUPITER/SATURN 1977
CONFIGURATION

FR No. MJS77-3-180C

AMENDMENT No. 1

PAGE 1 OF 1

DATE: 14 February 1979

PER ECR No. N/A

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JET PROPULSION LABORATORY

No. MJS77-3-190
3 March 1975

FUNCTIONAL REQUIREMENT
MARINER JUPITER/SATURN 1977
STRUCTURAL DESIGN CRITERIA

1.0 SCOPE

This document establishes the criteria and approach for the structural design of the Mariner Jupiter/Saturn 1977 (MJS77) spacecraft (S/C).

2.0 APPLICABLE DOCUMENTS

The following documents form a part of this Functional Requirement.

NOTE

MJS77-3-100, Spacecraft Requirements and Constraints, applies to this document. Requirements of other MJS77 level 3 documents may also be applicable. It is the responsibility of the user to adequately acquaint himself with the organization and pertinent content of the level 3 documents, as well as with the material contained herein.

✱ REQUIREMENTS

Jet Propulsion Laboratory

MJS77-3-100	Functional Requirement, Mariner Jupiter/Saturn 1977 Spacecraft Requirements and Constraints
MJS77-3-230	Functional Requirement, Mariner Jupiter/Saturn 1977 Equipment List and Mass Allocations
MJS77-3-240	Functional Requirement, Mariner Jupiter/Saturn 1977 Environmental Design Requirements

OTHER DOCUMENTS

Jet Propulsion Laboratory

TM 33-694	A Shock Spectra and Impedance Method To Determine a Bound for Spacecraft Structural Loads

Military

MIL-HDBK 5	Metallic Materials and Elements for Aerospace Vehicle Structures

3.0 DEFINITION OF TERMS

3.1 Structure

The term structure defines all MJS77 parts and assemblies whose purpose is to sustain loads and/or pressures and provide physical support and/or containment.

✱ 3.2 Primary Structure

Any structural element whose failure would result directly in the general failure of the structural support of the S/C or of a major S/C assembly as listed in MJS77-3-230 Equipment List and Mass Allocations, weighing 22.7 kg (50 lb) or more.

3.3 Limit Loads

Limit loads represent the maximum physical loads the structure is expected to experience under specified conditions of operation or use. All loads used in this document are limit loads unless otherwise noted.

✱ 3.4 Allowable Yield Load

Allowable yield load is the maximum load a structure can sustain without yielding.

❋ 3.5 Allowable Ultimate Load

Allowable ultimate load is the maximum load a structure can sustain without failure.

❋ 3.6 Allowable Stress Data

Allowable stress data are those data obtained from the most recent revision of MIL-HDBK 5, Metallic Materials and Elements for Aerospace Vehicle Structures, or from other sources approved by the MJS77 Structures and Dynamics Engineer and the MJS77 Materials Engineer.

❋ 3.7 Factor of Safety (F. S.)

The F. S. is a multiplying factor applied to the limit load to account for design uncertainties that cannot be analyzed or accounted for in a rational manner. The F. S. for most structures is 1.0.

❋ 3.8 Hazard Factor

If the failure of a particular S/C component could result in injury to personnel, the limit load is multiplied by a hazard factor greater than 1.0.

❋ 3.9 Failure

Failure is defined as the condition under which the structure or any part thereof can no longer perform its intended function. Such a condition may be caused by gross yielding, instability, or rupture.

❋ 3.10 Yield Margin of Safety (M. S.)

$$M.S._{(yield)} = \frac{\text{allowable yield load (or stress)}}{\text{Limit load (or stress)} \times F.S.} - 1$$

❋ 3.11 Ultimate Margin of Safety

$$M.S._{(ultimate)} = \frac{\text{allowable ultimate load (or stress)}}{1.25 \times \text{Limit load (or stress)} \times F.S.} - 1$$

4.0 CRITERIA

4.1 Strength Requirements

❋ 4.1.1 Yield Requirement

The structure shall be capable of withstanding the limit load without permanent deformation. The yield margin of safety (paragraph 3.10) shall be positive.

✱4.1.2 Failure Requirement

The structure shall be capable of withstanding 1.25 × Limit Load without failure. The ultimate margin of safety (paragraph 3.11) shall be positive.

4.2 Pressure Vessels and Stored Energy Devices

✱4.2.1 Fracture Mechanics Criteria

All pressure vessels shall be analyzed using fracture mechanics methods. The "Safe-Life" approach shall be used to assure that the largest crack which could exist in each pressure vessel will not grow to failure during the intended life of the pressure vessel. Stress corrosion crack growth, fatigue crack growth and corrosion-fatigue crack growth will be accounted for in the design of each pressure vessel using fracture mechanics techniques.

✱4.2.2 Terminology for Fracture Mechanics Design of Pressure Vessels

✱4.2.2.1 Maximum Allowable Operating Stress, σ_{OP}. The maximum allowable operating stress is the total stress associated with a load condition.

✱4.2.2.2 Bulk Yield Stress, σ_{BY}. The bulk yield stress is the stress corresponding to the pressure at which the pressure-volume relationship permanently deviates from linearity.

✱4.2.2.3 Threshold Stress Intensity, K_{TH}. Below the threshold stress intensity, sustained load crack growth will not occur for the appropriate design/analysis conditions.

✱4.2.2.4 Critical Stress Intensity, K_{IC}. At the critical stress intensity, a crack will rapidly propagate to failure.

✱4.2.2.5 Initial Crack Depth, $(a/Q)_{NDT}$. The initial crack depth defines the largest crack which could exist in the pressure vessel at completion of non-destructive testing.

✱4.2.2.6 Fatigue Crack Growth $\Delta(a/Q)_{CYCLIC}$. The fatigue crack growth is the maximum accumulated increase in crack size due to all cyclic loading.

✱4.2.2.7 Master's Magnification Factor M_K. Master's magnification factor accounts for the effect of the ratio of crack depth to material thickness.

✱4.2.3 Stress Corrosion Crack Growth

Only fluids which do not initiate cracks may be allowed to contact pressure vessels. At least one valid data point for K_{th} shall be determined for each fluid that is pressurized inside a pressure vessel over the planned temperature range for that vessel. Data must also be available to show that all previous fluids (including unpressurized fluids) which have a lower K_{th} than the fluid being pressurized have been removed from any cracks which may exist in the pressure vessel.

✱ 4.2.4 Fatigue Crack Growth

The cyclic loading crack growth rate, $\Delta(a/Q)_{CYCLIC}$ in an inert environment must be determined for all pressure vessels over a range of temperatures, stresses and stress intensities encompassing the planned cyclic load operational range of the pressure vessel. The amount of data required will vary with the fracture mechanics factor of safety to be used.

✱ 4.2.5 Corrosion-Fatigue Crack Growth

The corrosion-fatigue crack growth rate, $\Delta(a/Q)_{CYCLIC}$, for all internal environments present during cyclic loading shall be determined for all pressure vessels even though the maximum applied cyclic stress intensity is below K_{th} for the material/environment combination. The effect of cyclic load frequency shall also be determined. The amount of data required will vary with the fracture mechanics factor of safety to be used.

✱ 4.2.6 Sustained Load Design Condition

The equation below shall be used to determine the maximum allowable fracture mechanics total stress for sustained load design of all pressure vessels:

$$(F.S.)\sigma_{op} \leq \frac{K_{TH}/M_K}{\sqrt{1.21\,\pi\,((a/Q)_{NDT} + \Delta(a/Q)_{CYC})}} \leq \sigma_{BY}$$

✱ 4.2.7 Flight Load Condition

The sum of the maximum allowable operating stress and flight cyclic loading stress shall not exceed 90 percent of the proof pressure stress or 90 percent of the yield strength of the material. In addition

a) σ_{op} shall satisfy equation 4.2.6 with consideration given to the potential accumulated increase in crack size due to cyclic loading

b) The corrosion-fatigue data must show a threshold frequency of cyclic loading above which the crack growth rate in the flight environment is equal to the crack growth rate in an inert environment.

❋4.2.8 Non-Destructive Testing (NDT) and Proof Testing

The most sensitive NDT method that is practical shall be used to determine $(a/Q)_{NDT}$ (paragraph 4.2.2.5). The proof pressure stress shall not exceed 90 percent of the material yield strength. When the pressure vessel dimensions and fracture properties are such that a crack deeper than the wall thickness will survive the proof test without fracturing, the proof pressure stress shall exceed the maximum allowable operating stress by 50 percent.

❋4.2.9 Other Criteria

When the wall thickness of a pressure vessel is determined by criteria other than fracture mechanics (e.g. vacuum collapse), the fracture mechanics criteria must still be verified by analysis.

❋4.2.10 Fracture Control Plan

Prior to design completion, a fracture control plan shall be developed for each pressure vessel or stored energy device. These plans must consider and constrain the entire design, fabrication, development, test and operation life of the vessel. An expected operational history of all loads and environments must be prepared prior to design completion. This operational history must accompany each vessel at all times prior to launch. Any proposed operation deviating from this history must be approved by a waiver prior to the operation.

❋4.2.11 Factors of Safety and Proof Test Factors

The following factors of safety and proof test factors apply to the design and test of pressure vessels and stored energy devices.

Items	Factors of Safety FS			
	Yield	Ultimate	Fracture Mechanics	Proof Test Factor
a) Pressure vessels remote from personnel			1.15	
b) Pressure vessels in presence of personnel			1.35	
c) Lines, fittings, hoses, connections, valves, transducers and pressurized tubings joints	2.25*	4.0*	1.5	1.5*

Note: *Only if fracture mechanics considerations are not applicable, otherwise use fracture mechanics factor of safety or proof test factor.

Items		Factors of Safety FS			
		Yield	Ultimate	Fracture Mechanics	Proof Test Factor
d)	Actuating cylinders which act as a reservoir under pressure	2.25*	4.0*	1.5	1.5*
e)	Actuating cylinders which do not act as a reservoir under pressure	1.6*	2.0*	1.5	1.5*
f)	Strain energy stored devices	1.6*	2.0*	1.5	1.5*
g)	Solid rocket motors			1.35	1.10

Note: *Only if fracture mechanics considerations are not applicable, otherwise use fracture mechanics factor of safety or proof test factor.

4.3 Stiffness Requirement

4.3.1 Deflection

Sufficient rigidity shall be provided to withstand all limit load conditions without structural deflections of a magnitude that would jeopardize proper functioning of the S/C or any component thereof. Special considerations for rigidity shall be given to critical areas such as surfaces used as references for guidance and control purposes. Deflections shall be considered excessive if they:

a) Cause unintentional contact between adjacent S/C components.

b) Cause the S/C to exceed the launch vehicle (LV) dynamics envelope.

c) Cause physical separation of any preloaded joint.

4.3.2 Mission Module Attitude Control/Structure Interaction

Appropriate mathematical models representing the dynamics of the Mission Module (MM) structure in the cruise configuration shall be developed and furnished to attitude and articulation control subsystem (AACS) for the investigation of the attitude control/structure interaction.

4.3.3 Structural/Thermal Interaction

Thermal deflections shall be considered for MM appendage structures. Boom structures shall have sufficient torsional rigidity to preclude thermal flutter.

4.4 Structural Nonlinearities

Nonlinear structural characteristics in the region of expected flight loads shall be kept to a minimum. Any significant nonlinear characteristics in this range shall be thoroughly investigated by analysis and/or test.

4.4.1 Mechanical Backlash

Mechanical backlash in all operating mechanisms that experience inertial loads of structural or dynamic significance to the S/C shall be kept to a minimum.

4.4.2 Energy-Dissipating Devices

All energy-dissipating devices used on the S/C structure shall have, where possible, linear or known nonlinear force-velocity and force-deflection relationships over the applicable range of frequencies, loads and temperatures.

4.4.3 Separation Joint Preload

Installation of the S/C on the adapter shall provide for sufficient axial preload such that no physical separation shall occur during any ultimate load conditions.

* 4.5 Fatigue

Fatigue shall be considered in the design of structural elements by avoidance of deleterious residual stresses and stress concentrations in conformity with good design practice. Special attention shall be given to elements subjected to repeated load cycles at high stress levels. Material selection shall consider fatigue characteristics in relation to the design requirements of the structural element. One flight type propellant tank must be cycled to ten times the number of expected cycles without failure to qualify the design for fatigue life.

4.6 Discontinuity and Residual Stresses

4.6.1 Discontinuity

Sharp discontinuities shall be avoided, where possible, in accordance with good design practice. The effects of stress concentration shall be included by the use of appropriate stress concentration factors applied to gross member stresses.

4.6.2 Residual Stresses

Residual stresses due to fabrication operations, assembly or proof testing will be evaluated and their effects added to the primary stresses where significant.

4.7 Thermal Effects

Consideration shall be given to deterioration of material properties and to stresses and deformation caused by temperature effects.

* 4.8 Ground Handling and Transportation

Assembly, handling and shipping loads shall be calculated. These loads shall generally be constrained such that launch and flight design requirements are not exceeded. All cases where ground conditions control the design shall be identified.

4.8.1 Damage Susceptibility

Not withstanding the foregoing section, structural elements of the S/C shall be designed so that they are not extremely vulnerable to damage during normal handling.

* 5.0 DETERMINATION OF LOADS IN PRIMARY STRUCTURE

5.1 General

An iterative approach will be accomplished in the loads analysis, design and stress analyses of the MJS77 S/C structure. Each step in this iterative process shall be based on the latest estimates of internal forces, applied loads, structural geometry and environmental conditions. Structural tests shall be performed during the design process to verify or to provide the bases for modification of analytical estimates of element strength, elastic characteristics, inertia distributions and stresses. Tests shall also be performed to provide assurance of structural adequacy in areas for which an analyses are impossible or impractical.

A design goal shall be to eliminate structural elements or mass which do not effectively contribute toward meeting the flight requirements and constraints of the structure.

5.2 Primary Structural Loads

* 5.2.1 Bounds on Modal Loads

Bounds on the flight loads shall be determined by a shock spectra and impedance method as shown in JPL Technical Memorandum 33-694. In this method, the S/C and the LV are each represented by their normal modes. Spacecraft cantilever modes are paired with LV modes within a ten percent frequency range. The maximum S/C modal loads are determined by allowing an artificial shift of the two resonant frequencies to produce tuning between the modes. Shock spectra envelopes are used to normalize these modal loads. Shock spectra are obtained from S/C/LV interface accelerations from previous Titan/Centaur flight data and loads analysis data. The relative impedance between the LV and S/C is used to determine a reduction factor of 0.4 to 1.0 to be applied to the shock spectra envelope. The modal member loads shall be determined for all possible reasonable pairings of modes.

5.2.2 Limit Loads

The total dynamic member loads shall be obtained by summing the modal loads by the root sum square technique. The quasi-static load shall be added to the root mean square dynamic loads as appropriate.

5.3 Loading Conditions

All potentially critical flight loading conditions shall be checked using the approach of paragraph 5.2.1.

Such conditions include:

a) Thrust and maneuver loads.

b) Preloads.

c) Staging and shutdown events.

d) Aerodynamic loading conditions.

6.0 STRUCTURAL ANALYSES

6.1 Mathematical Models

Detailed mathematical models of the S/C representing all frequencies below the highest frequency used for the interface reaction load shall be developed and updated. The mathematical model shall be modified to match test data as available.

6.2 Level of Analyses

Detailed stress analyses shall be performed on primary structural elements. Where applicable, tests may be performed in lieu of detailed analyses.

7.0 STRUCTURAL TESTS

7.1 General

Structural tests shall be conducted on the entire S/C and/or components as appropriate to verify analysis and design concepts, and obtain strength confirmation. Structural qualification tests shall be used together with analytical results to qualify primary structural members.

7.2 Development Test Model (DTM)

A DTM S/C shall be constructed using flight-type structural hardware for major structural elements and joints. Other elements may be mocked up to simulate the inertial properties and attachments of the actual elements, provided that the elastic properties of elements affecting S/C modes with high effective mass and with frequencies below 100 Hz are accurately represented.

7.3 Modal Surveys

Modal survey tests shall be run to verify the analytical mode shapes, resonant frequencies and modal damping used in the analysis.

*7.4 Structural Qualification

Structural qualification will be achieved through a combination of analysis and test. Test qualification of representative elements of primary structure will be accomplished through static testing and/or high-level modal testing at the limit load. Developmental testing at loads 25 percent greater than limit load will demonstrate the ultimate capability of representative structural elements.

*7.5 Load Limitation During Vibration Testing

During mid-frequency vibration testing of the DTM, PTM or flight S/C consistent with MJS77-3-240, Environmental Design Requirements, loads in primary structural members will be limited to those determined in paragraph 5.2.

7.6 Assembly Level Structural Testing

Development tests may be conducted, as appropriate, on primary structural elements at the assembly level to determine stiffness or modal characteristics or to verify strength characteristics.

(Insert in 618-205, MJS77 Functional Requirements Book)

Custodian: E. Chow

APPROVED:

System: R. Draper

Subsystem: E. Chow

R. J. Spehalski

JET PROPULSION LABORATORY

No. MJS77-3-200A
9 May 1977
Supersedes
MJS77-3-200
26 February 1975

FUNCTIONAL REQUIREMENT
MARINER JUPITER/SATURN 1977
INERTIAL PROPERTIES

* Denotes changes from previous issue.

1.0 SCOPE

This document establishes the functional requirements for the design and determination of the rigid body inertial (mass) properties of the Mariner Jupiter/Saturn 1977 (MJS77) spacecraft.

2.0 APPLICABLE DOCUMENTS

The following documents form a part of this Functional Requirement:

NOTE

MJS77-3-100, Spacecraft Requirements and Constraints, applies to this document. Requirements of other MJS77 level 3 documents may also be applicable. It is the responsibility of the user to adequately acquaint himself with the organization and pertinent content of the level 3 documents, as well as with the material contained herein.

FUNCTIONAL REQUIREMENTS

Jet Propulsion Laboratory

MJS77-3-100	Functional Requirement, Mariner Jupiter/Saturn 1977 Spacecraft Requirements and Constraints
MJS77-3-170	Functional Requirement, Mariner Jupiter/Saturn 1977 Functional Accuracies and System Capabilities
MJS77-3-180	Functional Requirement, Mariner Jupiter/Saturn 1977 Configuration
MJS77-3-230	Functional Requirement, Mariner Jupiter/Saturn 1977 Equipment List and Mass Allocation

OTHER DOCUMENTS

Jet Propulsion Laboratory

PD618-217	Mariner Jupiter/Saturn 1977 Spacecraft/Launch Vehicle System Requirements and Integration

DRAWING

Jet Propulsion Laboratory

10070962	Mariner Jupiter/Saturn 1977 Spacecraft Mechanical Configuration

3.0 DEFINITIONS

3.1 Mass Properties

The term "mass properties" includes mass, center-of-mass (CM), products of inertia and moments of inertia.

3.2 Spacecraft Elements

3.2.1 Mission Module

Mission Module (MM) of the MJS77 spacecraft includes all subsystems listed in Table 1 of MJS77-3-230, Equipment List and Mass allocation. See MJS77-3-180, Configuration.

3.2.2 Propulsion Module (PM)

PM of the MJS77 spacecraft includes all subsystems listed in Table 2 of MJS77-3-230. See MJS77-3-180.

* 3.2.3 Adapter

Adapter of the MJS77 spacecraft includes all subsystems listed in Table 3 of MJS77-3-230.

3.2.4 Spacecraft

Spacecraft is the combined MM and PM.

3.3 Spacecraft – Pre-Injection and Post-Injection

3.3.1 Pre-Injection Spacecraft Configuration

The pre-injection spacecraft includes all subsystems of the MM and PM in cluding the propellant and pressurant. All deployable booms, and devices are in the stowed positions.

3.3.2 Pre-Injection Configuration With Solid Motor Removed

This configuration includes all the subsystems described in paragraph 3.3.1 minus the solid motor.

* 3.3.3 Post-Injection Spacecraft Configuration

The post-injection spacecraft includes all subsystems described in paragraph 3.3.1 with the exception of liquid propellant, and solid propellant consumed during the injection phase.

3.4 Pre-Jettison Spacecraft

This configuration is identical to the configuration of paragraph 3.3.3 except the science boom and RTGs are fully deployed.

3.5 Post-Jettison Mission Module

This configuration is identical to the configuration of paragraph 3.4 except the burnout PM has been jettisoned.

3.6 Cruise Mission Module

3.6.1 Cruise Mission Module Dry Configuration

Cruise MM dry configuration includes all subsystem hardware of the MM but excluding all liquid propellant and pressurant. All deployable booms, and devices are in the fully deployed positions.

3.6.2 Cruise Mission Module Configuration

Cruise MM configuration includes all the subsystems described in paragraph 3.6.1 plus all the liquid propellants and pressurants after the nominal PM propellant usage.

4.0 REQUIREMENTS

* 4.1 Coordinate Systems

a) Spacecraft or the MM CM shall be specified with reference to distance from spacecraft axes or MM axes respectively as on the JPL MJS77 Spacecraft Mechanical Configuration Drawing 10070962 and defined in MJS77-3-180.

b) All subsystems CM shall be specifed with reference to distances from their respective mounting interfaces.

c) All moments of inertia and products of inertia calculations, and design specifications for the spacecraft or MM shall be described with respect to axes parallel to spacecraft or MM Cartesian coordinate systems with origins at the spacecraft or MM CM respectively.

4.2 Units

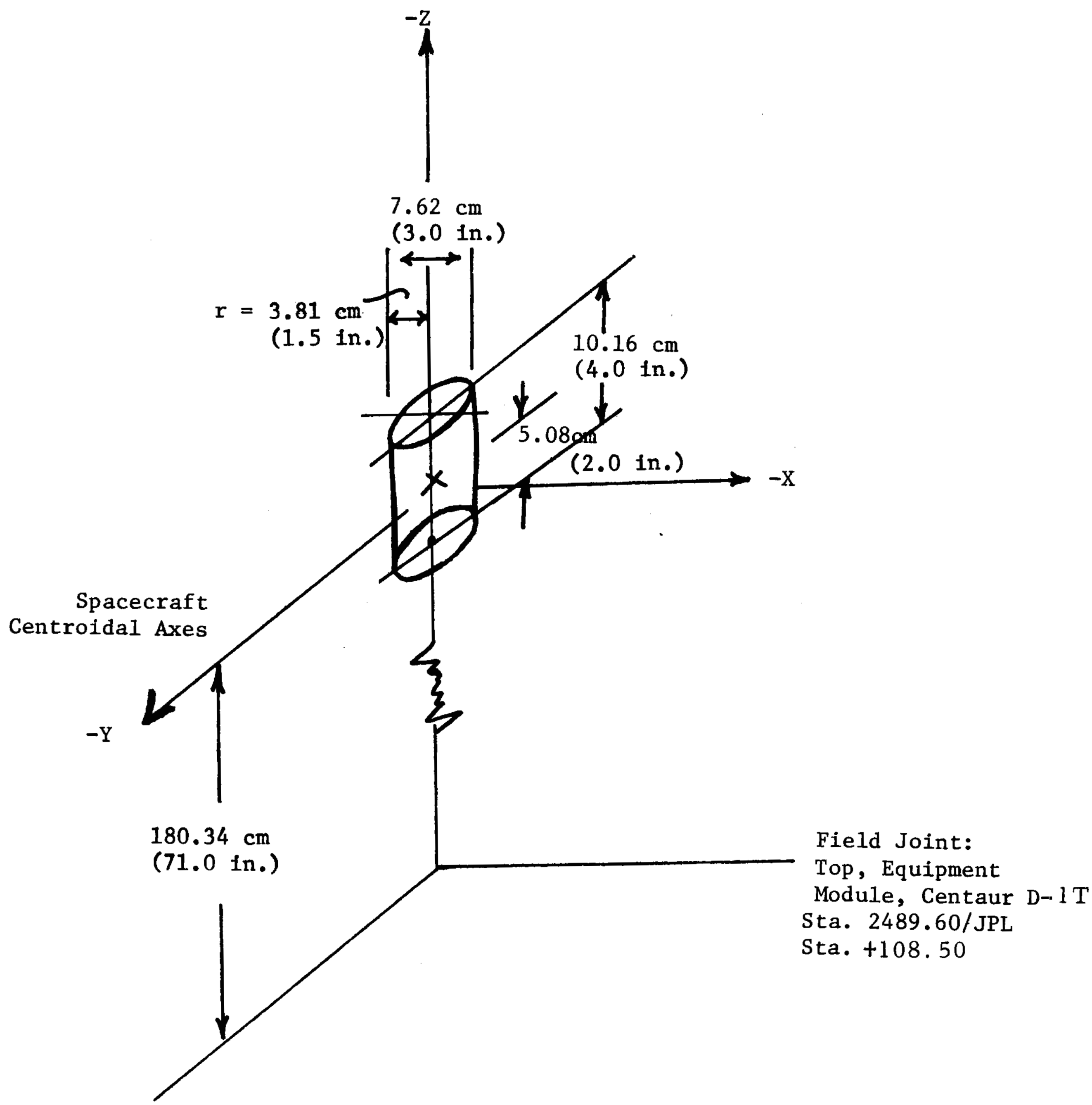
All mass properties, design specifications and measurements shall be specified and reported in the International System of Units (SI); the corresponding U.S. Customary units may be specified in parenthesis following the SI units.

		SI Units	(U.S. Customary)
a)	Mass	kilograms, kg	(pounds, lbm.)
b)	Center-of-Mass Location	centimeters, cm	(inches, in.)
c)	Moments of inertia and products of inertia	$kg\text{-}m^2$	(slug ft^2)

4.3 Design Requirements

4.3.1 Spacecraft Center-of-Mass Values

4.3.1.1 Launch Vehicle Requirements. The CM of the pre-injection spacecraft plus the adapter shall be within the envelope defined on Figure 1.



* Figure 1. Spacecraft Plus Adapter Center-of-Mass Envelope - Pre-Injection Configuration With All Propellants and Pressurants

✱ 4.3.1.2 Spacecraft Requirement. The CM of the pre-injection spacecraft minus the solid motor shall be within the envelope defined in MJS77-3-170. However, the location of the CM shall be known within a cylinder of 0.19 cm (0.075 in.) 3 σ radius and ±0.51 cm (0.20 in.) 3 σ length with cylinder ℄ parallel to Z axis.

The solid rocket motor thrust line shall be aligned through that CM as specified in MJS77-3-170, Functional Accuracies and System Capabilities.

✱ 4.3.2 Moments of Inertia and Products of Inertia Envelope Values

Minimum and maximum values of MJS77 spacecraft moments of inertia and products of inertia are given in Table 1 for various configurations. For spacecraft or subsystem designs, the calculated values shall fall within the ranges of these given minimum/maximum values.

4.4 Accuracy of Mass Properties

4.4.1 Flight System Mass Properties

The required accuracies of system mass property calculations and measurements prior to launch shall be as indicated in Table 2.

4.4.2 Flight Propellants and Pressurants Mass Properties

The mass measurements accuracy for the propellant and pressurant at launch shall be as follows:

a) Hydrazine: ±0.5 percent

b) Pressurant mass: ±2.0 percent

c) Solid propellant mass: ±2-1/4 kg (5.00 lb)

The liquid propellant shall be assumed to be settled to the launch position and considered rigid for CM calculation purposes.

4.4.3 Flight Subsystems Mass Properties

The required accuracies of subsystem mass property calculation and measurements shall be as indicated in Table 3. The calculated limits on the subsystem CM location include its location error with respect to the spacecraft coordinates as well as its local CM location error with respect to its mounting interface. To avoid risks of damaging the flight hardware during handling of the subsystem, only the mass shall be measured (except for the solid motor which requires measurement of CM also). Calculations of other mass properties shall, where applicable, utilize the results of mass and CM measurements performed on similar developmental test hardware.

* Table 1. Design Requirements - MJS77 Spacecraft and Subsystem Mass Moments of Inertia and Mass Products of Inertia

Configuration	Mass kg (lb)	Moments of Inertia* kg-m^2 (slug-ft^2)			Products of Inertia** kg-m^2 (slug-ft^2)		
		I_{xx}	I_{yy}	I_{zz}	$\lvert I_{xy} \rvert$	$\lvert I_{xz} \rvert$	$\lvert I_{yz} \rvert$
MM + PM Max	2015 (4444)	NA	NA	NA	40 (30)	40 (30)	40 (30)
Min (S/C Pre-Injection)	NA	1627 (1200)	1356 (1000)	651 (480)	0 (0)	0 (0)	0 (0)
MM + PM Max	956 (2107)	NA	NA	NA	40 (30)	40 (30)	40 (30)
Min (S/C Post-Injection)	NA	1152 (850)	881 (650)	569 (420)	0 (0)	0 (0)	0 (0)
MM + PM RTG and Science booms deployed Max	956 (2107)	3932 (2900)	1030 (760)	3254 (2400)	40 (30)	40 (30)	490 (362)
Min (S/C Pre-Jettison)	NA	3186 (2350)	813 (600)	2712 (2000)	0 (0)	0 (0)	270 (200)
MM RTG and Science booms deployed Max	792 (1746)	3322 (2450)	407 (300)	3254 (2400)	40 (30)	40 (30)	515 (380)
Min (MM Post-Jettison)	NA	2712 (2000)	271 (200)	2712 (2000)	0 (0)	0 (0)	285 (210)
MM All booms deployed Max	792 (1746)	4339 (3200)	949 (700)	3932 (2900)	20 (15)	20 (15)	20 (15)
Min (MM Cruise)	NA	3661 (2700)	528 (390)	3186 (2350)	0 (0)	0 (0)	0 (0)
Scan Platform Max	105 (230)	14 (10)	15 (11)	14 (10)	NA	NA	NA
Min (Elevation axis parallel to Y axis)	NA	NA	NA ***	NA	NA	NA	NA

* About the CM of the given configuration.
NA Not Applicable/no design requirement for this condition.
** Products of Inertia are absolute values and can be plus or minus.
*** This is for spacecraft only. For actuator design this number should not exceed 10 slug-ft^2.

* Table 2. Mass Property Accuracy for Major Assemblies

Item	Technique	Required Accuracy			
		Mass	Center-of-Mass	Moments of Inertia	Products of Inertia
Spacecraft (Pre-Injection W/O Solid Motor)	*Calculated	±0.25%	±0.22 cm (0.09 in.) X and Y ±0.51 cm (0.20 in.) Z	±5%	±8.0 kg-m^2 (6.0 slug-ft^2)
	**Measured	±2 kg (4.40 lb)	±0.19 cm (0.075 in.) Radius in X - Y Plane Z not measured	Not measured	Not measured
Mission Module (Post-Jettison and Cruise)	*Calculated	±0.25%	±0.22 cm (0.09 in.) X and Y only ±0.51 cm (0.20 in.) Z	±5%	±8.0 kg-m^2 (6.0 slug-ft^2)
	Measured	Not measured	Not measured	Not measured	Not measured
Spacecraft Adapter	*Calculated	±0.5%	±0.75 cm (0.30 in.) X and Y ±1.50 cm (0.60 in.) Z	Not calculated	Not calculated
	Measured	±0.5%	Not measured	Not measured	Not measured
TCAPU***(Dry), Propulsion Module (W/O Solid Motor)	*Calculated	±0.25%	±0.22 cm (0.09 in.) X and Y ±0.51 cm (0.20 in.) Z	±5%	±8.0 kg-m^2 **** (6.0 slug-ft^2)
	Measured	±0.25%	±0.19 cm (0.075 in.) Radius in X - Y Plane Z not measured	Not measured	Not measured
Solid-Propellant Motor	*Calculated	±0.2%	±0.04 cm (0.017 in.) X and Y ±1.78 cm (0.70 in.) Z	±5%	Not calculated
	Measured	±2-1/4 kg (5.00 lb)	±0.04 cm (0.017 in.) X and Y ±1.78 cm (0.70 in.) Z	Not measured	Not measured

* Based on measured subsystem mass data.

** W/O High Gain Antenna (HGA), liquid propellants and pressurants.

*** Trajectory correction/attitude propulsion unit.

**** TCAPU product of inertia not calculated.

✱ Table 3. Mass Property Accuracy for Subsystems

Item	Technique	Required Accuracy			
		Mass*	Center-of-Mass**	Moments of Inertia	Products of Inertia
Subsystems in or about Mission Module Bus	Calculated	±5.0%	±0.25 cm (0.10 in.)	Not calculated	Not calculated
	Measured	±0.1%	Not measured	Not measured	Not measured
High Gain Antenna, Scan Plat-form Science Experiments	Calculated	±5.0%	±1.02 cm (0.40 in.) X and Y ±2.04 cm (0.80 in.) Z	±5% (HGA only)	Not calculated
	Measured	±0.1%	±0.34 cm (0.17 in.) Radius in X-Y Plane Z Not measured (HGA only)	Not measured	Not measured
Magnetometer Boom	Calculated	±5.0%	±5.08 cm (2.0 in.) when extended	±5%	Not calculated
	Measured	±0.2%	Not measured	Not measured	Not measured
Radioisotope Thermo-electric Generators	Calculated	±2.0%	±1.02 cm (0.4 in.) X and Y ±2.04 cm (0.8 in.) Z	±5%	Not calculated
	Measured	±0.2%	±0.34 cm (0.17 in.) X, Y and Z	Not measured	Not measured

*The measured mass accuracy is ±0.01 kg (0.02 lb) for identifiable items per the MJS77-3-230 of 4 kg (8.82 lb) or less.

**Values shown are total CM uncertainty allowable. (See paragraphs 5.5 and 5.6 for location accuracy required of Subsystem Cognizant Engineers, Spacecraft Structure Cognizant Engineers, respectively).

5.0 MASS PROPERTIES DETERMINATION

5.1 <u>Calculation of System and Subsystem Mass Properties</u>

All system mass properties of the MM and of the spacecraft shall be calculated for the configurations indicated in paragraphs 3.2, 3.3, 3.4, 3.5 and 3.6. The calculations of subsystem mass properties for the RTGs, and the calculations of mass and CM values for each subsystem and of spatially separated subassemblies shall be made. All size and coordinate location dimensions used in the calculations shall be consistent with MJS77 subassembly and assembly drawings.

* 5.2 <u>Measurement and Maintenance of Flight Hardware Mass Values</u>

The mass and two axes (X and Y) CM of the PM less solid rocket-motor, the TCAPU assembly less liquid propellants and pressurants and the spacecraft in the pre-injection configuration less liquid propellants, pressurants and solid rocket motor shall be measured by Division 35 personnel under the direction of the Mass Properties Engineer. All subsystem masses (to the level identified in Tables 1 through 3 of MJS77-3-230) shall be measured by the responsible Subsystem Cognizant Engineer prior to delivery to Spacecraft Assembly Facility (SAF).

A complete mass and CM inventory of all spacecraft subsystem and system hardware shall be maintained by SAF personnel subsequent to the hardware delivery to SAF.

5.3 <u>Mass Property Verification</u>

The calculated and measured values of mass properties of the items specified in Tables 1 and 2 shall be within the accuracy stated.

S/C modifications subsequent to flight S/C mass properties verification testing may necessitate reverification of mass properties. It shall be the responsiblity of the Mass Properties Engineer to evaluate the need for reverification of mass properties subsequent to S/C modifications.

5.4 <u>Accuracy of Determination Techniques</u>

The degree of accuracy involved in mass properties determinations shall be sufficient to satisfy:

a) The requirements of paragraph 4.4.

b) Accountability of all elements of the spacecraft and adapter.

5.5 Responsibility for Determination of Subsystem Mass Properties

The cognizant engineer of each subsystem shall be responsible for obtaining the mass properties of the subsystem under his cognizance. He shall assure that calculations and measurements of the mass properties of all components and parts of the subsystem have been obtained as specified in paragraph 4.4 and the resultant data is disseminated as in paragraph 5.7. Total mass of each subsystem shall not exceed that allocated in MJS77-3-230.

The subsystem local CM locations shall be specified by the Subsystem Cognizant Engineers with respect to the individual mounting interfaces. The local CM location accuracy of all subsystems shall be as follows:

a) For the RTGs, HGA and all subsystems on the scan platform

$\leq$ 60 percent of the value shown in Table 3.

b) For all other subsystems

$\leq$ 80 percent of the value shown in Table 3.

5.6 Responsibility for Subsystem Interface Locations

The Division 35 Spacecraft Structure Cognizant Engineers shall be responsible for the determination of interface locations of all subsystems relative to the spacecraft system coordinates, and to the accuracy as follows:

a) For the RTG and all subsystems on the scan platform

$\leq$ 40 percent of the values shown in Table 3.

b) All other subsystems

$\leq$ 20 percent of the values shown in Table 3.

5.7 Reporting of Mass Properties

Generation of the subsystem mass property information (by calculation and/or measurements) at the components and parts level below the identifiable subsystems in MJS77-3-230 shall be the responsibility of the appropriate subsystem cognizant engineers. It shall be reported by the cognizant engineers periodically after review by System Mass specialists, as changes occur and upon request, to the Division 35 Mass Property Engineer. The Division 35 MJS77 mass property engineer will prepare and maintain the equipment mass list. The mass properties of the spacecraft system shall be prepared, maintained and the information shall be released by the Division 35 Mass Property Engineer based on the data received. The MJS77 System Engineer will publish the formal project mass list and mass properties reports.

REVISION PAGE

Revision	Date	ECRs Incorporated	Comments
Original	26 Feb 1975		
A	9 May 1977	36122, 36231, 36532	Revise per ECRs listed.

FUNCTIONAL REQUIREMENT AMENDMENT

(Insert in Book 618-205, MJS77 Functional Requirements Book)

TITLE:	
MARINER JUPITER/SATURN 1977 DESIGN CRITERIA FOR SPACECRAFT TEMPERATURE CONTROL	FR No. MJS77-3-210A AMENDMENT No. 3 PAGE 1 OF 6 DATE: 5 August 1977 PER ECR No. See Remarks

DESCRIPTION OF CHANGE:

Revise the following tables per the attached changes:

1) Table 1, page 6, Spacecraft Temperature Control Requirements

2) Table 3, page 12, Spacecraft Orientation Constraints

3) Table 4, page 16, RHU Requirements

DISTRIBUTION:

List 197

REMARKS:

1. ECRs 36908 and 36912 incorporate changes to Table 1.
2. ECRs 36595 and 36634 incorporate changes to Table 3.
3. ECR 36922 incorporates change to Table 4.

APPROVED:

R.C. Becker   RAB for SPEHALSKI   [illegible]

SYSTEM

JPL 3930 (11-69)

Revise Table 1, page 6, as follows:

	Assembly	Operating Range (°C)		Non-Operating Range (°C)	
		Allowable Long Term Range (> 4 Hrs)	Allowable Short Term Range (< 4 Hrs)	Allowable Long Term Range (> 4 Hrs)	Allowable Short Term Range (< 4 Hrs)
WAS:	MAG LFM Sensors	-15/50	-15/50	-15/50	-15/50
IS:	MAG LFM Sensors	-15/55	-15/55	-15/55	-15/55
	MAG Boom				
WAS:	Pinpullers/Latch	-48/68	-48/68	N/A	N/A
	Deployment Rate Limiter	-15/30	-15/30	-15/30	-15/30
	Dampers	0/20	0/20	0/20	0/20
IS:	Pinpullers	-48/68	-48/68	N/A	N/A
	Latch	-15/45	-15/45	N/A	N/A
	Deployment Rate Limiter	-15/40	-15/40	-15/50	-15/50
	Dampers	15/50	15/50	15/50	15/50

Revise Table 3, page 12, as follows:

Table 3. Spacecraft Orientation Constraints

	Operational Mode	Applicability (AU)	Max. Allowable Off-Sun Duration	Orientation Constraint
WAS:	4) Trajectory Correction Maneuver (TCM)	1.0 to 2.0	1.0 hr x $(AU)^2$ plus Duration of Pitch Turns	Turns must be ROLL ($-360° \leq R \leq 360°$). Then NEGATIVE POLARITY PITCH ($-180° \leq P \leq 0$), then reacquire.
IS:	4) Trajectory Correction Maneuver (TCM)	1.0 to 2.0	1.0 hr x $(AU)^2$ plus Duration of Pitch Turns	Wind turns must be ROLL ($\|R\| \leq 360°$), then NEGATIVE PITCH ($-180° \leq P \leq 0°$), then ROLL ($\|R\| \leq 360°$) ending with the Sun in the +Y half of the Y/Z plane. Unwind turns must be the complement of the wind turns.
WAS:	6) Science Calibration Target Maneuver	1.5 to 2.0	Same as TCM	Same as TCM except a ±10° Post-Pitch Roll turn is allowed.
IS:	6) Science Calibration Target Maneuver	1.5 to 2.0	Same as TCM	Same as TCM except a ±10° Roll turn after the Wind Turn sequence is allowed.

Table 3. Spacecraft Orientation Constraints (contd)

	Operational Mode	Applicability (AU)	Max. Allowable Off-Sun Duration	Orientation Constraint
WAS:	7) Sun Reacquisition Maneuver	1.0 to 3.0	3.5 hours	Turn sequence must begin with a YAW turn and consist of alternate YAW/PITCH turns where Y = ±360° and P = ±72° (all PITCH turns must be of the same polarity). Pause periods between turns must be minimized. Note: 5 YAW/4 PITCH turns will provide 4 π steradian coverage for the Sun Sensor.
IS:	7) Sun Reacquisition Maneuver	1.0 to 3.0	3.5 hours	Turn sequence must begin with a PITCH turn and consist of alternate PITCH/YAW turns where P = ±360° and Y = ±72° (all YAW turns must be of the same polarity). Pause periods between turns must be minimized. Note: 5 PITCH/4 YAW turns will provide 4 π steradian coverage for the Sun Sensor.
ADD:	8) Brewster Plate Calibration Maneuver	1.0 to 2.0	Same as TCM	Same as TCM.

Table 3. Spacecraft Orientation Constraints (contd)

	General Constraints
WAS:	1) Maneuvers 4, 5, and 6 above shall all be initiated from a sun-oriented* configuration.
IS:	1) Maneuver 5 above shall be initiated from a Sun-oriented* configuration. Maneuvers 4, 6, and 8 above shall be initiated from a Near Sun-oriented** configuration.
WAS:	2) S/C temperatures ... initiating maneuvers 4, 5, or 6.
IS:	2) S/C temperatures ... initiating maneuvers 4, 5, 6, or 8.
ADD:	** "Near Sun-oriented" denotes the Sun lying within 18 degrees of the S/C -Z axis.

Revise Table 4, page 16, as follows:

Table 4. RHU Requirements

	RHU Location	Quantity Required
WAS:	Magnetometer Boom Dampers	6
IS:	Magnetometer Boom Dampers	4
WAS:		Total 26
IS:		Total 24

FUNCTIONAL REQUIREMENT AMENDMENT

(Insert in 618-205 MJS77 Functional Requirements Book)

TITLE:

MARINER JUPITER/SATURN 1977
DESIGN CRITERIA FOR
SPACECRAFT TEMPERATURE CONTROL

FR No. MJS77-3-210A

AMENDMENT No. 1

PAGE 1 **OF** 2

DATE: 7 April 1977

PER ECR No. See Remarks

DESCRIPTION OF CHANGE:

Revise Table 1, pages 6 and 7, as follows:

	Assembly	Operating Range, °C: Allowable Long Term Range (> 4 hrs)	Operating Range, °C: Allowable Short Term Range (< 4 hrs)	Non-operating Range, °C: Allowable Long Term Range (> 4 hrs)	Non-operating Range, °C: Allowable Short Term Range (< 4 hrs)
Page 6					
WAS:	PLS				
	*Sensor	-160/80	-160/80	-160/80	-160/80
IS:	PLS				
	*Sensor	-170/80	-170/80	-170/80	-170/80
Page 7					
WAS:	*Sun Sensor	-5/40	-5/40	-5/40	-5/40
IS:	*Sun Sensor	-7/35	-7/35	-7/35	-7/35

DISTRIBUTION:

List 197

REMARKS: ECRs 36546 and 36677 incorporate changes to Table 1.
ECRs 36583, 36678, and 36681 incorporate changes to Table 4.

APPROVED:

Table 4. RHU* Requirements

RHU Location	Quantity Required
Outboard Low Field Magnetometer Sensor (OBLFM)	3
Inboard Low Field Magnetometer Sensor (IBLFM)	3
Outboard High Field Magnetometer Sensor (OBHFM)	2
Inboard High Field Magnetometer Sensor (IBHFM)	2
Magnetometer Boom Dampers	6
Sun Sensor	6
AP Pitch Thruster Bracket	4
*Radioisotope Heater Units 1.0 thermal watts each at EOM.	Total 26

(Insert in 618-205, MJS77 Functional Requirements Book)

Custodian: R. Becker

APPROVED:

System: R. F. Draper

Subsystem: R. Becker

R. J. Spehalski

JET PROPULSION LABORATORY

No. MJS77-3-210A
11 November 1976

Supersedes
MJS77-3-210
18 April 1975

FUNCTIONAL REQUIREMENT

MARINER JUPITER/SATURN 1977

DESIGN CRITERIA FOR SPACECRAFT TEMPERATURE CONTROL

* Denote Changes from previous issue.

1.0 SCOPE

This document contains design criteria and requirements to be used for the temperature control of the Mariner Jupiter/Saturn 1977 (MJS77) spacecraft system. The provisions of this document apply to spacecraft elements down to the electronic subassembly level, but do not apply at the electronic component and circuit board level.

This document specifies the allowable temperature ranges for spacecraft equipment and the conditions under which these ranges must be maintained by the spacecraft system thermal design. In turn, the design requirements and constraints necessary for the implementation of this temperature control are specified herein. These criteria apply to all spacecraft subsystems, since every subsystem contains some of the thermal design features used to effect temperature control. These temperature control requirements and constraints are associated with the flight equipment environments. Temperature limits specified are not FA or TA limits, but are related to their derivation.

2.0 APPLICABLE DOCUMENTS

The following documents form a part of this Functional Requirement.

NOTE

MJS77-3-100, Spacecraft Requirements and Constraints, applies to this document. Requirements of other MJS77 level 3 documents may also be applicable. It is the responsibility of the user to adequately acquaint himself with the organization and pertinent content of the level 3 documents, as well as with the material contained herein.

REQUIREMENTS

Jet Propulsion Laboratory

MJS77-2-100	Mariner Jupiter/Saturn 1977 Spacecraft Design Criteria
MJS77-3-100	Functional Requirement, Mariner Jupiter/Saturn 1977 Spacecraft Requirements and Constraints
MJS77-3-120	Functional Requirement, Mariner Jupiter/Saturn 1977 Spacecraft Flight Sequence Implementation
MJS77-3-180	Functional Requirement, Mariner Jupiter/Saturn 1977 Flight Equipment Configuration
MJS77-3-220	Functional Requirement, Mariner Jupiter/Saturn 1977 Flight Electronic Equipment Design
MJS77-3-240	Functional Requirement, Mariner Jupiter/Saturn 1977 Environmental Design Requirements
MJS77-3-250	Functional Requirement, Mariner Jupiter/Saturn 1977 Power Profile and Allocation

OTHER DOCUMENTS

Jet Propulsion Laboratory

PD 618-228	Mariner Jupiter/Saturn 1977, Spacecraft System Environmental Program Policy and Requirements

PD 618-262	Functional Requirements, Mariner Jupiter/Saturn 1977 Magnetics Control Requirements Document

3.0 DESIGN CRITERIA

3.1 Duration

Provisions shall be made to maintain temperature control for all spacecraft assemblies during ground test operations and for the duration of the mission as specified in MJS77-2-100, Spacecraft Design Criteria. Prior to launch, the burden of maintaining temperature control shall be on the Support Equipment (SE) and ground handling procedures and not on the spacecraft.

3.2 Environment

3.2.1 Ground

The SE and ground handling procedures shall be capable of maintaining prelaunch temperatures within the limits specified for ground operations under the environmental conditions given in MJS77-3-240, Environmental Design Requirements.

3.2.2 Flight

The system thermal design shall be capable of maintaining flight temperatures within the limits specified in Table 1 for aerodynamic, planetary and solar heat inputs at mission extremes, including uncertainties.

3.2.3 System Type Approval Test

The system thermal design shall be capable of maintaining solar-thermal-vacuum test temperatures within assembly type approval test ranges for the environmental design levels given in MJS77-3-240. These environments are not expected in flight, but may be experienced during system-level solar-thermal-vacuum testing.

3.3 Spacecraft Conditions

3.3.1 Spacecraft Power State

The spacecraft power states under which temperature control is to be maintained are given in MJS77-3-250, Power Profile and Allocation. Temperature control provisions are not required for power states other than those listed, even though spacecraft logic permits the attainment of such states. Control shall be maintained for the actual power dissipation of the flight equipment, which may differ from the levels given in MJS77-3-250 due to variations in duty cycle or estimation uncertainties.

* Table 1. Spacecraft Temperature Control Requirements (sheet 1 of 4)

Assembly	Operating Range, °C			Non-Operating Range, °C			Maximum Allowable Temperatures During Ground Operations in Air, °C	Notes
	Allowable Long Term Range (>4 Hrs)	Allowable Short Term Range (<4 Hrs)	Preferred Range	Allowable Long Term Range (>4 Hrs)	Allowable Short Term Range (<4 Hrs)	Preferred Range		
<u>Bus</u>								
EA 1 RFS (XMitter)	5/50	5/50		5/50	5/50		55	1
EA 2 DSS	10/40	10/40		10/40	10/40		45	1
EA 3 CCS	12/43	12/43	18/35	12/43	5/43	15/43	45	1
EA 4 FDS	5/50	5/50		5/50	5/50		45	1
EA 5 HYPACE	12/43	12/43		12/43	12/43		45	1
EA 6 DRIRU	5/50	5/50		5/50	5/50		50	1
EA 7 PWR	5/50	5/50	10/35	N/A	N/A		55	
EA 8 PSU	5/50	5/50		5/50	5/50		50	1
EA 9 RFS (XPonder)	5/50	5/50	10/20	5/50	5/50		45	1
USO	5/47	5/47	5/25	5/50	5/50		50	1
*EA 10 MDS/MAG	5/50	5/50	10/30	5/50	5/50		45	1
Canopus Trackers	-5/40	-5/40		-5/40	-5/40		45	2
Sun Detectors	-135/50	-135/50		-135/50	-135/50		45	5
PRA Electronics	5/50	5/50		5/50	5/50		50	2
*PRA Antenna Deploy Mechanism	5/40	5/40		5/40	5/40		45	3
*Brewster Plate	-135/60	-135/60		-135/60	-135/60		45	3
PWS Electronics	5/50	5/50		5/50	5/50		50	2
*Fuse Bleed Resistor Assemblies	-5/60	-5/60		-5/60	-5/60		45	3
0.2-Lbf Thruster Mounting Bracket	13/50	13/50	>16	13/50	13/50	>16	55	4
*PROP Tank	10/38	10/38 (35/38)					45 Dry, 38 Serviced	13, 14
*PROP Tank Gradient	<2	<2 (<5)	<2					15, 14
<u>PROP Dist. System</u>								
Tubing, Fittings, Valves and IPU Filter	10/38	10/55		10/38	10/55		55	6
PCA and Latch Valves	10/38	10/38		N/A	N/A		45	6
* Hydrazine Disconnect and Compliance Volume Lines	N/A	10/40		10/40	10/45		45	6

* Table 1. Spacecraft Temperature Control Requirements (sheet 2 of 4)

Assembly	Operating Range, °C: Allowable Long Term Range (>4 Hrs)	Operating Range, °C: Allowable Short Term Range (<4 Hrs)	Operating Range, °C: Preferred Range	Non-Operating Range, °C: Allowable Long Term Range (>4 Hrs)	Non-Operating Range, °C: Allowable Short Term Range (<4 Hrs)	Non-Operating Range, °C: Preferred Range	Maximum Allowable Temperatures During Ground Operations in Air, °C	Notes
TVC Engines (5 and 100-Lbf)								
*Reactor	N/A	10/N/A		N/A	10/N/A		50	6, 7
*Valve	N/A	10/71		N/A	10/110		50	6, 7, 9
*Pressure Transducer	N/A	10/75		N/A	10/75		50	6, 7
Solid Rocket Mtr								
*Grain (Bulk)	N/A	10/32	20/30	N/A	N/A		32	6, 9
Case (Lateral Grad.)	N/A	<3	0	N/A				8, 9
Case (Axial Grad.)	N/A	<11	<3	N/A				8, 9
*Safe & Arm Assy.	N/A	10/32	15/25	N/A	N/A		32	6, 9
Propulsion Module (Except IPU) and Adapter								
* Battery	N/A	20/45	25/30	N/A	N/A		45	3, 9
* Remote Driver Module	N/A	5/50		N/A	N/A		40	3, 9
*Scan Platform Latch Assy	N/A	5/50		N/A	N/A		45	3, 9
*Low Shock Release Nuts	N/A	-7/70		N/A	N/A		45	3, 9
*Super Zip and Detonators	N/A	-40/80		N/A	N/A		45	6, 9
*RTG Boom Pinpullers	N/A	-48/68		N/A	N/A		45	6, 9
*Accelerometers	N/A	-15/50		N/A	-15/50		45	3
*Accelerometer Amplifiers	N/A	5/50		N/A	5/50		45	3
Squibs	N/A	-105/70		N/A	N/A		45	3, 9
*PM/TVC Dampers	N/A	0/35		N/A	N/A		45	3, 9
Scan Platform								
ISS Vidicons	-10/30	-10/30		-10/30	-10/30		35	5
ISS Electronics	-5/40	-5/40		-5/40	-5/40		45	2
NA Optics Gradient								
Axial	<5	<5	<5	20	20	20	10	10
Circumferential	<3	<3	<3	10	10	10	10	11

✻ Table 1. Spacecraft Temperature Control Requirements (sheet 3 of 4)

Assembly	Operating Range, °C			Non-Operating Range, °C			Maximum Allowable Temperatures During Ground Operations in Air, °C	Notes
	Allowable Long Term Range (>4 Hrs)	Allowable Short Term Range (<4 Hrs)	Preferred Range	Allowable Long Term Range (>4 Hrs)	Allowable Short Term Range (<4 Hrs)	Preferred Range		
IRIS Electronics	-5/40	-5/40	10/40	-5/40	-5/40	10/40	45	2
*IRIS Optics	-73 ±2.5	-73 ±2.5	-73 ±0.2	-75.5/20	-75.5/20	-73 ±2.5	35	3, 7
*MIRIS Electronics	-5/40	-5/40	10/40	-5/40	-5/40	10/40	45	2
*MIRIS Optics	-133 ±1.0	-133 ±1.0	-133 ±0.2	-134/20	-134/20	-133 ±1.0	35	3, 7
PPS	-20/20	-20/20		-20/20	-20/20		35	3
* UVS	-20/25	-20/25	-10	-20/25	-20/25	-10	45	3
Scan Actuators	-15/50	-15/50		-15/50	-15/50		45	3
*Az Tube Cable	>-55	>-55	20	>-55	>-55	20	N/A	6
Isolated Science and Appendages								
LECP								
LEMPA	-20/20	-20/20	-20/0	-20/20	-20/20	-20/10	35	5
LEPT	-20/20	-20/20	0/10	-20/20	-20/20	-20/10	35	5
Electronics and Motor	-20/40	-20/40	10/20	-20/40	-20/40	10/20	40	2
CRS								
Electronics, HETs and TET	-20/15	-20/15	-15/15	-20/15	-20/15	-15/15	35	2, 5
* LETs	-25/15	-25/15	-15/15	-25/15	-25/15	-15/15	35	5
PLS								
* Sensor	-160/80	-160/80		-160/80	-160/80		40	3
* Electronics	-10/35	-10/35		-10/35	-10/35		40	2
*PRA Antennas	-200/150	-200/150		-200/150	-200/150		45	3, 7
*MAG LFM Sensors	-15/45	-15/45	25 ±10	-15/45	-15/45	25 ±10	50	3
MAG HFM Sensors	-40/40	-40/40	0/15	-40/40	-40/40		45	3
*Mag Boom	-25/25	-25/25		-200/70	-200/70			3, 9
* Pinpullers/Latch	-48/68	-48/68		N/A	N/A		50	6, 9
* Deployment Rate Limiter	-15/30	-15/30	20	-15/30	-15/30	20	40	3, 9
* Dampers	0/20	0/20	10	0/20	0/20	10	50	6
* Cable	-25/50	-25/50	25	-200/70	-200/70	25	50	3, 9
* Astromast	-25/50	-25/50	25	-200/70	-200/70	25	50	3, 9

✻ Table 1. Spacecraft Temperature Control Requirements (sheet 4 of 4)

Assembly	Operating Range, °C			Non-Operating Range, °C			Maximum Allowable Temperatures During Ground Operations in Air, °C	Notes
	Allowable Long Term Range (>4 Hrs)	Allowable Short Term Range (<4 Hrs)	Preferred Range	Allowable Long Term Range (>4 Hrs)	Allowable Short Term Range (<4 Hrs)	Preferred Range		
*RTG & Sci Boom Deploy Mech.	N/A	-18/41		-195/50	-195/50		45	3, 9
*RTG Cruise Damper	0/30	0/30		N/A	N/A			3
RTG	<270	<280	<270	N/A	N/A		280	1
Axial ΔT	89	89		N/A	N/A			8, 16
* Axial Gradient (ΔT/in.)	17	17		N/A	N/A			16
* Radial ΔT	<56	<56		N/A	N/A			8, 16
* Radial Gradient (ΔT/in.)	<6	<6		N/A	N/A			16
* Fin (Tip to Root)	17	17		N/A	N/A			8, 16
*Sun Sensor	-5/40	-5/40		-5/40	-5/40		50	5
*Shunt Radiator and Sci Cal Target	-160/130	-160/130		N/A	N/A		90	3
S/X Antenna								
* S-Band Feed and LGA	-200/75	-200/75		-200/75	-200/75		65	6
* Structure (except FSS mounting Plate)	-200/125 (-200/82)	-200/125 (-200/82)		N/A	N/A		65	6, 12
* FSS Mounting Plate	-200/125	-200/125		N/A	N/A		65	6

✱ Table 1 Notes

These notes are used in conjunction with Table 1.

1) Average Shear plate or radiating surface temperature.

2) Average electronics chassis temperature.

3) Bulk average temperature.

4) Mounting pad temperature.

5) Detector temperature.

* 6) Temperature range not to be exceeded at any point on assembly. In the case of the propellant lines to the TCAPU thrusters, this applies up to the propellant inlet adapter. In the case of the AZ Tube Cable, this applies to the flexing portion only.

7) Subsystem Design Agency responsible for meeting requirement.

8) Temperature difference between any two points on the exterior surface of the assembly.

* 9) Operating limits apply only from launch through deployment, ignition, actuation, or initiation of function.

*10) Temperature difference between the flight temperature transducer locations on the optics housing.

*11) Temperature difference between any two points on a single optical element.

*12) Limits in parentheses apply only during acceleration (powered flight).

*13) Average tank wall temperature on the liquid side.

*14) Limits in parentheses apply only at initiation of IPU operation.

*15) Difference between the average tank wall temperatures on the liquid side and on the gas side.

*16) Limits apply only at Liftoff.

Table 1 Definitions

The definitions specified in Table 1 are defined herein:

1) Operating Range: Powered and Functioning. In the case of the Propulsion Assemblies, operating is defined as functioning during a period of engine operation, even though the actual engine firings may be intermittent.

2) Non-Operating Range: Unpowered. If any assembly is to function following a non-operating condition, a temperature within the Operating Range must be obtained prior to initiating operation.

3) Allowable Long Term Range: The maximum temperature range acceptable for all parts of the mission except transients of less than four hours.

4) Allowable Short Term Range: The maximum temperature range acceptable for transients not to exceed four hours in duration at each occurrence.

5) Ground Operations Limit: The maximum acceptable temperature for in-air testing at the spacecraft system level and for the period between launch and initial temperature stabilization.

3.3.2 Spacecraft Configuration

Temperature control shall be maintained during prelaunch, ascent, and flight in the corresponding configurations as defined by the requirements of MJS77-3-180, Spaceflight Equipment Configuration. The position of the scan platform shall not be constrained for purposes of temperature control at distances from the sun exceeding 3.0 astronomical units (A. U.). Near Earth, platform pointing shall be confined to the anti-sunward hemisphere. At solar distances between 1.0 and 3.0 A. U., platform pointing in the sunward hemisphere shall be limited as dictated by the requirement not to exceed the upper temperature limits of the science instruments as given in Table 1.

3.3.3 Spacecraft Orientation

The spacecraft orientations for the sequence defined by MJS77-3-120, Spacecraft Flight Sequence Implementation, shall be accommodated by the spacecraft thermal design. Off sun orientations are specifically constrained by Table 3.

3.3.4 Failure Mode Provisions

The system thermal design shall be adequate to assure that the malfunction protection requirements are met as specified in MJS77-3-100. With exceptions allowed as noted in MJS77-3-100, no single failure shall induce unfailed assembly temperatures beyond TA test levels or beyond the level known to significantly degrade equipment reliability or data quality, whichever occurs first.

3.4 Combination of Environmental and Spacecraft Induced Effects

Table 2 summarizes the combinations of thermally significant parameters which must be accommodated by the system thermal design. The general guideline to be followed is that the allowable temperature ranges of Table 1 must not be exceeded for the extreme conditions of the planned mission, but there is no such requirement for abnormal combinations of environment and spacecraft condition.

3.5 Approach

3.5.1 System Test Configuration

Spacecraft temperatures shall be maintained within the limits specified in Table 1 by the use of environmental control, special handling procedures, and operational constraints as required.

Table 2. Flight Temperature Control Design Conditions

Operational Mode	Maximum Duration	Solar Intensity ($S=135.3\ mw/cm^2$)	Planetary Heating	Spacecraft Orientation
1) Launch and Ascent	See MJS77-3-120	0.0 to 1.0S	Earth	As Dictated by Launch Requirements
2) Sun Acquisition	30 Min	1.0S	Earth	(See Table 3)
3) Canopus Acquisition	70 Min	1.0S	None	Sun-Oriented Roll
4) Near Earth Cruise	70 to 85 days	1.0 to 0.45S	None	(See Table 3)
5) Earth-Saturn Cruise	4 Yrs	0.45 to 0.01S	None	Earth Oriented (See Table 3)
6) Trajectory Correction Maneuver (TCM)	(See Table 3)	1.0 to 0.01S	None	(See Table 3)
7) Science Calibration Maneuver	(See Table 3)	1.0 to 0.01S	None	(See Table 3)
8) Science Calibration Target Maneuver	(See Table 3)	1.0 to 0.01S	None	(See Table 3)
9) Jupiter Encounter	160 Days	0.04S	Jupiter	Earth Oriented
10) Solar/Earth Occultation@Jupiter	2.5 Hrs	0.04 to 0.0S	Jupiter	Earth Oriented
11) Saturn Encounter	160 Days	0.01S	Saturn	Earth Oriented
12) Solar/Earth Occultation@Saturn	1.5 Hrs	0.01 to 0.0S	Saturn	Earth Oriented

* Table 3. Spacecraft Orientation Constraints

Operational Mode	Applicability (A. U.)	Maximum Allowable Off-Sun Duration	Orientation Constraint
1) Launch and Ascent	1.0	As Required	None.
2) Initial Sun Acquisition	1.0	One 360° Turn @π mr/sec	Turn may be about any S/C axis or axes, but must be continuous.
3) Cruise	1.0 to 1.5	Continuous	Sun limited to +X/+Y quadrant of Sun Sensor Field-of-View.
	1.5 to 3.0	Continuous	Sun limited to Sun Sensor Field-of-View.
4) Trajectory Correction Maneuver (TCM)	1.0 to 2.0	1.0 hr x $(AU)^2$ plus Duration of Pitch Turns	Turns must be ROLL ($-360° \le R \le 360°$, then NEGATIVE POLARITY PITCH ($-180° \le P \le 0$), then reacquire.
5) Science Calibration Maneuver	1.0 to 1.5	One 360° turn at 1.0 AU increasing linearly with AU to ten 360° turns at 1.5 AU.	Turns must be ROLL and/or PITCH. Only PITCH turns apply toward maximum allowable number of turns, but each PITCH turn must be complete (i. e., 360°).
	1.5 to 2.0	Ten 360° turns at π mr/sec	
6) Science Calibration Target Maneuver	1.0 to 1.5	Same as TCM	Same as TCM.
	1.5 to 2.0	Same as TCM	Same as TCM except a ±10° post-pitch roll turn is allowed.
7) Sun Reacquisition Maneuver	1.0 to 3.0	3.5 hrs	Turn sequence must begin with a YAW turn and consist of alternate YAW/PITCH turns where Y = ±360° and P = ±72° (all PITCH turns must be of same polarity). Pause periods between turns must be minimized. Note: 5 YAW/4 PITCH turns will provide 4π steradian coverage for the Sun Sensor.

General Constraints

1) Maneuvers 4, 5, and 6 above shall all be initiated from a Sun-oriented* configuration.
2) S/C temperatures shall be at equilibrium before initiating maneuvers 4, 5, or 6.
3) The elapsed time between subsequent maneuvers shall be sufficient to assure that (2) is met.

*"Sun-oriented" denotes the Sun lying along the S/C -Z axis.

3.5.2 System Solar-Thermal-Vacuum Tests

The Proof Test Model (PTM) shall be maintained within TA assembly test levels and other flight spacecraft shall be maintained within FA assembly test levels by the use of flight design features alone, except where the test configuration or environmental simulation induces nonflight conditions. SE and operational procedures shall be used in these cases and shall be more generally applied to protect the spacecraft in the event of a spacecraft or facility failure.

3.5.3 On-Pad

A system of ducted conditioned air or dry nitrogen, together with selective insulation, shall be used to maintain acceptable spacecraft temperatures within the Centaur standard shroud during prelaunch operations. Heaters powered from the ground via the umbilical shall be required for temperature preconditioning of some S/C equipment.

3.5.4 Flight

Flight-proven thermal design techniques shall be used to control the spacecraft heat balance such that acceptable temperatures are obtained in flight. In general, these techniques will influence or control configuration, packaging, conductive and radiative paths, and expernal surface finish.

3.5.4.1 Main Equipment Compartment (Bus). The temperature control approach for the bus shall be basically the same as for past Mariner spacecraft, including:

a) Maximum isolation from solar heating, using multilayer insulation on the sunward side.

b) Multilayer insulation on the shaded side to minimize gradients and control heat losses.

c) Heat rejection at electronic bay faces, primarily via thermostatically controlled louvers.

d) Maximum internal coupling to suppress gradients, simplify thermal design, and improve reliability.

* 3.5.4.2 Scan Platform. Instruments on the scan platform shall be thermally coupled within a blanketed enclosure with temperature control implemented by controlling the radiating area for the enclosure such that acceptable temperature levels are achieved. The IRIS/MIRIS optics shall be thermally isolated from other instruments and thermostatically controlled.

3.5.4.3 Cruise Science and Appendages. Both passive and active temperature control techniques shall be employed. Shades, shields, surface properties, configuration, heaters, or conductive coupling shall be controlled as needed to produce acceptable temperatures.

* 3.5.5 Temperature Control Devices

Variable emittance louvers and several types of heaters will be used.

Thermostatically actuated louvers shall be used to regulate the heat radiated from the main equipment compartment, the scan platform and some individual science instruments and sensors. The louvered area shall be sufficient to compensate for power variations within the compartment, variations in solar heat input, and uncertainties in the performance of the thermal shields and blankets. Maintaining all louvers within their control range during the mission shall be a design goal.

Radioisotope heater units (RHUs) and electrical heaters shall be used where supplemental heat sources are mandatory. Electrical heaters shall be fixed (continuously on), replacement (on when equipment is off), commandable by CCS from ground command, or programmed, or thermostatically actuated. Heater power shall be limited to the minimum required to maintain allowable temperatures. Heaters shall be powered by dc directly from the shunt regulator, except where compelling circumstances dictate otherwise. RHUs shall be used wherever possible to minimize electrical power usage, but shall not be used where radiation effects per MJS77-3-240, are a concern.

3.6 Subsystem Requirements

3.6.1 Packaging

The packaging of the electronics shall be as specified in MJS77-3-220, Flight Electronic Equipment Design, so as to provide a minimum number of separable interfaces between a source of heat and a surface radiating to space.

3.6.1.1 Dissipated Power

The rate of heat transported from a bus subassembly to the external shear plate shall not exceed 2.0 W per attachment screw. The rate of heat transported to the external shear plate shall not exceed 0.04 W/cm^2 (0.25 W/in.^{2}) of available shear plate radiating area unless special packaging provisions are made to prevent overheating.

3.6.2 Surface Finish Control

a) The temperature control surface properties for spacecraft subsystems shall be as required by the spacecraft thermal design and specified by the cognizant temperature control engineer.

b) Surface finishes shall be easily cleanable or repairable to restore original properties after ground handling. They shall not chip, dust, or peel when exposed to the launch and flight environments.

c) Surface finish outgassing products shall be a minimum when exposed to a vacuum and predicted flight temperatures. If necessary, the paints shall be outgassed prior to vacuum exposure to prevent contamination of temperature control and optical surfaces.

4.0 DESIGN REQUIREMENTS

* 4.1 Temperature Requirements

The allowable and preferred spacecraft temperatures are listed in Table 1. Allowable temperature ranges are requirements levied on the system thermal design. Adequate margin must be provided to account for the degradation of material properties and uncertainty in spacecraft performance and environmental conditions such that these ranges can be maintained with high confidence. Conservative thermal verification tests with temperature control models (TCMs) and with the PTM and FLT spacecraft, and uncertainty analyses for marginal design situations shall be used to verify the accomplishment of this goal.

Preferred temperature ranges are design goals. Where possible, the thermal design will be targeted for these ranges under nominal mission conditions.

4.1.1 Relationship to Assembly FA, TA, and Temperature Test Levels

The FA test levels shall in all cases exceed the allowable flight ranges given in Table 1. TA test levels and equipment design levels are successively broader ranges, the descriptions for which are given in MJS77-3-240. The rationale for these levels is given in PD 618-228, Environmental Program Policy and Requirements. If the allowable temperature for ground operations given in Table 1 exceeds the FA test level, special in-air temperature tests will be required, per PD 618-228.

4.2 Heater Requirements

Electrical heater requirements are shown in MJS77-3-250. Replacement heaters shall match the actual heat dissipation of the replaced electronics within ±5 percent for all science equipment. Other heaters shall dissipate the power shown in MJS77-3-250 within +3 percent. Table 4 lists required RHUs.

✱ Table 4. RHU* Requirements

RHU Location	Quantity Required
Outboard Low Field Magnetometer Sensor (OBLFM)	3
Inboard Low Field Magnetometer Sensor (IBLFM)	3
Outboard High Field Magnetometer Sensor (OBHFM)	2
Inboard High Field Magnetometer Sensor (IBHFM)	2
Magnetometer Boom Dampers	3
Sun Sensor	6
Propulsion IPU Quick Disconnect and Associated Hydrazine Lines	5
*Radioisotope Heater Units 1.0 thermal watts each.	

REVISION PAGE

Revision	Date	ECRs Incorporated	Comments
Original	18 April 1975		
A	11 November 1976	36199, 36231, 36279, 36280, 36346, 36463, 36098, 36127 36375	

FUNCTIONAL REQUIREMENT AMENDMENT

TITLE:

FUNCTIONAL REQUIREMENT
MARINER JUPITER/SATURN 1977
FLIGHT ELECTRONIC EQUIPMENT DESIGN

FR No. MJS77-3-220

AMENDMENT No. 1

PAGE 1 **OF** 1

DATE: 24 July 1975

PER ECR No.

DESCRIPTION OF CHANGE:

Revise paragraph 6.3, page 16, as follows:

IS: Shipping and handling equipment shall be per JPL Drawing 10073927.

WAS: Shipping and handling equipment shall be per JPL Drawing 10073427.

DISTRIBUTION:

List No. 197

REMARKS:

APPROVED:

SYSTEM

(Insert in 618-205, MJS77 Functional Requirements Book)

Custodian: B. W. Stebbins

APPROVED:

System: [signature] R. F. Draper

[signature] W. E. Layman

[signature] B. W. Stebbins

JET PROPULSION LABORATORY

No. MJS77-3-220
12 March 1975

FUNCTIONAL REQUIREMENT

MARINER JUPITER/SATURN 1977 FLIGHT

ELECTRONIC EQUIPMENT DESIGN

✱ Denotes change

1.0 SCOPE

1.1 Electronic Equipment Design Requirements

This document specifies the functional requirements for the mechanical design of Mariner Jupiter/Saturn 1977 (MJS77) flight electronic equipment. Packaging considerations relative to structural, electrical, thermal and configurational requirements are identified.

1.2 Applicability

The requirements expressed herein are to be applied to the mechanical design of MJS77 flight electronic equipment. Where special requirements are recognized, calling for techniques, different from those defined in this document, the MJS77 Electronic Equipment Engineer shall approve, in advance, the use of alternatives. These requirements pertain primarily to those electronic subsystems that are contained in the bays of the primary structure of the MJS77 Mission Module. The appropriate Division 35 Technical Support Representative should be contacted for specific requirements of subsystems/ subassemblies located elsewhere.

2.0 APPLICABLE DOCUMENTS

The following documents form a part of this Functional Requirement:

NOTE

MJS77-3-100, Spacecraft Requirements and Constraints, applies to this document. Requirements of other level 3 documents may also be applicable. It is the responsibility of the user to adequately acquaint himself with the organization and pertinent content of the level 3 documents, as well as with the material contained herein.

REQUIREMENTS

Jet Propulsion Laboratory

MJS77-2-100	Spacecraft Design Criteria
MJS77-3-100	Functional Requirement, Mariner Jupiter/Saturn 1977 Spacecraft Requirements and Constraints
MJS77-3-180	Functional Requirement, Mariner Jupiter/Saturn 1977 Configuration
MJS77-3-190	Functional Requirement, Mariner Jupiter/Saturn 1977 Structural Design Criteria
MJS77-3-210	Functional Requirement, Mariner Jupiter/Saturn 1977 Design Criteria for Spacecraft Temperature Control
MJS77-3-240	Functional Requirement, Mariner Jupiter/Saturn 1977 Environmental Design Requirements
MJS77-3-260	Functional Requirement, Mariner Jupiter/Saturn 1977 Electrical Grounding and Interfacing
MJS77-4-2009	Functional Requirement, Mariner Jupiter/Saturn 1977 Flight Equipment Cabling System

OTHER DOCUMENTS

Jet Propulstion Laboratory

618-52	Mariner Jupiter/Saturn 1977 Project Policies and Requirements for Science Investigations
618-211	Mariner Jupiter/Saturn 1977, Parts, Materials and Process Requirements
618-232	Mariner Jupiter/Saturn 1977 Configuration Management Plan
DM509306	Electronic Equipment and Cabling Design and Fabrication Requirements and Process Techniques

✱ DRAWINGS

Jet Propulsion Laboratory

10063244	Electronic Subassembly (Baseline Control Drawing)
10063461	DSP Special Component Mounting
10062445	Mariner Jupiter/Saturn 1977 Electronic Packaging Arrangement
10066432	Electronic Assembly/Bus Structure Interface Control Drawing
10073927	Assembly Handling and Shipping Equipment

3.0 FUNCTIONAL REQUIREMENTS

3.1 General Packaging Design Requirements

a) Electronic equipment shall be designed as replaceable assemblies. Each assembly shall, in general, be comprised of replaceable subassemblies. Where practical, electronic equipment will be contained in the bays of the primary structure, however, scientific instruments, Sun sensors and other equipment with special viewing requirements will be mounted to satisfy those requirements.

b) Electronic equipment located in the bays shall be packaged in standardized electronic assemblies.

c) Electronic packaging design shall meet the requirements for survival and reliable operation in the MJS77 Mission environment. Adequate protection against degradation during handling, testing, shipping and storage and suitable access to equipment, for adjustment, repair and modification shall be provided.

d) Overall requirements for electronic packaging design are for both assembly and subassembly and shall meet the requirements in DM509306, Electronic Equipment and Cabling Design and Fabrication Requirements and Processing Techniques.

✱ 3.1.1 Equipment Location

The location of electronic equipment shall be consistent with the requirements of MJS77-3-180. Configuration, and the location of electronic assemblies, in the bays, shall be controlled by JPL Drawing 10062445, Electronic Packaging Arrangement. Electronic assemblies are located with attention to functional, cabling, temperature control, radiation, magnetic, and center-of-gravity considerations.

3.1.2 System Requirements

Electronic packaging design shall conform to the criteria established in MJS77-2-100, Spacecraft Design Criteria, and meet the requirements contained in MJS77-3-100, Spacecraft Requirements and Constraints.

3.1.3 Electrical Requirements

a) Requirements contained in MJS77-3-260, Electrical Grounding and Interfacing, shall be met, relative to:

   1) Chassis-Circuitry Isolation.

   2) Electrical Bonding.

   3) Magnetic Fields.

   4) Grounding of Shields.

   5) Grounding of Reference Trees.

b) Equipment developing or using voltage greater than 250 V during any mission phase shall meet the design and testing requirements as specified in DM509306, paragraph 3.4.5, to prevent corona, or other forms of arcing, in atmospheric pressures ranging from sea level to the vacuum of space. This requirement applies even to equipment that is not powered during the ascent through the critical pressure region.

3.1.4 Structural Requirements

The electronic assemblies and subassemblies shall have structural characteristics consistent with MJS77-3-190, Structural Design Criteria.

3.1.5 Environmental Requirements

The packaging design of the electronic assemblies shall contribute to the ability of electronic equipment to withstand the environments anticipated during the mission. Specifically, the packaging design shall be developed with consideration for the environments specified in MJS77-3-240, Environmental Design Requirements, and the requirements, guidelines and constraints established in MJS77-3-210, Design Criteria for Spacecraft Temperature Control.

3.1.6 Materials and Process Requirements

Materials, hardware and fabrication process shall conform to the applicable portions of 618-211, Parts, Materials and Processes Control Requirements. Use of magnetic materials shall be avoided.

3.1.7 Identification Requirements

Identifying markings shall, as a minimum, meet the requirements of 618-232, MJS77 Configuration Management Plan, for engineering subsystems and for science subsystems use 618-52, Project Policies and Requirements for Science Investigations.

3.1.8 Threaded Fasteners

Threaded fasteners shall conform to DM509306, paragraph 3.2.1.6. Fasteners shall conform to the applicable portions of PD 618-211.

3.1.9 Installation Requirements

Qualified fixtures and tooling shall be used to permit reliable installation and removal of electronic assemblies and subassemblies with no resultant damage to, degradation of, the mechanical or electrical characteristics of the equipment.

* 3.1.10 Shipping and Handling

Shipping and handling of electronic equipment will be in conformance with DM509306, paragraph 3.2.7, and environmental requirements of MJS77-3-240, paragraph 3.1. All standard shipping and handling equipment will be supplied by JPL as GFE.

3.2 Electronic Assembly Design Requirements

Electronic assemblies shall conform to the geometry as shown in Figure 1.

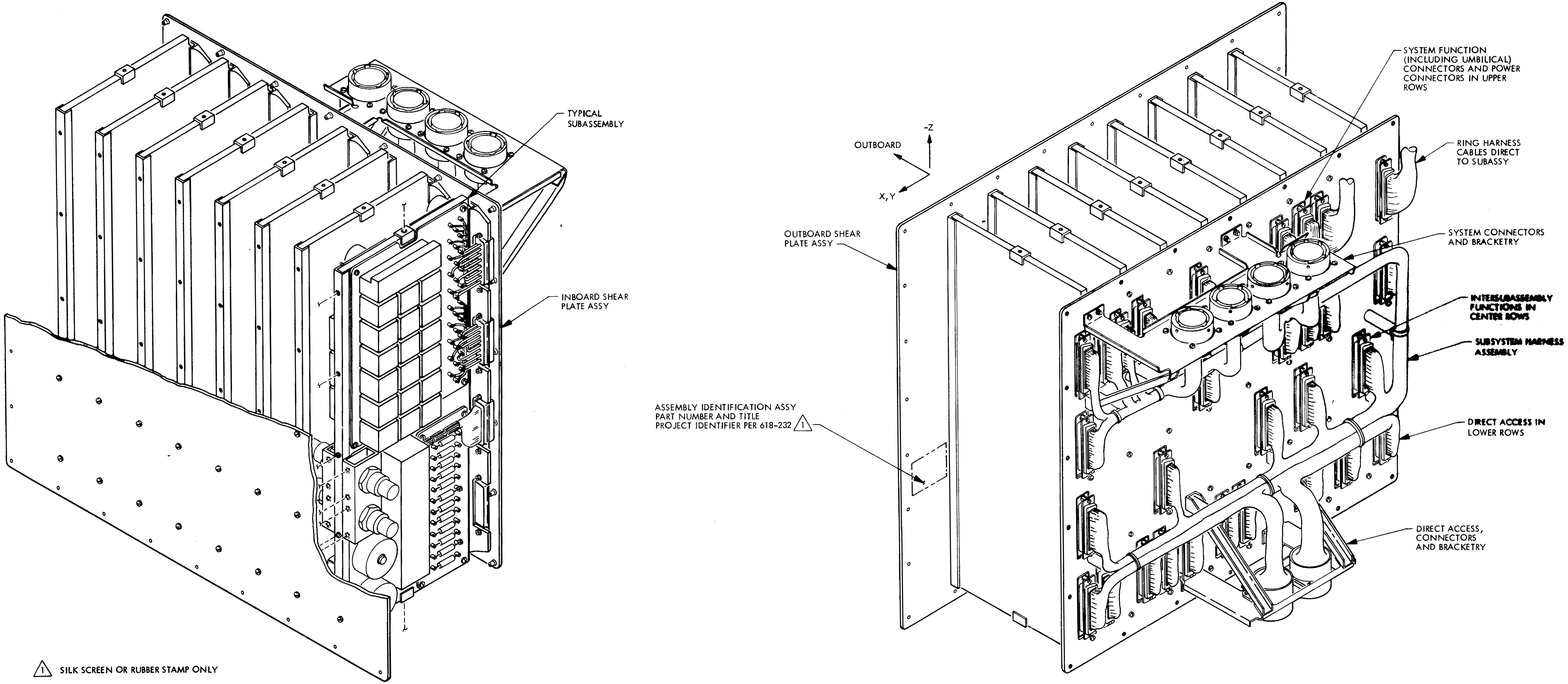


Figure 1. Typical Dual Shear Panel Electronic Assembly

3.2.1 Structural Requirements

a) The electronic assemblies mounted in the bays of the primary structure form an integral part of that structure. The electronic subassemblies contained within each electronic assembly contribute to the strength and rigidity of the assembly. These characteristics are derived principally from the shear plates of the electronic assembly and from the subchassis of each electronic subassembly. The requirements for the design of spacecraft structural elements are specified in MJS77-3-190, Structural Design Criteria.

b) Inboard and the outboard surface elements of each electronic assembly shall be designed to function as a primary shearplate when mounted on the primary structure; all holes, discontinuities and loads at attachment points in the shearplates shall be controlled in order to assure structural integrity. The subchassis of each subassembly shall provide lateral stability to the assembly and primary structure. The shock and vibration inputs to the electronic assembly are specified in MJS77-3-240, Environmental Design Requirement. The shock and vibration design criteria for subassemblies are specified in paragraph 5.1.

3.2.2 Thermal Requirements

Consistent with special equipment requirements, the electronic assemblies shall be designed to provide conductive heat paths to the primary structure. Subassemblies within each assembly will serve as thermal conductors. Subassemblies with high heat dissipation should be distributed to assist in the temperature control of all elements within the electronic assembly. Adjacent subassemblies shall make reciprocal use of radiative and conductive heat transfer to the maximum extent consistent with other factors. The electronic assembly shall provide a surface suitable for application of required temperature control finishes. Surface flatness and the number of fasteners used shall be compatible with temperature control design requirements. Design criteria for thermal interfaces are specified in MJS77-3-210, Design Criteria for Spacecraft Temperature Control.

3.2.3 Electronic Assembly Internal Configuration

The following considerations apply to the internal configuration of the electronic assembly:

a) All equipment of one subsystem should be confined to a single electronic assembly wherever practical, for ease of handling, testing and checkout.

b) Electronic subassemblies requiring a large number of electrical interconnections with each other should be located adjacently or in close proximity.

c) Electronic subassemblies with heat dissipation should be so distributed within the assembly as to aid in establishing temperature control within the specified limits.

d) Special positioning required by temperature transducers, gyroscopes and other devices shall be provided.

3.2.4 Assembly Harness

The electronic subassemblies within each electronic assembly are, in general, interconnected with one or more removable harnesses. A typical assembly harness is shown in Figure 1. Harnesses will be designed with consideration for the requirements expressed in this document. Basic functional requirements of harnesses are contained in MJS77-4-2009, Cabling Subsystem. As a goal, the direct access checkout cabling harness shall be independent of the flight wiring, and be capable of being removed prior to flight.

3.3 Electronic Subassembly Design Requirements

Within an electronic assembly, the configuration shall be standardized to provide flexibility in location of the subassemblies. Subassembly envelopes may be varied as required to satisfy particular design requirements and packaging objectives. The interface requirements for these subchassis are specified in Section 4.0. For special component mounting (other than on printed wiring boards) within a subassembly, see JPL Drawing No. 10063461, DSP Special Component Mounting.

3.3.1 Viking Orbiter 1975 Inherited Subassemblies

Subassemblies inherited from VO'75 (either actual hardware or design) must be adapted for proper mounting into the MJS77 electronic assembly. Coordination with the appropriate Division 35 Technical Support Representative will be required for the detailed design of this adaptation.

3.3.2 Shielding Requirements for Typical Mounting

Electronic subassemblies shall be shielded as required to prevent detrimental electromagnetic interference or electrical cross-coupling, whether internally or externally generated. These requirements are specified in MJS77-3-240. Provision shall be made, internal to each subassembly, for reliable connection of electrical ground wires or conductors.

3.3.3 Subassembly Wiring

The subassemblies shall be designed such that system functions, ac power input, direct access, and subassembly interconnect functions do not utilize the same subassembly connectors. Subassembly intraconnections shall not be made through the subassembly connectors. Each function which goes to more than one destination shall be allocated a separate pin on the subassembly connector for each destination. The location of subassembly connectors will be selected such that wire length in the external cabling is minimized. System functions will be assigned to connectors near the system interconnect harness, power near the power distribution harness (both in the -Z direction), and direct access to connectors near the lower end (+Z direction in accordance with MJS77-3-180), of the subassembly.

3.3.4 Structural Requirements

The subassembly subchassis shall be designed as a mechanically integrated, load-sharing member of the electronic assembly. Adequate stiffness shall be provided to ensure that fragile parts, modules and interconnections are not damaged by levels of shock and vibration described in paragraph 5.1.

4.0 INTERFACE DEFINITIONS

4.1 Interface Requirements

The mechanical interfaces of each electronic assembly, and each subassembly that is mounted in an electronic assembly, shall be controlled by Interface Control Drawings (ICD). For information purposes, JPL Drawing 10063244, Electronic Subassembly (Baseline Control Drawing), may be used.

* 4.1.1 Electronic Assembly Interfaces

The interface of the electronic assemblies to the MJS77 bus will be specified by JPL Drawing 10066932. MJS77 Electronic Assembly/Bus Structure Interface Control Drawing.

5.0 PERFORMANCE PARAMETERS

The design of the electronic assembly shall ensure that a minimum stress is imposed on electrical parts within the total range of mission environments.

5.1 Shock Vibration

* 5.1.1 Shock

Electronic equipment component level design requirements shall be in compliance with Figure 2. All relays shall incorporate protective packaging techniques for shock and vibration.

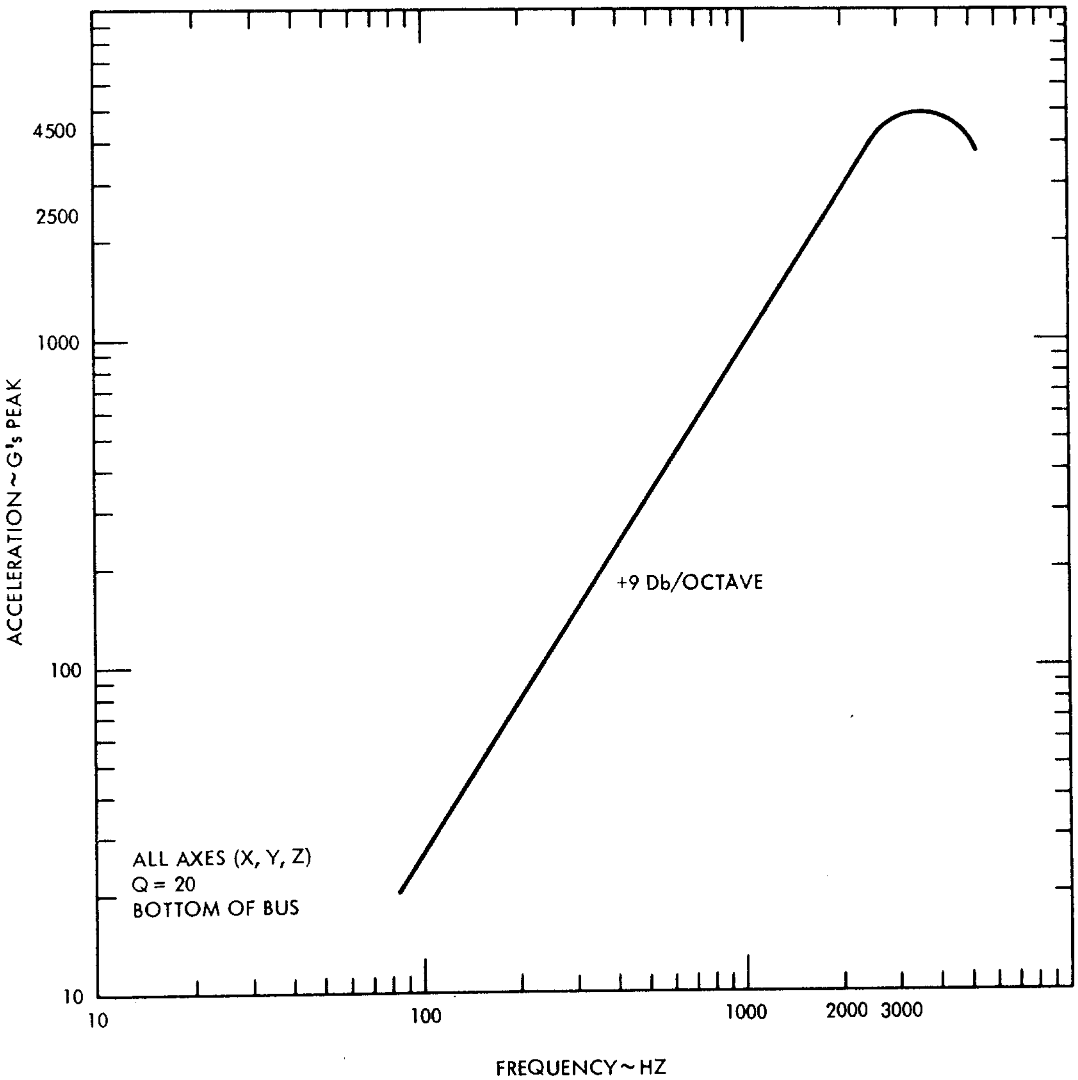


Figure 2. MJS77 Shock Spectrum Electronic Subassembly Design Criteria (Component Level)

5.1.2 Vibration

Electronic equipment shall be designed so that the fundamental resonant frequency and transmissability in all axes fall in the conservative or adequate design region as shown on Figure 5. Figures 3 and 4 define the sine and random vibration levels that components are subjected to when mounted on an MJS77 subchassis.

5.2 Thermal

The maximum subassembly heat dissipation shall not exceed 0.0078 W/cm^2 (0.05 $W/in.^2$) of component mounting area per side without special considerations.

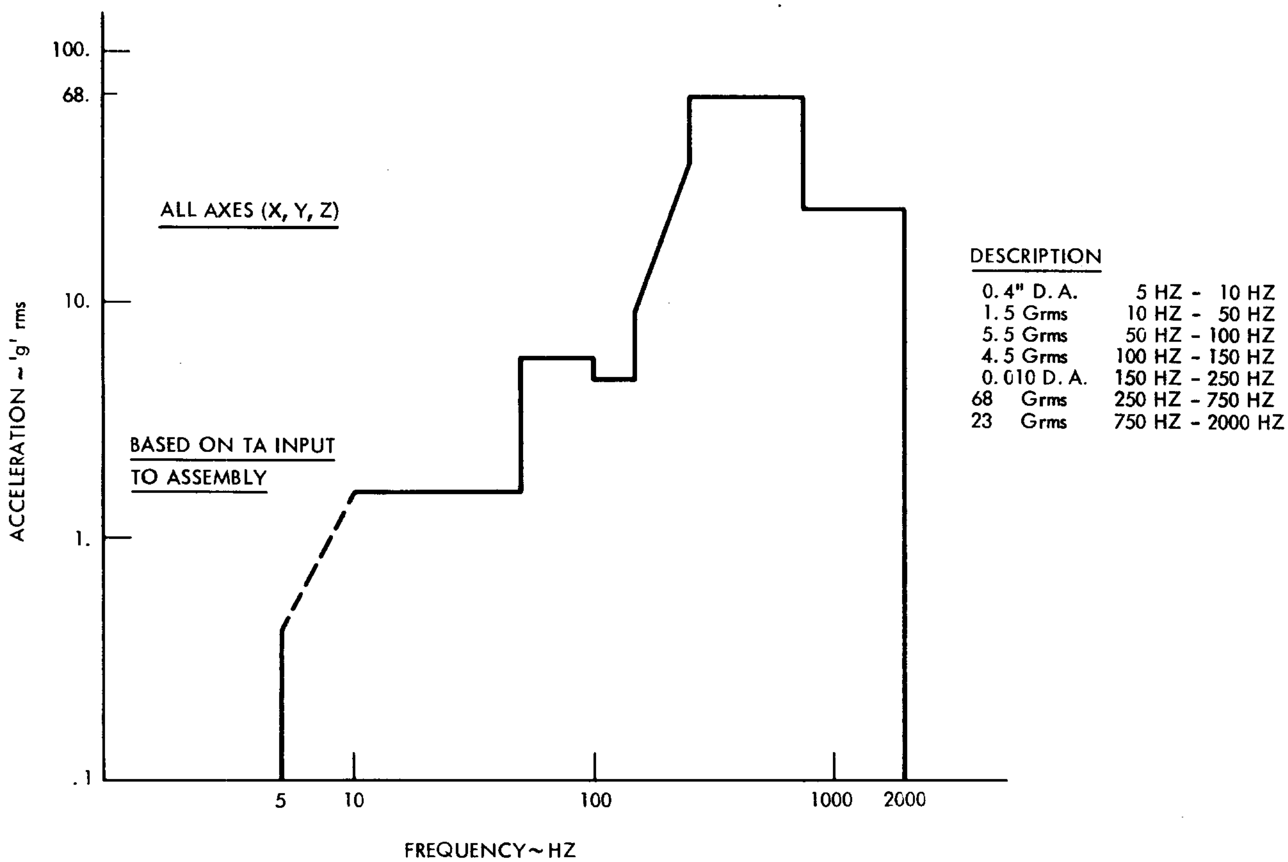


Figure 3. MJS77 Sine Vibration Electronic Subassembly Design Criteria (Component Level)

5.3 EMI

(TBD)

✱ 5.4 Radiation Protection

The electronic assembly inboard and outboard shear panels shall provide dose and fluence margin of 2.0 in accordance with MJS77-3-240.

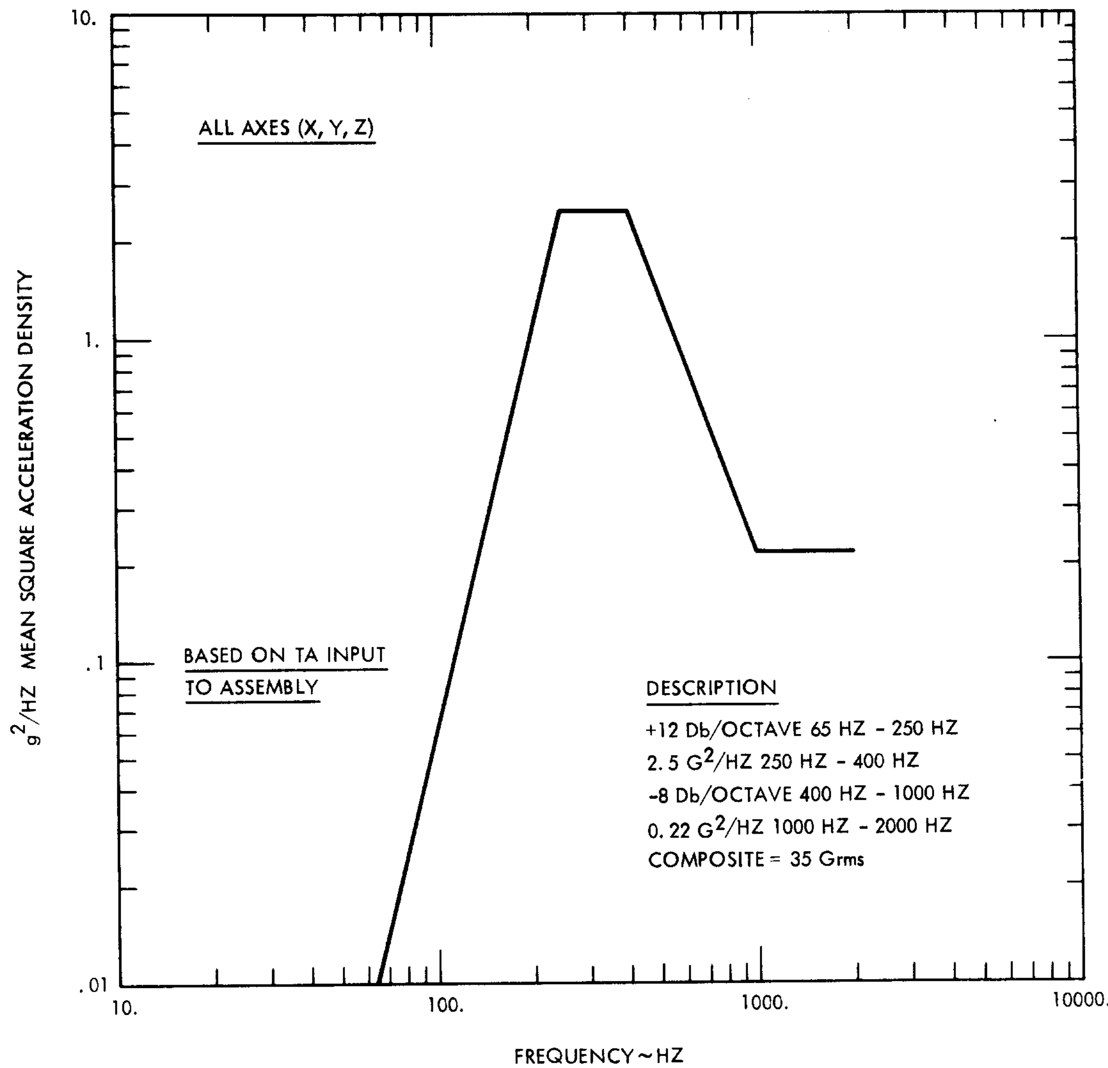


Figure 4. MJS77 Random Vibration Electronic Subassembly Design Criteria (Component Level)

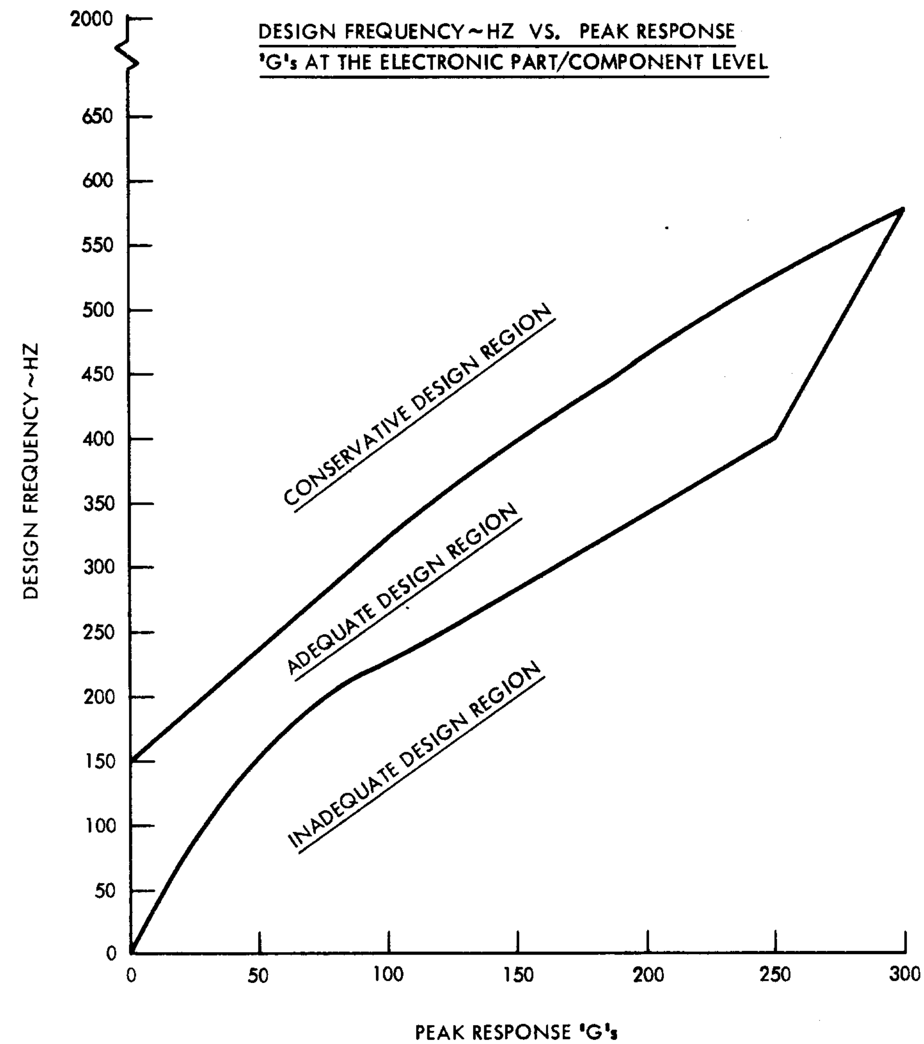


Figure 5. Electronic Equipment Dynamic Design Criteria (Component Level)

6.0 PHYSICAL CHARACTERISTICS AND CONSTRAINTS

6.1 Mass and Volume

MJS77 electronic equipment shall be designed for minimum mass and volume consistent with high reliability, ease of fabrication, environmental stress, handling, durability, operational considerations, and flexibility to permit modification and/or rework without significant degradation.

6.2 Alternate Design Techniques, Process and Materials

The use of design techniques, processes and materials other than those specified in this document requires approval in advance, as stated in paragraph 1.2. Such use will be based upon prior qualification to ensure that equipment will survive environmental shock, vibration, temperature excursions and provide long term operation in outer space. Compatibility must be achieved with applicable sections of 618-211.

* 6.3 Handling and Shipping

Appropriate handling fixtures and containers as defined in DM509306, Electronic Equipment and Cabling Design, and Fabrication Requirements and Process Techniques, shall be provided to protect electronic equipment during fabrication, checkout, testing, shipping, storage and installation. Shipping and handling equipment shall be per JPL Drawing 10073427, Assembly Handling and Shipping Equipment.

7.0 SAFETY CONSIDERATIONS

7.1 Insulation of Electrical Conductors

Electrical conductors, except the engagement surfaces of connector contacts, shall be completely insulated to prevent inadvertent short circuits resulting from contact with conductive foreign material during operation of the MJS77 spacecraft and maintain the safety of personnel. In rare cases where it is not feasible to coat conductors due to functional requirements, physical separation and/or other design techniques shall be utilized to prevent equipment damage.

7.2 Connectors

The use of pins or sockets in particular connectors shall be determined from considerations of safety to personnel and equipment. Where system design dictates a requirement that may present a safety problem, adequate marking and labeling shall be used to assure safe procedural practices. MJS77-3-100 specifies certain requirements for MJS77 electrical interface.

FUNCTIONAL REQUIREMENT AMENDMENT

(Insert in 618-205, MJS77 Functional Requirements Book)

TITLE: FUNCTIONAL REQUIREMENT MARINER JUPITER/SATURN 1977 EQUIPMENT LIST AND MASS ALLOCATIONS	FR No. MJS77-3-230C AMENDMENT No. 2 PAGE 1 OF 1 DATE: 14 February 1979 PER ECR No. N/A

DESCRIPTION OF CHANGE:

A. This document has been removed from control and placed in a non-maintenance category.

B. Changes authorized by the following ECRs will not be incorporated into this document:

36787
36818
36822
36922
36972
36973

DISTRIBUTION: Distribution list attached	REMARKS: APPROVED: SYSTEM

(Insert in 618-205, MJS77 Spacecraft Functional Requirements Book)

Custodian: G. E. Cunningham

APPROVED:

System: R. F. Draper

G. E. Cunningham

/7C

JET PROPULSION LABORATORY

No. MJS77-3-230C
31 May 1977

Supersedes
MJS77-3-230B
19 July 1976

FUNCTIONAL REQUIREMENT
MARINER JUPITER/SATURN 1977
EQUIPMENT LIST AND MASS ALLOCATIONS

* Denotes changes from previous issue.

1.0 SCOPE

This document establishes the Mariner Jupiter/Saturn 1977 (MJS77) subsystem equipment list and mass allocations. The equipment list includes all spacecraft flight configured items plus the Adapter. The mass list includes subsystem allocations for the Mission Module (MM), the Propulsion Module (PM) and the Adapter.

2.0 APPLICABLE DOCUMENTS

The following documents form a part of this Functional Requirement.

NOTE

MJS77-3-100, Spacecraft Requirements and Constraints, applies to this document. Requirements of other MJS77 level 3 documents may also be applicable. It is the responsibility of the user to adequately acquaint himself with the organization and pertinent content of the level 3 documents, as well as with the material contained herein.

REQUIREMENTS

Jet Propulsion Laboratory

MJS77-3-100	Functional Requirement, Mariner Jupiter/Saturn 1977 Spacecraft Requirements and Constraints
MJS77-3-180	Functional Requirement, Mariner Jupiter/Saturn 1977 Configuration
MJS77-3-200	Functional Requirement, Mariner Jupiter/Saturn 1977 Inertial Properties

OTHER DOCUMENTS

Jet Propulsion Laboratory

PD618-51	Mariner Jupiter/Saturn 1977 Mission and Science Requirements Document
PD618-232	Mariner Jupiter/Saturn 1977 Spacecraft System Configuration Management Plan

DRAWINGS

Jet Propulsion Laboratory

10062350	Mariner Jupiter/Saturn 1977 Drawing Tree

3.0 REQUIREMENTS

3.1 Conflicting Requirements

In case of conflict between the requirements of this document and any other Functional Requirement, Project Document or the Drawing Tree, the conflict shall be referred to the Spacecraft System Engineer for resolution.

3.2 Equipment List

All items of equipment satisfying one or more of the following criteria are specified in Tables 1, 2 and 3.

a) The equipment would reasonably be expected to be detached from the spacecraft or a higher assembly in the Spacecraft Assembly Facility (SAF).

b) The equipment will be environmentally tested as a separate unit.

c) The equipment will be delivered to another division or subsystem for subsequent assembly and delivery to the SAF. (Examples: RTG inter-structures, antenna structures, propulsion structure, etc.)

d) The major subassemblies of the equipment included in a), b) or c) above, having one or more electrical interfaces and which would be assigned individual reference designation numbers.

3.2.1 Criterion for Indenture

Any items which are included in a higher level of assembly are indented immediately below said assembly.

3.2.2 Applications

The Equipment and Mass Allocation lists shall contain information which will enable it to be used as the basis for other system level oriented lists such as:

a) Mass Properties lists.

b) Environmental test configuration lists.

c) Quality Assurance lists.

3.2.3 Equipment Identification

Items in the list shall be identified in accordance with PD618-232, Configuration Management Plan, and the MJS77 Drawing Tree.

3.2.4 Configuration

The list shall reflect the MM, the PM, and the Adapter in the configuration shown in MJS77-3-180, Configuration.

3.3 Mass

3.3.1 Mass Control

Spacecraft mass control is the responsibility of the Spacecraft System Engineer. Management of subsystem equipment masses to assure conformance to the allocations of this document is the responsibility of the subsystem cognizant engineering/technical section.

* 3.3.2 Spacecraft and Adapter Launch Mass

The maximum launch configuration mass of the combination of the MM, the PM, the Adapter and the S/C contingency allowance shall be 2062.06 kg (4546.84 lb). Also included in the above mass is any equipment furnished by the launch system which remains on the spacecraft after launch vehicle separation.

3.3.2.1 Mission Module Post-Jettison Mass. The MM post-jettison separated mass is the total hardware mass mounted forward of the MM-PM separation plane after jettison of the PM including propellants, residuals, and all gases. The mass shall not exceed 792.0 kg (1746.36 lb) as specified in 618-51, Mission and Science Requirements Document, Vol. I.

3.3.2.2 Spacecraft Pre-Injection Mass. The spacecraft pre-injection mass is the total hardware mass mounted forward of the PM-Adapter separation plane including all propellants, residuals and all gases prior to spacecraft separation from the adapter. The spacecraft pre-injection mass shall not exceed that shown in Table 4.

3.3.2.3 Adapter Mass. The Adapter mass is the total mass of JPL hardware freed from the spacecraft at separation from the Centaur. The total mass of the adapter shall not exceed that shown in Table 4.

3.3.2.4 Spacecraft Propellant Mass. The propellant mass is the total mass of the combined propellant in the PM and MM. The propellant mass shall not exceed that shown in Table 4.

3.3.2.5 Propellant Consumption Mass. The consumption mass is that mass of the propellant consumed during the injection and jettison sequences. The consumption mass is shown in sequence in Table 4.

3.3.2.6 Subsystem Allocations. The total mass of all flight configured items for each subsystem shall not exceed their allocated mass as shown in Table 5.

Table 1. Mission Module Equipment List

REF NO.	DRAWING NO.	ITEM	*SECT
**** 2001 STRUCTURE SUBSYSTEM ****			
2001	10062240	BUS STRUCTURE ASSY	352
2001	10062266	CABLE SUPPORT RING ASSY	352
2001	10073891	RTG INTERSTITIAL STRUCT (2)	352
2001	10062278	RTG BOOM OUTBOARD ASSY	352
2001	10062262	RTG BOOM INBOARD ASSY	352
2001	10062279	RTG LATCH TRUSS ASSY	352
2001	10062263-1	RTG OUTRIGGER ASSY	352
2001	10062263-2	RTG OUTRIGGER ASSY	352
2001	10062291	RTG CABLE SUPPORT ASSY	352
2001	10062264	MM/TCAPU TRUSS ASSY	352
2001	10062237	SCAN PLATFORM ASSY	352
2001	10062238	SCIENCE BOOM STRUCT ASSY	352
2001	10062239	SCIENCE OUTRIGGER ASSY	352
2001	10067810	HIGH GAIN ANTENNA STRUCTURE ASSY	352
2001	10062260-1	ANTENNA SUPPORT TRUSS ASSY	352
2001	10062260-2	ANTENNA SUPPORT TRUSS ASSY	352
2001	10062260-3	ANTENNA SUPPORT TRUSS ASSY	352
2001	10077612	SHUNT RADIATOR STRUT ASSY	352
2001	10073680	BAY 1 SHEAR PLATE OUTBOARD	352
2001	10073679	BAY 1 SHEAR PLATE INBOARD	352
* 2001	10082408-1	BAY 1 SHEAR PLATE INBOARD,ALT	352
2001	10073682	BAY 2 SHEAR PLATE OUTBOARD	352
2001	10073681	BAY 2 SHEAR PLATE INBOARD	352
2001	10073684	BAY 3 SHEAR PLATE OUTBOARD	352
2001	10073683	BAY 3 SHEAR PLATE INBOARD	352
2001	10073686	BAY 4 SHEAR PLATE OUTBOARD	352
2001	10073685	BAY 4 SHEAR PLATE INBOARD	352
2001	10073688	BAY 5 SHEAR PLATE OUTBOARD	352
2001	10073687	BAY 5 SHEAR PLATE INBOARD	352
2001	10073690	BAY 6 SHEAR PLATE OUTBOARD	352
2001	10073689	BAY 6 SHEAR PLATE INBOARD	352
2001	10073692	BAY 7 SHEAR PLATE OUTBOARD	352
2001	10073691	BAY 7 SHEAR PLATE INBOARD	352
2001	10073694	BAY 8 SHEAR PLATE OUTBOARD	352
* 2001	10083074	BAY 8 SHEAR PLATE OUTBOARD,ALT	352
2001	10073693	BAY 8 SHEAR PLATE INBOARD	352
* 2001	10073693-2	BAY 8 SHEAR PLATE INBOARD,ALT	352
2001	10073696	BAY 9 SHEAR PLATE OUTBOARD	352
2001	10073695	BAY 9 SHEAR PLATE INBOARD	352
2001	10073698	BAY 10 SHEAR PLATE OUTBOARD	352
* 2001	10073698-2	BAY 10 SHEAR PLATE OUTBOARD,ALT	352
2001	10073697	BAY 10 SHEAR PLATE INBOARD	352
* 2001	10073697-2	BAY 10 SHEAR PLATE INBOARD,ALT	352
2001	10075660-4	BAY 1 CONN BRACKET UPPER	352
2001	10075659-5	BAY 1 CONN BRACKET LOWER DIRECT ACCESS	352
2001	10078623-1	BAY 2 CONN BRACKET LOWER DIRECT ACCESS	352
2001	10075660-5	BAY 3 CONN BRACKET UPPER	352
2001	10077583	BAY 3 CONN BRACKET LOWER	352
2001	10076300	BAY 4 CONN BRACKET UPPER	352
2001	10077584-3	BAY 4 CONN BRACKET LOWER	352
2001	10077584-2	BAY 4 CONN BRACKET LOWER	352
2001	10075660-6	BAY 5 CONN BRACKET LOWER	352
2001	10075660-7	BAY 5 CONN BRACKET LOWER DIRECT ACCESS	352

Table 1. Mission Module Equipment List (contd)

REF NO.	DRAWING NO.	ITEM	* SECT
**** 2001 STRUCTURE SUBSYSTEM ****			
2001	10075660-9	BAY 6 CONN BRACKET UPPER	352
2001	10075660-8	BAY 6 CONN BRACKET LOWER DIRECT ACCESS	352
2001	10075659-2	BAY 7 CONN BRACKET UPPER	352
2001	10075660-2	BAY 7 CONN BRACKET UPPER	352
2001	10075660-3	BAY 7 CONN BRACKET LOWER DIRECT ACCESS	352
2001	10077585	BAY 9 CONN BRACKET UPPER	352
2001	10077586	BAY 9 CONN BRACKET LOWER DIRECT ACCESS	352
2001	10075659-3	BAY 10 CONN BRACKET UPPER	352
2001	10075659-4	BAY 10 CONN BRACKET LOWER DIRECT ACCESS	352
*2001A25	10076964	SCIENCE CALIBRATION TARGET/SHUNT RADIATOR	352
2001AC7	10078566	ACCELEROMETER	351
2001	10078392-1	SUPPORT LOUVER	352
2001	10078392-2	SUPPORT LOUVER	352
2001	10078393	PLATE LOUVER	352
2001	10078449	CHANNEL SUN SENSOR	352
2001	10078450	HOUSING RHU (6)	352
2001	10077930	SUPPORT SUN SENSOR	352
2001	10077934	CABLE STRUT	352
-*2001BF1	10081947	SCAN PLATFORM FUSE/BLEEDER ASSY	352
**** 2002 RADIO FREQUENCY SUBSYSTEM ****			
*2002XB1	10082385	X-BAND ALT TWTA	339
*2002DC1	10082409	DISCHARGE CONT ALT X-BAND TWTA	339
2002DX1/2	10070501	DIPLEXER (2)	339
2002HI1/2	240040	HIGH POWER ISOLATORS	339
2002LI1/2	240041	LOWER POWER ISOLATORS	339
2002OF1/2	10070454	OUTPUT FILTER (2)	339
*2002SA1/2	10064021	S-BAND TWTA	339
*2002SA1/2	10082493	S-BAND SSA ASSY	339
*2002TB1	10082221	TERM BD.S-BAND TRANSMITTER SWITCH	339
*2002XA1/2	10064022	X-BAND TWTA	339
2002FH1	10070651	S-BAND FILTER HYBRID	339
2002SW1	10070551	RCVR RF SWITCH	339
2002SW2	10070601	XMTR RF SWITCH	339
2002CX1	10070701-1	INTERBAY COAXIAL CABLES	339
2002CX2	10070702-1	INTERBAY COAXIAL CABLES	339
2002CX3	10070703-1	INTERBAY COAXIAL CABLES	339
2002CX4	10070704-1	INTERBAY COAXIAL CABLES	339
2002CX5	10070705-1	INTERBAY COAXIAL CABLES	339
2002CX6	10070706-1	INTERBAY COAXIAL CABLES	339
2002CX33	10070191-5	INTERBAY COAXIAL CABLES	339
2002CX34	10070191-6	INTERBAY COAXIAL CABLES	339
2002CX35	10070191-7	INTERBAY COAXIAL CABLES	339
2002CX36	10070191-8	INTERBAY COAXIAL CABLES	339
2002CX37	10070191-9	INTERBAY COAXIAL CABLES	339
2002CX38	10070191-10	INTERBAY COAXIAL CABLES	339
2002CX39	10070191-11	INTERBAY COAXIAL CABLES	339
2002CX40	10070191-12	INTERBAY COAXIAL CABLES	339
2002CX41	10070741	CABLE COAX ISOLATOR	339
2002CX42	10070742	CABLE COAX ISOLATOR	339
2002CX43	10070743	CABLE COAX ISOLATOR	339

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**** 2002 RADIO FREQUENCY SUBSYSTEM ****			
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2002CX7	10070191-3	INTRABAY COAXIAL CABLES	339
2002CX8	10070191-4	INTRABAY COAXIAL CABLES	339
2002CX9	10070709-1	INTRABAY COAXIAL CABLES	339
*2002CX10	10070717-2	INTRABAY COAXIAL CABLES	339
2002CX11	10070711-1	INTRABAY COAXIAL CABLES	339
2002CX12	10070712-1	INTRABAY COAXIAL CABLES	339
2002CX13	10070713-1	INTRABAY COAXIAL CABLES	339
2002CX14	10070714-1	INTRABAY COAXIAL CABLES	339
2002CX15	10070715-1	INTRABAY COAXIAL CABLES	339
2002CX16	10070716-1	INTRABAY COAXIAL CABLES	339
2002CX17	10070070-1	INTRABAY COAXIAL CABLES	339
2002CX18	10070070-2	INTRABAY COAXIAL CABLES	339
2002CX19	10070070-3	INTRABAY COAXIAL CABLES	339
2002CX20	10070070-4	INTRABAY COAXIAL CABLES	339
2002CX21	10070070-5	INTRABAY COAXIAL CABLES	339
2002CX22	10070070-6	INTRABAY COAXIAL CABLES	339
2002CX23	10070070-7	INTRABAY COAXIAL CABLES	339
2002CX24	10070070-8	INTRABAY COAXIAL CABLES	339
2002CX25	10070070-9	INTRABAY COAXIAL CABLES	339
2002CX26	10070070-10	INTRABAY COAXIAL CABLES	339
2002CX27	10070070-11	INTRABAY COAXIAL CABLES	339
2002CX28	10070070-12	INTRABAY COAXIAL CABLES	339
2002CX29	10070070-13	INTRABAY COAXIAL CABLES	339
2002CX30	10070070-14	INTRABAY COAXIAL CABLES	339
*2002CX31	10070731-2	INTRABAY COAXIAL CABLES	339
*2002CX32	10070732-2	INTRABAY COAXIAL CABLES	339
2002AN1-8		COAXIAL ATTENUATORS (8)	339
2002ST1/2	10070024	S-BAND TRANSPONDERS (2)	339
2002XE1/2	10070353	X-BAND EXCITERS (2)	339
2002LF1/2	10070194	LOW PASS FILTER (2)	339
2002AI1	10070252	ACIS	339
2002UC1	10070022	ULTRA STABLE OSCILLATOR/CONTROL	339
**** 2003 MODULATION/DEMODULATION SUBSYSTEM ****			
2003A1/3	10064031	COMMAND DETECTOR UNIT (2)	339
2003A2/4	10064032	TLM MODULATION UNIT (2)	339
**** 2004 POWER SUBSYSTEM ****			
2004RG1/2/3	10062261	RADIOSOTOPE THERMOELECTRIC GENERATORS (3)	342
2004A20	10064049	POWER CONTROL	342
2004A21	10064047	POWER DISTRIBUTION	342
2004A22	10064046	2.4 KHZ INVERTER SUBASSY	342
2004A23	10064044	SHUNT REGULATOR SUBASSY	342
2004A24	10064043	DISCHARGE CONTROL SUBASSY	342
**** 2005 COMMAND COMPUTER SUBSYSTEM ****			
2005PR1/2	10064053	CCS/AACS PROCESSOR (2)	361
2005OU1/2	10064052	OUTPUT UNIT (2)	361

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REF NO.	DRAWING NO.	ITEM	* SECT
**** 2005 COMMAND COMPUTER SUBSYSTEM ****			
2005PS1/2	10064051	POWER SUPPLY (2)	361
2005M1/2	10064054	CCS/AACS MEMORY (2)	361
2005PR1/2P3	10070973-3	JUMPER PLUG P3 (2)	361
2005PR1/2P8	10070973-2	JUMPER PLUG P8 (2)	361
2005OU1/2P6	10070973-1	JUMPER PLUG P6 (2)	361
**** 2006 FLIGHT DATA SUBSYSTEM ****			
2006A1	10064061	POWER CONVERTER	362
2006A2	10064062	ENGINEERING TREES AND ADC	362
2006A3	10064063	ENGINEERING LOGIC	362
2006A4	10064064	MEMORIES	362
2006A5	10064065	PROCESSOR	362
2006A6	10064066	SCIENCE I/O LOGIC	362
2006A7	10064067	TIMING LOGIC	362
* 2006A8	10064068	RS CODER	362
**** 2007 ATTITUDE AND ARTICULATION CONTROL SUBSYSTEM ****			
2007IS1	10064074	INERTIAL SENSOR SUBASSY	343
2007IE1/2/3	10064075	INERTIAL ELECTRONICS SUBASSY A/B/C (3)	343
2007SS1	10070996	SUN SENSOR	343
2007CT1/2	10062349	CANOPUS STAR TRACKERS (2)	343
2007PR1/2	10064053	CCS/AACS PROCESSOR (2)	361
2007HL1/2	10064072	HYBIC LOGIC SUBASSY (2)	343
2007HP1/2	10064071	HYBIC POWER SUBASSY (2)	343
2007M1/2	10064054	CCS/AACS MEMORY (2)	361
2007SA1/2	10062288	SCAN ACTUATOR AZ/EL (2)	343
2007CE1	10064076	CAPTURE ELECTRONICS SUBASSY	343
2007CE2	10064077	CAPTURE ELECTRONICS SUBASSY	343
2007PR1/2P8	10070973-4	JUMPER PLUG P8 (2)	343
**** 2008 PYROTECHNIC SUBSYSTEM ****			
2008PS11/12	10066868	SEPARATION ISOLATION VALVE SQUIBS (2)	345
2008A1	10068395	PYRO SWITCHING UNIT	345
2008PP1 SQ1/2	10068123	MAGNETOMETER BOOM RELEASE SQUIB (2)	345
2008SQ1RD 1-4	10068122	MISSION MODULE SEPARATION SQUIB (4)	345
2008SQ2RD 1-4	10068122	MISSION MODULE SEPARATION SQUIB (4)	345
**** 2009 CABLING SUBSYSTEM ****			
* 2009	10073419	GROUND WIRE,UPPER RING CABLE SUPPORT	352
2009	10076916	ACCELEROMETER AMPL CALIB SHORTING CONN	352
2009W1	10063961	UPPER RING SIGNAL HARNESS	352
2009W2	10063962	RFS TWT HARNESS	352
2009W3	10063963	MDS DIRECT ACCESS HARNESS	352
2009W4	10063964	POWER HARNESS	352
2009W5	10063965	CCS HARNESS	352
2009W6	10063966-1	FDS HARNESS	352

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**** 2009 CABLING SUBSYSTEM ****			
2009W6	10063966-2	FDS HARNESS	352
2009W7	10063967-1	HYPACE HARNESS	352
2009W7	10063967-2	HYPACE HARNESS	352
2009W8	10063968	PYRO DISTRIBUTION HARNESS	352
2009W9	10063969	UPPER RING POWER HARNESS	352
2009W13	10063973	DSS DIRECT ACCESS HARNESS	352
-* 2009W14	10063974	RFS DISCHARGE CONTROL CABLE ASSY	352
2009W15	10063975	PLATFORM ACTUATOR HARNESS	352
2009W16	10063976	DSS HARNESS	352
2009W17	10063977	TCAPU INSTRUMENTATION AND CONTROL HARNESS	352
2009W20	10073394	MM R.F. MONITOR CABLE	352
2009W22	10063982	RFS TRANSPONDER HARNESS	352
2009W23	10073382	PWS GROUNDING STRAP	352
2009W24	10063984	SHUNT RADIATOR HARNESS	352
2009W25	10063985	PLATFORM ACTUATOR BOOM HARNESS	352
2009W30	10063990	PLATFORM SCIENCE HARNESS	352
2009W31	10063991	MAGNETOMETER INTERCONNECT HARNESS	352
2009W32	10063992	CRUISE SCIENCE HARNESS	352
2009W33	10063993	MAGNETOMETER DIRECT ACCESS HARNESS	352
2009W34	10063994	PLATFORM SCIENCE BOOM HARNESS	352
2009W35	10063995	MAGNETOMETER BOOM CABLE	352
2009W36	10063996	ISS INTERCONNECT HARNESS	352
2009W37	10063997	IRIS POWER INTERCONNECT HARNESS	352
2009W38	10063998	TCAPU PYRO HARNESS	352
2009W40A/B/C	10073380	RTG CABLE	352
2009W41	10073381	POWER DIRECT ACCESS HARNESS	352
2009W43	10073383	ISS DIRECT ACCESS HARNESS	352
2009W44	10073384	RTG POWER BOOM CABLE	352
2009W45	10073385	RTG POWER BUS CABLE	352
2009W46	10073386	RTG INSTRUMENTATION CABLE	352
2009W47	10073387	DRIRU HARNESS	352
2009W48	10073388	MM ADAPTER PYRO HARNESS	352
2009W49	10073389	MM ADAPTER RING HARNESS	352
2009W50	10073390	MM ADAPTER SIGNAL HARNESS	352
2009W51	10073391	MM ADAPTER RF MONITOR HARNESS	352
2009W52	10073392	RFS BAY 9 DIRECT ACCESS HARNESS	352
2009W53	10073393	RFS BAY 1 DIRECT ACCESS HARNESS	352
2009W55	10073395	CCS INTERCONNECT HARNESS	352
2009W57	10073397	DRIRU DIRECT ACCESS HARNESS	352
2009W58	10063979	MM IRIS INSTR PYRO HARNESS	352
2009W68	10063983	SCI BOOM IRIS INSTR PYRO HARNESS	352
2009W77	10073398	HYPACE DIRECT ACCESS HARNESS	352
2009W78	10063986	SCI PLATFORM IRIS INSTR PYRO HARNESS	352
**** 2010 PROPULSION SUBSYSTEM ****			
2010	10062265	TRAJECTORY CORRECTION + ATTITUDE PROP UNIT	344
2010A1	10073602	PROPELLANT TANK ASSEMBLY	344
2010A2/3	10073615	PROPELLANT CONTROL ASSEMBLY (2)	344
2010A4-7	10073616	ISOLATION VALVE,LATCHING (4)	344
2010A8,10 12-17	10065398-1	THRUSTER/VALVE ASSY W/PRESSURE TRANSDUCER (8)	344

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**** 2010 PROPULSION SUBSYSTEM ****			
2010A9,11 18-23	10065398-2	THRUSTER/VALVE ASSY (8)	344
2010TT1-7		TEMPERATURE TRANSDUCER (7)	344
2010B1	10078422	PWR,AACS + PROP BLEED ASSY'	344
2010BF17	10076818	PROP BLEED + FUSE ASSY	344
**** 2011 TEMPERATURE CONTROL SUBSYSTEM ****			
*2011	10062295	RTG PLUME SHIELD	352
*2011	10073928-1	RADIOISOTOPE HEATER UNIT	352
*2011	10073936-1	LOUVER ASSY,SINGLE BLADE	352
*2011	10073936-2	LOUVER ASSY,DOUBLE BLADE	352
*2011	10073958-1	LOUVER ASSY,BUS,2	352
*2011	10077710-1	THERMAL SHIELD INSTALL,CRUISE SUN SENSOR (2)	353
*2011	10077713-1	PLASMA BLANKET	353
*2011	10077713-2	PLASMA BLANKET	353
*2011	10077713-3	PLASMA BLANKET	353
*2011	10077713-4	PLASMA BLANKET	353
*2011	10077716-1	HYDRAZINE DISCONNECT BLANKET	353
*2011	10077717-1	SUN SENSOR BLANKET	353
*2011	10077717-2	SUN SENSOR BLANKET	353
*2011	10077718-1	MAGNETOMETER BLANKET	353
*2011	10077718-2	MAGNETOMETER BLANKET	353
*2011	10077718-3	MAGNETOMETER BLANKET(2)	353
*2011	10077718-4	MAGNETOMETER BLANKET	353
*2011	10077718-5	MAGNETOMETER BLANKET(2)	353
*2011	10077718-6	MAGNETOMETER BLANKET(2)	353
*2011	10077719-1	PRA/PWS BLANKET	353
*2011	10077719-2	PRA/PWS BLANKET	353
*2011	10077719-3	PRA/PWS BLANKET	353
*2011	10077721-1	MAGNETOMETER SUPPORT TRUSS BLANKET	353
*2011	10077721-2	MAGNETOMETER SUPPORT TRUSS BLANKET	353
*2011	10077721-3	MAGNETOMETER SUPPORT TRUSS BLANKET	353
*2011	10077722-1	SCIENCE BOOM SUPPORT TRUSS BLANKET	353
*2011	10077722-2	SCIENCE BOOM SUPPORT TRUSS BLANKET	353
*2011	10077722-3	SCIENCE BOOM SUPPORT TRUSS BLANKET	353
*2011	10077722-4	SCIENCE BOOM SUPPORT TRUSS BLANKET	353
*2011	10077722-5	SCIENCE BOOM SUPPORT TRUSS BLANKET	353
*2011	10077723-1	HI GAIN ANTENNA SUPPORT TRUSS BLANKET (2)	353
*2011	10077723-2	HI GAIN ANTENNA SUPPORT TRUSS BLANKET (2)	353
*2011	10077723-3	HI GAIN ANTENNA SUPPORT TRUSS BLANKET (2)	353
*2011	10077724-1	MISSION MODULE TRUSS BLANKET	353
*2011	10077724-2	MISSION MODULE TRUSS BLANKET (2)	353
*2011	10077724-3	MISSION MODULE TRUSS BLANKET	353
*2011	10077724-4	MISSION MODULE TRUSS BLANKET	353
*2011	10077724-5	MISSION MODULE TRUSS BLANKET	353
*2011	10077724-6	MISSION MODULE TRUSS BLANKET	353
*2011	10077724-7	MISSION MODULE TRUSS BLANKET	353
*2011	10077724-8	MISSION MODULE TRUSS BLANKET	353
*2011	10077724-9	MISSION MODULE TRUSS BLANKET	353
*2011	10077724-10	MISSION MODULE TRUSS BLANKET	353
*2011	10077724-11	MISSION MODULE TRUSS BLANKET	353
*2011	10077724-12	MISSION MODULE TRUSS BLANKET	353

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REF NO.	DRAWING NO.	ITEM	* SECT
**** 2011 TEMPERATURE CONTROL SUBSYSTEM ****			
*2011	10077724-13	MISSION MODULE TRUSS BLANKET	353
*2011	10077724-14	MISSION MODULE TRUSS BLANKET	353
*2011	10077724-15	MISSION MODULE TRUSS BLANKET	353
*2011	10077724-16	MISSION MODULE TRUSS BLANKET	353
*2011	10077725-1	BUS BLANKET	353
*2011	10077725-2	BUS BLANKET	353
*2011	10077725-3	BUS BLANKET	353
*2011	10077725-4	BUS BLANKET	353
*2011	10077725-5	BUS BLANKET	353
*2011	10077725-6	BUS BLANKET	353
*2011	10077725-7	BUS BLANKET	353
*2011	10077725-8	BUS BLANKET	353
*2011	10077725-9	BUS BLANKET	353
*2011	10077725-10	BUS BLANKET	353
*2011	10077726-1	T/VA BLANKET (4)	353
*2011	10077726-2	T/VA BLANKET (8)	353
*2011	10077726-3	T/VA BLANKET (4)	353
*2011	10077727-1	LECP BLANKET	353
*2011	10077727-2	LECP BLANKET	353
*2011	10077727-3	LECP BLANKET	353
*2011	10077727-4	LECP BLANKET	353
*2011	10077727-5	LECP BLANKET	353
*2011	10077728-1	CRS BLANKET	353
*2011	10077728-2	CRS BLANKET	353
*2011	10077728-3	CRS BLANKET	353
*2011	10077728-4	CRS BLANKET	353
*2011	10077728-5	CRS BLANKET	353
*2011	10077728-6	CRS BLANKET	353
*2011	10077728-7	CRS BLANKET	353
*2011	10077728-8	CRS BLANKET	353
*2011	10077730-1	THERMAL BLANKET WRAP	353
*2011	10077730-2	THERMAL BLANKET WRAP	353
*2011	10077730-3	THERMAL BLANKET WRAP	353
*2011	10077730-4	THERMAL BLANKET WRAP	353
*2011	10077730-5	THERMAL BLANKET WRAP	353
*2011	10077730-6	THERMAL BLANKET WRAP	353
*2011	10077730-7	THERMAL BLANKET WRAP	353
*2011	10077731-1	BLANKET RETAINER,SCAN PLATFORM	353
*2011	10077732-1	BOOM SUPPORT STRUT BLANKET	353
*2011	10077732-2	BOOM SUPPORT STRUT BLANKET	353
*2011	10077733-1	SCAN PLATFORM BLANKET	353
*2011	10077733-2	SCAN PLATFORM BLANKET	353
*2011	10077733-3	SCAN PLATFORM BLANKET	353
*2011	10077733-4	SCAN PLATFORM BLANKET	353
*2011	10077733-5	SCAN PLATFORM BLANKET	353
*2011	10077733-6	SCAN PLATFORM BLANKET	353
*2011	10077733-7	SCAN PLATFORM BLANKET	353
*2011	10077733-8	SCAN PLATFORM BLANKET	353
*2011	10077733-9	SCAN PLATFORM BLANKET (2)	353
*2011	10077733-10	SCAN PLATFORM BLANKET	353
*2011	10077733-11	SCAN PLATFORM BLANKET	353
*2011	10077733-12	SCAN PLATFORM BLANKET	353

Table 1. Mission Module Equipment List (contd)

REF NO.	DRAWING NO.	ITEM	* SECT
**** 2011 TEMPERATURF CONTROL SUBSYSTFM ****			
*2011	10077733-13	SCAN PLATFORM BLANKFT	353
*2011	10077733-14	SCAN PLATFORM BLANKFT	353
*2011	10077733-15	SCAN PLATFORM BLANKET	353
*2011	10077733-16	SCAN PLATFORM BLANKET	353
*2011	10077733-17	SCAN PLATFORM BLANKET	353
*2011	10077733-18	SCAN PLATFORM BLANKET	353
*2011	10077734-1	PROPELLANT TANK BLANKET	353
*2011	10077734-2	PROPELLANT TANK BLANKET	353
*2011	10077735-1	SUN SENSOR CABLE SUPPORT STRUT BLANKET	353
*2011	10077736-1	THRUSTER BRACKET BLANKET	353
*2011	10077736-2	THRUSTER BRACKET BLANKFT	353
*2011	10077736-3	THRUSTER BRACKET BLANKET	353
*2011	10077736-4	THRUSTER BRACKET BLANKET	353
*2011	10077736-5	THRUSTER BRACKET BLANKET	353
*2011	10077736-6	THRUSTER BRACKET BLANKFT	353
*2011	10077738-1	BUS BLANKET ATTACH STRIP (13)	353
*2011	10077738-2	BUS BLANKFT ATTACH STRIP (13)	353
*2011	10077738-3	BUS BLANKET ATTACH STRIP (13)	353
*2011	10077738-4	BUS BLANKET ATTACH STRIP (13)	353
*2011	10077738-5	BUS BLANKET ATTACH STRIP (13)	353
*2011	10077738-6	BUS BLANKET ATTACH STRIP (13)	353
*2011	10077738-7	BUS BLANKET ATTACH STRIP (13)	353
*2011	10077738-8	BUS BLANKET ATTACH STRIP (13)	353
*2011	10077739-1	RTG CABLF BLANKET	353
*2011	10077740-1	MAG CABLE BLANKFT	353
*2011	10077742-1	SCIENCE BOOM CABLE BLANKET	353
*2011	10077742-2	SCIENCE BOOM CABLE BLANKET	353
**** 2012 MECHANICAL DEVICES SUBSYSTEM ****			
2012	10078719-1	RTG THERMAL RELEASE	352
2012	10078719-2	RTG THERMAL RELEASE	352
2012	10062292-1	BOOM DEPLOYMENT MECH,RTG	352
2012	10062292-2	BOOM DEPLOYMENT MECH,SCI	352
2012PP1	10028045-4	HOUSING ASSY PINPULLER MAG BOOM	352
2012	10077857	STRUT ASSY,BIPOD	352
2012	10075562	RATE LIMITER ASSY,MAG BOOM	352
2012SS1	10062289-1	SCIENCE BOOM FOLDING STRUT	352
2012RS1	10062289-2	RTG BOOM FOLDING STRUT	352
2012RD1-4	10077638	RELEASE NUTS WITHOUT SQUIBS (4)	352
2012MB1	10062280	MAG BOOM + SUPT STRU ASSY	352
2012	10076577-1	SUPPORT TRUSS ASSY,SCIENCE BOOM	352
2012	10076577-2	SUPPORT TRUSS ASSY,SCIENCE BOOM	352
**** 2016 DATA STORAGE SUBSYSTEM ****			
2016A1	10065436	DATA STORAGE TRANSPORT SUBASSEMBLY	361
2016A2	10064092	TACH CHANNEL AND PLAYBACK SUBASSEMBLY	361
2016A3	10064093	RECORD AND CONTROL LOGIC SUBASSEMBLY	361
2016A4	10064094	POWER SUPPLY AND MOTOR DRIVER SUBASSEMBLY	361

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**** 2017 S/X BAND ANTENNA SUBSYSTEM ****			
2017HL1	10067800	HG/LG ANTENNA ASSY	336
2017W2	10067837	HIGH GAIN ANTENNA LOWER CABLE	336
2017W3	10067860	HIGH GAIN ANTENNA RHCP UPPER WAVEGUIDE ASSY	336
2017W4	10067857	HIGH GAIN ANTENNA RHCP LOWER WAVEGUIDE ASSY	336
2017W5	10067858	HIGH GAIN ANTENNA LHCP UPPER WAVEGUIDE ASSY	336
2017W6	10067863	HIGH GAIN ANTENNA LHCP LOWER WAVEGUIDE ASSY	336
2017W8	10067839	LOW GAIN ANTENNA LOWER CABLE ASSY	336
**** 2021 COSMIC RAY SUBSYSTEM ****			
2021A1	10062249	COSMIC RAY ASSY	316
**** 2022 PLANETARY RADIO ASTRONOMY SUBSYSTEM ****			
2022A1	10062252	PRA RECEIVER	316
* 2022A2	20510-01-0100	ANTENNA BRACKET ASSY	316
**** 2023 PLASMA WAVE SUBSYSTEM ****			
2023A1	10062251	PLASMA WAVE ASSY	316
**** 2025 LOW ENERGY CHARGED PARTICLE SUBSYSTEM ****			
2025A1	10062248	LOW ENERGY CHARGED PARTICLE ASSY	316
**** 2027 PHOTOPOLARIMETER SUBSYSTEM ****			
2027A1	10062243	PHOTOPOLARIMETER ASSY	316
2027A2	10062301	BREWSTER PLATE	316
**** 2032 PLASMA SUBSYSTEM ****			
2032A1	10062247	PLASMA ASSY	316
**** 2034 ULTRAVIOLET SPECTROMETER SUBSYSTEM ****			
2034A1	10062242	ULTRAVIOLET SPECTROMETER ASSY	316
**** 2035 MAGNETOMETER SUBSYSTEM ****			
2035EA1	10064082	ANALOG ELECTRONICS SUBASSY	316
2035FD1	10064081	DIGITAL ELECTRONICS SUBASSY	316
2035IH1	10062253	INBOARD HIGH FIELD SENSOR	316
2035OH1	10062254	OUTBOARD HIGH FIELD SENSOR	316
2035IL1	10062255	INBOARD LOW FIELD SENSOR	316
2035OL1	10062256	OUTBOARD LOW FIELD SENSOR	316
**** 2036 IMAGING SCIENCE SUBSYSTEM ****			
2036	10062250	WIDE ANGLE CAMERA ASSY	321
2036A2	10075670	OPTICS ASSY	321
2036A4	10075670	FILTER WHEEL SHUTTER ASSY	321
2036A6	1146100	CAMERA HEAD	321

Table 1. Mission Module Equpment List (contd)

REF NO.	DRAWING NO.	ITEM	* SECT
**** 2036 IMAGING SCIENCE SUBSYSTEM ****			
2036	10062300	NARROW ANGLE CAMERA ASSY	321
2036A1	10063302	OPTICS ASSY	321
2036A5	1146100	CAMERA HEAD	321
2036A3	10063355	FILTER WHEEL SHUTTER ASSY	321
2036EA1	10062257	SUPPORT ELECTRONICS (NARROW ANGLE)	321
2036EA2	10062257	SUPPORT ELECTRONICS (WIDE ANGLE)	321
2036EA3	10062258	POWER SUPPLY (NARROW ANGLE)	321
2036EA4	10062258	POWER SUPPLY (WIDE ANGLE)	321
**** 2039 INFRARED INTERFEROMETER SPECTROMETER AND RADIOMETER SUBSYSTEM ****			
2039A1	10062244	INFRARED INTERFEROMETER SPECT + RADIOMETER ASY	316
2039A2	10062246	ELECTRONICS	316
2039A3	10062245	POWER SUPPLY	316
→ 2039A4	10062310	DEPLOYABLE COVER	316
2039A1	10062259	MIRIS INSTRUMENT	316
2039A2	10062303	MIRIS ELECTRONICS	316
2039A3	10062304	MIRIS POWER SUPPLY	316
**** 2050 SYSTEM FASTENERS + BRACKETS ****			
2050	N/A	SYSTEM FASTENERS + BRACKETS	352

Table 2. Propulsion Module Equipment List

REF NO.	DRAWING NO.	ITEM	* SECT
**** 2001 STRUCTURE SUBSYSTEM ****			
2001	10062233	PROP MODULE STRUCTURE ASSY	352
*2001	10082114	PM BALLAST	352
**** 2004 POWER SUBSYSTEM ****			
2004A17	10062275	SILVER-ZINC PROP BATTERY	342
**** 2007 ATTITUDE AND ARTICULATION CONTROL SUBSYSTEM ****			
2007RD1	10062276	AACS REMOTE DRIVER MODULE	343
**** 2008 PYROTECHNIC SUBSYSTEM ****			
2008IG1/2	10062302	SOLID MOTOR IGNITER SQUIBS (2)	345
2008SQ1PP 3-6	10068123	RTG BOOM LATCH SQUIB (4)	345
2008SQ2PP 3-6	10068123	RTG BOOM LATCH SQUIB (4)	345
2008SS1	10039579	SCAN PLATFORM LATCH SQUIB	345
**** 2009 CABLING SUBSYSTEM ****			
2009W10	10063970	PM RF MONITOR	352
2009W11	10063971	PM RING HARNESS	352
2009W12	10063972	PM IPU HARNESS	352
2009W18	10063978	PM PYRO HARNESS	352
**** 2010 PROPULSION SUBSYSTEM ****			
2010	10062270	INJECTION PROPULSION UNIT	344
2010A26	10062277	SOLID ROCKET MOTOR	344
2010A27-30	10066092	ROCKET ENGINE ASSY (4)	344
2010A31-34	10073586	ROCKET ENGINE ASSY ROLL (4)	344
*2010TT1-7		TEMPERATURE TRANSDUCER (7)	344
2010B11	10078421	PROP BLEED ASSY	344
2010F12	10077851	PROP FUSE ASSY	344
**** 2011 TEMPERATURE CONTROL SUBSYSTEM ****			
*2011	10062212	SCAN PLATFORM PLUME SHIELD ASSY	352
*2011	10077720-1	IPU BLANKET	353
*2011	10077720-2	IPU BLANKET	353
*2011	10077720-3	IPU BLANKET	353
*2011	10077720-4	IPU BLANKET (4)	353
*2011	10077720-5	IPU BLANKET (4)	353
*2011	10077720-6	IPU BLANKET (4)	353
*2011	10077720-7	IPU BLANKET (4)	353
*2011	10077720-8	IPU BLANKET (4)	353
*2011	10077720-9	IPU BLANKET (2)	353
*2011	10077720-10	IPU BLANKET (2)	353
*2011	10077720-11	IPU BLANKET	353
*2011	10077720-12	IPU BLANKET	353
*2011	10077720-13	IPU BLANKET	353

Table 2. Propulsion Module Equipment List (contd)

REF NO.	DRAWING NO.	ITEM	* SECT
**** 2012 MECHANICAL DEVICES SUBSYSTEM ****			
2012	10062296	SCIENCE BOOM LATCH	352
2012	10076111-1	SEPARATION DEVICE ASSY RTG	352
2012	10076111-2	SEPARATION DEVICE ASSY RTG	352
2012PP3-6	10076112	HOUSING ASSY PINPULLER RTG W/O SQUIB (4)	352
2012	10040032	RELEASE BOLTS (4)	352
2012	10040070	BOLT CATCHER HOUSING (4)	352
2012	10058670	BOLT CATCHER SLEEVES (4)	352
2012	10051291-1	SEPARATION SPRINGS-3	352
2012	10051291-2	SEPARATION SPRING	352
2012RV1	10032606	MANIFOLD ASSY SCIENCE PLATFORM LATCH	352
2012PT1	10056284	PRESS TRANSDUCER SCIENCE PLATFORM LATCH	352
2012	10062305	PM/TVC DAMPER ASSY	352
*2012	10082018	PLUME SHIELD,RTG,PROP MODULE	352
**** 2050 SYSTEM FASTENERS + BRACKETS ****			
2050	N/A	SYSTEM FASTENERS + BRACKETS	352

Table 3. Adapter Equipment List

REF NO.	DRAWING NO.	ITEM	* SECT
**** 2001 STRUCTURE SUBSYSTEM ****			
2001	10062232	ADAPTURE STRUCT ASSY	352
2001	10062234	SC/LV SEPARATION BAND	352
2001	10062297	ENVIRONMENTAL BAFFLE FRAME ASSY	352
2001AC1-6	10078566	ACCELEROMETER (6)	351
*2001AA1-6	10025263-2	ACCELEROMETER AMPLIFIER (6)	351
*2001AA7	10025263-3	ACCELEROMETER AMPLIFIER	351
**** 2004 POWER SUBSYSTEM ****			
*2004	N15A217A	LONG RANGE BEACON	342
*2004	N15F210A	SHORT RANGE BEACON	342
**** 2008 PYROTECHNIC SUBSYSTEM ****			
2008B1SQ1/2	10076044	DETONATOR ASSY R.H. (2)	345
2008B1SQ3/4	10076045	DETONATOR ASSY L.H. (2)	345
2008	1234388	PYRO ELEMENTS S/C/LV SEP BAND	345
**** 2009 CABLING SUBSYSTEM ****			
2009W28	10063988	ADAPTER PYRO HARNESS	352
2009W29	10063989	ADAPTER RING HARNESS	352
2009W27	10063987	ADAPTER RF MONITOR	352
**** 2010 PROPULSION SUBSYSTEM ****			
2010F29	10079581	PYRO FUSE ASSY	344
**** 2011 TEMPERATURE CONTROL SUBSYSTEM ****			
2011	10062298	ENVIRONMENTAL BAFFLE FABRIC	353
*2011	10077732-1	ADAPTER BLANKET	353
**** 2012 MECHANICAL DEVICES SUBSYSTEM ****			
2012	10050097	SEPARATION SPRING ASSY (3)	352
**** 2050 SYSTEM FASTENERS + BRACKETS ****			
2050	N/A	SYSTEM FASTENERS + BRACKETS	352

Table 4. Spacecraft Mass Allocations

	Allocated (kilograms)			
	Mission Module	Propulsion Module	Adapter	Spacecraft
Spacecraft and Adapter (Launch)	806.68	*1,208.80	46.58	*2,062.06
Adapter			46.58	
Spacecraft (Pre-Injection)				*2,015.48
Solid Propellant and Inerts		*1,045.89		
Hydrazine	14.07			
Spacecraft (Pre-Jettison)				955.52
Hydrazine Holdup	0.61			
Burned Out P/M		162.91		
M/M (Post-Jettison)	792.00			
Hydrazine and Pressurant	91.19			
M/M End of Mission	700.81			

Table 5. Subsystem Mass Allocations

Subsystem	Allocated Mass (kilograms)		
	Mission Module	Propulsion Module	Adapter
Structure	*149.78	*44.04	34.48
Radio Frequency	* 43.62		
Modulation Demodulation	9.60		
Power	137.52	2.32	1.54
Computer Command	15.50		
Flight Data	* 16.89		
Attitude and Articulation Control	* 42.79	1.61	
Pyrotechnic	4.73	0.14	
Cabling	* 47.28	3.11	2.20
Propulsion	* 35.68	*96.82	0.02
Temperature Control	* 17.88	*12.63	* 3.84
Mechanical Devices	* 18.16	* 9.12	1.50
Data Storage	15.69		
S/X Band Antenna	* 5.65		
Cosmic Ray	7.13		
Planetary Radio Astronomy	7.35		
Plasma Wave	1.54		
Low Energy Charged Particle	* 7.57		
Photopolarimeter	3.74		
Plasma	* 10.21		
Ultraviolet Spectrometer	4.43		
Magnetometer	5.73		
Imaging Science	* 39.48		
Modified Infrared Interferometer Spectrometer and Radiometer	* 25.02		
System	5.27	0.98	0.46

REVISION PAGE

Revision	Date	ECRs Incorporated	Comments
Original	22 May 1975		
A	23 Jan 1976	36043, 36098, 36123 and 36153	Tables 1, 2, and 3
		36043, 36052, 36054, 36064, 36069, 36084, 36086, 36088, 36098, 36123, 36138, 36144, and 36153	Tables 4 and 5
B	19 July 1976	36085, 36127, 36146, 36169, 36179, 36181, 36185, 36190, 36211, 36215, 36230, 36231, 36233, 36279, 36280, 36286, 36288, 36299, 36325, 36307, 36327, 36328, 36277	Tables 4 and 5
		36127, 36179, 36231, 36327, 36366	Tables 1, 2, and 3
C	31 May 1977	36324, 36349, 36362, 36374, 36398, 36414, 36428, 36445, 36453, 36460, 36462, 36463, 36469, 36477, 36487, 36490, 36515, 36519, 36521, 36526, 36530, 36541, 36546, 36559, 36566, 36571, 36574, 36583, 36597, 36603, 36610, 36633, 36656, 36657, 36670, 36671, 36716, 36737, 36681	Revise per ECRs listed

(Insert in 618-205, MJS77 Functional Requirements Book)

Custodian: T. E. Gindorf

APPROVED:

System: R. F. Draper

for T. E. Gindorf

JET PROPULSION LABORATORY

No. MJS77-3-240A

13 October 1976
Supersedes
MJS77-3-240
14 March 1975

FUNCTIONAL REQUIREMENT
MARINER JUPITER/SATURN 1977
ENVIRONMENTAL DESIGN REQUIREMENTS

✱ Denote changes from previous issue.

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TABLES

ILLUSTRATIONS

1.0 SCOPE

1.1 Purpose

This document, in accordance with PD618-228, Spacecraft System Environmental Program Policy and Requirements Document, defines all environmental design requirements for the Mariner Jupiter/ Saturn 1977 (MJS77) spacecraft and its assemblies. The purpose of these design requirements is to assure the compatibility of each assembly design with the specified environments and corresponding mission mode.

1.2 Applicability

The requirements within this document have been established for spacecraft design purposes and are not to be interpreted as test requirements. These requirements, however, should never be exceeded by test requirements; although in some instances they will be equivalent.

The design requirements have been established for predicted spacecraft environments. These environments have been grouped into three separate mission phases. The general categories are:

a) Ground Operations and Handling

b) Launch

c) Flight (Post Propulsion Module Operations)

Acceptable compatibility with the design requirements shall be demonstrated by test or analyses (as defined in PD618-260, Environmental Test and Analysis Configuration Document, and PD618-228). Appendix A associates the verification tests in PD618-260 with the design requirements of this document.

If any requirements specified in this document conflict with state-of-the-art hardware development or if they should impose excessive costs, major design penalties or operational restrictions beyond those already assumed for overall mission design, the Environmental Requirements Engineer and Spacecraft System Engineer should be informed. An example is a science instrument detector that must be maintained with a narrower temperature or relative humidity range than specified in this document to preserve its functional characteristics.

Spacecraft equipment is referred to as "assemblies." Assemblies are defined as spacecraft elements that are installed or replaced on the spacecraft as discrete equipment items and are carried as provisional spares. The MJS77 spacecraft assemblies fulfilling this criteria are identified in PD618-260.

2.0 APPLICABLE DOCUMENTS

The following documents form a part of this Functional Requirement.

NOTE

MJS77-3-100, Spacecraft Requirements and Constraints, applies to this document. Requirements of other MJS77 level 3 documents may also be applicable. It is the responsibility of the user to adequately acquaint himself with the organization and pertinent content of the level 3 documents, as well as with the material contained herein.

REQUIREMENTS

Jet Propulsion Laboratory

MJS77-3-100	Functional Requirement, Mariner Jupiter/Saturn 1977 Spacecraft Requirements and Constraints
MJS77-3-260	Functional Requirement, Mariner Jupiter/Saturn 1977 Electrical Grounding and Interfacing

DOCUMENTS

Jet Propulsion Laboratory

PD618-228	Mariner Jupiter/Saturn 1977 Spacecraft System Environment Program Policy and Requirements
PD618-260	Mariner Jupiter/Saturn 1977 Spacecraft System Environmental Test and Analysis Configuration Document
PD618-261	Mariner Jupiter/Saturn 1977 Spacecraft System Electromagnetic Compatibility Control Requirements Document
PD618-262	Mariner Jupiter/Saturn 1977 Spacecraft System Magnetic Control Requirements Document

Air Force

T.O. 00.25.203	Standards and Guidelines for the Design and Operation of Cleanrooms and Supplemental Devices

3.0 ENVIRONMENTAL DESIGN REQUIREMENTS

The design of flight equipment shall permit environmental testing of the equipment in the assembly, subsystem, and system configurations as defined in PD618-260. Any schedule, design or operational impacts resulting from this requirement shall be brought to the attention of the Environmental Requirements Engineer and the Spacecraft Systems Engineer. If the mission mode does not require the assembly to function during an environmental exposure, the assembly shall be designed to endure the environment without degradation.

Assembly, handling, and shipping environments shall be constrained such that the launch and flight environmental design requirements are not exceeded. The Spacecraft Subsystem/Assembly Cognizant Engineer is responsible for controlling environmental exposure of spacecraft assemblies prior to Spacecraft Assembly Facility (SAF) delivery. The MJS77 System Test and Operations Manager is responsible for controlling environments within SAF and Air Force Eastern Test Range (AFETR) assembly and test facilities assigned to MJS77.

3.1 Ground Operations and Handling Environmental Design Requirements

Ground operations and handling environmental requirements include those environments that MJS77 flight equipment will encounter during assembly level fabrication and testing and during system fabrication and functional testing until launch at AFETR. Ground handling will include transportation and storage of the equipment in shipping containers.

3.1.1 Particulate Contamination

The flight equipment external surfaces shall be designed to be cleanable with isopropyl alcohol. Other JPL approved cleaning agents may be used if their usage is coordinated in advance with the Environmental Requirements Engineer to assure compatibility with Project Planetary Quarantine (P.Q.) requirements. The flight equipment shall be designed to operate in clean work areas or work station requirements as prescribed in Air Force Document, Standards and Guidelines for the Design and Operation of Cleanrooms and Supplemental Devices, T.O. 00.25.203, Sections III and V through IX.

3.1.2 Temperature and Pressure

Temperature and pressure ranges are specified in Tables 1 and 2 for ground handling operations. Design requirements for controlled and uncontrolled environments are contained in the tables.

3.1.2.1 Controlled Temperature/Pressure Environment. A controlled environment exists when the temperature and pressure ranges are maintained within specified, restrictive limits. MJS77 assemblies should be designed and restricted to the controlled environment limits of Table 1 unless not possible or cost effective to do so. If hardware constraints require temperature limits inside the Table 1 ranges, special active thermal control devices/procedures may be necessary.

Table 1. Ground Handling Temperature and Pressure (Controlled Limits)

Temperature Range	Pressure Range
5 to 45°C	7×10^4 N/m^2 (520 torr) to 1×10^5 N/m^2 (760 torr)
Transient: 5°C/Hr.	

3.1.2.2 Uncontrolled Temperature/Pressure Environment. Table 2 specifies environment extremes that encompass uncontrolled temperature/pressure ranges for all climates and handling altitudes. If these design requirements are assumed, design verification tests will be mandatory.

Table 2. Ground Handling Temperature and Pressures (Uncontrolled Limits)

Temperature Range	Pressure Range
-40 to +70°C	1.2×10^4 N/m^2 (87.5 torr) to 1×10^5 N/m^2 (760 torr)
Transient: 15°C/Hr.	

3.1.3 Humidity

Relative humidity ranges are specified in Tables 3 and 4 for ground handling operations. Design requirements for controlled and uncontrolled humidity levels are contained in the tables.

3.1.3.1 Controlled Humidity. A controlled humidity environment exists when the levels are constrained within restrictive limits as specified in Table 3. MJS77 assemblies should be designed and restricted to these limits unless not possible or cost effective to do so.

Table 3. Humidity (Controlled Limits)

Relative Humidity	Temperature Range
70%	5 to 45°C

3.1.3.2 Uncontrolled Humidity. Uncontrolled humidity ranges are specified in Table 4 and encompass all ambient conditions. If these design requirements are assumed, design verification tests will be mandatory.

Table 4. Humidity (Uncontrolled Limits)

Relative Humidity	Temperature Range
100%	-40 to 70°C

3.1.4 Shipping and Transportation Vibration

Shipping containers for spacecraft equipment shall be designed so that flight assemblies in the containers shall be subjected to an environment no more severe than that specified in paragraph 3.2.2.2 when the acceleration levels of Table 5 are imposed on their containers. These levels assume the use of commercial trucks and aircraft with proper placement and securing of the containers within the vehicle.

Table 5. Acceleration Levels for Shipping and Transportation Vibration

Frequency (Hz)	Acceleration Level (*G pk)
2.5 to 35	1.3
35 to 48	3.0
48 to 500	5.0

*Standard acceleration due to gravity - 980.665 cm/s^2

3.1.5 Shipping and Transportation Shock

Flight assemblies in shipping containers shall be subjected to shock environments no greater than that specified in paragraph 3.2.6, when the shipping container is subjected to the applicable drop heights in Table 6.

Table 6. Drop Heights for Shipping and Transportation Shock (Commercial Handling)

Total Mass of Assembly and Container		Drop Height	
(kg)	(lb)	(cm)	(in)
0 to 9.1	(0 to 20)	107	(42)
9.1 to 22.7	(20 to 50)	91	(36)
22.7 to 113.6	(50 to 250)	76	(30)
113.6 to 227.3	(250 to 500)	61	(24)
≥227.3	(≥500)	48	(18)

3.1.6 Electromagnetic and Magnetic Interference Requirements

This paragraph and paragraphs 3.2.8 and 3.3.8 contains minimum electromagnetic and magnetic requirements that new and inherited flight hardware must be compatable with. If the equipment can be designed at reasonable cost with electromagnetic and magnetic characteristics that are superior to those based on the minimum design requirements, the Environmental Requirements Engineer and the Spacecraft System Engineer should be so appraised of this capability and the additional cost involved.

The spacecraft assemblies shall also be designed consistent with MJS77-3-260, Electrical Grounding and Interfacing, and PD618-261, Electromagnetic Compatibility Control Requirements.

3.1.6.1 Magnetic Field Restraints. All mission module flight hardware shall be designed to satisfy static and dynamic magnetic field restraints given below. Magnetic design practices are contained in Project Document 618-262, Magnetic Control Requirements.

3.1.6.1.1 Static Magnetic Fields. The flight assemblies shall be designed to function within specification after exposure to magnetic fields of 5.0 mT (50 Gauss) which will be experienced during TA perm-deperm operations.

Static magnetic fields generated by permanent magnets, steady-state circuits, etc., in Mission Module (MM) equipment shall be limited to the levels given in Table 7. All flight hardware will be designed to operate within specification after being demagnetized by a 4 mT (peak) (40 Gauss) field prior to final magnetic field measurements.

Table 7. Post Demagnetization* Static Magnetic Field Restraints for Mission Module Assemblies

Hardware	Maximum Allowable Radial Magnetic Field nT (gamma) one meter from center of assembly	
	New Hardware	Inherited Hardware
Complete Subsystems Mounted Together in a Bay	10	40
Scan Platform Instruments	20	30
Each RTG	15	NA
All Other Assemblies	5	5

*4.0 mT (Peak) Demagnetization

3.1.6.1.2 Dynamic Magnetic Field. Slowly varying (less than 10 Hz) discrete frequency magnetic fields in MM equipment shall not exceed 10 nT (p-p) at one meter from the center of any assembly. The magnetic field of any assembly shall not change by more than 1/3 of its static field requirement or 5 nT at 1 m, whichever is larger, as the result of its current field, mode changes, or mechanical movement of magnetic devices.

3.1.6.2 Electromagnetic Compatibility. Electrical and electronic assemblies and subsystems shall be designed to operate reliably with electromagnetic compatibility in the spacecraft environment per the requirements specified below.

3.1.6.2.1 Interference Susceptibility

3.1.6.2.1.1 Signal Circuit Conducted Transient Susceptibility. The input and output end circuits of unshielded digital circuits including direct access inter-stage and umbilical, shall be immune to the transient pulse (both positive and negative) shown in Figure 1 and either the voltage or current (whichever occurs first in test) given in Table 8 during the "1" state, the "0" state and the transitional states from "1" to "0" or "0" to "1".

All unshielded intersubsystem analog input and output end-circuits, including direct access and umbilical shall also be immune to the transient pulse depicted in Figure 1 and Table 8.

3.1.6.2.1.2 Ground Line Conducted Transient Susceptibility. Each electronic assembly externally referenced circuit common shall be immune to pulses of both positive and negative polarity, as shown in Figure 1 of 3 V peak or 0.3 A peak, whichever occurs first, injected in series with circuit common between the subsystem and support equipment. In demonstration, the circuit return tree shall not be connected. Subsystems wherein the circuit common is normally referenced internally to chassis are not subject to this requirement.

* 3.1.6.2.1.3 DC Power Line Susceptibility. All subsystems utilizing spacecraft regulated DC power shall be immune to sinusoidal signals of 100 mV p-p from 30 Hz to 50 kHz superimposed on the DC voltage. These subsystems shall also be immune to positive and negative transients shown in Figure 1 of +10 V and -10 V when caused to appear between the power lead and its return.

3.1.6.2.2 Interference Emission

3.1.6.2.2.1 Signal Circuit Conducted Emission. Conducted electrical noise is defined as any short-term voltage deviation from the expected signal, emitted from the output end-circuit, originating within the sending subsystem and measured between the signal and the return line. Unless otherwise specified in the approved circuit data sheet, such short-term deviation shall be within the limit shown on the circuit data sheet and not more than ±5 percent of the maximum peak-to-peak voltage of the expected signal.

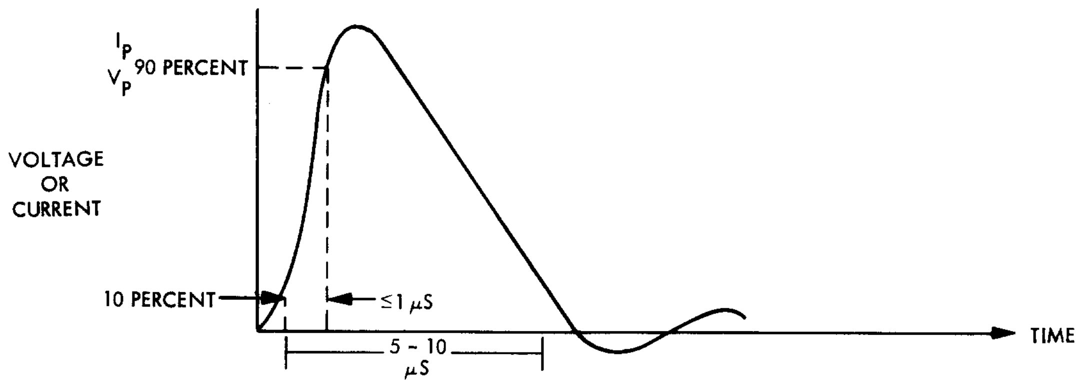


Figure 1. Transient Test Pulse

✱ Table 8. Conducted Transient Pulse Susceptibility

Circuit Classification	Transient Pulse Amplitude* (0 to Peak)	
Intersubsystem, Quiet		
Untwisted	+1, -1 V	+100, -100 mA
Twisted	+0.3, -0.3 V	+30, -30 mA
Intersubsystem, Noisy		
Untwisted	+3, -3 V	+300, -300 mA
Twisted	+1, -1 V	+100, -100 mA
Power (Subsystems with dc Power Input)	+10 V, -10 V	NA
Pyro	NA	NA
Direct Access, Umbilical and Interstage	+3, -3 V	+300, -300 mA

*Voltage or current value, whichever is first reached, as test pulse amplitude is increased.

✱ 3.1.6.2.2.2 DC Power Line Conducted Emission. Regulated dc loads shall not introduce a ripple current (30 Hz to 50 kHz) whose peak-to-peak magnitude is greater than 1 percent of the average steady-state current when operating from a source with a dynamic impedance of less than 0.1 ohm up to 5 kHz and less than 1.0 ohm from 5 kHz to 50 kHz. (Reference MJS77-3-100, paragraph 3.6.2.3 h).

3.1.6.2.2.3 RF Radiated Emission. RF radiated interference, as measured at one meter, shall not exceed the levels described in Table 9. Transmitters are exempt from these requirements at their assigned output frequencies.

* Table 9. RF Radiated Emission

RF Emission Limits Measured at 1 m Distance	
Frequency Range (MHz)	Field Intensity (dBm/m^2)
5 to 10,000 (except as noted below and in para. 3.3.10.2.2.3)	-40
2050 to 2160	-140
1860 to 1870	-75

3.2 Launch Environmental Design Requirements

The Launch Environmental Design Requirements consist of the environments that the spacecraft will encounter during on-pad and launch operations through the propulsion module operations after launch.

3.2.1 Explosive Atmosphere

Flight assemblies shall be designed to operate without igniting an explosive atmosphere existing within the pressure, temperature and auto ignition temperature ranges of Table 10.

Table 10. Range of Explosive Atmosphere Physical Characteristics

Explosive Atmosphere Physical Characteristics	Range
Pressure	1.33×10^4 N/m^2 (100 torr) to 1.06×10^5 N/m^2 (800 torr)
Temperature	5 to 45°C
Auto-Ignition Temperature	350 to 750°C
Chemical Constituents	Hydrogen (fuel) and air (oxidizer) combined in any potentially explosive mixture ratio.

3.2.2 Sinusoidal Vibration

3.2.2.1 Spacecraft. Launch Vehicle (LV) and Propulsion Module (PM) induced transient environments are presented as a sinusoidal vibration requirement specified in Figure 2. The design requirement vibration sweeprate is 2 oct/min (up and down in frequency). Spacecraft structural interaction with the boost vehicle results in levels that are enveloped by the MJS77-3-240 sine vibration requirements. This spectrum is derived as an input to the MM bus primary structure near the adapter/bus attach points for MM design purposes and is applicable to the PM/Centaur interface attach point for PM design purposes.

The application of the Figure 2 vibration spectrum to spacecraft structure design is defined in MJS77-3-190, Structural Design Criteria. Primary structure (structural elements supporting hardware weighing 22.7 kg or more) is designed by flight loads analysis for structural frequencies of 40 Hz or less. The loads analysis is based on spacecraft transient environments occurring during the launch phase of the mission. Above 40 Hz the spectrum of Figure 2, MJS77-3-240 is the design criteria. Secondary structure (all other structure) is to be designed with the MJS77-3-240 criteria throughout the specified frequency range.

3.2.2.2 Spacecraft Assemblies. Sinusoidal vibration requirements for assemblies are presented in Table 11. These levels should be assumed at the assembly mounting points in any direction with a sweep rate of 2 oct/min.

Table 11. Sinusoidal Vibration Levels

Frequency (Hz)	Acceleration Level Bus Assemblies	Frequency (Hz)	Acceleration Level - Propulsion Module Assemblies and Other Assemblies
5 to 17	1.02 cm (0.4 in.) DA*	5 to 23	1.02 cm (0.4 in.) DA*
		23 to 100	8.0 G_{rms}
17 to 2000	4.5 G_{rms}	100 to 2000	4.5 G_{rms}
*Double Amplitude			

3.2.3 Random Vibration

3.2.3.1 Spacecraft. The launch and aerodynamic acoustic field induced mechanical vibration design requirement is specified as Gaussian random vibration in Figure 3. The spectrum specified in Figure 3 shall be assumed for design considerations. The total exposure time design requirement is 3 min applicable to launch thrust axis and all lateral axes.

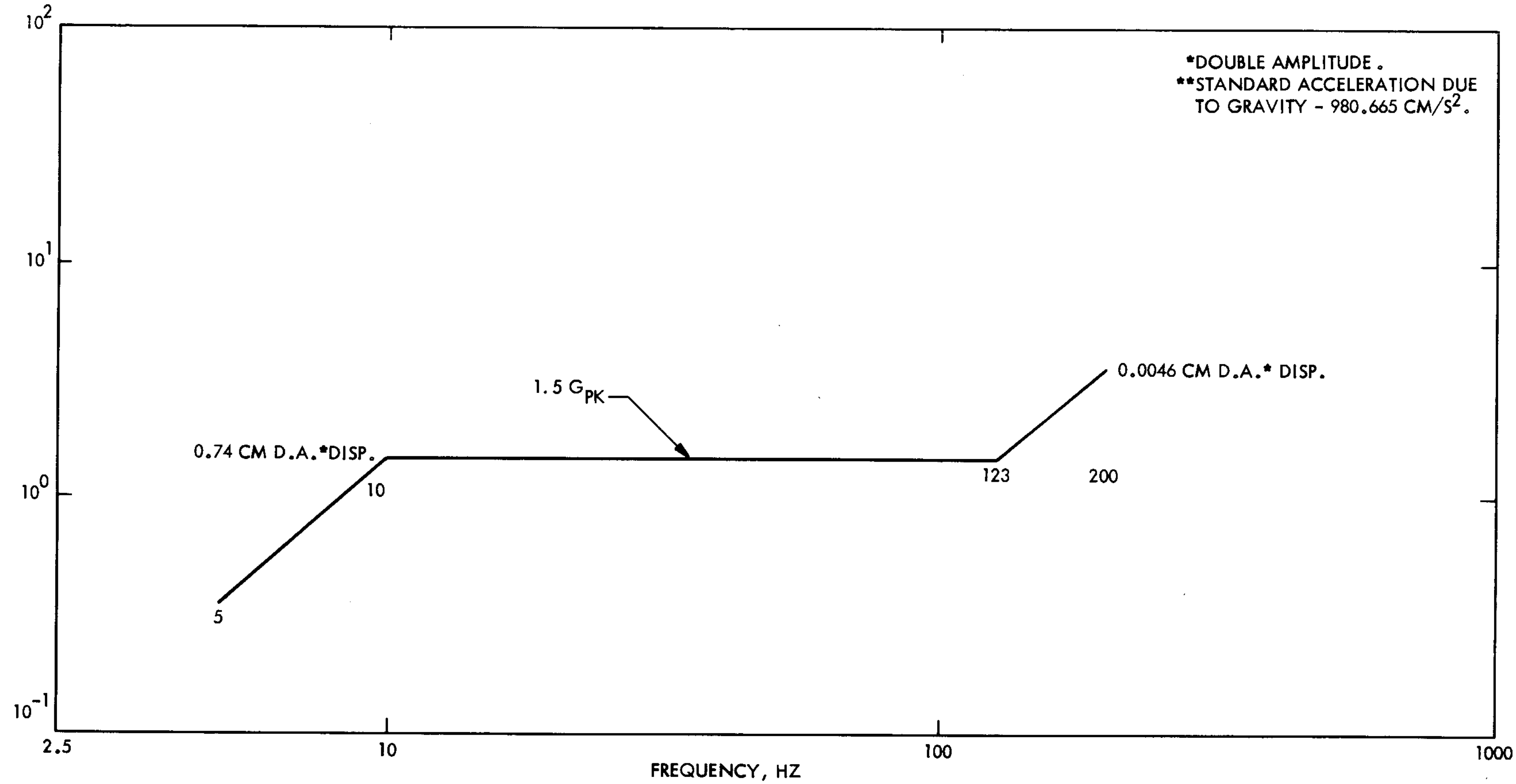
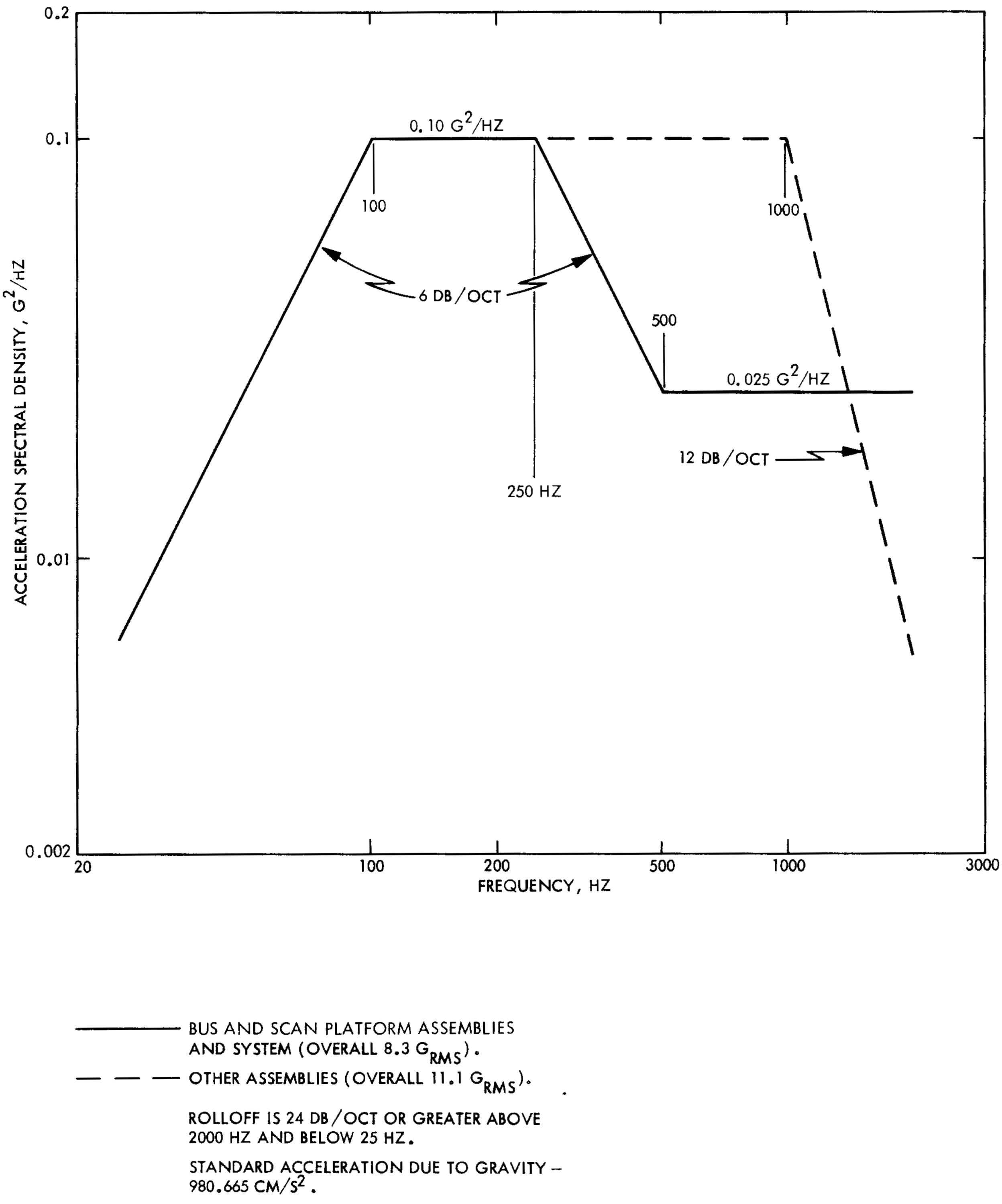


Figure 2. Sinusoidal Vibration



✱ Figure 3. Random Vibration Spectra

3.2.3.2 Spacecraft Assemblies. The Gaussian random vibration requirements are contained in Figure 3. They are derived as an input to the assembly mounting points in any direction. The flight equipment shall be capable of 3 min of random vibration exposure in each of any three axes including axes of maximum response.

3.2.4 Acoustic

The acoustic requirement for assemblies and the spacecraft consists of a reverberant acoustic field of 143 dB with 1/3 octave band sound pressure levels as specified in Table 12. The exposure time design requirement is 3 min.

3.2.5 Static Acceleration

Launch static acceleration design requirements are shown in Table 13 for the spacecraft system and assemblies.

3.2.6 Pyrotechnic Shock. The pyrotechnic shock requirements consist of the shock spectra in Figures 4A and 4B. These spectra cover the Spacecraft/Launch Vehicle separation environment and the MM/PM separation. The equipment designer should select the applicable shock spectra based on its location or specific designation as indicated on the shock spectra curves. For design purposes, the waveform of the transient defined by the shock spectra may be assumed to be exponentially decaying complex sinusoids with approximate decay time of 7 ms.

3.2.7 Launch Profile Pressure Decay

The spacecraft and flight assemblies shall be designed for an atmospheric pressure reduction rate with a maximum of $8.65 \times 10^3 \pm 1.06 \times 10^3$ (N/m^2)/SEC (65.0 ±8 torr/sec) beginning from a rate of less than 1.33×10^3 (N/m^2)/SEC (10.0 torr/sec) and returning to a rate of less than 1.33×10^3 (N/m^2)/SEC in a period of less than 5.0 s.

3.2.8 Electromagnetic and Magnetic Interference Requirements

3.2.8.1 Magnetic Field Restraints. All MM flight hardware shall be designed to satisfy static and dynamic magnetic field restraints during the launch phase as specified below.

3.2.8.1.1 Static Magnetic Fields. Static magnetic fields generated by permanent magnets, steady-state circuits, etc., in MM equipment shall be limited to the levels given in Table 7.

Table 12. Acoustic Sound Pressure Levels

1/3 Octave Band Center Frequency (Hz)	Sound Pressure Level (dB ref 2×10^{-4} dynes/cm^2)
50	130.5
63	131
80	132
100	133
125	133.5
160	134
200	134
250	133.5
315	131.5
400	128.5
500	126.5
630	124
800	122
1000	119.5
1250	118
1600	116.5
2000	115
2500	113.5
3150	112
4000	110.5
5000	109
6300	107.5
8000	106
10000	104.5
Overall	143

3.2.8.1.2 Dynamic Magnetic Field

See paragraph 3.1.6.1.2.

3.2.8.2 Electromagnetic Compatibility

See paragraph 3.1.6.2.

Table 13. Static Acceleration Levels

Direction	Acceleration* (G)
Thrust Axis	+12 -4
Any Lateral Axis	±2
*Standard acceleration due to gravity - 980.665 cm/s^2.	

3.2.8.2.1 Interference Susceptibility

3.2.8.2.1.1 Signal Circuit Conducted Transient Susceptibility

See paragraph 3.1.6.2.1.1.

3.2.8.2.1.2 Ground Line Conducted Transient Susceptibility

See paragraph 3.1.6.2.1.2.

* 3.2.8.2.1.3 DC Power Line Susceptibility

See paragraph 3.1.6.2.1.3.

3.2.8.2.1.4 RF Radiated Susceptibility

Flight equipment shall withstand the RF radiated environment described in Table 14.

* Table 14. RF Radiation Susceptibility

Frequency Range, MHz	RF Power Density, W/m^2
2220 to 2302	5.0 avg
5600 to 5800	120 peak
8402 to 8434	0.75 avg

3.2.8.2.2 Interference Emission

3.2.8.2.2.1 Signal Circuit Conducted Emission

See paragraph 3.1.6.2.2.1.

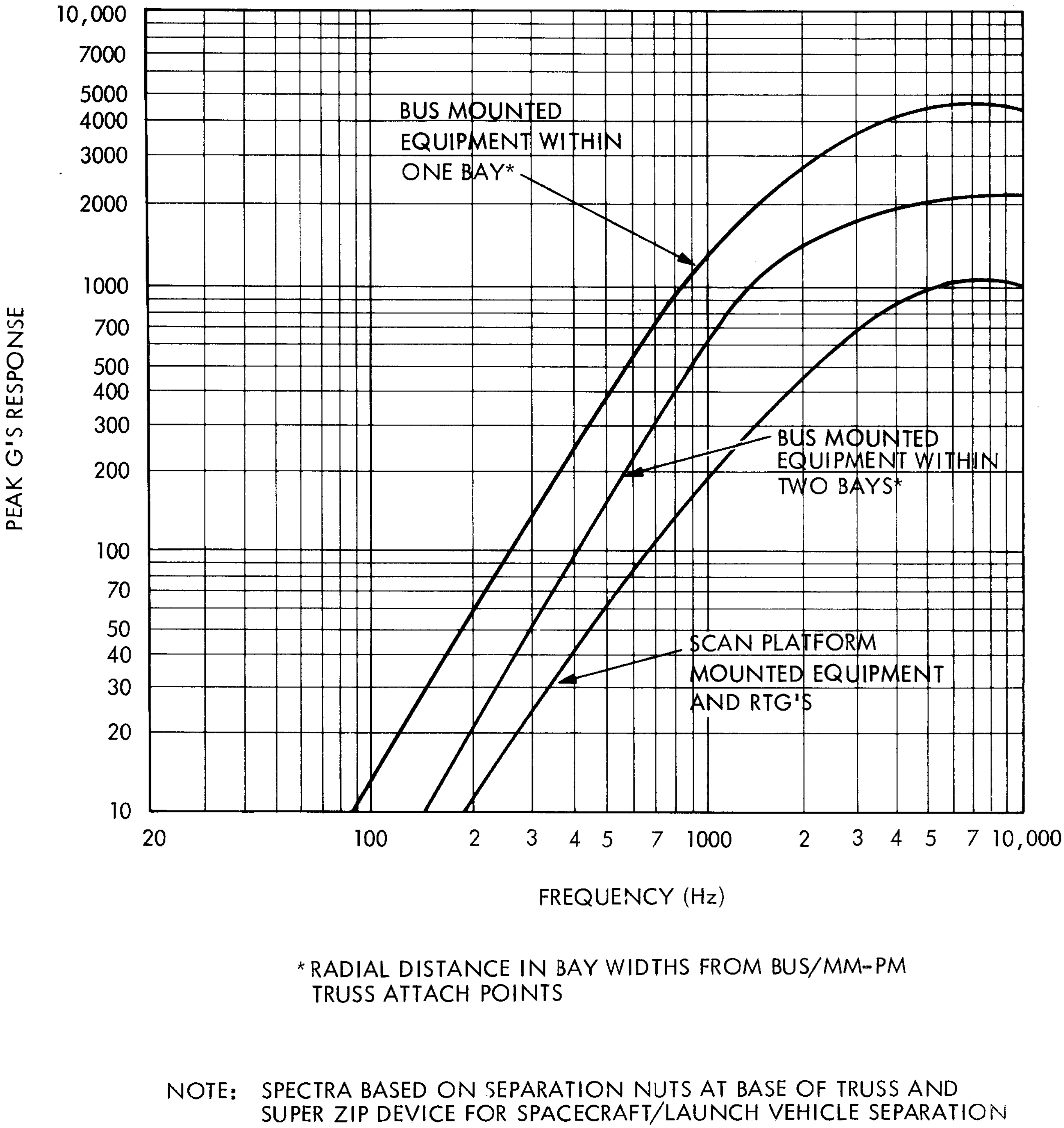
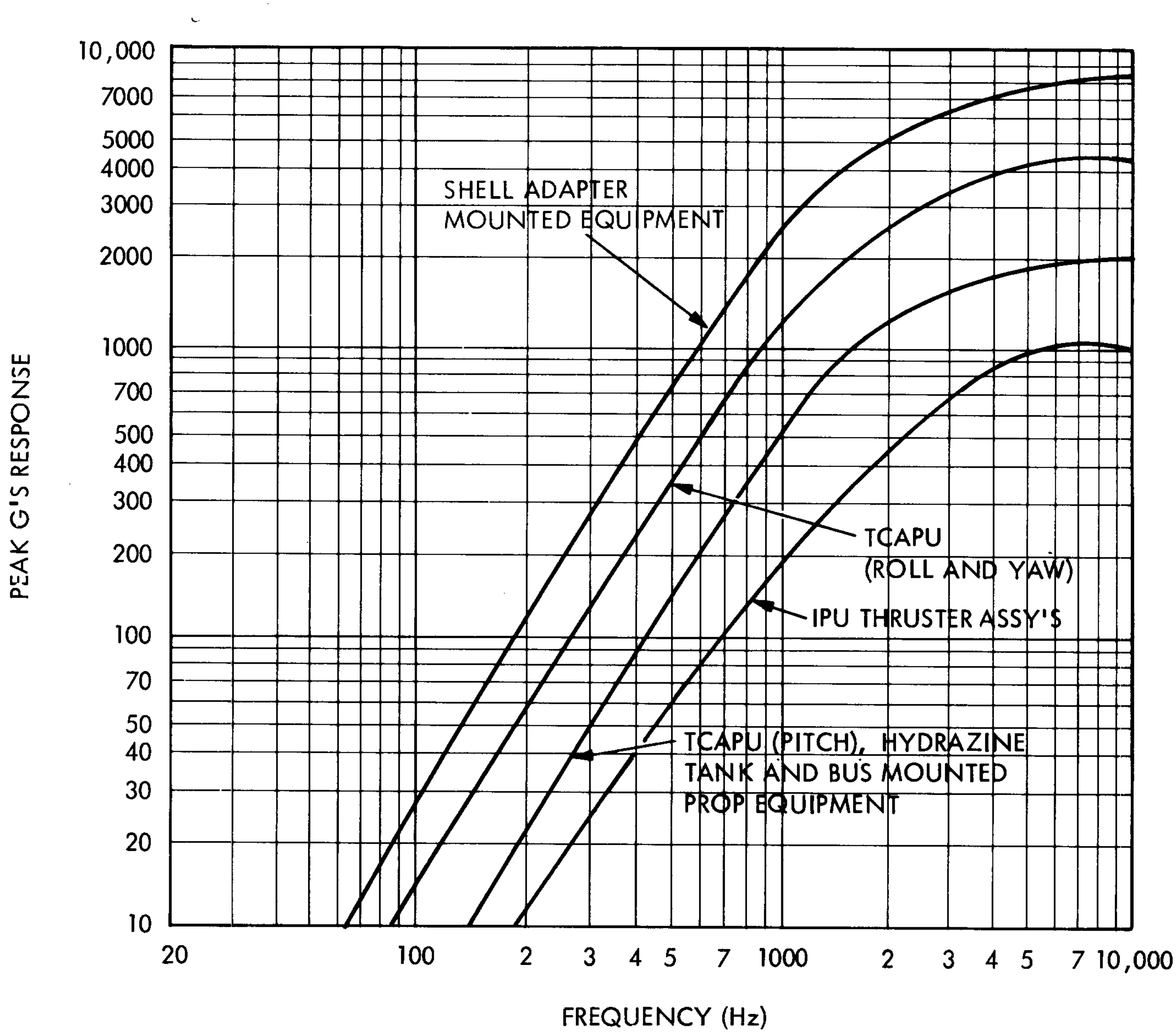


Figure 4A. Bus Mounted, Scan Platform Equipment and RTGs Pyrotechnic Shock Spectra (Q = 20)



NOTE: SPECTRA BASED ON SEPARATION NUTS AT BASE OF TRUSS AND SUPER ZIP DEVICE FOR SPACECRAFT/LAUNCH VEHICLE SEPARATION

Figure 4B. Propulsion Subsystem Equipment Pyrotechnic Shock Spectra (Q = 20)

* 3.2.8.2.2.2 DC Power Line Conducted Emission

See paragraph 3.1.6.2.2.2.

* 3.2.8.2.2.3 RF Radiated Emission

See paragraph 3.1.6.2.2.3.

3.2.9 Radioisotope Thermoelectric Generator (RTG) Radiation

See paragraphs 3.3.7 and 3.3.7.1.

3.2.10 Radioisotope Heater Unit (RHU) Radiation

See paragraphs 3.3.7 and 3.3.7.2.

3.3 Mission Module Flight Environmental Design Requirements

These requirements consist of the environments that the MM will encounter after its separation from the LV and PM operations have been accomplished.

3.3.1 Thermal Radiation

Exposed portions of the MM and flight assemblies shall be designed to withstand the limiting thermal radiation design levels specified in Table 15. The percentages of the solar constant associated with wavelengths shorter than λ in the wavelength range of 0.085 to 7.00 microns are given in Table 16.

3.3.2 Temperature

The flight assemblies shall be designed to withstand temperature requirements based on type approval (TA) test requirements. It is anticipated that most MJS77 electronics will have a TA test requirement of -20 to +75°C. The recommended design margin is 10°C in excess of the TA test requirements. The designer may exceed the recommended design margin at his discretion. Temperature requirements for assemblies which will have levels different than the above range will be specified by the Environmental Requirements Engineer as required by subsystem schedules.

3.3.3 Vacuum

3.3.3.1 Ambient Pressure. The design pressures for the mission range from 1×10^5 N/m^2 (760 torr) to 1.3×10^{-12} N/m^2 (1×10^{-14} torr).

3.3.3.2 Radiation Pressure. The MM and its assemblies shall be designed to function within the radiation pressure on the sunlit side of the MM as specified in Figure 5 for the cruise and encounter sequences of the mission.

Table 15. Thermal Radiation Design Requirements

	Limiting Thermal Radiation Levels	
	Design Minimum Flux ($mWcm^{-2}$)	Design Maximum Flux ($mWcm^{-2}$)
Direct Solar Radiation	0	163.0
Earth Reflected Radiation	0	57.3
Jupiter Reflected Radiation	0	0.05
Saturn Reflected Radiation	0	0.03
	Effective Black Body Temperatures	
	Design Minimum Temperature (°K)	Design Maximum Temperature (°K)
Earth IR Radiation	215	297
Jupiter IR Radiation	128	140
Saturn IR Radiation	91	103

Table 16. Solar Spectral Irradiance Data 0.0850 to 7.0 Microns

λ (μm)	P (%)	λ (μm)	P (%)	λ (μm)	P (%)
0.0850	3.8×10^{-4}	0.36	5.317	0.67	43.745
0.0900	3.9×10^{-4}	0.365	5.723	0.68	44.816
0.0950	4.0×10^{-4}	0.37	6.151	0.69	45.856
0.1000	4.1×10^{-4}	0.375	6.583	0.70	46.880
0.1050	4.2×10^{-4}	0.38	7.003	0.71	47.882
0.1100	4.2×10^{-4}	0.385	7.413	0.72	48.865
0.1150	4.3×10^{-4}	0.39	7.819	0.73	49.827
0.1200	4.4×10^{-4}	0.395	8.242	0.74	50.769
0.1250	4.7×10^{-4}	0.40	8.725	0.75	51.691
0.1300	4.9×10^{-4}	0.405	9.293	0.80	56.019
0.1350	5.2×10^{-4}	0.41	9.920	0.85	59.890
0.1400	5.4×10^{-4}	0.415	10.572	0.90	63.358
0.1450	5.6×10^{-4}	0.42	11.222	0.95	66.544
0.1500	5.8×10^{-4}	0.425	11.858	1.0	69.465
0.1550	6.3×10^{-4}	0.43	12.474	1.1	74.409
0.1600	6.9×10^{-4}	0.435	13.084	1.2	78.386
0.1650	8.2×10^{-4}	0.44	13.726	1.3	81.638
0.1700	1.01×10^{-3}	0.445	14.415	1.4	84.343
0.1750	1.31×10^{-3}	0.45	15.141	1.5	86.645
0.1800	1.70×10^{-3}	0.455	15.892	1.6	88.607
0.1850	2.33×10^{-3}	0.46	16.653	1.7	90.256
0.1900	3.16×10^{-3}	0.465	17.414	1.8	91.590
0.1950	5.2×10^{-3}	0.47	18.168	1.9	92.643
0.2000	8.1×10^{-3}	0.475	18.921	2.0	93.489
0.2050	1.34×10^{-2}	0.48	19.682	2.1	94.202
0.2100	2.05×10^{-2}	0.485	20.430	2.2	94.827
0.2150	3.53×10^{-2}	0.49	21.156	2.3	95.370
0.22	0.0502	0.495	21.878	2.4	95.858
0.225	0.0729	0.50	22.599	2.5	96.294
0.23	0.0972	0.505	23.313	2.6	96.671
0.235	0.1205	0.51	24.015	2.7	97.007
0.24	0.1430	0.515	24.702	2.8	97.310
0.245	0.1681	0.52	25.379	2.9	97.584
0.25	0.1944	0.525	26.060	3.0	97.828
0.255	0.2267	0.53	26.743	3.1	98.038
0.26	0.270	0.535	29.419	3.2	98.218
0.265	0.328	0.54	28.084	3.3	98.372
0.27	0.405	0.545	28.738	3.4	98.505
0.275	0.486	0.55	29.381	3.5	98.620
0.28	0.564	0.555	30.017	3.6	98.724
0.285	0.644	0.56	30.648	3.7	98.819
0.29	0.811	0.565	31.276	3.8	98.906
0.295	1.008	0.57	31.908	3.9	98.985
0.30	1.211	0.575	32.542	4.0	99.058
0.305	1.417	0.58	33.176	4.1	99.125
0.31	1.656	0.585	33.809	4.2	99.186
0.315	1.924	0.59	34.440	4.3	99.241
0.32	2.219	0.595	35.065	4.4	99.291
0.325	2.552	0.60	35.683	4.5	99.337
0.33	2.928	0.61	36.902	4.6	99.379
0.335	3.324	0.62	38.098	4.7	99.416
0.34	3.722	0.63	39.270	4.8	99.450
0.345	4.118	0.64	40.421	4.9	99.482
0.35	4.517	0.65	41.550	5.0	99.511
0.355	4.919	0.66	42.658	6.0	99.718
				7.0	99.819

λ (μm) is wavelength; and P is the percentage of the solar constant associated with wavelengths shorter than λ.

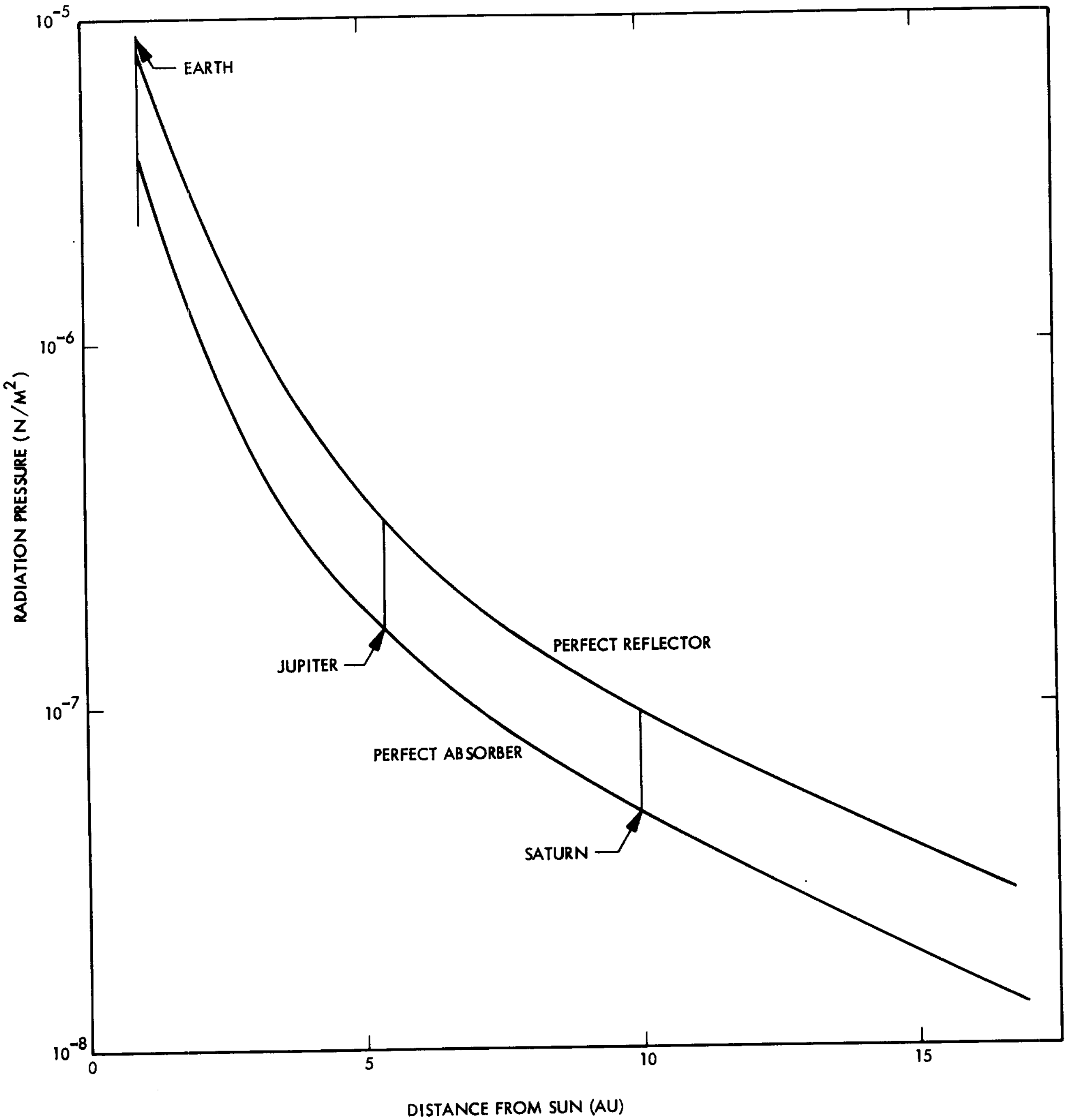


Figure 5. Radiation Pressure

✱ 3.3.4 Solid Particles

3.3.4.1 Meteoroids. Meteoroid design fluences and particle characteristics for the MJS77 mission are tabulated in Table 17. For purposes of meteoroid shielding design, the total fluence for any surface is the fluence in Table 17 multiplied by the directional factor (DF) appropriate for that surface. DF is given as a function of the surface orientation in Figure 6; longitude and latitude are angular displacements of the surface normal in a spacecraft centered coordinate system. Latitude is measured from the plane parallel to the ecliptic, the plane corresponding to 0 deg latitude. Longitude is measured in the plane of the ecliptic with the spacecraft z-axis corresponding to 0 deg longitude. For latitudes other than 0, ±30, ±60, ±85, and ±90 deg, linear interpolation between the values in Figure 6 should be used to determine DF. While exposed to this environment, the MM shall be designed to execute its mission with a 95 percent probability of success.

✱ 3.3.4.2 Saturn E(D') Ring Micrometeoroids. The integral fluences of particles whose mass equals or exceeds a particular value within the range 10^{-9} to 10^{3} grams are listed in Table 18. The values are for a single passage through Saturn's ring plane along a typical MJS77 trajectory. Particle density and mean relative velocity (Particles/Spacecraft) are also tabulated. The entries in second column assume that all ring particles have the same mass M and thus represent an upper limit to the integral fluence. The entries in third column arbitrarily assume a size distribution caused by grinding and modified by other processes which remove particles from Saturn's rings in certain mass ranges. The MM shall be designed to execute its mission with a 95 percent or greater probability of success in a single exposure to the column two environment. In the event this imposes a severe design penalty, and waiver consideration must include analysis of both column two and three entries.

The direction from which solid particles impact the mission module during Saturn ring plane crossing can be evaluated from the fact the particles are in approximately circular orbits about Saturn. Three cases are important: 1) the inbound ring plane crossing for the JSI and JSG type trajectories; 2) the outbound ring plane crossing for the JSI and JSG type trajectories; and 3) the ring plane crossing for the Uranus option. The range cone and clock angles which should be used to evaluate the particle impact hazard are specified in Table 19.

3.3.5 Magnetic Field

The MM shall operate as required in the magnetic fields defined below.

3.3.5.1 Geomagnetic Field. The maximum geomagnetic field is 5×10^{4} nT (0.5 Gauss).

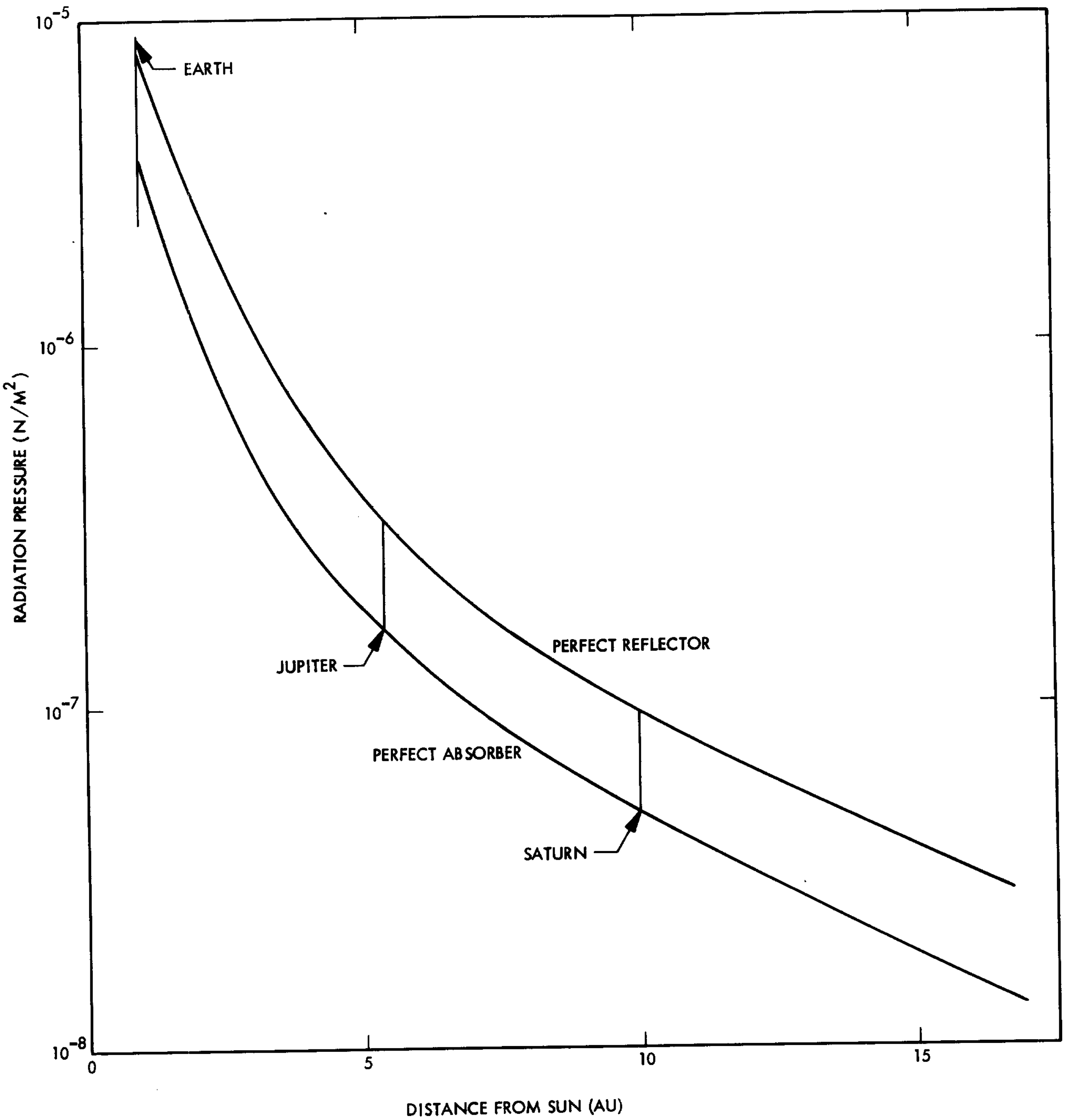


Figure 5. Radiation Pressure

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✱ 3.3.4.2 Saturn E(D') Ring Micrometeoroids. The integral fluences of particles whose mass equals or exceeds a particular value within the range 10^{-9} to 10^{3} grams are listed in Table 18. The values are for a single passage through Saturn's ring plane along a typical MJS77 trajectory. Particle density and mean relative velocity (Particles/Spacecraft) are also tabulated. The entries in second column assume that all ring particles have the same mass M and thus represent an upper limit to the integral fluence. The entries in third column arbitrarily assume a size distribution caused by grinding and modified by other processes which remove particles from Saturn's rings in certain mass ranges. The MM shall be designed to execute its mission with a 95 percent or greater probability of success in a single exposure to the column two environment. In the event this imposes a severe design penalty, and waiver consideration must include analysis of both column two and three entries.

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3.3.5 Magnetic Field

The MM shall operate as required in the magnetic fields defined below.

3.3.5.1 Geomagnetic Field. The maximum geomagnetic field is 5×10^{4} nT (0.5 Gauss).

Table 17. Meteoroids

Particle Mass (grams)	Integral Fluences (Particles m^{-2} of mass greater than M)
10^{-10}	2.0×10^{3}
10^{-9}	7.9×10^{2}
10^{-6}	8.8
10^{-5}	7.0×10^{-1}
10^{-4}	5.4×10^{-2}
10^{-3}	2.6×10^{-3}
10^{-2}	1.9×10^{-4}
10^{-1}	1.0×10^{-5}
10^{0}	8.0×10^{-7}
Mean relative speed (km/s)	14
Particle mass density (g/cm^3)	0.5

* Table 18. Saturn E Ring Particle Distribution

Particle Mass, M (g)	Integral Fluence Particles $\geq$ M (m^{-2})	Integral Fluence Particles $\geq$ M (m^{-2})
1.0×10^{-9}	1.9×10^{4}	8.3×10^{3}
1.0×10^{-8}	1.9×10^{4}	8.3×10^{3}
1.4×10^{-8}	1.9×10^{4}	8.3×10^{3}
3.4×10^{-8}	1.1×10^{4}	3.7×10^{3}
1.0×10^{-7}	5.2×10^{3}	1.0×10^{3}
2.7×10^{-7}	2.6×10^{3}	2.0×10^{2}
3.8×10^{-7}	2.1×10^{3}	2.1×10^{-5}
3.9×10^{-7}	2.7×10^{-3}	2.1×10^{-5}
1.0×10^{-7}	2.7×10^{-3}	2.1×10^{-5}
1.0	2.7×10^{-3}	2.1×10^{-5}
2.7×10^{2}	2.7×10^{-3}	2.1×10^{-5}
1.0×10^{3}	1.1×10^{-3}	4.6×10^{-6}
Particle Density	1.0 g/cm^3	
Mean Relative Velocity	19 km/s	

* Table 19. Saturn E Ring Direction of Solid Particle Impact Relative to the Mission Module

Trajectory	Cone Angle	Clock Angle
JSI-JSG Inbound	149 ± 10	236 ± 5
JSI-JSG Outbound	141 ± 20	168 ± 20
Uranus Option	126 ± 15	298 ± 10

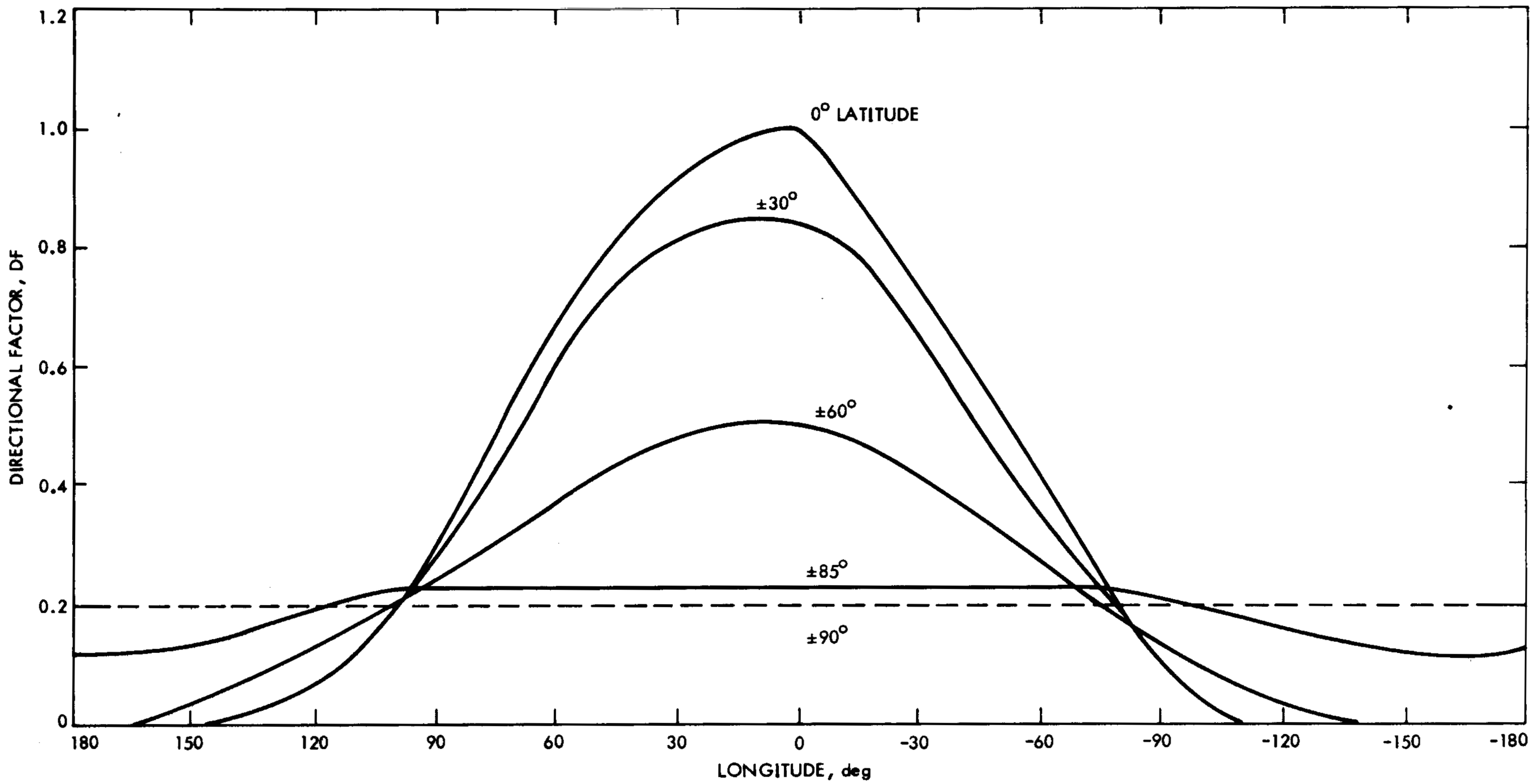

Figure 6. Meteoroid Directional Factor as a Function of Surface Orientation

3.3.5.2 Interplanetary Magnetic Field. The maximum interplanetary magnetic field is 25 nT (25 x 10^{-5} Gauss) during the duration of the mission.

3.3.5.3 Jupiter Magnetic Field. The maximum magnetic field at Jupiter during encounter is 3.7 x 10^3 nT (0.037 Gauss). This limit of planetary magnetic field at Jupiter is to also be used for design purpose at Saturn.

* 3.3.6 Natural Charged-Particle Radiation

The MM assemblies shall be designed to function within specification during and after exposure to Earth, Jupiter, and Saturn radiation belts, large solar proton events, solar wind proton and galactic cosmic radiation.

The radiation design requirements for protons and electrons are specified in terms of total radiation requirements to be satisfied considering all natural radiation sources.

Charged particle radiation levels are specified in Table 19. The assemblies shall function within specification during and after exposure to the total equivalent 20 MeV proton fluence and the total electron dose of 6 x 10^4 rad-Si. The assemblies shall also be designed for functional compatibility, (considering rate effects) within the specified maximum peak equivalent 3 MeV electron flux and the maximum peak equivalent 20 MeV proton flux.

The levels in Table 20 are external (unshielded) environments containing no margins. Parts environments are to be controlled by the application of shielding as required, to satisfy the established design margins. The radiation design margin is defined as the ratio of the surface, material or electronic piece part (or component) capability to the localized ambient environment. For MJS77 the radiation design margin for electrons is based strictly on dose since ionization is the dominant damage mechanism. The electron dose radiation design margin for engineering subsystems and the imaging subsystem is two and for the science instruments it is a minimum of unity. The radiation design margin for interference effects is related to charged particle flux and is the same as defined above for the respective subsystems except for the imaging subsystem where the radiation design margin is unity for flux. For protons where displacement damage is of most concern (except for exterior spacecraft surfaces) the radiation design margin is based on displacement fluence and is the same as applied to electron dose for the subsystems listed. These design margins apply to all subsystem locations containing electronics. The minimum acceptable capability of parts must be consistent with an electron dose of 6 x 10^4 rad-Si, and a proton fluence of 1 x 10^{10} p/cm^2 (20 MeV Eq.). These levels and the design margin philosophy are consistent with project imposed constraints on the anticipated weight penalty attributed to shielding. The margins are summarized below:

* Table 20. Charged Particle and Nuclear Radiation

NOTE: All Values Unshielded - Shielding will alter the local electronics environments significantly.

	Bus Mounted Electronics and Science Instruments		Non-Bus Mounted Science Instruments**	
Particles	Peak Flux ($cm^{-2}s^{-1}$) Unshielded	Fluence (cm^{-2}) Unshielded	Peak Flux ($cm^{-2}s^{-1}$) Unshielded	Fluence (cm^{-2}) Unshielded
Protons*	9×10^7 (E > 1 MeV)	5×10^{12} (20 MeV Eq)	9×10^7 (E > 1 MeV)	5×10^{12} (20 MeV Eq)
Electrons (Peak Values Selected)	2×10^8 [$11R_J$] (E > 0.4 MeV) 4×10^0Rad(Si)/s [$11R_J$]	4×10^{12} [$5R_J$] (3 MeV Eq) 2×10^5Rad(Si) [$9.5R_J$]	2×10^8 [$11R_J$] (E > 0.4 MeV) 4×10^0Rad(Si)/s [$11R_J$]	4×10^{12} [$5R_J$] (3 MeV Eq) 2×10^5Rad(Si) [$9.5R_J$]
RTG AND RHU Neutrons ($1.0 \le E \le 3.0$ MeV)	80	1×10^{10}	10	1×10^9
RTG and RHU Gamma ($0.3 \le E \le 3.0$ MeV)	3200	1×10^3*** Rad (Si)	350***	100*** Rad (Si)

NOTE:
*Proton flux and fluence assume a 1 MeV cutoff. Proton levels for true external surface problems are higher than those above. The level is 3.1×10^8 Rad (Si).
**Value for Scan Platform Instrument Location; for all other locations contact Environmental Requirements Engineers.
***Unshielded ionization dose level is really controlled by electron and proton environments above.

Subsystems	Electron* Dose	Proton Fluence	Charged Particle Flux
Engineering	2	2	2
Imaging	2	2	1
Non-Imaging Science	1	1	1

*Surface effects have the same radiation design margins.

Additional design information related to charged particle fluence and flux spectra as a function of particle energy which is necessary for shielding and other spectral sensitive activities is presented in Appendix B. Figure B-1 depicts fluxes for electrons and for protons with cutoffs of 0.4 and 1.0 MeV, respectively. Table B-1 presents integral and differential fluxes for JSI trajectories. Evaluations of low energy (<1 MeV) electron fluxes at other Jovian periapsis may differ from those in Table B-1. If evaluations at other periapsis are being performed obtain new fluxes for the proper R_j from the Environmental Requirements Engineer.

Equivalent displacement damage factors and fluence to ionization dose conversion factors as a function of particle energy are presented in Appendix C. The curves are necessary to reduce electron and proton flux and fluence spectra to single/energy equivalent flux and fluence values and total dose rate and dose.

The levels in Table 20 are external (unshielded) environments containing no margins. Parts environments are to be controlled by the application of shielding as required, to satisfy the established design margins. The radiation design margin is defined as the ratio of the surface, material or electronic piece part (or component) capability to the localized ambient environment. For MJS77 the radiation design margin for fluence for the engineering subsystems and the imaging subsystem is two and for the science instruments it is a minimum of unity. The radiation design margin for flux is the same, except for the imaging subsystem where the radiation design margin is unity for flux. These design margins apply to both electrons and protons. These shielded design margins apply to all subsystem locations containing electronics. In addition to the displacement-fluence requirement for electronics, there is a firm requirement that no electronics location within the bus will be subjected to an ionizing dose greater than 62.5 k rads (Si). The minimum acceptable capability of parts must be consistent with an electron fluence of 5×10^{12} e/cm^2 (3 MeV Eq.) and a proton fluence of 1×10^{10} p/cm^2 (20 MeV Eq.). These levels and the design margin philosophy are consistent with project imposed constraints on the anticipated weight penalty attributed to shielding.

Additional design information related to charged particle fluence and flux spectra as a function of particle energy which is necessary for shielding and other spectral sensitive activities is presented in Appendix B.

Equivalent displacement damage factors and fluence to ionization dose conversion factors as a function of particle energy are presented in Appendix C. The curves are necessary to reduce electron and proton flux and fluence spectra to single/energy equivalent flux and fluence values and total dose rate and dose.

3.3.7 Nuclear Radiation

Flight electronic assemblies shall be designed to function within specification during exposure to the neutrons and gammas emitted from the RTGs and RHUs as specified in Table 20. The neutron fluence and gamma dose design requirements are integrated values over four years and are total spectrum values having an average energy in the ranges of $0.3 \leq E \leq 3.0$ MeV for gammas and $1.0 \leq E \leq 3.0$ MeV for neutrons. The combined RTG and RHU radiation limits specified in Table 20 are to be interpreted as the minimum allowable threshold of spacecraft equipment susceptibility to nuclear radiation. The radiation contribution from both RTGs and RHUs must be considered to insure that an assembly will not be affected by the total radiation resulting from the RHUs and RTGs. Compatibility with the total nuclear radiation environment must be demonstrated by analysis. Detailed radiation spectra needed for design analysis for each of these radiation fields can be obtained by request from the Environmental Requirements Engineer.

3.3.7.1 Radioisotope Thermoelectric Generators (RTG)

The RTG radiation is currently based on the HELIPAK RTG design and fuel that is five years old at beginning and ten years old at end of mission plus one year, pure plutonium oxide with 1.2 ppm (^{236}Pu, ^{232}U, and ^{228}Th) and a neutron source intensity of 7,000 n/s-g ^{238}Pu at the fuel sphere level. A self multiplication factor of 1.18 was used to obtain neutron source intensity at the RTG level.

3.3.7.2 Radioisotope Heater Unit (RHU)

The RHU radiation is currently based on a one-watt unit design with fuel that is five years old at the beginning and ten years old at the end of mission plus one year, pure plutonium oxide with 1.2 ppm (^{236}Pu, ^{232}U, and ^{228}Th) and a neutron source intensity of 7,000 n/s-g ^{238}Pu. MJS77 spacecraft assemblies employing RHUs or adjacent to RHUs shall be designed to function within the RHU neutron and gamma radiation levels of Table 21.

Table 21. RHU Neutron and Gamma Radiation

Distance From RHU (cm)	Neutron		Gamma	
	Peak Flux (cm^{-2}-s^{-1})	Fluence (cm^{-2})	Peak Flux (cm^{-2}-s^{-1})	Fluence (Rad-Si)
0	3.1×10^{2}	3.9×10^{10}	3.2×10^{3}	2.0×10^{3}
2	1.1×10^{2}	1.4×10^{10}	1.3×10^{3}	8.0×10^{2}
4	5.7×10^{1}	7.0×10^{9}	6.4×10^{2}	4.0×10^{2}
6	3.1×10^{1}	3.9×10^{9}	3.2×10^{2}	2.0×10^{2}
8	1.9×10^{1}	2.5×10^{9}	2.0×10^{2}	1.3×10^{2}
10	1.3×10^{1}	1.7×10^{9}	1.4×10^{2}	9.0×10^{1}
15	5.7×10^{0}	7.4×10^{8}	6.4×10^{1}	4.0×10^{1}
20	3.2×10^{0}	4.2×10^{8}	3.2×10^{1}	2.0×10^{1}
50	6.4×10^{-1}	8.3×10^{7}	6.0×10^{0}	4.0×10^{0}
100	1.8×10^{-1}	2.3×10^{7}	1.6×10^{0}	1.0×10^{0}

3.3.8 Mission Module Electrostatic Charge Potential

Maximum charging currents equal to 2×10^{-10} A/cm^2 will be experienced during Jupiter encounter. The MM shall be designed so that the maximum difference of potential between any two points on the MM surface does not exceed 10 V when these currents are conducted through the MM.

Note: Known exceptions to the above requirement will be treated on an individual basis.

3.3.9 Mission Module Flight Dynamic Environments

Dynamic environments of low magnitude will be generated during MM trajectory correction maneuvers. Figure 7 contains a random vibration spectrum for the scan platform and bus during

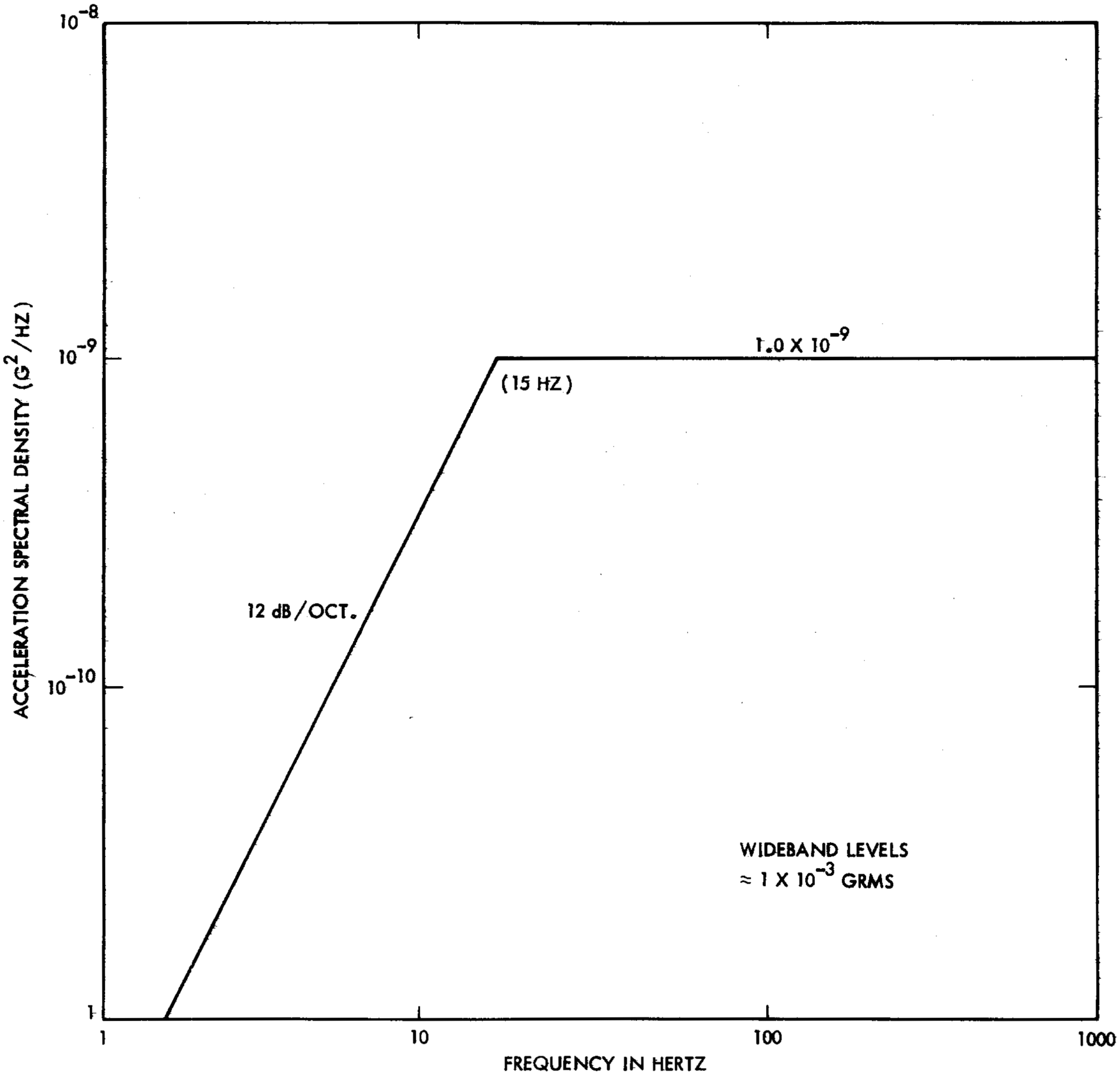

Figure 7. Random Vibration at Bus/Platform Due to AACS Thrusters

attitude control and trajectory correction operations. Figures 8 and 9 contain sine vibration spectra at the IRIS/MIRIS location (scan platform) and PLS location (scan platform boom). Environments are given for scan actuator operator including low frequency environments at the various slewing rates and for operation of the significant environment producing science instruments, the LECP (stepping) and the ISS (shutter and filter wheel operation).

3.3.10 Electromagnetic and Magnetic Interference Requirements

3.3.10.1 **Magnetic Field Restraints. All MM flight hardware shall be designed to satisfy static and dynamic magnetic field restraints during the mission flight phase as specified below.**

3.3.10.1.1 Static Magnetic Fields

See paragraph 3.2.8.1.1

3.3.10.1.2 Dynamic Magnetic Field

See paragraph 3.1.6.1.2

3.3.10.2 Electromagnetic Compatibility

See paragraph 3.1.6.2

3.3.10.2.1 Interference Susceptibility

3.3.10.2.1.1 Signal Circuit Conducted Transient Susceptibility

See paragraph 3.1.6.2.1.1

3.3.10.2.1.2 Ground Line Conducted Transient Susceptibility

See paragraph 3.1.6.2.1.2

* 3.3.10.2.1.3 DC Power Line Susceptibility

See paragraph 3.1.6.2.1.3.

3.3.10.2.1.4 RF Radiated Susceptibility. Flight equipment shall withstand the RF radiated environment described in Table 22.

Table 22. RF Radiation Susceptibility

Frequency Range, MHz	RF Power Density, W/m^2
5 - 40 (Jovian Dekametric Radiation)	0.025 avg.

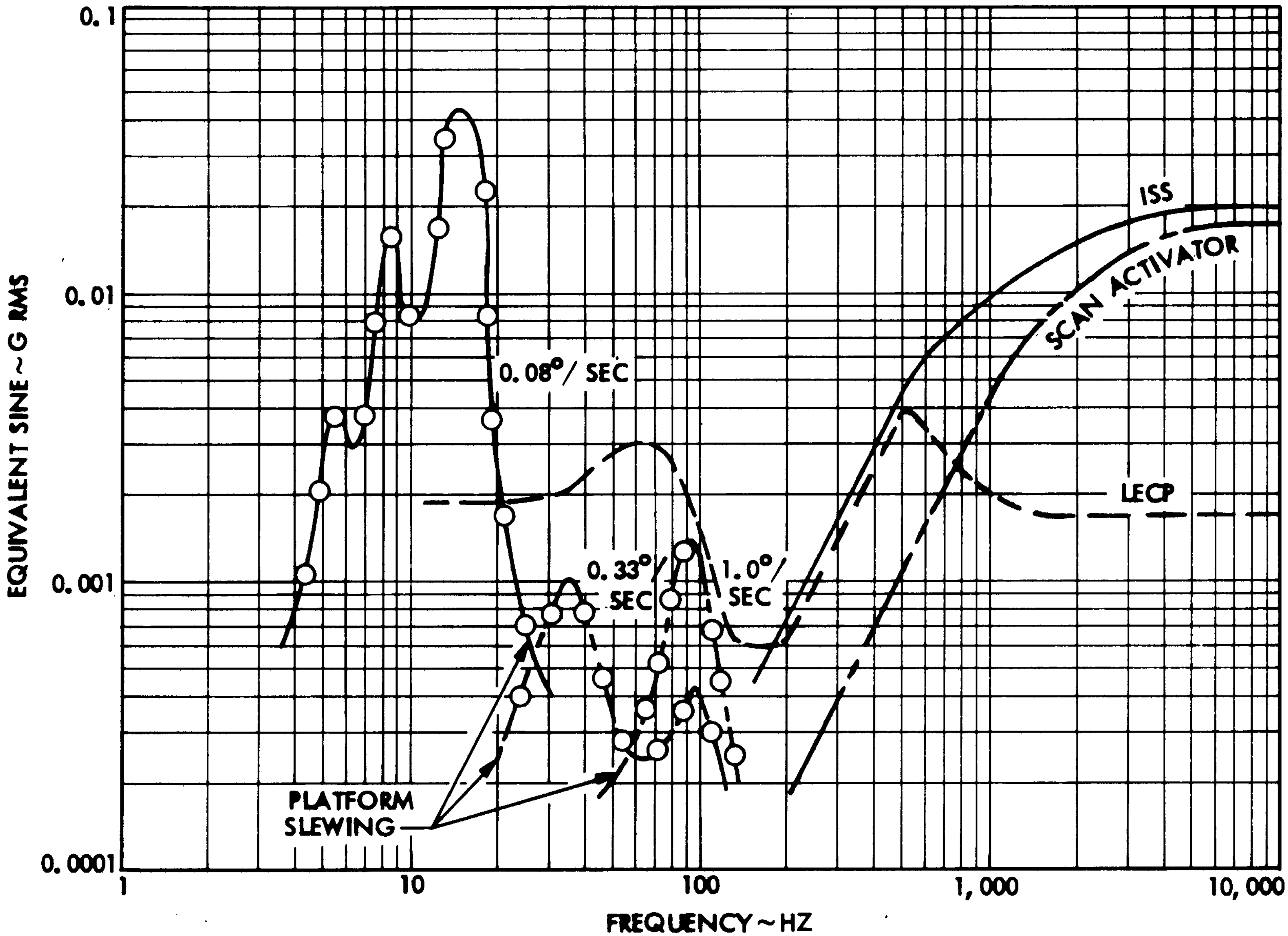

Figure 8. Flight Dynamic Environment at IRIS/MIRIS

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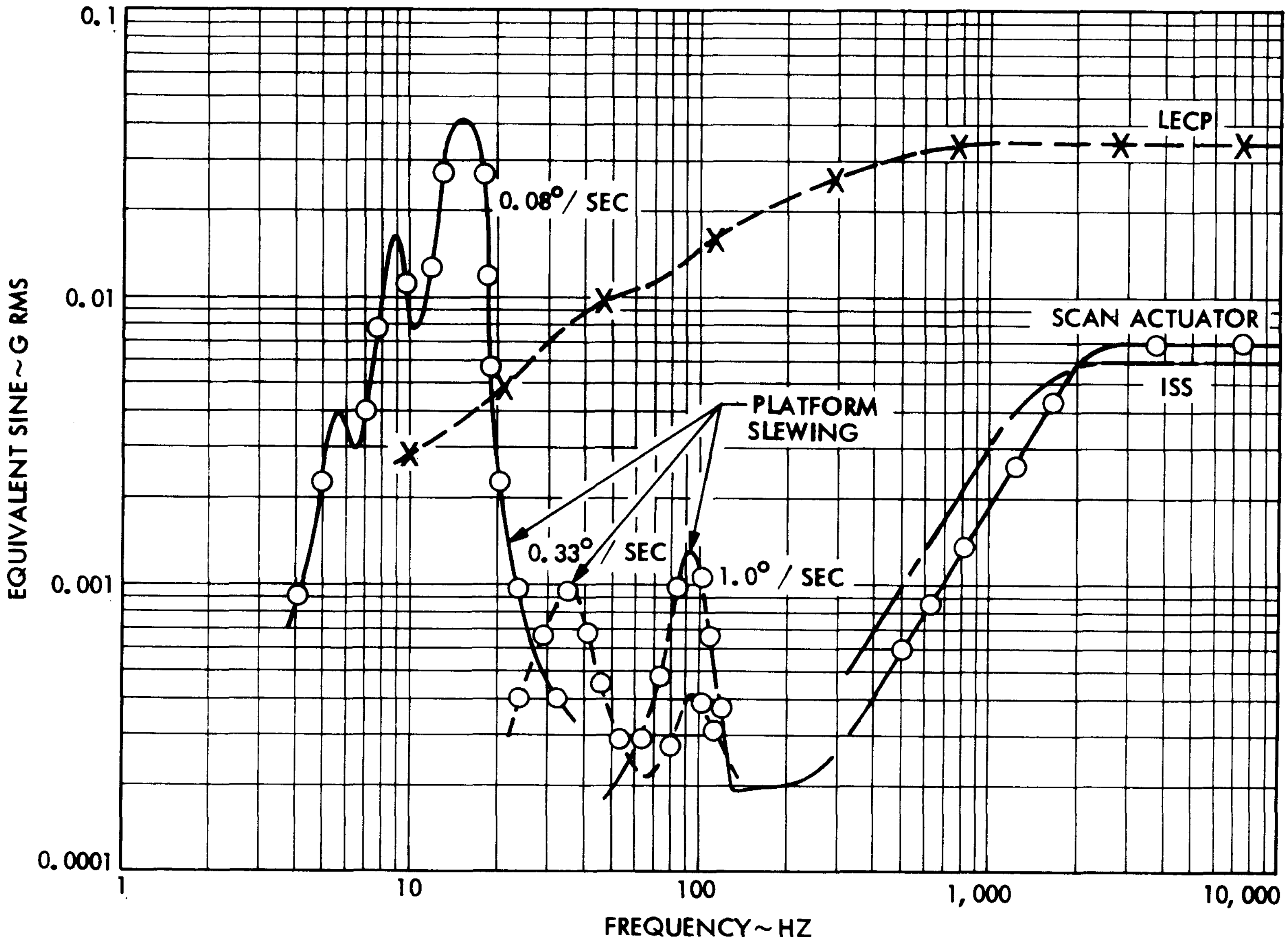

Figure 9. Dynamic Environment at PLS

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3.3.10.2.2 Interference Emission

3.3.10.2.2.1 Signal Circuit Conducted Emission

See paragraph 3.1.6.2.2.1

* 3.3.10.2.2.2 DC Power Line Conducted Emission

See paragraph 3.1.6.2.2.2.

* 3.3.10.2.2.3 RF Radiated Emission. Science experiment subsystems shall not exceed the levels described in Figures 10 and 11 and paragraph 3.1.6.2.2.3.

Other subsystems shall not exceed the levels specified in paragraph 3.1.6.2.2.3.

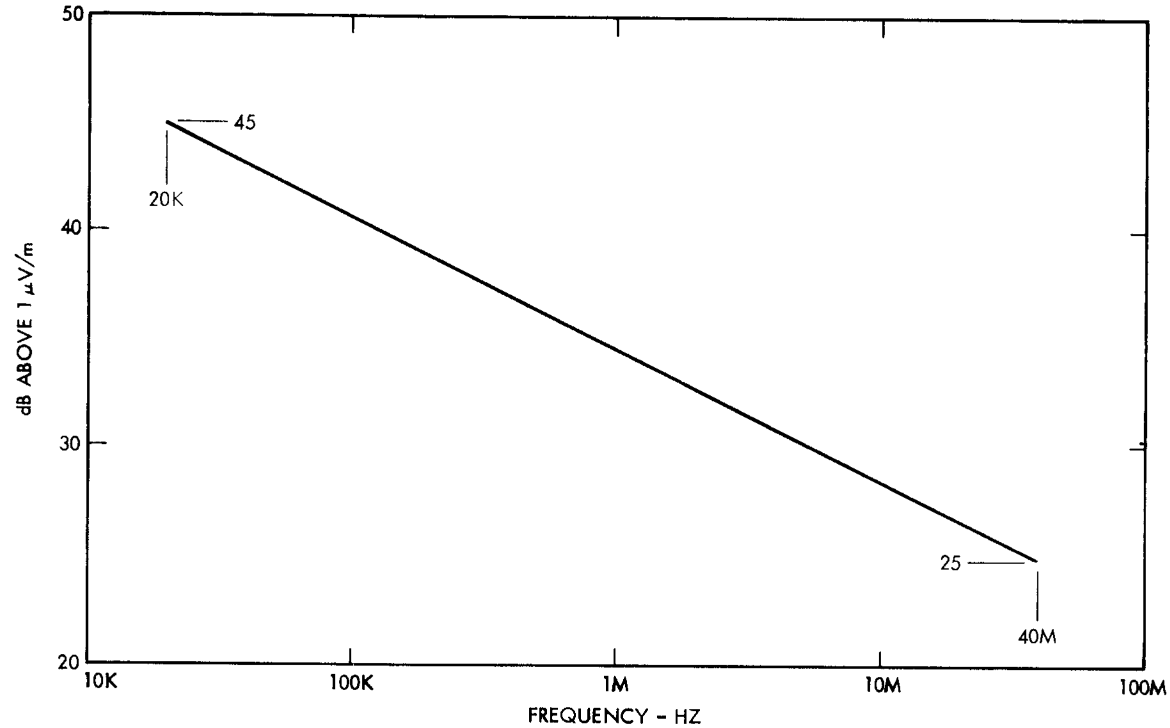


Figure 10. Radiated Emission Narrowband

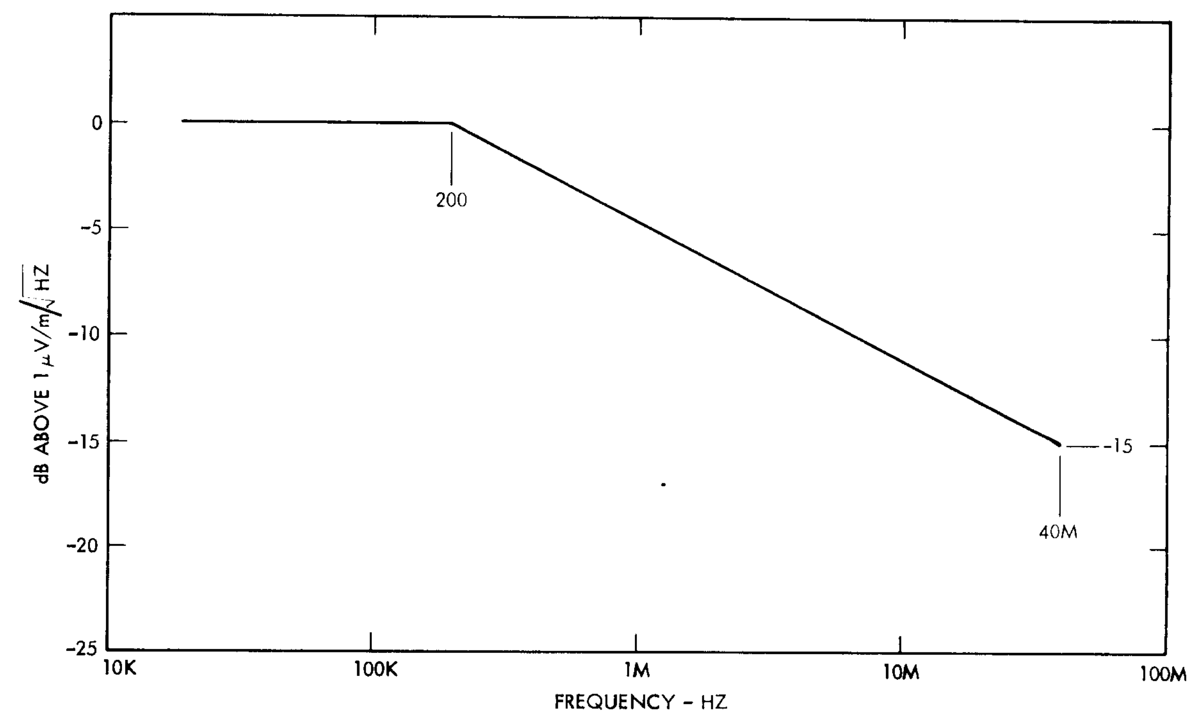


Figure 11. Radiated Emission Broadband

REVISION PAGE

Revision	Date	ECRs Incorporated	Comments
Original	14 March 1975	N/A	
A	13 October 1976	36103	1) Corrections and changes in EMC, dynamics and solid particles. 2) Various new requirements in EMC area. 3) New section on Saturn E(D') ring micrometeoroids.
		36269	Corrects the radiation design requirements as per Jan 1976 Election Model.
		36466	Incorporate latest data on microphonic environment.

APPENDIX A

DESIGN REQUIREMENTS AND ASSOCIATED VERIFICATION TESTS

APPENDIX A

DESIGN REQUIREMENTS AND ASSOCIATED VERIFICATION TESTS

Environmental Design Requirements (MJS77-3-240)		Environmental Test or Analysis Requirement (As specified in Environmental Test and Analysis Configuration Document, 618-260 and per the requirements of Project Policy and Requirements Document, 618-228)
Paragraph	Design Requirement Description	Analysis or Test Requirement Description
3.1	GROUND OPERATIONS AND HANDLING	
3.1.1	Particulate Contamination	Test Not Required
3.1.2	Temperature and Pressure	Temperature
3.1.3	Humidity	Humidity (Not Required if Approved Procedures followed.)
3.1.4	Shipping and Transportation Vibration	Trans. Vib. (Not Required if Approved Procedures followed.)
3.1.5	Shipping and Transportation Shock	Trans. Shock (Not Required if Approved Procedures followed.)
3.1.6	Electromagnetic and Mag. Interference Requirements	The Magnetic Test will include exposure to a demagnetizing field.
3.1.6.1	Magnetic Field Restraints	
3.1.6.1.1	Static Magnetic Fields	Magnetic Measurements
3.1.6.1.2	Dynamic Magnetic Field	Magnetic Measurements
3.1.6.2	Electromagnetic Compatability (EMC)	
3.1.6.2.1	Interference Susceptibility	

Environmental Design Requirements (MJS77-3-240)		Environmental Test or Analysis Requirement (As specified in Environmental Test and Analysis Configuration Document, 618-260 and per the requirements of Project Policy and Requirements Document, 618-228)
Paragraph	Design Requirement Description	Analysis or Test Requirement Description
3.1.6.2.1.1	Signal Circuit Conducted Transient Susceptibility	EMC Conducted Susceptibility
3.1.6.2.1.2	Ground Line Conducted Transient Susceptibility	EMC Conducted Susceptibility
3.1.6.2.2	Interference Emission	
3.1.6.2.2.1	Signal Line Conducted Emission	EMC Conducted Emission
3.1.6.2.2.2	RF Radiated Emission	EMC Radiated Emission
3.2	LAUNCH ENVIRONMENT DESIGN REQUIREMENT	
3.2.1	Explosive Atmosphere	Explo. Atmos. Test Not Required if Approved Procedures followed.
3.2.2	Sinusoidal Vibration	Vibration Sine Vibration (Assy. & Sys. Levels)
3.2.3	Random Vibration	Random Vibration (Assemblies Only)
3.2.4	Acoustic	Acoustic
3.2.5	Static Acceleration	Static Acceleration - Test or Analysis
3.2.6	Pyrotechnic Shock	Pyro Shock
3.2.7	Launch Profile Press. Decay	Launch Pressure Profile - Test or Analysis
3.2.8	Electromagnetic and Mag. Interference Requirements	(See paragraph 3.1.6.)

Environmental Design Requirements (MJS77-3-240)		Environmental Test or Analysis Requirement (As specified in Environmental Test and Analysis Configuration Document, 618-260 and per the requirements of Project Policy and Requirements Document, 618-228)
Paragraph	Design Requirement Description	Analysis or Test Requirement Description
3.2.9	Radioisotope Thermoelectric Generator Radiation	(See paragraph 3.3.7 and 3.3.7.1)
3.2.10	Radioisotope Heater Unit Radiation	(See paragraph 3.3.7 and 3.3.7.2)
3.3	MISSION MODULE FLT. ENVIR. DESIGN REQUIREMENTS	
3.3.1	Thermal Radiation	No Tests Required
3.3.2	Temperature	Thermal/Vacuum
3.3.3	Vacuum	Vacuum Environment Imposed as part of Thermal/Vacuum Test
3.3.3.1	Ambient Pressure	(See paragraph 3.3.3.)
3.3.3.2	Radiation Pressure	No Tests Required
3.3.4	Meteroids	Meteroids - Susceptibility Analyses Will be Performed on select basis
3.3.5	Magnetic Field	
3.3.5.1	Geomagnetic Field	No Tests Required
3.3.5.2	Interplanetary Mag. Field	No Tests Required
3.3.5.3	Jupiter Magnetic Field	No Tests Required
3.3.6	Natural Charged Particle Radiation	Electron & Proton Radiation Analysis
3.3.7	Nuclear Radiation	RTG and RHU Radiation - Test or Analysis

Environmental Design Requirements (MJS77-3-240)		Environmental Test or Analysis Requirement (As specified in Environmental Test and Analysis Configuration Document, 618-260 and per the requirements of Project Policy and Requirements Document, 618-228)
Paragraph	Design Requirement Description	Analysis or Test Requirement Description
3.3.8	Mission Module Electrostatic Charge Potential	Analysis on select basis
3.3.9	Mission Module Flight Dynamic Environments	Maneuver and Science Instrument Induced Dynamics - Test or analysis on select basis as determined necessary
3.3.10	Electromagnetic and Magnetic Interference Requirements	(See paragraph 3.1.6.)

APPENDIX B

JUPITER NATURAL RADIATION ENVIRONMENTS FLUX/FLUENCE SPECTRA

APPENDIX B

This appendix contains the information listed below.

1) Energy spectra for electron and proton peak flux and fluence (Tables B-1 and B-2).

2) Electron and proton flux and fluence, and electron dose as functions of magnetic shell parameter and perijove distance respectively for equatorial Jupiter fly-bys(Figures B-1, B-2, and B-3).

The electron spectra were derived using the results of integrations along the Jupiter Saturn Io (JSI) trajectory including peak fluxes. The proton spectra were derived using the results of integrations along the Jupiter Saturn Ganymede (JSG) trajectory.

The Jupiter and solar proton peak fluxes are independent and should not be added. However, the fluences are accumulative and should be added, although the solar event contribution is negligible except at the very highest energies. The MM should be designed for the accumulative proton fluence of Table B-1and the 95 percent probability solar flare proton fluence of Table B-2. Additional values of solar flare proton fluence are included to provide a basis for evaluating the shield requirement sensitivity to the solar flare proton environment.

The curves presenting fluence vs. perijove distance were derived assuming phasing with the magnetic pole to provide maximum fluence.

Special attention should be paid to the energy at which radiation spectra are cut-off when applying these data as design requirements. The energy cut-off is significant for equipment with sensitive surfaces exposed directly to the radiation field and for equipment only slightly shielded. The energy cut-off is not significant for equipment inside the bus.

Potentially sensitive surfaces such as optics, thermal coatings, filter materials, etc. may require consideration of proton spectra below the minimum energy cut-off of Table B-1. The Environmental Requirements Engineer should be consulted in such situations.

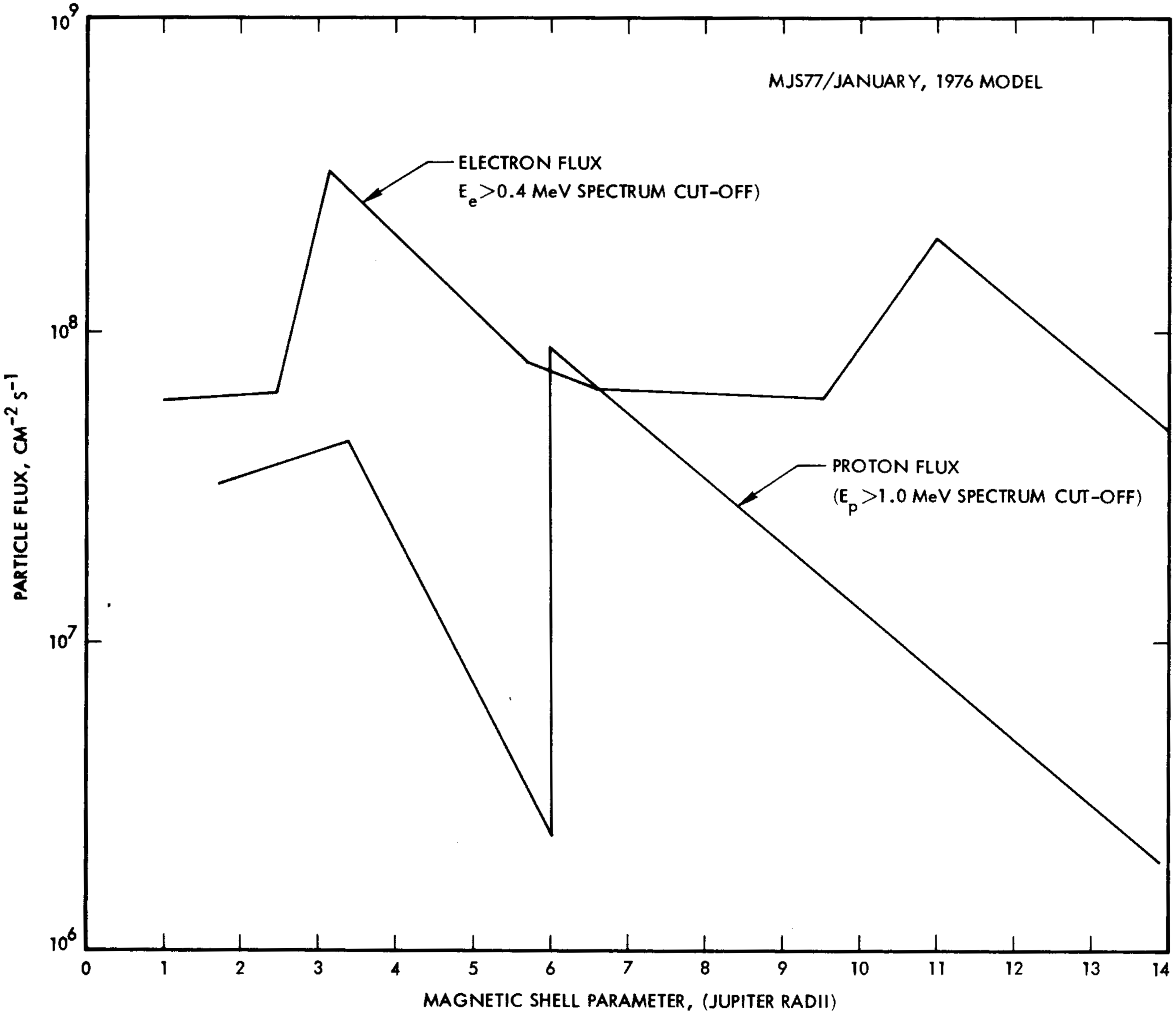
Table B-1. Integral and Differential Peak Flux, Fluence, and Equivalent Fluence of Jupiter Electrons and Protons (January 1976 Electron Model)

	Energy, E (MeV)	Integral Peak Flux (cm^{-2}s^{-1})	Differential Peak Flux (cm^{-2}s^{-1}MeV^{-1})	Integral Fluence (cm^{-2})	Differential Fluence (cm^{-2}MeV^{-1})	Equivalent[1] Fluence (cm^{-2})	Total Dose (Rad (Si))
ELECTRONS	0.40	4.7(7)	3.4(7)	5.4(12)	1.1(13)	3.9(12)	1.5(5)
	0.63	4.3(7)	1.1(7)	3.8(12)	4.5(12)	3.6(12)	1.1(5)
	1.0	4.1(7)	4.3(6)	2.7(12)	1.9(12)	3.3(12)	8.4(4)
	1.6	3.9(7)	2.7(6)	2.0(12)	7.4(12)	3.0(12)	6.6(4)
	2.5	3.6(7)	2.6(6)	1.6(12)	3.3(11)	2.6(12)	5.4(4)
	4.0	3.2(7)	2.9(6)	1.2(12)	1.8(11)	2.3(12)	4.3(4)
	6.3	2.5(7)	3.1(6)	8.9(11)	1.3(11)	1.8(12)	3.3(4)
	10.0	1.5(7)	2.3(6)	5.2(11)	7.9(10)	1.2(12)	2.0(4)
	16.0	5.6(6)	9.3(5)	2.1(11)	3.1(10)	5.6(11)	9.2(3)
	25.0	14.(6)	2.0(5)	5.9(10)	7.4(9)	2.0(11)	3.1(3)
	40.0	2.0(5)	2.2(4)	1.2(10)	1.1(9)	5.2(10)	8.2(2)
	63.0	2.8(4)	1.9(3)	2.5(9)	1.4(8)	1.3(10)	2.1(2)
	100.0	2.8(3)	1.4(2)	4.9(8)	1.7(7)	3.2(9)	5.4(1)
PROTONS	1.0	8.5(7)	1.8(8)	2.5(12)	5.0(12)	5.1(12)	6.0(6)
	1.6	8.2(7)	4.2(7)	9.5(11)	1.2(12)	1.9(12)	1.6(6)
	2.5	1.3(7)	1.0(7)	3.8(11)	3.1(11)	6.8(11)	4.6(5)
	4.0	5.0(6)	2.5(6)	1.5(11)	7.4(10)	2.2(11)	1.3(5)
	6.3	2.1(6)	6.2(5)	6.5(10)	1.9(10)	7.8(10)	3.7(4)
	10.0	9.5(5)	1.5(5)	2.8(10)	4.9(9)	3.0(10)	1.1(4)
	16.0	4.7(5)	4.4(4)	1.3(10)	1.3(9)	1.1(10)	3.6(3)
	25.0	2.2(5)	1.7(4)	5.4(9)	4.8(8)	4.0(9)	1.1(3)
	40.0	6.3(4)	6.0(3)	1.3(9)	1.3(8)	7.2(8)	1.9(2)
	63.0	5.1(3)	5.9(2)	8.7(7)	1.0(7)	3.9(7)	1.0(1)
	100.0	7.9(1)	8.3(0)	1.3(6)	1.3(5)	4.3(5)	1.4(01)

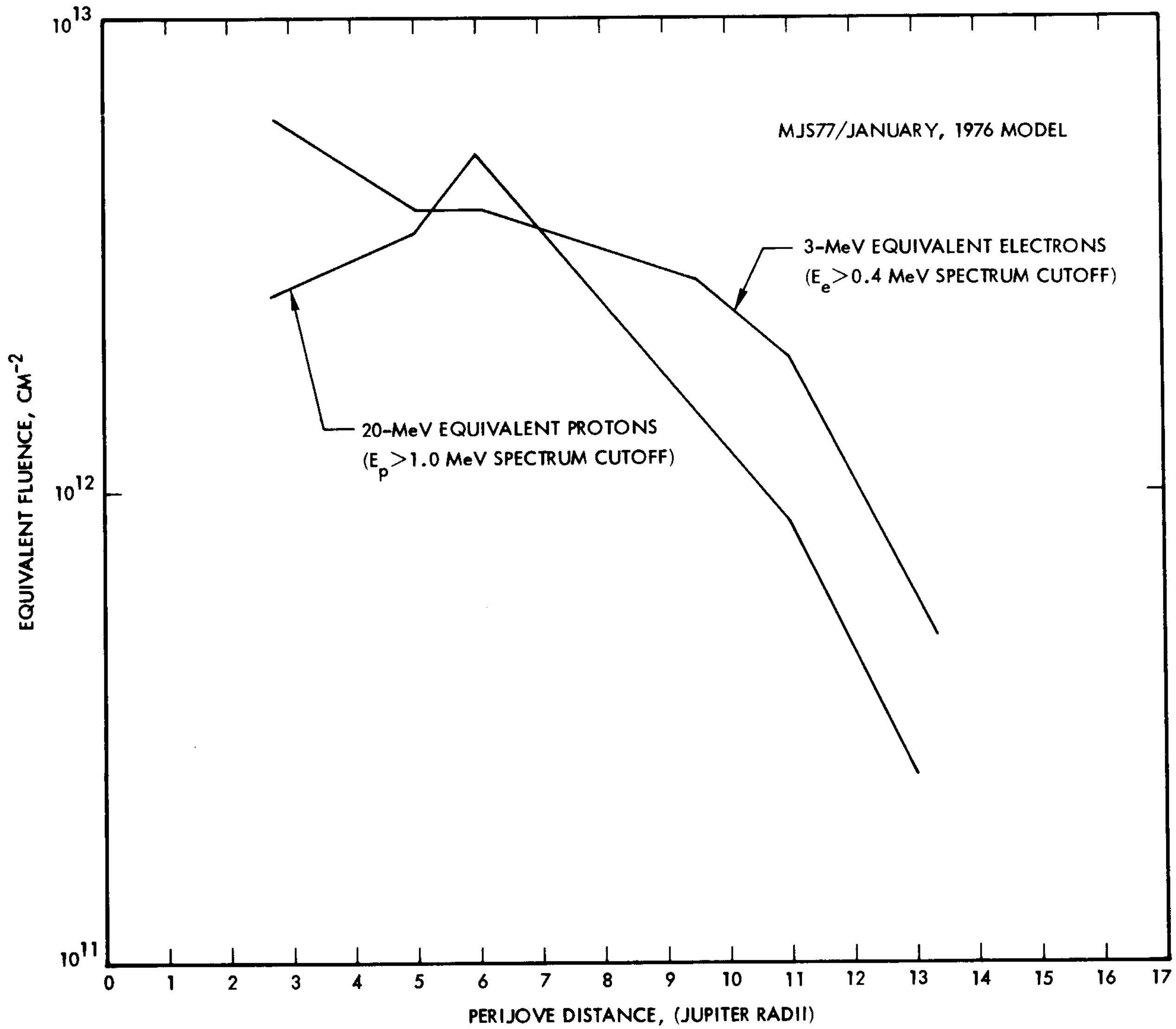
[1] Displacement damage equivalenced to 3 MeV for electrons. 20 MeV for protons, considering only those particles with energy exceeding the threshold E.

Table B-2. Differential Energy Spectra for Solar Proton Event Environments

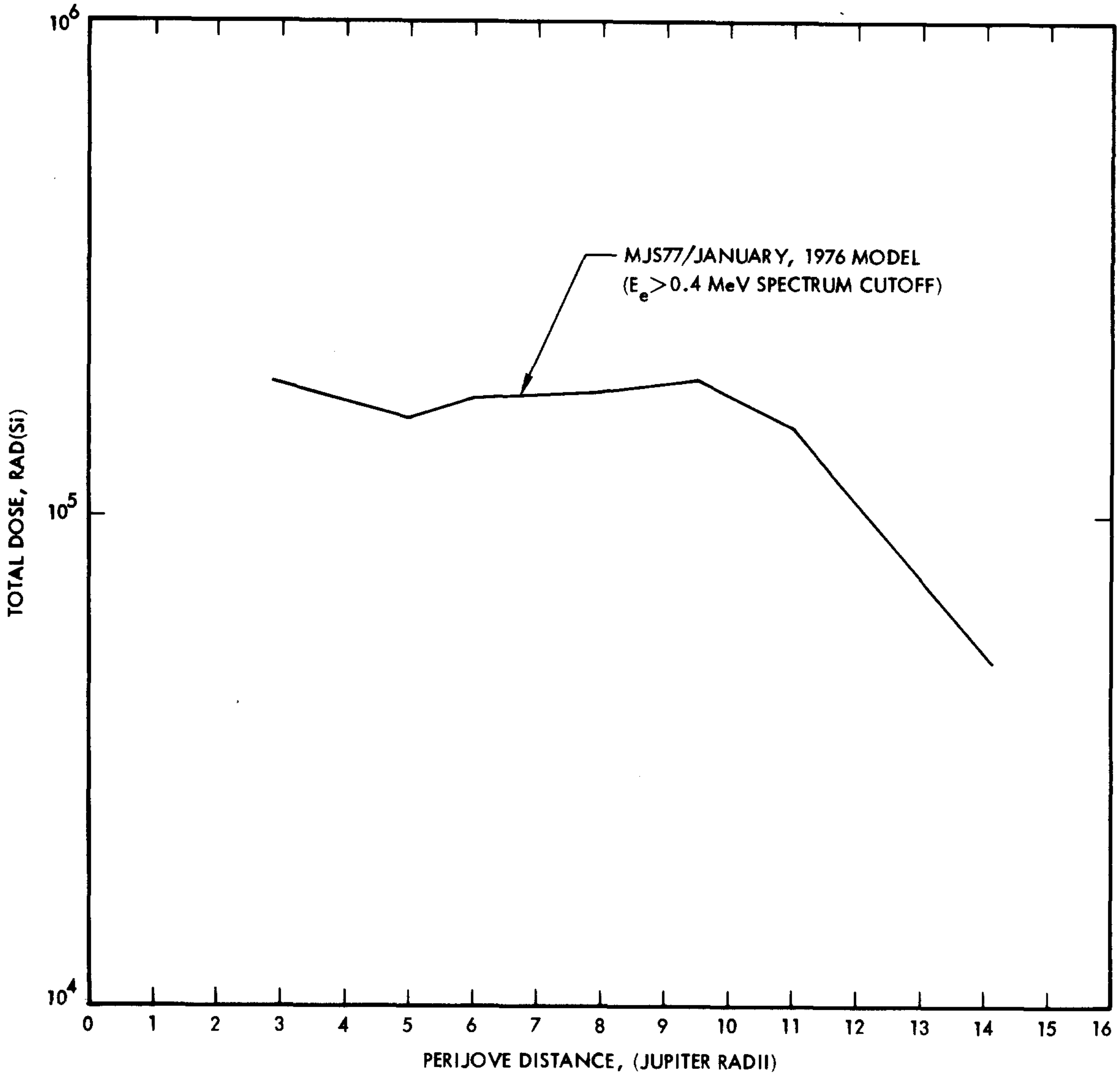
	PROTON ENERGY, E_p (MeV)	PROBABILITY THAT FLUX OR FLUENCE NOT BE EXCEEDED 50%	75%	90%	95%
DIFFERENTIAL PEAK FLUX, j ($cm^{-2}s^{-1}MeV^{-1}$)	1.0	2.4(5)	7.0(6)	7.0(6)	7.0(6)
	1.6	7.1(4)	2.2(6)	2.2(6)	2.2(6)
	2.5	2.2(4)	7.0(5)	7.0(5)	7.0(5)
	4.0	6.5(3)	2.2(5)	2.2(5)	2.2(5)
	6.3	2.0(3)	7.0(4)	7.0(4)	7.0(4)
	10.0	6.0(2)	2.2(4)	2.2(4)	2.2(4)
	16.0	1.8(2)	7.0(3)	7.0(3)	7.0(3)
	25.0	5.6(3)	2.2(3)	2.2(3)	2.2(3)
	40.0	1.6(1)	7.0(2)	7.0(2)	7.0(2)
	63.0	5.0(0)	2.2(2)	2.2(2)	2.2(2)
	100.0	1.5(0)	7.0(1)	7.0(1)	7.0(1)
DIFFERENTIAL FLUENCE, f ($cm^{-2}MeV^{-1}$)	1.0	2.1(10)	2.1(10)	2.1(10)	2.1(10)
	1.6	7.8(9)	8.1(9)	8.5(9)	9.8(9)
	2.5	3.0(9)	3.2(9)	3.6(9)	4.4(9)
	4.0	1.1(9)	1.3(9)	1.4(9)	1.9(9)
	6.3	4.3(8)	5.0(8)	6.0(8)	8.7(8)
	10.0	1.7(8)	2.0(8)	2.4(8)	3.8(8)
	16.0	3.6(7)	4.9(7)	1.5(8)	2.3(8)
	25.0	8.3(6)	3.0(7)	8.7(7)	1.4(8)
	40.0	2.5(6)	1.4(7)	4.2(7)	6.6(7)
	63.0	1.1(6)	5.6(6)	1.7(7)	2.6(7)
	100.0	2.3(5)	1.2(6)	3.6(6)	5.6(6)



* Figure B-1. Jupiter Equatorial Fluxes



* Figure B-2. Equivalent Fluence for Equatorial Jupiter Fly-Bys



* Figure B-3. Total Electron Spacecraft Surface Dose for Equatorial Jupiter Fly-Bys

APPENDIX C

RADIATION DISPLACEMENT DAMAGE AND IONIZATION DOSE CONVERSION FACTORS

APPENDIX C

Table C-1 and Figures C-1 through C-4 contain charged particle displacement damage factors and ionization dose conversions. Table C-1 provides listings of the equivalent displacement damage factors for protons, electrons, and neutrons, and the fluence to ionization dose conversion factors for protons, electrons, neutrons, and gammas. These listings cover the particle energy ranges of the radiation environments specified in Section 3.3.6 of this document. Figures C-1 through C-4 contain plots of the tabulated data for user convenience.

Table C-1. Table of Equivalent Displacement Damage and Ionization Dose Conversion Factors

E (MeV)	Protons		Electrons		Neutrons		Gammas
	Ionization (RAD[Si]/p/cm^2)	20-MeV Equivalent Displacement	Ionization (RAD[Si]/e/cm^2)	3-MeV Equivalent Displacement	Ionization (RAD[Si]/n/cm^2)	1-MeV Equivalent Displacement	Ionization (RAD[Si]/γ/cm^2)
0.01	1.00-5	354.0	2.70-7	0	—	—	5.35-9
0.015	1.00-5	253.0	2.00-7	0	—	—	2.10-9
0.02	1.00-5	173.0	1.62-7	0	—	—	1.10-9
0.03	1.00-5	114.0	1.26-7	0	—	—	5.00-10
0.045	1.00-5	74.3	8.94-8	0	1.0-12	0.10	2.35-10
0.065	8.50-6	50.4	6.92-8	0	1.1-12	0.10	1.31-10
0.10	6.90-6	31.7	5.23-8	0	1.0-12	0.10	7.35-11
0.15	6.11-6	20.4	4.14-8	.033	5.0-13	0.10	7.49-11
0.20	5.60-6	14.9	3.60-8	.060	1.7-11	0.83	9.37-11
0.30	4.85-6	9.42	3.04-8	0.087	1.0-11	0.71	1.47-10
0.45	4.12-6	5.91	2.70-8	0.15	1.1-11	0.83	2.15-10
0.65	3.44-6	3.82	2.53-8	0.23	1.7-11	1.70	3.06-10
1.00	2.82-6	2.26	2.45-8	0.38	2.0-11	1.00	4.43-10
1.50	2.17-6	2.26	2.42-8	0.57	2.7-11	1.25	6.07-10
2.00	1.81-6	2.26	2.45-8	0.73	3.2-11	1.37	7.70-10
3.00	1.36-6	2.26	2.50-8	1.00	5.6-11	1.60	1.05-9
4.50	1.01-6	1.77	2.58-8	1.23	8.4-11	1.83	1.45-9
6.50	7.72-7	1.49	2.64-8	1.49	6.0-10	2.00	1.88-9
10.0	5.57-7	1.28	2.72-8	1.84	1.0-9	2.16	2.60-9
15.0	4.07-7	1.15	2.78-8	2.24	7.0-10	2.30	4.18-9
20.0	3.25-7	1.00	2.83-8	2.57	—	—	5.54-9
30.0	2.36-7	0.920	2.90-8	3.13	—	—	8.40-9
45.0	1.72-7	0.745	2.96-8	3.82	—	—	—
65.0	1.29-7	0.563	3.01-8	4.56	—	—	—
100.0	9.37-8	0.345	3.07-8	5.63	—	—	—

NOTE: 1.00-5 = 1.00×10^{-5}

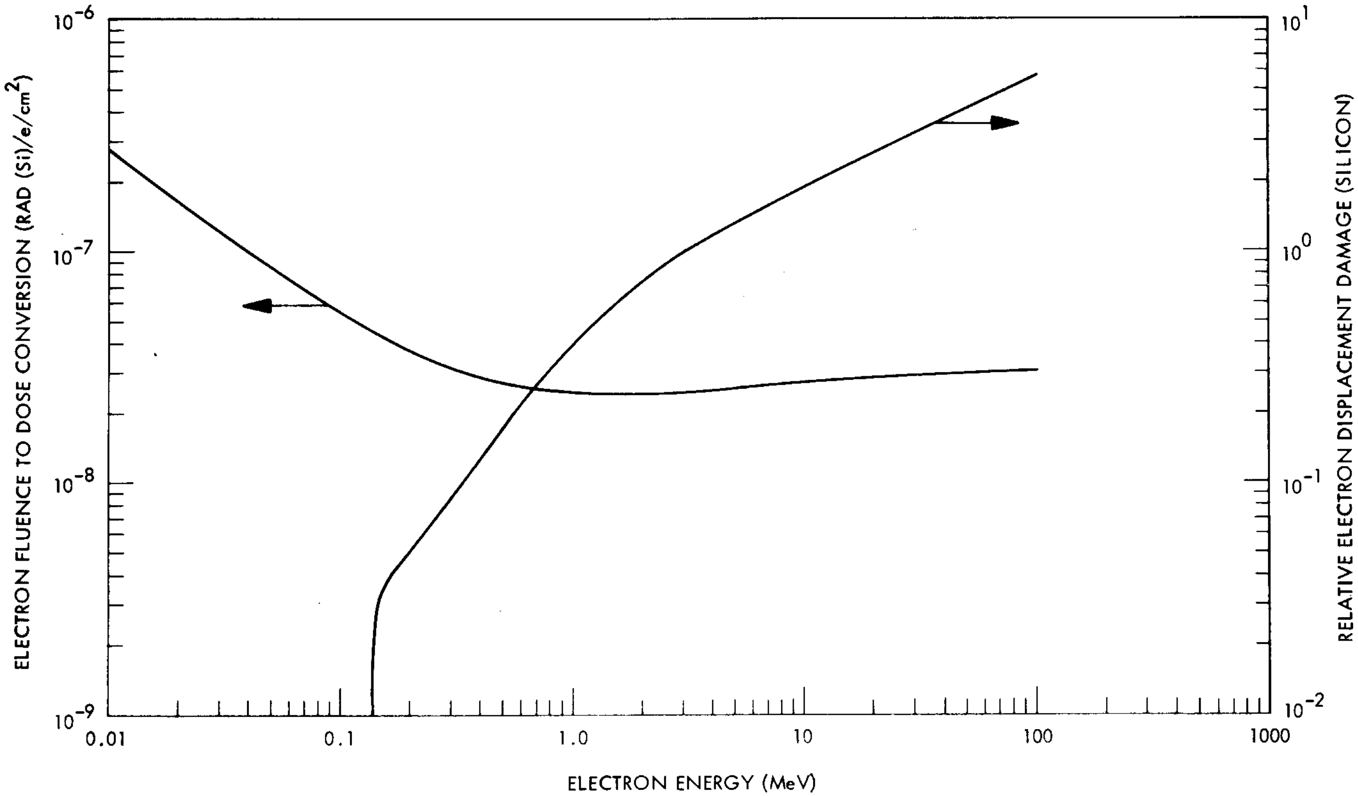


Figure C-1. Ionization Energy Deposition and 3-MeV Electron Equivalent Displacement Damage in Silicon

MJS77-3-240A

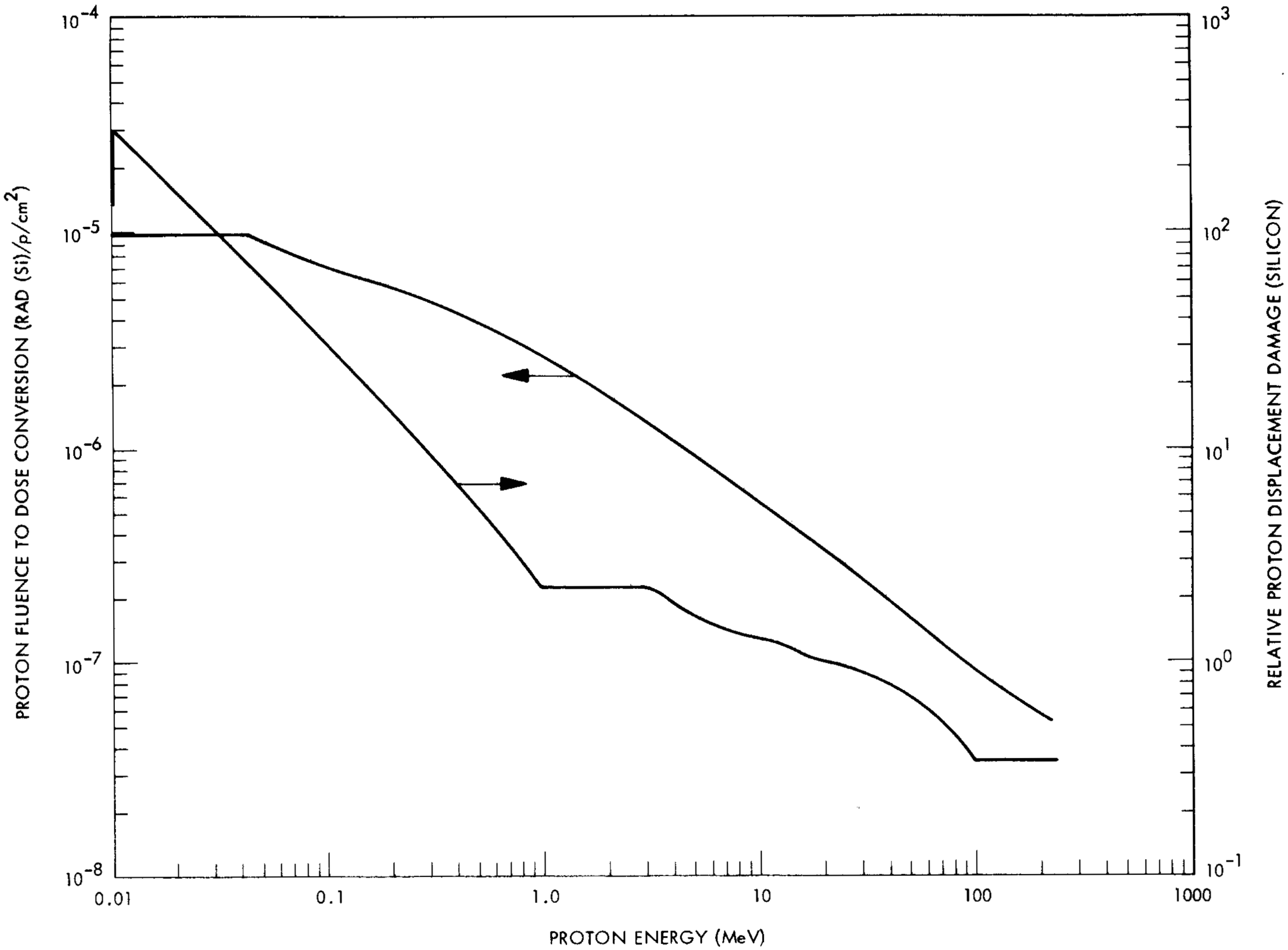


Figure C-2. Ionization Energy Deposition and 20-MeV Proton Equivalent Displacement Damage in Silicon

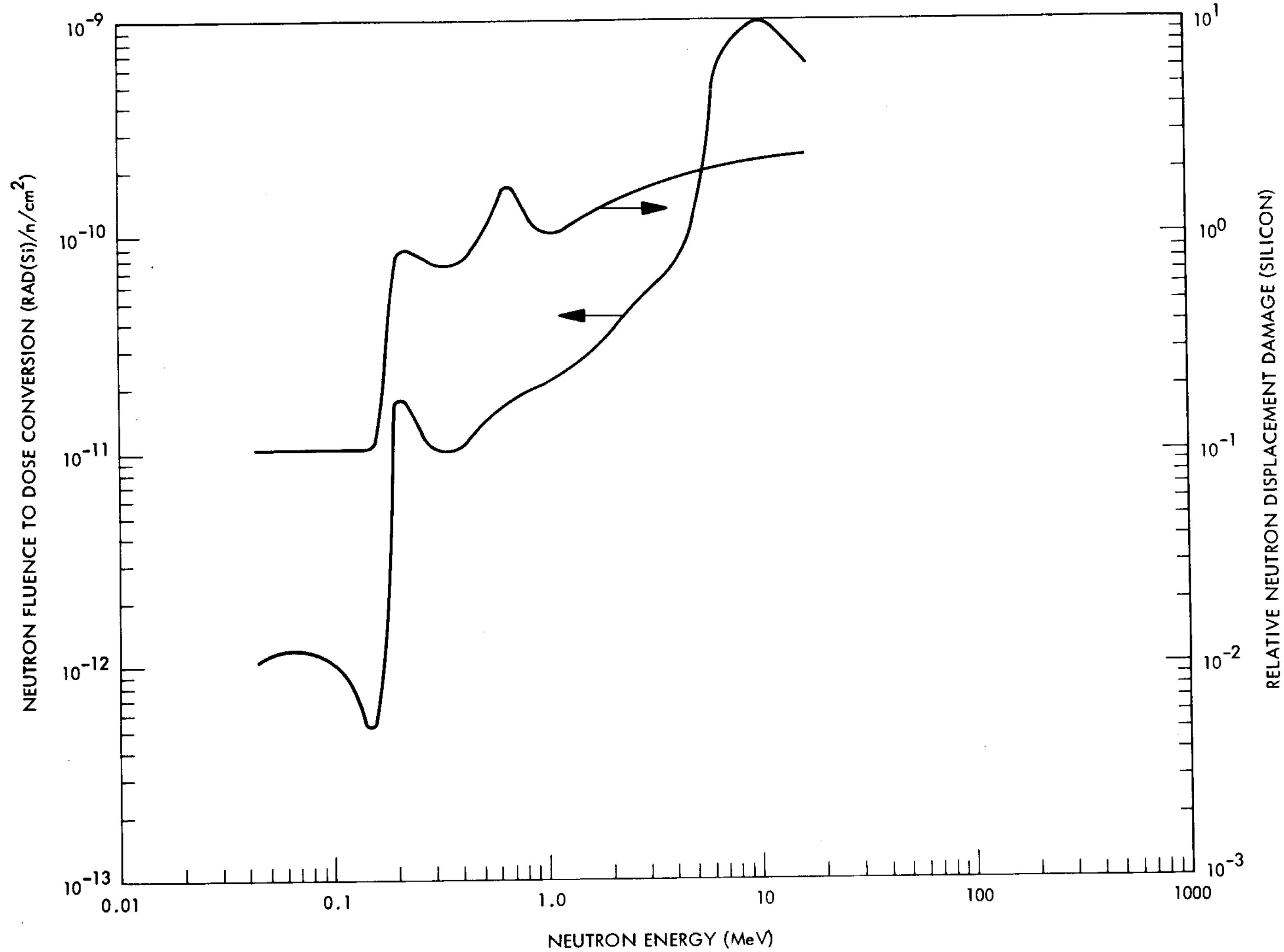


Figure C-3. Ionization Energy Deposition and 1-MeV Neutron Equivalent Displacement Damage in Silicon

MJS77-3-240A

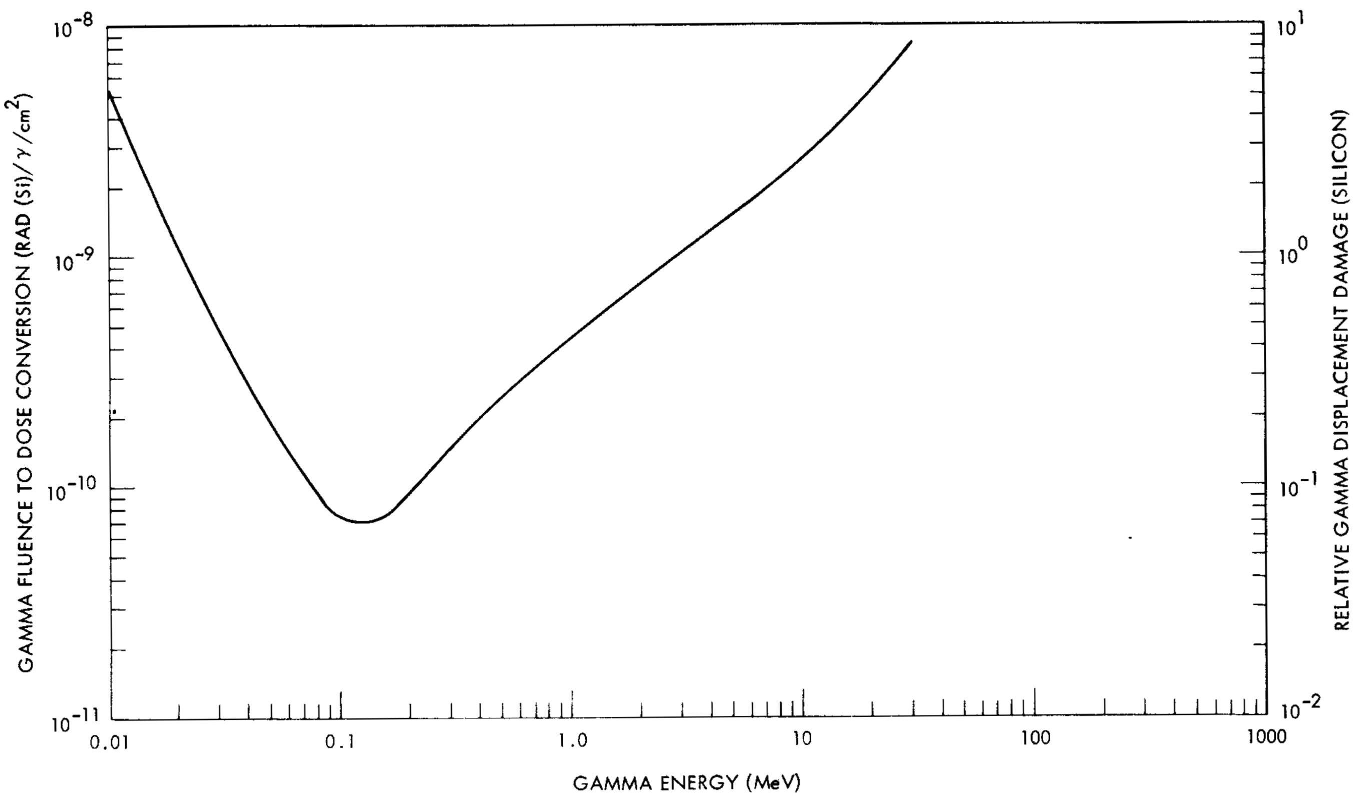


Figure C-4. Gamma Ionization Energy Deposition in Silicon

NASA — JPL — Coml., L.A., Calif.

7.3 Handling of Dangerous Material

Recognized safety practices and manufacturers instructions shall be followed in the handling of flammable or toxic materials.

FUNCTIONAL REQUIREMENT AMENDMENT

(Insert in 618-205, MJS77 Functional Requirements Book)

TITLE:

FUNCTIONAL REQUIREMENT
MARINER JUPITER/SATURN 1977
POWER PROFILE AND ALLOCATION

FR No. MJS77-3-250A

AMENDMENT No. 1

DATE: 14 February 1979

PER ECR No. N/A

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(Insert in 618-205, MJS77 Functional Requirements Book)

Custodian: G. E. Cunningham

APPROVED:

System: R. F. Draper

G. E. Cunningham

JET PROPULSION LABORATORY

No. MJS77-3-250A
8 June 1977

Supersedes
MJS77-3-250
8 July 1975

FUNCTIONAL REQUIREMENT
MARINER JUPITER/SATURN 1977
POWER PROFILE AND ALLOCATION

* Denote changes from previous issue

1.0 SCOPE

This document allocates the power to the Mariner Jupiter/Saturn 1977 (MJS77) spacecraft loads and identifies the expected power available for the major identifiable modes of operation throughout the mission. Power figures used herein represent the maximum steady-state power, at nominal voltages and the flight acceptance (FA) temperature ranges, allocated to spacecraft subsystems. Power switching requirements and load transient tables are also included.

2.0 APPLICABLE DOCUMENTS

The following documents form a part of this Functional Requirement:

NOTE

MJS77-3-100, Spacecraft Requirements and Constraints, applies to this document. Requirements of other MJS77 level three documents may also be applicable. It is the responsibility of the user to adequately acquaint himself with the organization and pertinent content of the level three documents, as well as with the material contained herein.

JPL 2600 3/76

REQUIREMENTS

Jet Propulsion Laboratory

MJS77-1-100	Functional Requirement, Mariner Jupiter/Saturn 1977 Introduction
MJS77-3-100	Functional Requirement, Mariner Jupiter/Saturn 1977 Spacecraft Requirements and Constraints
MJS77-3-120	Functional Requirement, Mariner Jupiter/Saturn 1977 Spacecraft Flight Sequence Implementation
MJS77-3-260	Functional Requirement, Mariner Jupiter/Saturn 1977 Electrical Grounding and Interfacing
MJS77-4-2004	Functional Requirement, Mariner Jupiter/Saturn 1977 Spacecraft Power Subsystem

3.0 ELEMENTS

3.1 Calculations

Table 1 lists the equations that are utilized in arriving at the total spacecraft power demand and margin as shown in the power profile subsystem summary (Table 6). They represent the equations used to make each calculation, and appear in the table in the same order as calculated. Figure 1 has been derived from Table 1. Figure 1 shows how the 2.4 kHz engineering and science loads and the dc loads are combined with the radioisotope thermoelectric generator (RTG) capabilities and how the power margins are established.

3.2 Power Equipment Efficiencies and Power Capabilities

Table 2 lists data points from the efficiency curves for the various power conversion equipment and data points from the RTG power capability curves.

3.3 Notes and Assumptions

Table 3 lists notes and assumptions pertinent to the power profile.

* 3.4 Power Modes

Table 4 is a listing of the major identifiable power operational modes. These significant modes of operation are derived from MJS77-3-120, Flight Sequence Implementation. Table 5 tabulates the power state of each subassembly/subsystem for every major identifiable power operational mode.

Table 6 summarizes and totals the subassembly/subsystem loads of Table 5 and compares them to the RTG power capability of Table 2 to calculate a power margin as a function of the flight mode.

* 3.5 Power Allocations

The loads of Table 7 shall be considered as the MJS77 subsystem and subassembly allocated power. These allocations shall be maximum values of the power (averages over 1/2 cycle, 220 μ seconds, for 2.4 kHz loads) at worst temperature (high power) within the FA temperature range at nominal voltage and with nominal circuit parameters.

Pulses of duration less than 1 millisecond and energy less than 1.5 milliwatt-seconds will be supplied by the energy storage elements within the power subsystem electronics. Pulsed loads of duration greater than 1 millisecond or of energy exceeding 1.5 milliwatt-seconds are shown in Table 8. DC loads are the peak values; 2.4 kHz loads are the average power for the half cycle that consumes the maximum power.

* 3.6 Load Transients

Operating transient loads, shown in Table 8, are load variations from the values listed in the subassembly detailed tabulation (Table 5), exclusive of turn-on transients and are commanded on only at times when sufficient spacecraft power is available.

Load increments shall conform to paragraph 3.6.2.3 of MJS77-3-100.

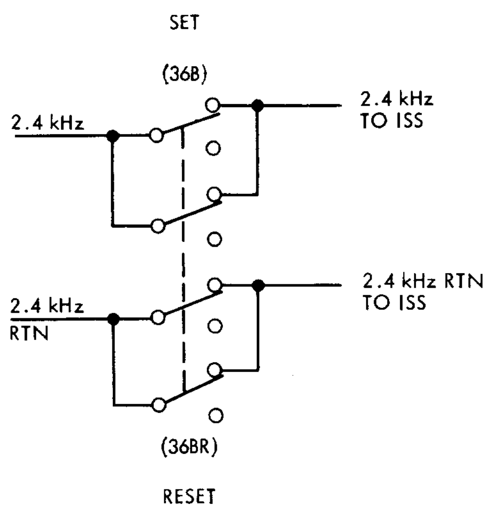
* 3.7 Subsystem Switching

Figure 2 shows the simplified schematic functional equivalents of the single thread and the dual relays used to swtich the MJS77 subsystem functions.

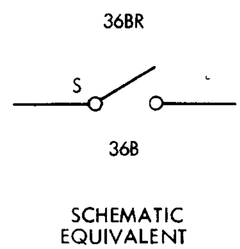
Three configurations are shown:

1) Single thread relays consisting of one "four-pole double-throw" (4PDT) relay performing an "ON/$\overline{\text{OFF}}$" function.

Example: ISS-WA PWR supply ON/OFF

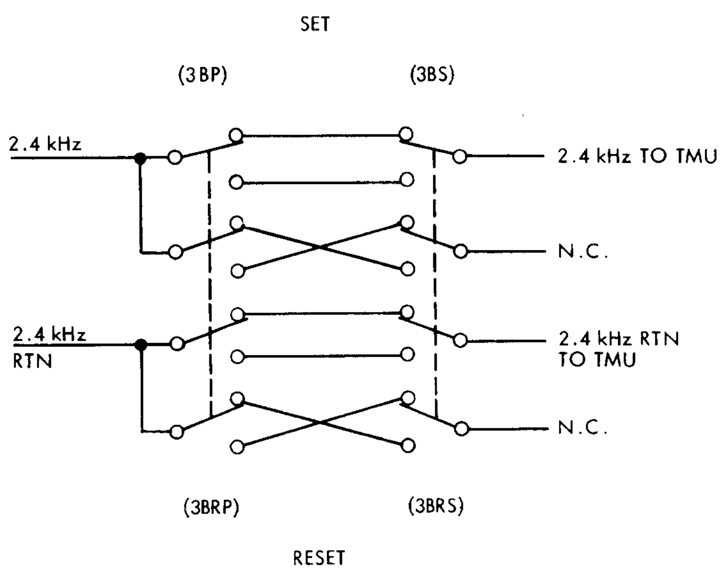


(1) 4-PDT RELAY

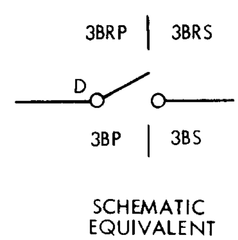


2) Dual relays consisting of two "four-pole double-throw" (4PDT) relays performing on "ON/$\overline{\text{OFF}}$" function.

Example: TMU ON/OFF

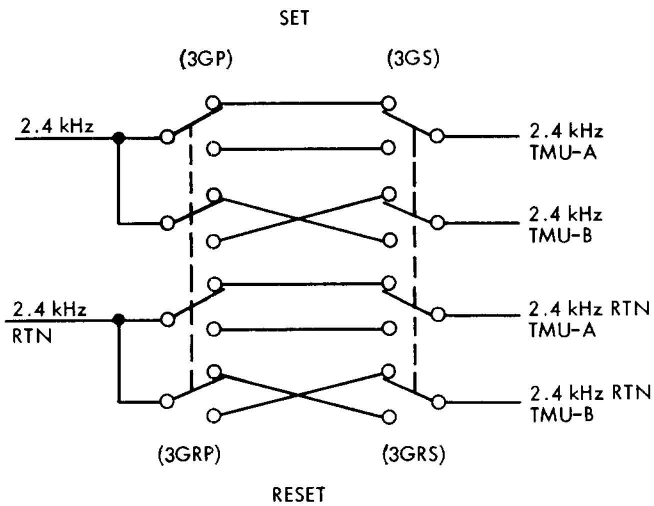


(2) 4-PDT RELAYS

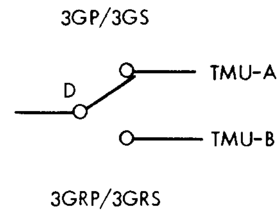


3) Dual relays consisting of two "four-pole double-throw (4DPT) relays performing a "SELECT" function.

Example: TMU-A/TMU-B SELECT



(2) 4-PDT RELAYS



SCHEMATIC EQUIVALENT

Table 1. Power Profile Equations

A.	2.4 kHz Inverter Engineering Load	=	MDS + PWR + CCS + FDS + AACS + PYRO + DSS
B.	2.4 kHz Inverter Science Load	=	PRA + PWS + LECP + PLS + UVS + MAG + ISS-N + ISS-W + MIRIS
C.	Total 2.4 kHz Inverter Load	=	A + B
D.	Power Factor Loss	=	$[1-(\text{Inverter Efficiency})]\ [(C)\ \left(\frac{1-Pf^2}{Pf^2}\right)]$
E.	2.4 kHz Inverter Input	=	C ÷ (Inverter Efficiency) Table 2
F.	2.4 kHz Inverter Loss	=	E - (C + D)
G.	Regulator DC Loads	=	RFS + PWR + DRIRU + PROP + SCI + TC/S + TC/E + Contingency Temperature Control Science
H.	Total DC Load	=	E + G
I.	Power Source Logic (PSL) Output Current	=	H ÷ 30 Vdc
J.	Power Source Distribution Cable Loss	=	I^2 (PSL/Distribution Resistance) Table 2
K.	Power Source Logic Output Wiring Loss	=	I^2 (PSL Output Wiring Resistance) Table 2
L.	Total DC Bus Power	=	H + J + K
M.	Total RTG Power Capability (MIN)	=	3 [RTG Power (Minimum)] x (End Heating Coefficient) Table 2
N.	Total Input Circuit Resistance	=	(RTG/PSL Cable Resistance) + (PSL Input Wiring Resistance) + (PSL Diode Resistance) Table 2
O.	Total RTG Current	=	[(M ÷ 30 V) - (Diode Voltage ÷ RTG Resistance)] ÷ [1 + (N ÷ RTG Resistance)] Table 2
P.	RTG Cable Loss	=	O^2 (RTG/PSL Resistance) Table 2
Q.	Power Source Logic Input Circuit Loss	=	O^2 [(N - (RTG/PSL Cable Resistance)] + O (Diode Voltage)
R.	Net Power Capability	=	M - P - Q
S.	Power Margin	=	R - L
T.	Shunt Regulator + Shunt Radiator Dissipation Power	=	S + Contingency - Regulator Cable Loss
U.	Repeat steps M through T for most probable RTG power capability.		

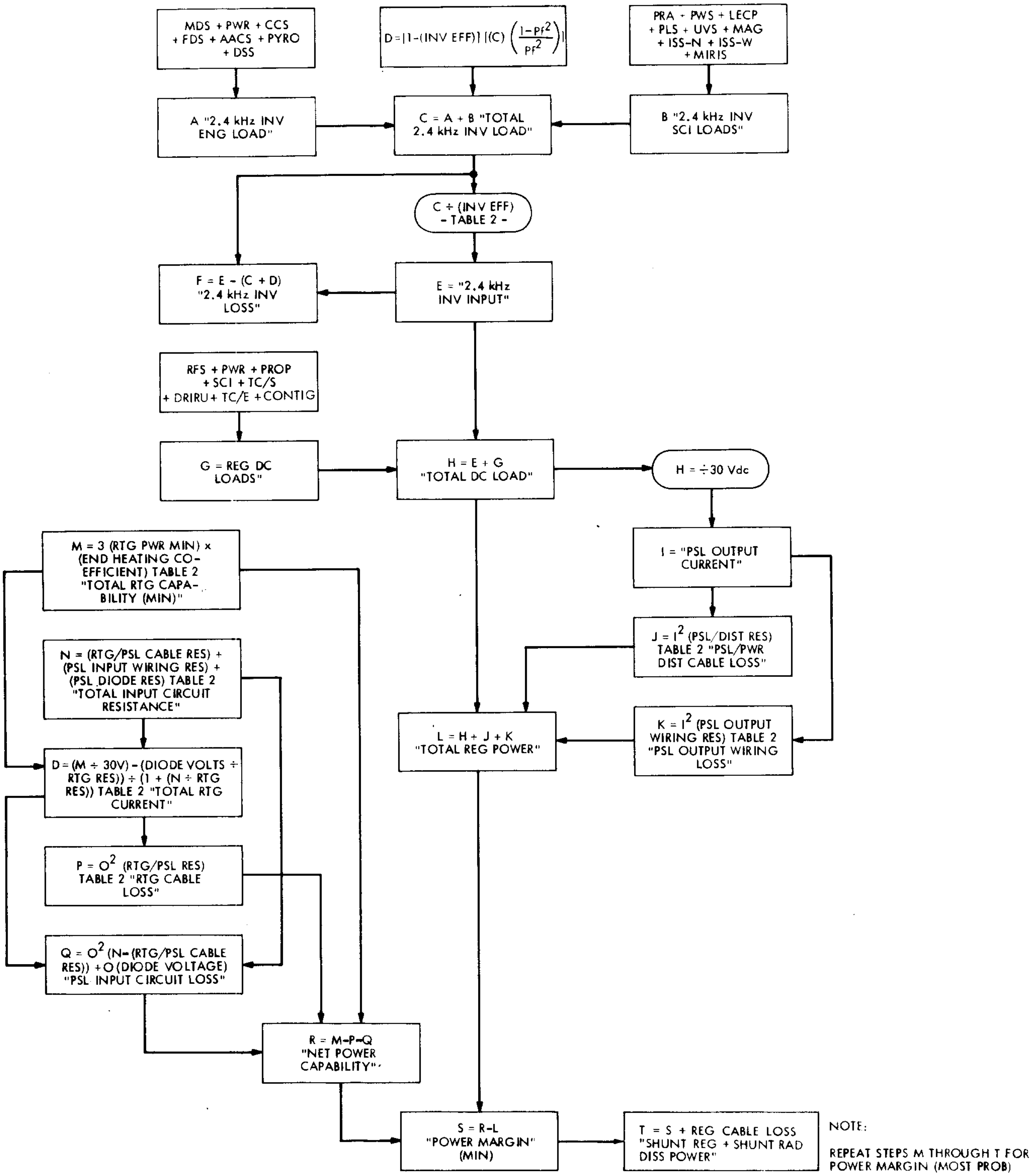


Figure 1. MJS77 Power Profile Program Flow Diagram

Table 2. MJS77 Power Profile Power Efficiencies

2.4KHZ INV EFFICIENCY

PWR	100.0000	125.0000	150.0000	175.0000	200.0000	225.0000	250.0000	275.0000	300.0000
EFF	.9530	.9550	.9555	.9550	.9530	.9500	.9470	.9450	.9425

RTG POWER

	RTG NO.	UNSHORT	U+ 5M	U+ 10M	U+ 20M	U+ 40M	U+ 60M	U+ 80M	U+120M	U+200M	U+300M
MINIMUM											
	1	91.48	93.87	95.51	97.57	99.97	101.60	102.69	104.22	106.94	108.03
	2	91.73	94.13	95.86	97.84	100.25	101.88	102.98	104.50	107.23	108.33
	3	92.48	94.91	95.67	98.65	101.07	102.72	103.82	105.37	108.12	109.22
MOST PROBABLE											
	1	94.33	95.80	98.60	100.62	103.09	104.78	105.90	107.47	110.28	111.40
	2	94.33	96.80	98.60	100.62	103.09	104.78	105.90	107.47	110.28	111.40
	3	96.18	98.70	100.55	102.59	105.11	106.83	107.97	109.58	112.44	113.58

		LAUNCH	L+ 10M	L+ 20M	L+ 30M	L+ 60M	L+100M	L+110M	L+115M	L+130M	L+200M	L+400M
MINIMUM												
	1	108.90	91.40	88.20	90.50	104.20	117.20	118.60	123.70	127.20	132.60	143.30
	2	109.20	89.90	86.50	88.80	102.50	116.00	117.40	122.80	126.30	133.60	144.30
	3	110.10	91.40	88.20	90.50	104.30	117.80	117.20	124.40	128.00	135.00	145.00
MOST PROBABLE												
	1	112.30	96.90	93.50	95.90	110.00	123.50	124.90	130.20	133.80	139.40	149.80
	2	112.30	95.00	91.60	94.00	108.10	122.00	123.40	128.90	132.50	140.00	150.40
	3	114.30	97.80	94.40	96.80	111.20	125.20	124.60	132.10	135.80	143.10	152.80

		YEAR -00-	YEAR -01-	YEAR -02-	YEAR -03-	YEAR -04-	YEAR -05-	YEAR -06-	YEAR -07-	YEAR -08-
MINIMUM										
	1	148.30	143.80	137.10	130.60	123.90	115.00	106.50	97.00	85.00
	2	148.40	144.10	137.50	130.80	124.20	115.10	106.50	97.00	85.00
	3	150.30	145.80	139.80	132.80	126.20	116.00	107.00	97.50	95.00
MOST PROBABLE										
	1	152.90	148.40	144.90	141.80	139.00	136.20	134.00	132.30	131.00
	2	152.90	148.30	144.60	141.50	138.90	136.20	134.00	132.30	131.00
	3	155.00	150.00	146.30	143.30	140.50	137.00	134.20	132.50	131.00

END HEATING COEFFICIENTS,RTG 1,2,3 1.0000 1.0000 1.0000

* Table 3. MJS77 Power Profile

Notes and Assumptions:

1. All power values are in watts.

2. Each power entry includes the load and its transformer/rectifier ineff- ciency as applicable.

3. The loads shown are estimated or measured maximum values of the power (averaged over 1/2 cycle, 220 μ seconds, for 2.4 kHz loads) at worst temperature (high power) within the FA temperature range at nominal voltage and with nominal circuit parameters.

   Pulses of duration less than 1 millisecond and energy less than 1.5 milliwatt-seconds will be supplied by the energy storage elements within the power subsystem electronics. Pulsed loads of duration greater than 1 millisecond or of energy exceeding 1.5 milliwatt-seconds are shown in Table 8. DC loads are the peak values; 2.4 kHz loads are the average power for the half cycle that consumes the maximum power.

4. Loads that are sequenced so their power requirements can be time shared are indicated by a common alphabetic character following their power tabulation. The time shared loads not included in the summation for the subsystem summary are enclosed with ( ).

   PLS instrument is allocated 8.3 watts peak and PLS supplemental allocated 4.6 watts maximum. These will be time shared so that total power does not exceed 8.3 watts. On the power profile, the electronics will be shown as 8.3 watts and the electronic supplental will be as shown as 0 watts.

5. Power is allocated for slewing the scan platform only one axis at a time.

6. Cable losses are calculated by computing the total current at the rated line voltage for the power handled and multiplying the square of the current by the line resistance. The RTG cable resistance is one-third the average resistance of the three cables.

7. At least one TWTA shall be powered at all times, and the X-band and S-band TWTAs shall not be operated in the high power modes simul- taneously (temperature control requirement).

8. A maximum of 150 watts at 32 volts dc is supplied directly to the IPU-REA valve drivers from the battery during injection.

9. Gyro powers shown during launch phase are of short duration and occur only during periods of high vehicle rates. Gyro power specifics are shown in Table 9.

Table 3. MJS77 Power Profile (contd)

10. LECP stepper motor power assumes 50 Hz mode. 60 Hz mode is commandable and may be selected in flight if boom resonance characteristics allow. 60 Hz mode will decrease power consumption by approximately 17 percent for modes indicated, to 0.35 W and 1.33, respectively.

11. Uranus modes are included for informational purposes only.

12. Several modes have power requirements which exceed the most probable RTG capabilities. These mission mode listings represent current mission planning baseline requirements using allocated (not actual) power. Where necessary, actual mission modes may have to be modified in light of actual subsystem power consumption and actual RTG capability.

Table 4. MJS77 Power Profile Operational Modes

Mode No.	Time	Name	Description/Sequence
1	L-480 Minutes	UNSHORT (RTG UNSHORT)	Minimum S/C Load
2	L-477 Minutes	TURN ON	Minimum S/C Load to Process TLM Information
3	L-312 Minutes	POWER ON	Turn ON Pre-Launch Loads - Gyros Low Rate - DSS ON
4	L+/-0 Minutes	LAUNCH	2 Gyros at Low Rate Saturated - IPU Htrs ON - TCAPU Htrs ON
5	L+10 Minutes	MECO 1	Begin Parking Orbit Coast
6	L+12 Minutes	COAST 1	2 Gyros at Low Rate - BRI Htr ON
7	L+20 Minutes	MIN PWR	Minimum RTG Power After Vent
8	L+40 Minutes	COAST 2	Pyro/TCAPU/CCS Pre-Arm
9	L+42 Minutes	MES 2	2 Gyros Low Rate Saturated - IPU Red Valve Htrs OFF
10	L+51 Minutes	MECO 2	2 Gyros High Rate
11	L+52 Minutes	SOLID ROCKET MOTOR BURN	PSU Event - TCAPU and IPU Htrs OFF
12	L+53 Minutes	POST INJECTION	TCAPU and IPU Htrs ON
13	L+56 Minutes	DEPLOY 1	RTG Boom Set 2 Release
14	L+56 Minutes	DEPLOY 2	Science Boom and RTG Boom Set 1 Release
15	L+65 Minutes	P.M. JETTISON	IPU and TCAPU Htrs OFF - PSU Event
16	L+69 Minutes	MAG BOOM DEPLOY	MAG Boom Deployed - MAG ON - PSU Event
17	L+114 Minutes	SUN ACQUIRE	Start Sun Acquire
18	L+125 Minutes	ANT DEPLOY	PRA/PWS Antenna Deploy
19	L+150 Minutes	CANOPUS ACQUIRE	2 Gyros Low Rate
20	L+240 Minutes	FIRST CRUISE	S-Band Hi Power - DSS OFF
21	L+285 Minutes	HEATERS ON	Repl Htrs ON
22	L+360 Minutes	NEAR EARTH	Science, S-HI, X-L0
23	L+48 Hours	USO ON	USO ON
24	L+3 Days	EARTH CRUISE	RTG Max Power
25	L+1.8 Year	CRUISE	Cruise From Earth to Jupiter - RTG at 2 Year Power
26	L+1.8 Year	CRUISE TRACKING	Earth to Jupiter Every 2 Weeks
27	L+1.8 Year	SCIENCE MANEUVER	Earth to Jupiter Every 2 Months - DSS ON
28	L+1.8 Year	PLAYBACK	Earth to Jupiter Data Return and Tracking
29	L+1.8 Year	TCM	Earth to Jupiter Orientation for Firing
30	L+1.8 Year	FIRING	Earth to Jupiter Firing
31	L+1.9 Year	FAR ENCOUNTER (J)	Science ON - S-Band HI, X-Band L0
32	L+1.9 Year	FAR ENC (J)	Gyros OFF - DSS ON S-Low X-High
33	L+1.9 Year	NEAR ENCOUNTER (J)	Gyros ON - 2 Low Rate
34	L+1.9 Year	IO ENCOUNTER	LECP Stepper HI Power
35	L+1.9 Year	OCCULTATION (J)	Gyros ON, LECP Stepper Low Power, MAG Sen Htr Off
36	L+2 Year	POST ENCOUNTER (J)	Gyros ON, MAG Sen Htr ON
37	L+4.0 Year	CRUISE	Jupiter to Saturn Cruise - DSS OFF
38	L+4.0 Year	CRUISE TRACKING	Jupiter to Saturn Every 2 Weeks
39	L+4.0 Year	SCIENCE MANEUVER	Jupiter to Saturn Every 2 Months - DSS ON
40	L+4.0 Year	PLAYBACK	Jupiter to Saturn Data Return and Tracking
41	L+4.0 Year	TCM	Jupiter to Saturn Orientation for Firing
42	L+4.0 Year	FIRING	Jupiter to Saturn Firing - S-Low, X-Off
43	L+4.1 Year	FAR ENCOUNTER (S)	Encounter Instruments ON - S-Low - X-High
44	L+4.1 Year	FAR ENC (S2)	DSS ON - Gyros OFF S-Low X-High
45	L+4.1 Year	NEAR ENCOUNTER 1 (S)	Gyros ON - DSS OFF
46	L+4.1 Year	NEAR ENCOUNTER 2 (S)	Gyros ON - DSS ON - S-Low - X-Low
47	L+4.1 Year	OCCULTATION (S)	Gyros ON - DSS ON - S-Low - X-Low
48	L+4.2 Year	POST ENCOUNTER 1 (S)	Gyros ON - DSS ON - S-Low - X-Low
49	L+4.2 Year	POST ENCOUNTER 2 (S)	Gyros OFF - DSS ON - S-Low - X-High
50	L+4.2 Year	POST ENCOUNTER 3 (S)	Gyros OFF - DSS OFF - S-Low - X-High
51	L+8.0 Year	FAR ENCOUNTER 1 (U)	Gyros OFF - DSS OFF - S-Low X-Low
52	L+8.0 Year	FAR ENCOUNTER 2 (U)	Gyros OFF - DSS ON - S-Off X-Low
53	L+8.0 Year	FAR ENCOUNTER 3 (U)	Gyros OFF - DSS ON - S-Off X-High
54	L+8.0 Year	FAR ENCOUNTER 4 (U)	Gyros OFF - DSS ON - S-Low X-Off

* Table 5. MJS77 Power Profile Subassembly Detail Tabulation (sheet 1 of 6)

OPERATIONAL MODE	UNSHRT (1) L-480M	TURNON (2) L-477M	PWR ON (3) L-312M	LAUNCH (4) L+ 0M	MECO 1 (5) L+ 10M	COAST 1 (6) L+ 12M	MINPWR (7) L+ 20M	COAST 2 (8) L+ 40M	MES 2 (9) L+ 42M	MECO 2 (10) L+ 48M
2.4KHZ INV ENG LOADS										
MDS TMU	.00	5.05	5.05	5.05	5.05	5.05	5.05	5.05	5.05	5.05
CDU	5.35	5.35	5.35	5.35	5.35	5.35	5.35	5.35	5.35	5.35
PWR TLM	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12
DISTRIBUTION	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52
DISCHARGE CON	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10
CCS	26.06	26.06	26.06	23.74	23.74	23.74	23.74	23.74	23.74	23.74
FDS	.00	14.14	14.14	14.14	14.14	14.14	14.14	14.14	14.14	14.14
AACS PROCESSOR	22.32	22.32	22.32	22.32	22.32	22.32	22.32	22.32	22.32	22.32
MAJOR PWR SUP	.00	.00	14.44	14.44	14.44	14.44	14.44	14.44	14.44	14.44
AP THRUSTERS	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
AP TH REP HTR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
CST	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
SUN SHUTTER	.00	.00	5.05	5.05	5.05	5.05	5.05	5.05	5.05	5.05
SUN SENSOR	.00	.00	.85	.85	.85	.85	.85	.85	.85	.85
SCAN ACT	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
SCAN POTS	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PYRO INSTM	.00	.00	3.84	3.84	3.84	3.84	3.84	3.84	3.84	3.84
PSU	.00	.00	.00	.00	.00	.00	.00	.00	.00	.52
DSS	.00	.00	20.20	22.73	22.73	22.73	22.73	22.73	22.73	22.73
REPL HTR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
STRU BAY 1 HTR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
BAY 2 HTR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
BAY 6 HTR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PROP TCM HTR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
2.4KHZ INV SCI LOADS										
SCI PRA	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PWS	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
LECP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PLS	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
UVS	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
MAG	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
MAG SEN HTRS	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
ISS	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
MIRIS STBY	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
MIRIS PRI	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
REGULATED DC LOADS										
RFS ACIS AND SW	.87	.87	.87	.87	.87	.87	.87	.87	.87	.87
RCVR	5.30	5.30	5.30	5.30	5.30	5.30	5.30	5.30	5.30	5.30
S-BAND EXC	.00	.00	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37
S-BAND TWT	.00	.00	34.70	34.70	34.70	34.70	34.70	34.70	34.70	34.70
X-BND EXCITER	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
X-BAND TWT	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
USO	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PWR POWER CONTROL	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02
SHUNT REG	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02
DISCHARGE CON	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
FDS	.60	.00	.00	.00	.00	.00	.00	.00	.00	.00
AACS GYROS	.00	.00	15.06	44.20	44.20	20.60	20.60	20.60	44.20	27.60
SCI CRS	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
LECP STEPPER	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PPS	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PRA ANT MOTOR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
TC/S CRS SUPP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
CRS REPL	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
LECP MAIN SUP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
LECP LEPT SUP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
LECP REPL	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PPS SUPP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PLS REPL	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PLS SUPP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
UVS REPL	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
ISS-N OPTICS	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
ISS-N VID REP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
ISS-W VID REP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
ISS-N ELE REP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
ISS-W ELE REP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
MIRIS REPL	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
TC/E AZ ACT REP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
SUN SEN HTR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
IPU VALVE HTR	.00	.00	20.31	20.31	20.31	20.31	20.31	20.31	20.31	20.31
IPU RED V HTR	.00	.00	14.92	14.92	14.92	14.92	14.92	14.92	14.92	14.92
IPU THRUS HTR	.00	.00	18.40	18.40	18.40	18.40	18.40	18.40	.00	.00
TCAPU RED HTR	.00	.00	.00	.00	.00	.00	11.77	11.77	11.77	11.77
SCN PLTFM HTR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

Table 5. MJS77 Power Profile Subassembly Detail Tabulation (sheet 2 of 6)

OPERATIONAL MODE		SRMBRN (11) L+ 51M	PSTINJ (12) L+ 52M	DEPLOY 1 (13) L+ 53M	DEPLOY 2 (14) L+ 56M	PM JET (15) L+ 65M	MAGDEP (16) L+ 69M	SUN AQ (17) L+114M	ANTDEP (18) L+125M	CANOP AQ (19) L+15CM	FIRST CR (20) L+240M
2.4KHZ INV ENG LOADS											
MDS	TMU	5.05	5.05	5.05	5.05	4.65	4.65	4.65	4.65	4.65	4.65
	CDU	5.35	5.35	5.35	5.35	5.35	5.35	5.35	5.35	5.35	5.35
PWR	TLM	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12
	DISTRIBUTION	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52
	DISCHAREE CON	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10
CCS		26.06	26.06	26.06	26.06	26.06	26.06	26.06	26.06	26.06	26.06
FDS		14.14	14.14	14.14	14.14	14.14	14.14	14.14	14.14	14.14	14.14
AACS	PROCESSOR	22.32	22.32	22.32	22.32	22.32	22.32	22.32	22.32	22.32	22.32
	MAJOR PWR SUP	14.44	14.44	14.44	14.44	14.44	14.44	14.44	14.44	14.44	14.44
	AP THRUSTERS	.00	.00	.00	.00	(5.05)B	(5.05)B	(5.05)B	(5.05)B	(5.05)B	(5.05)B
	AP TH REP HTR	.00	.00	.00	.00	13.20 B	13.20 B	13.20 B	13.20 B	13.20 B	13.20 B
	CST	.00	.00	.00	.00	.00	.00	.00	2.53	2.53	2.53
	SUN SHUTTER	.00	5.05	5.05	5.05	5.05	5.05	.00	.00	.00	.00
	SUN SENSOR	.85	.85	.85	.85	.85	.85	.85	.85	.35	.85
	SCAN ACT	.00	.00	.00	5.05	5.05	5.05	5.05	5.05	5.05	5.05
	SCAN POTS	.00	.00	.00	.17	.17	.17	.17	.17	.17	.17
PYRO	INSTM	3.84	3.84	3.84	3.84	3.84	2.83	2.83	2.83	2.83	2.83
	PSU	25.45	.52	25.45	.52	25.45	25.45	.00	.00	.00	.00
DSS		22.73	22.73	22.73	22.73	22.73	22.73	22.73	27.00	27.00	27.00
	REPL HTR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
STRU	BAY 1 HTR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	BAY 2 HTR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	BAY 6 HTR	.00	.00	.00	.00	.00	.00	.00	.00	.00	16.40
PROP	TCM HTR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
2.4KHZ INV SCI LOADS											
SCI	PRA	.00	.00	.00	.00	.00	.00	.00	6.35	6.35	6.35
	PWS	.00	.00	.00	.00	.00	.00	.00	1.38	1.38	1.38
	LECP	.00	.00	.00	.00	.00	4.12	4.12	4.12	4.12	4.12
	PLS	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	UVS	.00	.00	.00	.00	.00	.00	.00	1.97	1.97	1.97
	MAG	.00	.00	.00	.00	.00	3.28	2.78	2.78	2.78	2.78
	MAG SEN HTRS	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	ISS	.00	.00	.00	.00	.00	.00	.00	.00	.00	41.71
	MIRIS STBY	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
	MIRIS PRI	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
REGULATED DC LOADS											
RFS	ACIS AND SW	.87	.87	.87	.87	.87	.87	.87	.87	.97	.87
	RCVR	5.30	5.30	5.30	5.30	5.30	5.30	5.30	5.30	5.30	5.30
	S-BAND EXC	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37
	S-BAND TWT	34.70	34.70	34.70	34.70	34.70	34.70	34.70	34.70	34.70	89.70
	X-BND EXCITER	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	X-BAND TWT	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	USO	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PWR	POWER CONTROL	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02
	SHUNT REG	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02
	DISCHARGE CON	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
FDS		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
AACS	GYROS	72.00	36.62	27.60	27.60	27.60	27.60	16.86	16.86	16.86	.00
SCI	CRS	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	LECP STEPPER	.00	.00	.00	.00	.00	.42	.42	.42	.42	.42
	PPS	.00	.00	.00	.00	.00	.00	.00	.00	.00	2.42
	PRA ANT MOTOR	.00	.00	.00	.00	.00	.00	.00	15.00	.00	.00
TC/S	CRS SUPP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	CRS REPL	.00	.00	.00	.00	.00	5.23	5.23	5.23	5.23	5.23
	LECP MAIN SUP	.00	.00	.00	.00	.00	4.15	4.15	4.15	4.15	4.15
	LECP LEPT SUP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	LECP REPL	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	PPS SUPP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	PLS REPL	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	PLS SUPP	.00	.00	.00	.00	.00	4.60	4.60	4.60	4.60	4.60
	UVS REPL	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	ISS-N OPTICS	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	ISS-N VID REP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	ISS-W VID REP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	ISS-N ELE REP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	ISS-W ELE REP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	MIRIS REPL	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
TC/E	AZ ACT REP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	SUN SEN HTR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	IPU VALVE HTR	.00	20.31	20.31	20.31	20.31	3.35	3.35	3.35	3.35	3.35
	IPU RED V HTR	.00	14.92	14.92	14.92	14.92	2.97	2.97	2.97	2.97	2.97
	IPU THRUS HTR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	TCAPU RED HTR	.00	11.77	11.77	11.77	11.77	11.77	.00	.00	.00	.00
	SCN PLTFM HTR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

Table 5. MJS77 Power Profile Subassembly Detail Tabulation (sheet 3 of 6)

	OPERATIONAL MODE	HEATER ON (21) L+285M	NRERTH SC (22) L+360M	USO ON (23) L+ 48H	EARTH CR (24) L+ 30	CRUISE (25) L+1.8Y	CRUISE TR (26) L+1.8Y	SCI MV (27) L+1.8Y	PLAYBK TR (28) L+1.8Y	MANV OR (29) L+1.8Y	FIRING (30) L+1.8Y
2.4KHZ INV ENG LOADS											
MDS	TMU	4.65	4.65	4.65	4.65	4.65	4.65	4.65	4.65	4.65	4.65
	CDU	5.35	5.35	5.35	5.35	5.35	5.35	5.35	5.35	5.35	5.35
PWR	TLM	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12
	DISTRIBUTION	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52
	DISCHARGE CON	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10
CCS		26.06	26.06	26.06	26.06	23.74	23.74	26.06	26.06	26.06	26.06
FDS		14.14	14.14	14.14	14.14	12.02	12.02	12.02	12.02	14.14	14.14
AACS	PROCESSOR	22.32	22.32	22.32	22.32	22.32	22.32	22.32	22.32	22.32	22.32
	MAJOR PWR SUP	14.44	14.44	14.44	14.44	14.44	14.44	14.44	14.44	14.44	14.44
	AP THRUSTERS	(5.05)B	(5.05)B	(5.05)B	(5.05)B	(5.05)B	(5.05)B	(5.05)B	(5.05)B	(5.05)B	25.25 B
	AP TH REP HTR	13.20 B	13.20 B	13.20 B	13.20 B	13.20 B	13.20 B	13.20 B	13.20 B	13.20 B	(13.20)B
	CST	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53
	SUN SHUTTER	.00	.00	.00	.00	.00	.00	5.05	.00	5.05	5.05
	SUN SENSOR	.85	.85	.85	.85	.85	.85	.85	.85	.85	.85
	SCAN ACT	5.05	5.05	5.05	5.05	5.05	5.05	5.05	5.05	5.05	5.05
	SCAN POTS	.17	.17	.17	.17	.17	.17	.17	.17	.17	.17
PYRO	INSTM	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83
	PSU	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
DSS		27.00	27.00	27.00	27.00	.00	.00	27.00	27.00	27.00	27.00
	REPL HTR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
STRU	BAY 1 HTR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	BAY 2 HTR	.00	.00	.00	.00	19.20	19.20	.00	.00	.00	.00
	BAY 6 HTR	16.40	16.40	16.40	16.40	16.40	16.40	.00	16.40	.00	.00
PROP	TCM HTR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
2.4KHZ INV SCI LOADS											
SCI	PRA	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35
	PWS	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38
	LECP	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12
	PLS	.00	.00	8.30	8.30	8.30	8.30	8.30	8.30	8.30	8.30
	UVS	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97
	MAG	2.78	2.78	2.78	2.78	2.78	2.78	3.28	2.78	2.78	2.78
	MAG SEN HTRS	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02
	ISS	41.71	41.71 A	41.71 A	41.71 A	.00	.00	.00	.00	.00	.00
	MIRIS STBY	1.60	1.60	1.60	1.60	7.90	7.90	7.90	7.90	7.90	7.90
	MIRIS PRI	.00	(15.60)A	(15.60)A	(15.60)A	.00	.00	15.60	.00	.00	.00
REGULATED DC LOADS											
RFS	ACIS AND SW	.87	.87	.87	.87	.87	.87	.87	.87	.87	.87
	RCVR	5.30	5.30	5.30	5.30	5.30	5.30	5.30	5.30	5.30	5.30
	S-BAND EXC	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37
	S-BAND TWT	89.70	89.70	89.70	89.70	89.70	34.70	89.70	34.70	89.70	89.70
	X-BND EXCITER	.00	3.30	3.30	3.30	.00	3.30	.00	3.30	.00	.00
	X-BAND TWT	.00	49.30	49.30	45.30	.00	49.30	.00	72.60	.00	.00
	USO	.00	.00	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30
PWR	POWER CONTROL	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02
	SHUNT REG	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02
	DISCHARGE CON	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
FDS		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
AACS	GYROS	.00	.00	.00	.00	.00	.00	16.86	.00	16.86	16.86
SCI	CRS	.00	5.23	5.23	5.23	5.23	5.23	5.23	5.23	5.23	5.23
	LECP STEPPER	.42	.42	.42	.42	.42	.42	.42	.42	.42	.42
	PPS	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42
	PRA ANT MOTOR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
TC/S	CRS SUPP	.00	.00	.00	2.80	2.80	2.80	2.80	2.80	2.80	2.80
	CRS REPL	5.23	.00	.00	.00	.00	.00	.00	.00	.00	.00
	LECP MAIN SUP	4.15	4.15	4.15	4.15	4.15	4.15	4.15	4.15	4.15	4.15
	LECP LEPT SUP	.51	.51	.51	.51	.51	.51	.51	.51	.51	.51
	LECP REPL	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	PPS SUPP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	PLS REPL	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	PLS SUPP	4.60	4.60	.00	.00	.00	.00	.00	.00	.00	.00
	UVS REPL	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	ISS-N OPTICS	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60
	ISS-N VID REP	.00	.00	.00	.00	5.56	5.56	5.56	5.56	5.56	5.56
	ISS-W VID REP	.00	.00	.00	.00	5.56	5.56	5.56	5.56	5.56	5.56
	ISS-N ELE REP	.00	.00	.00	.00	10.50	10.50	10.50	10.50	10.50	10.50
	ISS-W ELE REP	.00	.00	.00	.00	10.50	10.50	10.50	10.50	10.50	10.50
	MIRIS REPL	13.00	13.00	13.00	13.00	13.00	13.00	.00	13.00	13.00	13.00
TC/E	AZ ACT REP	.00	.00	.00	.00	3.50	3.50	3.50	3.50	3.50	3.50
	SUN SEN HTR	.00	.00	.00	.00	1.80	1.80	1.80	1.80	1.80	1.80
	IPU VALVE HTR	3.35	3.35	3.35	3.35	3.35	3.35	3.35	3.35	3.35	3.35
	IPU RED V HTR	2.97	2.97	2.97	2.97	2.97	2.97	2.97	2.97	2.97	2.97
	IPU THRUS HTR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	TCAPU RED HTR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	SCN PLTFM HTR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

* Table 5. MJS77 Power Profile Subassembly Detail Tabulation (sheet 4 of 6)

OPERATIONAL MODE	FARENC J1 (31) L+1.9Y	FARENC J2 (32) L+1.9Y	NR ENC J (33) L+1.9Y	IO ENC (34) L+1.9Y	OCCULT J (35) L+1.9Y	POSTEN J (36) L+2.0Y	CRUISE (37) L+4.0Y	CRUISE TR (38) L+4.0Y	SCI MV (39) L+4.0Y	PLAYBK TR (40) L+4.0Y
2.4KHZ INV ENG LOADS										
MDS TMU	4.65	4.65	4.65	4.65	4.65	4.65	4.65	4.65	4.65	4.65
CDU	5.35	5.35	5.35	5.35	5.35	5.35	5.35	5.35	5.35	5.35
PWR TLM	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12
DISTRIBUTION	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52
DISCHARGE CON	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10
CCS	26.06	26.06	26.06	26.06	26.06	26.06	23.74	23.74	26.06	26.06
FDS	12.02	12.02	12.02	12.02	12.02	12.02	12.02	12.02	12.02	12.02
AACS PROCESSOR	22.32	22.32	22.32	22.32	22.32	22.32	22.32	22.32	22.32	22.32
MAJOR PWR SUP	14.44	14.44	14.44	14.44	14.44	14.44	14.44	14.44	14.44	14.44
AP THRUSTERS	(5.05)8	(5.05)8	(5.05)8	(5.05)8	(5.05)8	(5.05)8	(5.05)8	(5.05)8	(5.05)8	(5.05)8
AP TH REP HTR	13.20 8	13.20 8	13.20 9	13.20 8	13.20 8	13.20 8	13.20 8	13.20 8	13.20 8	13.20 8
CST	2.53	2.53	2.53	2.53	.00	2.53	2.53	2.53	2.53	2.53
SUN SHUTTER	.00	.00	.00	.00	5.05	.00	.00	.00	5.05	.00
SUN SENSOR	.85	.85	.85	.85	.85	.85	.85	.85	.85	.85
SCAN ACT	5.05	5.05	5.05	5.05	5.05	5.05	5.05	5.05	5.05	5.05
SCAN POTS	.17	.17	.17	.17	.17	.17	.17	.17	.17	.17
PYRO INSTM	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83
PSU	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
DSS	27.00	27.00	27.00	27.00	27.00	27.00	.00	.00	27.00	27.00
REPL HTR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
STRU BAY 1 HTR	.00	.00	.00	.00	.00	.00	.00	.00	24.20	.00
BAY 2 HTR	.00	.00	.00	.00	.00	.00	19.20	19.20	.00	.00
BAY 6 HTR	16.40	16.40	.00	.00	.00	.00	16.40	16.40	.00	16.40
PROP TCM HTR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
2.4KHZ INV SCI LOADS										
SCI PRA	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35
PWS	1.38	1.38	1.79	1.79	1.79	1.79	1.38	1.38	1.38	1.38
LECP	3.98	3.98	3.78	3.78	3.78	4.12	4.12	4.12	4.12	4.12
PLS	8.30	8.30	8.30	8.30	8.30	8.30	8.30	8.30	8.30	8.30
UVS	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97
MAG	3.28	3.28	3.28	3.28	3.28	3.28	2.78	2.78	3.28	2.78
MAG SEN HTRS	.00	2.02	2.02	2.02	2.02	2.02	.00	2.02	2.02	.00
ISS	41.71	41.71	41.71	41.71	41.71	41.71	.00	.00	.00	.00
MIRIS STBY	7.90	7.90	7.90	7.90	7.90	7.90	7.90	7.90	7.90	7.90
MIRIS PRI	15.60	15.60	15.60	15.60	15.60	15.60	.00	.00	.00	.00
REGULATED DC LOADS										
RFS ACIS AND SW	.87	.87	.87	.87	.87	.87	.87	.87	.87	.87
RCVR	5.30	5.30	5.30	5.30	5.30	5.30	5.30	5.30	5.30	5.30
S-BAND EXC	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37
S-BAND TWT	89.70	34.70	34.70	34.70	34.70	34.70	89.70	34.70	34.70	34.70
X-BND EXCITER	3.30	3.30	3.30	3.30	3.30	3.30	.00	3.30	.00	3.30
X-BAND TWT	49.30	72.60	72.60	72.60	72.60	72.60	.00	49.30	.00	72.60
USO	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30
PWR POWER CONTROL	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02
SHUNT REG	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02
DISCHARGE CON	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
FDS	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
AACS GYROS	.00	.00	16.86	16.86	16.86	16.86	.00	.00	16.86	.00
SCI CRS	5.23	5.23	5.23	5.23	5.23	5.23	5.23	5.23	5.23	5.23
LECP STEPPER	.42	.42	.42	1.60	.42	.42	.42	.42	.42	.42
PPS	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42
PRA ANT MOTOR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
TC/S CRS SUPP	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80
CRS REPL	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
LECP MAIN SUP	4.15	4.15	4.15	4.15	4.15	4.15	4.15	4.15	4.15	4.15
LECP LEPT SUP	.51	.51	.51	.51	.51	.51	.51	.51	.51	.51
LECP REPL	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PPS SUPP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PLS REPL	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PLS SUPP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
UVS REPL	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
ISS-N OPTICS	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60
ISS-N VID REP	.00	.00	.00	.00	.00	.00	5.56	5.56	5.56	5.56
ISS-W VID REP	.00	.00	.00	.00	.00	.00	5.56	5.56	5.56	5.56
ISS-N ELE REP	.00	.00	.00	.00	.00	.00	10.50	10.50	10.50	10.50
ISS-W ELE REP	.00	.00	.00	.00	.00	.00	10.50	10.50	10.50	10.50
MIRIS REPL	.00	.00	.00	.00	.00	.00	13.00	13.00	13.00	13.00
TC/E AZ ACT REP	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
SUN SEN HTR	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80
IPU VALVE HTR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
IPU RED V HTR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
IPU THRUS HTR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
TCAPU RED HTR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
SCN PLTFM HTR	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00

*Table 5. MJS77 Power Profile Subassembly Detail Tabulation (sheet 5 of 6)

OPERATIONAL MODE	MANV OR (41) L+4.0Y	FIRING (42) L+4.0Y	FARENC S1 (43) L+4.1Y	FARENC S2 (44) L+4.1Y	NRENCG S (45) L+4.1Y	NR ENC S (46) L+4.1Y	OCCULT S (47) L+4.1Y	POSTEN S1 (48) L+4.2Y	POSTEN S2 (49) L+4.2Y	POSTEN S3 (50) L+4.2Y
2.4KHZ INV ENG LOADS										
MDS TMU	4.65	4.65	4.65	4.65	4.65	4.65	4.65	4.65	4.65	4.65
CDU	5.35	5.35	5.35	5.35	5.35	5.35	5.35	5.35	5.35	5.35
PWR TLM	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12
DISTRIBUTION	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52
DISCHARGE CON	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10
CCS	26.06	26.06	26.06	26.06	26.06	26.06	26.06	26.06	26.06	26.06
FDS	14.14	14.14	12.02	12.02	12.02	12.02	12.02	12.02	12.02	12.02
AACS PROCESSOR	22.32	22.32	22.32	22.32	22.32	22.32	22.32	22.32	22.32	22.32
MAJOR PWR SUP	14.44	14.44	14.44	14.44	14.44	14.44	14.44	14.44	14.44	14.44
AP THRUSTERS	(5.05)B	25.25 B	(5.05)B	(5.05)B	(5.05)B	(5.05)B	(5.05)B	(5.05)B	(5.05)B	(5.05)B
AP TH REP HTR	13.20 B	(13.20)B	13.20 B	13.20 B	13.20 B	13.20 B	13.20 B	13.20 B	13.20 B	13.20 B
CST	2.53	2.53	2.53	2.53	2.53	2.53	.00	2.53	2.53	2.53
SUN SHUTTER	5.05	5.05	.00	.00	.00	.00	5.05	.00	.00	.00
SUN SENSOR	.85	.85	.85	.85	.85	.85	.85	.85	.85	.85
SCAN ACT	5.05	5.05	5.05	5.05	5.05	5.05	5.05	5.05	5.05	5.05
SCAN POTS	.17	.17	.17	.17	.17	.17	.17	.17	.17	.17
PYRO INSTM	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83
PSU	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
DSS	27.00	27.00	27.00	27.00	.00	27.00	27.00	27.00	27.00	.00
REPL HTR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
STRU BAY 1 HTR	.00	24.20	.00	.00	.00	.00	.00	.00	.00	.00
BAY 2 HTR	.00	.00	.00	.00	19.20	.00	.00	.00	.00	19.20
BAY 6 HTR	.00	.00	16.40	16.40	.00	.00	.00	.00	16.40	16.40
PROP TCM HTR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
2.4KHZ INV SCI LOADS										
SCI PRA	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35
PWS	1.38	1.38	1.38	1.38	1.79	1.79	1.79	1.79	1.38	1.38
LECP	4.12	4.12	3.98	3.98	3.78	3.78	3.78	3.98	3.98	3.98
PLS	8.30	8.30	8.30	8.30	8.30	8.30	8.30	8.30	8.30	8.30
UVS	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97
MAG	2.78	2.78	3.28	3.28	3.28	3.28	3.28	2.78	2.78	2.78
MAG SEN HTRS	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
ISS	.00	.00	41.71	41.71	41.71	41.71	41.71	41.71	41.71	41.71
MIRIS STBY	7.90	7.90	7.90	7.90	7.90	7.90	7.90	7.90	7.90	7.90
MIRIS PRI	.00	.00	15.60	15.60	15.60	15.60	15.60	15.60	15.60	15.60
REGULATED DC LOADS										
RFS ACIS AND SW	.87	.87	.87	.87	.87	.87	.87	.87	.87	.87
RCVR	5.30	5.30	5.30	5.30	5.30	5.30	5.30	5.30	5.30	5.30
S-BAND EXC	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37
S-BAND TWT	89.70	34.70	89.70	34.70	34.70	34.70	34.70	34.70	34.70	34.70
X-BND EXCITER	.00	.00	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30
X-BAND TWT	.00	.00	49.30	72.60	72.60	49.30	49.30	49.30	72.60	72.60
USO	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30
PWR POWER CONTROL	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02
SHUNT REG	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02
DISCHARGE CON	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
FDS	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
AACS GYROS	16.86	16.86	.00	.00	16.86	16.86	16.86	16.86	.00	.00
SCI CRS	5.23	5.23	5.23	5.23	5.23	5.23	5.23	5.23	5.23	5.23
LECP STEPPER	.42	.42	.42	.42	.42	.42	.42	.42	.42	.42
PPS	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42	2.42
PRA ANT MOTOR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
TC/S CRS SUPP	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80
CRS REPL	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
LECP MAIN SUP	4.15	4.15	4.15	4.15	4.15	4.15	4.15	4.15	4.15	4.15
LECP LEPT SUP	.51	.51	.51	.51	.51	.51	.51	.51	.51	.51
LECP REPL	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PPS SUPP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PLS REPL	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PLS SUPP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
UVS REPL	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
ISS-N OPTICS	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60
ISS-N VID REP	5.56	5.56	.00	.00	.00	.00	.00	.00	.00	.00
ISS-W VID REP	5.56	5.56	.00	.00	.00	.00	.00	.00	.00	.00
ISS-N ELE REP	10.50	10.50	.00	.00	.00	.00	.00	.00	.00	.00
ISS-W ELE REP	10.50	10.50	.00	.00	.00	.00	.00	.00	.00	.00
MIRIS REPL	13.00	13.00	.00	.00	.00	.00	.00	.00	.00	.00
TC/E AZ ACT REP	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
SUN SEN HTR	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80
IPU VALVE HTR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
IPU RED V HTR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
IPU THRUS HTR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
TCAPU RED HTR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
SCN PLTFM HTR	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00

* Table 5. MJS77 Power Profile Subassembly Detail Tabulation (sheet 6 of 6)

	OPERATIONAL MODE	FARENC 1U (51) L+8.0Y	FARENC 2U (52) L+8.0Y	NR ENC U (53) L+8.0Y	OCCULT U (54) L+8.0Y
2.4KHZ INV ENG LOADS					
MDS	TMU	5.05	5.05	5.05	5.05
	CDU	5.35	5.35	5.35	5.35
PWR	TLM	2.12	2.12	2.12	2.12
	DISTRIBUTION	1.52	1.52	1.52	1.52
	DISCHARGE CON	.10	.10	.10	.10
CCS		26.06	26.06	26.06	26.06
FDS		12.02	12.02	12.02	12.02
AACS	PROCESSOR	22.32	22.32	22.32	22.32
	MAJOR PWR SUP	14.44	14.44	14.44	14.44
	AP THRUSTERS	(5.05)B	(5.05)B	(5.05)B	(5.05)B
	AP TH REP HTR	13.20 B	13.20 B	13.20 B	13.20 B
	CST	2.53	2.53	2.53	.00
	SUN SHUTTER	.00	.00	.00	5.05
	SUN SENSOR	.85	.85	.85	.85
	SCAN ACT	5.05	5.05	5.05	5.05
	SCAN POTS	.17	.17	.17	.17
PYRO	INSTM	2.83	2.83	2.83	2.83
	PSU	.00	.00	.00	.00
DSS		.00	27.00	27.00	27.00
	REPL HTR	.00	.00	.00	.00
STRU	BAY 1 HTR	.00	.00	.00	24.20
	BAY 2 HTR	19.20	.00	.00	.00
	BAY 6 HTR	16.40	16.40	16.40	.00
PROP	TCM HTR	.00	.00	.00	.00
2.4KHZ INV SCI LOADS					
SCI	PRA	6.35	6.35	6.35	6.35
	PWS	1.38	1.38	1.38	1.38
	LECP	3.98	3.98	3.98	3.98
	PLS	8.30	8.30	8.30	8.30
	UVS	1.97	1.97	1.97	1.97
	MAG	3.28	3.28	3.28	3.28
	MAG SEN HTRS	.00	.00	.00	.00
	ISS	41.71	41.71	41.71	41.71
	MIRIS STBY	7.90	7.90	7.90	7.90
	MIRIS PRI	15.60	15.60	15.60	15.60
REGULATED DC LOADS					
RFS	ACIS AND SW	.87	.87	.87	.87
	RCVR	5.30	5.30	5.30	5.30
	S-BAND EXC	2.37	2.37	2.37	2.37
	S-BAND TWT	34.70	.00	.00	34.70
	X-BND EXCITER	3.30	3.30	3.30	.00
	X-BAND TWT	49.30	49.30	72.60	.00
	USO	3.30	3.30	3.30	3.30
PWR	POWER CONTROL	2.02	2.02	2.02	2.02
	SHUNT REG	2.02	2.02	2.02	2.02
	DISCHARGE CON	1.01	1.01	1.01	1.01
FDS		.00	.00	.00	.00
AACS	GYROS	.00	.00	.00	16.86
SCI	CRS	5.23	5.23	5.23	5.23
	LECP STEPPER	.42	.42	.42	.42
	PPS	2.42	2.42	2.42	2.42
	PRA ANT MOTOR	.00	.00	.00	.00
TC/S	CRS SUPP	2.80	2.80	2.80	2.80
	CRS REPL	.00	.00	.00	.00
	LECP MAIN SUP	4.15	4.15	4.15	4.15
	LECP LEPT SUP	.51	.51	.51	.51
	LECP REPL	.00	.00	.00	.00
	PPS SUPP	.00	.00	.00	.00
	PLS REPL	.00	.00	.00	.00
	PLS SUPP	.00	.00	.00	.00
	UVS REPL	.00	.00	.00	.00
	ISS-N OPTICS	2.60	2.60	2.60	2.60
	ISS-N VID REP	.00	.00	.00	.00
	ISS-W VID REP	.00	.00	.00	.00
	ISS-N ELE REP	.00	.00	.00	.00
	ISS-W ELE REP	.00	.00	.00	.00
	MIRIS REPL	.00	.00	.00	.00
TC/E	AZ ACT REP	3.50	3.50	3.50	3.50
	SUN SEN HTR	1.80	1.80	1.80	1.80
	IPU VALVE HTR	.00	.00	.00	.00
	IPU RED V HTR	.00	.00	.00	.00
	IPU THRUS HTR	.00	.00	.00	.00
	TCAPU RED HTR	.00	.00	.00	.00
	SCN PLTFM HTR	6.00	6.00	6.00	6.00

* Table 6. MJS77 Power Profile Subsystem Tabulation (sheet 1 of 6)

OPERATIONAL MODE	UNSHRT (1) L-480M	TURNON (2) L-477M	PWR ON (3) L-312M	LAUNCH (4) L+ 0M	MECO 1 (5) L+ 10M	COAST 1 (6) L+ 12M	MINPWR (7) L+ 20M	COAST 2 (8) L+ 40M	MES 2 (9) L+ 42M	MECO 2 (10) L+ 48M
2.4KHZ INV ENG LOADS										
MOS	5.35	10.40	10.40	10.40	10.40	10.40	10.40	10.40	10.40	10.40
PWR	3.74	3.74	3.74	3.74	3.74	3.74	3.74	3.74	3.74	3.74
CCS	26.06	26.06	26.06	23.74	23.74	23.74	23.74	23.74	23.74	23.74
FDS	.00	14.14	14.14	14.14	14.14	14.14	14.14	14.14	14.14	14.14
AACS	22.32	22.32	42.66	42.66	42.66	42.66	42.66	42.66	42.66	42.66
PYRO	.00	.00	3.84	3.84	3.84	3.84	3.84	3.84	3.84	4.36
DSS	.00	.00	20.20	22.73	22.73	22.73	22.73	22.73	22.73	22.73
STRU	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PROP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
TOTAL ENG LOAD	57.47	76.66	121.04	121.25	121.25	121.25	121.25	121.25	121.25	121.77
2.4KHZ INV SCI LOAD										
SCI	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
AC WIRING LOSS	.08	.13	.32	.32	.32	.32	.32	.32	.32	.32
TOTAL 2.4KHZ INV LOAD	59.15	78.39	122.96	123.17	123.17	123.17	123.17	123.17	123.17	123.69
2.4KHZ INV LOSS AT PF=1.0	3.34	4.12	5.81	5.82	5.82	5.82	5.82	5.82	5.82	5.84
POWER FACTOR	.9456	.9442	.9513	.9517	.9517	.9517	.9517	.9517	.9517	.9529
PWR FACTOR LOSS	.20	.33	.56	.55	.55	.55	.55	.55	.55	.54
TOTAL 2.4KHZ INV INPUT	62.70	82.85	129.32	129.54	129.54	129.54	129.54	129.54	129.54	130.07
REGULATED DC LOADS										
RFS	6.17	6.17	43.24	43.24	43.24	43.24	43.24	43.24	43.24	43.24
PWR	5.05	5.05	5.05	5.05	5.05	5.05	5.05	5.05	5.05	5.05
FDS	.60	.00	.00	.00	.00	.00	.00	.00	.00	.00
AACS	.00	.00	15.06	44.20	44.20	20.60	20.60	20.60	44.20	27.60
SCI	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
TC/S	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
TC/E	.00	.00	53.63	53.63	53.63	53.63	65.40	65.40	47.00	47.00
TOTAL REG DC LOAD	11.82	11.22	116.98	146.12	146.12	122.52	134.29	134.29	139.49	122.89
DC WIRING LOSS	.06	.11	.54	.67	.67	.56	.62	.62	.63	.56
TOTAL DC BUS POWER	74.58	94.17	246.85	276.33	276.33	252.62	264.45	264.45	269.66	253.52
RTG CAPABILITY (MIN)	275.69	280.26	319.61	328.20	272.60	270.66	262.90	283.53	286.28	294.52
RTG CIRCUIT LOSS	1.20	1.24	1.61	1.70	1.17	1.15	1.09	1.27	1.29	1.37
NET POWER CAPABILITY (MIN)	274.49	279.02	318.00	326.50	271.43	269.51	261.81	282.27	284.99	293.15
POWER MARGIN (MIN)	199.91	184.85	71.15	50.18	-4.90	16.88	-2.64	17.82	15.33	39.63
SHUNT REGULATOR DISS	42.57	41.21	33.93	31.66	.00	14.79	.00	15.48	13.60	28.08
SHUNT RADIATOR DISS	153.84	140.44	36.39	18.10	.00	2.05	.00	2.28	1.69	11.29
SHUNT RAD CABLE LOSS	3.50	3.19	.83	.41	.00	.05	.00	.05	.04	.26
RTG CAPABILITY (MOST PROB)	284.84	289.56	330.22	339.10	289.70	287.66	279.50	300.90	303.74	312.26
RTG CIRCUIT LOSS	1.28	1.32	1.72	1.81	1.32	1.30	1.23	1.43	1.46	1.54
NET POWER CAP. (MOST PROB)	283.56	288.24	328.50	337.29	288.38	286.36	278.27	299.47	302.28	310.72
POWER MARGIN (MOST PROB)	208.98	194.07	81.65	60.96	12.05	33.73	13.82	35.02	32.62	57.20
SHUNT REGULATOR DISS	41.77	42.44	32.63	33.64	10.98	25.37	12.41	26.00	24.80	33.14
SHUNT RADIATOR DISS	163.49	148.26	47.93	26.71	1.04	8.18	1.37	8.82	7.65	23.52
SHUNT RAD CABLE LOSS	3.72	3.37	1.09	.61	.02	.19	.03	.20	.17	.53

* Table 6. MJS77 Power Profile Subsystem Tabulation (sheet 2 of 6)

OPERATIONAL MODE	SRMBRN (11) L+ 51M	PSTINJ (12) L+ 52M	DEPLOY 1 (13) L+ 53M	DEPLOY 2 (14) L+ 56M	FM JET (15) L+ 65M	MAGDEP (16) L+ 69M	SUN AQ (17) L+114M	ANTDEP (18) L+125M	CANOP AQ (19) L+150M	FIRST CR (20) L+240M
2.4KHZ INV ENG LOADS										
MDS	10.40	10.40	10.40	10.40	10.00	10.00	10.00	10.00	10.00	10.00
PWR	3.74	3.74	3.74	3.74	3.74	3.74	3.74	3.74	3.74	3.74
CCS	26.06	26.06	26.06	26.06	26.06	26.06	26.06	26.06	26.06	26.06
FDS	14.14	14.14	14.14	14.14	14.14	14.14	14.14	14.14	14.14	14.14
AACS	37.61	42.66	42.66	47.88	61.08	61.08	56.03	58.56	58.56	58.56
PYRO	29.29	4.36	29.29	4.36	29.29	28.28	2.83	2.83	2.83	2.83
DSS	22.73	22.73	22.73	22.73	22.73	22.73	22.73	27.00	27.00	27.00
STRU	.00	.00	.00	.00	.00	.00	.00	.00	.00	16.40
PROP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
TOTAL ENG LOAD	143.97	124.09	149.02	129.31	167.04	166.03	135.53	142.33	142.33	158.73
2.4KHZ INV SCI LOAD										
SCI	1.60	1.60	1.60	1.60	1.60	9.00	8.50	18.20	18.20	59.91
AC WIRING LOSS	.41	.33	.44	.36	.56	.60	.43	.53	.53	.97
TOTAL 2.4KHZ INV LOAD	145.98	126.02	151.06	131.27	169.20	175.63	144.46	161.06	161.06	219.61
2.4KHZ INV LOSS AT PF=1.0	6.80	5.93	7.03	6.15	7.93	8.28	6.73	7.51	7.51	11.40
POWER FACTOR	.9907	.9535	.9898	.9517	.9900	.9886	.9577	.9588	.9588	.9629
PWR FACTOR LOSS	.13	.55	.15	.61	.18	.22	.62	.71	.71	1.12
TOTAL 2.4KHZ INV INPUT	152.92	132.50	158.25	138.04	177.31	184.13	151.81	169.28	169.28	232.13
REGULATED DC LOADS										
RFS	43.24	43.24	43.24	43.24	43.24	43.24	43.24	43.24	43.24	98.24
PWR	5.05	5.05	5.05	5.05	5.05	5.05	5.05	5.05	5.05	5.05
FDS	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
AACS	72.00	36.62	27.60	27.60	27.60	27.60	16.86	16.86	16.86	.00
SCI	.00	.00	.00	.00	.00	.42	.42	15.42	.42	2.84
TC/S	.00	.00	.00	.00	.00	13.98	13.98	13.98	13.98	13.98
TC/E	.00	47.00	47.00	47.00	47.00	18.09	6.32	6.32	6.32	6.32
TOTAL REG DC LOAD	120.29	131.91	122.89	122.89	122.89	108.38	85.87	100.87	85.87	126.43
DC WIRING LOSS	.68	.61	.70	.60	.80	.77	.51	.66	.60	1.21
TOTAL DC BUS POWER	273.89	265.03	281.84	261.52	301.00	293.29	238.19	270.81	255.75	359.77
RTG CAPABILITY (MIN)	298.64	300.01	301.39	305.51	316.00	320.00	367.36	377.97	387.13	407.48
RTG CIRCUIT LOSS	1.41	1.42	1.43	1.47	1.57	1.61	2.13	2.25	2.36	2.62
NET POWER CAPABILITY (MIN)	297.23	298.60	299.96	304.04	314.43	318.39	365.23	375.72	384.77	404.86
POWER MARGIN (MIN)	23.35	33.57	18.12	42.51	13.43	25.10	127.04	104.91	129.02	45.09
SHUNT REGULATOR DISS	19.34	25.28	15.70	29.22	12.10	20.47	13.71	24.00	13.83	30.14
SHUNT RADIATOR DISS	3.92	8.10	2.36	12.99	1.30	4.53	110.81	79.11	112.63	14.61
SHUNT RAD CABLE LOSS	.09	.18	.05	.30	.03	.10	2.52	1.80	2.56	.33
RTG CAPABILITY (MOST PROB)	316.52	317.94	319.36	323.62	334.47	338.61	387.54	398.47	407.93	428.60
RTG CIRCUIT LOSS	1.58	1.59	1.61	1.65	1.76	1.81	2.37	2.50	2.63	2.90
NET POWER CAP. (MOST PROB)	314.94	316.35	317.75	321.97	332.71	336.81	385.17	395.96	405.30	425.70
POWER MARGIN (MOST PROB)	41.05	51.32	35.91	60.44	31.71	43.52	146.98	125.15	149.55	65.93
SHUNT REGULATOR DISS	28.66	31.96	26.43	33.58	24.32	29.59	23.06	13.57	24.96	33.97
SHUNT RADIATOR DISS	12.11	18.93	9.27	26.26	7.23	13.61	121.16	109.10	121.82	31.24
SHUNT RAD CABLE LOSS	.28	.43	.21	.60	.16	.31	2.75	2.48	2.77	.71

✻ Table 6. MJS77 Power Profile Subsystem Tabulation (sheet 3 of 6)

OPERATIONAL MODE	HEATER ON (21) L+285M	NRERTH SC (22) L+360M	USO ON (23) L+ 48H	EARTH CR (24) L+ 3D	CRUISE (25) L+1.8Y	CRUISE TR (26) L+1.8Y	SCI MV (27) L+1.8Y	PLAYBK TR (28) L+1.8Y	MANV OR (29) L+1.8Y	FIRINE (30) L+1.8Y
2.4KHZ INV ENG LOADS										
MDS	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
PWR	3.74	3.74	3.74	3.74	3.74	3.74	3.74	3.74	3.74	3.74
CCS	26.06	26.06	26.06	26.06	23.74	23.74	26.06	26.06	26.06	26.06
FDS	14.14	14.14	14.14	14.14	12.02	12.02	12.02	12.02	14.14	14.14
AACS	58.56	58.56	58.56	58.56	58.56	58.56	63.61	58.56	63.61	75.66
PYRO	2.83	2.63	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83
DSS	27.00	27.00	27.00	27.00	.00	.00	27.00	27.00	27.00	27.00
STRU	16.40	16.40	16.40	16.40	35.60	35.60	.00	16.40	.00	.00
PROP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
TOTAL ENG LOAD	158.73	158.73	158.73	158.73	146.49	146.49	145.26	156.61	147.38	159.43
2.4KHZ INV SCI LOAD										
SCI	61.93	61.93	70.23	70.23	34.82	34.82	50.92	34.82	34.82	34.82
AC WIRING LOSS	.99	.99	1.07	1.07	.66	.66	.79	.74	.68	.80
TOTAL 2.4KHZ INV LOAD	221.65	221.65	230.03	230.03	181.97	181.97	196.97	192.17	182.88	195.05
2.4KHZ INV LOSS AT PF=1.0	11.57	11.57	12.28	12.28	8.67	8.67	9.65	9.32	8.72	9.52
POWER FACTOR	.9635	.9635	.9631	.9631	.9675	.9675	.9581	.9654	.9587	.9465
PWR FACTOR LOSS	1.12	1.12	1.22	1.22	.68	.68	1.03	.80	.88	1.32
TOTAL 2.4KHZ INV INPUT	234.33	234.33	243.52	243.52	191.32	191.32	207.65	202.30	192.49	205.88
REGULATED DC LOADS										
RFS	98.24	150.84	154.14	154.14	101.54	99.14	101.54	122.44	101.54	101.54
PWR	5.05	5.05	5.05	5.05	5.05	5.05	5.05	5.05	5.05	5.05
FDS	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
AACS	.00	.00	.00	.00	.00	.00	16.86	.00	16.86	16.86
SCI	2.84	8.07	8.07	8.07	8.07	8.07	8.07	8.07	8.07	8.07
TC/S	30.09	24.86	20.26	23.06	55.18	55.18	42.18	55.18	55.18	55.18
TC/E	6.32	6.32	6.32	6.32	11.62	11.62	11.62	11.62	11.62	11.62
TOTAL REG DC LOAD	142.54	195.14	193.84	196.64	181.46	179.06	185.32	202.36	198.32	198.32
DC WIRING LOSS	1.33	1.73	1.78	1.81	1.31	1.29	1.40	1.55	1.40	1.49
TOTAL DC BUS POWER	378.20	431.20	439.15	441.97	374.09	371.67	394.37	406.21	392.21	405.69
RTG CAPABILITY (MIN)	414.54	426.32	447.14	447.11	418.32	418.32	418.32	418.32	418.32	418.32
RTG CIRCUIT LOSS	2.71	2.86	3.15	3.15	2.76	2.76	2.76	2.76	2.76	2.76
NET POWER CAPABILITY (MIN)	411.84	423.46	443.99	443.96	415.56	415.56	415.56	415.56	415.56	415.56
POWER MARGIN (MIN)	33.63	-7.75	4.84	1.99	41.47	43.89	21.19	9.35	23.35	9.87
SHUNT REGULATOR DISS	25.31	.00	4.67	1.96	28.83	29.73	17.89	8.71	19.34	9.15
SHUNT RADIATOR DISS	8.13	.00	.17	.03	12.36	13.85	3.23	.63	3.92	.70
SHUNT RAD CABLE LOSS	.18	.00	.00	.00	.28	.31	.07	.01	.09	.02
RTG CAPABILITY (MOST PROB)	435.46	446.90	460.61	460.57	437.84	437.84	437.84	437.84	437.84	437.84
RTG CIRCUIT LOSS	2.99	3.15	3.35	3.34	3.02	3.02	3.02	3.02	3.02	3.02
NET POWER CAP. (MOST PROB)	432.47	443.75	457.27	457.23	434.82	434.82	434.82	434.82	434.82	434.82
POWER MARGIN (MOST PROB)	54.27	12.54	18.12	15.26	60.73	63.15	40.45	28.61	42.61	29.13
SHUNT REGULATOR DISS	32.61	11.39	15.71	13.54	33.61	33.83	28.42	22.59	29.26	22.89
SHUNT RADIATOR DISS	21.17	1.13	2.36	1.67	26.51	28.67	11.76	5.88	13.05	6.10
SHUNT RAD CABLE LOSS	.48	.03	.05	.04	.60	.65	.27	.13	.30	.14

* Table 6. MJS77 Power Profile Subsystem Tabulation (sheet 4 of 6)

OPERATIONAL MODE	FARENC J1 (31) L+1.9Y	FARENC J2 (32) L+1.9Y	NR ENC J (33) L+1.9Y	IO ENC (34) L+1.9Y	CCCULT J (35) L+1.9Y	POSTEN J (36) L+2.0Y	CRUISE (37) L+4.0Y	CRUISE TR (38) L+4.0Y	SCI MV (39) L+4.0Y	PLAYBK TR (40) L+4.0Y
2.4KHZ INV ENG LOADS										
MDS	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
PWR	3.74	3.74	3.74	3.74	3.74	3.74	3.74	3.74	3.74	3.74
CCS	26.06	26.06	26.06	26.06	26.06	26.06	23.74	23.74	26.06	26.06
FDS	12.02	12.02	12.02	12.02	12.02	12.02	12.02	12.02	12.02	12.02
AACS	58.56	58.56	58.56	58.56	61.08	58.56	58.56	58.56	63.61	58.56
PYRO	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83
DSS	27.00	27.00	27.00	27.00	27.00	27.00	.00	.00	27.00	27.00
STRU	16.40	16.40	.00	.00	.00	.00	35.60	35.60	24.20	16.40
PROP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
TOTAL ENG LOAD	156.61	156.61	140.21	140.21	142.73	140.21	146.49	146.49	169.46	156.61
2.4KHZ INV SCI LOAD										
SCI	90.47	92.49	92.70	92.70	92.70	93.04	32.80	34.82	35.32	32.80
AC WIRING LOSS	1.25	1.27	1.12	1.12	1.15	1.13	.65	.66	.84	.73
TOTAL 2.4KHZ INV LOAD	248.33	250.37	234.03	234.03	236.58	234.38	179.94	181.97	205.62	190.14
2.4KHZ INV LOSS AT PF=1.0	13.95	14.02	12.63	12.63	12.85	12.66	8.54	8.67	10.29	9.19
POWER FACTOR	.9615	.9620	.9569	.9569	.9573	.9569	.9668	.9675	.9675	.9647
PWR FACTOR LOSS	1.47	1.47	1.48	1.48	1.50	1.49	.68	.68	.86	.81
TOTAL 2.4KHZ INV INPUT	263.65	265.86	248.15	248.15	250.93	248.53	189.17	191.32	216.77	200.13
REGULATED DC LOADS										
RFS	154.14	122.44	122.44	122.44	122.44	122.44	101.54	99.14	46.54	122.44
PWR	5.05	5.05	5.05	5.05	5.05	5.05	5.05	5.05	5.05	5.05
FDS	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
AACS	.00	.00	16.86	16.86	16.86	16.86	.00	.00	16.86	.00
SCI	8.07	8.07	8.07	9.25	8.07	8.07	8.07	8.07	8.07	8.07
TC/S	10.06	10.06	10.06	10.06	10.06	10.06	55.18	55.18	55.18	55.18
TC/E	11.30	11.30	11.30	11.30	11.30	11.30	11.30	11.30	11.30	11.30
TOTAL REG DC LOAD	188.62	156.92	173.78	174.96	173.78	173.78	181.14	178.74	143.00	202.04
DC WIRING LOSS	1.91	1.67	1.61	1.62	1.64	1.62	1.29	1.28	1.17	1.53
TOTAL DC BUS POWER	454.18	424.45	423.54	424.73	426.34	423.92	371.60	371.35	360.94	403.70
RTG CAPABILITY (MIN)	416.37	416.37	416.37	416.37	416.37	414.40	374.30	374.30	374.30	374.30
RTG CIRCUIT LOSS	2.73	2.73	2.73	2.73	2.73	2.71	2.21	2.21	2.21	2.21
NET POWER CAPABILITY (MIN)	413.63	413.63	413.63	413.63	413.63	411.69	372.09	372.09	372.09	372.09
POWER MARGIN (MIN)	-40.55	-10.82	-9.91	-11.10	-12.71	-12.23	.49	.74	11.15	-31.61
SHUNT REGULATOR DISS	.00	.00	.00	.00	.00	.00	.49	.74	10.23	.00
SHUNT RADIATOR DISS	.00	.00	.00	.00	.00	.00	.00	.00	.89	.00
SHUNT RAD CABLE LOSS	.00	.00	.00	.00	.00	.00	.00	.00	.02	.00
RTG CAPABILITY (MOST PROB)	436.81	436.81	436.81	436.81	436.81	435.80	418.40	418.40	418.40	418.40
RTG CIRCUIT LOSS	3.01	3.01	3.01	3.01	3.01	2.99	2.76	2.76	2.76	2.76
NET POWER CAP. (MOST PROB)	433.81	433.81	433.81	433.81	433.81	432.81	415.64	415.64	415.64	415.64
POWER MARGIN (MOST PROB)	-20.37	9.35	10.27	9.08	7.46	8.88	44.05	44.29	54.70	11.94
SHUNT REGULATOR DISS	.00	8.71	9.49	8.47	7.05	8.30	29.78	29.87	32.70	10.89
SHUNT RADIATOR DISS	.00	.63	.76	.59	.40	.57	13.94	14.10	21.50	1.02
SHUNT RAD CABLE LOSS	.00	.01	.02	.01	.01	.01	.32	.32	.49	.02

* Table 6. MJS77 Power Profile Subsystem Tabulation (sheet 5 of 6)

OPERATIONAL MODE	MANV OR (41) L+4.0Y	FIRING (42) L+4.0Y	FARENC S1 (43) L+4.1Y	FARENC S2 (44) L+4.1Y	NRENCG S (45) L+4.1Y	NR ENC S (46) L+4.1Y	OCCULT S (47) L+4.1Y	POSTEN S1 (48) L+4.2Y	POSTEN S2 (49) L+4.2Y	POSTEN S3 (50) L+4.2Y
2.4KHZ INV ENG LOADS										
MDS	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
PWR	3.74	3.74	3.74	3.74	3.74	3.74	3.74	3.74	3.74	3.74
CCS	26.06	26.06	26.06	26.06	26.06	26.06	26.06	26.06	26.06	26.06
FDS	14.14	14.14	12.02	12.02	12.02	12.02	12.02	12.02	12.02	12.02
AACS	63.61	75.66	58.56	58.56	58.56	58.56	61.08	58.56	58.56	58.56
PYRO	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83
DSS	27.00	27.00	27.00	27.00	.00	27.00	27.00	27.00	27.00	.00
STRU	.00	24.20	16.40	16.40	19.20	.00	.00	.00	16.40	35.60
PROP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
TOTAL ENG LOAD	147.38	183.63	156.61	156.61	132.41	140.21	142.73	140.21	156.61	148.81
2.4KHZ INV SCI LOAD										
SCI	32.80	32.80	90.47	90.47	90.68	90.68	90.68	90.38	89.97	89.97
AC WIRING LOSS	.67	.97	1.25	1.25	1.03	1.11	1.13	1.10	1.24	1.16
TOTAL 2.4KHZ INV LOAD	180.85	217.40	248.33	248.33	224.12	232.00	234.54	231.69	247.82	239.94
2.4KHZ INV LOSS AT PF=1.0	8.60	11.22	13.85	13.85	11.77	12.45	12.67	12.43	13.81	13.14
POWER FACTOR	.9579	.9562	.9615	.9615	.9580	.9562	.9566	.9562	.9615	.9632
PWR FACTOR LOSS	.99	1.31	1.47	1.47	1.33	1.48	1.50	1.48	1.47	1.32
TOTAL 2.4KHZ INV INPUT	190.33	229.93	263.65	263.65	237.21	245.93	248.71	245.60	263.10	254.39
REGULATED DC LOADS										
RFS	101.54	46.54	154.14	122.44	122.44	99.14	99.14	99.14	122.44	122.44
PWR	5.05	5.05	5.05	5.05	5.05	5.05	5.05	5.05	5.05	5.05
FDS	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
AACS	16.86	16.96	.00	.00	16.86	16.86	16.86	16.86	.00	.00
SCI	8.07	8.07	8.07	8.07	8.07	8.07	8.07	8.07	8.07	8.07
TC/S	55.18	55.18	10.06	10.06	10.06	10.06	10.06	10.06	10.06	10.06
TC/E	11.30	11.30	11.30	11.30	11.30	11.30	11.30	11.30	11.30	11.30
TOTAL REG DC LOAD	198.00	143.00	188.62	156.92	173.78	150.48	150.48	150.48	156.92	156.92
DC WIRING LOSS	1.38	1.26	1.91	1.66	1.53	1.43	1.46	1.43	1.65	1.58
TOTAL DC BUS POWER	389.71	374.19	454.18	422.23	412.52	397.84	400.65	397.51	421.67	412.89
RTG CAPABILITY (MIN)	374.30	374.30	371.39	371.39	371.39	371.39	371.39	368.49	368.49	368.49
RTG CIRCUIT LOSS	2.21	2.21	2.18	2.18	2.18	2.18	2.18	2.14	2.14	2.14
NET POWER CAPABILITY (MIN)	372.09	372.09	369.21	369.21	369.21	369.21	369.21	366.35	366.35	366.35
POWER MARGIN (MIN)	-17.62	-2.10	-84.97	-53.02	-43.31	-28.63	-31.44	-31.16	-55.32	-46.54
SHUNT REGULATOR DISS	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
SHUNT RADIATOR DISS	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
SHUNT RAD CABLE LOSS	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
RTG CAPABILITY (MOST PROB)	418.40	418.40	417.42	417.42	417.42	417.42	417.42	416.46	416.46	416.46
RTG CIRCUIT LOSS	2.76	2.76	2.75	2.75	2.75	2.75	2.75	2.73	2.73	2.73
NET POWER CAP. (MOST PROB)	415.64	415.64	414.67	414.67	414.67	414.67	414.67	413.72	413.72	413.72
POWER MARGIN (MOST PROB)	25.93	41.45	-39.51	-7.55	2.15	16.83	14.03	16.21	-7.95	.83
SHUNT REGULATOR DISS	20.98	28.82	.00	.00	2.12	14.75	12.58	14.28	.00	.82
SHUNT RADIATOR DISS	4.83	12.35	.00	.00	.03	2.04	1.41	1.89	.00	.00
SHUNT RAD CABLE LOSS	.11	.28	.00	.00	.00	.05	.03	.04	.00	.00

✻ Table 6. MJS77 Power Profile Subsystem Tabulation (sheet 6 of 6)

OPERATIONAL MODE	FARENC 1U (51) L+8.0Y	FARENC 2U (52) L+8.0Y	NR ENC U (53) L+8.0Y	OCCULT U (54) L+8.0Y
2.4KHZ INV ENG LOADS				
MDS	10.40	10.40	10.40	10.40
PWR	3.74	3.74	3.74	3.74
CCS	26.06	26.06	26.06	26.06
FDS	12.02	12.02	12.02	12.02
AACS	58.56	58.56	58.56	61.08
PYRO	2.83	2.83	2.83	2.83
DSS	.00	27.00	27.00	27.00
STRU	35.60	16.40	16.40	24.20
PROP	.00	.00	.00	.00
TOTAL ENG LOAD	149.21	157.01	157.01	167.33
2.4KHZ INV SCI LOAD				
SCI	90.47	90.47	90.47	90.47
AC WIRING LOSS	1.17	1.25	1.25	1.36
TOTAL 2.4KHZ INV LOAD	240.85	248.73	248.73	259.16
2.4KHZ INV LOSS AT PF=1.0	13.22	13.89	13.89	14.70
POWER FACTOR	.9630	.9613	.9613	.9638
PWR FACTOR LOSS	1.33	1.48	1.48	1.49
TOTAL 2.4KHZ INV INPUT	255.40	264.10	264.10	275.35
REGULATED DC LOADS				
RFS	99.14	64.44	87.74	46.54
PWR	5.05	5.05	5.05	5.05
FDS	.00	.00	.00	.00
AACS	.00	.00	.00	16.86
SCI	8.07	8.07	8.07	8.07
TC/S	10.06	10.06	10.06	10.06
TC/E	11.30	11.30	11.30	11.30
TOTAL REG DC LOAD	133.62	98.92	122.22	97.88
DC WIRING LOSS	1.43	1.30	1.43	1.37
TOTAL DC BUS POWER	390.45	364.32	387.75	374.60
RTG CAPABILITY (MIN)	255.00	255.00	255.00	255.00
RTG CIRCUIT LOSS	1.02	1.02	1.02	1.02
NET POWER CAPABILITY (MIN)	253.98	253.98	253.98	253.98
POWER MARGIN (MIN)	-136.47	-110.35	-133.77	-120.63
SHUNT REGULATOR DISS	.00	.00	.00	.00
SHUNT RADIATOR DISS	.00	.00	.00	.00
SHUNT RAD CABLE LOSS	.00	.00	.00	.00
RTG CAPABILITY (MOST PROB)	393.00	393.00	393.00	393.00
RTG CIRCUIT LOSS	2.43	2.43	2.43	2.43
NET POWER CAP. (MOST PROB)	390.57	390.57	390.57	390.57
POWER MARGIN (MOST PROB)	.12	26.25	2.82	15.96
SHUNT REGULATOR DISS	.12	21.18	2.76	14.09
SHUNT RADIATOR DISS	.00	4.95	.06	1.83
SHUNT RAD CABLE LOSS	.00	.11	.00	.04

* Table 7. MJS77 Power Profile Power Load Coding Table

			1	2	3	4	5	6	7	8	9	POWER FACTOR	SOURCE BUS	CURRENT COEFF.
ENGINEERING														
MDS	TMU		.00	4.65	5.05	.00	.00	.00	.00	.00	.00	.870	AC2	.30
	CCU		.00	5.35	.00	.00	.00	.00	.00	.00	.00	.890	AC1	1.00
PWR	TLM		.00	2.12	.00	.00	.00	.00	.00	.00	.00	.960	AC1	.50
	DISTRIBUTION		.00	1.52	.00	.00	.00	.00	.00	.00	.00	.980	AC1	.00
	DISCHARGE CON		.00	.10	.00	.00	.00	.00	.00	.00	.00	.980	AC1	1.00
CCS			.00	23.74	26.06	.00	.00	.00	.00	.00	.00	.980	AC1	.95
FDS			.00	12.02	14.14	12.27	.00	.00	.00	.00	.00	.960	AC2	.00
AACS	PROCESSOR		.00	22.32	.00	.00	.00	.00	.00	.00	.00	.900	AC1	.30
	MAJOR PWR SUP		.00	14.44	.00	.00	.00	.00	.00	.00	.00	.900	AC1	.40
	AP THRUSTERS	B	.00	5.05	25.25	.00	.00	.00	.00	.00	.00	.900	AC1	1.00
	AP TH REP HTR	B	.00	13.20	.00	.00	.00	.00	.00	.00	.00	1.000	AC1	1.00
	CST		.00	2.53	.00	.00	.00	.00	.00	.00	.00	.900	AC1	2.00
	SUN SHUTTER		.00	5.05	.00	.00	.00	.00	.00	.00	.00	.950	AC1	1.00
	SUN SENSOR		.00	.85	.00	.00	.00	.00	.00	.00	.00	.900	AC1	1.00
	SCAN ACT		.00	5.05	.00	.00	.00	.00	.00	.00	.00	.900	AC1	1.00
	SCAN POTS		.00	.17	.00	.00	.00	.00	.00	.00	.00	.900	AC1	1.00
PYRO	INSTM		.00	2.83	3.84	.00	.00	.00	.00	.00	.00	.992	AC2	.00
	PSU		.00	.52	25.45	.00	.00	.00	.00	.00	.00	-.810	AC1	1.00
DSS			.00	20.20	22.73	27.00	.00	.00	.00	.00	.00	.990	AC2	.55
	REPL HTR		.00	10.60	.00	.00	.00	.00	.00	.00	.00	1.000	AC2	1.00
STRU	BAY 1 HTR		.00	24.20	.00	.00	.00	.00	.00	.00	.00	1.000	AC2	1.00
	BAY 2 HTR		.00	19.20	.00	.00	.00	.00	.00	.00	.00	1.000	AC2	1.00
	BAY 6 HTR		.00	16.40	.00	.00	.00	.00	.00	.00	.00	1.000	AC1	1.00
PROP	TCM HTR		.00	3.10	.00	.00	.00	.00	.00	.00	.00	1.000	AC2	1.00
SCIENCE														
SCI	PRA		.00	6.35	.00	.00	.00	.00	.00	.00	.00	.964	AC2	.00
	PWS		.00	1.38	1.79	.00	.00	.00	.00	.00	.00	.980	AC2	.00
	LECP		.00	3.78	3.98	4.12	.00	.00	.00	.00	.00	.910	AC2	1.00
	PLS		.00	8.30	.00	.00	.00	.00	.00	.00	.00	.950	AC2	.00
	UVS		.00	1.97	.00	.00	.00	.00	.00	.00	.00	.980	AC2	1.00
	MAG		.00	2.78	3.28	.00	.00	.00	.00	.00	.00	.960	AC2	.00
	MAG SEN HTRS		.00	2.02	.00	.00	.00	.00	.00	.00	.00	1.000	AC2	1.00
	ISS	A	.00	21.92	41.71	.00	.00	.00	.00	.00	.00	.950	AC2	.20
	MIRIS STBY		.00	1.60	7.90	.00	.00	.00	.00	.00	.00	.950	AC2	1.00
	MIRIS PRI	A	.00	15.60	.00	.00	.00	.00	.00	.00	.00	.950	AC2	.87
REGULATED DC														
RFS	ACIS AND SW		.00	.87	.00	.00	.00	.00	.00	.00	.00		DC1	1.00
	RCVR		.00	5.30	.00	.00	.00	.00	.00	.00	.00		DC1	-1.00
	S-BAND EXC		.00	2.37	.00	.00	.00	.00	.00	.00	.00		DC2	-1.00
	S-BAND TWT		.00	34.70	89.70	.00	.00	.00	.00	.00	.00		DC2	-1.00
	X-BND EXCITER		.00	3.30	.00	.00	.00	.00	.00	.00	.00		DC2	-1.00
	X-BAND TWT		.00	49.30	72.60	.00	.00	.00	.00	.00	.00		DC2	-1.00
	USO		.00	3.30	.00	.00	.00	.00	.00	.00	.00		DC1	1.00
PWR	POWER CONTROL		.00	2.02	.00	.00	.00	.00	.00	.00	.00		DC1	-1.00
	SHUNT REG		.00	2.02	.00	.00	.00	.00	.00	.00	.00		DC1	-1.00
	DISCHARGE CON		.00	1.01	.00	.00	.00	.00	.00	.00	.00		DC1	-1.00
FDS			.00	.60	.00	.00	.00	.00	.00	.00	.00		DC1	-1.00
AACS	GYROS		.00	16.86	20.60	15.06	27.60	36.62	44.20	72.00	.00		DC1	-1.00
SCI	CRS		.00	5.23	.00	.00	.00	.00	.00	.00	.00		DC2	.00
	LECP STEPPER		.00	.42	1.60	.00	.00	.00	.00	.00	.00		DC2	1.00
	PPS		.00	2.42	.00	.00	.00	.00	.00	.00	.00		DC2	-1.00
	PRA ANT MOTOR		.00	15.00	.00	.00	.00	.00	.00	.00	.00		DC2	1.00
TC/S	CRS SUPP		.00	2.80	.00	.00	.00	.00	.00	.00	.00		DC2	1.00
	CRS REPL		.00	5.23	.00	.00	.00	.00	.00	.00	.00		DC2	1.00
	LECP MAIN SUP		.00	4.15	.00	.00	.00	.00	.00	.00	.00		DC2	1.00
	LECP LEPT SUP		.00	.51	.00	.00	.00	.00	.00	.00	.00		DC2	1.00
	LECP REPL		.00	3.54	.00	.00	.00	.00	.00	.00	.00		DC2	1.00
	PPS SUPP		.00	2.80	.00	.00	.00	.00	.00	.00	.00		DC2	1.00
	PLS REPL		.00	4.37	.00	.00	.00	.00	.00	.00	.00		DC2	1.00
	PLS SUPP		.00	4.60	.00	.00	.00	.00	.00	.00	.00		DC2	1.00
	UVS REPL		.00	1.97	.00	.00	.00	.00	.00	.00	.00		DC2	1.00
	ISS-N OPTICS		.00	2.60	.00	.00	.00	.00	.00	.00	.00		DC2	1.00
	ISS-N VID REP		.00	5.56	.00	.00	.00	.00	.00	.00	.00		DC2	1.00
	ISS-W VID REP		.00	5.56	.00	.00	.00	.00	.00	.00	.00		DC2	1.00
	ISS-N ELE REP		.00	10.50	.00	.00	.00	.00	.00	.00	.00		DC2	1.00
	ISS-W ELE REP		.00	10.50	.00	.00	.00	.00	.00	.00	.00		DC2	1.00
	MIRIS REPL		.00	13.00	.00	.00	.00	.00	.00	.00	.00		DC2	1.00
TC/E	AZ ACT REP		.00	3.50	.00	.00	.00	.00	.00	.00	.00		DC2	1.00
	SUN SEN HTR		.00	1.80	2.90	4.70	.00	.00	.00	.00	.00		DC2	1.00
	IPU VALVE HTR		.00	3.35	20.31	.00	.00	.00	.00	.00	.00		DC2	1.00
	IPU RED V HTR		.00	2.97	14.92	.00	.00	.00	.00	.00	.00		DC2	1.00
	IPU THRUS HTR		.00	18.40	.00	.00	.00	.00	.00	.00	.00		DC2	1.00
	TCAPU RED HTR		.00	11.77	.00	.00	.00	.00	.00	.00	.00		DC2	1.00
	SCN PLTFM HTR		.00	6.00	.00	.00	.00	.00	.00	.00	.00		DC2	1.00

✻ Table 8. Power Profile Operating Transient Loads

LOAD VARIATIONS FROM THE VALUES LISTED IN THE SUBASSEMBLY DETAILED TABULATION, EXCLUSIVE OF TURN-ON TRANSIENTS.

SUBSYSTEM	VARIATION WATTS	COMMENT
DSS	-4.5	1.7 SECONDS AFTER EACH SPEED INCREASE AND 1.7 SECONDS AFTER THE START OF EACH RECORD MODE. PWR WILL DECREASE 4.5 WATTS TO STEADY STATE PWR OF 22.73 WATTS.
LECP	+0.1	FOR 24 MINUTES EACH DAY FOR IN-FLIGHT CALIBRATION DURING NEAR-ENCOUNTER. ONCE PER WEEK DURING FAR ENCOUNTER AND CRUISE.
PPS	-0.8	2.4 W PEAK FOR 0.2 S, 1.6 W FOR 0.4 S, (0.6 S CYCLE) DURING ENCOUNTER. COMMANDED BY FDS.
MAG	+11.0	DURING MODES 24-31; AND 36-43 FLIPPER HEATER POWER REQUIRED TWICE WEEKLY FOR FOUR PERIODS. EACH PERIOD OF OPERATION SHALL BE APPROX 6 MINUTES.
ISS	-1.0	VIDICON DEFLECTION CIRCUITRY.
	+10.0	IN-FLIGHT CALIBRATION. COMMANDABLE. 10 SEC. ONE EACH 96 SEC FOR SEVERAL FRAMES. EARLY ENCOUNTER AND POST-ENCOUNTER.
MIRIS	+34.6	FLASH OFF HEATER. COMMANDABLE. NEVER DURING ENCOUNTER.
	-3.2	RAMP UP AND DOWN ON 49 S CYCLE.
USO	+2.0	FOR THE FIRST 5 HOURS AFTER TURN ON.
PROP	+13.18	WILL OCCUR IF ONE SET OF TCAPU THRUSTERS FAILS. USED TO SWITCH FROM SYSTEM A TO B AND ON THE FIRST USE OFTCAPU THRUSTERS AT APPROX. L+63M
	+13.18	PROP ISO VALVE ON TCM OPERATES BEFORE AND AFTER EACH MANEUVER.
	+7.85	TCM HTRS REQUIRED 4 HOURS PRIOR TO TCM'S.
PRA/PWS	+60.0	ANTENNA DEPLOY. VALUE SHOWN REPRESENTS A STALLED MOTOR AND PWR REQUIRED TO BLOW A 1.5 AMP FUSE
PYRO	+19.0	CAPACITOR DISCHARGE -- OCCURS FOR 2 SECONDS AFTER EACH PYRO EVENT.
STRU	+10 TO 15	MAG CAL COIL ENABLED.POWER VARIES AS COIL RESISTANCE VARIES AS FUNCTION OF TEMP. 10 W NEAR EARTH, 15 W NEAR SATURN.

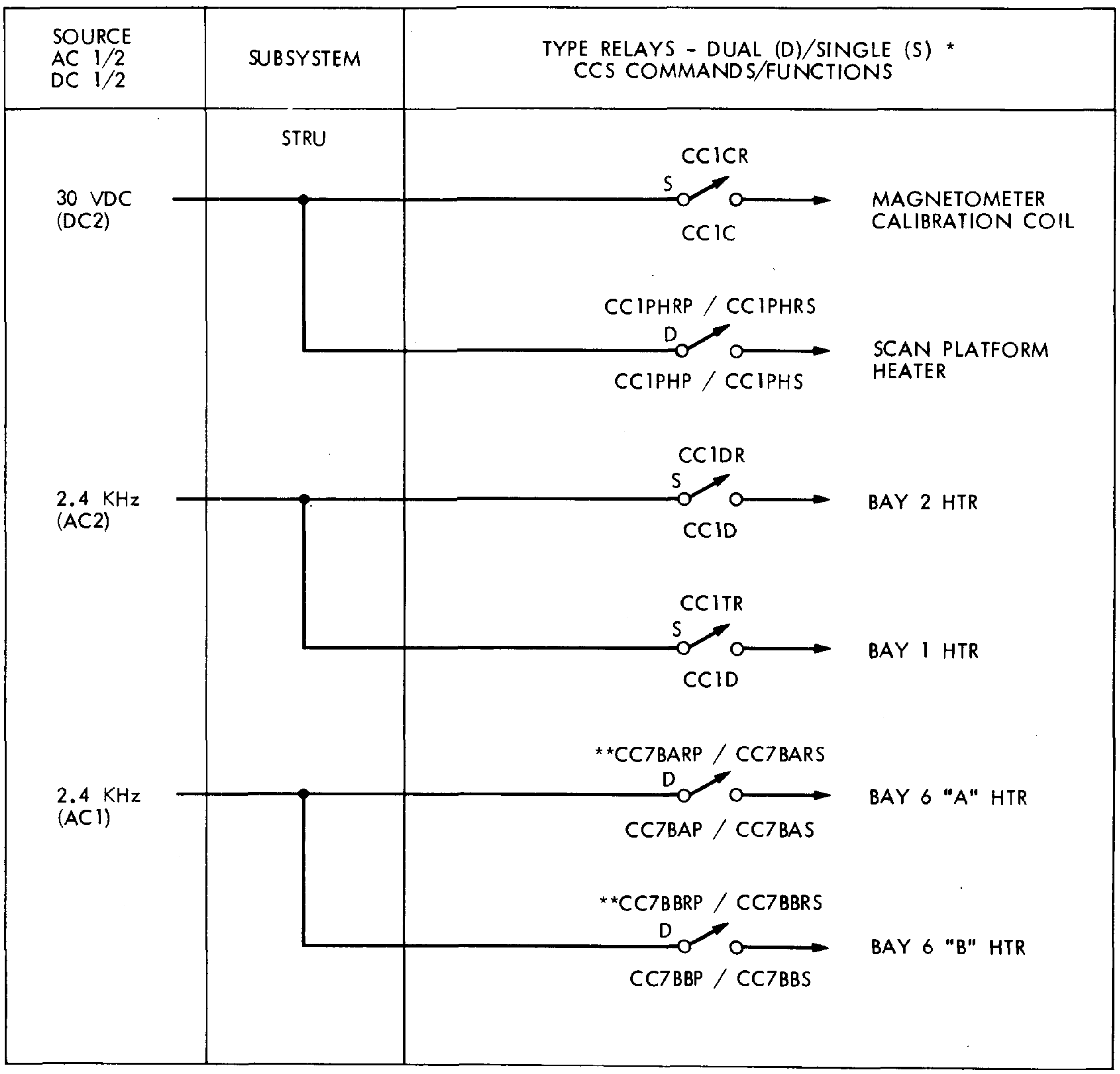
* Table 9. Gyro Power

Mission Phase	Assumed Vehicle Rates Deg/Sec	Equation	Total Power Watts	Mission Mode
All axes Inertial and Command Turn 2 Gyros at Low Rate	≤ 0.23 (one S/C axis) ≤ 0.003 (two S/C axes)	⚠1 2(7.5)+2(4.0)(0.23)+2(4.0)(0.003)	16.86	17, 18, 19, 27, 29, 30, 33, 34, 35, 36, 39, 41, 42, 45, 46, 47, 48, 54
Launch 2 Gyros at Low Rate	≤ 0.2 (P & Y) ≤ 0.5 (R)	⚠1 2(7.5)+2(4.0)(0.2)+2(4.0)(0.5)	20.60	6, 7, 8
Gyro Health Ground Test 2 Gyros at Low Rate	≤ 0.004 (P, Y, R) (Earth Rotation)	⚠1 2(7.5)+4(4.0)(0.004)	15.06	3
Post Injection and Commanded Turn 2 Gyros at High Rate	≤ 2.88 (one S/C axis) ≤ 1.0 (two S/C axes)	2(9.0)+2(2.4)(2.88)+2(2.4)(1.0)	36.62	12
Deploy and Jettison 2 Gyros at High Rate	≤ 1.0 (P, Y, R)	2(9.0)+4(2.4)(1.0)	27.60	10, 13, 14, 15, 16
Launch 2 Gyros at Low Rate Saturated	≥ 1.0 (P, Y, R)	⚠1 2(7.5)+4(4.0)(1.0)+2(6.6)	44.20	4, 5, 9
P.M. Burn 2 Gyros at High Rate	≤ 7.0 (P & Y) ≤ 1.5 (R)	2(9.0)+3(2.4)(7.0)+1(2.4)(1.5)	72.00	11

Quiescent Power (Low Rate): 7.5 watts/gyro
Quiescent Power (High Rate): 9.0 watts/gyro

Saturation Power: 6.6 watts/gyro
Rate: 2.4 watts/(deg/sec)/axis (High Rate)
4.0 watts/(deg/sec)/axis (Low Rate)

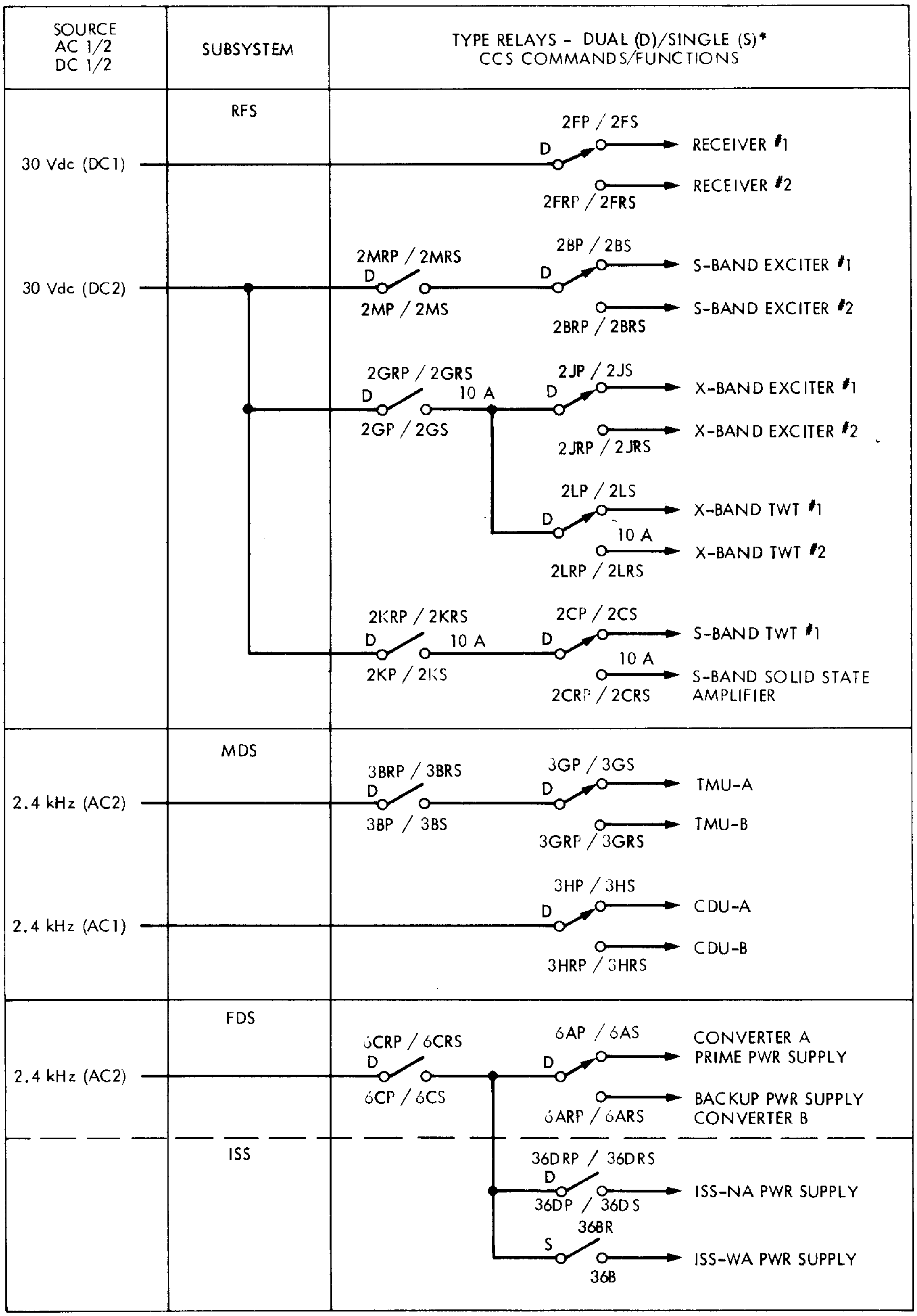
⚠1 On any Mission Phase where the gyro is turned on in the low rate mode (7.5 watts/gyro), there is a peak turn on power of 9.0 watts/gyro for 10 seconds. This is a transient delta of +1.5 watts/gyro above quiescent steady-state power for 10 seconds.



*ALL RELAYS HAVE 2 A CONTACTS UNLESS OTHERWISE NOTED

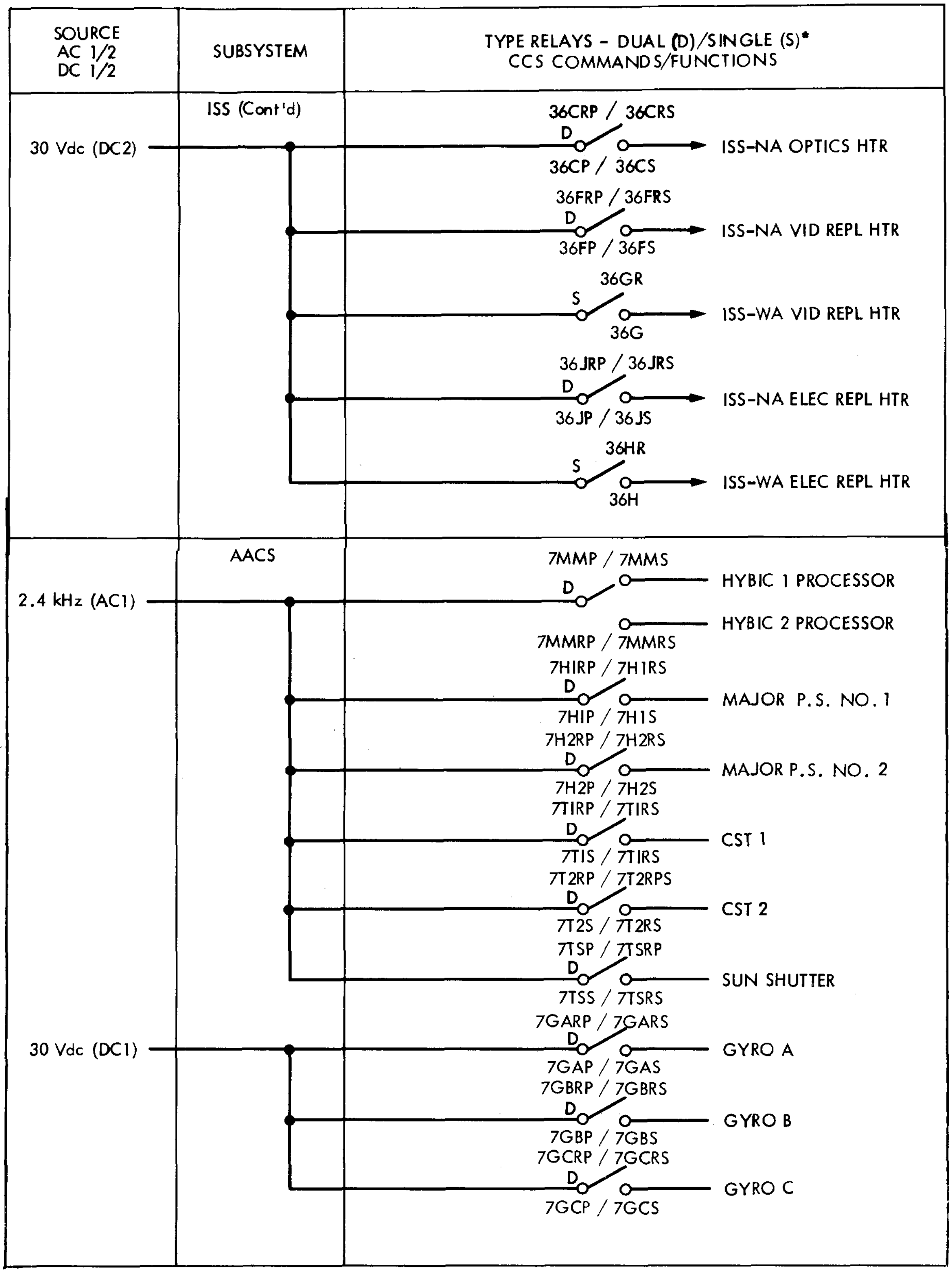
**BAY 6 HEATERS ARE ASSIGNED TO STRU ALTHOUGH THE COMMAND MNEMONICS INDICATE AACS. THESE RELAYS WERE ORIGINALLY DESIGNATED AACS SPARES

* Figure 2. User Subsystem Functions Switched by Power Subsystem



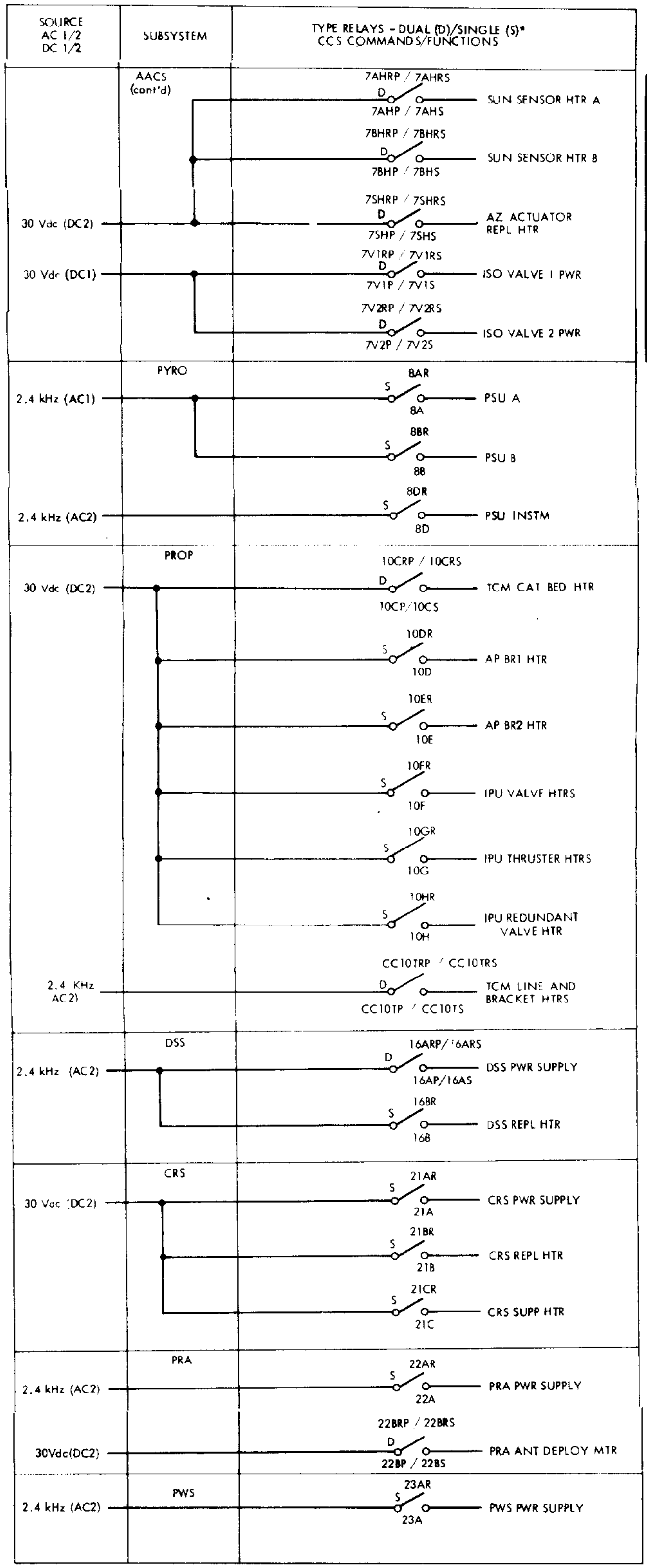
*ALL RELAYS HAVE 2 A CONTACTS UNLESS OTHERWISE NOTED

*Figure 2. User Subsystem Functions Switched by Power Subsystem (Contd)



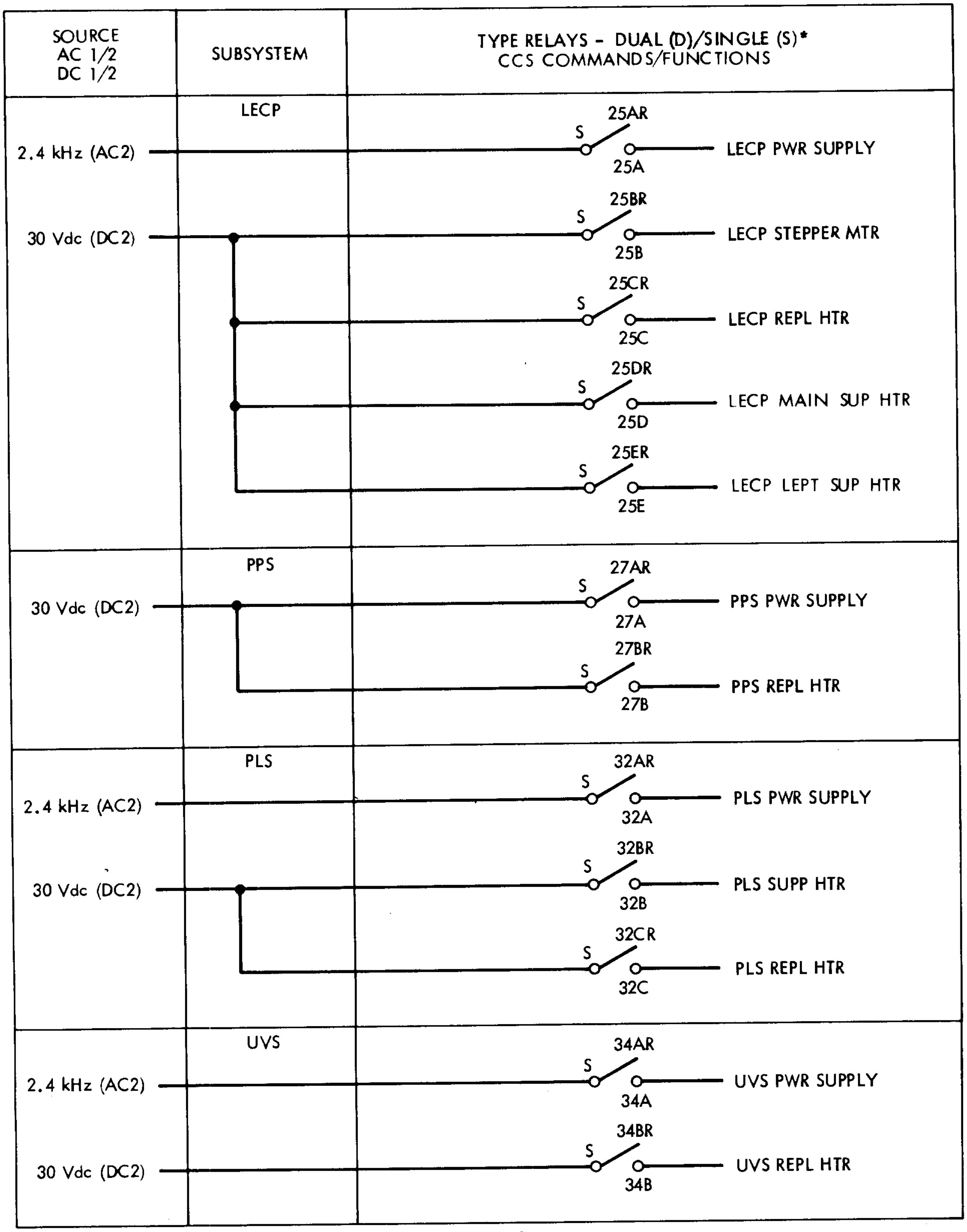
*ALL RELAYS HAVE 2 A CONTACTS UNLESS OTHERWISE NOTED

Figure 2. User Subsystem Functions Switched by Power Subsystem (Cont'd)



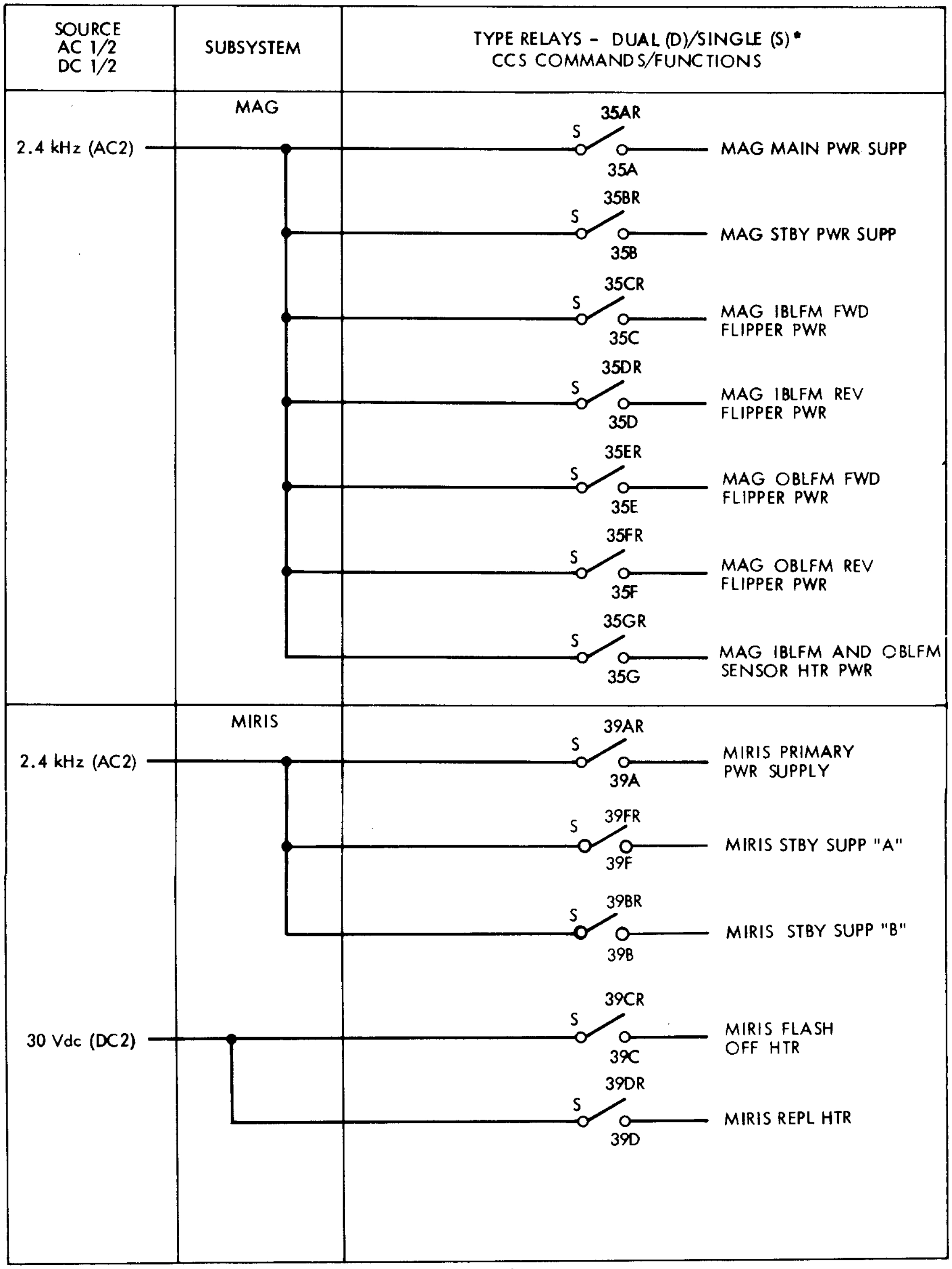
*ALL RELAYS HAVE 2 A CONTACTS UNLESS OTHERWISE NOTED

* Figure 2. User Subsystem Functions Switched by Power Subsystem (Contd)



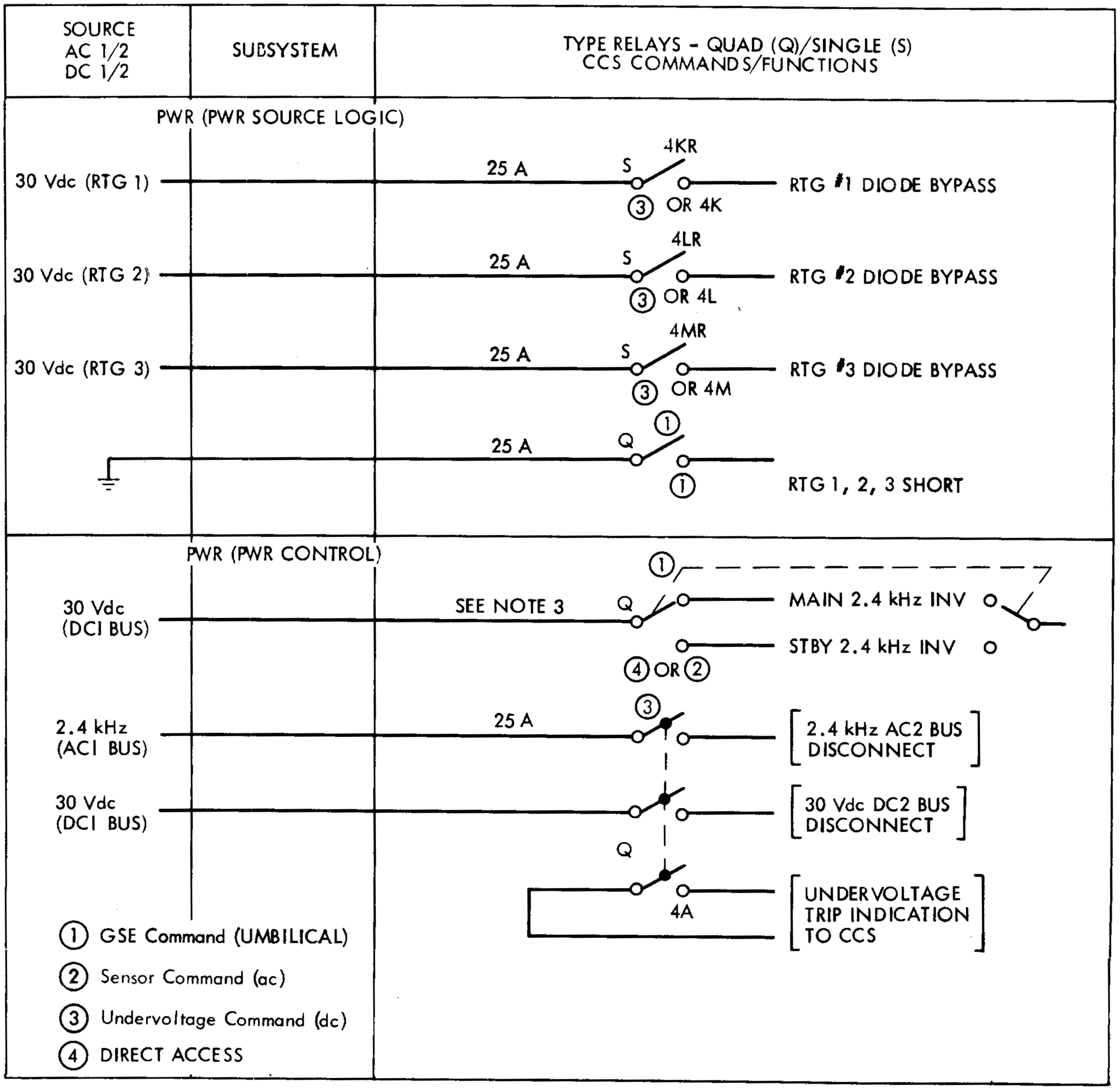
*ALL RELAYS HAVE 2 A CONTACTS UNLESS OTHERWISE NOTED

* Figure 2. User Subsystem Functions Switched by Power Subsystem (Contd)



*ALL RELAYS HAVE 2 A CONTACTS UNLESS OTHERWISE NOTED

* Figure 2. User Subsystem Functions Switched by Power Subsystem (Contd)



NOTES:

1. MAXIMUM STEADY STATE POWER FOR EACH OF THE USERS SUBSYSTEM FUNCTIONS SHALL BE SHOWN IN THE SUBASSEMBLY DETAIL TABULATION (TABLE 5). OPERATING TRANSIENT LOADS ARE SHOWN IN TABLE 8.
2. FUSE CONFIGURATION FOR EACH USERS SUBSYSTEM SHALL BE DEFINED IN MJS77-3-260
3. CONSISTS OF THREE (3) SETS OF QUADS (12 RELAYS). FOUR 25 A, FOUR 10 A AND FOUR 2 A

*Figure 2. User Subsystem Functions Switched by Power Subsystem (Contd)

REVISION PAGE

Revision	Date	ECRs Incorporated	Comments
Original	8 July 1975		
A	8 June 1977	36054, 36086, 36121, 36127, 36141, 36190, 36191, 36198, 36206, 36209, 36221, 36230, 36231, 36266, 36273, 36285, 36309, 36326, 36367, 36414, 36416, 36424, 36453, 36464, 36492, 36500, 36523, 36524, 36525, 36546, 36583, 36597, 36701, 36705, 36711, 36748, 36791,	Revised document per ECRs listed

(Insert in 618-205, MJS77 Functional Requirements Book and 618-206, MJS77 Support Equipment Design Book)

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JET PROPULSION LABORATORY

No. MJS77-3-260A
17 August 1976
Supersedes
MJS77-3-260
14 March 1975

FUNCTIONAL REQUIREMENT
MARINER JUPITER/SATURN 1977
ELECTRICAL GROUNDING AND INTERFACING

* Denote changes from previous issue.

1.0 SCOPE

1.1 Purpose

This document states the electrical grounding and electrical interface functional requirements for the Mariner Jupiter/Saturn 1977 (MJS77) spacecraft, including the Mission Module (MM) and Propulsion Module (PM), in addition to the Spacecraft Adapter, System Test Complex Equipment (STCE), and Launch Complex Equipment (LCE). Systems concerns are also identified, relating to grounding and interfacing in bench checkout and facility areas.

1.2 Applicability

a) The electrical interface circuits to which this document applies are those circuits listed in MJS77-3-110 and MJS77-3-1110, Functional Block Diagrams and Interface Listings.

b) The requirements of this document are applied in detail to specific interface circuits and equipment by circuit data sheets which are identified in JPL Drawing 10063288, Circuit Data Sheet Index and Guide. In the event of conflict, the Circuit Data Sheet shall govern. Interstage circuits are governed also by, 618-59, Mariner Jupiter/Saturn 1977, Launch Vehicle System Requirements.

c) Electromagnetic environments affecting the design of grounding and interfacing are defined in MJS77-3-240, Environmental Design Requirements.

d) Requirements affecting the physical design of interfacing equipment and cabling are contained in MJS77-3-220, Electronic Equipment Design; MJS77-3-180, Configuration; MJS77-4-2009, Cabling; MJS77-3-1130, Test Facilities; MJS77-4-2109, Support Equipment Cabling; and DM504264, Support Equipment Consoles.

Electrical Design Criteria are presented in MJS77-3-100, Spacecraft Requirements and Constraints and MJS77-3-1100, Support Equipment Requirements and Constraints.

* 2.0 APPLICABLE DOCUMENTS

The following documents form a part of this Functional Requirement to the extent specified herein:

NOTE

MJS77-3-100, Spacecraft Requirements and Constraints, applies to this document. Requirements of other MJS77 level 3 documents may also be applicable. It is the responsibility of the user to adequately acquaint himself with the organization and pertinent content of the level 3 documents, as well as with the material contained herein.

REQUIREMENTS

<u>Jet Propulsion Laboratory</u>

MJS77-3-100	Functional Requirement, Mariner Jupiter/Saturn 1977 Spacecraft Requirements and Constraints
MJS77-3-110	Functional Requirement, Mariner Jupiter/Saturn 1977 Functional Block Diagram and Interface Listings
MJS77-3-180	Functional Requirement, Mariner Jupiter/Saturn 1977 Flight Equipment, Configuration

MJS77-3-220	Functional Requirement, Mariner Jupiter/Saturn 1977 Flight Electronic Equipment Design
MJS77-3-240	Functional Requirement, Mariner Jupiter/Saturn 1977 Environmental Design Requirements
MJS77-3-1100	Functional Requirement, Mariner Jupiter/Saturn 1977 Support Equipment Requirements and Constraints
MJS77-3-1110	Functional Requirement, Mariner Jupiter/Saturn 1977 Support Equipment Functional Block Diagram and Interface Listings
MJS77-3-1130	Functional Requirement, Mariner Jupiter/Saturn 1977 Support Equipment Test Facilities
MJS77-4-2009	Functional Requirement, Mariner Jupiter/Saturn 1977 Flight Equipment Cabling Subsystem
MJS77-4-2109	Functional Requirement, Mariner Jupiter/Saturn 1977 Support Equipment Cabling

PROJECT DOCUMENTS

Jet Propulsion Laboratory

618-59	Mariner Jupiter/Saturn 1977, Launch Vehicle System Requirements
618-263	Mariner Jupiter/Saturn 1977, Electrostatic Control for Assembly and Test Areas

DESIGN REQUIREMENTS

Jet Propulsion Laboratory

DM504264	Support Equipment Consoles
DM509306	Electronic Equipment and Cabling, Design and Fabrication Requirements and Processing Techniques, Vol. I

SAFETY MANUALS

Jet Propulsion Laboratory

(No number)	JPL Safety Manual
601-4	JPL Flight Project Safety Guide

U.S Air Force

AFETRM 127-1	Range Safety Manual

DRAWINGS

Jet Propulsion Laboratory

10063288	Circuit Data Sheet Index and Guide

3.0 ELECTRICAL GROUNDING AND INTERFACING

3.1 + Flight Equipment General

a) The content of this section applies to the design of flight equipment. Parts of this section applying also in whole or in part to support equipment are identified (+).

b) Requirements applying to Support Equipment (SE) only are presented in Section 4.0.

c) These requirements apply directly to interfaces and grounding design and, when applicable, to internal equipment design.

d) With respect to grounding and interfacing, equipment adopted from the Viking Orbiter project is acceptable provided that the equipment characteristics are compatible with the requirements of this document.

e) Modified requirements may be negotiated with the Spacecraft System Engineer.

f) Terms with special meanings for the purposes of this document are defined where used, or in paragraph 5.3.

3.2 Electrical Grounding

The objective of electrical grounding is to produce an equipotential spacecraft surface, by the reduction of potentials induced from the ambient plasma, and currents flowing in the structure. Proper spacecraft electrical grounding requires attention to structural grounding and circuit grounding.

3.2.1 Structural Grounding

The spacecraft physical structure provides several electrical functions, including the following:

a) Uniform distribution of electrical charges.

b) Grounding of electronics.

c) Limiting of the differential charging of components and surfaces.

d) Attenuation of radiated EMI entering or leaving shielded compartments.

To support these functions, the materials and construction methods for spacecraft external assemblies, bay assemblies, subassemblies, chassis, subchassis and other components shall be such that electrical properties of the spacecraft structure are maintained throughout the service life of the spacecraft.

* 3.2.1.1 Bonding. To provide electrical continuity throughout the structure, electronic frames and other conductive parts, adequate bonding (electrical conductivity) shall be provided across contiguous assemblies, subassemblies, subchassis, blanket layers, and other mounted components. Bonding requirements apply to rigid and articulating mounting joints for all components with conductive surfaces. To minimize mechanical requirements, high conductivity bonds (E), medium conductivity bonds (M), low conductivity bonds (L), and wire bonds (W), are recognized, as defined in paragraph 5.3. All MM external conductive surfaces shall at a minimum be bonded to the (L) requirement and in no instance shall more than 10.0 V exist during flight between any two external, conductive surfaces. Examples of specific bonding requirements are:

	Bond
Internal Joints in the Bus Upper and Lower Rings	E
Bus Upper and Lower Rings to Bay Electronic Assembly	E
Internal Joints in the Bus Cable Support Structure	E
Bay Shearplate to Bay Subchassis	E

Joint	Bond
Bus or Platform to External or Platform Electronic Item*	E
Bus or Platform to External or Platform Non-Electronic Item	M
Bus or Platform to Thermal Blanket Metallic Layers	L
Articulating or Other Special Joint Between Electronic Items	W

Note: There is no system requirement for bonding of small, difficult-to-ground electronic elements such as toroidal transformer cores and unused relay contacts.

3.2.1.2 + Grounding for Test and Operations. During system test, the bus structure shall be connected to the system test complex electrical ground point. This point shall be the common ground point for the spacecraft and support equipment and shall be connected by as short a path as practical to the facility instrumentation ground system. During free-mode tests, ground paths from bus structure to external points shall not be present.

* 3.2.1.3 + Static Grounding. An electrical grounding lug shall be provided on the spacecraft basic structure. The purpose of the grounding lug is to facilitate safe and reliable electrical connection to a ground system. The spacecraft basic structure grounding lug shall be in proximity to the radio frequency subsystem transmitters electronic chassis.

* 3.2.2 + Circuit Grounding

All circuitry interconnecting semiconductors, capacitors, transformers, and other electronic components shall be provided with an electrical path to structure. The single point grounding method will be used for all circuitry except fast signal circuits (defined in paragraph 5.3) for which grounding treatment will be specified in the Circuit Data Sheets (CDS). The single point ground method provides but one ground path to bus structure from any circuit or group of circuits, with the result that circuit currents do not flow in any chassis or structure. It must be understood that this objective is realized only for dc. For ac signals, multiple paths will occur through the stray capacity present between circuit components and structure.

*Except for insulated chassis as identified on Figure 2.

The first purpose of grounding is to maintain an equipotential ground plane available to all circuits. Except for the ground path, circuit elements should be electrically isolated from chassis such that circuit currents flowing in structure are two or more orders of magnitude less than in the circuit return wire. The second purpose of grounding is to ensure that no significant voltage exists between circuit return and structure (or unrelated circuitry). The minimum required ground path conductivity (maximum resistivity) therefore ranges from milliohms for low level electronic circuits, to kilohms, for circuit with fault-limiting resistance, to megohms, for circuits only requiring electrostatic discharge paths. Specific grounding requirements are contained in the following subparagraphs and in paragraph 3.3.8 and subparagraphs.

It should be noted that the single point grounding method requires that there be no more than one path from any circuit or groups of circuits to structure but does not require the use of only one ground tree. See paragraph 3.2.2.2.

* 3.2.2.1 + Chassis – Circuitry Isolation. Except for RF stages, packaging techniques will be used as illustrated on Figure 1 which electrically isolate all circuitry from chassis ground. See also, MJS77-3-220.

For each subsystem or assembly, isolation between circuit common and chassis shall be not less than 1.0 MΩ and not more than 0.01 μF, including the subsystem wiring harness distributed capacity, however, circuit commons normally referenced internally to chassis within the subsystem or assembly are not subject to this requirement. For circuit commons not internally referenced to chassis, lumped capacitance shall not be inserted between circuit common and chassis. Minimum capacitance from circuit common to chassis is a goal. More stringent dc insulation requirements may be specified to ensure quality of insulation.

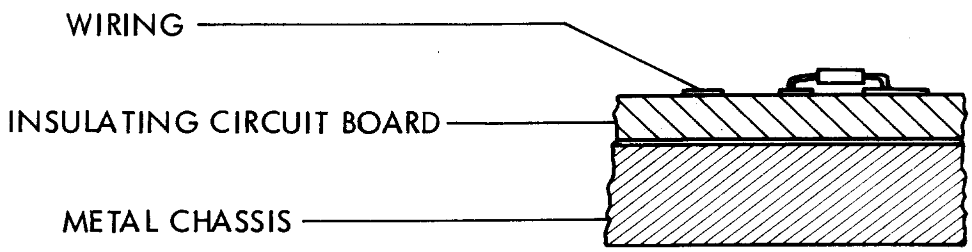


Figure 1. Chassis – Circuitry Isolation

✻ 3.2.2.2 Circuit Reference Tree. The circuit reference trees (ground trees) provide grounding for circuit commons within the subsystems and for interface circuit returns, to meet the purposes and criteria expressed in paragraphs 3.2.2 and 3.3.8.3. The spacecraft circuit reference trees are:

Name	Identity No.
RFS (TWTA)	2.1
RFS (Transponders)	2.2
DC PWR	4.1
AC PWR	4.2
CCS	5
FDS	6
AACS	7
PYRO	8
PRA	22
PWS	23

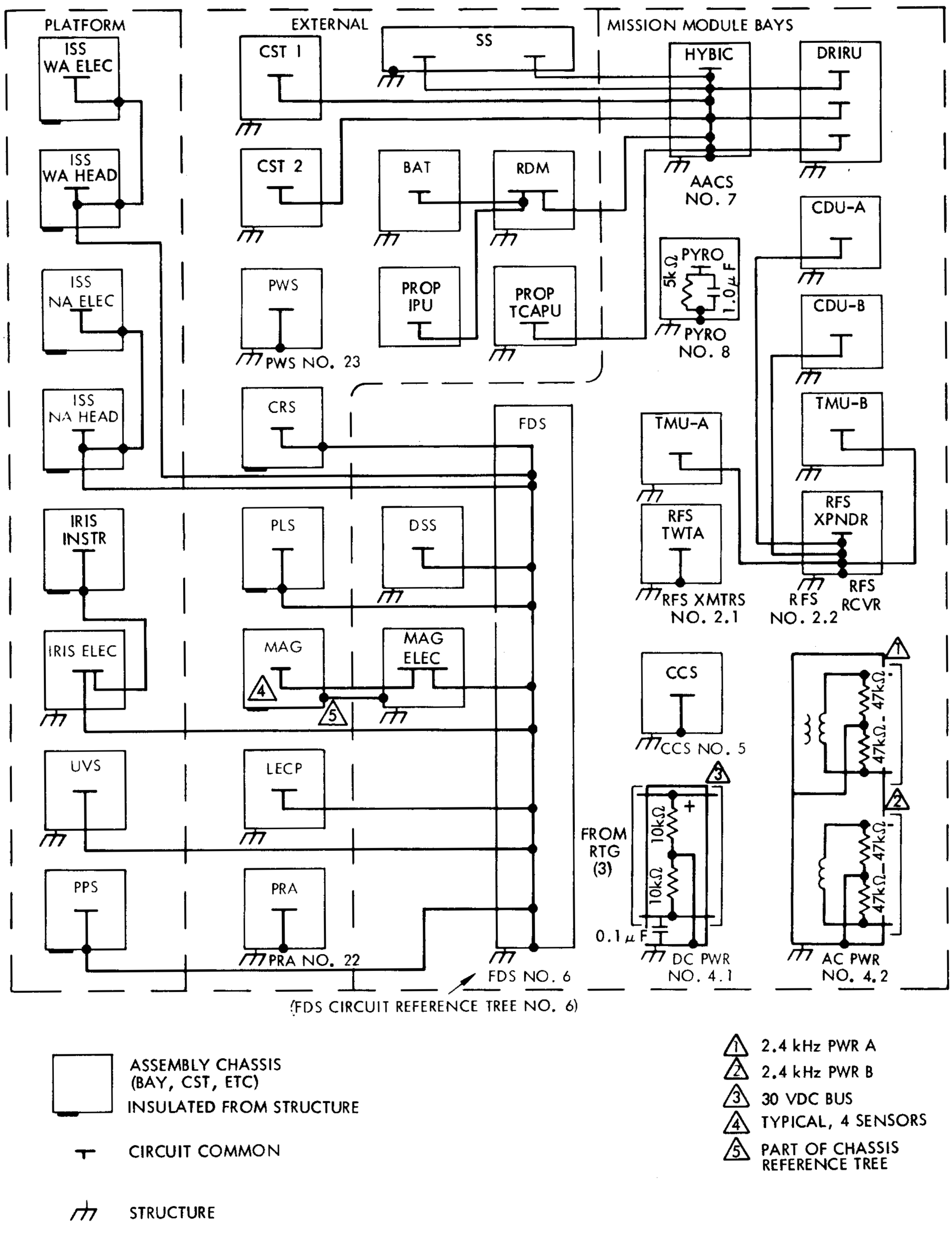
The circuit reference trees are as shown on Figure 2. For simplicity, interface circuit returns have been omitted.

✻ 3.2.2.3 Chassis Reference Tree. The chassis of electronic bay subassemblies, electrical actuators, and other powered electronic packages with plug-in electrical connectors shall be connected to structure by means of chassis reference trees. The wiring of the chassis reference tree shall be carried where practical in the quiet bundle, as stated in paragraph 3.3.11, and shall be independent of other electrical bonding. The structure of the MM, PM, and Spacecraft Adapter shall be interconnected by chassis reference tree wiring or by cable shielding terminated in two or more of the stages.

3.3 + Electrical Interfacing

To achieve economical and proven interface design, emphasis shall be given to the standardization of electrical interface circuits. Circuits with identical functional requirements shall be of identical design. Also, to the extent practical, interfaces shall be limited to the standard circuit types identified in Table 1*. The requirements applying to each circuit are stated in Table 1 in the columns

*See Table 1 on page 35/36



* Figure 2. Circuit Reference Trees

headed, End-circuit Type, Cable Type, Signal Class, Signal Amplitude, Conducted Noise Emission, Conducted Noise Susceptibility, Overload and Fault Protection, End Circuit Grounding and Isolation, Wire Group, Wire Shield and Wire Bundle. Additional requirements and information are stated under like headings in this Section. Unless otherwise noted, requirements apply to equipment functioning in the system configuration.

Since these interface circuit requirements are not comprehensive, interface circuit design shall be evaluated by the designer with respect to type of construction, compactness, mass, temperature range, vibration, packaging, signal amplitude, signal delay, transition time, output impedance, input impedance, power consumption, power voltage, number of required principal and ancillary parts, spurious output, radiated EMI, susceptibility to conducted and radiated EMI and transient interference, susceptibility to particles and fields, primary failure mode, isolation, intended area of application and any related factors.

In selecting a standard circuit for a particular interface function, first consult the Cable Type and Signal Class information in Table 1, identifying possibly suitable circuit types. Then, to determine the most suitable circuit, compare the given end-circuit types, signal amplitude, isolation and other circuit characteristics with the requirements of the equipment to be interfaced.

Where there is not a standard circuit type for a signal with special characteristics, a full description and analysis of proposed special circuitry shall be submitted by the designer for approval by the Spacecraft System Engineer.

3.3.1 End-Circuit Type

The sending and receiving end-circuits are identified in Table 1 by end-circuit numbers. In paragraph 5.2, these numbers are correlated with manufacturers' specifications and other information.

* 3.3.2 Cable Type

End-circuit noise immunity and other characteristics must be compatible with cabling noise levels and line parameters, therefore, end-circuit types associated in Table 1 with particular cable types shall only be used with those cable types. Flight, Inter-Stage, Direct Access and Umbilical cable types have been defined.

3.3.3 Signal Class

The class of signal which may be carried by the circuit type is designated in Table 1.

3.3.4 Signal Amplitude

The signal amplitudes are specified in Table 1 as nominal, peak-to-peak voltages. No new, non-standard signal circuits shall be implemented with a nominal signal amplitude of greater than 16 V and, for quiet circuits, greater than 10 V. Signal characteristics at the receiving subsystem input terminals may differ from the nominal to the extent specified in paragraphs 3.3.5 and 3.3.6.

Distributed power amplitudes given in Table 1 for information are derived from specifications in MJS77-3-100, Spacecraft Requirements and Constraints.

3.3.5 Conducted Noise Emission

For digital circuits (bi-level and coded command circuits of Table 1), as specified in MJS77-3-240, short term signal amplitude deviations (due to distortion and interference originating within the sending subsystem) shall be not more than ±5 percent of the expected signal peak-to-peak amplitude and within the limits shown in the Circuit Data Sheets. The maximum permissible amplitude deviation from any cause (short term and other effects originating within the sending subsystem) shall be as shown by the circuit data sheet waveform envelope and, unless otherwise shown thereon, shall be not more than ±10 percent of the expected signal peak-to-peak amplitude. If the circuit normally functions at certain times in a weak-signal mode, to that extent, the conducted noise emission requirement does not apply.

No signal from relay or switch contacts shall exhibit more than 1.5 ms of contact bounce. Relay, solenoid and stepper motor coils shall be equipped with diodes or other transient suppression devices. The armature response time shall not be adversely lengthened in consequence of transient suppression.

3.3.6 Conducted Noise Susceptibility

All interface signal circuits shall be designed to perform acceptably in the presence of system and subsystem electrical noise and interference. For bi-level circuits, conducted emission from the sending subsystem may modify the signal within the constraint of paragraph 3.3.5. Also, electrical noise or interference within the receiving subsystem may further modify the signal. Finally, electrical noise may be introduced on the system interconnecting wiring. The test levels for system wiring noise are given below. Immunity to system wiring noise greater than given may be necessary, depending on acceptable error rates, degradation due to radiation, coupling due to shared circuit returns, etc.

	Quiet Bundle (V peak)	Noisy Bundle (V peak)
Cross-Coupling		
Untwisted Group	1.0*	3.0*
Twisted Group	0.3*	1.0*
Shielded Group	0.1	0.3
Common-Mode		
Signal Ground	3.0	3.0

3.3.7 Overload and Fault Protection

Overload and fault protection requirements for ac power circuits, dc power circuits, signal circuits, command circuits, analog telemetry circuits, interstage circuits, direct access circuits and umbilical circuits are as follows.

3.3.7.1 Power Circuit. Except for that equipment adopted from the Viking Orbiter project which is not so equipped, all equipment using spacecraft distributed ac or dc power shall protect the power source by means of overload devices placed within the using subsystem. Fuses shall be the means of providing overload protection. Overload protection other than fuses shall be used only with the approval of the Spacecraft System Engineer. Fusing shall be in accordance with the following:

a) Two fuses, one of which is diode-isolated, shall be used, as shown in Figure 3.

b) To permit fuse integrity tests at the system level, each fuse shall have power routed to it through separate connector pins, as shown in Figure 3.

c) Fuse mounting shall provide for visual inspection and ease of replacement.

d) Subsystems shall function normally over the specified range of ac or dc power source voltage with either fuse failed-open.

3.3.7.1.1 Signal and Power Circuits. As indicated in Figure 2, distributed power circuits shall be grounded at the power source. In the event of a transient or continuing short from a power line to chassis or structure, part or all of the power voltage will appear within the associated ground system due to the voltage drop across the protective grounding resistors. Signal and power circuits on which this common-mode voltage would be impressed shall be capable of continued operation.

*As specified in MJS77-3-240. Occasional pulses may exceed this value.

3.3.7.2 Command Circuit. For CCS commands, the absolute maximum command signal current and voltage shall be as follows:

	Discrete Command	Coded Command
Open Switch Vdc	35	21
Closed Switch mA	160/400	10

These maximum ratings do not relax other signal amplitude requirements. For CCS, FDS and AACS redundant commands, the interface capability to send and receive all commands to a subsystem shall be maintained in the event that one command switch remains closed following command issuance, instead of normally re-opening.

3.3.7.3 Analog Telemetry Circuit. Analog telemetry signals to the FDS shall be limited to absolute maximum voltages of +7, -1. No single failure in the output end-circuit shall allow the signal voltage to exceed this range. The output end-circuit source impedance shall be 3 ± 2 kΩ, except that the source impedance may be as high as 10 kΩ if the resultant inaccuracy is acceptable. No adverse effect upon the sending subsystem performance or on the remaining telemetry signals from the subsystem shall occur, as a result of:

a) A failure in the sending end-circuit.

b) A failure in the receiving end-circuit which places a potential in the range, -3 to +10 V, through 1 kΩ, between the signal line and FDS circuit common.

Low-pass filters or other circuit elements shall not be wired in with temperature sensors.

3.3.7.4 Inter-Stage Circuit. Damage to in-flight separation connectors during stage separation such that the exposed pins of a separated connector are shorted together or to chassis in any combination shall not reduce the functional capability of any equipment still having a mission function.

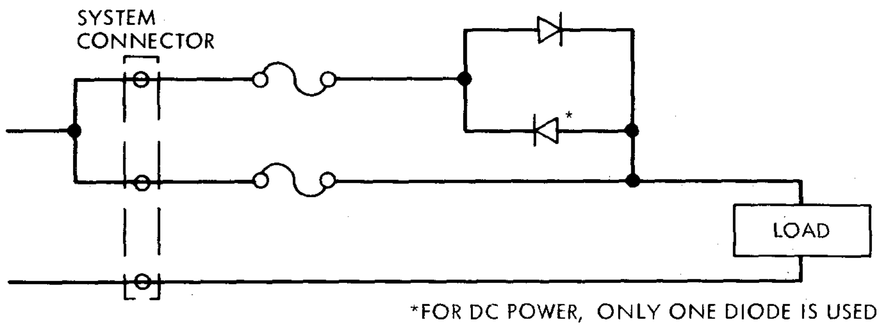


Figure 3. Fuse Connection

* 3.3.7.5 + Direct Access and Umbilical Circuit. As a goal, damage to direct access or umbilical circuits, such that conductors in a cable or connector are shorted together or to chassis in any combination shall not induce damage in flight or SE circuitry.

Direct Access and Umbilical circuits shall be designed to impose no adverse loading on flight circuitry during any test operation. In the prevention of loading, primary emphasis shall be given to support equipment end-circuit design. If it is not feasible to eliminate loading through support equipment design, supplemental means, such as series resistors, shall be employed in the design of the flight equipment end-circuits.

3.3.7.6 Pyrotechnic Firing Circuits. Pyrotechnic firing circuits shall meet the intent of AFETRM 127-1, Range Safety Manual.

3.3.8 + End-Circuit Grounding and Isolation

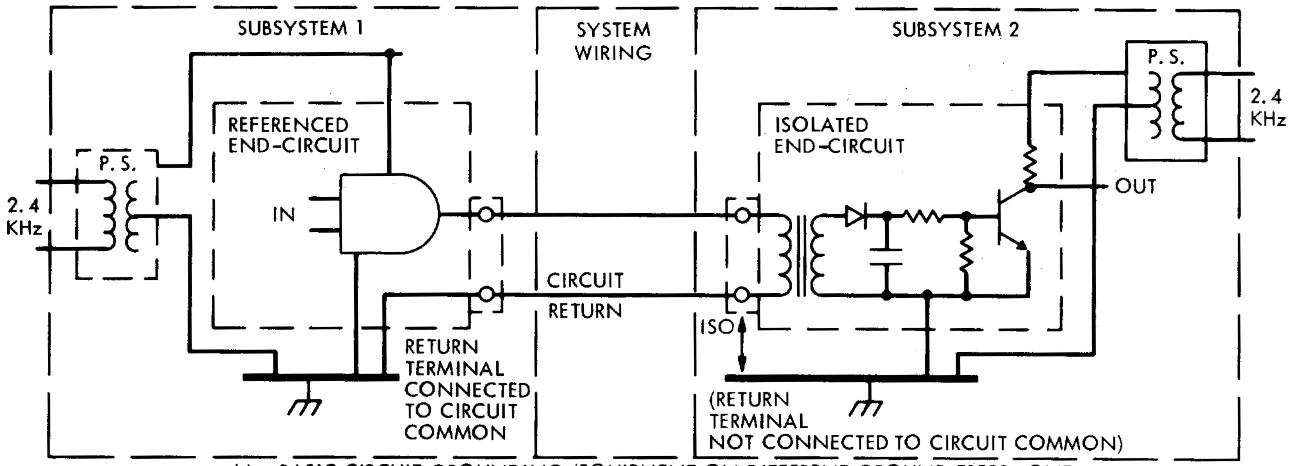
To implement the single point grounding concept of no ground loops and no floating circuitry, the basic interface circuit is provided with one referenced end-circuit and one isolated end-circuit, as explained below. Specific requirements are contained in Table 1.

3.3.8.1 + Referenced End-Circuit. An end-circuit is referenced by connecting the return terminal to the circuit common of the subsystem (assembly) containing the end-circuit. The circuit common is connected to structure through a circuit reference tree, as specified in paragraph 3.2.2.2.

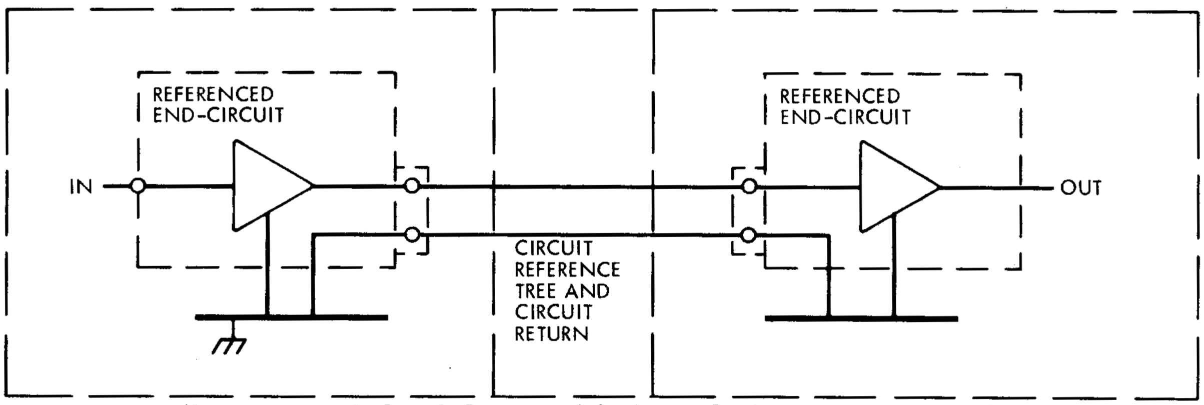
3.3.8.2 + Isolated End-Circuit. The return terminal of an isolated end-circuit is not connected to the circuit common of its subsystem but is connected instead through the circuit return conductor to the return terminal of the other end-circuit, and therefore to the circuit common of the other subsystem, as shown in Figure 4A.

For flight equipment, the isolated end-circuit shall present not less than 1.0 MΩ resistance and, for signal circuits, not more than 400 pF of capacity, exclusive of cabling, measured from each input terminal to circuit common. The minimum net isolation required of two or more end-circuits sharing a circuit return shall be the above resistance divided by the number of sharing end-circuits and the above capacitance multiplied by the number of sharing end-circuits. Equipment shall maintain end-circuit isolation with power on and power off.

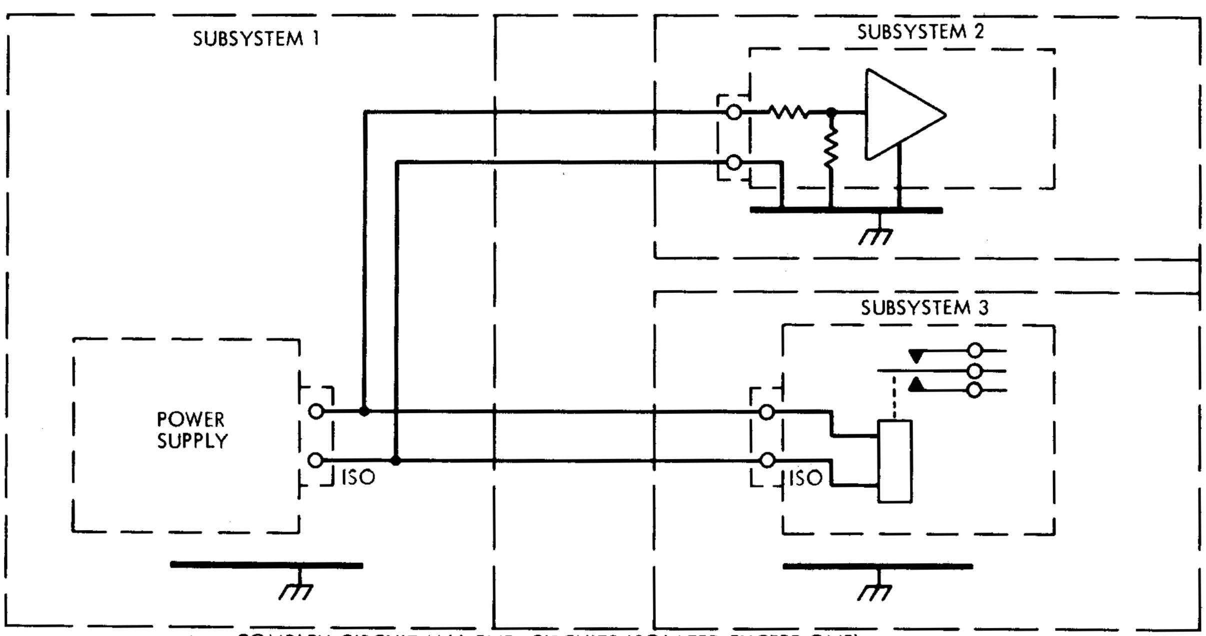
The requirement for not more than 400 pF of capacitance is relaxed to 0.01 μF per circuit for analog telemetry signal isolated end-circuits that require RF filtering capacitors connected between the end-circuit terminals and chassis. However, see the requirement for temperature sensors in paragraph 3.3.7.3.



4A. BASIC CIRCUIT GROUNDING (EQUIPMENT ON DIFFERENT GROUND TREES, ONE END-CIRCUIT ISOLATED)



4B. ALTERNATE CIRCUIT GROUNDING (EQUIPMENT ON SAME GROUND TREE, BOTH END-CIRCUITS REFERENCED)



4C. COMPLEX CIRCUIT (ALL END-CIRCUITS ISOLATED EXCEPT ONE)

Figure 4. End-Circuit Grounding and Isolation (Examples)

For support equipment, the isolated end-circuit shall present not less than 1.0 MΩ resistance and not more than 400 pF capacitance, measured from each end-circuit terminal to circuit common (chassis). The measurement is made at the rack connector with the system cabling disconnected and thus includes only the capacitance of the end-circuit and the rack interior cabling. The minimum net isolation required of two or more support equipment end-circuits sharing a circuit return shall be the above resistance divided by the number of sharing end-circuits and the above capacitance multiplied by the number of sharing end-circuits.

3.3.8.3 + End Circuit Grounding and Isolation Criteria. In each interface circuit, the option exists of referencing either end-circuit. The determination shall be based on maintenance of interface simplicity, uniformity and reliability. The isolation and referencing established by Table 1 were derived partly to achieve uniform practice for a signal class or within a subsystem, and partly from inherent end-circuit characteristics. For some circuits, as shown in Figure 4B, the necessity for an isolated end-circuit may be avoided. Referencing both end-circuits in this way is only permissible if, in laying out the circuit reference tree, circuit commons have been connected together as shown and the requirements of paragraph 3.3.8.3.1 have been met. For isolated end-circuits or isolated power supplies that are associated with fast signals, minimum capacitance from circuitry to chassis is a goal.

A more complex grounding scheme may be used where it is safe and advantageous to do so. One such scheme is illustrated in Figure 4C.

Note that no ground loop exists in any of the circuits illustrated, reflecting the general requirement for no ground loops.

3.3.8.3.1+ Shared Circuit Return. Several circuits may share a common return only where end-circuit referencing and isolation are in accord with the principles just defined and no adverse coupling will be introduced.

3.3.8.3.2 CCS End-Circuit Isolation. To minimize the possibility of computer command subsystem (CCS) state changes due to electrical transients, all CCS end-circuits shall be isolated. This requirement does not apply to the flight CCS end-circuits for the direct access interface.

3.3.8.3.3 DC Power User End-Circuit Isolation. Each subsystem receiving power from the dc regulated bus shall have its power circuit return isolated from circuit common and structure.

3.3.8.3.4 AC Power User End-Circuit Isolation. AC power shall be distributed only to isolated loads consisting of transformers or (heater) resistors.

3.3.8.3.5 Analog Telemetry User End-Circuit Isolation. For analog telemetry circuits, the sending end-circuit shall be isolated. This requirement does not apply to an end-circuit in a subsystem having the circuit common referenced to the FDS circuit common.

3.3.8.3.6 Coaxial Cable End-Circuit Isolation. See paragraph 3.3.10.4.

3.3.8.3.7 + Direct Access and Umbilical End-Circuit Isolation. End-circuit isolation from circuit common shall be provided for all direct access and umbilical circuits. Except for circuits using temperature transducers or relay coils as isolated flight end-circuits, this isolation shall be in the support equipment. The coaxial circuits shall provide isolation by means of dc blocks, located in the support equipment cabling, external to the equipment.

* 3.3.8.3.8 Isolation Limited for Static Discharge. To dissipate static electrical charge, the overall isolation of an interface circuit shall not exceed 10^8 ohms, including that part of a circuit which loses ground reference due to switching, uncoupling of a test connector, or stage separation. If necessary, a static discharge path of not less than 2.0 MΩ and preferably not less than 5.0 MΩ shall be provided from the circuit, to chassis or ground tree. Some short paths are exempt, see paragraph 3.2.1.1.

3.3.9 + Wire Group

The basic wire group consists of two wires per circuit, or a single wire for each of several circuits sharing one circuit return wire. Multiple wires may be used where necessary to reduce voltage-drop. Redundant wires to increase reliability shall only be provided to meet project requirements, as stated in Circuit Data Sheets.

For each circuit, the wires shall be routed to minimize the area enclosed by the wires; out and return wiring shall be provided in each cable section. As specified in Table 1, twisted pairs, triples or quadruples shall be used for indicated circuit types. Wiring shall be selected and routed to minimize electromagnetic field generation and pick-up.

3.3.10 Wire-Shield

Standard wire-shield grounding practice is specified in Table 1 by reference to Figure 5. The number of intermediate connectors may vary from that shown in the figure. Except in off-ground subsystems, standard practice is to ground the shield by connecting the end of the shield through a short reference conductor to the connector pin or socket, then from the other side of the connector through another conductor to subchassis. These conductors shall be insulated, and be no longer than 6 in. and 3 in., respectively. At intermediate connectors, reference conductors are connected as in Figure 5.

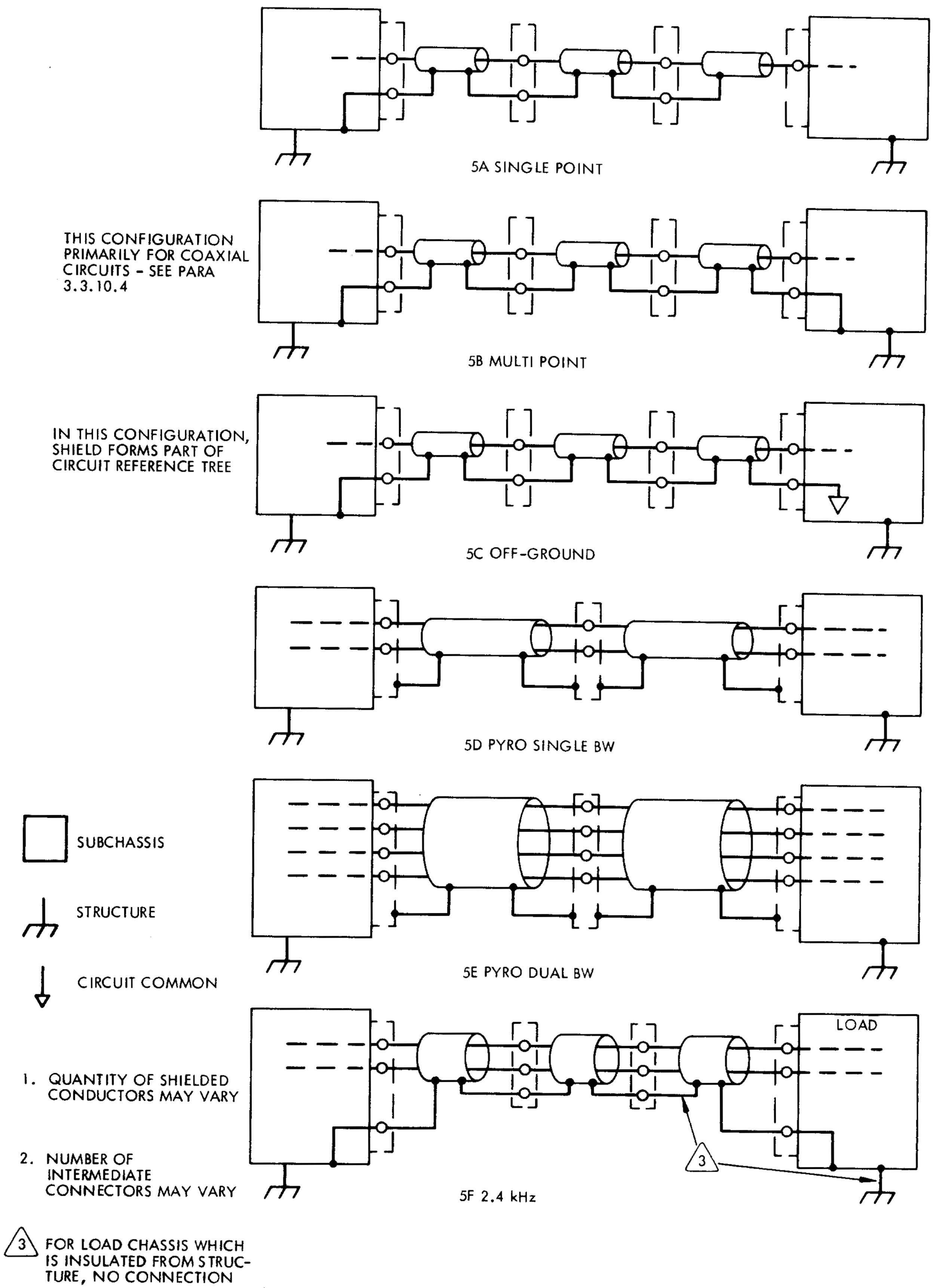


Figure 5. Shield Grounding Methods (examples)

3.3.10.1 + Non-Standard Wire-Shield. To effect savings in weight, reduce complexity or improve shielding effectiveness, departure from standard shielding practice is permissible. Justification shall be based on signal transition time, signal frequency, duty cycle, acceptable error rate of receptor circuit, sensitivity to shunt line capacity, the possibility of ringing in lines, and whether source or receptor circuits are in the minority, or one subsystem is especially sensitive to electrical interference, or one or more circuit commons are off-ground, or one or both end-circuits are referenced, etc.

3.3.10.2 Inter-Stage Wire-Shield. Inter-stage wire-shield grounding shall be designed with consideration for circuit cross-coupling and common mode noise control, RF barriers at stage interfaces, isolation of flight circuitry and chassis from support equipment and other systems, maintenance of shield grounds following stage separation, availability of connector contacts, and for standard and non-standard shield practice.

3.3.10.3 + Direct Access and Umbilical Wire-Shield. To maintain the RF barrier at the spacecraft, all umbilical and direct access circuit shields shall be grounded to chassis at the spacecraft and isolated from support equipment chassis and circuit common.

3.3.10.4 Coaxial Cable Shield. Circuits shall employ coaxial cable and coaxial cable connectors only as necessary to control standing waves and signal leakage. For coaxial circuits interconnecting flight equipment referenced to different ground trees, high pass filtering (dc blocking) shall be provided in the center conductor and shield as necessary to prevent the formation of a ground loop.

3.3.11 + Wire Bundle

The basic wire bundle consists of all the wires of a cable or harness that route along a single path. However, in the ring harness, in umbilical cabling, and in other harnesses where practical, separate bundles are provided for incompatible circuit categories. Except for different assignments in Circuit Data Sheets, bundling shall be as follows:

Category	Code	Maximum Signal Amplitude V_{p-p} (Nominal)
Quiet	Q	10 (30 V, umbilical)
Noisy (and dc power)	N	30 (100 V, umbilical)
Power (ac)	P	100
Pyrotechnic Squib	PY	—
Radio Frequency	RF	—

In Table 1, circuits are assigned to bundles as indicated by the codes. Reference trees are also carried where practical in the Quiet bundle.

The minimum electrical isolation between any two circuits routed through different bundles is constrained as follows. In the table below, source-receptor circuit pairs are defined for each coupling mode of concern, e.g., power bundle to noisy bundle, etc. To demonstrate acceptable inter-bundle cable isolation, a test voltage (or current) as indicated, applied to a source circuit, would produce a voltage (or current) in the receptor circuit no greater than indicated. The circuit pairs shown are those with the least inter-bundle isolation and hence the pick-up voltage or current in the table is for the worst case. For the receptor circuit, simulated end-circuit loads shall be used, as shown.

Coupling Path	Source Circuit				Receptor Circuit				
	Volts	Amps	Transition (μs)	Wire Group	Wire Group	E Test Load (Ω)	Volts	I Test Load (Ω)	mA
P → N	50	5	1.0	TP	SC	10 K	0.6	20	10
P → Q	50	5	1.0	TP	SC	10 K	0.2	20	3.0
N → Q	30	1	10	SC	SC	10 K	0.2	20	3.0

SC Single Conductor
TP Twisted Pair

3.3.11.1 Wire Bundle Shield. External and platform wire bundles may be partly or completely enclosed in thermal blanketing. This blanketing shall be bonded, as required in paragraph 3.2.1.1.

4.0 SUPPORT EQUIPMENT ELECTRICAL GROUNDING AND INTERFACING

4.1 General

The content of this Section applies to support equipment only. However, the section structure parallels that of Section 3.0. Paragraphs in this section are to be read in conjunction with applicable material in the indicated Section 3.0 paragraphs.

4.2 Electrical Grounding

The objective of support equipment electrical grounding is to produce equipotential grounding throughout the support equipment, by control of induced potentials from the ambient electromagnetic environment and circuit currents flowing between circuitry and structure. Achieving the proper support equipment grounding requires attention to structural (enclosure) grounding and circuit grounding.

4.2.1 Structural Grounding

The support equipment component chassis are conductively mounted to the equipment racks. The rack frames are grounded by the Instrumentation Ground Tree (IGT) as defined in paragraph 4.2.1.3. Structural grounding provides two electrical functions:

a) Uniform distribution and drain of electrical charges.

b) Unipotential ground reference for the electronics.

To support these functions, the materials and construction methods for racks, assemblies, subassemblies, chassis, subchassis and other elements shall be such that the electrical ground system properties remain constant throughout the service life of the equipment.

4.2.1.1 Bonding. Adequate bonding (electrical conductivity) shall be provided across contiguous assemblies, subassemblies, chassis, subchassis and other rack and junction box internal elements, as specified in DM504264, Support Equipment Consoles.

4.2.1.2 Electronic Enclosure. Support equipment rack and component shield grounding shall meet the requirements of DM504264.

4.2.1.3 Grounding for Test and Operations. Single point grounding of support equipment at the system test complex ground point is provided by the IGT as shown in Figure 6. Circuit common, chassis and rack frame for each subsystem rack are thus connected to the ground point through one path, normally, the third wire in the 115 V line cord. External to the rack, this wire shall be 10 ga or larger. For rack groups (two or more racks bolted together)

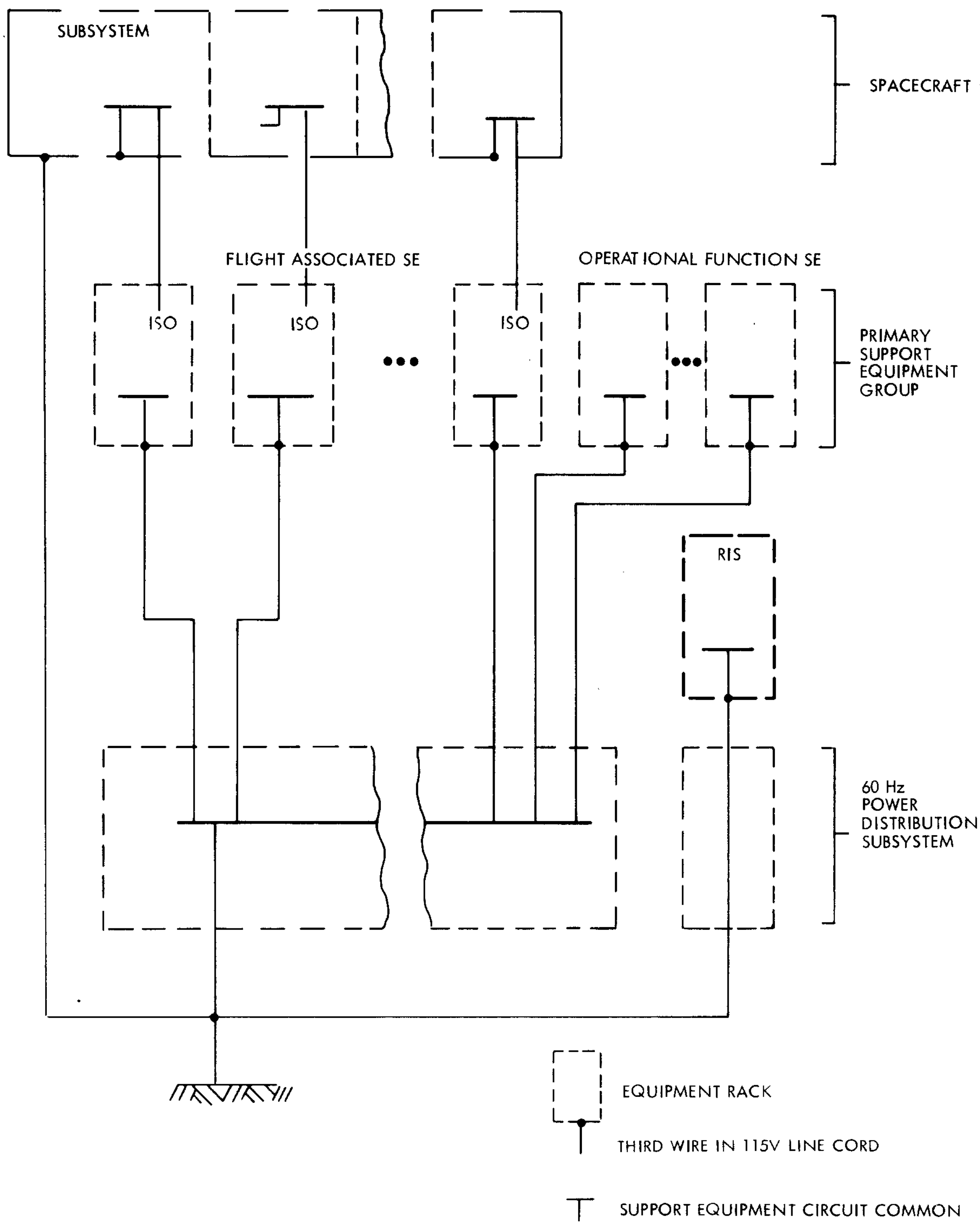


Figure 6. Instrumentation Ground Tree

more than one power cord may be used. Since both cords follow the same route to the power distribution point (located near the system test complex ground point), the "one path" rule of the single point grounding method is essentially maintained. The mission and test computer remote input subsystem (RIS) in the system test complex is similarly grounded by a separate tree, connected to the same ground point as the IGT.

The single point grounding plan is modified at the launch complex in that all equipment racks and other enclosures, e.g., junction boxes, are grounded to facility structure, locally. This method is used because physical considerations would interfere with the mechanization of single point rack grounding and less stringent grounding requirements exist due to the functional characteristics of such equipment.

Launch complex equipment (LCE) racks shall therefore be referenced directly to facility structure grounds through grounding straps. To ensure personnel safety, reference through the power cord third wire shall also be maintained.

4.2.1.4 Static Grounding. An electrical grounding lug shall be provided on all full-size support equipment racks. This lug shall not protrude into any zone of activity, but shall be accessible to provide safe and reliable ground connection during special tests.

4.2.2 Circuit Grounding

Circuitry interconnecting semiconductors, capacitors, transformers, oscilloscopes, test panels and other electronics shall be provided with electrical paths to structure as defined in Section 3.0.

4.2.2.1 Chassis – Circuitry Isolation. Packaging techniques will be used which electrically isolate circuitry from structure, as defined in Section 3.0.

4.2.2.2 Circuit Reference Tree. Support equipment circuitry is referenced to the system test complex ground point by means of the IGT. In each support equipment subsystem, the circuit common is, except for isolated end-circuits and associated power supplies, connected directly to chassis. The IGT, as defined in paragraph 4.2.1.3, connects the equipment rack frames to the ground point and therefore grounds the circuitry.

The current in any branch of the IGT shall not exceed 5.0 mA, peak.

4.2.2.3 Portable Equipment Grounding. Whenever portable or temporary test equipment is connected to the spacecraft or support equipment, such equipment shall be powered from 60 Hz ac through an isolation transformer, or from batteries, and be provided with a static ground connection to the Spacecraft structure or support equipment rack ground lug, as appropriate.

4.2.2.4 Remote Equipment Grounding. Equipment not in the immediate vicinity of the primary support equipment group shall not be powered from IGT-Referenced outlets. Grounding within such equipment shall not introduce a ground loop.

4.3 Interfacing

Interface requirements for support equipment interfacing with the spacecraft or with other support equipment, follow. Section 3.0, paragraph 3.3, applies. Table 2 for support equipment is equivalent to Table 1 for flight equipment.

4.3.1 End-Circuit Types

The sending and receiving end-circuit types are identified by end-circuit numbers in Table 2. In paragraph 5.2, these numbers are related to manufacturers' specifications and other information.

4.3.2 Cabling Type

End-circuit noise immunity and other characteristics must be compatible with cabling noise levels and line parameters, therefore, circuit types designated in Tables 1 and 2 for particular SE cable types shall only be used with those cable types. Direct Access, Umbilical, Support Equipment - Support Equipment, Support Equipment - Remote Input Subsystem, Support Equipment - Central Recording Subsystem, Power - Support Equipment, and Power - Remote Input Subsystem cable types have been defined.

4.3.3 Signal Class

The signal class for which a circuit type may be used is as shown in Table 2.

4.3.4 Signal Amplitude

Unless otherwise noted, signal amplitudes specified in Table 2 are peak-to-peak voltages.

4.3.5 Conducted Noise Emission

For bi-level circuits, short term signal amplitude deviations (due to distortion and interference originating within the sending subsystem) shall be not more than ±5 percent of the expected signal peak-to-peak amplitude and within the limits shown in the circuit data sheets. The maximum permissible amplitude deviation from any cause (short term, drift or other effect originating within the

Table 2. Support Equipment Standard Interface Circuit Requirements

Standard Circuit Type		Requirements[d]													
		End-Circuit Type[a]		Cable Type	Signal Class	Signal Amplitude, Nominal, p-p	Conducted Noise Emission	Conducted Noise Susceptibility	Overload and Fault Protection	End-Circuit Grounding and Isolation		Wire Length, Maximum	Wire Group b	Wire Shield b	Wire Bundle
		Send	RCV							Send	RCV				
101	Current Mode + OI	14	15	SE-SE	Bi-Level	4.0 mA	0.2 mA	NA	NA	R	I	40 m	TP	c	NA
102	National + OI	22	23	SE-SE	Bi-Level	5 V	0.3 V	NA	NA	R	I	40 m	TP	c	NA
103	Contacts — Ampl.	NA	NA	SE-RIS	Bi-Level	5 V	3.3.5	NA	NA	I	R	40 m	NA	c	NA
104	Ampl. — Galvo	NA	NA	SE-CRS	Analog	5 V	NA	NA	NA	R	I	40 m	NA	c	NA
105	Ampl. — Tape	NA	NA	SE-CRS	Analog/ Digital	1.0 Vrms	NA	NA	NA	I	R	40 m	NA	c	NA
106	60 HZ 1	Fig. 6	Fig. 7	PWR-SE	Rack PWR to SE	115 V, 1ϕ rms	NA	NA	4.3.7.1	4.3.8.1		20 m	4.2.1.3	NA	60
107	60 HZ 2	Fig. 6	Fig. 7	PWR-RIS	Rack PWR to RIS	115 V, 1ϕ rms	NA	NA	4.3.7.1	4.3.8.1		20 m	4.2.1.3	NA	60
108	RF	NA	NA	SE-SE	RF	NA	NA	NA	NA	4.3.7.3		40 m	Coax	Fig. 4B	RF
109	Driver — Gate + OI	22	39	SE-RIS	Bi-Level	5 V	NA	NA	NA	R	I	30 m	TP	Fig. 5A	NA

Abbr:

CRS	Central Recording Subsystem
I	Isolated
NA	Not Applicable (No Req't in this Doc.)
R	Referenced
RF	Radio Frequency
RIS	Remote Input Subsystem
OI	Optically Isolated

Notes:

a See Table 3
b Information only
c Ground shield at one end, but not at both
d For Direct Access and Umbilical Circuits, see Table 1

sending subsystem) shall be as shown by the circuit data sheet waveform envelope and, unless otherwise shown thereon, shall be not more than ±10 percent of the expected signal peak-to-peak amplitude. If the circuit normally functions at certain times in a weak-signal mode, to that extent, the conducted noise emission requirement does not apply.

4.3.6 Conducted Noise Susceptibility

All interface signal circuits shall be designed to operate acceptably in the presence of system and subsystem electrical noise and interference. For bi-level circuits, conducted emission from the sending subsystem may modify the signal within the constraint of paragraph 4.3.5. Also, electrical noise or interference within the receiving subsystem may further modify the signal. Finally, electrical noise may be introduced on the system interconnecting wiring.

4.3.7 Overload and Fault Protection

Overload and fault protection requirements for 115 V, 60 Hz facility power circuits, direct access circuits and umbilical circuits, follow.

4.3.7.1 Rack Power Circuit. Delivery of only one phase of the 115 V facility power to one particular support equipment subsystem shall be an objective. Each such power circuit shall be equipped with a circuit breaker in the power distribution subsystem (PDS). Ground current monitoring will also be provided in the PDS.

4.3.7.2 Direct Access and Umbilical Circuit. See paragraph 3.3.7.5.

4.3.8 End-Circuit Grounding and Isolation

See Section 3.0 and Table 2.

4.3.8.1 AC Power User End-Circuit Isolation. Except for remote SE, ac, 115 V power shall be distributed to support equipment only from the PDS. Power shall be distributed only to multiple shield isolation transformers, connected as shown in Figure 7.

4.3.8.2 Direct Access and Umbilical Circuit Isolation. See Section 3.0, paragraph 3.3.8.3.7.

4.3.8.3 Coaxial Cable End-Circuit Isolation. Coaxial cables between the spacecraft and support equipment and coaxial cables between support equipment racks (or junction boxes) referenced to separate

*As specified in MJS77-3-240. Occasional pulses may exceed this amplitude.

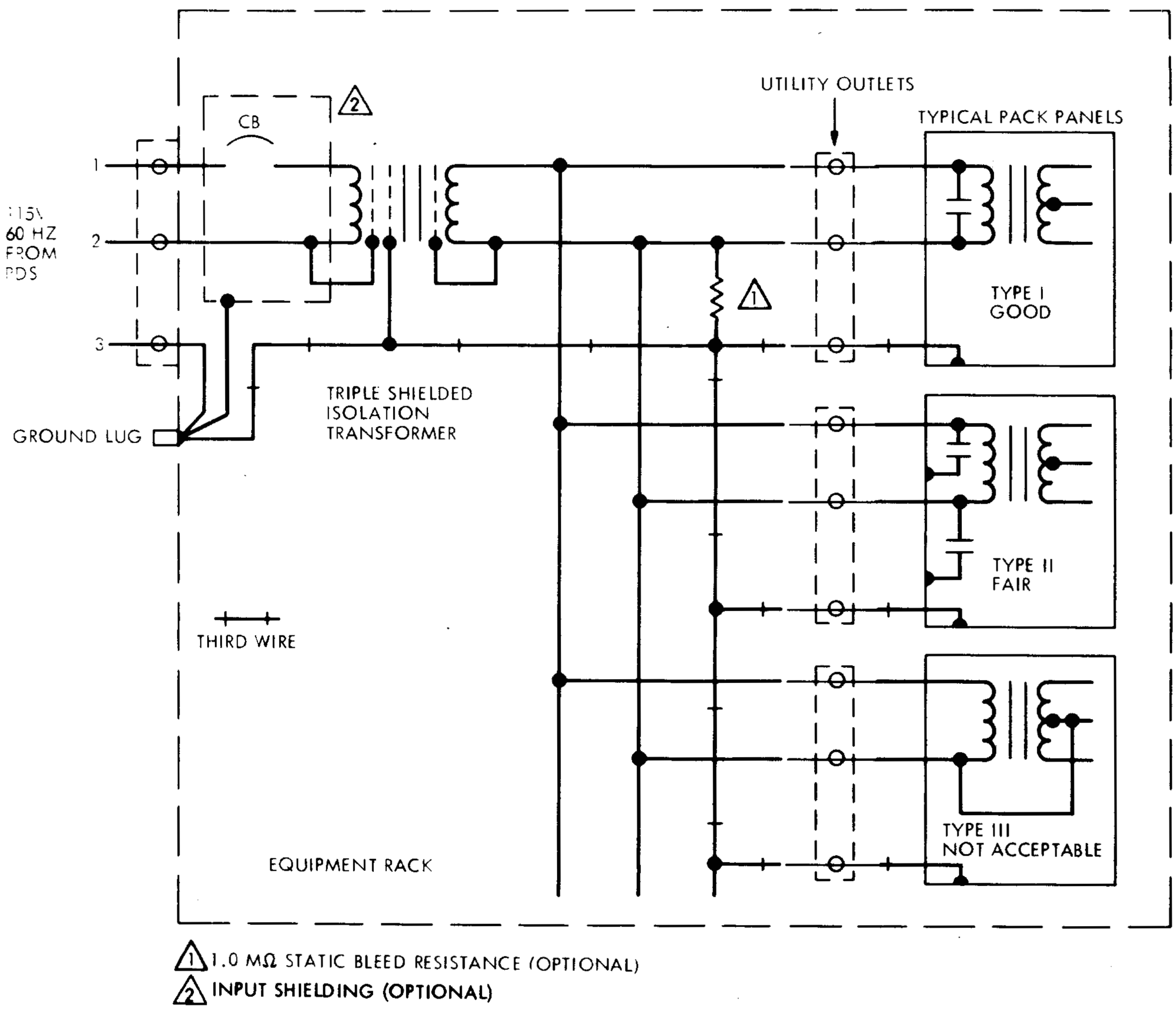


Figure 7. Isolation Transformer

branches of the IGT shall have a dc block inserted and visible, at a point in the cable, external to the equipment. The block shall be effective for both the inner and outer (shield) conductors.

* 4.3.9 Wire Length

Except where existing cabling is to be used with Project approval, system and subsystem cabling shall be no longer than necessary (with a modest margin) to accommodate the test configurations in which the cables will be used. Cabling which simulates system wiring, including umbilical replacement cabling in the system test complex and flight replacement cabling in bench checkout equipment, ideally simulates the critical characteristics of the cabling that is being replaced. BCE cabling is typically longer than the flight cabling; the BCE cable length should be kept as short as practical.

4.3.10 Wire Group

Requirements are specified in Table 2.

4.3.11 Wire Shield

Standard wire-shield grounding practice is specified in Table 2 by reference to Figure 5 or footnote. For non-standard practice, see Section 3.0.

4.3.12 Wire Bundle

In umbilical cabling, separate bundles are provided for a) quiet circuits and b) other (noisy and power) circuits. 115 V, 60 Hz power is carried separately from all other circuit categories. Umbilical circuit types are assigned to bundles as shown in Section 3.0.

4.3.13 Other Interface Circuit Requirements

The following paragraphs relating to direct access circuits, umbilical circuits, system simulation circuits and remote input subsystem circuits do not require supporting reference to Table 2 or Section 3.0.

4.3.13.1 Direct Access Circuit Signal Conditioning. Except for battery test line fuses, buffers or amplifiers or other in-line conditioning packages shall not be inserted in the direct access cabling between the spacecraft and the support equipment test sets. In-line devices in the umbilical interface between the spacecraft and the support equipment shall be held to a minimum.

4.3.13.2 Umbilical Circuit Uniform Design. Umbilical interface circuits which are used in both the system test complex and launch complex configurations shall be designed to function in both configurations without modification of the end-circuits or in-line equipment.

4.3.13.3 System Simulation Circuit Cable Parameters. Cabling that replaces flight wiring in bench checkout equipment, as part of the simulation of interfacing subsystems, and cabling in the system test complex that represents launch complex umbilical cabling are the primary examples of system simulation cabling. System simulation cabling shall be designed as far as practical to duplicate critical parameters of the cabling being replaced. For umbilical power circuits, for example, ohmic resistance may be critical. Typically, the replacement cabling, being shorter would be fabricated with lighter gage wire to produce conductivity approximately equivalent to the resistance in the umbilical cabling. For simulated interface circuits in bench checkout equipment, line-to-line capcitance may be critical. The longer cabling simulating the flight cabling would be fabricated with wires having thicker insulation than the flight wiring, to produce overall capacitance approximately equal to the line-to-line capacitance in the flight wiring. Since satisfactory test performance is a strong consideration, the objective is system simulation cabling with critical parameters as realistic as possible and not less favorable than those of the cabling being simulated.

4.3.13.4 Remote Input Subsystem Circuits. Circuits transferring data from the SE to the MTC shall be implemented with Circuit Type 109 as defined in Table 2. The end-circuits shall be as listed in Table 3. An equivalent type of driver is acceptable. The isolation specified in the Table may be reversed where necessary to achieve compatibility with the shield grounding contained in existing cabling.

5.0 NOTES

5.1 General

This section contains information which is too detailed for inclusion in Sections 3.0 and 4.0.

5.2 End-Circuit Specifications

For information, sources of end-circuit devices and end-circuit specifications are presented in Table 3.

5.3 Definitions

Term definitions that are necessary for correct interpretation of the requirements are as follows:

Acceptable Performance. Equipment functioning with error rates, signal resolution and controllability sufficient to ensure realization of mission objectives under all test and flight environments, configurations and states, i.e., operation in conformance with the functional requirements.

Analysis. Reasoning and calculations in written form on which a design decision is based.

* Table 3. End-Circuit Data Sources[a]

1 End-Circuit No.	2 Type	3 Manufacturer	4 MFR Type No.	5 JPL STD No.
10	Pressure Transducer	Statham Instruments	—	—
14	Current Driver	Harris Semiconductor	HD245	ST11498
15	Current Receiver	Harris Semiconductor	HD246	ST11498
17	SR Switch	Siliconix	DG133	ST11496
22	Line Driver[b]	National Semiconductor	DM7830	—
23	Line Receiver[b]	National Semiconductor	DM7830	—
26	Relay Coil	Teledyne	412	CS506099
26	Relay Contacts	Teledyne	412	CS506099
27	Temp Sensor	Rosemount	118	ST11855[g]
28	CMOS Gate	RCA	4050	ST11868
29	CMOS Gate (Inverting)	RCA	4049	ST11868
30	CMOS Receiver[d]	RCA	4049/ 4050	ST11868
32	Commutator	JPL[e]	—	ST11868
33	Temp Receiver	JPL[e]	—	ST11868
34	High Speed Comparator[d]	National Semiconductor	LM139	ST11869
35	Carrier Receiver	JPL[f]	—	—
36	Isolated Switch	JPL[f]	—	—
37	CMOS SPST or SPDT Switch[c]	RCA	4053	ST11868
38	Medium Speed Comparator[e]	National Semiconductor	LM139	ST11869
39	Gate, Optically Isolated[b]	Hewlett-Packard	5082-4360	-
41	Pyro Squib, SBW			
42	Pyro Squib, DSW			
43	Pressure Transducer	Standard Control I.	213	-

Explanation —

Column 1 As shown in Tables 1, 2
Column 2 End-circuit generic name
Column 3 Principal or typical source
Column 4 Partial No., not indicative of packaging, variant types, etc.

a Information only
b Support Equipment only
c With signal excitation from receiving subsystem
d With RC filter time constant > 0.3 μs (5K Ω x 60 pF)
e As used in FDS
f As used in CCS
g And others
h With RC filter time constant > 6.0 μs.

Barrier, RF. At interfaces between stages, shield grounding or other measures designed to attenuate unwanted transfer of RF energy.

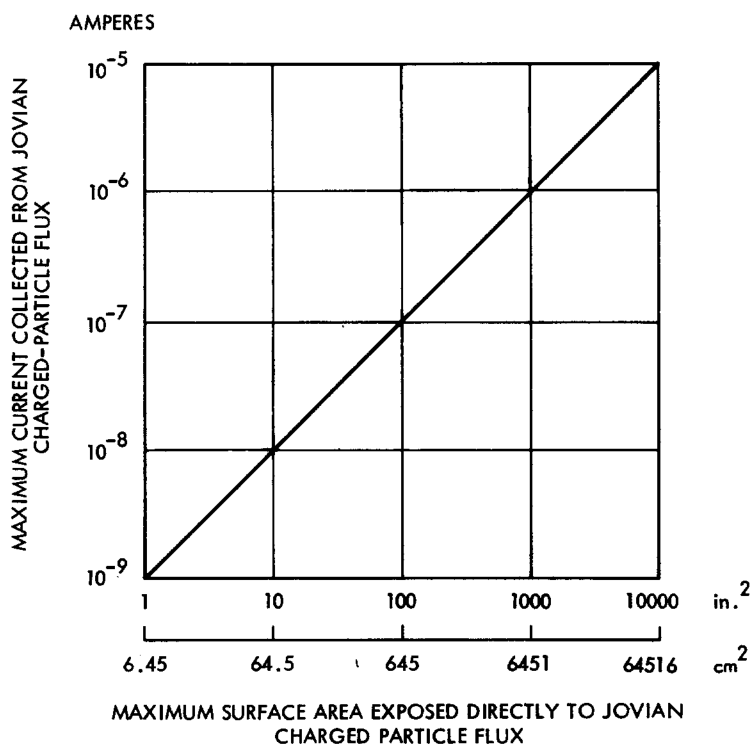
Bi-Level. With "low" and "high" voltage or current values, representing two alternate states.

Bonding. The existence of or provision for, electrical conductivity between objects held together by mounting joints or interconnected by wires or straps.

Bond, High Conductivity. (E) Resistance between the bonded objects of 0.025 ohms, or less. No test voltage applied between the objects shall exceed 0.10 V and no test current through the bond shall exceed 4.0 mA.

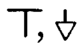
Bond, Medium Conductivity. (M) Resistance between the bonded objects of 10,000 ohms, or less. Test verification would be with two tests; one with a current in the range, 8.00 to 13.00 uA and another with a current in the range, 0.90 to 1.20 mA.

Bond, Low Conductivity. (L) Resistance between the bonded objects such that less than 10.0 V appears across the bond when a current level determined in accordance with Figure 8 passes through the bond.

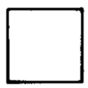


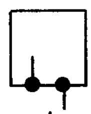
* Figure 8. Equipotential Bonding Design Current vs. Hardware Surface Area

* Bond, Wire. (W) Resistance between objects interconnected by the bond wire (or wire shield) of 0.250 ohms or less. Test verification would be with applied voltage between the objects of not more than 0.20 V.

Circuit Common.  A network of conductors or printed wiring used within a subsystem to establish a zero reference potential for subsystem circuitry.

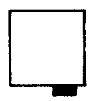
Circuit Return. That side of a two-wire circuit which is intended to hold a zero potential with respect to chassis, in the presence of a signal. (A balanced circuit will generally not have a circuit return.)

Chassis. 

Chassis, Connection To. 

Internal
External

Alternate symbol, also denoting structure

Chassis, Insulated. 

Assembly, e.g., science instrument, mounted with supports which insulate the chassis from supporting structure.

Common-Mode Voltage. An unwanted voltage in ground line or structure or both, appearing between the terminals of an isolated end-circuit, and circuit common (or chassis). If the voltage from one terminal to circuit common is unequal to the other voltage, the common-mode voltage is the instantaneous average value.

Conducted Noise. An unwanted voltage between signal line and return line.

Conducted Noise Emission. Any voltage emitted from the end-circuit output terminals, instead of or modifying the expected signal.

Contact Bounce. In a relay or switch contact set, the making and breaking of the contact members one or more times before a permanent state of contact or non-contact is reached.

Direct Access Circuits. Spacecraft-support equipment interface circuits which are connected only during system and subsystem testing. Direct access connections are not available on the launch pad.

DC Block. Capacitance elements inserted in the center and outer conductors of a coaxial cable to provide high impedance at low frequencies while maintaining low impedance at the signal frequency.

Electrical Connector. 

End-Circuit. A relay, transformer, transistor and/or other parts designed to transmit or receive signals through a wire or cable harness between subsystems or other pieces of equipment.

Fast Signal. A digital signal with a 0 to 1 or 1 to 0 transition time of less than 100 ns for flight circuits, 400 ns for inter-stage circuits or 1600 ns for direct access or umbilical circuits.

Ground Line. The wires and other conductors forming an electrical ground path from a circuit common to structure.

Ground Loop. The presence of two or more current carrying paths between nominally zero potential points creating one or more ground loops.

External. Not part of a mission module electronic bay assembly. External electronic equipment consists of the Canopus Trackers, PWS, CRS, PLS, LECP, Sun Sensors and similar items.

Flight-Associated Equipment Group. Collectively, the equipment racks interfacing the spacecraft directly or through in-line junction boxes. CRS, RIS and similar racks, not included.

Isolated. Having large resistance and reactance from circuitry to structure.

Interface Circuit. Basically, a circuit consisting of two end-circuits and interconnecting wiring, transferring signal or power from one subsystem to another, or from one part of a subsystem to another remote part of the same subsystem.

Reference. Connection from the return terminal of a device to a point in a circuit reference tree or other ground system.

Structure. See, Chassis, Connection To.

Umbilical Circuits. Circuits which connect the spacecraft through the launch complex umbilical connector to the Launch Complex Equipment or, in the System Test Complex, the equivalent circuits.

Telemetry Signal. An electrical analog of temperature or other measurand, sent from a transducer in a subsystem, to the FDS. Digital, status and event signals are included in the definition.

* 6.0 SAFETY

The requirements stated in this document have been drafted with consideration for the safety of equipment and personnel. In addition, safety requirements pertaining to the design of electrical grounding and interfacing are stated in other documents, as indicated:

-	JPL Safety Manual, Section 4
601-4	JPL Flight Project Safety Guide
DM509306	JPL Design Requirement, Electronic Equipment and Cabling, Vol I, Design
DM504264	Support Equipment Consoles
618-263	MJS77 Electrostatic Control for Assembly and Test Areas
127-1	AFETRM Range Safety Manual

REVISION PAGE

Revision	Date	ECRs Incorporated	Comments	
Initial Release	14 March 1975	N/A		
A	17 Aug '76	36078	Affected Paragraphs:	3.2.1.1 3.2.2.1 3.3.2 3.3.7.5 3.3.8.3.8 4.3.9
			Changes to:	Figure 2 Table 3 Table 1
		36263	Changes to:	Figure 2
		36304	Affected Paragraphs: Changes to:	3.2.2.2 Figure 2
		36371	Affected Paragraphs:	3.2.1.1 3.2.1.2 3.2.2 3.2.2.3 3.3.8.3.8 5.3 6.0
			Changes to:	Figure 2 Table 3 Figure 8

* Table 1. Standard Interface Circuit Requirements

	Standard Circuit Type	Requirements												
		End-Circuit Type g		Cable Type	Signal Class	Signal Amplitude	Conducted Noise Emission	Conducted Noise Susceptibility	Overload and Fault Protection	End-Circuit Grounding and Isolation		Wire Group a, e	Wire Shield a, e	Wire Bundle a
		Send	RCV							Send	RCV			
1	Transducer-Commutator	NA	32	F	Analog Tlm	3.0 V	NA	3.3.6	3.3.7.3	I[f]	R	SCR	NA	Q
2	Temp Sensor Temp Rcvr	27	33	F	Temp Tlm	0.35 V	NA	3.3.6	3.3.7.3	I	R	TP	NA	Q
3	Radio Frequency	NA	NA	F, I-S, UM	VHF, UHF	NA	NA	NA	NA	R	R	Coaxial	Fig. 5B	RF
4	Strain Gage-Commutator	10	32	F	Pressure Tlm	3.0 V	NA	3.3.6	3.3.7.3	I[f]	R	TQ	NA	Q
6	CMOS Gate-CMOS Rcvr	28/29	30	F	Bi-Level	10.0 V	3.3.5	3.3.6	NA	R	R	SCGL	NA	Q
7	CMOS SPST-MS Comparator	37	38	F	Bi-Level	5.0 V	3.3.5	3.3.6	NA	I	R	TP		Q
8	CMOS SPDT-HS Comparator	37	34	F	Bi-Level	5.0 V	3.3.5	3.3.6	NA	I	R	TT		Q
11	SR Switch-CMOS Rcvr	17	30	F	Bi-Level	10.0 V	3.3.5	3.3.6	NA	I	R	TP	NA	Q
16	SR Switch-Carrier Rcvr	NA	35	F	Bi-Level	8.5 V	NA	3.3.6	NA	I	R	SCR	NA	Q
17	SR Switch SR Rcvr	36	NA	F	Coded Command[b]	10.0 V	3.3.5	3.3.6	3.3.7.2	I	R	SCR	NA	Q
18	Curr Driver-Curr Rcvr	14	15	F	High Rate Data	4.0 mA	3.3.5	3.3.6	NA	R	R	TP	Fig. 5C	Q
20	SR Driver-Coil	NA	26	F	Bi-Level	28.0 V	3.3.5	3.3.6	NA	R	I	SCR	NA	N
21	Contacts-SR Rcvr	26	NA	F	Command	10.0 V	3.3.5[c]	3.3.6[d]	3.3.7.2	I	R	SCR	NA	Q
22	Contacts-Coil	26	26	F, I-S, DA, UM	Command	28.0 V	3.3.5[c]	3.3.6	3.3.7.2	I	R	SCR	NA	N
24	SBW Squib	NA	NA	F, I-S	Pyro Firing	NA	NA	NA	3.3.7.4	R	I	TP	Fig. 5D	PY
25	DBW Squib	NA	NA	F, I-S	Pyro Firing	NA	NA	NA	3.3.7.4	R	I	TQ	Fig. 5E	PY
27	dc Bus-dc Converter	NA	NA	F, I-S, DA, UM	dc Power	30.0 V	NA	NA	3.3.7.1	R	I	TP	NA	N
28	ac Bus-Transformer	NA	NA	F	ac Power	100.0 V	NA	NA	3.3.7.1	R	I	TP	Fig. 5F	P
29	ac Bus-Heater	NA	NA	F	ac Heater Pwr	100.0 V	NA	NA	3.3.7.1	R	I	TP	Fig. 5F	P
30	dc Bus-Heater	NA	NA	F	dc Heater Pwr	30.0 V	NA	NA	3.3.7.1	R	I	TP	NA	N

Abbreviations:

CMOS Complementary Metal Oxide Semiconductor
DA Direct Access
DBW Dual Bridgewire
F Flight
HS High Speed
I Isolated
I-S Inter-Stage
MS Medium Speed
NA Not Applicable (No Req't in this Doc.)
Q Quiet
P Power
PY Pyrotechnic
R Referenced
RCVR Receiver
RF Radiofrequency
SBW Single Bridgewire
SCGL Single Conductor and Ground Line
SCR Single Conductor and Return
SPDT Single Pole Double Throw
SPST Single Pole Single Throw
SR Semiconductor
TP Twisted Pair
TQ Twisted Quad
TT Twisted Triple
UM Umbilical

Notes:

a Information, only
b Includes, data, strobe and enable functions
c In this paragraph, only the contact bounce requirement applies
d Receiver shall perform acceptably despite sender contact bounce.
e For single circuit
f Isolation not mandatory where End-Circuit can be referenced to the FDS Circuit Reference Tree.
g SeeTable 3

NASA — JPL — Coml., L.A., Calif.

FUNCTIONAL REQUIREMENT AMENDMENT

(Insert in 618-205, MJS77 Functional Requirements Book)

TITLE:

FUNCTIONAL REQUIREMENT
MARINER JUPITER/SATURN 1977
FLIGHT EQUIPMENT
TELEMETRY AND COMMAND HANDLING

FR No. MJS77-3-270
AMENDMENT No. 1
PAGE 1 **OF** 1
DATE: 14 February 1979
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JET PROPULSION LABORATORY

No. MJS77-3-270
10 September 1975

FUNCTIONAL REQUIREMENT

MARINER JUPITER/SATURN 1977 FLIGHT EQUIPMENT

TELEMETRY AND COMMAND HANDLING

* Denotes change to original 9 October 74 draft.
** Denotes change to latest review copy.

1.0 SCOPE

This document establishes the functional requirements for the Telemetry and Command Handling portions of the Mariner Jupiter/Saturn 1977 (MJS77) spacecraft. For the purposes of this document, Telemetry Handling is defined as those functions required to prepare and process both science and engineering data during any phase of the mission for subsequent transmission to earth. Command Handling is defined as those functions required to process and execute either real-time or stored programmed command functions transmitted from the earth during any phase of the mission.

2.0 APPLICABLE DOCUMENTS

The following documents form a part of this functional requirement:

NOTE

MJS77-3-100, Spacecraft Requirements and Constraints, applies to this document. Requirements of other MJS77 level 3 documents may also be applicable. It is the responsibility of the user to adequately acquaint himself with the organization and pertinent content of the level 3 documents, as well as with the material contained herein.

REQUIREMENTS

Jet Propulsion Laboratory

MJS77-3-100	Functional Requirement, Mariner Jupiter/Saturn 1977 Spacecraft Requirements and Constraints
MJS77-3-110	Functional Requirement, Mariner Jupiter/Saturn 1977 Functional Block Diagram and Interface Listings
MJS77-3-280	Functional Requirement, Mariner Jupiter/Saturn 1977 Telemetry Measurements and Data Formats
MJS77-3-290	Functional Requirement, Mariner Jupiter/Saturn 1977 Command Structure and Assignments
MJS77-3-300	Functional Requirement, Mariner Jupiter/Saturn 1977 Telecommunications
MJS77-3-310	Functional Requirement, Mariner Jupiter/Saturn 1977 Software Requirements

3.0 TELEMETRY REQUIREMENTS

** 3.1 General

The MJS77 spacecraft (S/C) shall contain equipment to perform the telemetry functions as defined in Section 1.0 of this document. The individual subsystem roles in performing the telemetry functions shall be as specified in MJS77-3-100, Spacecraft Requirements and Constraints and MJS77-3-300, Telecommunications.

The data flow block diagram, depicted in Figure 1, shows the functional flow of all MJS77 spacecraft telemetry data.

3.2 Data Management

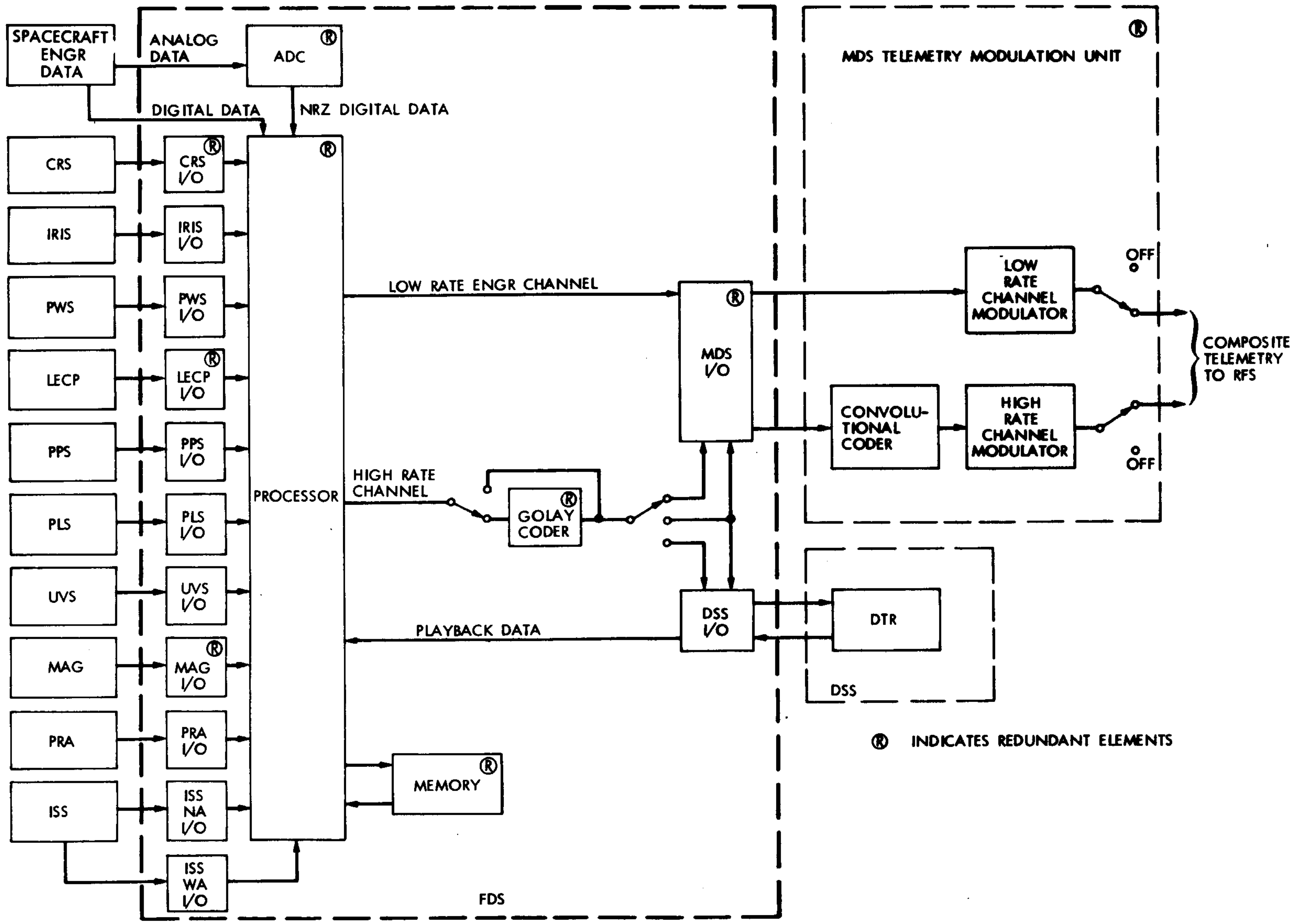
All data shall be classified into one of four (4) groups:

a) Engineering Data

b) Memory Data

c) General Science Data

d) Imaging Data



* * Figure 1. Telemetry Data Flow Functional Block Diagram

General Science data is further categorized according to instrument source as follows:

a) Cosmic Ray Subsystem (CRS)

b) Planetary Radio Astronomy Subsystem (PRA)

c) Plasma Wave Subsystem (PWS)

d) Low Energy Charged Particle Subsystem (LECP)

e) Photopolarimeter Subsystem (PPS)

f) Plasma Subsystem (PLS)

g) Ultraviolet Spectrometer Subsystem (UVS)

h) Magnetometer Subsystem (MAG)

i) Infrared Interferometer Spectrometer and Radiometer Subsystem (IRIS)

3.2.1 Engineering Data

Engineering Data is that information which is required to monitor the status and performance of S/C engineering subsystems and science instruments, and consists specifically of those measurements defined in MJS77-3-280, Telemetry Measurements and Data Formats.

3.2.1.1 Engineering Data Selection Criteria. The priority in selecting engineering telemetry measurements is listed below. This order of priorities shall be used in the assignment of measurements to the formats listed in MJS77-3-280.

a) Measurements necessary for flight operations.

b) Measurements that give positive indication of onboard events.

c) Measurements required for selecting between alternate modes of operation or redundant elements.

d) Measurements of subsystem parameters directly affecting system performance.

e) Measurements necessary to evaluate the performance of subsystems not previously flown.

f) Measurements necessary to evaluate the performance of a subsystem previously flown.

3.2.2 Memory Data

Memory data is that data residing in the memories of the computer command subsystem (CCS), flight data subsystem (FDS), and attitude and articulation control subsystem (AACS) which provides either internal or external subsystem control.

* 3.2.3 General Science Data

General science data consists of the data produced by all non-imaging science instruments with the exception of those measurements included in the engineering data stream for the purpose of monitoring the status/performance of those instruments.

* 3.2.4 Imaging Data

Imaging data consists of all data produced by the ISS with the exception of those measurements included in the engineering data stream for the purpose of monitoring the status/performance of the ISS.

3.3 Data Acquisition

All data generated by spacecraft subsystems shall be initially routed to the FDS for conditioning and processing before being sent to the modulation demodulation subsystem (MDS) and/or the data storage subsystem (DSS). All measurements shall be sampled at the rates and in the sequences as specified in MJS77-3-280.

3.4 Data Transmission

There shall be two (2) telemetry subcarriers (channels) provided for the transmission of spacecraft data: a low rate channel and a high rate channel. The low rate channel shall function only at S-band whereas the high rate channel shall function at either S- or X-band.

* 3.4.1 Low-Rate Channel

The low rate channel shall contain real-time engineering data exclusively and is normally on only during planetary encounter periods when the high rate channel is operating at X-band. The low rate channel shall contain engineering data only, operate at a single rate of 40 bps, and shall be commanded on or off by CCS command to the MDS. It shall be possible to remove low rate channel telemetry modulation from the radio frequency subsystem (RFS) interface by CCS command to the MDS.

* 3.4.2 High-Rate Channel

The high rate channel shall normally be on at all times during the mission. This channel may contain any of the following types of data.

a) Real-time engineering only

b) Real-time general science and engineering

c) Real-time general science, engineering and imaging

d) Real-time general science, engineering and playback

e) Playback only

It shall be possible to remove high rate channel telemetry modulation from the RFS interface by CCS command to the MDS. The telemetry rates and modes available on the high rate channel shall be as specified in Section 3.8 of this document.

3.5 Data Processing

Processing to be performed on data shall consist of A/D conversion, buffering, selected fixed-length compression and editing, formatting and source error protection coding.

3.5.1 Initial Data Forms

Data shall be presented to the FDS in either analog or digital form. Digital data may consist of discrete event pulses, binary levels, or serial NRZ data. Analog data shall consist of variable voltages. All analog engineering data shall be restricted to the ranges specified in MJS77-3-280. Data presented to the MDS or DSS shall be in the form of serial NRZ data.

3.5.2 A/D Conversion

Data presented to the FDS as analog voltages shall be converted to 8-bit binary coded digital words. When the data is introduced into the serial data stream, it shall be most significant bit (MSB) first.

* 3.5.3 Data Editing and Compression

The FDS shall provide the capability of executing simple, fixed length compression/editing schemes on selected science data. Individual instrument editing and compression requirements shall be as specified in Section 5.0 of this document.

3.5.4 Source Error Protection Coding

The FDS shall provide the capability to code the general science and engineering data transmitted on the high rate channel with a Golay (24, 12) code interleaved to depth 36. This interleaving scheme shall be as defined in MJS77-3-280. General science and engineering data shall always be Golay-coded when being transmitted in real time with imaging or playback data or when being recorded with imaging data. General science and engineering data transmitted during cruise shall not be Golay-coded. Engineering data transmitted on the low rate channel shall not be Golay coded.

3.6 Data Formatting

All data shall be assembled by the FDS into the formats as specified in MJS77-3-280.

3.7 Data Storage

Data storage shall be provided by the DSS via a single digital tape recorder (DTR). The operational specifications relating to storage capacity, start-stop cycles, and number of passes shall be as specified in MJS77-3-100.

* 3.7.1 Data Recording

The DSS shall be capable of recording any of the following on command from the CCS:

a) Imaging data and Golay coded general science and engineering data at 115.2 kbps.

b) Golay coded general science and engineering data at 7.2 kbps.

c) Non Golay coded special occultation general science and engineering data at 7.2 kbps.

d) Engineering only data at 7.2* kbps.

Recording shall be accomplished sequentially, one track at a time. During the record mode the DSS start/stop operation shall be capable of being controlled by either FDS or CCS command.

** 3.7.2 Data Playback

The DSS shall be capable of playing back data to the FDS at any of the following rates on command from the CCS:

a) 57.6 kbps

b) 33.6 kbps

c) 21.6 kbps

d) 7.2 kbps

All playback data shall be sequential, one track at a time, and in the same direction as it was recorded.

3.8 Telemetry Modes and Rates

3.8.1 Engineering Only

3.8.1.1 General. It shall be possible to acquire and transmit real-time engineering data at either 40 or 1200 bps. Engineering only telemetry modes shall be used during launch, memory readouts, trajectory correction maneuvers, and, if necessary, to aid in the diagnosis of anomalous in-flight performance of the Mission Module (MM). The high rate channel shall accommodate both the 40 and 1200 bps

*Rate of engineering data acquisition is 1200 bps. Method of transforming 1200 bps engineering rate to 7.2 kbps record rate is described in paragraph 3.8.1.3.

engineering rate whereas the low rate channel shall accommodate only the 40 bps rate. All engineering formats shall be as specified in MJS77-3-280. It shall be possible to alter the engineering formats in accordance with the requirements as specified in MJS77-3-310, Software Requirements. A summary of the engineering telemetry modes available is shown in Table 1.

* 3.8.1.2 Launch Mode. Engineering data at 40 bps shall be transmitted at S-band via the high rate channel and also routed to the Centaur for transmission with Centaur telemetry data during the majority of the launch phase. A short time (TBD) prior to Centaur separation, the CCS shall command the FDS to switch to the transmission of 1200 bps engineering data at S-band via the high rate channel. The formats in use at 40 and 1200 bps during the launch phase shall be identical. The FDS shall provide the high rate engineering data to the DSS for recording. The method of matching the 1200 bps engineering data acquisition rate to the 7200 bps DSS record rate is identical to that described in paragraph 3.8.1.3. No additional performance requirements shall be levied on the DSS for recording of launch telemetry data.

* 3.8.1.3 Trajectory Correction Maneuver (TCM) Mode. High rate engineering data shall be acquired and recorded on the MM's tape recorder during TCM. A 2880 bit minor frame length and 0.4 s minor frame time shall be employed. The first 480 bits shall be actual engineering data whereas the last 2400 bits shall be filler. This process affectively increases the 1200 bps engineering acquisition rate to the 7200 bps stream required by the DSS.

* 3.8.1.4 CCS Memory Readout Mode. CCS memory readout shall be accomplished by replacing engineering data with readout data. The implementation shall be to place 8-bit bytes of readout data, MSB first, on engineering commutator positions 108 through 159. Since 28 bits are required to readout one CCS memory word, the eighth bit of each byte shall be a repeat of the 7th bit of the byte. Readout at 1200 bps or 40 bps over the high rate channel shall be possible. The CCS readout shall be accomplished by a subroutine in the CCS. The capability shall exist to read out all or any portion of the memory.

* 3.8.1.5 FDS Memory Readout Mode. FDS memory readout shall be accomplished by replacing engineering data with readout data. The implementation shall be to place 8-bit bytes of readout data, MSB first, on engineering commutator positions 108 through 159. Readout at 1200 bps or 40 bps over the high rate channel shall be possible. The FDS readout shall be accomplished by a subroutine in the FDS. The capability shall exist to read out all or any portion of the memory.

* 3.8.1.6 AACS Memory Readout Mode. AACS memory readout at 1200 bps, 40 bps, or 10* bps over the high rate channel shall be possible. The capability shall exist to read out all or any portion of that memory which is powered. Two formats shall be employed depending on the readout rate in effect.

*No requirement for a 10 bps AACS memory readout mode has been identified.

Table 1. Engineering Only Telemetry Modes

		Low Rate Channel Configuration			High Rate Channel Configuration					Tape Recorder Configuration			
Mode	Function	Status	Contents	Format Designator	Status	Transmission Frequency	Contents	Rate (b/s)	Format Designator (4)	Status	Record/ Playback Contents	Rate (b/s)	Format Designator (4)
ENGR-1	High Rate Launch Engineering	Off	N/A	N/A	On	S-Band	Launch Engineering	1200	X0010000	Record	Launch Engineering	(1) 7200	X0011000
ENGR-2	Low Rate Launch Engineering	Off	N/A	N/A	On	S-Band	Launch Engineering	40	X0001000	Slew	N/A	N/A	N/A
ENGR-3	Cruise Engineering	Off	N/A	N/A	On	S-Band	Cruise Engineering	40 or 10	X0001001 X0000001	Off	N/A	N/A	N/A
ENGR-4	TCM Engineering	Off	N/A	N/A	On	S-Band	TCM (2) Engineering	1200	X0010011	Record	TCM Engineering	(1) 7200	X0011011
ENGR-5	Encounter Engineering	Off	N/A	N/A	On	S-Band (3)	Encounter Engineering	40	X0001010	Off	N/A	N/A	N/A
ENGR-6	Low Rate FDS Memory Readout	Off	N/A	N/A	On	S-Band (3)	FDS Memory Data	40	X0001111	Off	N/A	N/A	N/A
ENGR-7	Low Rate CCS Memory Readout	Off	N/A	N/A	On	S-Band (3)	CCS Memory Data	40	X0001110	Off	N/A	N/A	N/A
ENGR-8	Low Rate AACS Memory Readout	Off	N/A	N/A	On	S-Band (3)	AACS Memory Data & AACS Telemetry	40	X0001101	Off	N/A	N/A	N/A
ENGR-9	High Rate FDS Memory Readout	Off	N/A	N/A	On	S or X Band	FDS Memory Data	1200	X0010111	Off	N/A	N/A	N/A
ENGR-10	High Rate CCS Memory Readout	Off	N/A	N/A	On	S or X Band	CCS Memory Data	1200	X0010110	Off	N/A	N/A	N/A
ENGR-11	High Rate AACS Memory Readout	Off	N/A	N/A	On	S or X Band	AACS Memory Data & Non-AACS Telemetry	1200	X0010101	Off	N/A	N/A	N/A

Notes: (1) Engineering data acquisition rate is 1200 bps.
(2) Real time acquisition of TCM data not required.
(3) Transmission at X-band is possible but unlikely for these modes.
(4) "X" in MSB position of format designator word is replaced by a "1" for S/C FLT-1 or a "0" for S/C FLT-2.

3.8.1.6.1 <u>High Rate Memory Readout (1200 bps)</u>. In the high rate memory readout mode AACS memory data shall appear in 18 positions on the 100 deck of the engineering commutator. Each minor frame shall contain the AACS memory address of the data word that follows plus four additional data words. The remaining locations in the engineering commutator shall contain normal engineering data.

3.8.1.6.2 <u>Low Rate Memory Readout (40 and 10 bps)</u>. In the low rate memory readout mode normal AACS telemetry data shall appear in 25 positions on the 100 deck. All remaining positions normally allocated to non-AACS telemetry (with the exception of the 64 bit header) shall contain AACS memory readout data.

3.8.2 <u>Cruise (Pre-Saturn Encounter)</u>

General science and engineering data shall be acquired and transmitted at S-band via the high rate channel during cruise. The rates available for cruise shall be 2560, 1280, 640, 320, 160, and 80 bps. The rate in use at any time will depend on the prevailing telecommunications link capability. The allocation of data rate for all cruise modes shall be as specified in Table 2. Cruise formats shall be as specified in MJS77-3-280. A summary of the cruise telemetry modes available is shown in Table 3.

✱ Table 2. Cruise Data Rate Allocations

Instrument Rate (bps)	Channel Rate (bps)					
	2560	1280	640	320	160	80
CRS	260*	250*	125*	62*	31*	20
PRA	266-2/3*	266-2/3*	131*	65*	32*	1-2/3
PWS	32*	32*	16*	4*	2*	1-5/12
LECP	128*	64*	64*	32*	16*	16-2/3
PPS	30*	30*	2*	1*	.5*	1/2
PLS	203*	32*	32*	32*	16*	16-2/3
UVS	48*	48*	24*	6*	3*	2-2/9
MAG	1200*	450*	188*	94*	47*	5-15/16
Engineering Rate (bps)	40	40	10	10	10	10
Header Rate (bps)	106-2/3	53-1/3	26-2/3	13-1/3	6-2/3	3-1/3

*Note: Allocations shown are only representative. Final rates and allocations are TBD.

Table 3. Cruise Telemetry Modes

		Low Rate Channel Configuration			High Rate Channel Configuration					Tape Recorder Configuration			
Mode	Function	Status	Contents	Format Designator	Status	Transmission Frequency	Contents	Rate (b/s)	Format Designator ②	Status	Record/ Playback Contents	Rate (b/s)	Format Designator ②
CR-1	Cruise Science and Engineering	Off	N/A	N/A	On	S-Band	Cruise Science and Engineering	2560	X0100000	Off	N/A	N/A	N/A
CR-2	Cruise Science and Engineering	Off	N/A	N/A	On	S-Band	Cruise Science and Engineering	1280	X0100001	Off	N/A	N/A	N/A
CR-3	Cruise Science and Engineering	Off	N/A	N/A	On	S-Band	Cruise Science and Engineering	640	X0100010	Off	N/A	N/A	N/A
CR-4	Cruise Science and Engineering	Off	N/A	N/A	On	S-Band	Cruise Science and Engineering	320	X0100011	Off	N/A	N/A	N/A
CR-5	Cruise Science and Engineering	Off	N/A	N/A	On	S-Band	Cruise Science and Engineering	160	X0100100	Off	N/A	N/A	N/A
CR-6	Cruise Science and Engineering	Off	N/A	N/A	On	S-Band	Cruise Science and Engineering	80	X0100101	Off	N/A	N/A	N/A
CR-7 ①	Cruise Science and Engineering	Off	N/A	N/A	On	S-Band	Cruise Science and Engineering	40	X0100110	Off	N/A	N/A	N/A
CR-8 ①	Cruise Science and Engineering	Off	N/A	N/A	On	S-Band	Cruise Science and Engineering	20	X0100111	Off	N/A	N/A	N/A
CR-9 ①	Cruise Science and Engineering	Off	N/A	N/A	On	S-Band	Cruise Science and Engineering	10	X0101000	Off	N/A	N/A	N/A

NOTE: ① Mode intended for post-Saturn operations. Formats and software will not be developed until extended mission approval is given.

② "X" in MSB position of format designator word is replaced by a "1" for S/C FLT-1 or a "0" for S/C FLT-2.

3.8.3 Cruise (Post-Saturn Encounter)

The capability shall exist to implement post-Saturn cruise modes at rates of 40, 20, and 10 bps over the high rate channel. Formats and allocations for these modes shall not be developed until extended mission approval is given.

3.8.4 General Science Maneuver Mode

During general science roll and yaw maneuvers, general science and engineering data shall be acquired at 3.6 kbps, Golay coded to 7.2 kbps and recorded on the MM's tape recorder. The format in use shall be the normal encounter general science and engineering format as specified in MJS77-3-280. Subsequent to the completion of the maneuver, this data shall be played back via the high rate channel. Real-time, Golay coded general science and engineering data at 7.2 kbps (using the normal encounter general science and engineering format) may be transmitted concurrently with science maneuver playback data if the channel rate employed is 67.2, 44.8 kbps or 29,866-2/3 bps.

3.8.5 Encounter Modes

3.8.5.1 General. During planetary encounter periods it shall be possible to transmit any of the following data sets over the high rate channel:

a) Real-time general science and engineering.

b) Real-time general science, engineering, and imaging.

c) Real-time general science and engineering, time-multiplexed with playback data.

d) Playback data only.

It shall also be possible to:

a) Simultaneously transmit and record 115.2 kbps general science, engineering, and imaging data or

b) Record 115.2 kbps general science, engineering, and imaging data while transmitting the Golay coded general science and engineering portion at 7.2 kbps.

During encounter modes when the high rate channel is operating at X-band, the low rate channel shall contain engineering only data at 40 bps transmitted at S-band. The formats for the engineering data at S-band and imbedded engineering data at X-band shall be identical. All encounter mode formats shall be as specified in MJS77-3-280.

A summary of all encounter modes available is shown in Tables 4 and 5.

✱✱ Table 4. Encounter General Science Telemetry Modes

		Low Rate Channel Configuration			High Rate Channel Configuration					Tape Recorder Configuration			
Mode	Function	Status ⑦	Contents	Designator ⑧	Status	Transmission Frequency	Contents	Rate (bps)	Format Designator ⑧	Status	Record/Playback Contents	Rate	Format Designator ⑧
GS-1	Standard Encounter GS&E	On	Encounter Engineering	X0001010	On	X-Band	Standard Encounter GS&E	① 7,200	X0101001	Off	N/A	N/A	N/A
GS-2	Standard Encounter GS&E + Special PRA	On	Encounter Engineering	X0001010	On	X-Band	Standard Encounter GS&E + Special PRA	115,200	X0110001	Off	N/A	N/A	N/A
GS-3 ⑥	Standard Occultation	On	Encounter Engineering	X0001010	On	X-Band	Standard Encounter GS&E	① 7,200	X0101010	Record	Standard Encounter GS&E	7,200 ①	X1001010
GS-4	Standard Encounter GS&E + Special PWS	On	Encounter Engineering	X0001010	On	X-Band	Standard Encounter GS&E + Special PWS	115,200	X0101011	Off	N/A	N/A	N/A
OC-1	Special Occultation	On	Encounter Engineering	X0001010	On	X-Band	Special Occultation GS&E	② 7,200	X0101100	See Note ③	See Note ③	② 7,200	X1001100
PB-1	Playback + Standard Encounter GS&E	On	Encounter Engineering	X0001010	On	X-Band	Playback + Standard Encounter GS&F	67,200	X1001110	Playback	See Note ④	57,600	Variable
PB-2	Playback + Standard Encounter GS&E	On	Encounter Engineering	X0001010	On	X-Band	Playback + Standard Encounter GS&E	44,800	X1001101	Playback	See Note ④	33,600	Variable
PB-3	Playback + Standard Encounter GS&E	On	Encounter Engineering	X0001010	On	X-Band	Playback + Standard Encounter GS&E	29,866-2/3	X1001100	Playback	See Note ④	21,600	Variable
PB-4	Playback Only	On	Encounter Engineering	X0001010	On	X-Band	Playback Only	21,600	Variable	Playback	See Note ④ & ⑤	21,600	Variable
PB-5	Playback Only	On	Encounter Engineering	X0001010	On	X-Band	Playback Only	7,200	Variable	Playback	See Note ④ & ⑤	7,200	Variable

Notes:
① Actual GS&E data rate is 3,600 bps which is Golay coded to 7,200 bps.
② Actual GS&E data rate. Golay coding is not employed in this mode.
③ High rate channel data is also routed to the tape recorder for optional recording.
④ This will consist of whatever data has been previously put on the recorder. Currently the possibilities are Standard Encounter GS&E, Special Occultation GS&E. Standard Encounter GS&E + Imaging, or high rate engineering acquired during TCM's.
⑤ This is uninterrupted tape playback data. The transmission format is that which was recorded.
⑥ Low rate channel and high rate channel telemetry modulation will normally be removed from the RFS interface in this mode.
⑦ Low rate channel data rate is always 40 bps.
⑧ "X" in MSB position of format designator word is replaced by a "1" for S/C FLT-1 or a "0" for S/C FLT-2.

** Table 5. Encounter Imaging Modes

		Low Rate Channel Configuration			High Rate Channel Configuration					Tape Recorder Configuration			
Mode	Function	Status	Contents ①	Format Designator ②	Status	Transmission Frequency	Contents	Rate (bps)	Format Designator ②	Status	Record/ Playback Contents	Rate	Format Designator ②
IM-1	**Full Resolution Imaging + Standard Encounter GS&E**	On	Encounter Engineering	X0001010	On	X-Band	Full Resolution Imaging + Standard Encounter GS&E	115,200	X1011111	Off	N/A	N/A	N/A
IM-2	**Standard Encounter GS&E + Record Full Resolution Imaging**	On	Encounter Engineering	X0001010	On	X-Band	Standard Encounter GS&E	7,200	X1011110	Record	Full Resolution Imaging + Standard Encounter GS&E	115,200	X1011110
IM-3	**Record & Tran Transmit Full Resolution Imaging + Standard Encounter GS&E**	On	Encounter Engineering	X0001010	On	X-Band	Full Resolution Imaging + Standard Encounter GS&E	115,200	X1011101	Record	Full Resolution Imaging + Standard Encounter GS&E	115,200	X1011101
IM-4	**Standard Encounter GS&E + Full Resolution 3/4 Edited Imaging**	On	Encounter Engineering	X0001010	On	X-Band	Standard Encounter GS&E + Full Resolution 3/4 Edited Imaging	89,600	X1011100	Off	N/A	N/A	N/A
IM-5	**Standard Encounter GS&E + 2:1 Slow Scan Imaging**	On	Encounter Engineering	X0001010	On	X-Band	Standard Encounter GS&E + 2:1 Slow Scan Imaging	67,200	X1011011	Off	N/A	N/A	N/A
IM-6	**Standard Encounter GS&E + 1/2 Edited Imaging**	On	Encounter Engineering	X0001010	On	X-Band	Standard Encounter GS&E + 1/2 Edited Imaging	67,200	X1011010	Off	N/A	N/A	N/A
IM-7	**Standard Encounter GS&E + 3:1 Slow Scan Imaging**	On	Encounter Engineering	X0001010	On	X-Band	Standard Encounter GS&E + 3:1 Slow Scan Imaging	44,800	X1011001	Off	N/A	N/A	N/A
IM-8	**Standard Encounter GS&E + 1/3 Edited Imaging**	On	Encounter Engineering	X0001010	On	X-Band	Standard Encounter GS&E + 1/3 Edited Imaging	44,800	X1011000	Off	N/A	N/A	N/A
IM-9	**Standard Encounter GS&E + Edited 3:1 Slow Scan Imaging**	On	Encounter Engineering	X0001010	On	X-Band	Standard Encounter GS&E + Edited 3:1 Slow Scan Imaging	29,866-2/3	X1010111	Off	N/A	N/A	N/A
IM-10	**Standard Encounter GS&E + 1/5 Edited Imaging**	On	Encounter Engineering	X0001010	On	X-Band	Standard Encounter GS&E + 1/5 Edited Imaging	29,866-2/3	X1010110	Off	N/A	N/A	N/A

① **Low rate channel data rate is always 40 bps.**

② **"X" in MSB position of format designator word is replaced by "1" for S/C FLT-1 or a "0" for S/C FLT-2. Bit position 3, counting from MSB, is a "0" when valid imaging data is transmitted in the frame of a "1" when invalid imaging data is transmitted.**

** Table 5. Encounter Imaging Modes (Contd)

		Low Rate Channel Configuration			High Rate Channel Configuration					Tape Recorder Configuration			
Mode	Function	Status	Contents ①	Format Designator ②	Status	Transmission Frequency	Contents	Rate (bps)	Format Designator ②	Status	Record/ Playback Contents	Rate	Format Designator
IM-11	Standard Encounter GS&E + 5:1 Slow Scan Imaging	On	Encounter Engineering	X0001010	On	X-Band	Standard Encounter GS&E + 5:1 Slow Scan Imaging	29,866-2/3	X1010101	Off	N/A	N/A	N/A
IM-12	Standard Encounter GS&E + 1/2 Edited, 5:1 Slow Scan Imaging	On	Encounter Engineering	X0001010	On	X-Band	Standard Encounter GS&E + 1/2 Edited, 5:1 Slow Scan Imaging	19,200	X1010100	Off	N/A	N/A	N/A
IM-13	Standard Encounter GS&E + 10:1 Slow Scan Imaging	On	Encounter Engineering	X0001010	On	X-Band	Standard Encounter GS&E + 10:1 Slow Scan Imaging	19,200	X1010011	Off	N/A	N/A	N/A
IM-14	Standard Encounter GS&E + 1/10 Edited Imaging	On	Encounter Engineering	X0001010	On	X-Band	Standard Encounter GS&E + 1/10 Edited Imaging	19,200	X1010010	Off	N/A	N/A	N/A

① Low rate channel data rate is always 40 bps.

② "X" in MSB position of format designator word is replaced by "1" for S/C FLT-1 or a "0" for S/C FLT-2. Bit position 3, counting from MSB, is a "0" when valid imaging data is transmitted in the frame or a "1" when invalid imaging data is transmitted.

3.8.5.2 General Science and Engineering Encounter Modes

3.8.5.2.1 Standard General Science and Engineering Encounter Mode. The format associated with the standard general science and engineering encounter mode will be used during the majority of the encounter phase. In this mode general science and engineering data shall be acquired at 3.6 kbps, Golay coded to 7.2 kbps and transmitted in real-time, recorded on the DSS, or both. The bit rate allocations for this mode shall be as specified in Table 6.

* 3.8.5.2.2 Special Occultation Mode. A special occultation mode shall be available to accommodate short-term higher data rate requests for the UVS and PPS. In this mode the FDS shall generate a non-Golay coded 7.2 kbps occultation format which is routed to both the MDS and DSS. Recording of the special occultation data is therefore optional. The bit rate allocations for the special occultation mode shall be as specified in Table 6. Imaging data acquisition shall be prohibited at all times when the special occultation mode is in effect.

* 3.8.5.2.3 Special PRA Snapshot Mode. The FDS shall provide a special mode to accommodate short term PRA high data rate requirements. In this mode imaging pixel data shall be replaced by non-Golay coded PRA data. The standard general science and engineering encounter format (GS-1) shall be generated concurrently and time multiplexed with the PRA data to form a composite 115.2 kbps data stream. The status portion of the PRA data field in the imbedded GS-1 format shall be updated at the normal 6 s rate. The remainder of the PRA data field shall represent a re-readout of the last scan prior to entering this mode. Bit rate allocations for this mode shall be as specified in Table 6.

* 3.8.5.2.4 Special PWS Snapshot Mode. The FDS shall provide a special mode to accommodate short-term PWS high data rate requirements. In this mode imaging pixel data shall be replaced by non-Golay coded PWS data. The standard general science and engineering encounter format (GS-1) shall be generated concurrently and time multiplexed with the PWS data to form a composite 115.2 kbps data stream. The PWS data in the imbedded GS-1 format shall not be changed. Bit rate allocations for this mode shall be as specified in Table 6.

* 3.8.5.2.5 Special LECP Near Encounter Mode. A special mode shall be available for the LECP during the planetary near encounter phase (~ E ±3 days). The bit rate allocation for the LECP during this mode shall remain at 600 bps, however the relative proportion of LECP RATE and PHA data shall change. Details concerning this mode shall be as specified in paragraph 5.5.8 of this document.

✱ Table 6. Encounter General Science Data Rate Allocations

User Allocation (bps) \ Telemetry Mode	Standard Encounter (GS-1)	Special Occultation (OC-1)	Special PRA (GS-2)	Special PWS (GS-4)
CRS	260	260	260	260
PRA	266-2/3	266-2/3	266-2/3*	266-2/3
PWS	32	32	32	32**
LECP	600	600	600	600
PPS	40	1, 046-2/3	40	40
PLS	32	32	32	32
UVS	333-1/3	4, 000	333-1/3	333-1/3
MAG	750	750	750	750
IRIS	1, 120	40	1, 120	1, 120
Overhead (Imbedded GS-1)	106-2/3	106-2/3	106-2/3	106-2/3
Imbedded Engineering	40	40	40	40
Special Status	16	16	16	16
Filler	3-1/3	10	3-1/3	3-1/3
ISS Status/Engr	N/A	N/A	266-2/3	266-2/3
Overhead (GS-2)	N/A	N/A	1, 066-2/3	1, 066-2/3
High Rate PRA	N/A	N/A	106, 666-2/3	N/A
High Rate PWS	N/A	N/A	N/A	106, 666-2/3
Total	3, 600	7, 200	115, 200	115, 200

*Only status portion of imbedded PRA data is updated at normal 6 s rate. Remainder of imbedded PRA data field represents re-readout of the scan prior to entering GS-2.

**PWS analog step frequency data.

* 3.8.5.3 General Science, Engineering, and Imaging Modes. The FDS shall be capable of generating the modes shown in Table 5 for the simultaneous acquisition of general science, engineering, and imaging data. Software resource limitations will prevent all modes shown in Table 5 from being developed. Exactly which total subset of modes are finally implemented will depend upon future mission planning activities and firmer estimates of telecommunications link performance. The general science and engineering data acquisition rate for all imaging modes shall be 3.6 kbps. General science and engineering data shall be Golay coded to 7.2 kbps and restricted to the GS-1 format when operating in all imaging modes.

3.8.5.4 General Science, Engineering and Playback Modes. In these modes real-time general science and engineering data shall be time multiplexed with playback data and transmitted over the high rate channel. The format associated with the real-time general science and engineering data shall be that of the standard encounter mode. Channel transmission rates for these modes shall be 67.2 kbps, 44.8 kbps, or 29.866-2/3 bps with corresponding DSS playback rates of 57.6, 33.6, or 21.6 kbps respectively.

* 3.8.5.5 Playback Only Modes. In these modes playback data only shall be transmitted over the high rate channel at 21.6 or 7.2 kbps. Real-time engineering data at 40 bps shall be transmitted over the low rate channel.

4.0 COMMAND REQUIREMENTS

4.1 General

Ground commands are required to carry out flight sequences and counter unexpected events. These commands will be issued in a predetermined timing sequence via onboard program control or as received from the ground. During the course of the mission, the majority of commands utilized by the spacecraft subsystems will be issued by the CCS in its role as sequencer of events and the FDS in its role of controlling science instruments. Ground commands are used to program the CCS, FDS, and AACS memories and to back up onboard sequenced events.

The MJS77 S/C shall contain equipment to perform the command functions as defined in Section 1.0 of this document. The individual subsystem roles in performing the command functions shall be as specified in MJS77-3-100 and MJS77-3-300. Figure 2 shows the functional organization of those elements comprising the MJS77 S/C Command System.

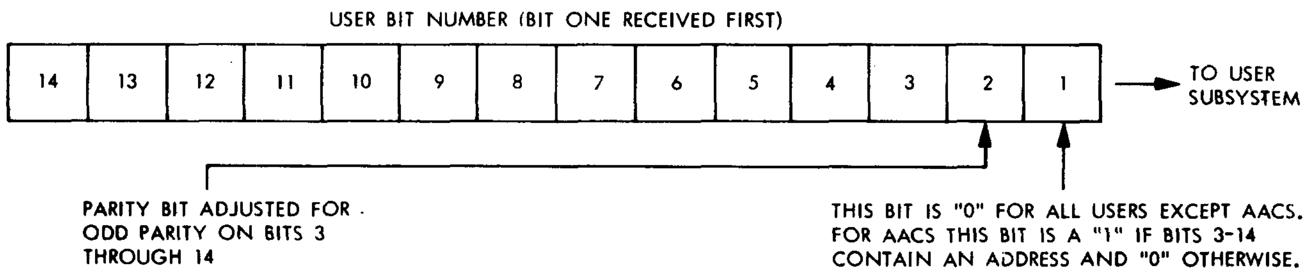
4.2 Command Types

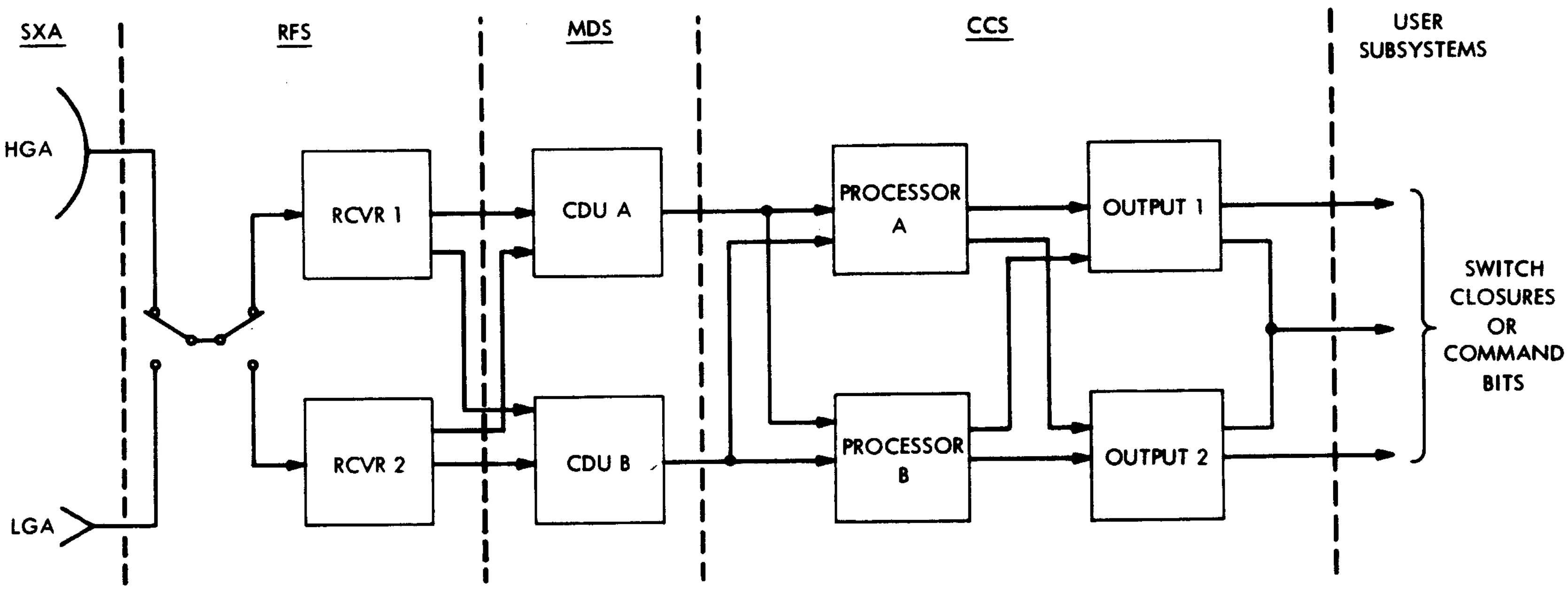
4.2.1 Computer Command Subsystem

There shall be three types of commands associated with the CCS: Discrete Commands (DC), Coded Commands (CC), and Processor Commands (PC). Each type shall use the 97-bit command word format as specified in paragraph 4.6.1 of this document. The DC and CC commands shall be used to select and control subsystems other than the CCS. PCs are used only to program and control the CCS, FDS, and AACS.

4.2.1.1 Discrete Command (DC). This type of command shall be decoded by the CCS and result in a CCS output unit discrete switch closure to a user subsystem. A DC can be issued under CCS program control or upon receipt of a ground command word. All DCs together with CCS bit assignments for all DC operator and accumulator words shall be as specified in MJS77-3-290, Command Structure and Assignments.

4.2.1.2 Coded Command (CC). This type of command shall be partially decoded by the CCS and then transferred as a serial 14-bit word to the selected user subsystem for further decoding. A CC can be issued either under CCS program control or upon receipt of a ground command word. All CCs together with CCS bit assignments for all CC operator and accumulator words shall be as specified in MJS77-3-290. Subsystem receiving CCs shall be the FDS, AACS, DSS, MDS, and PWR. The general format for all coded commands to user subsystems is shown below.





MJS77-3-270

Figure 2. Functional Block Diagram, Command System

4.2.1.3 Processor Command (PC). This type of command shall be used to control and program the CCS, FDS, and AACS. There are seven types of PCs as listed below. CCS bit assignments for PC operator words shall be as specified in MJS77-3-290. PC accumulator words shall be as described in paragraph 4.7.2.3 of this document.

a) BLOCK.

1) Program execute.

2) Conditional program execute.

3) CCS memory load.

4) FDS memory software load.

5) FDS memory hardware load.

6) AACS memory load.

b) STORE (STW).

c) STORE INDIRECT (STW*).

d) INTERNAL EXECUTE (IEX).

e) EXECUTE (XEC).

f) TRANSFER (TRA).

g) RETURN (RET).

4.2.2 Flight Data Subsystem

The FDS shall be capable of issuing three types of commands to the science instruments — discrete commands, serial commands, and level commands. Commands shall be issued to instruments at regular intervals based upon tables stored in FDS memory. A command change to an instrument is made by modifying the appropriate FDS memory word from the CCS or the ground. The next time the FDS program accesses that word, the updated command information is transmitted to the instrument.

4.2.2.1 Discrete Commands. Discrete commands shall consist of pulses which will be used as resets, to step multiplexers, sample ADC's, or any other appropriate function.

4.2.2.2 Serial Commands. Serial commands to instruments shall be limited to a maximum length of 12 bits. These commands shall be decoded by the user instrument to affect required mode changes. Serial commands shall conform to the bit pattern structures as specified in MJS77-3-290.

4.2.2.3 Level Commands. Level commands shall consist of bi-level command lines which are set high or low depending on the contents of the appropriate FDS memory control word.

4.2.3 Toggle Commands

The use of toggle commands (i.e., commands which alternately switch from state A to state B on the first command pulse, and then from state B to state A on the next command pulse, etc.) shall be expressly prohibited.

4.2.4 Power Switching Commands

Commands for accomplishing power switching for major subassemblies of other mission module subsystems shall be directed to the power subsystem.

4.2.5 Trajectory Correction Maneuver (TCM) Commands

TCMs shall be under control of the Computer Command Subsystem. This includes providing the appropriate commands to the AACS to:

a) Turn the mission module to position the thrust axis in the proper orientation in inertial space.

b) Initiate the TCM thruster firing period and terminate after the thruster firing period has expired as determined by CCS count, and

c) Return the mission module to its celestial references.

Ground command shall initiate the entire maneuver sequence. Ground command is available to abort the sequence if the MM is in the correct position to receive ground commands.

4.3 Command Bit Rate

The uplink command rate to the MM shall be 16 bps.

4.4 Command Interfaces

The connections between the CCS output units and each subsystem receiving commands shall be as shown on Figure 3.

4.5 Command Acquisition, Detection, and Decoding

The command detector unit (CDU) must be in-lock before command data bits will be sent to the CCS. The acquisition sequence, described on Figure 4, is required to attain detector lock. The sequence is at least 65 command bit-times of subcarrier only (at 512 Hz) followed by a minimum of 25 bit-times of subcarrier half-added with bit sync (at 16 Hz). A CDU lock indicator interrupt will

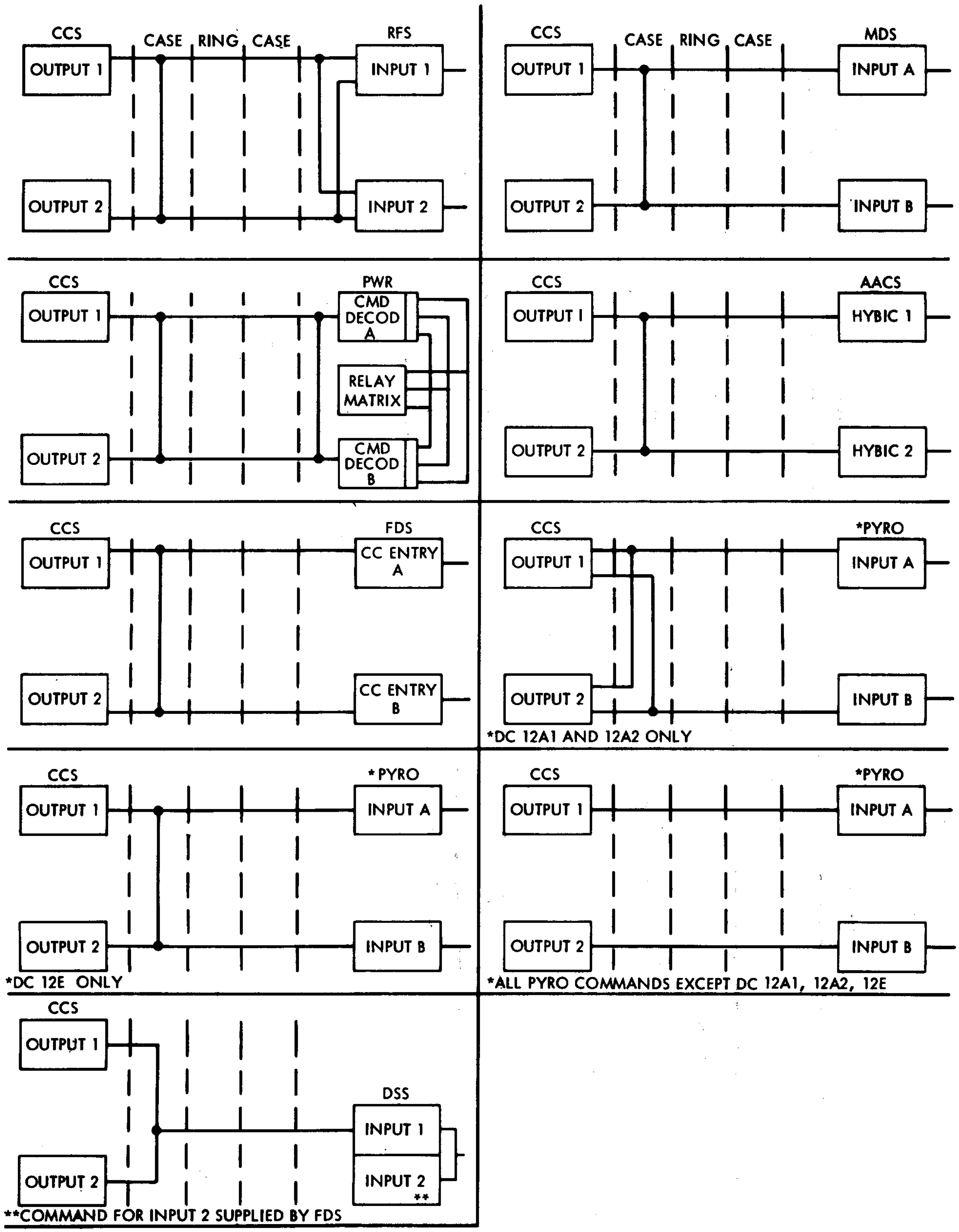
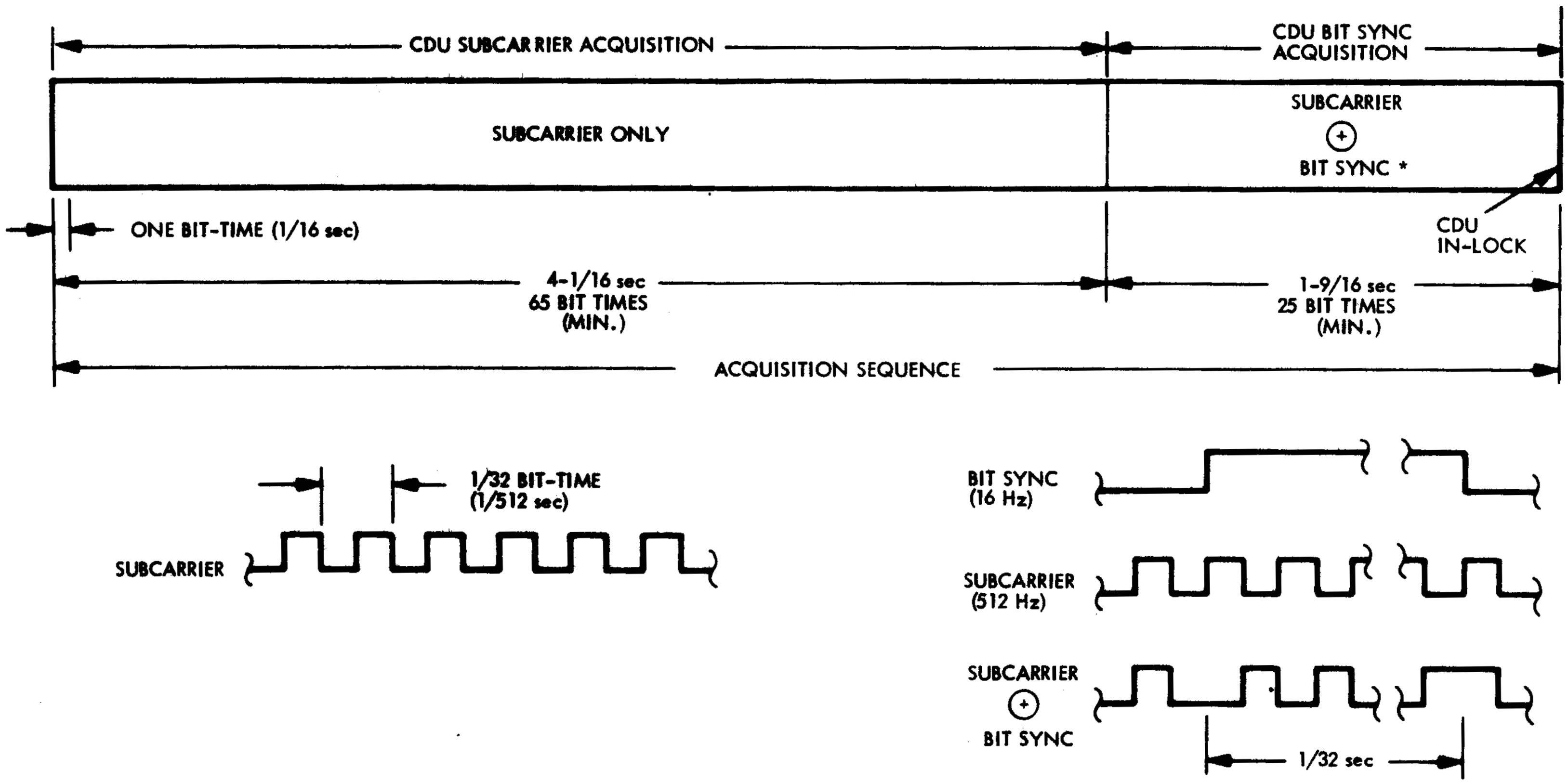


Figure 3. CCS Command Interfaces



*DERIVED BY TRANSMISSION OF MANCHESTER ENCODED ZERO COMMAND BITS.

Figure 4. Acquisition Sequence

alert the CCS to initialize for processing command data each time there is a change in CDU lock status. The CCS decodes the data bits to detect valid commands and issues the commands to the appropriate user subsystem. Commands will be executed by the CCS 10 bit-times after receipt of a valid command if the CDU remains in lock.

4.6 Command Formats

There shall be two formats used for commanding the MJS 77 S/C:

a) Command Word - which uses the command word format to send single commands to be executed in real-time.

b) BLOCK Load - which consists of the command word format followed by a data block and is used to load CCS, FDS, and AACS memories, or to execute, as if it were a subroutine, the instructions contained in the data block.

4.6.1 Command Word Format

The command format that shall be used whenever there is a requirement to send a single command to the MJS77 S/C is shown in Figure 5.

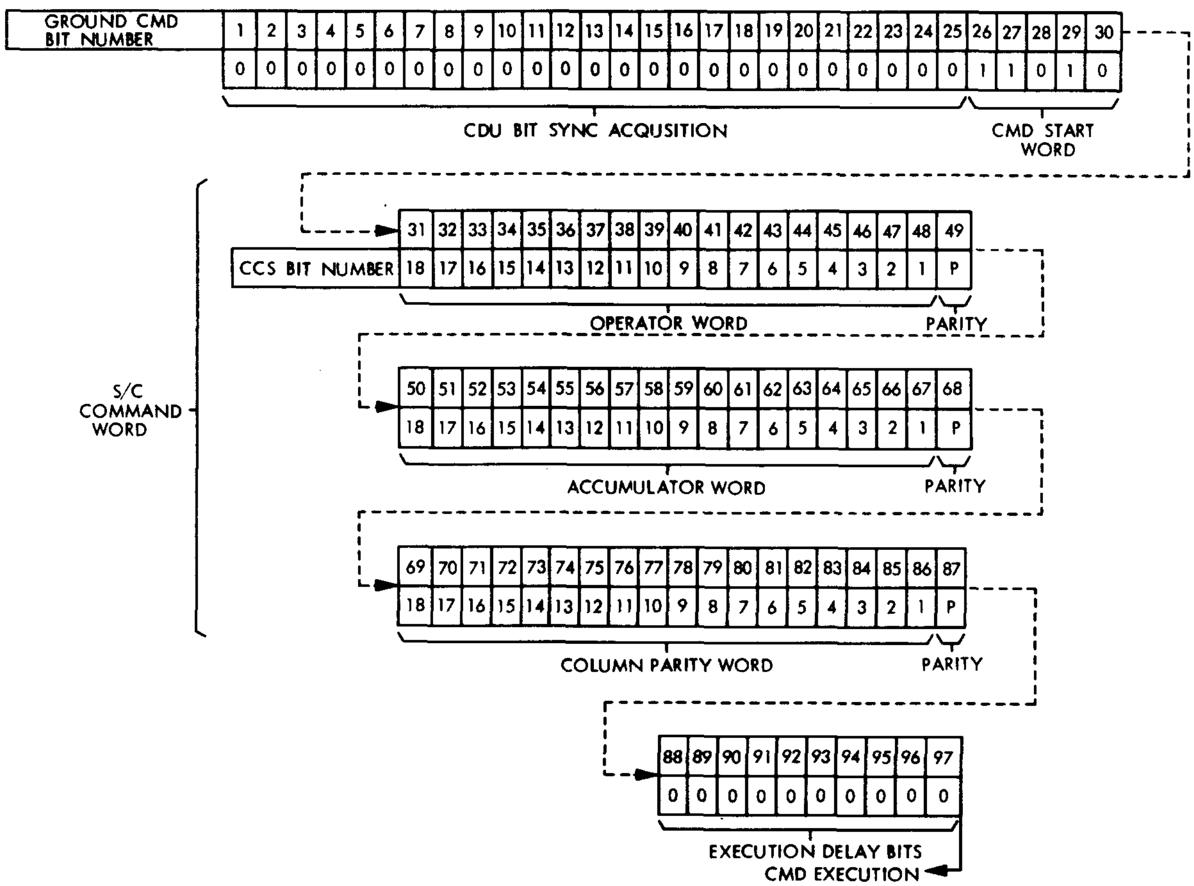


Figure 5. Command Word Format

The command-start word (11010) is used to provide command synchronization. The operator word provides a command type and parameter information to the CCS while the accumulator word provides data for the operation. The column parity word is odd parity on the operator and accumulator words. In addition, each word requires odd parity. This is accomplished by setting parity bit P such that the 18 bits of the word and the parity bit contain an odd number of ones.

4.6.2 Block Load Format

The command format, shown on Figure 6, shall be used when sending multiple commands to the MJS77 S/C for loading the CCS, FDS, or AACS memories, or to execute, as if it were a subroutine, the instructions contained in the data block. A block load command word is followed by a data block consisting of 1 to 50 18-bit data words, with parity on each. The operator word specifies the Block Type and the Block Size and the accumulator word contains the Block ID and Block Number. The data block follows, terminated with column parity on the data block.

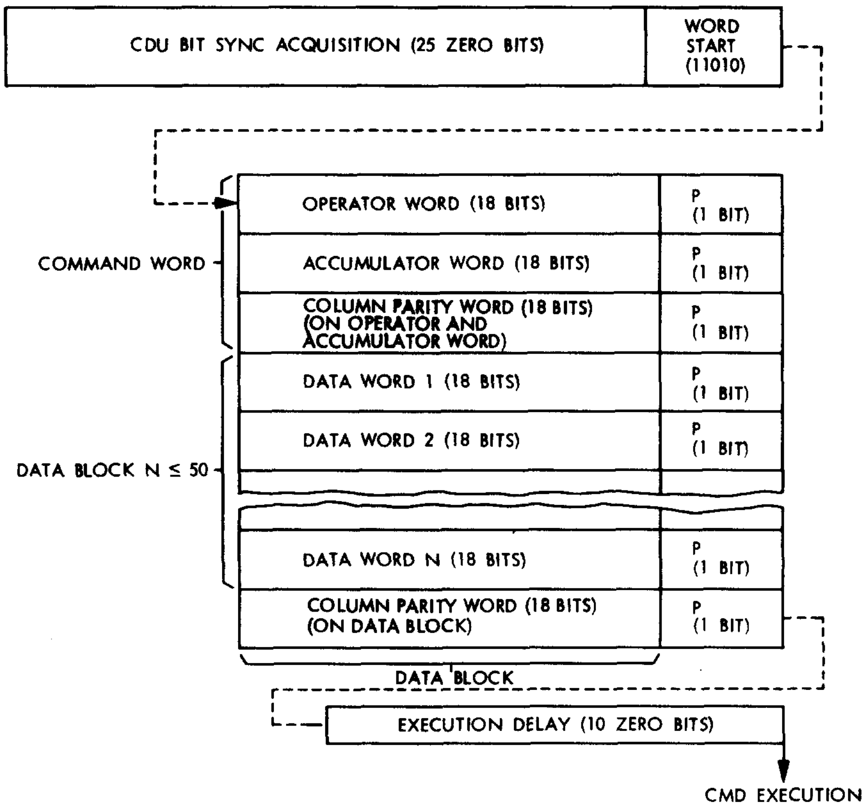


Figure 6. Block Load Format

4.7 Command Word Format Description

4.7.1 CCS Operator Word

The operator word provides a command type and parameter information to the CCS. The seven processor and the coded, direct command operator words are shown in Table 7.

4.7.1.1 Spacecraft ID. The spacecraft ID (bit 1) indicates which spacecraft is being commanded. Commands will not be executed unless the spacecraft ID corresponds to the spacecraft processing the command.

4.7.1.2 Processor ID. The processor ID (bits 2 and 3) indicates which processor(s) will be used in carrying out the operation. Commands will not be executed unless the processor ID (A and/or B) corresponds to the unit(s) processing the command.

4.7.1.3 Modifier ID and Modifier. The modifier ID indicates whether the command is a CC or DC command; or one of the PC commands. The modifier ID, one of eight codes, identifies the format and use of the 12-bit modifier portion of the operator word and the corresponding 18-bit accumulator word. The modifier ID (bits 4-6) and modifier (bits 7-18) for all commands are shown in Table 7.

4.7.1.3.1 ID 000 - Block Command. For modifier ID 000 (Block Command) the modifier portion of the operator word has the following format:

3 Bits	3 Bits	6 Bits
Type	000	No. Words

The 6 bit No. Words indicate the number (n) of 18-bit data words (1 to 50) in the block load. Type has three bits which indicate one of seven possible formats for the data contained in the n data words of the block load.

4.7.1.3.1.1 Type 011 - CCS MEMORY LOAD BLOCK. The format for memory load blocks is shown in Figure 7. A maximum of 49 memory words (18 bits/word) may be loaded with a single block command, if the memory addresses are consecutive. Non-consecutive addresses may be loaded with a single block command; the maximum number of different addresses is 25 (assuming no consecutive addresses).

Table 7. CCS Operator Words

			GROUND CMD BIT NUMBER	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
			CCS BIT NUMBER	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
DC or CC	1	DC or CC		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1			
PC	2	Store		1	Memory Address										(LSB)	0	1	1			
PC	3	Transfer		(MSB)	Memory Address										(LSB)	0	1	0			
PC	4	Internal Execute;		0	0	0							0	1	0	1	0	0			
PC		Enable Processors to Output 1					0	0	0	0	0	1									
PC		Inhibit Processors to Output 1					0	0	1	0	0	0									
PC		Enable Processors to Output 2					0	0	0	0	1	0									
PC		Inhibit Processors to Output 2					0	1	0	0	0	0									
PC		Enable Other Processor's Outputs					0	0	0	1	0	0									
PC		Inhibit Other Processor's Outputs					1	0	0	0	0	0									
PC	5	Block					0	0	0	Block Size						0	0	0			
PC		FDS Memory	Software Load	1	0	0															
PC		FDS Memory		1	0	1															
PC		FDS Memory	Hardware Load	1	1	0															
PC		CCS Memory Load		0	1	1															
PC		Program Execute		0	0	0															
PC		Conditional Program Execute		0	0	1															
PC		Conditional Program Execute		0	1	0															
PC		AACS Memory Load		1	1	1															
PC	6	Return		Memory Address												1	0	1			
PC	7	Store Indirect		Memory Address												1	1	0			
PC	8	Execute		Memory Address												1	1	1			

Modifier
Modifier ID
Processor ID { 1 = Processor B; 1 = Processor A }
Spacecraft ID { 1 = MJS77-2; 0 = MJS77-3 }

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CCS BIT NUMBER	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
DATA	CCS BASE ADDRESS												N_1					
	CCS MEMORY WORD 1																	
	• • •																	
	CCS MEMORY WORD N_1																	
	CCS BASE ADDRESS												N_2					
	CCS MEMORY WORD 1																	
	• • •																	
	CCS MEMORY WORD N_2																	

WARNING

No attempt should be made to store words in memory addresses below 2048 (4000 octal) unless immediately preceded by a special store command.

Notes:

1. N_1 is the number of consecutive memory words to be loaded beginning at the specified CCS base address; N_2 is the number of consecutive CCS memory words to be loaded beginning at the specified base address etc.
2. If the CCS Memory Word contains a CCS instruction as well as an address, the CCS address is entered in CCS bits 7-18 followed by the CCS instruction in CCS bits 1-6.

Figure 7. MJS77 PC Commands, CCS Memory Load Data Block

4.7.1.3.1.2 Type 000 - Program Execute Block. The format for program execute blocks is shown in Figure 8. This block is the same as the CCS Memory Load block except that CCS program control is transferred to the first word of the data block and the instructions contained in the data block are then executed. At the end of the Program Execute block, CCS control is returned to the on-board CCS programs.

Unconditional program execute blocks are used to transmit a special sequence of events or routine that is to be executed only once; immediately upon receipt by the CCS. This special routine or sequence is not retained in memory but rather is executed from the command buffer. No other command shall be sent to the CCS until the execute block has finished executing.

CCS BIT NUMBER	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
DATA	CCS MEMORY WORD 1																	
	CCS MEMORY WORD 2																	
	• • • • • •																	
	CCS MEMORY WORD N																	

WARNING

No attemp should be made to store words in memory addresses below 2048 (4000 octal) unless immediately preceded by a special store command.

Notes:

1. N is the number of CCS memory words to be loaded; N $\leq$ 49.
2. If the CCS Memory Word contains a CCS instruction as well as an address, the CCS address is entered in CCS bits 7-18 followed by the CCS instruction in CCS bits 1-6.

Figure 8. MJS77 PC Commands, Program Execute Load and Conditional Program Execute Load Data Block

4.7.1.3.1.3 <u>Type 001 or 010 - Conditional Program Execute Block.</u> This block will follow a series of CCS memory load blocks (see Figure 9) containing instructions that are to be executed only if all of the preceding memory load blocks have been accepted by the CCS. Execution of this block establishes the necessary linkages that permit the initiation of the instructions contained in the previous blocks. If the out-of-sequence indicator is set, indicating that all preceding blocks have not been properly received, the conditional execute block will be rejected and the linkages will not be established. The format for conditional program execute blocks is shown in Figure 8.

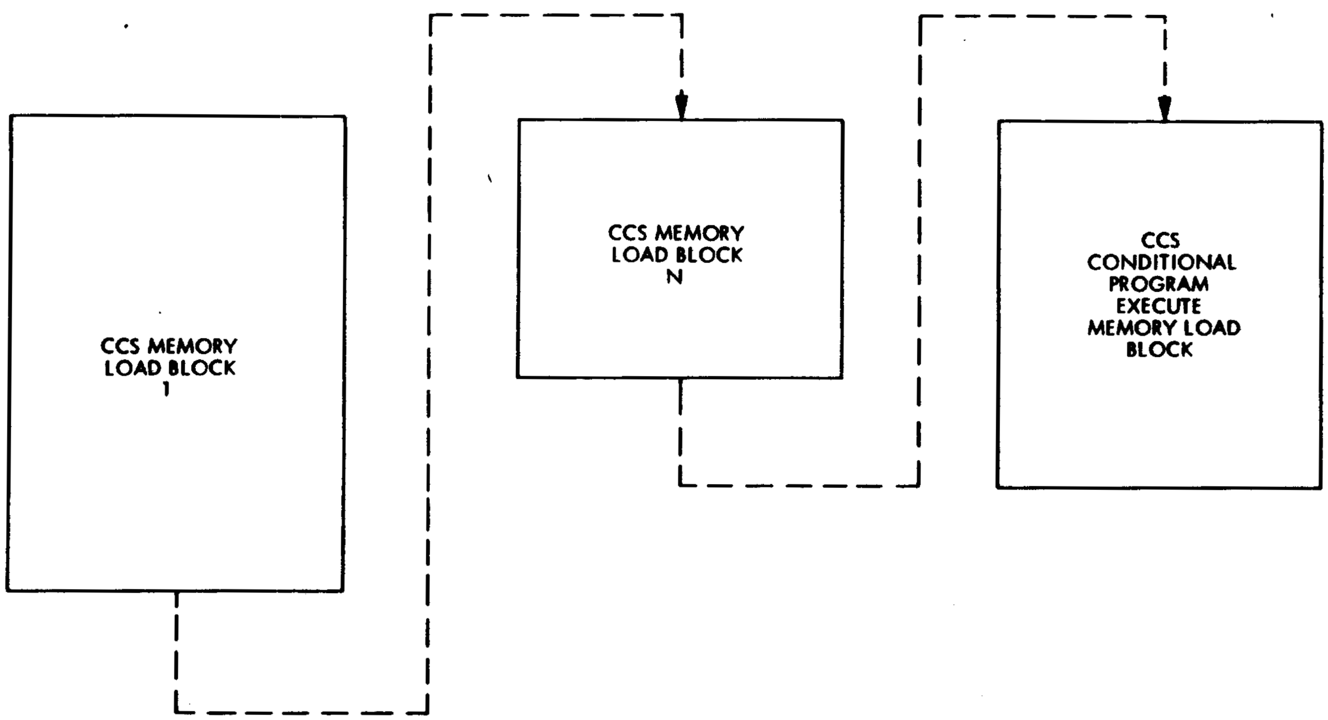


Figure 9. MJS77 Conditional Program Execute Block Load

4.7.1.3.1.4 <u>Type 100 or 101 — FDS Memory Software Load Block</u>. The format for FDS memory software load blocks as transmitted from the ground to the CCS command buffer is shown in Figure 10. FDS software loads permit updating FDS memory contents without interfering with a running program.

The sequence of operations associated with a FDS software load via the CCS shall be as follows:

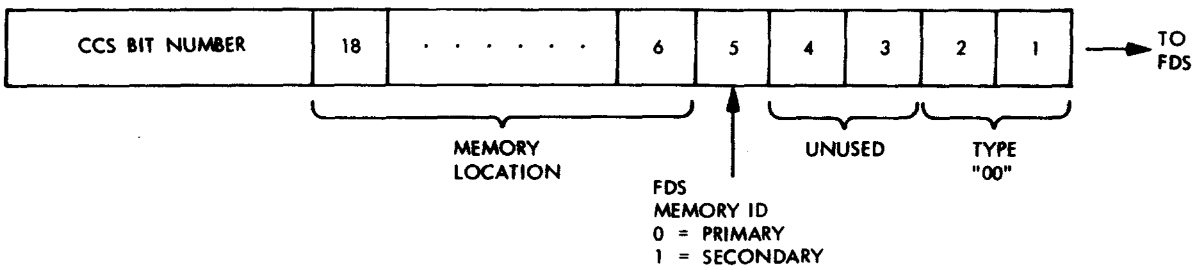
a) The CCS shall send a coded command to the FDS which alerts the FDS of the block load and specifies that it is a <u>software</u> block load. This command also disables the hardware decoding logic, specifies whether the block load is for the primary or secondary FDS memory, and whether the FDS memory protect circuitry should be disabled. The memory protect circuitry shall only be disabled when the block load involves updating protected memory.

b) The CCS shall segment the command words in the command buffer as shown in Figure 11 and output these commands to the FDS through the event output routine.

c) The FDS shall reconstruct the original 16 bit data words from the coded commands received from the CCS. Each 16 bit data word is prefaced by two bits (the TYPE field) which are used to specify whether the following 16 bits are memory address, data, or the end of the block load. As can be seen from Figure 11, three CCS coded commands are required to transfer two 16-bit data words to the FDS.

d) If sequential memory locations are to be loaded, only one address word (the starting address) shall be required. Data words that follow shall be loaded in consecutive memory locations. As a result, a maximum of 49 memory words may be loaded with a single block command if the memory addresses are consecutive. "Scatter loading" shall be accomplished by specifying an address for each data word.

e) FDS memory address specification shall conform to the format as shown below:



f) Upon receipt of the end of block load command from the CCS, the FDS shall re-enable the hardware decode logic and memory protect circuitry (if disabled for the load).

4.7.1.3.1.5 Type 110 - FDS Memory Hardware Load Block. The format for FDS memory hardware load blocks is the same as that for software load blocks shown in Figure 10. FDS program operation shall be stopped when updating FDS memory contents with a hardware load. All features of the hardware load mode are identical to that described for the software load mode except for the following:

a) When the "end of block load" is received during a hardware block load, the FDS shall begin executing the program at address zero of the primary memory.

b) The hardware load will cause a discontinuity in spacecraft time since the entire FDS is stopped.

4.7.1.3.1.6 Type 111 - AACS Memory Load Block. The format for AACS memory load blocks as transmitted from the ground to the CCS command buffer is the same as that shown in Figure 7 for CCS memory loads. Assuming the block passes CCS parity checks, the CCS segments the command words in the command buffer as shown in Figure 12 and outputs this information as coded commands to the AACS. The following points should be noted from Figure 12:

a) The number of words in the block (M) is not transmitted to AACS. This information is for CCS internal use only.

b) For AACS memory loads, the first word in the block will always contain an address - hence the first coded command of the block will always have C_1 set equal to "1".

c) AACS will load data words in consecutive addresses (from the starting address) unless told otherwise. "Scatter loading" is accomplished by specifying an address for each data word.

4.7.1.3.2 ID 001 - DC or CC Command. The modifier portion of the operator word contains all zeroes.

4.7.1.3.3 ID 010 - TRANSFER (TRA) Command. The TRANSFER operator word is used to transfer CCS processor control. Table 8 describes the operator word and accumulator word necessary for a TRA. The entry address is specified in bits 7-18 of the operator word. The accumulator word may contain parameters. This will generally be a subroutine which may or may not require the use of the accumulator word for data or parameters.

4.7.1.3.4 ID 011 - STORE (STW) Command. The STORE operator word is used to store a single word in CCS memory. Table 9 describes the operator word and accumulator word for a STW. Bits 7-18 of the operator word specifies the CCS address into which the accumulator word contents are to be stored.

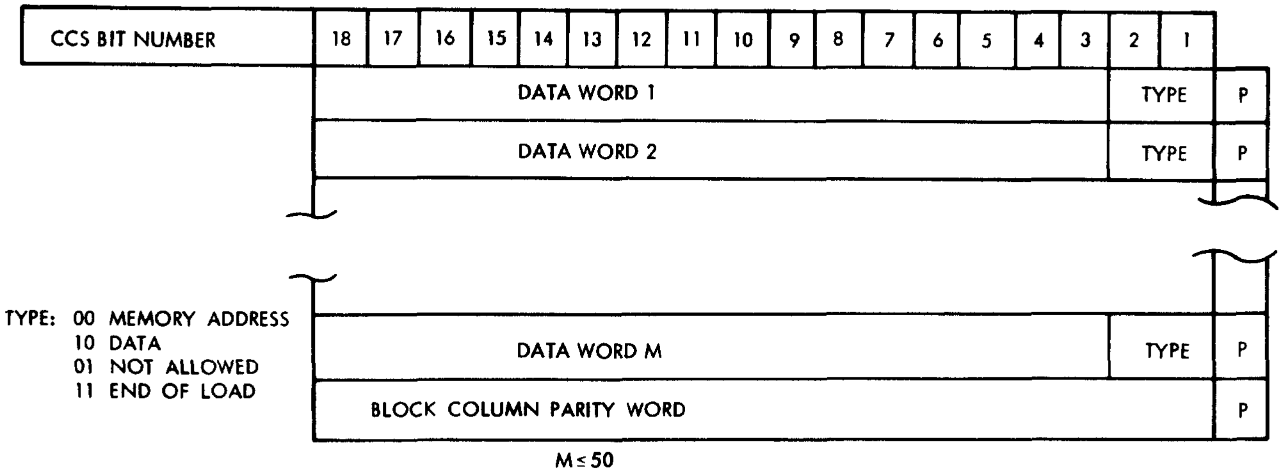
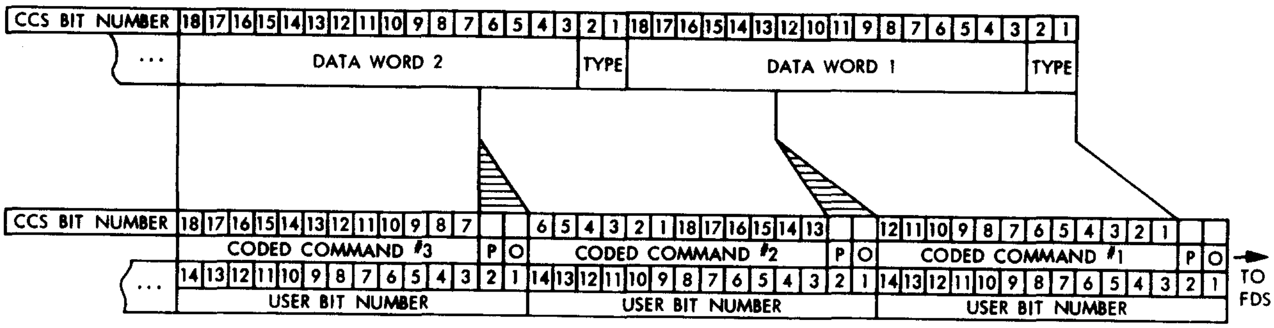


Figure 10. MJS77 PC Commands, Data Block FDS Software Memory Load

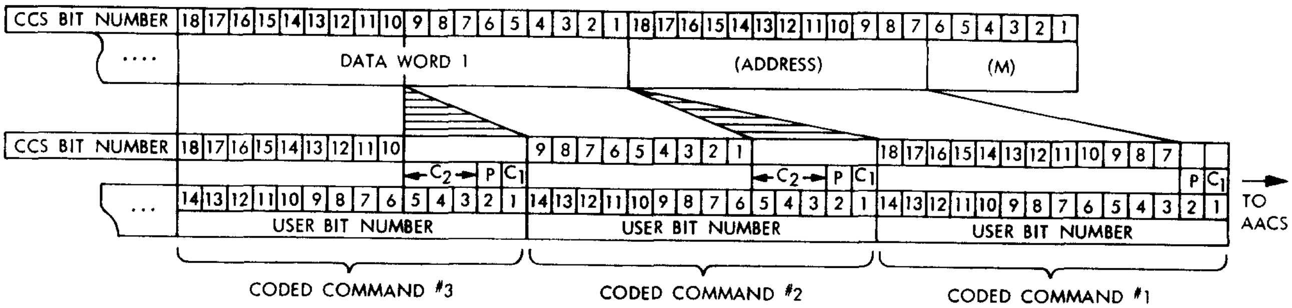


NOTES: 1) USER BIT #1 RECEIVED FIRST BY USER SYBSYSTEM

2) P REPRESENTS ODD PARITY ON USER BITS 3-14

3) USER BITS 1 AND 2 ARE GENERATED BY CCS AND NOT INCLUDED IN THE CCS BLOCK LOAD

Figure 11. FDS Command Word to CC Conversion



NOTES: 1) USER BIT #1 RECEIVED FIRST BY USER SUBSYSTEM

2) C_1 AND C_2 ARE CODE BITS GENERATED BY CCS AND NOT INCLUDED IN THE CCS BLOCK LOAD

3) C_1 = 1 = ADDRESS
C_1 = 0 = $\overline{\text{ADDRESS}}$

4) P REPRESENTS ODD PARITY ON USER BITS 3-14

5) C_2 FIELD DEFINITION:

USER BIT NUMBER 5	4	3	CODED COMMAND CONTENTS
0	0	0	DC WORD
1	0	0	1st HALF DATA/INSTRUCTION
0	1	0	2nd HALF DATA
1	1	0	2nd HALF INSTRUCTION
x	x	1	11 BIT WORD

6) M < 50

Figure 12. AACS Command Word to CC Conversion

Table 8. MJS77 PC Commands, TRANSFER

Operator/Accumulator Word

		31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Ground Command Bit Number		31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
CCS Bit Number		18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Transfer Word (TRA) PC Command														0	1	0			
CCS Memory Address (0 through 4095)		MSB											LSB						
CCS Processor Addressed by Command	Processor A Memory																0	1	
	Processor B Memory																1	0	
	Processor A and B Memories																1	1	
MJS77 Address	MJS77-2																		1
	MJS77-3																		0

TRA Operator Word

	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
Ground Command Bit Number	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
CCS Bit Number	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Memory Word	MSB																	LSB

TRA Accumulator Word

Table 9. MJS77 PC Commands, STORE

Operator/Accumulator Words

		31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Ground Command Bit Number		31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
CCS Bit Number		18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Store Word (STW) PC Command														0	1	1			
CCS Memory Address (2048 through 4095)		1	MSB										LSB						
CCS Processor Addressed by Command	Processor A Memory																0	1	
	Processor B Memory																1	0	
	Processor A and B Memories																1	1	
MJS77 Address	MJS77-2																		1
	MJS77-3																		0

STW Operator Word

	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
Ground Command Bit Number	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
CCS Bit Number	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Memory Word	MSB																	LSB

STW Accumulator Word

NOTES:

1. If the CCS Memory Word contains a CCS instruction as well as an address, the CCS address is entered in CCS bits 7 - 18 followed by the CCS instruction in CCS bits 1 - 6.

4.7.1.3.5 ID 100 - INTERNAL EXECUTE (IEX) Command. The INTERNAL EXECUTE operator word is used to set up the CCS processor-to-output unit paths, or to selectively enable or disable a processor. Table 10 describes the operator word and accumulator word necessary for an IEX. The accumulator word is not used and is set to all zeros. Bits 10 through 15 of the modifier portion of the operator word specifies the role between the processors and the output units.

4.7.1.3.6 ID 101 - RETURN (RET) Command. The RETURN operator word is used to cause a CCS indirect transfer to the location specified by the Memory address indicated in bits 7-18. The accumulator word may contain data or parameters and is used as indicated in the transfer instruction. Table 11 shows the operator and accumulator word for a RET.

4.7.1.3.7 ID 110 - STORE INDIRECT (STW*) Command. The STORE INDIRECT operator word is used to indirectly store the accumulator word in the location specified by the address indicated. Table 12 shows the operator and accumulator word for a STW*.

4.7.1.3.8 ID 111 - EXECUTE (XEC) Command. The EXECUTE operator word is used to execute the instruction in the location specified by the address contained in bits 7-18 of the operator word. Table 13 shows the operator and accumulator word for a XEC.

4.7.2 CCS Accumulator Word

4.7.2.1 DC Accumulator Word. The DC accumulator word is the address of the discrete switch location in the CCS command matrix. The DC accumulator words are shown in Table 3 of MJS77-3-290.

4.7.2.2 CC Accumulator Word. The CC accumulator word is partially decoded by the CCS to determine the appropriate user subsystem and is then issued to the user subsystem for final decoding. The CC accumulator words are shown in Table 4 of MJS77-3-290.

4.7.2.3 PC Accumulator Words. The PC accumulator words are used to program and control the CCS, FDS, and AACS. The function for each PC accumulator word is as follows:

BLOCK. The block accumulator word indicates the block ID and the block number. The block accumulator word format is shown and described in Table 14.

TRANSFER. The transfer accumulator word may contain data or parameters used in a CCS subroutine as required per Table 8.

STORE. The store accumulator word is the single word which is to be stored in CCS memory per Table 9.

INTERNAL EXECUTE. The internal execute accumulator word is not used and is set to all zeros per Table 10.

Table 10. MJS77 PC Commands, INTERNAL EXECUTE

Operator/Accumulator Word

		31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Ground Command Bit Number		31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
CCS Bit Number		18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Internal Execute (IEX) PC Command:		0	0	0							0	1	0	1	0	0			
CCS Processor to Output Units	Enable processors to output unit 1				0	0	0	0	0	1									
	Inhibit processors to output unit 1				0	0	1	0	0	0									
	Enable processors to output unit 2				0	0	0	0	1	0									
	Inhibit processors to output unit 2				0	1	0	0	0	0									
	Enable other processors outputs				0	0	0	1	0	0									
	Inhibit other processors outputs				1	0	0	0	0	0									
CCS Processor Addressed by Command	Processor A																0	1	
	Processor B																1	0	
	Processor A and B																1	1	
MJS77 Address	MJS77-2																		1
	MJS77-3																		0

IEX Operator Word

	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
Ground Command Bit Number	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
CCS Bit Number	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
IEX Accumulator Word	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

IEX Accumulator Word

WARNING: This command should never be sent with a "1" in position 18.

Table 11. MJS77 PC Commands, RETURN

Operator/Accumulator Word

Ground Command Bit Number		31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
CCS Bit Number		18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Return Word (RET) PC Command														1	0	1			
CCS Memory Address (0 through 4095)		MSB											LSB						
CCS Processor Addressed by Command	**Processor A Memory**																0	1	
	Processor B Memory																1	0	
	Processor A and B Memories																1	1	
MJS77 Address	MJS77-2																		1
	MJS77-3																		0

RET Operator Word

Ground Command Bit Number	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
CCS Bit Number	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Memory Word	MSB																	LSB

RET Accumulator Word

Table 12. MJS77 PC Commands, STORE INDIRECT

Operator/Accumulator Word

Ground Command Bit Number		31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
CCS Bit Number		18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
STORE INDIRECT (STW*) PC Command														1	1	0			
CCS Memory Address (0 through 4095)		MSB											LSB						
CCS Processor Addressed by Command	Processor A Memory																0	1	
	Processor B Memory																1	0	
	Processor A and B Memories																1	1	
MJS77 Address	MJS77-2																		1
	MJS77-3																		0

STW* Operator Word

Ground Command Bit Number	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
CCS Bit Number	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Memory Word	MSB																	LSB

STW* Accumulator Word

Table 13. MJS77 PC Commands, EXECUTE

Operator/Accumulator Word

Ground Command Bit Number		31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
CCS Bit Number		18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Execute Word (XEC) PC Command														1	1	1			
CCS Memory Address (0 through 4095)		MSB											LSB						
CCS Processor Addressed by Command	Processor A Memory																0	1	
	Processor B Memory																1	0	
	Processor A and B Memories																1	1	
MJS77 Address	MJS77-2																		1
	MJS77-3																		0

XEC Operator Word

Ground Command Bit Number	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
CCS bit Number	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Memory Word	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

XEC Accumulator Word

MJS77-3-270

RETURN. The return accumulator word may contain data or parameters used in a CCS subroutine as required per Table 11.

STORE INDIRECT. The store indirect accumulator word is the information which is to be stored per Table 12.

EXECUTE. The execute accumulator word is not used and is set to all zeros per Table 13.

Table 14. MJS77 PC Commands, Block Accumulator Word

GROUND COMMAND BIT NUMBER	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
CCS BIT NUMBER	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
BLOCK ID	MSB											LSB						
BLOCK NO.													MSB					LSB

The Block ID and No. are used to give every command block a unique identifier. The Block ID and No. are also used to control the CCS out-of-sequence indicator under the following ground rules.

a) Any accumulator word with a zero Block number has no effect on the out-of-sequence indicator.

b) The out-of-sequence indicator is reset only by receiving a new command with a Block No. equal to one.

c) Example of out-of sequence operation.

Block ID	Block No.	Out-of-Sequence Indicator
6	1	Reset
6	2	No change
7	0	No change
6	3	No change
6	5	Set*
6	6	
8	0	
7	1	Reset

*Since 6-4 is missing in the sequence, 6-5, 6-6, and 8-0 will all be marked out of sequence. Because of this, the out-of-sequence indicator will be set, and any conditional program execute block will be rejected unless the indicator is first reset. The out-of-sequence indicator will reset with 7-1.

4.7.3 Command Parity

4.7.3.1 CCS Parity Checks on Uplink Commands. Bits 26 through 30 of the base command word format represent the command start code and shall be recognized with single bit error tolerance. The P's in Figures 5 and 6 represent odd row parity over the preceding 18 bit word (i.e., the sum of the number of ones in P and the 18 bit word is odd.) The column parity word consists of 18 parity bits. Each of these bits represents odd parity for the corresponding column. The acceptance criteria for the command header and data block shall be as specified in Figure 13. All commands received with a condition "A" or "C" shall cause the timer associated with the CCS command loss routine to be reset.

4.7.3.2 Subsystem Response to Coded Command Parity Error. The CCS shall generate odd parity on all coded commands which are sent to the coded command user subsystems (FDS, AACS, MDS, DSS, and PWR). User subsystems shall check parity on coded commands and, in the event of a parity error, the subsystem response shall be as follows:

a) FDS - The FDS shall execute the command and inform the ground of a parity error via FDS status telemetry.*

b) AACS - The AACS shall not execute the command but shall inform the CCS via the power code interface and the ground via AACS status telemetry. CCS response to the power code indication is TBD.*

c) MDS - The MDS shall not execute the command. Ground or CCS notification of a parity error shall not be required.

d) DSS - The DSS shall not execute the command. Ground or CCS notification of a parity error shall not be required.

e) PWR - The PWR shall not execute the command. Ground or CCS notification of a parity error shall not be required.

*Notification shall be sufficient to identify within which block the command parity error occurred but the exact command in error may not be determinable.

HEADER ACCEPTANCE CRITERIA

# COLUMN PARITY ERROR \ # ROW PARITY ERROR	0	1	≥2
0	A	A	T
1	T	C	T
≥2	T	T	T

DATA BLOCK ACCEPTANCE CRITERIA

# COLUMN PARITY ERROR \ # ROW PARITY ERROR	0	1	≥2
0	A	A	R
1	R	C	R
≥2	R	R	R

A = accept block with no errors or a single row parity bit error.

C = correct single bit error at junction of column parity bit error position and row parity bit error position.

R = reject the format as probably having two errors. Start looking for a new command start code.

T = terminate decoding operations until a new CDU lock indication is received.

Figure 13. CCS Command Acceptance Criteria

5.0 INSTRUMENT DATA AND CONTROL REQUIREMENTS

5.1 General

The FDS shall supply all instrument timing and control functions as specified in MJS77-3-110.

5.1.1 FDS-Instrument Logic Signal Conventions

Positive logic signal conventions (output a "1" when the signal amplitude is high and a "0" when the signal amplitude is low) shall apply to all FDS-instrument interfaces with the exception of the PWS. For the PWS the output shall be a "0" when the signal amplitude is high and a "1" when the signal amplitude is low.

5.1.2 FDS-Instrument Data Transfer Characteristics

All digital data sent to or received from the science instruments shall be serial NRZ and transmitted most significant bit (MSB) first. With the exception of video and high rate PRA and PWS data, all digital data shall be transferred at 14.4kHz. High rate PRA and PWS data shall be transferred at 115.2 kHz whereas video data shall be transferred at an instantaneous rate of 172.8 kHz.

The FDS shall supply a continuous 14.4 kHz shift clock to each science instrument with the exception of the PWS for the purposes of transferring serial command and science data. During periods of data transfer, the receiving subsystem shall sample the serial data on the leading edge of the shift clock. The sending subsystem shall shift on the trailing edge of the shift clock.

5.1.3 Instrument Engineering Measurements

The FDS shall accommodate and sample all instrument engineering measurements as specified in MJS77-3-280.

5.1.4 FDS-Instrument Serial Commands

All serial commands issued by the FDS to control science instrument operation shall conform to the bit patterns as specified in MJS77-3-290.

5.2 Cosmic Ray Subsystem (CRS)

5.2.1 Discrete Commands

The FDS shall provide five (5) discrete pulse commands to accommodate the following CRS functions:

a) Turning on CRS high voltage.

b) Synchronizing the CRS rate and status data readout to the FDS.

c) Starting the CRS internal calibration sequence.

d) Stepping the CRS analog multiplexer.

e) Resetting the CRS analog multiplexer to a known position.

5.2.2 Serial Command

The FDS shall provide a 12 bit serial command word for CRS instrument control. This command word shall be sent every 48 s.

5.2.3 Bi-Level Commands

The FDS shall provide a bi-level command to control which set of redundant interface lines are used.

5.2.4 Interface Redundancy

The FDS shall provide redundancy for those CRS functions as specified in MJS77-3-110. Redundant CRS I/O logic shall also be included in the FDS. The redundant function shall be selectable as a set by the FDS upon receipt of a ground command. The FDS shall always send the redundant signals to the CRS but shall take data only from the data line which was selected.

5.2.5 Data Acquisition

CRS data acquisition shall be controlled by the frequency at which the FDS issues PHA, RATE, and STATUS word gates. The FDS shall issue these word gates so as to generate CRS data as specified in Table 17.

5.3 Planetary Radio Astronomy Subsystem (PRA)

5.3.1 Discrete Commands

The FDS shall provide three discrete pulse commands to accommodate the following PRA functions:

a) Initiating the analog to digital conversion process.

b) Stepping the analog multiplexer.

c) Resetting the analog multiplexer to a known position.

Table 17. CRS Data Acquisition Schedule

Cruise Mode	CRS Allocation (bps)	PHA Data (bps)	RATE Data (bps)	STATUS Data (bps)
CR-1	250*			
CR-2	250*			
CR-3	125*			
CR-4	62*			
CR-5	31*			
CR-6	20			
CR-7	Formats and allocations will not be developed until extended mission approval is given.			
CR-8				
CR-9				
General Science Encounter Mode	**CRS Allocation (bps)**	**PHA Data (bps)**	**RATE Data (bps)**	**STATUS Data (bps)**
GS-1	262	200	60	2
GS-2	262	200	60	2
GS-3	262	200	60	2
GS-4	262	200	60	2
OC-1	262	200	60	2

*Allocations shown are only representative. Final rates and allocations are TBD.

5.3.2 Serial Commands

The FDS shall supply the PRA with two classes of serial command words which are transmitted from the FDS to PRA on the same interface line. The class of command shall be recognized by the PRA by the respective time of arrival relative to the status word gate. The first command sent after the status word gate shall be the PRA mode command (MODE CMD) and the second command sent after the status word gate shall be the PRA configuration command (CONFG CMD). In general, MODE CMDS shall be generated by the FDS program during flight, while CONFG CMDS that are not associated with LEVEL commands shall be changed only in response to a ground command.

MODE CMDS shall determine the mode of operation of the instrument (POLLO, POLHI, etc.) and the preset radiometer frequency for the POLHI, FIXLO, and VLOBR modes. A MODE CMD shall be required for every scan. When a MODE CMD is sent, the instrument shall be operated in that mode for at least one full scan (198 science data samples). However, if the instrument receives a MODE CMD before completing a full scan, it shall start a new scan in accordance with the new command. Nine frequency code words of 9 bits each shall be transmitted by ground command and stored in the FDS. The FDS program must merge the appropriate one of these frequency codes into each PRA MODE CMD which specifies either POLHI, FIXLO, VLOBR, or the GS-2 data mode.

A CONFG CMD shall follow each of the eight MODE CMDS for LEVEL and the first MODE CMD following the 48s LEVEL period. At all other times a CONFG CMD shall only occur in response to a ground command.

A DIG STATUS word readout shall follow a MODE CMD, and precede the first ADC START pulse, to confirm the proper receipt and response to the commands. The 16 bit DIG STATUS word data which is read out once per scan, to provide information on the status and operation of the instrument, shall be inserted into the bit stream in place of the first two ADC DATA words. Four bits of mode code are included in the DIG STATUS word.

5.3.3 Special Clock Frequencies

The FDS shall provide the following two special clock frequencies to the PRA:

a) A continuous 172.8 kHz signal used to synchronize the analog to digital converter.

b) A continuous 76.8 kHz square wave used to generate local oscillator frequencies.

5.3.4 Data Acquisition

PRA data acquisition shall be controlled by the frequency at which the FDS issues signals to initiate the analog to digital conversion process and the status word gate. PRA data shall be acquired at the rates shown in Tables 2 and 6, and in the mode sequences shown in Tables 18 through 25, respectively.

5.3.5 Data Modes

The PRA shall operate in six different data modes: POLLO, POLHI, HARAD, VLOBR, FIXLO, and LEVEL. In all data modes except POLHI, the average rate of data transfer between the PRA and FDS shall be 266-2/3 bps. Depending on the mission phase, the FDS shall insert all or a portion of the 266-2/3 bps data into the telemetry stream. In the POLHI mode, 200 data samples are acquired at a rate of 115.2 kbps and rate buffered into the telemetry stream at 266-2/3 bps. In the GS-2 data mode, PRA data at 115.2 kbps is inserted into the telemetry stream. The PRA data will be interrupted for the insertion of standard encounter GS&E data for 4.3 ms out of every 60 ms.

5.3.6 Data Mode Sequencing

A mode sequence shall consist of 240 (8 $\times$ 30) scans, taken in various modes, according to a sequence specification. This sequence specifies:

a) The order of the modes

b) The number of scans in each mode

c) Which of the nine pre-stored frequency codes are to be inserted into each of the mode commands for POLHI, FIXLO, VLOBR, and the GS-2 data mode

d) Which of eight calibration level codes is to be inserted in the CONFG CMD which accompanies the LEVEL MODE commands.

Seven such sequence specifications (six for Cruise and one for Jupiter/Saturn encounter) will be developed. It should be noted that the VLOBR mode is not used because the spacecraft bit rate is too high to use the Low Data Rate Sequence. However, the

VLOBR mode and the Low Data Rate Sequence requirements shall be maintained in the event that post-Saturn spacecraft operation becomes a reality.

In those telemetry modes where the PRA data rate allocation is 266-2/3 bps a scan requires 6 s and a mode sequence requires 1440 s, or 24 minutes.

The mode sequences shall be as presented in Tables 18 through 24, with Blocks A and B filled in by the appropriate mode for the sequence. The apparent half-frame symmetry is destroyed by the LEVEL mode only and will be discussed below. Blocks A and B contain modes as determined by ground command of the FDS. The mode contained in Block A is separately commanded and independent of the mode commanded for Block B. Table 25 is a composite of Tables 18 through 24.

In the POLHI, FIXLO, and VLOBR modes, the FDS shall command the PRA to one of nine ground loaded frequencies, seven of which are used for the normal mode sequences and the remaining two are used for the GS-2 data mode. VLOBR has only one ground loaded frequency while POLHI and FIXLO have three. The three frequencies for POLHI and the three frequencies for FIXLO shall be commanded in a 1, 2, 1, 3 sequence.

The POLLO and HARAD modes contain a complete cycle within each 6 s interval and therefore require the least command bits.

The LEVEL mode requires a full 48 s frame for a complete instrument calibration cycle. Since the commands for the first half of the frame are different than those of the second half of the frame, the inherent half-frame symmetry is destroyed. During LEVEL, the FDS sends the LEVEL mode command followed by an FDS modified CONFG CMD. The FDS modifies the CONFG CMD by masking the 4 LBS's of the stored CONFG CMD and substituting the sequence of the 4 LSB's described in Table 26. The first mode command following LEVEL will be accompanied by the stored CONFG CMD as shown in the sequence of MODE and CONFG CMDS that is contained in Table 26.

Table 18. CR-1 PRA Mode Sequence Diagram

1 FULL SEQUENCE 30 frames

Frame	Scan 1 (0–6 sec)	Scan 2 (6–12 sec)	Scan 3 (12–18 sec)	Scan 4 (18–24 sec)	Scan 5 (24–30 sec)	Scan 6 (30–36 sec)	Scan 7 (36–42 sec)	Scan 8 (42–48 sec)
1				POLLO				
2	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8
3				HARAD				
4	F_1	F_2	F_1	F_3	F_1	F_2	F_1	F_3
5				POLLO				
6				HARAD				
7	F_1	F_2	F_1	F_3	F_1	F_2	F_1	F_3
8	F_1	F_2	F_1	F_3	F_1	F_2	F_1	F_3
9				POLLO				
10	F_1	F_2	F_1	F_3	F_1	F_2	F_1	F_3
11				HARAD				
12	P_{h1}	P_{h2}	P_{h1}	P_{h3}	P_{h1}	P_{h2}	P_{h1}	P_{h3}
13				POLLO				
14–24				BLOCK A				
25–30				BLOCK B				

TIME, sec: 0, 6, 12, 18, 24, 30, 36, 42, 48

Table 19. CR-2 PRA Mode Sequence Diagram

1 FULL SEQUENCE 30 frames

Frame	Scan 1	Scan 2	Scan 3	Scan 4	Scan 5	Scan 6	Scan 7	Scan 8
1	POLLO							
2	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8
3	HARAD							
4	F_1	F_2	F_1	F_3	F_1	F_2	F_1	F_3
5	POLLO							
6	P_{h1}	P_{h2}	P_{h1}	P_{h3}	P_{h1}	P_{h2}	P_{h1}	P_{h3}
7	F_1	F_2	F_1	F_3	F_1	F_2	F_1	F_3
8	F_1	F_2	F_1	F_3	F_1	F_2	F_1	F_3
9	POLLO							
10	F_1	F_2	F_1	F_3	F_1	F_2	F_1	F_3
11	HARAD							
12	P_{h1}	P_{h2}	P_{h1}	P_{h3}	P_{h1}	P_{h2}	P_{h1}	P_{h3}
13	POLLO							
14								
15								
16								
17								
18								
19	BLOCK A							
20								
21								
22								
23								
24								
25								
26								
27	BLOCK B							
28								
29								
30								

TIME, sec: 0, 6, 12, 18, 24, 30, 36, 42, 48

Table 20. CR-3 PRA Mode Sequence Diagram

SCANS

Frame	1	2	3	4	5	6	7	8
1				POLLO				
2	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8
3				HARAD				
4	F_1	F_2	F_1	F_3	F_1	F_2	F_1	F_3
5				POLLO				
6	P_{h1}	P_{h2}	P_{h1}	P_{h3}	P_{h1}	P_{h2}	P_{h1}	P_{h3}
7	P_{h1}	P_{h2}	P_{h1}	P_{h3}	P_{h1}	P_{h2}	P_{h1}	P_{h3}
8	F_1	F_2	F_1	F_3	F_1	F_2	F_1	F_3
9				POLLO				
10	F_1	F_2	F_1	F_3	F_1	F_2	F_1	F_3
11				HARAD				
12	P_{h1}	P_{h2}	P_{h1}	P_{h3}	P_{h1}	P_{h2}	P_{h1}	P_{h3}
13				POLLO				
14–24				BLOCK A				
25–30				BLOCK B				

1 FULL SEQUENCE 30 frames

TIME, sec (TBD)

Table 21. CR-4 PRA Mode Sequence Diagram

1 FULL SEQUENCE 30 frames

Frame	SCANS 1	2	3	4	5	6	7	8
1				POLLO				
2	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8
3				HARAD				
4	F_1	F_2	F_1	F_3	F_1	F_2	F_1	F_3
5				POLLO				
6	P_{h1}	P_{h2}	P_{h1}	P_{h3}	P_{h1}	P_{h2}	P_{h1}	P_{h3}
7	P_{h1}	P_{h2}	P_{h1}	P_{h3}	P_{h1}	P_{h2}	P_{h1}	P_{h3}
8	F_1	F_2	F_1	F_3	F_1	F_2	F_1	F_3
9				POLLO				
10	F_1	F_2	F_1	F_3	F_1	F_2	F_1	F_3
11				HARAD				
12	P_{h1}	P_{h2}	P_{h1}	P_{h3}	P_{h1}	P_{h2}	P_{h1}	P_{h3}
13				POLLO				
14								
15								
16								
17								
18								
19				BLOCK A				
20								
21								
22								
23								
24								
25								
26								
27				BLOCK B				
28								
29								
30								

0

TIME, sec (TBD)

Table 22. CR-5 PRA Mode Sequence Diagram

SCANS

Frame	1	2	3	4	5	6	7	8
1	POLLO							
2	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8
3	HARAD							
4	F_1	F_2	F_1	F_3	F_1	F_2	F_1	F_3
5	POLLO							
6	P_{h1}	P_{h2}	P_{h1}	P_{h3}	P_{h1}	P_{h2}	P_{h1}	P_{h3}
7	P_{h1}	P_{h2}	P_{h1}	P_{h3}	P_{h1}	P_{h2}	P_{h1}	P_{h3}
8	F_1	F_2	F_1	F_3	F_1	F_2	F_1	F_3
9	POLLO							
10	F_1	F_2	F_1	F_3	F_1	F_2	F_1	F_3
11	P_{h1}	P_{h2}	P_{h1}	P_{h3}	P_{h1}	P_{h2}	P_{h1}	P_{h3}
12	P_{h1}	P_{h2}	P_{h1}	P_{h3}	P_{h1}	P_{h2}	P_{h1}	P_{h3}
13	POLLO							
14–24	BLOCK A							
25–30	BLOCK B							

1 FULL SEQUENCE 30 frames

0

TIME, sec (TBD)

Table 23. CR-6 PRA Mode Sequence Diagram

SCANS

Frame	1	2	3	4	5	6	7	8
1	POLLO							
2	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8
3	HARAD							
4	F_1	F_2	F_1	F_3	F_1	F_2	F_1	F_3
5	POLLO							
6	P_{h1}	P_{h2}	P_{h1}	P_{h3}	P_{h1}	P_{h2}	P_{h1}	P_{h3}
7	P_{h1}	P_{h2}	P_{h1}	P_{h3}	P_{h1}	P_{h2}	P_{h1}	P_{h3}
8	P_{h1}	P_{h2}	P_{h1}	P_{h3}	P_{h1}	P_{h2}	P_{h1}	P_{h3}
9	POLLO							
10	F_1	F_2	F_1	F_3	F_1	F_2	F_1	F_3
11	P_{h1}	P_{h2}	P_{h1}	P_{h3}	P_{h1}	P_{h2}	P_{h1}	P_{h3}
12	P_{h1}	P_{h2}	P_{h1}	P_{h3}	P_{h1}	P_{h2}	P_{h1}	P_{h3}
13	POLLO							
14–24	BLOCK A							
25–30	BLOCK B							

1 FULL SEQUENCE 30 frames

TIME, min: 0, 16, 32, 48, 64, 80, 96, 112, 128

Table 24. PRA Encounter Mode Sequence Diagram

1 FULL SEQUENCE 30 frames

Frame	Scan 1	Scan 2	Scan 3	Scan 4	Scan 5	Scan 6	Scan 7	Scan 8
1				POLLO				
2	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8
3				HARAD				
4	F_1	F_2	F_1	F_3	F_1	F_2	F_1	F_3
5								
6								
7								
8	P_{h1}	P_{h2}	P_{h1}	P_{h3}	P_{h1}	P_{h2}	P_{h1}	P_{h3}
9								
10								
11				POLLO				
12				HARAD				
13	F_1	F_2	F_1	F_3	F_1	F_2	F_1	F_3
14								
15								
16								
17	P_{h1}	P_{h2}	P_{h1}	P_{h3}	P_{h1}	P_{h2}	P_{h1}	P_{h3}
18								
19								
20								
21				POLLO				
22				HARAD				
23	F_1	F_2	F_1	F_3	F_1	F_2	F_1	F_3
24								
25								
26								
27	P_{h1}	P_{h2}	P_{h1}	P_{h3}	P_{h1}	P_{h2}	P_{h1}	P_{h3}
28								
29								
30								

TIME, sec: 0 6 12 18 24 30 36 42 48

Table 25. PRA Composite Mode Sequence Diagram

1 FULL SEQUENCE 30 frames

	CR-1	CR-2	CR-3	CR-4	CR-5	CR-6		ENC
1	P_L	P_L	P_L	P_L	P_L	P_L		P_L
2	L	L	L	L	L	L		L
3	H	H	H	H	H	H		H
4	F	F	F	F	F	F		F
5	P_L	P_L	P_L	P_L	P_L	P_L		P_L
6	H	P_h	P_h	P_h	P_h	P_h		P_h
7	F	F	P_h	P_h	P_h	P_h		P_h
8	F	F	F	F	F	P_h		P_h
9	P_L	P_L	P_L	P_L	P_L	P_L		P_h
10	F	F	F	F	F	F		P_h
11	H	H	H	H	P_h	P_h		P_L
12	P_h	P_h	P_h	P_h	P_h	P_h		H
13	P_L	P_L	P_L	P_L	P_L	P_L		F
14								P_h
15								P_h
16								P_h
17								P_h
18								P_h
19			BLOCK A					P_h
20								P_h
21								P_L
22								H
23								F
24								P_h
25								P_h
26								P_h
27			BLOCK B					P_h
28								P_h
29								P_h
30								P_h

Table 26. PRA Level Mode Command Sequence

LEVEL	1	0	1	0	0	0	0	0	0	0	0	0	0
CONFG	1	C_{11}	C_{10}	C_9	C_8	C_7	C_6	C_5	C_4	1	0	0	0
LEVEL	2	0	1	0	0	0	0	0	0	0	0	0	0
CONFG	2	C_{11}	C_{10}	C_9	C_8	C_7	C_6	C_5	C_4	1	0	0	1
LEVEL	3	0	1	0	0	0	0	0	0	0	0	0	0
CONFG	3	C_{11}	C_{10}	C_9	C_8	C_7	C_6	C_5	C_4	1	0	1	0
LEVEL	4	0	1	0	0	0	0	0	0	0	0	0	0
CONFG	4	C_{11}	C_{10}	C_9	C_8	C_7	C_6	C_5	C_4	1	0	1	1
LEVEL	5	0	1	0	0	0	0	0	0	0	0	0	0
CONFG	5	C_{11}	C_{10}	C_9	C_8	C_7	C_6	C_5	C_4	1	1	0	0
LEVEL	6	0	1	0	0	0	0	0	0	0	0	0	0
CONFG	6	C_{11}	C_{10}	C_9	C_8	C_7	C_6	C_5	C_4	1	1	0	1
LEVEL	7	0	1	0	0	0	0	0	0	0	0	0	0
CONFG	7	C_{11}	C_{10}	C_9	C_8	C_7	C_6	C_5	C_4	1	1	1	0
LEVEL	8	0	1	0	0	0	0	0	0	0	0	0	0
CONFG	8	C_{11}	C_{10}	C_9	C_8	C_7	C_6	C_5	C_4	1	1	1	1
HARAD		0	0	0	1	0	0	0	0	0	0	0	0
CONFG		C_{11}	C_{10}	C_9	C_8	C_7	C_6	C_5	C_4	C_3	C_2	C_1	C_0

5.4 Plasma Wave Subsystem (PWS)

5.4.1 Discrete Commands

The FDS shall provide three discrete pulse commands to accommodate the following PWS functions:

a) Initiating the analog to digital conversion process.

b) Stepping the narrow bandpass filter.

c) Resetting the narrow bandpass filter to a known position.

5.4.2 Bi-Level Commands

The FDS shall provide two bi-level commands to:

a) Select the input preamplifier gain and

b) Activate the waveform analyzer.

5.4.3 Special Frequencies

The FDS shall provide a continuous 172.8 kHz signal to synchronize the PWS analog to digital converter.

5.4.4 Data Acquisition

PWS data acquisition shall be controlled by the FDS. In the step frequency mode two PWS analog outputs shall be routed to the FDS engineering commutator for analog conversion by the engineering ADC. In the PWS waveform mode, data acquisition shall be controlled by the frequency at which the FDS initiates the analog to digital conversion process.

5.4.5 Data Modes

The PWS shall operate in two different data modes - step frequency and waveform (+ step frequency). In the step frequency mode the PWS routes analog data to the FDS. The FDS subsequently provides 8-bit conversion and inserts this data into the high rate data channel. In the waveform mode, a PWS 8-bit word (two consecutive 4-bit samples) is routed to the FDS every 69.44 μs which is then inserted into the high rate channel. Normal step frequency operation is also maintained when in the waveform mode.

5.4.6 Data Mode Sequencing

The PWS shall operate in the step frequency mode except for selected periods during the Jupiter encounter phase when imaging data is not being acquired and the telecommunications capability can support 115.2 kbps.

5.5 Low Energy Charged Particle Subsystem (LECP)

5.5.1 Discrete Commands

The FDS shall provide three (3) discrete pulse commands to accommodate the following LECP functions:

a) Stepping the LECP rotator to the next position in the direction it is traveling. This command shall occur every 8m in cruise and every 24 s during encounter.

b) Stepping the LECP calibrate and housekeeping analog multiplexers.

c) Resetting the LECP calibrate and housekeeping analog multiplexers to a known position.

5.5.2 Serial Commands

The FDS shall provide a 12-bit and a 7-bit serial command word to the LECP. The 12-bit command word shall control the instrument configuration (including the motor stow mode (MOSTO) as described in paragraph 5.5.9) and the 7-bit command shall control the rate/status data readout. The FDS shall send the 12-bit LECP configuration command every 48 seconds. Rate commands shall be supplied as a function of data mode.

5.5.3 Bi-Level Commands

The FDS shall supply a bi-level command to select the appropriate set of redundant interface lines.

5.5.4 Special Frequencies

The FDS shall supply a continuous 201.6 kHz clock which is used for internal instrument timing and PHA digitizing.

5.5.5 Interface Redundancy

The FDS shall provide redundancy for those LECP functions as specified in MJS77-3-110 to complement existing instrument redundancy. Redundant functions shall be selected as a set by the FDS upon receipt of a ground command.

5.5.6 FDS LECP I/O Logic Redundancy

The FDS shall provide redundant LECP I/O logic which is selectable by ground command.

5.5.7 LECP Data Acquisition

LECP data acquisition shall be controlled by the frequency at which the FDS issues PHA and RATE/STATUS word gates. The FDS shall issue these word gates so as to generate LECP data as specified in Table 27.

5.5.8 LECP Encounter Data Modes

The FDS shall provide two data modes for the LECP during the encounter phase - one for far encounter and one for near encounter (~E ±3 days). In both modes the LECP data rate shall be 600 bps. In the far encounter mode the proportion of RATE/STATUS to PHA data shall be 400 and 200 bps respectively. During the near encounter mode the entire 600 bps shall be devoted to RATE/STATUS data. Selection between the far encounter and near encounter modes shall be by ground command.

The readout structure for both the far encounter and near encounter modes shall be as shown on Figure 12.

The RATE/STATUS sample order for far encounter shall be as shown on Figure 13. PHA sampling is not shown but shall occur at the times indicated on Figure 12. Near encounter sampling shall be as shown on Figure 14. The numbers refer to specific groups of LECP rate channels.

5.5.9 Loss of Sun Algorithm

The CCS, upon receiving the loss of sun gate signal from the AACS, shall send the appropriate commands to the FDS to modify the LECP configuration command. The command shall be modified so as to rotate the LECP into the parking position which places the 0 deg end of the LEPT behind the sunshade.

5.6 Photopolarimeter Subsystem (PPS)

5.6.1 Serial Command

The FDS shall provide a 12 bit serial command to control all instrument operating modes. This command shall control the following functions:

a) Filter wheel position

b) Polarization analyzer wheel position

c) Aperture wheel position

d) High voltage switch

e) J mode initiate

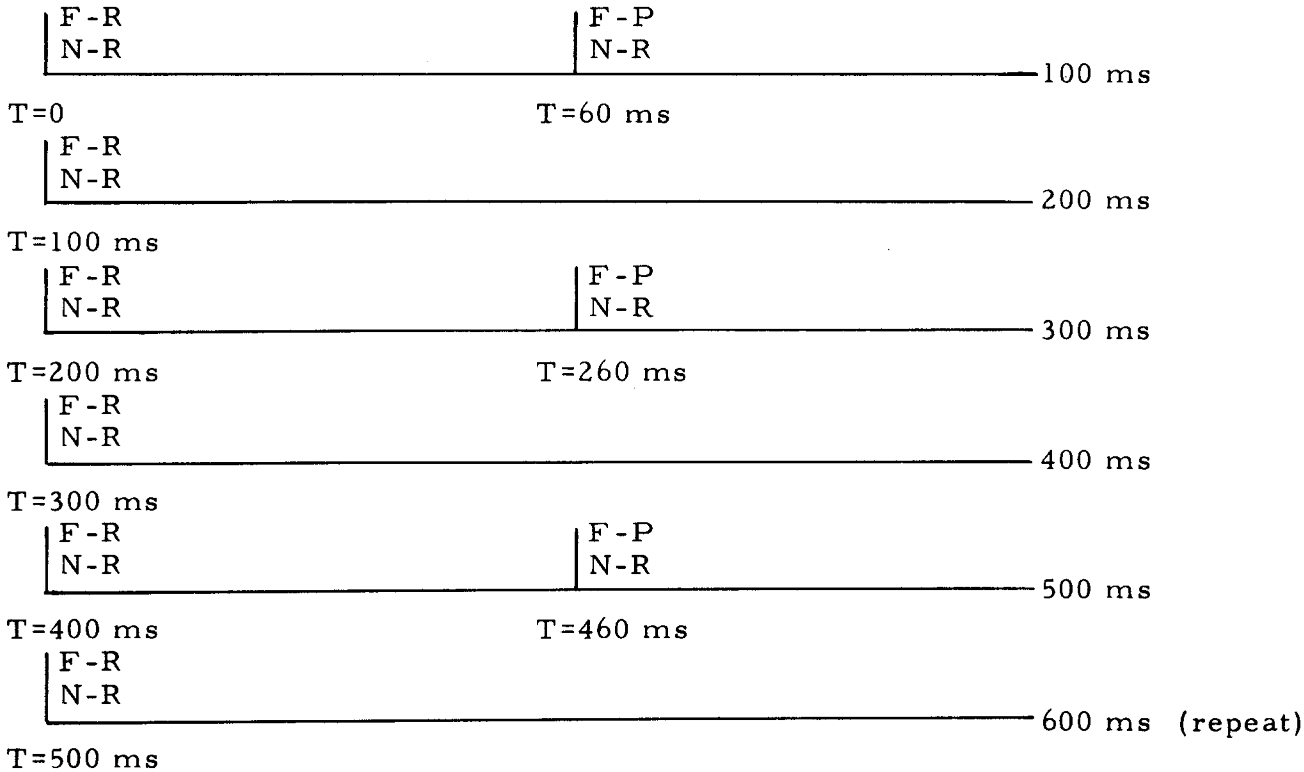
f) Sun sensor inhibit

g) High voltage control override

Table 27. LECP Data Acquisition Schedule

Cruise Mode	LECP Allocation (bps)	PHA Data (bps)	RATE/STATUS Data (bps
CR-1	128*		
CR-2	64*		
CR-3	64*		
CR-4	32*		
CR-5	16-2/3*		
CR-6	16-2/3	11-1/9	5-5/9
CR-7	Formats and allocations will not be developed until extended mission approval is given.		
CR-8			
CR-9			
All Encounter Modes	600	200 (Far Enc)	400 (Far Enc)
	600	0 (Near Enc)	600 (Near Enc)

*Allocations shown are only representative. Final rates and allocations are TBD.



F = Far Encounter Mode

N = Near Encounter Mode

R = Rate Data

P = PHA Data

Figure 12. LECP Encounter Mode Readout Structure

T=0 T=1.2 s

1	2	3	4	1	2	7	5	1	2	3	6
1	2	9	4	1	2	3	5	1	2	11	6
1	2	3	4	1	2	8	5	1	2	3	6
1	2	10	4	1	2	3	5	1	2	12	6
1	2	3	4	1	2	7	5	1	2	3	6
1	2	9	4	1	2	3	5	1	2	13	6
1	2	3	4	1	2	8	5	1	2	3	6
1	2	10	4	1	2	3	5	1	2	14	6
1	2	3	4	1	2	7	5	1	2	3	6
1	2	9	4	1	2	3	5	1	2	15	6
1	2	3	4	1	2	8	5	1	2	3	6
1	2	10	4	1	2	3	5	1	2	11	6
1	2	3	4	1	2	7	5	1	2	3	6
1	2	9	4	1	2	3	5	1	2	12	6
1	2	3	4	1	2	8	5	1	2	3	6
1	2	10	4	1	2	3	5	1	2	13	6
1	2	3	4	1	2	7	5	1	2	3	6
1	2	9	4	1	2	3	5	1	2	16	6
1	2	3	4	1	2	8	5	1	2	3	6
1	2	10	4	1	2	3	5	1	2	17	6

T=24 s

Figure 13. LECP Far Encounter Format

T=0 T=1.2 s

1	2	3	4	5	6	1	2	3	4	7	9	1	2	3	4	15	17
1	2	3	4	5	6	1	2	3	4	7	9	1	2	3	4	15	17
1	2	3	4	5	6	1	2	3	4	7	9	1	2	3	4	15	17
1	2	3	4	5	6	1	2	3	4	7	9	1	2	3	4	15	17
1	2	3	4	5	6	1	2	3	4	7	9	1	2	3	4	15	17
1	2	3	4	5	6	1	2	3	4	7	9	1	2	3	4	15	17
1	2	3	4	5	6	1	2	3	4	7	9	1	2	3	4	15	17
1	2	3	4	5	6	1	2	3	4	7	9	1	2	3	4	15	17
1	2	3	4	5	6	1	2	3	4	7	9	1	2	3	4	15	17
18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18

T=12 s

Figure 14. LECP Near Encounter Format

5.6.2 PPS Data Acquisition

PPS data acquisition shall be controlled by the PPS Data/Count Control signal supplied by the FDS. When this signal is low, the PPS is accumulating counts. When the signal goes high, the PPS shall load 30 bits of data into its output register with the next occurrence of the shift clock. The data shall be transferred to the FDS with the following 30 shift clock pulses. PPS data shall be acquired at the rates shown in Tables 2 and 6.

5.6.3 Data Compression Algorithm

PPS data presented to the FDS shall consist of a 20 bit science data word followed by 10 bits of status data. The FDS shall compress all PPS 20-bit science data words into 14 bits; a 4-bit exponent (A) and a 10-bit mantissa (B). When compressed PPS data is inserted into the telemetry stream, the exponent (A) shall precede the mantissa (B). In performing this compression algorithm, the FDS shall:

a) Count the number of leading "zeros" (LZ) until a "one" is found in the uncompressed word.

b) Set A = 10-LZ but never less than zero.

c) If A = 0, transmit the 10 LSBs of the uncompressed word as B.

d) If A $\neq$ 0, transmit the 10 MSBs following the MSB equal to one of the uncompressed word as B.

5.6.4 Data Modes

The PPS shall operate in one of three data modes as a function of mission phase: Cruise, Encounter, and Special Occultation.

5.6.4.1 Encounter Mode Operation. The encounter mode shall consist of stepping, by FDS command, 5 analyzer wheel positions for each of 8 filter wheel positions. In addition it shall be possible to hold the filter wheel in any position while cycling the analyzer wheel, or to hold any of these combinations throughout the data frame. The data frame comprises 40 measurements of 600 ms. each. Each measurement shall consist of 400 ms. of count accumulation and 200 ms. of wheel positioning.

5.6.4.2 Cruise Mode Operation. The cruise mode shall consist of stepping, by FDS command, the analyzer wheel and filter wheel as in the encounter mode. In addition, it shall be possible to execute fixed operations where, by command, any one of the combinations can be held fixed. The frame time shall vary in accordance with the different cruise data rates.

5.6.4.3 Special Occultation Mode Operation. The special occultation mode shall consist of maintaining a fixed configuration (changeable by command from occultation to occultation). In this mode every 600 ms. the FDS shall transmit:

a) One complete 24 bit sample (a 4-bit exponent, 10 bit mantissa, and 10 bits of status) and

b) 59 10 bit log compressed samples where each sample is comprised of the 3 LSBs of the exponent and the 7 MSBs of the mantissa.

5.7 Plasma Subsystem (PLS)

5.7.1 Discrete Commands

The FDS shall provide two discrete pulse commands to accommodate the following PLS functions:

a) Stepping the PLS analog monitor multiplexer

b) Resetting the PLS analog monitor multiplexer to a known position.

5.7.2 Serial Command

The FDS shall supply a 12 bit serial command (only the 8 LSB's are used) to control PLS instrument parameters and sequencing including the in-flight calibration sequence.

5.7.3 Special Frequencies

The FDS shall provide two special frequencies to control the following PLS functions:

a) A continuous 230.4 kHz clock used by the PLS for digitization of analog signals and internal timing.

b) A continuous squarewave which defines the PLS integration time for the normal (0.24 s) and fast (0.06 s) sequences.

5.7.4 Data Acquisition

PLS data acquisition shall be controlled by the frequency at which the FDS issues the PLS data word gate. Each occurrence of the word gate shall cause the transfer of a 16 bit data word into the FDS. The PLS data acquisition rate, as a function of telemetry mode, shall be as specified in Tables 2 and 6.

5.7.5 Data Words

Each PLS data word shall be 16 bits long and represent an 8-bit logarithmic compression of the amplitude of a measurement chain output and 8 bits of status. The instrument shall transmit to the FDS, one word for each of three main detector channels and one lateral detector channel for each energy level in each mode. The number or words per mode shall be as follows:

a) L Mode: 16 measurements — 64 data words/cycle

b) M Mode: 128 measurements — 512 data words/cycle

c) E_1 Mode: 16 measurements — 64 data words/cycle

d) E_2 Mode: 16 measurements — 64 data words/cycle

5.7.6 Data Modes

The PLS shall operate in four data modes - L, M, E_1, and E_2. Data mode selection shall be via the two MSB's of the 8 bit serial command word.

5.7.7 Data Mode Sequencing

The FDS shall send commands and sample clock pulses to achieve a data cycle containing the following elements:

Normal Cruise Sequence

a) L Mode (Main and Lateral Detector) 16 Positive Ion Levels/Collector

b) M Mode (Main Detector) 128 Positive Ion Levels/Collector

c) E_1 Mode (Lateral Detector) 16 Electron Levels

d) E_2 Mode (Lateral Detector) 16 Electron Levels with option for either 2 E_1 or 2 E_2 Modes.

Fast Cruise Sequence

a) M Mode (Main Detector) 128 Positive Ion Levels/Collector

b) E_1 Mode (Lateral Detector) 16 Electron Levels

Encounter Sequence

a) L Mode (Main and Lateral Detector) 16 Positive Ion Levels/ Collector

b) M Mode (Main and Lateral Detector) 128 Positive Ion Levels/ Collector

c) E_1 Mode (Lateral Detector) 16 Electron Levels

d) E_2 Mode (Lateral Detector) 16 Electron Levels

5.7.7 Data Processing

The FDS processing of PLS data shall be as follows:

Fast Cruise Sequence

All of the lateral detector E mode data and alternately the first and last 96 samples of each main detector output in the M mode shall be transmitted.

Normal Cruise Sequence

All of the L mode data, all lateral detector E mode data and alternately, the first and last 96 samples of each main detector output in the M mode shall be transmitted.

Encounter Sequence

All of the L mode data, all lateral detector E mode data and alternately the first and last 72 samples for all four detector channels in the M mode shall be transmitted.

5.8 Ultraviolet Spectrometer Subsystem (UVS)

5.8.1 Discrete Command

The FDS shall provide one discrete pulse command which occurs twice each 96 s and resets word selection to words 1 and 2 (odd and even).

5.8.2 Bi-Level Control Commands

The FDS shall supply four (4) bi-level control lines to the UVS to control instrument operating modes. Three lines shall be used to set the UVS high voltage. The fourth line shall be used to select between the pulse counting mode and the pulse integration mode. A "0" shall command the pulse integration mode whereas a "1" shall command the pulse counting mode.

5.8.3 Data Acquisition

UVS data acquisition shall be controlled by the UVS Register Load Gate signal supplied by the FDS. This signal shall command the UVS to load its two 16-bit output registers with the next pair of words. These two 16-bit words shall be simultaneously transferred to the FDS by the next 16 shift clocks following the end of the Register Load Gate signal. UVS data shall be acquired at the rates and in the modes shown in Table 28.

5.8.4 Data Compression Algorithm

UVS data presented to the FDS shall consist of 16 bit words. The FDS shall compress all 16 bit words into 10 bits; a 4-bit exponent (A) and a 6-bit mantissa (B). When compressed UVS data is inserted into the telemetry stream, the exponent (A) shall precede the mantissa (B). In performing this compression algorithm, the FDS shall:

a) Count the number of leading "zeros" (LZ) until a "one" is found in the uncompressed word.

b) Set $A = 10 - LZ$ but never less than zero.

c) If $A = 0$, transmit the 6 LSB's of the uncompressed word as B.

d) If $A \neq 0$, transmit the 6 MSB's following the MSB equal to "one" as B.

5.8.5 Data Modes

The UVS shall operate in one of two data modes as a function of mission phase. The pulse integration mode shall be used during encounter and solar occultations whereas the pulse counting mode shall be used during cruise.

5.8.6 Data Buffering

When the UVS allocation is less than 64 bps, the FDS shall extract the full 128 measurement spectrum in less than 20 s and buffer the data as necessary.

5.8.7 UVS Load Gate Inhibit

During cruise periods when a given spacecraft is not being tracked it shall be possible to inhibit the UVS load gate and thus allow spectra accumulation over this interval. Implementation details regarding this function are TBD.

Table 28. UVS Data Acquisition Schedule

Cruise Mode	UVS Allocation (bps)	UVS Data Mode
CR-1	48*	Pulse Counting
CR-2	48*	Pulse Counting
CR-3	24*	Pulse Counting
CR-4	6*	Pulse Counting
CR-5	3*	Pulse Counting
CR-6	2-2/9	Pulse Counting
CR-7	Formats and allocations will not be developed until extended mission approval is given.	
CR-8		
CR-9		
All Encounter Modes except Special Occultation	333-1/3	Pulse Integration
Special Occultation	4000	Pulse Integration

*

5.9 Magnetometer Subsystem (MAG)

5.9.1 Discrete Commands

The FDS shall provide 4 discrete pulse commands to accommodate the following MAG functions:

a) SAMPLE which initiates an analog to digital conversion of the selected magnetometer and loads the resultant data (72 bits) into the MAG output registers.

b) RESET which loads MAG status data (24 bits) into the MAG status data output register and defines the time when automatic gain change occurs.

c) Stepping the analog multiplexer.

d) Resetting the analog multiplexer to a known position.

5.9.2 Serial Commands

The FDS shall supply the MAG with two 12-bit serial command words. The first command sent shall control the inboard sensors and associated electronics whereas the second word shall control the outboard sensors and associated electronics.

5.9.3 Special Frequencies

The FDS shall provide the MAG with four special frequencies. Each frequency shall be used to generate MAG sensor drive frequencies. The special frequencies shall be:

a) 50.4 kHz

b) 53.76 kHz

c) 60.48 kHz

d) 64.512 kHz

5.9.4 Interface Redundancy

The FDS shall provide redundancy for those MAG functions as specified in MJS77-3-110 to complement existing instrument redundancy. Redundant functions in the FDS shall be selected as a set by the FDS upon receipt of a ground command. Redundant functions in the MAG are selected by the choice of the MAG power supply.

5.9.5 Data Acquisition

MAG data acquisition shall be controlled by the FDS. Only low field magnetometer (LFM) data shall be acquired during cruise whereas both LFM and high field magnetometer (HFM) data shall be acquired during encounter. The data acquisition rate as a function of telemetry mode shall be as shown in Table 29.

Table 29. MAG Data Acquisition Schedule

Cruise Mode	MAG Allocation (bps)	HFM (bps)	LFM (bps)	Primary Sensor (bps)	Secondary Sensor (bps)	LFM Data Processing Mode
CR-1*	1200	0	1200	600	600	Straight Averaging
CR-2*	450	0	450	300	150	Straight Averaging
CR-3*	187.5	0	187.5	150	37.5	Straight Averaging
CR-4*	93.75	0	93.75	82.5	11.25	6-Bit Differencing
CR-5*	46.875	0	46.875	29.6875	17.1875	Delta Modulation
CR-6	5.9375	0	5.9375	3.75	2.1875	Delta Modulation
CR-7	Formats and allocations will not be developed until extended mission approval is given.					
CR-8						
CR-9						
All Encounter Modes	750	120	630	420 (LFM) 60 (OB HFM)	210 (LFM) 60 (IB HFM)	6-Bit Differencing

*Values shown are typical. Exact values must await FDS cruise mode program coding.

5.9.6 Data Processing

The FDS shall provide three types of data processing for MAG LFM data depending on the telemetry mode in effect. These are straight averaging, 6-bit differencing, and delta modulation. The form of data processing in use for each telemetry mode shall be as specified in Table 29.

5.9.6.1 LFM Straight Averaging Mode. In this mode 12-bit samples from the outboard LFM and 12-bit samples from the inboard LFM shall be averaged by the FDS and the resultant averages inserted into the output data stream. There shall be N_p and N_s points per average for the primary and secondary MAGS (p and s), respectively, as shown in Table 30.

Table 30. FDS LFM Data Processing

Cruise Mode	LFM Full 12 Bit Words				
	N_p	N_s	N_s/N_p		
CR-1*	1	1	1		
CR-2*	2	4	2		
CR-3*	4	16	4		
	LFM 6 Bit Differencing Words			LFM Full 12 Bit Words	
	N_p	N_s	N_s/N_p	K_p	K_s
CR-4*	4	40	10	20	4
	LFM 2 Bit DM Words			LFM Full 12 Bit Words	
	N_p	N_s	N_s/N_p	K_p	K_s
CR-5*	4	8	2	32	16
CR-6	30	60	2	30	15
	LFM 6 Bit Differencing Words			LFM Full 12 Bit Words	
	N_p	N_s	N_s/N_p	K_p	K_s
All Encounter Modes	1	2	2	5	5

5.9.6.2 LFM 6-Bit Differencing Mode. In this mode 6-bit differences of averages and less frequent full 12-bit averages shall be produced by the FDS and inserted into the output data stream. The 6-bit differences of averages which are inserted into the data stream shall be the 6 LSB's of the full 12-bit average. The number of points per average shall be as shown by N_p and N_s and the ratio of the number of 6-bit to full words shall be as shown by K_p and K_s in Table 30.

*Values shown are typical. Exact values must await FDS cruise mode program coding.

5.9.6.3 LFM Delta Modulation Mode. This mode is analagous to the 6-bit differencing mode except that the 6-bit difference of averages shall be replaced with 2-bit delta modulation (DM) of averages. The number of points per average shall be as specified by N_p and N_s, and the ratio of the number of 2-bit DM words to full 12-bit words shall be as specified by K_p and K_s in Table 30.

5.10 Imaging Science Subsystem (ISS)

5.10.1 Separate Camera Operation

The FDS shall supply separate and independent timing and control functions for the WA and NA cameras.

5.10.2 Discrete Commands

The FDS shall supply discrete pulse commands to accommodate the following ISS functions:

a) Opening the camera's shutter

b) Closing the camera's shutter

c) Resetting both shutter blades to the unshuttered position

d) Initiating light flooding

e) Initiating the analog-to-digital conversion process

f) Stepping the filter wheel

g) Stepping the engineering analog multiplexer

h) Resetting the analog multiplexer to a known position

5.10.3 Serial Command

The FDS shall provide a four bit serial command of which three bits are used to set the G1 vidicon voltage and one bit is used to determine the camera's gain state.

5.10.4 Bi-Level Commands

The FDS shall supply bi-level commands to accommodate the following ISS functions:

a) Defining which camera is being read out and erased

b) Controlling the vertical sweep during the erase cycle

c) Controlling the horizontal sweep

d) Controlling the status of the beam

e) Controlling the electronics calibrate mode

f) Controlling the optics calibrate mode (NA only)

5.10.5 Special Frequencies

The FDS shall provide a continuous 172.8 kHz clock used to provide bit sync for video analog-to-digital conversion.

5.10.6 Filter Wheel Operation

The FDS shall independently control the WA and NA filter wheels by ground command or via stored sequences in FDS memory. It shall be possible to advance either the WA or NA filter wheel from 0 to 4 steps during the corresponding prepare cycle.

5.10.7 Exposure Control

5.10.7.1 Shutter Operation. The FDS shall control the ISS shutters based upon ground commands or stored sequences. The length of these stored sequences shall be long enough to fill the tape recorder. The exposure time and mode (fixed or automatic), with the exception of the simultaneous exposure mode, may be selected independently for each camera. The FDS shall be able to store sequences of shutter commands involving the fixed mode and the automatic exposure mode.

5.10.7.2 Fixed Mode. In the fixed mode, the FDS shall be capable of commanding any of the exposure times listed in Table 31.

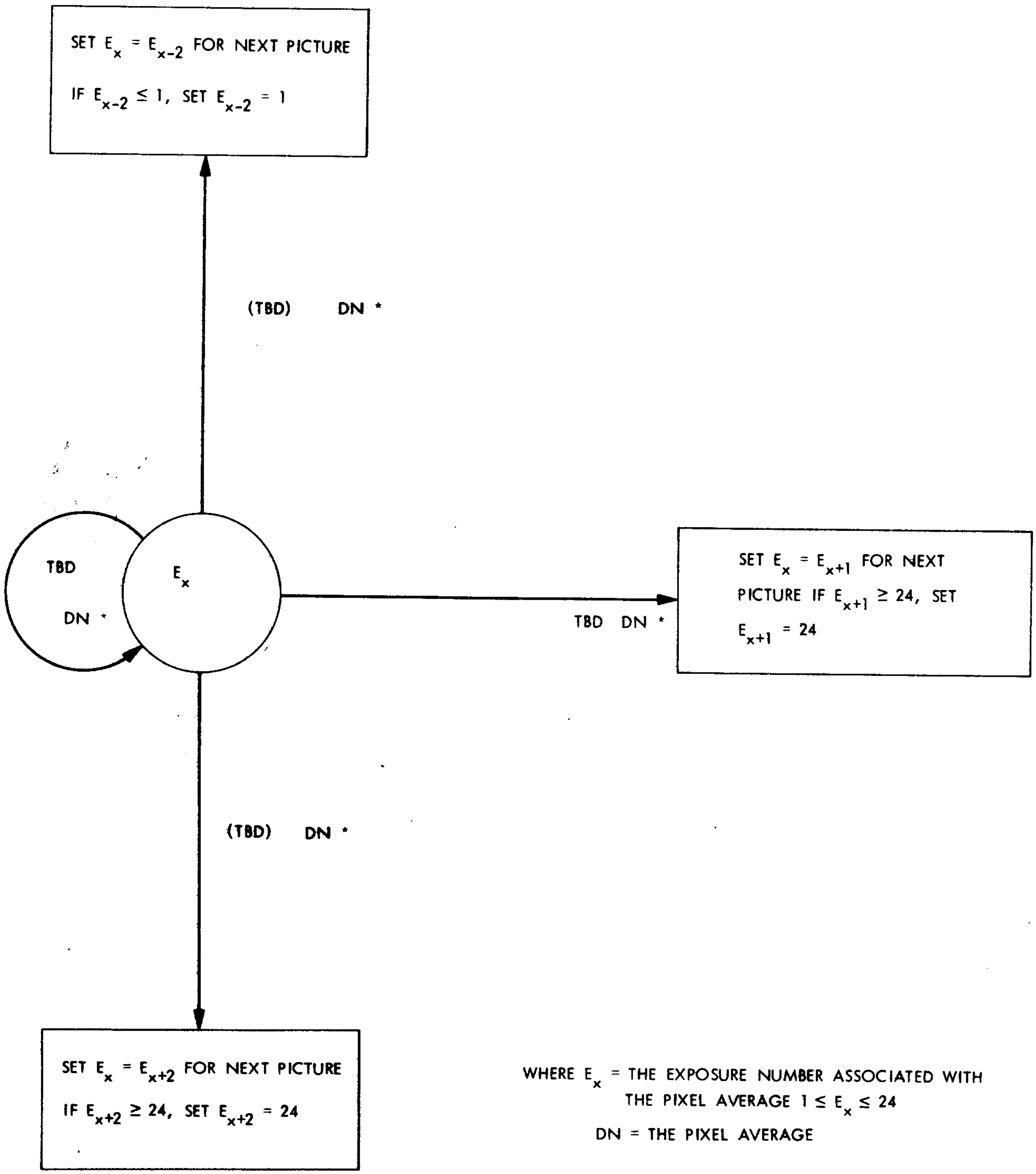
5.10.7.3 Automatic Mode. In the automatic mode, the FDS, in response to a ground command or stored sequence, shall set the exposure of the first picture of the automatic exposure sequence to the exposure time indicated by the command. When the picture is read out, the FDS shall perform an average of all pixels that exceed TBD DN. The pixel average shall be computed for each camera independently. If the number of pixels averaged exceeds TBD, the FDS shall use the pixel average according to the appropriate algorithm shown on Figures 15 and 16. If the number of pixels averaged does not exceed TBD, the exposure shall not change. As long as the system remains in the automatic mode, the FDS shall continue to use the pixel average of the preceding picture of that camera, according to the appropriate algorithm. In addition, the FDS shall automatically modify the calculated exposure to account for a change in filter-wheel position according to the following equation:

$$Em = fj - Fi + Ei$$

Table 31. ISS Exposure Intervals

Exposure Number (Ex)	Exposure Time* (E) (ms)	Exposure Number (Ex)	Exposure Time* (E) (ms)
1	5	13	360
2	7.5	14	480
3	12.5	15	720
4	15	16	960
5	22.5	17	1,440
6	30	18	1,920
7	45	19	2,880
8	60	20	3,840
9	90	21	5,760
10	120	22	7,680
11	180	23	11,520
12	240	24	15,360

*Commanded Exposure Times can be found by adding 2.014 ms to the value of E above.



NOTE: * THESE VALUES ARE TYPICAL AND ARE ADJUSTABLE DURING FLIGHT

Figure 15. Wide Angle Camera Auto Exposure Algorithm

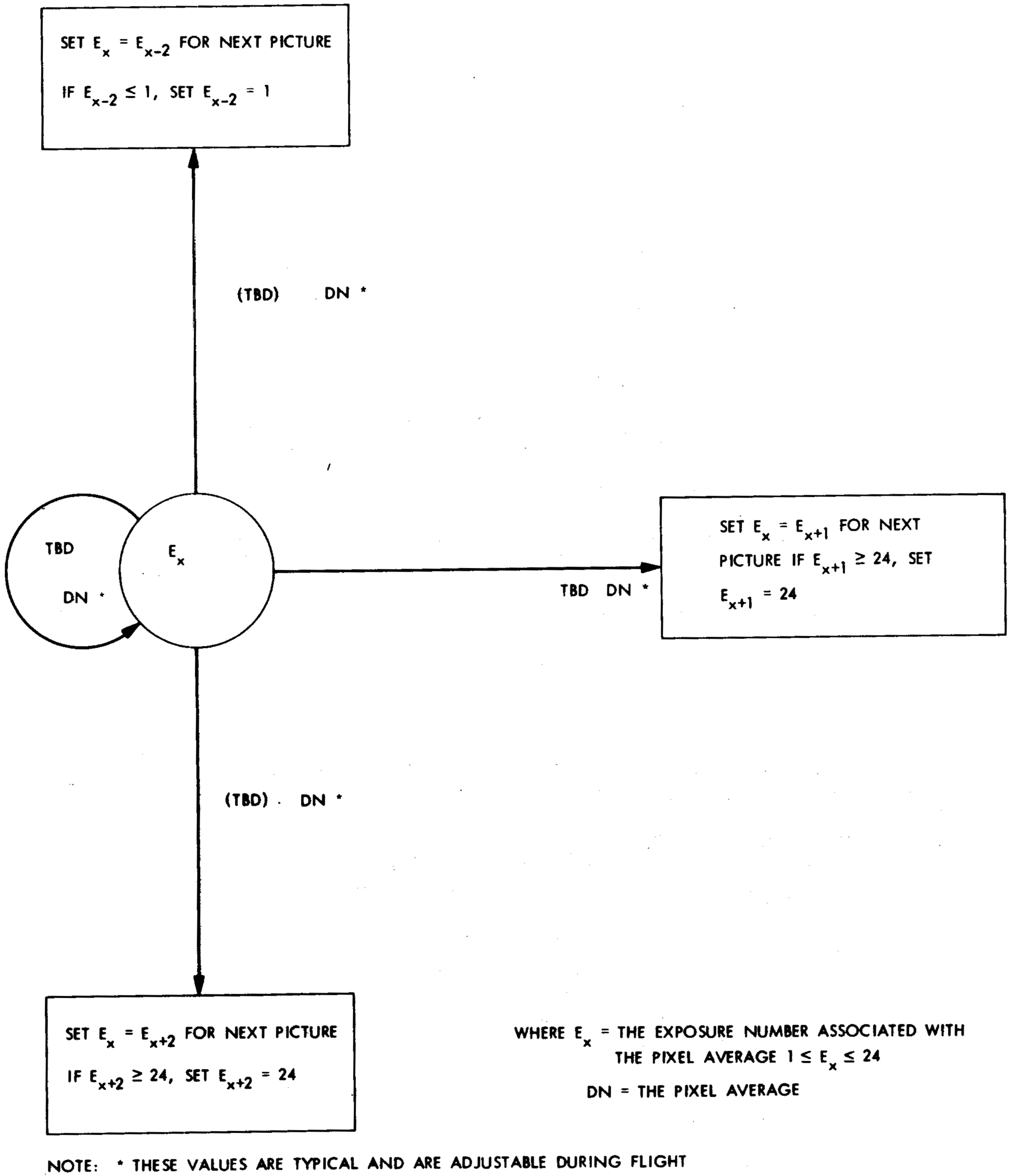


Figure 16. Narrow Angle Camera Auto Exposure Alogrithm

Where

Em = the modified exposure number for the next picture

Ei = the calculated exposure number associated with a filter position Fi

fi = the filter number associated with filter position Fi

fj = the filter number associated with the filter position of the next picture

$1 \leq Em \leq 24$
$1 \leq Ei \leq 24$
See Table 31 for exposure time (E) and exposure number (Ex)

$1 \leq fi \leq 24$
$1 \leq fj \leq 24$
$1 \leq Fi \leq 8$
See Tables 32 and 33 for filter positions (F) and filter number (fx)

The FDS shall be capable of modifying the values of fx during flight.

5.10.7.4 Long Exposure Mode. Long Exposures are defined as discrete exposure times which may be found from the following formula:

Exposure Time (seconds) = N(96) + 0.240

where N is an integer >0.

The FDS shall be capable of applying long exposure to either camera independently. The frame time for long exposure shall be 48 s.

5.10.7.5 Simultaneous Exposure Mode. The FDS shall be capable of shuttering the WA and NA cameras simultaneously. The following constraints apply when the simultaneous exposure mode is used:

a) For each adjacent simultaneous exposure pair with a 48 s frame time, a period of 48 s will exist during which no imaging data can be transmitted. For each adjacent simultaneous exposure pair at other slow scan rates, a period of 96 s will exist during which no imaging data can be transmitted.

b) The WA image must be stored on the vidicon for one ISS read-frame time.

c) The exposure of the two cameras will end simultaneously.

Table 32. Wide Angle Camera Filter Assignments

Position (F)	Filter Number (fx)	Filter
1		
2		
3		
4	TBD	
5		
6		
7		
8		

Table 33. Narrow Angle Camera Filter Assignments

Position (F)	Filter Number (fx)	Filter
1		
2		
3		
4	TBD	
5		
6		
7		
8		

5.10.7.6 Light Flooding. The FDS shall have the capability by ground command or from a stored sequence* to enable or disable the light-flooding lamps.

5.10.7.7 Partial Light Flood Mode. In this mode the FDS shall pulse the optics calibration lamps while the shutter is open. The fixed pulse interval employed shall be selected from the set specified in paragraph 5.10.8.1.2 of this document to produce a background video intensity level approximately 10 percent of saturation. The exposure interval shall be selected for each picture from the set listed in paragraph 5.10.8.1.1 of this document.

5.10.8 In-Flight Calibration

5.10.8.1 Optical Calibration. The FDS shall control the ISS NA optical calibration function. This function may be initiated by ground command or via a stored sequence.

5.10.8.1.1 Mode 1 - Calibration With Shutters. In this mode the FDS shall turn on the NA calibration lamps and expose eight frames through eight sequentially increasing shutter-controlled intervals. The shutter intervals shall be:

a) 120 ms**

b) 360 ms**

c) 720 ms**

d) 1440 ms**

e) 1920 ms**

f) 2880 ms**

g) 5760 ms**

h) 15360 ms

The frame time associated with this mode shall be 48 s.

*Requirement may need to be negotiated pending analysis of FDS software impact.

**These numbers are typical, actual value TBD.

5.10.8.1.2 Mode 2 - Calibration Without Shutters. In this mode the FDS shall leave the shutter open while pulsing the NA calibration lamps for eight frames through eight sequential time intervals. The lamp intervals shall be:

a) 120 ms*

b) 360 ms*

c) 720 ms*

d) 1440 ms*

e) 1920 ms*

f) 2880 ms*

g) 5760 ms*

h) 15360 ms

The frame time associated with this mode shall be 48 s.

5.10.8.2 Electronic Calibration. The FDS on ground command or from a stored sequence shall initiate an electronic signal to test the ISS signal chain. This signal shall last two ISS 48 s frame times synchronous with a read-frame start.

5.10.9 Beam Current On/Off Control

The FDS shall have the capability to independently switch the vidicon beam currents on and off by ground command or from a stored sequence. This function shall be arranged so that the most probable failure mode will result in a vidicon beam on condition.

5.10.10 Data Processing

The FDS shall provide both initiation and bit synchronization control for the ISS eight bit video analog-to-digital conversion process. The FDS shall process the imaging data such that it may be:

a) Recorded as full-frame data (WA and/or NA).

b) Transmitted in real-time using frame times of 48s, 96s, 144s, 240s, or 480s (NA and/or WA).

c) Transmitted and recorded in real-time (WA and/or NA).

d) Transmitted edited in real-time (WA and/or NA).

e) Transmitted after recording.

*These numbers are typical, actual values will be selected to match the numbers in Mode 1.

5.10.11 Data Modes

In order to transmit real-time video data during normal operations at each encounter, the FDS shall have the capability to provide the following data modes. Specifically which modes will be implemented via software shall be a function of priorities generated as a result of mission planning activities and resources available for FDS software development. Current priorities for imaging data mode development are specified in MJS77-3-310. The time T_F is that time required to read out a single imaging frame.

5.10.11.1 Full-Frame, Full Resolution, T_F = 48 Seconds. In this mode each pixel of each line shall be read out and inserted into the data stream either for real-time transmission or storage in the DSS. The option shall exist to concurrently record and transmit this data. Four types of camera operation shall be possible while operating in this mode. They are:

a) Alternate camera.

b) Simultaneous exposure.

c) Single camera (NA or WA).

d) Long exposure.

5.10.11.2 Full-Frame, Full-Resolution, T_F = 96 Seconds (2:1 Slow Scan). This mode is identical to that described in paragraph 5.10.11.1 except that the frame readout time increases to 96 s. This mode shall be used for real-time transmission only. Three types of camera operation shall be possible while operating in this mode. They are:

a) Alternate camera.

b) Simultaneous exposure.

c) Single camera (NA or WA).

5.10.11.3 Full-Frame, Full-Resolution, T_F = 144 Seconds (3:1 Slow Scan). This mode is identical to that described in paragraph 5.10.11.1 except that the frame readout time increases to 144 s. This mode shall be used for real-time transmission only. Three types of camera operation shall be possible while operating in this mode. They are:

a) Alternate camera.

b) Assymetric simultaneous exposure.

c) Assymetric single camera (NA or WA).

5.10.11.4 Full-Frame, Full-Resolution, T_F = 240 Seconds (5:1 Slow Scan). This mode is identical to that described in paragraph 5.10.11.1 except that the frame readout time increases to 240 s. This mode shall be used for real-time transmission only. Three types of camera operation shall be possible when operating in this mode. They are:

a) Alternate camera.

b) Assymetric simultaneous exposure.

c) Assymetric single camera (NA or WA).

5.10.11.5 Full-Frame, Full-Resolution, T_F = 480 Seconds (10:1 Slow Scan). This mode is identical to that described in paragraph 5.10.11.1 except that the frame readout time increases to 480 s. This mode shall be used for real-time transmission only. Three types of camera operation shall be possible when operating in this mode. They are:

a) Alternate camera.

b) Assymetric simultaneous exposure.

c) Assymetric single camera (NA or WA).

5.10.11.6 3/4-Frame Edit, T_F = 48 Seconds. In this mode the central 75 percent of each line (pixels TBD through TBD) shall be transmitted in real-time. The method of editing shall be as shown schematically on Figure 17. Three types of camera operation shall be possible while operating in this mode. They are:

a) Alternate camera.

b) Simultaneous exposure.

c) Single camera (NA or WA).

5.10.11.7 1/2 - Frame Edit, T_F = 48 Seconds. In this mode the central 50% of each line (pixels TBD through TBD) shall be transmitted in real time. The method of editing shall be as shown schematically on Figure 17. Three types of camera operation shall be possible while operating in this mode. They are:

a) Alternate camera.

b) Simultaneous exposure.

c) Single camera (NA or WA).

5.10.11.8 <u>1/3-Frame Edit, T_F = 48 Seconds.</u> In this mode the central 33-1/3 percent of each line (pixels 265 through 536) shall be transmitted in real-time. The method of editing shall be as shown schematically on Figure 17. Three types of camera operations shall be possible when operating in this mode. They are:

a) Alternate camera.

b) Simultaneous exposure.

c) Single camera (NA or WA).

5.10.11.9 <u>1/5-Frame Edit, T_F = 48 Seconds.</u> In this mode the central 20 percent of each line (pixels TBD through TBD) shall be transmitted in real-time. The method of editing shall be as shown schematically on Figure 17. Three types of camera operation shall be possible when operating in this mode. They are:

a) Alternate camera.

b) Simultaneous exposure.

c) Single camera (NA or WA).

5.10.11.10 <u>3:1 Slow Scan, Edited to 29.9 Kbps, T_F = 144 Seconds.</u> In this mode the central portion of each line (pixels TBD through TBD) shall be transmitted in real time. The method of editing shall be as shown schematically in Figure 17. Three types of camera operation shall be possible when operating in this mode. They are:

a) Alternate camera.

b) Assymetric simultaneous exposure.

c) Assymetric single camera (NA or WA).

5.10.11.11 <u>5:1 Slow Scan, 2:1 Partial Frame Edit, T_F = 480 Seconds.</u> This mode employs a 5:1 Slow Scan as described in paragraph 5.10.11.4, however, only the central 50 percent of each line (pixels 201 to 600) are transmitted. Three types of camera operation shall be possible when operating in this mode. They are:

a) Alternate camera.

b) Assymetric simultaneous exposure.

c) Assymetric single camera (NA or WA).

5.10.11.12 <u>1/10-Frame Edit, T_F = 48 Seconds.</u> In this mode one fifth of the pixels, equally separated, of every other line shall be transmitted in real time. The pixels chosen in each transmitted line shall be offset as shown schematically in Figure 18.

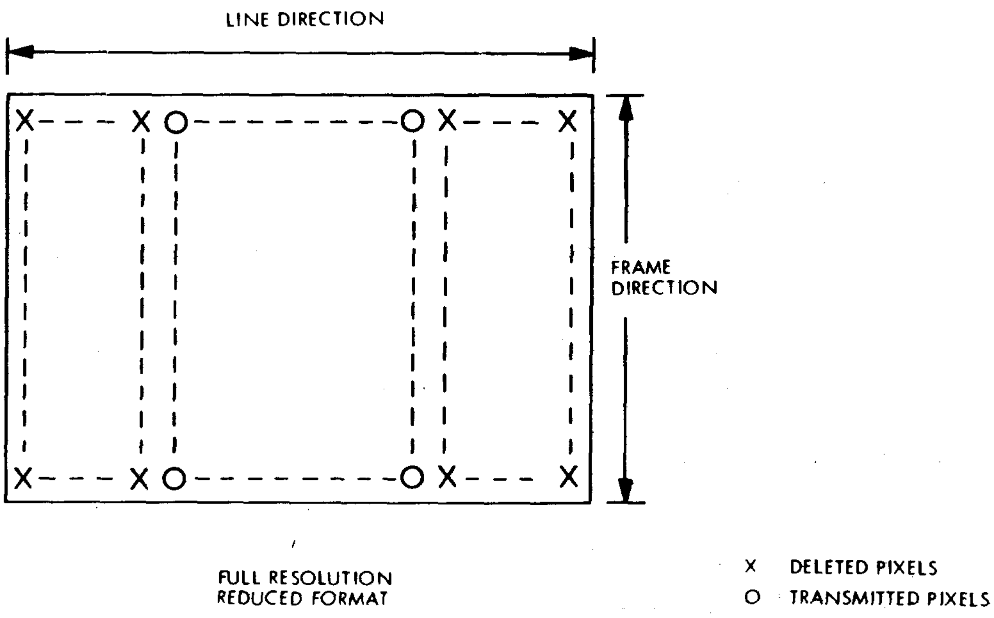


Figure 17. ISS Reduced Format Editing Option

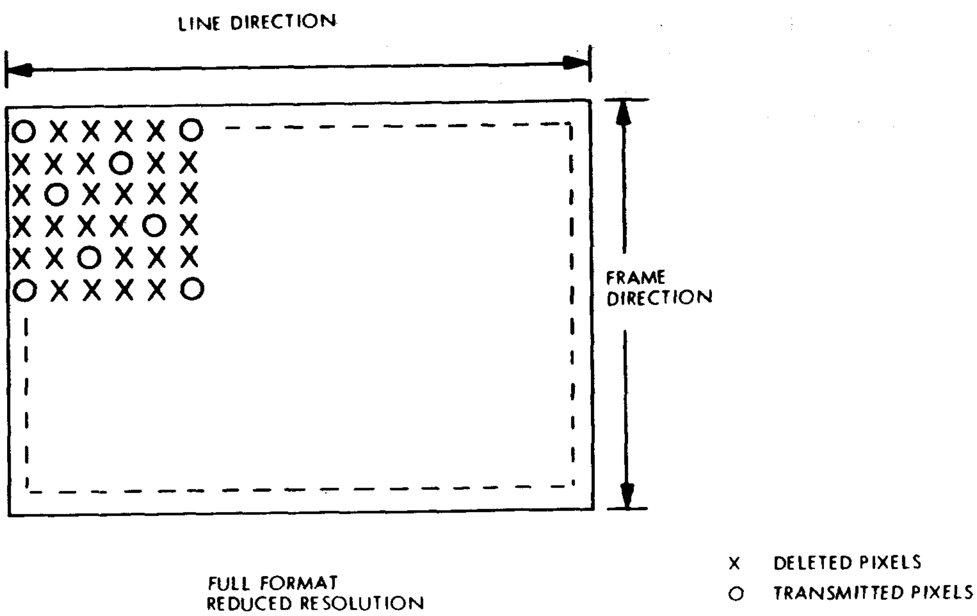


Figure 18. ISS Reduced Resolution Editing Option

5.11 Infrared Interferometer Spectrometer and Radiometer Subsystem (IRIS)

5.11.1 Discrete Command

The FDS shall supply a discrete pulse command to the IRIS every 48 s to initiate an IRIS scan.

5.11.2 Special Frequencies

The FDS shall provide the IRIS with the following special frequencies:

a) A continuous 403.2 kHz squarewave used for generating the carrier frequency of the single side-band modulator.

b) A continuous 480 Hz squarewave used as the neon reference frequency and to control the IRIS science data readout.

5.11.3 Data Acquisition

IRIS data acquisition shall be controlled by the relative timing between the IRIS frame start and the 480 Hz neon reference frequency. Fourteen-bit data words shall be transferred to the FDS following the third falling edge of the 480 Hz neon reference frequency after the IRIS frame start and every 6th falling edge thereafter.

5.11.4 Data Rate

The IRIS data rate shall be 1120 bps for all encounter modes except special occultation. In the special occultation mode, three 8-bit words (radiometer high gain analog, radiometer analog, and neon analog) shall be transmitted every .6 s (equivalent to a data rate of 40 bps). These measurements shall be sampled only every 6 s. however. These same measurements shall be sampled and included in all encounter modes as well.

FUNCTIONAL REQUIREMENT AMENDMENT

(Insert in 618-205, MJS77 Functional Requirements Book)

TITLE: FUNCTIONAL REQUIREMENT MARINER JUPITER/SATURN 1977 FLIGHT EQUIPMENT TELEMETRY MEASUREMENTS AND DATA FORMATS	**FR No.** MJS77- 3-280B **AMENDMENT No.** 3 **PAGE** 1 **OF** 1 **DATE:** 14 February 1979 **PER ECR No.** N/A

DESCRIPTION OF CHANGE:

A. This document has been removed from control and placed in a non-maintenance category.

B. Changes authorized by the following ECRs will not be incorporated into this document:

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36867
36997
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JET PROPULSION LABORATORY

INTEROFFICE MEMORANDUM

MJS: 2.154

February 24, 1976

TO: H.K. FREWING

FROM: D.R. JOHNSON

SUBJECT: ISS STATUS/ENGINEERING DATA FIELD

REFERENCE: IOM MJS: 2.147A, "UPDATE OF GS-1/GS-3 SUBCOM DEFINITIONS (REVISION A)", to H.K. FREWING from D.R. JOHNSON dated 2 December 1975.

This memo defines the 16 bit ISS STATUS/ENGINEERING data field that follows the 64 bit header in all imaging mode and GS-2 and GS-4. This is a 20 position subcom that will be output 40 times each 48 seconds (1 frame at 1:1 readout). The data is defined in terms of subcom position (1 thru 20) and bits (1 thru 16 where 1 is the most significant and first out). Subcom position 1 is output at LINES 1, 21, 41,.....781 and is followed in order by positions 2 thru 20.

<u>SUBCOM POS. 1</u>

BIT 1 CAMERA ID -- this is the camera presently being read out. "0" = WA (or simultaneous prepare), 1 = NA.

BITS 2-16 SHUTTERED PICTURE INDICATOR -- These bits will be "0s" when a picture has not been shuttered and "1s" when one has. Taking a "dark current picture" using parameter word A is considered a shuttered picture (all 1s for these bits).

<u>SUBCOM POS. 2</u>

BITS 1-16 SLOWS SCAN STATUS -- This word is TBD but is included here in order to enable the same processing to be used by all imaging modes. Most likely it will be an indication of the actual line being read out since the LINE COUNT part of SPACECRAFT TIME will continue to increment every 60ms for all data modes.

<u>SUBCOM POS. 3</u>

BITS 1-5 SPARES (zeros)

BIT 6 NA ELECTRONICS CAL STATUS -- This bit is a "1" when the electronics cal signal is ON and "0" when OFF.

BIT 7 — WA ELECTRONICS CAL STATUS -- This bit is a "1" when the electronics cal signal is ON and "0" when OFF.

BITS 8-12 — ACTUAL EXPOSURE TIME -- This word contains a 5 bit exposure number that represents the exposure time used for the picture being read out. Bit 8 is the MSB. MJS77-3-270 gives the exposure time versus exposure number crossreference. This word does not indicate that the picture being output was part of a long exposure.

BITS 13-16 — ACTUAL FILTER POSITION -- This word represents the filter wheel position for the picture being read out. Bits 13-15 are the 3-bit position (bit 13 is the MSB) and bit 16 is an odd parity bit.

POSITION	BITS 13	14	15	16
0	0	0	0	1
1	0	0	1	0
2	0	1	0	0
3	0	1	1	1
4	1	0	0	0
5	1	0	1	1
6	1	1	0	1
7	1	1	1	0

SUBCOM POS. 4

BITS 1-16 — PICTURE COUNT -- This word is incremented once for each "shuttered picture" (includes dark current pictures using parameter word A). It is reset only by command from CCS. The initial load state of the program will be "0".

SUBCOM POS. 5

PARAMETER WORD A present value

BITS 1-3 — MODE FIELD (bit 1 is the MSB)

001	NOSHUT
010	NAONLY
011	WAONLY
100	BOTALT
101	BOTSIM
110	BODARK (new mode)
111	NOSHUT (default)
000	NOSHUT (default)

BITS 4-8 — USE COUNT present value (bit 4 is the MSB)

BITS 9-16 These bits have 2 possible meanings. If all "0s," then the present parameter A word (bits 1-8) was stored in the right hand half (the least significant) of an FDS memory word and the next parameter A word will come from memory. (Or it could have been deliberately loaded as zeros to facilitate CCS pointer repositioning). If not "0s," then bits 9-11 represent the MODE field and 12-16 represent the USE field of the next parameter A word to be used. This also indicates the present word in use (bits 1-8) was initially stored in the left hand half of a FDS memory word. This definition is a direct result of storing 2 parameter A words in each FDS memory word.

SUBCOM POS. 6 PAR. WD. A INDICATOR BITS -- This word gives the status of the flags set in the FDS program to control the following imaging functions:

BITS 1-4 SPARE (all "0s")

BIT 5 NA CYCLE INDICATOR

0 = PREPARE
1 = READOUT

BIT 6 NA BEAM INDICATOR

0 = ON
1 = OFF

BIT 7 NA SHUTTER RESET INDICATOR

0 = ENABLE
1 = INHIBIT

BIT 8 NA SHUTTER OPEN INDICATOR

0 = ENABLE
1 = INHIBIT

BIT 9 NA SHUTTER CLOSE INDICATOR

0 = ENABLE
1 = INHIBIT

BIT 10 NA LIGHT FLOOD INDICATOR

0 = ENABLE
1 = INHIBIT

BIT 11 WA CYCLE INDICATOR

0 = PREPARE
1 = READOUT

BIT 12 WA BEAM INDICATOR

0 = ON
1 = OFF

BIT 13 WA SHUTTER RESET INDICATOR

0 = ENABLE
1 = INHIBIT

BIT 14 WA SHUTTER OPEN INDICATOR

0 = ENABLE
1 = INHIBIT

BIT 15 WA SHUTTER CLOSE INDICATOR

0 = ENABLE
1 = INHIBIT

BIT 16 WA LIGHT FLOOD INDICATOR

0 = ENABLE
1 = INHIBIT

The FDS program enables or inhibits the associated functions using these flag bits. The value of this indicator word is a function of the MODE and the cycle of that mode but is not unique for a given combination. They are listed below (bits 5 thru 16):

NOSHUT1	010111111111	(5FF)
NOSHUT2	111111010111	(FD7)
NAONLY1	000000111111	(03F)
NAONLY2	101111010111	(BC7)
WAONLY1	111111000000	(FC0)
WAONLY2	010111101111	(5EF)
BOTALT1	000000101111	(02F)
BOTALT2	101111000000	(BC0)
BOTSIM1	000000000000	(000)
BOTSIM2	101111010111	(BD7)
BOTSIM3	010111101111	(5EF)
BODARK1	000110101111	(1AF)
BODARK2	101111000110	(BC6)

SUBCOM POS. 7 PARAMETER WD. A POINTER -- This word gives the address in FDS memory where the next parameter word A pair is stored. When the word is used, the 8 MSBs are utilized first followed by the 8 LSBs after the previous use field has reached zero.

BITS 1-2 SPARES (00)

BITS 3-16 ADDRESS BITS -- 14 bits because the parameter word could be in either 8K memory.

SUBCOM. POS. 8 PARAMETER WD. B present value. This word specifies the NA camera exposure and filter stepping.

BITS 1-5 EXPOSURE MODE/TIME

0 = AUTO EXPOSURE MODE
N = FIXED EXPOSURE MODE where N is the exposure number, EN. (1-24 decimal)

BIT 6 FILTER STEPPING MODE

0 = POSITION MODE
1 = STEPS MODE

BITS 7-9 POSITION MODE-- This is the desired filter position.

STEPS MODE -- This gives the number of steps each prepare cycle.

BITS 10-16 USE FIELD present value.

SUBCOM POS. 9 PARAMETER WD. B POINTER -- This word gives the address in FDS memory where the next parameter B word is stored.

BITS 1-2 SPARES (00)

BITS 3-16 ADDRESS BITS -- 14 bits because the parameter word could be in either memory.

SUBCOM POS. 10 PARAMETER WD. C present value. This word specifies the WA camera exposure and filter stepping.

BITS 1-5 EXPOSURE MODE/TIME

0 = AUTO EXPOSURE MODE
N = FIXED EXPOSURE MODE where N is the exposure number, EN. (1-24 decimal)

BIT 6 FILTER STEPPING MODE

0 = POSITION MODE
1 = STEPS MODE

BITS 7-9 POSITION MODE -- This is the desired filter position.

STEPS MODE -- This gives the number of steps each prepare cycle.

BITS 10-16 USE FIELD present value.

SUBCOM POS. 11 PARAMETER WD. C POINTER -- This word gives the address in FDS memory where the next parameter B word is stored

BITS 1-2 SPARES (00)

BITS 3-16 ADDRESS BITS -- 14 bits because the parameter word could be in either memory.

SUBCOM POS. 12 PARAMETER WD. D present value.

BITS 1-5 NA OPTICS CAL TIME

0 = LIGHTS OFF
N = (1, to 24 decimal) Turns on the lights at the time the shutter is open when the exposure number has the value N.
25 = Turn on at t = 29.4 sec.

BITS 6-7 NA ACTUAL SHUTTER SELECT

0 = NORMAL
1 = LONG START
2 = LONG END
3 = LONG OPEN

BITS 8-9 WA ACTUAL SHUTTER SELECT

0 = NORMAL
1 = LONG START
2 = LONG END
3 = LONG OPEN

BITS 10-16 USE COUNT

0 = Get the next parameter word from the table
1-126 = Use the same parameter word and decrement the USE count.
127 = Use the same parameter word until the USE count is zeroed by CCS command.

SUBCOM POS. 13 PARAMETER D WORD INDICATOR BITS -- These bits are a function of D word bits 6 thru 9. They represent the 12 bits that are logically ORed with the parameter word A bits before the actual flags a set.

BITS 1-4 SPARES (zeros)

BITS 5-10 NA INDICATOR BITS

D WD. BITS 6-7	COMMANDED FUNCTION	INDICATOR BITS
0	NORMAL	000000
1	LONG START	000010
2	LONG END	011101
3	LONG OPEN	011111

BITS 11-16 WA INDICATOR BITS

D WD. BITS 8-9	COMMANDED FUNCTION	INDICATOR BITS
0	NORMAL	000000
1	LONG START	000010
2	LONG END	011101
3	LONG OPEN	011111

SUBCOM POS. 14 PARAMETER D WORD POINTER -- This word gives the address in FDS memory where the next parameter D word is stored.

BITS 1-2 SPARES (zeros)

BITS 3-16 ADDRESS BITS -- 14 bits because the parameter word could be in either memory.

SUBCOM POS. 15-19 -- ISS ANALOG ENGINEERING TELEMETRY. The WA and NA 10 position multiplexers are each sampled 5 times each ISS frame (48 sec). The multiplexers are advanced after each sample (every 9.6 sec) by WA and NA MUX STEP. The multiplexer is reset to position 1 by the dual purpose signal FILTER READ/MUX RESET. NA FILTER READ/MUX RESET is issued when the NA camera is in a PREPARE. WA FILTER READ/MUX STEP is sent when the NA camera is in a READ. The multiplexer position being sampled is, therefore, a function of the imaging sequence.

The data output in each frame is the result of sampling in the previous frame. PLEASE NOTE: Reference 1 incorrectly listed the readout order. WA data is output in the MSBs and NA data is in the LSBs.

The output order shown below assumes having been in BOTALT for at least 3 frames.

BOTALT CYCLE 2 (data from BOTALT cycle 1) NA READ, WA PREPARE (this cycle) SCT 60 = n.

SUBCOM POS	BITS 1-8 MUX POS.	BITS 9-16 MUX POS.
15	WA - ~~3~~ 2	NA - ~~8~~ 7
16	WA - ~~4~~ 3	NA - ~~9~~ 8
17	WA - ~~5~~ 4	NA - ~~10~~ 9
18	WA - ~~6~~ 5	NA - ~~1~~ 10
19	WA - ~~7~~ 6	NA - ~~2~~ 1

BOTALT CYCLE 1 (data from BOTALT cycle 2) WA READ, NA PREPARE (this cycle) SCT60 = n + 1

SUBCOM POS	BITS 1-8 MUX POS.	BITS 9-16 MUX POS.
15	WA - ~~8~~ 7	NA - ~~3~~ 2
16	WA - ~~9~~ 8	NA - ~~4~~ 3
17	WA ~~10~~ 9	NA - ~~5~~ 4
18	WA - ~~1~~ 10	NA - ~~6~~ 5
19	WA - ~~2~~ 1	NA - ~~7~~ 6

The readout will look odd during sequences having back-to-back PREPAREs (such as BOTSIM or going from NOSHUT cycle 1 to NAONLY). This entire structure is the result of the two things: (1) including BOTSIM, (2) being able to designate any 48 frame as a prepare cycle by entering one of the basic modes at the proper time. There is no alternative mechanization that would result in a "clean" readout of this data.

SUBCOM POS. 20 PIXEL AVERAGE/COMMAND STATUS

BITS 1-2 SPARES

BIT 3 PIXEL AVERAGE STATUS -- A "1" indicates more than the minimum number of pixels were used in the pixel average calculation from the previous frame. The exposure time can be modified based on this average if in the AUTO EXPOSURE mode. A "0" says less than the minimum were used and the exposure time can not be modified based on this average.

BITS 4-8 PIXEL AVERAGE is based on a sum of the 5 MSBs of all pixels exceeding the programed threshold of the camera read out in the previous frame.

PLEASE NOTE: All FDS programs do not contain automatic exposure (AEX) which includes the pixel summation coding. When AEX is not included, bits 3-8 are meaningless.

BIT 9 SPARE (zero)

BIT 10-16 ISS GI/GAIN COMMAND -- A command is sent to either WA or NA at the beginning of each frame according to the following algorithm: If the present cycle is a WA PREPARE or PREPARE for both cameras, the WA command is issued. If the present cycle is a NA PREPARE with a WA READ, the NA command is sent.

Bits 10-12 COMMAND BITS

Bits 13-16 FDS DESTINATION CODE
5 WA COMMAND
6 NA COMMAND

These 20 16-bit words are also output in the GS-3 subcom as shown in reference 1.

Please spread this around!

D. R. Johnson

D.R. JOHNSON

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DEC 1 1975

JET PROPULSION LABORATORY

INTEROFFICE MEMORANDUM

MJS: 2.146

25 November 1975

TO: H. K. Frewing

FROM: D. R. Johnson

SUBJECT: IM-1 ISS STATUS/ENGINEERING DATA FIELD

This memo defines the 16-bit ISS STATUS/ENGINEERING field in the IM-2 and IM-3 data modes. This 20 position subcom immediately follows the header (bits 65 - 80) will repeat 40 times per ISS frame (48 sec). Data is defined in terms of subcom position (1-20 decimal) and bit number (1-16 where bit 1 is the MSB and first out). Subcom position 1 is output at LINES 1, 21, 41, ...781, 1 and is followed in order by positions 2 thru 20.

SUBCOM POS. 1

Bit 1 CAMERA ID - this is the camera presently being read out ("0" is WA, "1" is NA).

Bits 2-16 SHUTTERED PICTURE INDICATOR - these bits are all "1s" when a picture has been shuttered and "0s" when no shuttering has occurred.

Taking a dark current pair (BODARK) using parameter word A, a recent addition, will set these bits to "1s" even though no shuttering has taken place because it is a significant picture that should be processed.

SUBCOM POS. 2

Bits 1-16 SLOW SCAN STATUS - exact definition TBD (Probably slow scan line count).

SUBCOM POS. 3

Bits 1-5 SPARES - "0s"

Bit 6 NA ELECTRONICS CAL STATUS - "0" is ON, "1" is OFF.

Bit 7 WA ELECTRONICS CAL STATUS - "0" is ON, "1" is OFF.

Bits 8-12 ACTUAL EXPOSURE TIME - This word contains a 5-bit exposure number that represents the exposure time used for the picture being read out. Bit 8 is MSB. This word does not indicate long exposures.

Bits 13-16 ACTUAL FILTER POSITION - this word indicates the filter wheel position for the picture being read out. Bits 13-15 are the 3-bit position and bit 16 is an odd parity bit.

POSITION	BITS 13	14	15	16
1	0	0	1	0
2	0	1	0	0
3	0	1	1	1
4	1	0	0	0
5	1	0	1	1
6	1	1	0	1
7	1	1	1	0
8	0	0	0	1

SUBCOM POS. 4

Bits 1-16 PICTURE COUNT - This word is incremented once for each "shuttered picture" and reset only by command from CCS.

SUBCOM POS. 5

PARAMETER A WORD present value (used in the current ISS frame).

SUBCOM POS. 6

PARAMETER A INDICATOR BITS used in the current ISS frame.

SUBCOM POS. 7

PARAMETER A WORD POINTER is the address in FDS memory where the next parameter A word pair is stored.

SUBCOM POS. 8

PARAMETER B WORD present value (used in the current ISS frame).

SUBCOM POS. 9

PARAMETER B WORD POINTER is the address in FDS memory where the next parameter B word is stored.

SUBCOM POS. 10

ARAMETER C WORD present value (used in the current ISS frame).

SUBCOM POS. 11

PARAMETER C WORD POINTER is the address in FDS memory where the next parameter C word is stored.

SUBCOM POS. 12

PARAMETER D WORD present value (used in the current ISS frame).

SUBCOM POS. 13

PARAMETER D INDICATOR BITS used in the current ISS frame.

SUBCOM POS. 14

PARAMETER D WORD POINTER is the address in FDS memory where the next parameter D word is stored.

SUBCOM POS. 15

ISS ANALOG ENGINEERING TELEMETRY

Bits 1-8 First NA sample taken in the previous ISS frame.

Bits 9-16 First WA sample taken in the previous ISS frame.

SUBCOM POS. 16

ISS ANALOG ENGINEERING TELEMETRY

Bits 1-8 Second NA sample taken in the previous ISS frame.

Bits 9-16 Second WA sample taken in the previous ISS frame.

SUBCOM POS. 17

ISS ANALOG ENGINEERING TELEMETRY

Bits 1-8 Third NA sample taken in the previous ISS frame.

Bits 9-16 Third WA sample taken in the previous ISS frame.

SUBCOM POS. 18

ISS ANALOG ENGINEERING TELEMETRY

Bits 1-8 Fourth NA sample taken in the previous ISS frame.

Bits 9-16 Fourth WA sample taken in the previous ISS frame.

SUBCOM POS. 19

ISS ANALOG ENGINEERING TELEMETRY

Bits 1-8 Fifth NA sample taken in the previous ISS frame.

Bits 9-16 Fifth NA sample taken in the previous ISS frame.

SUBCOM POS. 20

Bits 1-2 SPARES ("0s")

Bit 3 PIXEL AVERAGE STATUS - a "1" indicates more than the minimum number of pixels were used in the pixel average calculation and the exposure time can be modified based on this average if in the AUTO EXPOSURE mode. A "0" says less than the minimum were used and the exposure time cannot be modified based on this average.

Bit 4-8 PIXEL AVERAGE is based on a sum of the 5 MSBs of all pixels exceeding the programmed threshold of the camera read out in the previous ISS frame.

Bit 9-16 ISS G1/GAIN COMMAND STATUS

Bit 9 "0"

Bit 10-12 Command Bits

Bit 13-16 FDS Destination Code
5 WA Camera
6 NA camera

NOTES

The ISS Cog E should be contacted for definitions of the analog engineering samples and the command bits; however, the previous parameter A indicator bits must be used to determine whether the previous frame was a readout or prepare for each camera. More complete definitions of all subcom words concerning parameter words will be published in the near future.

Please pass this information on to the appropriate parties.

D. R. Johnson

D. R. Johnson

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233-501

2 elecs (c...)
2 ...
2 NA (front + back)
1 WA (back

JET PROPULSION LABORATORY

INTEROFFICE MEMORANDUM

MJS: 2.147B

15 December 1975

TO: H. K. Frewing

FROM: D. R. Johnson

SUBJECT: UPDATE OF GS-1/GS-3 SUBCOM DEFINITIONS (REVISION B)

This memo closes the remaining open items concerning the data read out in the 48 bit subcom field. Data is specified in terms of minor frame (MF) and bits (1-48 where bit 1 is the MSB and first out). The ISS portion also references the IM-1 ISS ANALOG/ENGINEERING subcom position since this is the output of that same data. The only changes are the inclusion of an IRIS CMD. Others are presented in a different form than was previously published.

MF1

Bit 1 CAMERA ID - this is the camera presently being read out ("0" is WA, "1" is NA).

Bits 2-16 SHUTTERED PICTURE INDICATOR - these bits are all "1s" when a picture has been shuttered and "0s' when no shuttering has occurred.

Taking a dark current pair (BODARK) using parameter word A, a recent addition, will set these bits to "1s" even though no shuttering has taken place because it is a significant picture that should be processed.

(Bits 1-16 are the same as ISS SUBCOM POS. 1)

Bits 17-32 SLOW SCAN STATUS - exact definition TBD (probably slow scan line count). (Same as ISS SUBCOM POS. 2)

Bits 33-37 SPARES - "0s"

Bit 38 NA ELECTRONICS CAL STATUS - "0" is ON, "1" is OFF.

Bit 39 WA ELECTRONICS CAL STATUS - "0" is ON, "1" is OFF.

Bits 40-44 ACTUAL EXPOSURE TIME - This word contains a 5-bit exposure number that represents the exposure time used for the picture being read out. Bit 40 is MSB. This word does not indicate long exposures.

Bits 45-48 ACTUAL FILTER POSITION - This word indicates the filter wheel position for the picture being read out. Bits 45-47 are the 3-bit position and bit 48 is an odd parity bit.

POSITION	BITS 13	14	15	16
1	0	0	1	0
2	0	1	0	0
3	0	1	1	1
4	1	0	0	0
5	1	0	1	1
6	1	1	0	1
7	1	1	1	0
8	0	0	0	1

(Bits 33-48 are the same as ISS SUBCOM POS. 3)

MF2

Bits 1-16 PICTURE COUNT - This word is incremented once for each "shuttered picture" and reset only by command from CCS. These bits are the same as ISS SUBCOM POS. 4.

Bits 17-32 PARAMETER WORD A present value (used in the current ISS frame). These bits are the same as ISS SUBCOM POS. 5.

Bits 33-48 PARAMETER A INDICATOR BITS used in the current ISS frame. These bits are the same as ISS SUBCOM POS. 6.

MF11

Bits 1-16 PARAMETER A WORD POINTER is the address in FDS memory where the next parameter A word pair is stored. These bits are the same as ISS SUBCOM POS. 7.

Bits 17-32 PARAMETER WORD B present value (used in the current ISS frame). These bits are the same as ISS SUBCOM POS. 8.

Bits 33-48 PARAMETER B WORD POINTER is the address in FDS memory where the next parameter B word is stored. These bits are the same as ISS SUBCOM POS. 9.

MF12

Bits 1-16 PARAMETER WORD C present value (used in the current ISS frame). These bits are the same as ISS SUBCOM POS. 10.

Bits 17-32 PARAMETER C WORD POINTER is the address in FDS memory where the next parameter C word is stored. These bits are the same as ISS SUBCOM POS. 11.

Bits 33-48 PARAMETER WORD D present value (used in the current ISS frame). These bits are the same as ISS SUBCOM POS. 12.

MF21

Bits 1-16 PARAMETER D WORD INDICATOR BITS used in the current ISS frame. These bits are the same as ISS SUBCOM POS. 13.

Bits 17-32 PARAMETER D WORD POINTER is the address in FDS memory where the next parameter D word is stored. These bits are the same as ISS SUBCOM POS. 14.

Bits 33-48 ISS ANALOG ENGINEERING TELEMETRY

Bits 33-40 First WA sample taken in the previous ISS frame.

Bits 41-48 First NA sample taken in the previous ISS frame.

These bits are the same as ISS SUBCOM POS. 15.

MF22

Bits 1-48 ISS ANALOG ENGINEERING TELEMETRY

Bits 1-8 Second WA sample taken in the previous ISS frame.

Bits 9-16 Second NA sample taken in the previous ISS frame.

Bits 17-24 Third WA sample taken in the previous ISS frame.

Bits 25-32 Third NA sample taken in the previous ISS frame.

Bits 33-40 Fourth WA sample taken in the previous ISS frame.

Bits 41-48 Fourth NA sample taken in the previous ISS frame.

These bits are the same as ISS SUBCOM POSITIONS 16, 17, and 18.

MF31

Bits 1-16 ISS ANALOG ENGINEERING TELEMETRY

Bits 1-8 Fifth WA sample taken in the previous ISS frame.

Bits 9-16 Fifth NA sample taken in the previous ISS frame.

Bits 17-48 Bits 17-18 SPARES ("0s")

Bit 19 PIXEL AVERAGE STATUS - a "1" indicates more than the minimum number of pixels were used in the pixel average calculation and the exposure time can be modified based on this average if in the AUTO EXPOSURE mode. A "0" says less than the minimum were used and the exposure time cannot be modified based on this average.

Bit 20-24 PIXEL AVERAGE is based on a sum of the 5 MSBs of all pixels exceeding the programmed threshold of the camera read out in the previous ISS frame.

Bit 25-32 ISS G1/GAIN COMMAND STATUS

Bit 25 "0"

Bit 26-28 Command Bits

Bit 29-32 FDS Destination Code
5 WA Camera
6 NA Camera

Bits 1-16 are the same as ISS SUBCOM POS. 19 and bits 17-32 are the same as ISS SUBCOM POS. 20.

Bits 33-48 PPS CMD

MF32

Bits 1-16 MAG CMD 1

Bits 17-32 MAG CMD 2

Bits 33-48 LECP CMD

MF41

Bits 1-16 UVS CMD

Bits 17-32 PLS CMD

Bits 33-48 PLS STATUS

MF42

Bits 1-16 PRA MODE CMD

Bits 17-32 PRA CONFIGURATION CMD

Bits 33-48 FDS CMD COUNTER

MF51

Bits 1-12	FIRST FDS CMD received in the previous 48 sec frame
Bits 13-16	SPARES ("0s")
Bits 17-28	Second FDS CMD received in the previous 48 sec frame
Bits 29-32	SPARES ("0s")
Bits 33-44	Third FDS CMD received in the previous 48 sec frame
Bits 45-48	SPARES ("0s")

MF52

Bits 1-12	Fourth FDS command received in the previous 48 second frame
Bits 13-16	SPARES ("0s")
Bits 17-28	Fifth FDS command received in the previous 48 second frame
Bits 29-32	SPARES ("0s")
Bits 33-44	Sixth FDS command received in the previous 48 second frame
Bits 45-48	SPARES ("0s")

MF61

Bits 1-12	Seventh FDS command received in the previous 48 second frame
Bits 13-16	SPARES ("0s")
Bits 17-28	Eighth FDS command received in the previous 48 second frame
Bits 29-32	SPARES ("0s")
Bits 33-48	CRS COMMAND

MF62

Bits 1-48	CRS STATUS (4 12-bit words)

MF71

Bits 1-48	CRS STATUS (4 12-bit words)

MF72

Bits 1-13 SPARES ("0s")

Bit 14 PWS INPUT RANGE STATE
0 = -40 dB
1 = 0 dB

Bit 15 SPARE ("0")

Bit 16 PWS WAVEFORM POWER
0 = OFF
1 = ON

Bits 17-32 IRIS COMMAND in the form:

X00000000XYY1011

X is MODE (bits 17 and 26)
0 = MODE 2 (144 sec scan)
1 = MODE 1 (48 sec scan)

YY is the gain bits

27	28	
0	0	GAIN 1 (default)
0	1	GAIN 1
1	0	GAIN 2
1	1	GAIN 3

Bits 33-48 LECP NE/FE FLAG STATUS (SLECPM)

0 = FAR ENCOUNTER
1 - NEAR ENCOUNTER

Please distribute to the appropriate people.

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JET PROPULSION LABORATORY

No. MJS77-3-280B
8 April 1977
Supersedes
18 February 1976

FUNCTIONAL REQUIREMENT
MARINER JUPITER/SATURN 1977 FLIGHT EQUIPMENT
TELEMETRY MEASUREMENTS AND DATA FORMATS

△ Denotes Amendment 2 changes to Revision B.

✻ Denotes tables, figures, and paragraphs which were either new to Revision B of this document or changed from Amendment 1 (Rev. A).

▌ Indicates specifically where tables, figures, and paragraphs having an ✻ were changed.

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1.0 SCOPE

This document establishes the Mariner Jupiter/Saturn 1977 telemetry measurements and data formats. Included are functional descriptions of the following:

a) General Telemetry Format Structure Characteristics.

b) Engineering Data Formats.

c) Memory Readouts.

d) Cruise Data Formats.

e) Encounter General Science Data Formats.

f) Encounter Imaging Data Formats.

g) Playback Formats.

2.0 APPLICABLE DOCUMENTS

The following documents form a part of this functional requirement:

NOTE

MJS77-3-100, Spacecraft Requirements and Constraints, applies to this document. Requirements of other MJS77 level 3 documents may also be applicable. It is the responsibility of the user to adequately acquaint himself with the organization and pertinent content of the level 3 documents, as well as with the material contained herein.

REQUIREMENTS

Jet Propulsion Laboratory

MJS77-3-100	Functional Requirement, Mariner Jupiter/Saturn 1977 Spacecraft Requirements and Constraints
MJS77-3-270	Functional Requirement, Mariner Jupiter/Saturn 1977 Telemetry and Command Handling
MJS77-3-310	Functional Requirement, Mariner Jupiter/Saturn 1977 Software Requirements

3.0 GENERAL TELEMETRY FORMAT STRUCTURE CHARACTERISTICS

The basic element comprising MJS77 data formats is the prime frame. In general, a prime frame will contain data from several sources. The data from each source is assembled into a subset which is an exact multiple of 8 bits. In addition, the length of each prime frame is an exact multiple of 16 bits. Prime frames are divided into the following three classes:

a) Non-Golay Coded (NGC) Frames.

b) Golay Coded (GC) Frames.

c) Hybrid (H) Frames.

The type of prime frame which is transmitted and/or recorded on the Mission Module's tape recorder is a function of the mission phase. Prime frames of the NGC class will be transmitted during all normal cruise periods. NGC prime frames of engineering data will be transmitted via S-band during normal encounter periods. GC and H prime frames are transmitted at X-band during encounter periods. Prime frames of the GC type are transmitted if the data is exclusively general science and engineering (GS&E) whereas prime frames of the H type are transmitted if the data includes real-time imaging, high rate PRA, high rate PWS or tape recorder playback data. The basic structure of each class of prime frame is shown in Figure 3-1.

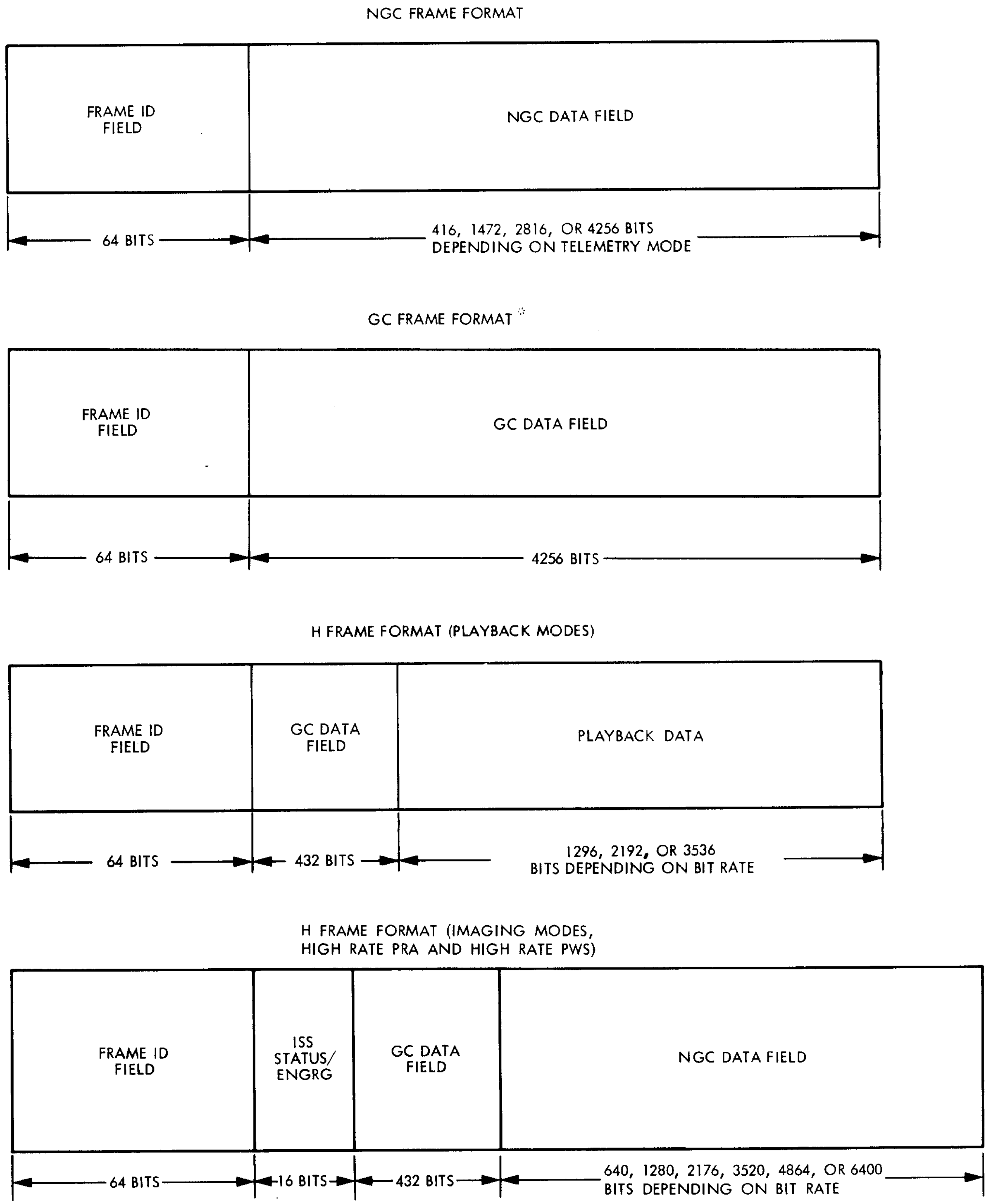
* 3.1 Frame Identification Field (FRID)

The first 64 bits of each frame contains a frame identification field which enables frame synchronization and decommutation of the received data. The structure of this field is shown in Figure 3-2, and the elements of which the field is comprised are described in paragraphs 3.1.1 through 3.1.3. All words in FRID are readout MSB first. Bit one is MSB.

3.1.1 Frame Synchronization Code

The frame synchronization code comprises the first 32 bits of FRID. The frame synchronization code employed for all MJS77 prime frames is:

0000 0011 1001 0001 0101 1110 1101 0011
(03915ED3)



* NOTE: THE ENTIRE GC FRAME (INCLUDING FRAME ID FIELD) IS GOLAY CODED.

* Figure 3-1. Prime Frame Basic Structure

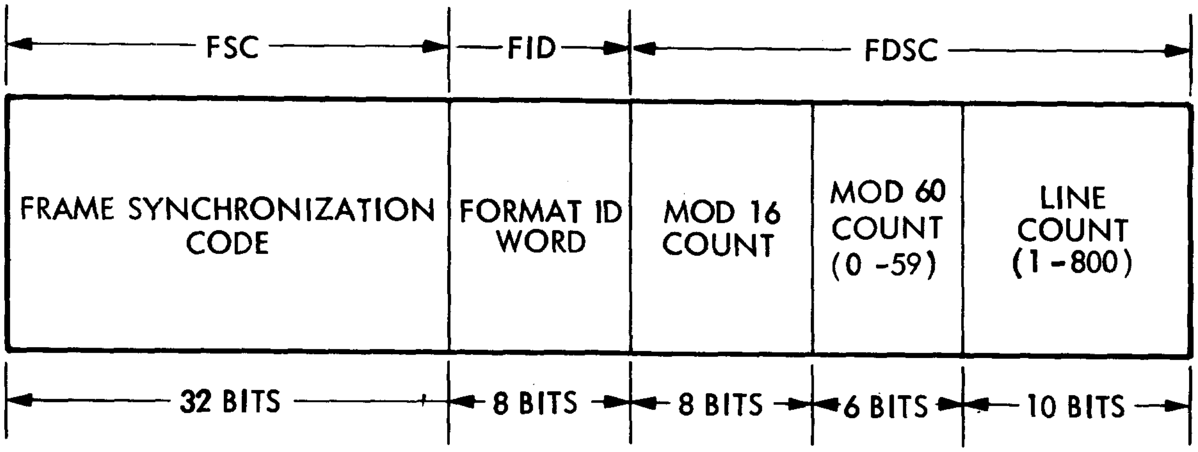


Figure 3-2. Frame Identification Field

3.1.2 Format ID Word (FID)

This is an 8-bit field used to uniquely identify the format (data mode) in use. This field appears in all minor frames. These bits are utilized as follows.

3.1.2.1 Format Type (Bits 1 and 2) (Bit 1 is MSB)

These bits are used to identify format types as shown below.

Bits 1 and 2	Format Type
0 0	Engineering without AACS Memory Readout
0 1	Engineering with AACS Memory Readout
1 0	Imaging/Playback
1 1	GS&E

3.1.2.2 Data Type (Bits 3 through 7)

Each format type is further defined as shown in paragraphs 3.1.2.2.1, 3.1.2.2.2, and 3.1.2.2.3.

* 3.1.2.2.1 Engineering Format Identification

Engineering formats are identified by data rate and data mode as shown in the two tables below.

Data Rate Identification

Bits 3 and 4	Engineering Data Rate (bps)
0 0	10
0 1	40
1 0	1200
1 1	7200 (1200 Recorded)

* Data Type Identification

Bits 5, 6, 7	Engineering Data Mode
0 0 0	Launch
0 0 1	Cruise
0 1 0	Encounter
0 1 1	TCM
1 0 0	Special
1 0 1	Modified Cruise
1 1 0	CCS Memory Readout
1 1 1	FDS Memory Readout

* 3.1.2.2.2 Science Format Identification

Science formats are identified as GS&E Formats or Imaging/ Playback Formats as shown in the table below.

Bits 3, 4, 5, 6, 7	GS&E Formats
0 0 1 1 1	CR-1
0 0 0 0 1	CR-2
0 0 0 1 0	CR-3
0 0 0 1 1	CR-4
0 0 1 0 0	CR-5
0 0 1 0 1	CR-6
0 1 0 1 0	GS-3
1 0 1 1 1	OC-1

Bits 3, 4, 5, 6, 7	Imaging/Playback Formats
1 1 1 1 0	IM-2
1 1 1 0 1	IM-3
1 1 1 0 0	IM-4
1 1 0 1 1	IM-5
1 1 0 1 0	IM-6
0 1 0 0 1	IM-7
1 1 0 0 0	IM-8
0 1 0 1 1	IM-9
1 0 1 1 0	IM-10
1 0 1 0 1	IM-11
1 0 1 0 0	IM-12
1 1 1 1 1	IM-13
1 0 0 1 0	IM-14
1 0 0 0 1	GS-2
0 1 1 1 1	GS-4
0 1 1 1 0	PB-1
0 1 1 0 1	PB-2
0 1 1 0 0	PB-3

3.1.2.3 S/C ID (Bit 8)(LSB)

The eighth bit position is used to identify mission module. A "1" will identify Flight 1 and a "0" will identify Flight 2.

3.1.2.4 Engineering Formats

Table 3-1 specifies each of the engineering formats by listing the function and telemetry mode mnemonic, describing the data stream structure by the type of prime frame used, and showing the format identifiers for the MDS low rate data stream, MDS high rate data stream, and the tape recorder data stream.

3.1.2.5 General Science and Engineering Formats

Table 3-2 specifies each of the general science and engineering formats by listing the function and telemetry mode mnemonic and showing the format identifiers used for the prime frame, embedded GS&E frame, and embedded engineering frame. The format identifiers are specified for the MDS low rate data stream, MDS high rate data stream, and tape recorder data stream.

3.1.2.6 Imaging and Playback Formats

Table 3-3 specifies each of the imaging and playback formats by listing the function and telemetry mode mnemonic and showing the format identifiers used for the prime frame, embedded GS&E frame, and embedded engineering frame. The format identifiers are specified for the MDS low rate data stream, MDS high rate data stream, and tape recorder data stream.

*3.1.3 Flight Data Subsystem Count (FDSC)

The FDSC comprises the last 24 bits of FRID as shown on Figure 3-2. This field is used to provide a mission module clock. Using this count it is possible to determine time and correlate events to within the time resolution of the frame count. The subfields within the FDSC are described in paragraphs 3.1.3.1 through 3.1.3.3.

✻ Table 3-1. Engineering Formats

Function	Telemetry Mode Mnemonic	MDS Low Rate Data Stream Contents			MDS High Rate Data Stream Contents					Tape Recorder Data Stream Contents				
		Status	Prime Frame Type	Prime Frame Format ID (2)	Status	Prime Frame Type	Prime Frame Format ID (2)	Embedded GS&E Format ID	Embedded Engr Format ID	Status	Prime Frame Type	Prime Frame Format ID (2)	Embedded GS&E Format ID	Embedded Engr Format ID
Low Rate Launch Engineering	LN-40	On	NGC	0001000X	Off	–	–	–	–	Off	–	–	–	–
High Rate Launch Eng to MDS	LN-12	Off	–	–	On	NGC	0010000X	–	–	On	NGC	0011000X (LN-72)	–	–
Cruise Engineering	CE-40	Off	–	–	On	NGC	0001001X	–	–	–	–	–	–	–
Low Rate Modified Cruise Engineering	MC-40	On	NGC	0001101X	Off	–	–	–	–	Off	–	–	–	–
High Rate Modified Cruise Engineering to MDS	MC-12	Off	–	–	On	NGC	0010101X	–	–	On	NGC	0011101X (MC-72)	–	–
Low Rate TCM Engineering	MN-40	On	NGC	0001011X	Off	–	–	–	–	Off	–	–	–	–
High Rate TCM Engineering to MDS	MN-12	Off	–	–	On	NGC	0010011X	–	–	On	NGC	0011011X (MN-72)	–	–
Encounter Engineering	EC-40	Off	–	–	On	NGC	0001010X	–	–	Off	–	–	–	–
Low Rate FDS Memory Readout	FD-40	Off	–	–	On	NGC	0001111X	–	–	Off	–	–	–	–
Low Rate CCS Memory Readout	CC-40	Off	–	–	On	NGC	0001110X	–	–	Off	–	–	–	–
Low Rate AACS Memory Readout	AA-40	Off	–	–	On	NGC	0101ABCX (1)	–	–	Off	–	–	–	–
High Rate FDS Memory Readout	FD-12	Off	–	–	On	NGC	0010111X	–	–	Off	–	–	–	–
High Rate CCS Memory Readout	CC-12	Off	–	–	On	NGC	0010110X	–	–	Off	–	–	–	–
High Rate AACS Memory Readout	AA-12	Off	–	–	On	NGC	0110ABCX (1)	–	–	Off	–	–	–	–

NOTES: (1) Bits 5, 6 and 7 specify the contents of engineering commutator locations not allocated to AACS memory data. See Section 4.4.1 for details.

(2) "X" in bit position 8 is for S/C ID. Flight 1 = "1" and Flight 2 = "0".

(3) **FDS routes identical 40 bps data streams to both the high rate and low rate channels when operating in the LN-40, CE-40, EC-40, FD-40, CC-40, and AA-40 engineering only modes.**

* Table 3-2. General Science and Engineering Formats

Function	Telemetry Mode Mnemonic	MDS Low Rate Data Stream Contents			MDS High Rate Data Stream Contents					Tape Recorder Data Stream Contents				
		Status	Prime Frame Type	Prime Frame Format ID (2)	Status	Prime Frame Type	Prime Frame Format ID (2)	Embedded GS&E Format ID	Embedded Engr (2) Format ID	Status	Prime Frame Type	Prime Frame Format ID (2)	Embedded GS&E (2) Format ID	Embedded Engr (2) Format ID
Cruise Science and Engineering	CR-1	Off	–	–	On	NGC	1100111X	–	0001001X		–	–	–	–
Cruise Science and Engineering	CR-2	Off	–	–	On	NGC	1100001X	–	0001001X	Off	–	–	–	–
Cruise Science and Engineering	CR-3	Off	–	–	On	NGC	1100010X	–	0000001X	Off	–	–	–	–
Cruise Science and Engineering	CR-4	Off	–	–	On	NGC	1100011X	–	0000001X	Off	–	–	–	–
Cruise Science and Engineering	CR-5	Off	–	–	On	NGC	1100100X	–	0000001X	Off	–	–	–	–
Cruise Science and Engineering	CR-6	Off	–	–	On	NGC	1100101X	–	0000001X	Off	–	–	–	–
Cruise Science and Engineering (3)	CR-7	Off	–	–	On	NGC	TBD	–	TBD	Off	–	–	–	–
Cruise Science and Engineering (3)	CR-8	Off	–	–	On	NGC	TBD	–	TBD	Off	–	–	–	–
Cruise Science and Engineering (3)	CR-9	Off	–	–	On	NGC	TBD	–	TBD	Off	–	–	–	–
Standard Encounter and Occultation GS&E	GS-3	On	NGC	0001010X	On	GC	1101010X	–	0001010X	See Note (1)	GC	1101010X	–	0001010X
Special Occultation	OC-1	On	NGC	0001010X	On	NGC	1110111X	–	0001010X	See Note (1)	NGC	1110111X	–	0001010X

NOTES:

(1) The FDS routes identical data streams to the MDS high rate channel and DSS in these modes. Recording is optional.

(2) "X" in bit position 8 is for S/C ID. Flight 1 = "1" and Flight 2 = "0".

(3) **At the present time, the Project has no plans to develop these formats.**

Table 3-3. Imaging and Playback Formats (Sheet 1 of 2)

Function	Telemetry Mode Mnemonic	MDS Low Rate Data Stream Contents			MDS High Rate Stream Contents					Tape Recorder Data Stream Contents				
		Status	Prime Frame Type	Prime Frame Format ID △2	Status	Prime Frame Type	Prime Frame Format ID △2	Embedded GS&F Format ID △2	Embedded Engr Format ID △2	Status	Prime Frame Type	Prime Frame Format ID △2	Embedded GS&E Format ID △2	Embedded Engr Format ID △2
Standard Encounter GS&E Plus Record Full Resolution Imaging	IM-2	On	NGC	0001010X	On	H	1101010X	–	0001010X	Record	H	1011110X	1101010X	0001010X
Record and Transmit Full Resolution Imaging Plus Standard Encounter GS&E	IM-3	On	NGC	0001010X	On	H	1011101X	1101010X	0001010X	△1	H	1011101X	1101010X	0001010X
Standard Encounter GS&E Plus Fill Resolution 3/4 Edited Imaging	IM-4	On	NGC	0001010X	On	H	1011100X	1101010X	0001010X	Off	–	–	–	–
Standard Encounter GS&E Plus 2:1 Slow Scan Imaging	IM-5	On	NGC	0001010X	On	H	1011011X	1101010X	0001010X	Off	–	–	–	–
Standard Encounter GS&E Plus 1/2 Edited Imaging	IM-6	On	NGC	0001010X	On	H	1011010X	1101010X	0001010X	Off	–	–	–	–
Standard Encounter GS&E Plus 3:1 Slow Scan Imaging	IM-7	On	NGC	0001010X	On	H	1001001X	1101010X	0001010X	Off	–	–	–	–
Standard Encounter GS&E Plus 1/3 Edited Imaging	IM-8	On	NGC	0001010X	On	H	1011000X	1101010X	0001010X	Off	–	–	–	–
Standard Encounter GS&E Plus Edited 3:1 Slow Scan Imaging	IM-9	On	NGC	0001010X	On	H	1001011X	1101010X	0001010X	Off	–	–	–	–
Standard Encounter GS&E Plus 1/5 Edited Imaging	IM-10	On	NGC	0001010X	On	H	1010110X	1101010X	0001010X	Off	–	–	–	–
Standard Encounter GS&E Plus 5:1 Slow Scan Imaging	IM-11	On	NGC	0001010X	On	H	1010101X	1101010X	0001010X	Off	–	–	–	–
Standard Encounter GS&E Plus 1/2 Edited 5:1 Slow Scan Imaging	IM-12	On	NGC	0001010X	On	H	1010100X	1101010X	0001010X	Off	–	–	–	–
Standard Encounter GS&E Plus 10:1 Slow Scan Imaging	IM-13	On	NGC	0001010X	On	H	1011111X	1101010X	0001010X	Off	–	–	–	–

NOTES: See Sheet 2.

* Table 3-3. Imaging and Playback Formats (Sheet 2 of 2)

Function	Telemetry Mode Mnemonic	MDS Low Rate Data Stream Contents			MDS High Rate Data Stream Contents					Tape Recorder Data Stream Contents				
		Status	Prime Frame Type	Prime Frame △2 Format ID	Status	Prime Frame Type	Prime Frame △2 Format ID	Embedded GS&F △2 Format ID	Embedded Engr △2 Format ID	Status	Prime Frame Type	Prime Frame Format ID	Embedded GS&E △2 Format ID	Embedded Engr △2 Format ID
Standard Encounter GS&E Plus 1/10 Edited Imaging	IM-14	On	NGC	0001010X	On	H	1010010X	1101010X	0001010X	Off	–	–	–	–
Standard Encounter GS&E Plus Special PRA	GS-2	On	NGC	0001010X	On	H	1010001X	1101010X	0001010X	△1	H	1010001X	1101010X	0001010X
Standard Encounter GS&E Plus Special PWS	GS-4	On	NGC	0001010X	On	H	1001111X	1101010X	0001010X	△1	H	1001111X	1101010X	0001010X
Playback Plus Standard Encounter GS&E	PB-1	On	NGC	0001010X	On	H	1001110X	1101010X	0001010X	Playback	Variable (see Note △3)			
Playback Plus Standard Encounter GS&E	PB-2	On	NGC	0001010X	On	H	1001101X	1101010X	0001010X	Playback	Variable (see Note △3)			
Playback Plus Standard Encounter GS&E	PB-3	On	NGC	0001010X	On	H	1001100X	1101010X	0001010X	Playback	Variable (see Note △3)			
Playback Only △5	PB-4	On	NGC	0001010X	On	Variable (see Notes △3 and △4)				Playback	Variable			
Playback Only △5	PB-5	On	NGC	0001010X	On	Variable (see Notes △3 and △4)				Playback	Variable			

NOTES:

△1 The FDS routes identical data streams to the MDS high rate channel and DSS in these modes. Recording is optional.

△2 "X" in bit position 8 is for S/C ID. Flight 1 = "1" and Flight 2 = "0".

△3 This will consist of whatever data has been previously put on the recorder. The possibilities are high rate engineering (LN-72, MC-72, or MN-72), GS-2, GS-3, IM-3, or OC-1.

△4 This is uninterrupted tape playback data.

△5 **At the present time, the Project has no plans to develop these formats.**

*3.1.3.1 Modulo 2^{16} Counter (MOD 16). MOD 16 is a 16-bit binary counter incremented every 48 minutes by the reset of the MOD 60 counter. This counter will keep unambiguous account of time for 6 years. Eight bits of the MOD 16 count are inserted in each minor frame. Table 3-4 defines the location of the eight most significant bits and the eight least significant bits of MOD 16 count as provided in each of the listed formats.

*Table 3-4. FDS Modulo 2^{16} (MOD 16) Count Reconstruction

Format	MOD 60 Count	Line Count	Modulo 2^{16} Bits
GS-2, GS-4, IM-3,..., IM-14, PB-1, PB-2, PB-3	N/A N/A	001, 003, 005,..., 799 002, 004, 006,..., 800	8 LSB 8 MSB
GS-3, IM-2, OC-1, CR-1	N/A N/A	001, 021, 041,..., 781 011, 031, 051,..., 791	8 LSB 8 MSB
CR-2	N/A N/A	001, 041, 081,..., 761 021, 061, 101,..., 781	8 LSB 8 MSB
CR-6	2d LSB = 0 2d LSB = 1	001, 641, 481 321, 161	8 LSB
	2d LSB = 0 2d LSB = 1	321, 161 001, 641, 481	8 MSB
Any 10 bps ENGR format	00, 02, 04, ..., 58	N/A	8 LSB
	01, 03, 05, ..., 59	N/A	8 MSB
Any 40 bps ENGR format	N/A N/A	001, 401 201, 601	8 LSB 8 MSB
Any 1200 or 7200 bps ENGR format	N/A	001, 014, 027, 041,..., 787 007, 021, 034, 047,..., 794	8 LSB 8 MSB

3.1.3.2 Modulo 60 Counter (MOD 60). MOD 60 is a 6-bit binary counter incremented every 48 seconds by the reset of the Line Counter. MOD 60 counts from zero to 59 and is reset every 48 minutes.

3.1.3.3 Line Count (LC). Line Count is a 10-bit binary counter incremented every 60 ms. LC counts from one to 800. This counter is reset after 48 seconds.

***3.2 Golay Coding**

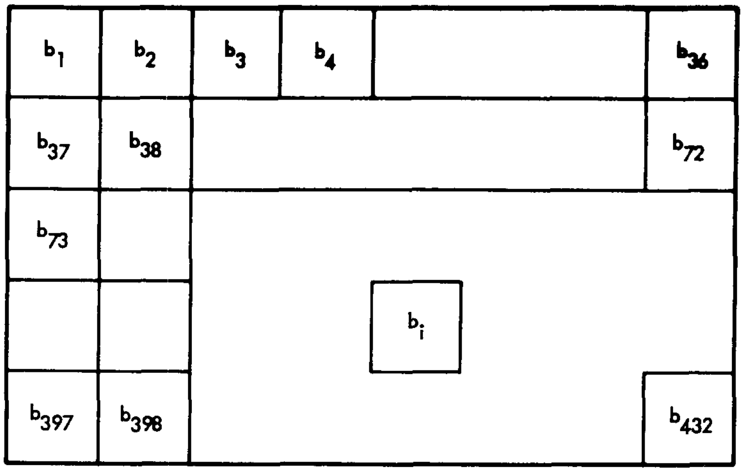
*3.2.1 Function. The Golay (24, 12) code, together with a K = 7, v = 1/2 convolutional code, is employed on MJS77 to construct a concatenated high rate data channel which simultaneously satisfies two different science data error rate requirements during planetary encounters. General science and engineering data is Golay coded prior to being time multiplexed with non-Golay coded imaging, high rate PRA or high rate PWS data. The performance of the code is such that, after being decoded, general science and engineering data will be delivered to the users with an error rate of $\leq 5 \times 10^{-5}$ even though the overall high rate data channel was operated at an error rate of 5×10^{-3}.

*3.2.2 Code Operation. The Golay (24, 12) code transforms a set of 12 data bits into a Golay code word comprised of 24 binary code symbols. The first 12 symbols of a Golay code word are identical to the 12 original data bits whereas the last 12 symbols of the Golay code word are a linear function of the 12 data bits. The code has the property that any combination of ≤ 3 symbol errors in a Golay code word can be exactly corrected and the occurrence of exactly 4 symbol errors can be unequivocally detected. [If > 4 symbol errors occur in a received Golay code word, the decoding process will, in general, produce additional symbol (and bit) errors.]

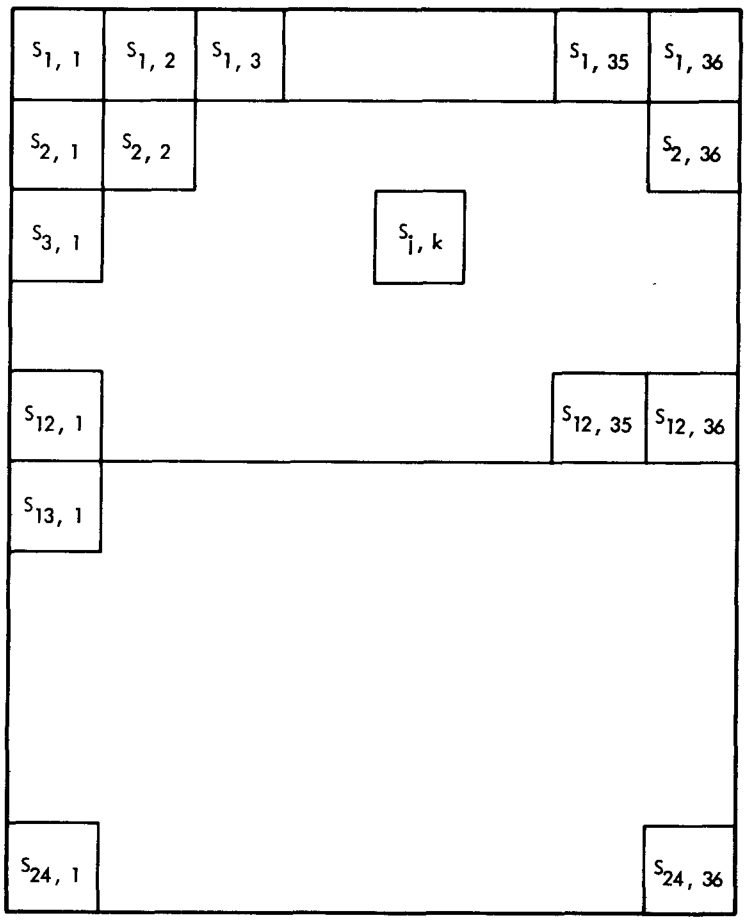
*3.2.3 Interleaving Depth. The MJS77 high rate channel design employs a K = 7, v = 1/2 convolutional code which is concatenated with the Golay code. The characteristics of the convolutional coding scheme are such that errors in the Golay code symbol stream tend to occur in bursts. For this reason, blocks of Golay code words (36 words per block) are interleaved on a bit-by-bit basis to provide increased protection against burst errors. This interleaving process is shown in Figure 3-3. Note that despite the interleaving process, the first 432 symbols of the Golay code block are identical to the original 432 data bits. The net effect of this interleaving process (referenced to as "interleaving to depth 36") is that the length of an error burst must be greater than 108 symbols before the error correction properties of the Golay code are exceeded.

***3.2.4 Bit Order**

All words in all formats are inserted into the telemetry stream MSB first. Bit 1 is MSB.



ORIGINAL (UNCODED) DATA SET



ASSOCIATED GOLAY CODE BLOCK

NOTES:

1. DATA SEQUENCE IS LEFT-TO-RIGHT BY TOP-TO-BOTTOM
2. b_i DENOTES THE i^{th} BIT IN A SEQUENCE OF 432 DATA BITS
3. $S_{j,k}$ DENOTES THE j^{th} CODE SYMBOL OF THE k^{th} CODE WORD OF AN 864 SYMBOL GOLAY CODE BLOCK

   (j TAKES ALL INTEGER VALUES FROM 1 TO 24 AND k TAKES ALL INTEGER VALUES FROM 1 TO 36)
4. EACH COLUMN IN THE GOLAY CODE BLOCK IS A GOLAY CODE WORD
5. THE FIRST 432 SYMBOLS OF THE GOLAY CODE BLOCK ARE IDENTICAL TO THE ORIGINAL DATA BITS:

   $S_{1,1} \equiv b_1$

   $S_{1,2} \equiv b_2$

   ⋮

   $S_{2,1} \equiv b_{37}$

   ETC

Figure 3-3. Golay Code Block Construction

4.0 ENGINEERING TELEMETRY

Engineering Telemetry is supplied at all times during the mission and is available through the low data rate channel (during planetary encounter periods) or through the high rate channel in the form of embedded frames within the science formats.

4.1 Engineering Data

Engineering data is composed of measurements taken from all subsystems to define the operational state and monitor the condition of the spacecraft. Data rates for engineering data are 10, 40, 1200 or 7200 (recorded) bps*. Operational mode and telecommunications link capability will determine the selection of data rate.

*4.1.1 Measurements

FDS provides inputs for 243 separate engineering measurements. Table 4-1 lists the engineering measurements by engineering number, function, and subsystem and indicates the engineering unit range.

*4.1.2 Formats

The structure of the engineering commutator is shown in Figure 4-1. This format structure provides positions for 230 8-bit telemetry words. Engineering data may be transmitted in 215 of these word positions. The format is arranged in 5 decks with the 100 deck having 60 word positions with 8 words used for FRID and 7 words used for subcommutated data. Subcommutation of data is provided by the 200 deck with 20 word positions, the 300 deck with 60 word positions, and the 400 deck with 60 word positions. In addition to these decks there is the A00/B00 deck with 30 positions utilized for AACS data only in engineering formats LN-40, LN-12, LN-72, CE-40, MC-40, MC-12, MC-72, MN-40, MN-12, MN-72, and EC-40.

Table 4-2 lists the engineering formats by function, mnemonic, and data rate. Tables 4-3 through 4-8, as identified below, show the commutator position assignments for each of the engineering telemetry measurements listed in Table 4-1.

Table 4-3	-	All Engineering Formats (referenced by E-No.)
Table 4-4	-	LN-40, LN-12, and LN-72 (referenced by deck position)
Table 4-5	-	CE-40 (as above)
Table 4-6	-	MC-40, MC-12, and MC-72 (as above)
Table 4-7	-	MN-40, MN-12, and MN-72 (as above)
Table 4-8	-	EC-40 (as above)

*Engineering data acquisition rate is 1200 bps; however, filler bits have been added to increase the rate to 7200 bps for DSS recording.

Δ* Table 4-1. Engineering Telemetry Measurements (sheet 1 of 13)

Measurement Number	Function	Sub-system	FDS Tree Switch	Eng Half	FDS Input	Eng Unit Range
	Structure					
E-000	Bay 1 Temp	001	67	A	0.35/0.7 V	-78/+100°C
E-001	Bay 2 Temp	001	D4	B	0.35/0.7 V	-78/+100°C
E-002	Bay 3 Temp	001	54	A	0.35/0.7 V	-78/+100°C
E-003	Bay 4 Temp	001	E4	B	0.35/0.7 V	-78/+100°C
E-004	Bay 5 Temp	001	64	A	0.35/0.7 V	-78/+100°C
E-005	Bay 6 Temp	001	F8	B	0.35/0.7 V	-78/+100°C
E-006	Bay 7 Temp	001	76	A	0.35/0.7 V	-78/+100°C
E-007	Bay 8 Temp	001	D5	B	0.35/0.7 V	-78/+100°C
E-008	Bay 9 Temp	001	77	A	0.35/0.7 V	-78/+100°C
E-009	Bay 10 Temp	001	F7	B	0.35/0.7 V	-78/+100°C
	Radio Frequency Subsystem					
E-020	RFS Status No. 1	002	06	A	Digital	–
E-021	RFS Status No. 2	002	8A	B	Digital	–
E-022	Receiver VCO Coarse Voltage	002	9A	B	0-3 V	±72.5 kHz
E-023	Receiver VCO Fine Voltage	002	2B	A	0-3 V	±25 kHz
E-024	Receiver AGC	002	3A	A	0-3 V	-70 to -150 dBm
E-025	*Receiver AGC	002	AA	B	0-3 V	-70 to -150 dBm
E-026	Receiver Ranging AGC V	002	C6	B	0-3 V	-70 to -150 dBm
E-027	Receiver Current	002	BA	B	0-3 V	0 to 200 mA
E-028	Receiver Local Oscillator Drive	002	4A	A	0-3 V	2 to 5 mW
E-029	Receiver VCO Temp	002	6C	A	0.35/0.7 V	-78/+100°C
E-030	USO Inner Oven Current	002	CA	B	0-3 V	0 to 50 mA

*Redundant measurement input to both FDS Commutator A and B tree switch.

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Δ *. Table 4-1. Engineering Telemetry Measurements (sheet 2 of 13)

Measurement Number	Function	Sub-system	FDS Tree Switch	Eng Half	FDS Input	Eng Unit Range
	Radio Frequency Subsystem (Contd)					
E-031	S-Band TWT/SSA Base Temp	002	7C	A	0.35/0.7 V	-78/+100°C
E-032	S-Band Hybrid Temp	002	DC	B	0.35/0.7 V	-78/+100°C
E-033	S-Band TWT/SSA Regulated Voltage	002	AC	B	0-3 V	3.54 to 25.85 V (TWT, XMT 1) -2.1 to 37.1 V (SSA, XMT 2)
E-034	S-Band Transmitter Drive	002	2D	A	0-3 V	14 to +8 dBm
E-035	S-Band TWT Cathode Current/SSA Input Current	002	3C	A	0-3 V	4.25 to 86.12 mA (TWT, XMT 1) 0.47 to 4.16 A (SSA, XMT 2)
E-036	S-Band TWT Helix Current	002	BC	A	0-3 V	1 to 20 mA
E-037	S-Band High Gain Antenna Drive	002	9C	B	0-3 V	30 to 43.5 dBm
E-038	S-Band Exciter Current	002	4C	A	0-3 V	0 to 100 mA
E-039	X-Band TWT Base Temp	002	FC	B	0.35/0.7 V	-78/+100°C
E-040	X-Band Hybrid Temp	002	5C	A	0.35/0.7 V	-77/+100°C
E-041	X-Band RF Monitor Temp	002	E7	B	0.35/0.7 V	-78/+100°C
E-042	X-Band Exciter Temp	002	DD	B	0.35/0.7 V	-78/+100°C
E-043	X-Band TWT Regulated Voltage	002	3B	A	0-3 V	.5 to 26.5 V
	X-Band TWT Helix Voltage*	002	3B	A	0-3 V	3401.5 to 4175.6 V
E-044	X-Band TWT Drive	002	9B	B	0-3 V	-2 to +6 dBm
E-045	X-Band TWT Helix Current	002	4B	A	0-3 V	1 to 8 mA (TWT 2, WJ) -0.241 to 5.67 mA (TWT 1, HAC, if flown)
E-046	X-Band TWT Cathode Current	002	AB	B	0-3 V	2.93 to 54.67 mA (TWT 2, WJ) 12.18 to 69.21 mA (TWT 1, HAC, if flown)
E-047	X-Band Exciter Current	002	BB	B	0-3 V	0 to 120 mA
E-048	X-Band High Gain Antenna Drive	002	2C	A	0-3 V	30 to 44 dBm
E-049	Transmitter RF Switch Temp	002	5D	A	0.35/0.7 V	-78/+110°C
E-050	Auxiliary Oscillator Temp	002	EC	B	0.35/0.7 V	-78/+100°C
E-051	Low Gain Antenna Drive	002	47	A	0-3 V	30 to 48.5 dBm

*Function if the Hughes Aircraft Alternate X-Band TWTA Assembly (2002 XB1) is flown.

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△ *Table 4-1. Engineering Telemetry Measurements (sheet 3 of 13)

Measurement Number	Function	Sub-system	FDS Tree Switch	Eng Half	FDS Input	Eng Unit Range
	Mod/Demod Subsystem					
E-060	MDS/FDS/PRA Status **(CDU/TMU Status)**	003	07	A	Digital	–
E-061	TMU Status 1	003	8B	B	Digital	–
E-062	TMU Status 2	003	8C	B	Digital	–
E-063	CDU SNR (Most Significant Byte)	003	0A	A	Digital	–
E-064	CDU SNR (Least Significant Byte)	003	0B	A	Digital	–
E-065	CDU Oscillator Monitor	003	87	B	Digital	–
	Power Subsystem					
E-070	2.4 kHz Inverter Input Current	004	C1	B	0-3 V	0 to 10 Adc
E-071	2.4 kHz Inverter Output Voltage	004	33	A	0-3 V	40 to 60 Vac
E-072	2.4 kHz Inverter Output Current	004	41	A	0-3 V	0 to 6 Aac
E-073	DC Bus Voltage	004	21	A	0-3 V	0 to 35 Vdc
E-074	DC Bus Current	004	36	A	0-3 V	0 to 10 Adc
E-075	Shunt Regulator Input Current	004	23	A	0-3 V	0 to 15 Adc
E-076	*2.4 kHz Inverter Input Current	004	46	A	0-3 V	0 to 10 Adc
E-077	*2.4 kHz Inverter Output Voltage	004	92	B	0-3 V	40 to 60 Vac
E-078	*2.4 kHz Inverter Output Current	004	B1	B	0-3 V	0 to 6 Aac
E-079	*DC Bus Voltage	004	C2	B	0-3 V	0 to 35 Vdc
E-080	*DC Bus Current	004	A6	B	0-3 V	0 to 10 Adc
E-081	*Shunt Regulator Input Current	004	96	B	0-3 V	0 to 15 Adc
E-082	**Shunt Regulator Temp**	004	6B	A	0.35/0.7 V	-78/+100°C
E-083	**Shunt Radiator Temp 1	004	73	A	0.35/0.7 V	-160/+240°C
E-084	**Shunt Radiator Temp 2	004	F3	B	0.35/0.7 V	-160/+240°C
E-085	RDM Voltage Monitor	004	32	A	0-3 V	0 to 50 Vdc

*Redundant measurement input to both FDS Commutator A and B tree switch.

**The temperature transducers for E-083 and E-084 are located at positions T/S1 and T/S4, respectively, for the S/N 003 (DTM), 004 (Flt 1), and 006 (PTM) shunt radiators. (See Figure 04-2, pg. 04-12, 618-505, Vol. IV, Sec IV). For the S/N 005 (Flt 2) radiator, E-083 and E-084 are located at positions T/S 3 and T/S 2, respectively. (See Figure 04-3, pg. 04-13, 618-505, Vol. IV, Sec. IV). △

Δ * Table 4-1. Engineering Telemetry Measurements (sheet 4 of 13)

Measurement Number	Function	Sub-system	FDS Tree Switch	Eng Half	FDS Input	Eng Unit Range
	Power Subsystem (Contd)					
E-100	RTG 1 Output Voltage	004	3D	A	0-3 V	0 to 35 Vdc
E-101	RTG 2 Output Voltage	004	90	B	0-3 V	0 to 35 Vdc
E-102	RTG 3 Output Voltage	004	49	A	0-3 V	0 to 35 Vdc
E-103	RTG 1 Output Current	004	A0	B	0-3 V	0 to 10 Adc
E-104	RTG 2 Output Current	004	40	A	0-3 V	0 to 10 Adc
E-105	RTG 3 Output Current	004	B0	B	0-3 V	0 to 10 Adc
E-106	*RTG 1 Output Current	004	20	A	0-3 V	0 to 10 Adc
E-107	*RTG 2 Output Current	004	91	B	0-3 V	0 to 10 Adc
E-108	*RTG 3 Output Current	004	30	A	0-3 V	0 to 10 Adc
E-109	RTG 1 Case Temp 3	004	5A	A	0.35/0.7 V	-9/+301°C
E-110	RTG 1 Case Temp 2	004	DA	B	0.35/0.7 V	-9/+301°C
E-111	RTG 2 Case Temp 1	004	6A	A	0.35/0.7 V	-9/+301°C
E-112	RTG 2 Case Temp 3	004	EA	B	0.35/0.7 V	-9/+301°C
E-113	RTG 3 Case Temp 1	004	7A	A	0.35/0.7 V	-9/+301°C
E-114	RTG 3 Case Temp 2	004	FA	B	0.35/0.7 V	-9/+301°C
E-115	Battery Temp	004	EB	B	0.35/0.7 V	-78/+100°C
E-245	FDS/PWR/Pyro Status (2.4 kHz Inv Status)	004	09	A	Digital	–
	Computer Command Subsystem					
E-130	CCS Output 1	005	04	A	Digital	–
E-131	CCS Output 2	005	05	A	Digital	–
E-132	*CCS Output 1	005	84	B	Digital	–
E-133	*CCS Output 2	005	85	B	Digital	–

*Redundant measurement input to both FDS Commutator A and B tree switch.

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Table 4-1. Engineering Telemetry Measurements (sheet 5 of 13)

Measurement Number	Function	Sub-system	FDS ID	Eng Half	FDS Input	Eng Unit Range
	Flight Data Subsystem					
E-140	FDS Status 1	006	8E	B	Digital	–
E-141	FDS Status 2	006	16	A	Digital	–
E-142	FDS Status 3	006	17	A	Digital	–
E-143	FDS Status 4	006	8D	B	Digital	–
E-144	FDS Status 5	006	15	A	Digital	–
E-145	FDS Status 6	006	8F	B	Digital	–
E-146	FDS Memory Word	006	08	A	Digital	
E-060	MDS/FDS/PRA Status (4.8 kHz A/B Status)	006	07	A	Digital	–
E-245	FDS/PWR/Pyro Status (FDS ID)	006	09	A	Digital	–
E-150	FDS Selected Source Voltage	006	25	A	0-3 V	*
E-151	FDS 30 V Inverter Output Voltage	006	45	A	0-3 V	0 to +14.84 V
E-152	FDS 10 V Bus Voltage	006	B5	B	0-3 V	0 to 15.0 V
E-153	FDS Power Converter A + 10 Current	006	35	A	0-3 V	0 to 1.14 A
E-154	FDS Power Converter B + 10 Current	006	**A5**	**B**	**0-3 V**	**0 to 1.14A**
E-155	FDS +3 V ADC A Voltage	006	A8	B	0-3 V	0 to 6.03 V
E-156	FDS +3 V ADC B Voltage	006	28	A	0-3 V	0 to 6.03 V
E-157	FDS Timing +5 Vdc	006	C5	B	0-3 V	0 to 7.45 V
E-160	Frame Sync Code	006	–	–	Digital	–
E-161	Frame Sync Code	006	–	–	Digital	–
E-162	Frame Sync Code	006	–	–	Digital	–
E-163	Frame Sync Code	006	–	–	Digital	–
E-164	Format ID Word	006	–	–	Digital	–
E-165	Mod 16 Counter	006	–	–	Digital	–
E-166	Mod 60 and Line Count	006	–	–	Digital	–
E-167	Line Count	006	–	–	Digital	–
	Attitude and Articulation Control Subsystem					
E-170	AACS Output A	007	01	A	Digital	–
E-171	AACS Output B	007	82	B	Digital	–

*Measurement	-3 V	-12 V	+12 V	+5 V	+10 VA	+10 VB	+10 VM	+10 VL
Engr Unit Range	-5.98 to 0 V	-19.44 to 0 V	0 to +17.85 V	0 to +7.47 V	0 to +14.88 V	0 to +14.88 V	0 to +14.88 V	0 to +14.88 V

Δ* Table 4-1. Engineering Telemetry Measurements (sheet 6 of 13)

Measurement Number	Function	Sub-system	AACS Mem Location (Octal)	Eng Half	FDS Input	Eng Unit Range
	Attitude and Articulation Control Subsystem (Contd)					
E-172	Pitch Gyro Accumulated Position	007	01	**	Digital	–
E-173	Power Code Queue Overflow Counter	007	02	**	Digital	–
E-174	Pitch Sun Sensor Position	007	03	**	Digital	–
E-175	Pitch Calculated Rate	007	04	**	Digital	–
E-176	Pitch Estimated Position	007	05	**	Digital	–
E-177	Pitch Sun Sensor Bias Angle, Fine	007	06	**	Digital	–
E-178	Pitch Sun Sensor Bias Angle, Coarse	007	07	**	Digital	–
E-179	Yaw Gyro Accumulated Position	007	10	**	Digital	–
E-180	Bad Parity Counter	007	11	**	Digital	–
E-181	Yaw Sun Sensor Position	007	12	**	Digital	–
E-182	Yaw Calculated Rate	007	13	**	Digital	–
E-183	Yaw Estimated Position	007	14	**	Digital	–
E-184	Yaw Sun Sensor Bias Angle, Fine	007	15	**	Digital	–
E-185	Yaw Sun Sensor Bias Angle, Coarse	007	16	**	Digital	–
E-186	Roll Gyro Accumulated Position	007	17	**	Digital	–
E-188	Roll Canopus Star Tracker Intensity	007	21	**	Digital	–
E-189	Roll Canopus Star Tracker Position	007	22	**	Digital	–
E-190	Roll Calculated Rate	007	23	**	Digital	–
E-191	Roll Estimated Position	007	24	**	Digital	–
E-192	Scan Platform Azimuth Position, Coarse	007	25	**	Digital	–
E-193	Scan Platform Azimuth Position, Fine	007	26	**	Digital	–
E-194	Scan Platform Elevation Position, Coarse	007	27	**	Digital	–
E-195	Scan Platform Elevation Position, Fine	007	30	**	Digital	–
E-196	Pitch/Yaw Sun Sensor Intensity	007	31	**	Digital	–
E-197	Roll Canopus Star Tracker Cone Angle	007	32	**	Digital	–

**AACS Note: For Commutator A use FDS ID number 01.
For Cummutator B use FDS ID number 82.

E-187, E-198, E-199, and E-229 (AACS memory locations 20, 33, 34, and 00) are unused; it is intended that location 00 never be used.

△* Table 4-1. Engineering Telemetry Measurements (sheet 7 of 13)

Measurement Number	Function	Sub-system	AACS Mem Location (Octal)	Eng Half	FDS Input	Eng Unit Range
	Attitude and Articulation Control Subsystem (Contd)					
E-200	AACS Status Word 1	007	35	**	Digital	–
E-201	AACS Status Word 2	007	36	**	Digital	–
E-202	AACS Status Word 3	007	37	**	Digital	–
E-203	AACS Status Word 4	007	40	**	Digital	–
E-204	AACS Status Word 5 (Mode Status)	007	41	**	Digital	–
E-205	AACS Status Word 6 (Gyro Status)	007	42	**	Digital	–
E-206	Configuration Register 1 (1st)	007	43	**	Digital	–
E-207	Configuration Register 1 (2nd)	007	44	**	Digital	–
E-208	Configuration Register 1 (3rd)	007	45	**	Digital	–
E-209	Pos. Pitch AP Valve Pulse Counter Value	007	46	**	Digital	–
E-210	Neg. Pitch AP Valve Pulse Counter Value	007	47	**	Digital	–
E-211	Pos. Yaw AP Valve Pulse Counter Value	007	50	**	Digital	–
E-212	Neg. Yaw AP Valve Pulse Counter Value	007	51	**	Digital	–
E-213	AACS/FDS Subsystem Health Check	007	52	**	Digital	–
E-214	Pos. Roll AP Valve Pulse Counter Value	007	53	**	Digital	–
E-215	Neg. Roll AP Valve Pulse Counter Value	007	54	**	Digital	–
E-216	Pos. Pitch TCM Valve Pulse Counter Value	007	55	**	Digital	–
E-217	Neg. Pitch TCM Valve Pulse Counter Value	007	56	**	Digital	–
E-218	Pos. Yaw TCM Valve Pulse Counter Value	007	57	**	Digital	–
E-219	Neg. Yaw TCM Valve Pulse Counter Value	007	60	**	Digital	–
E-220	Configuration Register 2 (1st)	007	61	**	Digital	–
E-221	Configuration Register 2 (2nd)	007	62	**	Digital	–
E-222	Configuration Register 2 (3rd)	007	63	**	Digital	–
E-223	AACS Spare	007	64	**	Digital	(Always 0)
E-224	Pitch Estimated Acceleration	007	65	**	Digital	–
E-225	Yaw Estimated Acceleration	007	66	**	Digital	–
E-226	Roll Estimated Acceleration	007	67	**	Digital	–
E-227	Cycle Error Counter	007	70	**	Digital	–
E-228	Interrupt 1 Counter	007	71	**	Digital	–

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Δ* Table 4-1. Engineering Telemetry Measurements (sheet 8 of 13)

Measurement Number	Function	Sub-system	FDS ID	Eng Half	FDS Input	Eng Unit Range
	Attitude and Articulation Control Subsystem (Contd)					
E-230	Gyro A Temp	007	56	A	0.35/0.7 V	-78/+100°C
E-231	Gyro B Temp	007	FD	B	0.35/0.7 V	-78/+100°C
E-232	Gyro C Temp	007	7D	A	0.35/0.7 V	-78/+100°C
E-233	Canopus Star Tracker 1 Temp	007	65	A	0.35/0.7 V	-78/+100°C
E-234	Canopus Star Tracker 2 Temp	007	E5	B	0.35/0.7 V	-78/+100°C
E-235	Scan Azimuth Temp	007	D6	B	0.35/0.7 V	-78/+100°C
E-236	Sun Sensor Temp	007	78	A	0.35/0.7 V	-78/+100°C
E-750	Memory Access Module (MAM) Readout	007	00	A	Digital	—
			AACS Mem Location (Optical)			
E-237	Memory Readout Address 1 (zeros)	007	72	**	Digital	(Always 0)
E-238	Memory Readout Address 2 (bits 9-12)	007	73	**	Digital	—
E-239	Memory Readout Address 3 (bits 1-8)	007	74	**	Digital	—
E-240	Memory Readout Data 1 (bits 17-18)	007	75	**	Digital	—
E-241	Memory Readout Data 2 (bits 9-16)	007	76	**	Digital	—
E-242	Memory Readout Data 3 (bits 1-8)	007	77	**	Digital	—
			FDS ID			
	Pyrotechnic Subsystem					
E-245	FDS/PWR/PYRO Status (PYRO Amps Ind)	008	09	A	Digital	—
E-246	Capacitor Bank A Voltage	008	39	A	0-3 V	0 to 45 Vdc
E-247	Capacitor Bank B Voltage	008	A9	B	0-3 V	0 to 45 Vdc
	Propulsion Subsystem					
E-270	Helium Pressure	010	24	A	0-3 V	0 to 500 psia
E-271	TCAPU N2H4 Pressure Branch 1	010	94	B	0-3 V	0 to 500 psia
E-272	TCAPU +Pitch TCM Thruster Chamber P	010	34	A	0-3 V	0 to 350 psia
E-273	TCAPU -Pitch TCM Thruster Chamber P	010	A4	B	0-3 V	0 to 350 psia
E-274	TCAPU +Yaw TCM Thruster Chamber P	010	44	A	0-3 V	0 to 350 psia

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Δ* Table 4-1. Engineering Telemetry Measurements (sheet 9 of 13)

Measurement Number	Function	Sub-system	FDS ID	Eng Half	FDS Input	Eng Unit Range
	Propulsion Subsystem (Contd)					
E-275	TCAPU -Yaw TCM Thruster Chamber P	010	B4	B	0-3 V	0 to 350 psia
E-276	+Pitch Thruster 1/+A Eng 1 Chamber P (MS Byte)	010	0C	A	Digital	–
E-277	+Pitch Thruster 1/+A Eng 1 Chamber P (LS Byte)	010	0D	A	Digital	–
E-278	-Pitch Thruster 1/-A Eng 1 Chamber P (MS Byte)	010	0E	A	Digital	–
E-279	-Pitch Thruster 1/-A Eng 1 Chamber P (LS Byte)	010	0F	A	Digital	–
E-280	+Yaw Thruster 1/+B Eng 2 Chamber P (MS Byte)	010	80	B	Digital	–
E-281	+Yaw Thruster 1/+B Eng 2 Chamber P (LS Byte)	010	81	B	Digital	–
E-282	+Roll Thruster 1/-B Eng 2 Chamber P (MS Byte)	010	83	B	Digital	–
E-283	+Roll Thruster 1/-B Eng 2 Chamber P (LS Byte)	010	86	B	Digital	–
E-284	+Pitch Thruster 2 Temp	010	51	A	0.35/0.7 V	-73/+765°C
E-285	-Pitch Thruster 2 Temp	010	E1	B	0.35/0.7 V	-73/+765°C
E-286	-Yaw Thruster 1 Temp	010	D1	B	0.35/0.7 V	-73/+765°C
E-287	+Yaw Thruster 2 Temp	010	61	A	0.35/0.7 V	-73/+765°C
E-288	-Yaw Thruster 2 Temp	010	F1	B	0.35/0.7 V	-73/+765°C
E-289	-Roll Thruster 1 Temp	010	52	A	0.35/0.7 V	-73/+765°C
E-290	+Roll Thruster 2 Temp	010	71	A	0.35/0.7 V	-73/+765°C
E-291	-Roll Thruster 2 Temp	010	D2	B	0.35/0.7 V	-73/+765°C
E-292	TCAPU Surface Temp 1	010	7B	A	0.35/0.7 V	-78/+100°C
E-293	TCAPU Surface Temp 2	010	F4	B	0.35/0.7 V	-78/+100°C
E-294	TCAPU Tank Temp 1	010	6D	A	0.35/0.7 V	-78/+100°C
E-295	TCAPU Tank Temp 2	010	E8	B	0.35/0.7 V	-78/+100°C
E-296	TCAPU Feed System Temp 1	010	68	A	0.35/0.7 V	-78/+100°C
E-297	TCAPU Feed System Temp 2	010	FB	B	0.35/0.7 V	-78/+100°C
E-298	Isolation Valve Position BR 1	010	C8	B	0-3 V	–
E-299	Isolation Valve Position BR 2	010	C9	B	0-3 V	–
E-300	IPU Solid Motor Chamber Pressure	010	C3	B	0-3 V	0 to 1200 psia
E-301	*IPU Solid Motor Chamber Pressure	010	22	A	0-3 V	-31/+398°C
E-302	IPU +Roll Engine 1 Temp	010	50	A	0.35/0.7 V	-31/+398°C

* Redundant measurement input to both FDS Commutator A and B tree switch.

Δ * Table 4-1. Engineering Telemetry Measurements (sheet 10 of 13)

Measurement Number	Function	Sub-system	FDS ID	Eng Half	FDS Input	Eng Unit Range
	Propulsion Subsystem (Contd)					
E-303	IPU -Roll Engine 1 Temp	010	D0	B	0.35/0.7 V	-31/+398°C
E-304	IPU +Roll Engine 2 Temp	010	60	A	0.35/0.7 V	-31/+398°C
E-305	IPU -Roll Engine 2 Temp	010	E0	B	0.35/0.7 V	-31/+398°C
E-306	IPU Line Temp 1	010	75	A	0.35/0.7 V	-78/+100°C
E-307	IPU Line Temp 2	010	F5	B	0.35/0.7 V	-78/+100°C
E-308	IPU Solid Motor Temp 1	010	5E	A	0.35/0.7 V	-78/+100°C
E-309	IPU Solid Motor Temp 2	010	DE	B	0.35/0.7 V	-78/+100°C
	Temperature Control Subsystem					
E-320	SCI Plume Shield Temp 1	011	E2	B	0.35/0.7 V	-75/+800°C
E-321	SCI Plume Shield Temp 2	011	F0	B	0.35/0.7 V	-75/+800°C
	Mechanical Devices Subsystem					
E-330	Science Latch Pressure	012	B9	B	0-3 V	0 to 3000 psia
E-331	Devices/Cabling Status	012	02	A	Digital	—
	Data Storage Subsystem					
E-340	DSS Motor Voltage	016	2A	A	0-3 V	-6 to +6V
E-341	DSS Transport Pressure	016	99	B	0-3 V	0 to 30 psia
E-342	Mode Status	016	88	B	Digital	—
E-343	Playback Status	016	89	B	Digital	—
	S/X Band Antenna Subsystem					
E-350	HGA Main Reflector Temp	017	63	A	0.35/0.7 V	-225/+120°C
E-351	(Disconnected)					
E-352	HGA X-Band Feed Horn Temp	017	F2	B	0.35/0.7 V	-225/+120°C
E-353	(Disconnected)					

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△✻ Table 4-1. Engineering Telemetry Measurements (sheet 11 of 13)

Measurement Number	Function	Sub-system	FDS Tree Switch	Eng Half	FDS Input	Eng Unit Range
	<u>Cosmic Ray Subsystem</u>					
E-360	CRS Analog Data	021	29	A	0-3 V	†
E-361	CRS Electronics Temp	021	57	A	0.35/0.7 V	-78/+100°C
E-362	CRS Telescope Temp	021	D7	B	0.35/0.7 V	-78/+100°C
	<u>PRA Subsystem</u>					
E-410	PRA Analog Data	022	2E	A	0-3 V	†
E-411	PRA Electronics Temp	022	DB	B	0.35/0.7 V	-78/+100°C
E-060	MDS/FDS/PRA Status (PRA Ant A/B Deploy)	022	07	A	Digital	—
	<u>Plasma Wave Subsystem</u>					
E-430	PWS Analog Output A	023	42	A	0-3 V	0 to 3V
E-431	*PWS Analog Output A	023	95	B	0-3 V	0 to 3V
E-432	PWS Analog Output B	023	A3	B	0-3 V	0 to 3V
E-433	*PWS Analog Output B	023	31	A	0-3 V	0 to 3V
E-434	PWS Power Supply Voltage	023	93	B	0-3 V	0 to 3V
E-435	PWS Temp	023	58	A	0.35/0.7 V	-78/+100°C
	<u>LECP Subsystem</u>					
E-450	LECP Analog Engineering Data	025	98	B	0-3 V	†
E-451	LECP Analog Calibration Data	025	48	A	0-3 V	†
E-452	(Disconnected)					
E-453	LECP LEMPA Tel Temp	025	66	A	0.35/0.7 V	-78/+100°C

*Redundant measurement input to both FDS Commutator A and B tree switch.
†See individual multiplexer measurements.

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Δ * Table 4-1. Engineering Telemetry Measurements (sheet 12 of 13)

Measurement Number	Function	Sub-system	FDS Tree Switch	Eng Half	FDS Input	Eng Unit Range
	Photopolarimeter Subsystem					
E-600	PPS Optics Temp	027	26	A	0-3 V	-40/+45°C
E-601	PPS Aperture Position	027	9E	B	0-3 V	0 to 3V
E-602	PPS Analyzer Position	027	3E	A	0-3 V	0 to 3V
E-603	PPS Filter Position	027	AE	B	0-3 V	0 to 3V
E-604	PPS HVPS Monitor	027	4E	A	0-3 V	0 to 3V
E-605	PPS LVPS Monitor	027	CE	B	0-3 V	0 to 3V
E-606	PPS Solar Sensor	027	BE	B	0-3 V	0 to 3V
E-607	PPS Electronics Temp Transducer	027	D8	B	0.35/0.7 V	-78/+100°C
	Plasma Subsystem					
E-620	PLS Analog Multiplexer Output	032	A2	B	0-3 V	†
E-621	PLS Electronics Temp	032	F6	B	0.35/0.7 V	-78/+100°C
E-622	PLS Sensor Temp	032	70	A	0.35/0.7 V	-225/+150°C
E-623	PLS Modulator Temp	032	[illegible]B	A	0.35/0.7 V	-78/+100°C
	UVS Subsystem					
E-640	UVS Temp	034	55	A	0.35/0.7 V	-78/+100°C
E-641	UVS High Voltage Monitor	034	CD	B	0-3 V	0 to 3000V
	Magnetometer Subsystem					
E-660	MAG Analog Multiplexer Output	035	38	A	0-3 V	†
E-661	MAG OB LFM Sensor Temp	035	6E	A	0.35/0.7 V	-78/+60°C
E-662	MAG IB LFM Sensor Temp	035	EE	B	0.35/0.7 V	-78/+60°C
E-663	MAG OB HFM Sensor Temp	035	7E	A	0.35/0.7 V	-78/+60°C
E-664	MAG IB HFM Sensor Temp	035	FE	B	0.35/0.7 V	-78/+60°C

† See individual multiplexer measurements (618-505, Vol. IV, Sec. IV)

Δ* Table 4-1. Engineering Telemetry Measurements (sheet 13 of 13)

Measurement Number	Function	Sub-system	FDS ID	Eng Half	FDS Input	Eng Unit Range
	Imaging Science Subsystem					
E-680	ISS NA Analog Engr TLM	036	43	A	0-3 V	†
E-681	ISS WA Analog Engr TLM	036	B3	B	0-3 V	†
E-682	ISS NA Vidicon Temp	036	F9	B	0.35/0.7 V	-78/+100°C
E-683	ISS WA Vidicon Temp	036	69	A	0.35/0.7 V	-78/+100°C
E-684	ISS NA Front Optics Temp	036	D9	B	0.35/0.7 V	-78/+100°C
E-685	ISS NA Rear Optics Temp	036	59	A	0.35/0.7 V	-78/+100°C
E-686	ISS WA Optics Temp	036	79	A	0.35/0.7 V	-78/+100°C
E-687	ISS NA Power Supply Temp	036	74	A	0.35/0.7 V	-78/+100°C
E-688	ISS WA Power Supply Temp	036	E9	B	0.35/0.7 V	-78/+100°C
	MIRIS Subsystem					
E-710	MIRIS Radiometer Analog	039	4D	A	0-3 V	0 to 3V
E-711	MIRIS Radiometer High Gain Analog	039	BD	B	0-3 V	0 to 3V
E-712	MIRIS Primary Mirror Temp	039	D3	B	0.35/0.7 V	-148/+45°C
E-713	MIRIS Primary Mirror Heater Analog	039	A7	B	0-3 V	0 to 5.73W
E-714	MIRIS Secondary Mirror Temp	039	62	A	0.35/0.7 V	-148/+45°C
E-715	MIRIS Secondary Mirror Heater Analog	039	27	A	0-3 V	0 to 2.12W
E-716	MIRIS Radiating Surface Temp	039	53	A	0.35/0.7 V	-148/+45°C
E-717	MIRIS Radiating Surface Heater Analog	039	37	A	0-3 V	0 to 3.0W
E-718	MIRIS Electronics Temp	039	ED	B	0.35/0.7 V	-78/+100°C
E-719	MIRIS Neon Analog	039	97	B	0-3 V	0 to 14.7 Vpp
E-720	MIRIS Standby Supply Status	039	C0	B	0-3 V	0 to 3V
	Attitude and Articulation Control Subsystem (Contd)					
E-750	Memory Access Module (MAM) Readout	007	00	A	Digital	—

† See individual multiplexer measurements (618-505, Vol. IV, Sec. IV)

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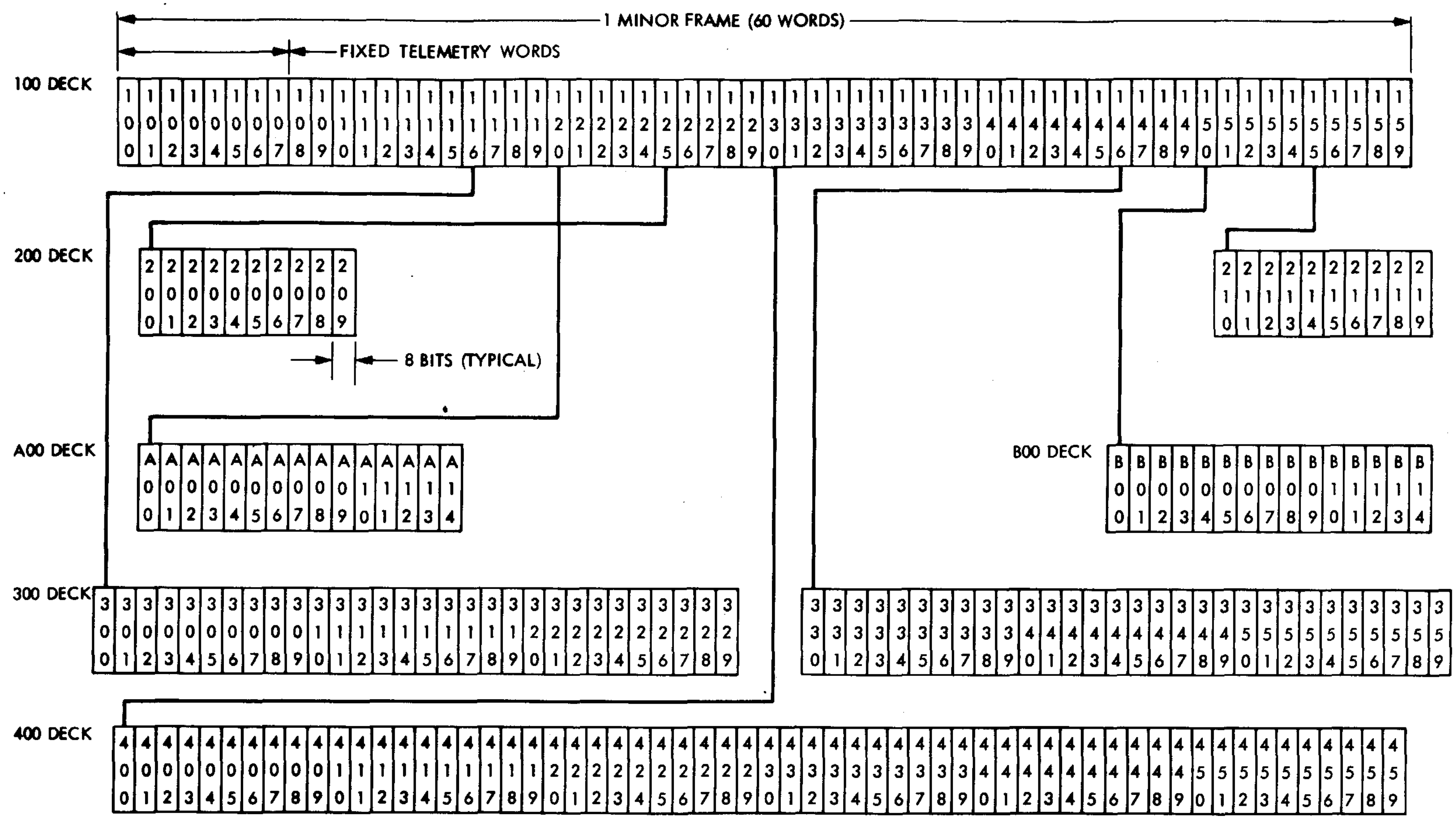


DECK CYCLE TIMES

ENGR RATE (bps)	100	200	A00 B00	300	400
10	48s	8m	12m	24m	48m
40	12s	2m	3m	6m	12m
1200	0.4s	4s	6s	12s	24s

WORD RATE RATIOS

100's EVERY MINOR FRAME 200's EVERY 10 MINOR FRAMES A00/B00's EVERY 15 MINOR FRAMES 300's EVERY 30 MINOR FRAMES 400's EVERY 60 MINOR FRAMES

Figure 4-1. MJS77 Engineering Telemetry Format Structure

✱ Table 4-2. Engineering Formats

Function	Mnemonic	Data Rate (bps)
High Rate Launch Engineering to MDS	LN-12	1200
High Rate Launch Engineering to DSS	LN-72	7200 (Recorded)*
Low Rate Launch Engineering	LN-40	40
Cruise Engineering	CE-40	40
High Rate Modified Cruise Engineering to MDS	MC-12	1200
High Rate Modified Cruise Engineering to DSS	MC-72	7200 (Recorded)*
Low Rate Modified Cruise Engineering	MC-40	40
High Rate TCM Engineering to MDS	MN-12	1200
High Rate TCM Engineering to DSS	MN-72	7200 (Recorded)*
Low Rate TCM Engineering	MN-40	40
Encounter Engineering	EC-40	40
Low Rate FDS Memory Readout	FD-40	40
Low Rate CCS Memory Readout	CC-40	40
Low Rate AACS Memory Readout	AA-40	40
High Rate FDS Memory Readout	FD-12	1200
High Rate CCS Memory Readout	CC-12	1200
High Rate AACS Memory Readout	AA-12	1200

*Data is the same as LN-12, MC-12, or MN-12 except filler has been added to increase rate to 7200 bps for DSS recording requirement.

4.1.3 Data Frames

A minor frame (MF) of engineering data is defined as one complete scan of the 100 deck. A major frame of engineering data is defined as one complete scan of all subcommutated data (excluding science multiplexer measurements described in paragraph 4.3.2).

△✱ Table 4-3. MJS77 Engineering Telemetry Format (sheet 1 of 9)

E NO.	FUNCTION	SUBSYS	FDS ID	ENG HALF	LN40 LN12 LN72	CE40	MC40 MC12 MC72	MN40 MN12 MN72	EC40	CMNTS
	STRUCTURE SUBSYSTEM									
E 000	BAY 1T	001	67	A	400	400	400	400	400	
001	BAY 2T	001	D4	B	401	401	401	401	401	
002	BAY 3T	001	54	A	402	402	402	402	402	
003	BAY 4T	001	E4	B	403	403	403	403	403	
004	BAY 5T	001	64	A	404	404	404	404	404	
005	BAY 6T	001	F8	B	405	405	405	405	405	
006	BAY 7T	001	76	A	406	406	406	406	406	
007	BAY 8T	001	D5	B	407	407	407	407	407	
008	BAY 9T	001	77	A	408	408	408	408	408	
009	BAY 10T	001	F7	B	409	409	409	409	409	
	RADIO FREQUENCY SUBSYSTEM									
020	RFS ST1	002	06	A	348	343	343	344	344	
021	RFS ST2	002	8A	B	349	344	344	345	345	
022	VCO C V	002	9A	B	121	121	121	121	121	
023	VCO F V	002	2B	A	216	122	122	122	122	*
024	RCV AGC	002	3A	A	127	127	127	127	127	
025	RCV AGC	002	AA	B	-	-	-	-	-	REDUND
026	RNG AGC V	002	C6	B	-	133	133	128	133	
027	RCV I	002	BA	B	213	137	137	137	137	*
028	LOC OSC D	002	4A	A	413	330	330	413	413	
029	RCV VCO T	002	6C	A	414	414	414	414	414	
030	USO OV I	002	CA	B	302	302	131	302	302	
031	S XMT BT	002	7C	A	415	415	415	415	415	*
032	S HYB T	002	DC	B	416	416	416	416	416	
033	S XMT V	002	AC	B	417	319	319	417	417	*
034	S XMT DR	002	2D	A	200	140	140	131	140	*
035	S XMT I	002	3C	A	131	448	448	333	330	*
036	S HELIX I	002	BC	B	419	419	419	419	419	
037	S HGA DR	002	9C	B	-	142	142	134	142	
038	S EXC I	002	4C	A	157	143	143	343	343	
039	X TWT BT	002	FC	B	-	420	420	-	420	*
040	X HYB T	002	5C	A	-	421	421	-	421	
041	X RFM T	002	E7	B	-	422	422	-	422	
042	X EXC T	002	DD	B	-	423	423	-	423	
043	X TWT V	002	3B	A	-	426	426	-	312	
044	X TWT DR	002	9B	B	-	351	351	-	139	
045	X HELIX I	002	4B	A	-	359	359	-	359	
046	X CAT I	002	AB	B	-	427	427	-	352	
047	X EXC I	002	BB	B	-	428	428	-	311	
048	X HGA DR	002	2C	A	-	300	300	-	143	
049	TRF SW T	002	5D	A	429	429	429	429	429	
050	AUX OSC T	002	EC	B	430	430	430	430	430	
051	LGA DR	002	47	A	136	136	136	136	-	
	MOD/DEMOD SUBSYSTEM									
060	MFP ST	003	07	A	124	124	124	124	124	
061	TMU ST1	003	8B	B	308	356	356	315	348	
062	TMU ST2	003	8C	B	309	357	357	316	349	

Δ✱Table 4-3. MJS77 Engineering Telemetry Format (sheet 2 of 9)

E NO.	FUNCTION	SUBSYS	FDS ID	ENG HALF	LN40 LN12 LN72	CE40	MC40 MC12 MC72	MN40 MN12 MN72	EC40	CMNTS
063	CDU SNR M	003	0A	A	-	-	151	-	-	
							157			
064	CDU SNR L	003	0B	A	-	-	152	-	-	
							158			
065	CDU OSC M	003	87	B	-	-	-	-	452	*
	POWER SUBSYSTEM									
070	INV IN I	004	C1	B	115	139	139	139	216	
071	2.4 INV V	004	33	A	300	109	109	109	109	*
072	2.4 INV I	004	41	A	110	110	110	110	110	
073	DC BUS V	004	21	A	112	112	112	112	112	
074	DC BUS I	004	36	A	109	115	115	115	115	*
075	SHUNT I	004	23	A	113	113	113	113	113	
076	INV IN I	004	46	A	447	-	-	452	-	REDUND
077	2.4 INV V	004	92	B	450	-	-	154	-	REDUND
078	2.4 INV I	004	B1	B	312	-	-	151	-	REDUND
					344					REDUND
					448					REDUND
079	DC BUS V	004	C2	B	452	-	-	206	-	REDUND
								218		REDUND
080	DC BUS I	004	A6	B	331	-	-	133	-	REDUND
								202		REDUND
081	SHUNT I	004	96	B	334	-	-	152	-	REDUND
					426					REDUND
082	SHNT RG T	004	6B	A	431	431	431	431	431	
083	RAD T1	004	73	A	432	432	432	432	432	
084	RAD T2	004	F3	B	433	433	433	433	433	
085	RDM V	004	32	A	122	-	-	-	-	
100	RTG 1V	004	3D	A	353	353	353	353	353	
101	RTG 2V	004	90	B	354	354	354	354	354	
102	RTG 3V	004	49	A	355	355	355	355	355	
103	RTG 1I	004	A0	B	323	323	323	323	323	
104	RTG 2I	004	40	A	324	324	324	324	324	
105	RTG 3I	004	B0	B	325	325	325	325	325	
106	RTG 1I	004	20	A	-	-	-	-	-	REDUND*
107	RTG 2I	004	91	B	-	-	-	319	-	REDUND
108	RTG 3I	004	30	A	-	-	-	359	-	REDUND
109	RTG 1T3	004	5A	A	306	306	306	306	306	
110	RTG 1T2	004	DA	B	307	307	307	307	307	
111	RTG 2T1	004	6A	A	326	326	302	326	326	
112	RTG 2T3	004	EA	B	327	327	-	327	327	
113	RTG 3T1	004	7A	A	346	346	-	346	346	
114	RTG 3T2	004	FA	B	347	347	-	347	347	
115	BAT T	004	EB	B	328	-	-	-	-	
	COMPUTER COMMAND SUBSYSTEM									
130	CCS OUT 1	005	04	A	118	118	118	118	118	
131	CCS OUT 2	005	05	A	119	119	119	119	119	
132	CCS OUT 1	005	84	B	-	-	-	-	-	REDUND*
133	CCS OUT 2	005	85	B	-	-	-	-	-	REDUND*

Δ✻Table 4-3. MJS77 Engineering Telemetry Format (sheet 3 of 9)

FLIGHT DATA SUBSYSTEM

E NO.	FUNCTION	SUBSYS	FDS ID	ENG HALF	LN40 LN12 LN72	CE40	MC40 MC12 MC72	MN40 MN12 MN72	EC40	CMNTS
140	FDS ST1	006	8E	B	337	442	442	442	442	
141	FDS ST2	006	16	A	338	443	443	443	443	
142	FDS ST3	006	17	A	339	444	444	444	444	
143	FDS ST4	006	8D	B	340	445	445	445	445	
144	FDS ST5	006	15	A	341	446	446	446	446	
145	FDS ST6	006	8F	B	342	447	447	447	447	
146	FDS M WD	006	08	A	137	158	134	318	136	*
150	SEL 50 V	006	25	A	427	-	326	451	-	*
151	30V INV	006	45	A	350	-	327	331	-	*
152	10V BUS	006	B5	B	351	-	346	332	-	*
153	PWR CON A	006	35	A	311	453	453	351	212	*
154	PWR CON B	006	A5	B	418	-	-	309	-	
155	3V ADC A	006	A8	B	303	303	303	303	303	
156	3V ADC B	006	28	A	304	304	304	304	304	
157	5V TIME	006	C5	B	428	-	347	358	-	

ATTITUDE AND ARTICULATION CONTROL SUBSYSTEM

E NO.	FUNCTION	SUBSYS	AACS MEM LOC	ENG HALF	LN40 LN12 LN72	CE40	MC40 MC12 MC72	MN40 MN12 MN72	EC40	CMNTS	
170	AACS O A	007	01+	A	-	-	-	-	-	+FDS ID*	
171	AACS O B	007	82+	B	-	-	-	-	-	+FDS ID*	
172	P GYRO AP	007	01	**	108 123 138 153	147	108 138	108 138	147		
173	PC Q CTR	007	02	**	A04	A00	-	-	B10	*	Δ
174	P SS POSN	007	03	**	-	148	117	117	108 128 148		
175	P RATE	007	04	**	132	117	132	132	117		
176	P ES POSN	007	05	**	A00 A05 A10	128	147	147	A00 A05		
177	P SS BA F	007	06	**	-	108	B10	B10	129		
178	P SS BA C	007	07	**	-	A10	A10	A10	A10		
179	Y GYRO AP	007	10	**	111 126 141 156	153	111 141	111 141	153		
180	BDPAR CTR	007	11	**	A03	A01	A01	A01	B11	*	Δ
181	Y SS POSN	007	12	**	-	151	123	123	111 131 151		
182	Y RATE	007	13	**	117 147	123	129	129	123		

Δ✱ Table 4-3. MJS77 Engineering Telemetry Format (sheet 4 of 9)

E NO.	FUNCTION	SUBSYS	AACS MEM LOC	ENG HALF	LN40 LN12 LN72	CE40	MC40 MC12 MC72	MN40 MN12 MN72	EC40	CMNTS
183	Y ES POSN	007	14	**	B00 B05 B10	131	153	153	B00 B05	
184	Y SS BA F	007	15	**	-	111	B11	B11	132	
185	Y SS BA C	007	16	**	-	A11	A11	A11	A11	
186	R GYRO AP	007	17	**	114 129 144 159	156	114 144	114 144	156	
188	R CT INT	007	21	**	-	114 129 144 159	159	159	159	
189	R CT POSN	007	22	**	-	154	126	126	114 134 154	
190	R RATE	007	23	**	135	126	135	135	126	
191	R ES POSN	007	24	**	A01 A06 A11	134	156	156	A01 A06	
192	SCA AZ C	007	25	**	A08	132	-	-	138	
193	SCA AZ F	007	26	**	B08	138	-	-	144	
194	SCA EL C	007	27	**	A09	135	-	-	135	
195	SCA EL F	007	30	**	B09	141	-	-	141	
196	PY SS INT	007	31	**	-	A02	A02	A02	A02	
197	R CT CA	007	32	**	-	A03	A03	A03	A03	
200	STAT 1	007	35	**	B01	B01	B01	B01	B01	
201	STAT 2	007	36	**	B02	B02	B02	B02	B02	
202	STAT 3	007	37	**	B03	B03	B03	B03	B03	
203	STAT 4	007	40	**	B04	B04	B04	B04	B04	
204	STAT MODE	007	41	**	B06	B06	B06	B06	B06	
205	STAT GYRO	007	42	**	B07	B07	B07	B07	B07	
206	CONF1 1ST	007	43	**	A12	A04	A04	A04	A04	
207	CONF1 2ND	007	44	**	A13	A08	A08	A08	A08	
208	CONF1 3RD	007	45	**	A14	A09	A09	A09	A09	
209	+P AP CTR	007	46	**	-	A12	A12	A12	A12	
210	-P AP CTR	007	47	**	-	B12	B12	B12	B12	
211	+Y AP CTR	007	50	**	-	A13	A13	A13	A13	
212	-Y AP CTR	007	51	**	-	B13	B13	B13	B13	
213	AC/FDS HC	007	52	**	A07	A07	A07	A07	A07	
214	+R AP CTR	007	53	**	-	A14	A14	A14	A14	
215	-R AP CTR	007	54	**	-	B14	B14	B14	B14	
216	+P TC CTR	007	55	**	-	-	A00	A00	-	
217	-P TC CTR	007	56	**	-	-	B00	B00	-	
218	+Y TC CTR	007	57	**	-	-	A05	A05	-	
219	-Y TC CTR	007	60	**	-	-	B05	B05	-	
220	CONF2 1ST	007	61	**	B12	B08	-	-	-	*
221	CONF2 2ND	007	62	**	B13	B09	-	-	-	*
222	CONF2 3RD	007	63	**	B14	B10	-	-	-	*
223	AACSSPARE	007	64	**	(SEE FORMAT LISTINGS)					
224	P EST ACC	007	65	**	-	-	B09	B09	-	*

Δ*Table 4-3. MJS77 Engineering Telemetry Format (sheet 5 of 9)

E NO.	FUNCTION	SUBSYS	AACS MEM LOC	ENG HALF	LN40 LN12 LN72	CE40	MC40 MC12 MC72	MN40 MN12 MN72	EC40	CMNTS	
225	Y EST ACC	007	66	**	-	-	B08	B08	-	*	
226	R EST ACC	007	67	**	-	-	A06	A06	-	*	
227	CYC E CTR	007	70	**	A02	A05	-	-	B09	*	Δ
228	INT 1 CTR	007	71	**	B11	A06	-	-	B08	*	Δ
229	UNUSED	007	00	**	-	-	-	-	-	*	Δ

E NO.	FUNCTION	SUBSYS	FDS ID	ENG HALF	LN40 LN12 LN72	CE40	MC40 MC12 MC72	MN40 MN12 MN72	EC40	CMNTS
230	GYRO A T	007	56	A	436	436	436	436	436	
231	GYRO B T	007	FD	B	437	437	437	437	437	
232	GYRO C T	007	7D	A	438	438	438	438	438	
233	CST 1 T	007	65	A	439	439	439	439	439	
234	CST 2 T	007	E5	B	440	440	440	440	440	
235	SCAN AZ T	007	D6	B	441	441	441	441	441	
236	SUN SEN T	007	78	A	425	425	425	425	425	

E NO.	FUNCTION	SUBSYS	AACS MEM LOC	ENG HALF	LN40 LN12 LN72	CE40	MC40 MC12 MC72	MN40 MN12 MN72	EC40	CMNTS
237	MEM RO A1	007	72	**	108	109	108	108	109	
238	MEM RO A2	007	73	**	111	110	111	111	110	
239	MEM RO A3	007	74	**	114	112	114	114	112	
240	MEM RO D1	007	75	**	117	113	117	117	113	
					126	118	126	126	118	
					135	122	135	135	122	
					144	127	144	144	127	
					153	136	153	153	136	
						140			140	
						145			145	
						152			152	
241	MEM RO D2	007	76	**	120	115	120	120	115	
					129	119	129	129	119	
					138	124	138	138	124	
					147	130	147	147	130	
					156	137	156	156	137	
						142			142	
						146			146	
						155			155	
242	MEM RO D3	007	77	**	123	116	123	123	116	
					132	121	132	132	121	
					141	125	141	141	125	
					150	133	150	150	133	
					159	139	159	159	139	
						143			143	
						149			149	
						157			157	

Table 4-3. MJS77 Engineering Telemetry Format (sheet 6 of 9)

E NO.	FUNCTION	SUBSYS	FDS ID	ENG HALF	LN40 LN12 LN72	CE40	MC40 MC12 MC72	MN40 MN12 MN72	EC40	CMNTS
	PYROTECHNIC SUBSYSTEM									
245	F/P/P ST	008	09	A	134	455	455	317	448	
246	BANK AV	008	39	A	145	-	-	-	-	
247	BANK BV	008	A9	B	154	-	-	-	-	
	PROPULSION SUBSYSTEM									
270	HELIUM P	010	24	A	207	207	207	140	300	
271	PRESS BR1	010	94	B	202	312	312	149 208	358	
272	+P TCM PC	010	34	A	-	-	-	142	-	
273	-P TCM PC	010	A4	B	-	-	-	143	-	
274	+Y TCM PC	010	44	A	-	-	-	145	-	
275	-Y TCM PC	010	B4	B	-	-	-	148	-	
276	PROP C1MS	010	0C	A	139	335	335	335	335	
277	PROP C1LS	010	0D	A	140	336	336	336	336	
278	PROP C2MS	010	0E	A	142	337	337	337	337	
279	PROP C2LS	010	0F	A	143	338	338	338	338	
280	PROP C3MS	010	80	B	148	339	339	339	339	
281	PROP C3LS	010	81	B	149	340	340	340	340	
282	PROP C4MS	010	83	B	151	341	341	341	341	
283	PROP C4LS	010	86	B	152	342	342	342	342	
284	+P THR2 T	010	51	A	412	412	412	412 426	412	
285	-P THR2 T	010	E1	B	420	418	418	418 427	418	
286	-Y THR1 T	010	D1	B	301	301	301	301	301	
287	+Y THR2 T	010	61	A	421	417	417	420 448	426	
288	-Y THR2 T	010	F1	B	422	450	450	421 450	427	
289	-R THR1 T	010	52	A	310	310	310	310	310	
290	+R THR2 T	010	71	A	423	452	452	422 453	428	
291	-R THR2 T	010	D2	B	454	454	454	423 454	454	
292	SURF T1	010	7B	A	313	313	313	313	313	
293	SURF T2	010	F4	B	314	314	314	314 429	314	
294	TANK T1	010	6D	A	315	315	315	201	320	
295	TANK T2	010	E8	B	345	345	345	211	451	
296	FEED T1	010	68	A	330	328	328	219	351	
297	FEED T2	010	FB	B	316	329	329	200	316	
298	ISO VAL 1	010	C8	B	317	317	317	157	317	
299	ISO VAL 2	010	C9	B	318	318	318	158	318	
300	MOTOR PC1	010	C3	B	128	-	-	-	-	
301	MOTOR PC2	010	22	A	158	-	-	-	-	
302	+R ENG 1T	010	50	A	335	-	-	-	-	
303	-R ENG 1T	010	D0	B	336	-	-	-	-	

△✱Table 4-3. MJS77 Engineering Telemetry Format (sheet 7 of 9)

E NO.	FUNCTION	SUBSYS	FDS ID	ENG HALF	LN40 LN12 LN72	CE40	MC40 MC12 MC72	MN40 MN12 MN72	EC40	CMNTS
304	+R ENG 2T	010	60	A	358	-	-	-	-	
305	-R ENG 2T	010	E0	B	359	-	-	-	-	
306	LINE T1	010	75	A	321	-	-	-	-	
307	LINE T2	010	F5	B	322	-	-	-	-	
308	MOTOR T1	010	5E	A	218	-	-	-	-	
309	MOTOR T2	010	DE	B	219	-	-	-	-	
	TEMP CONTROL SUBSYSTEM									
320	SCI PS T1	011	E2	B	208	-	-	-	-	
321	SCI PS T2	011	F0	B	217	-	-	-	-	
	MECHANICAL DEVICES SUBSYSTEM									
330	SCI LP	012	B9	B	210	-	-	-	-	
331	D/C ST	012	02	A	133	-	-	-	-	
	DATA STORAGE SUBSYSTEM									
340	DSS MV	016	2A	A	201	-	-	207	329	
341	DSS P	016	99	B	455	-	-	455	455	
342	MODE ST	016	88	B	214	320	320	356	356	*
343	PLAYB ST	016	89	B	215	358	358	357	357	*
	S/X BAND ANTENNA SUBSYSTEM									
350	HGA MR T	017	63	A	410	410	410	410	410	
351	(DISCONNECTED)									△
352	HGA XBF T	017	F2	B	343	311	311	320	331	
353	(DISCONNECTED)									△
	COSMIC RAY SUBSYSTEM									
360	CRS MUX	021	29	A	-	201	201	-	201	
361	CRS EL T	021	57	A	332	332	332	311	332	
362	CRS TEL T	021	D7	B	319	208	208	312	319	
	PRA SUBSYSTEM									
410	PRA MUX	022	2E	A	-	210	148	210	210	
411	PRA EL T	022	DB	B	435	413	413	300	435	
	PLASMA WAVE SUBSYSTEM									
430	PWS OUT A	023	42	A	-	-	-	-	-	
431	PWS OUT A	023	95	B	-	-	-	-	-	REDUND
432	PWS OUT B	023	A3	B	-	-	-	-	-	
433	PWS OUT B	023	31	A	-	-	-	-	-	REDUND
434	PWS V	023	93	B	-	309	309	328	315	*
435	PWS T	023	58	A	329	451	451	329	434	
	LECP SUBSYSTEM									
450	ENGR MUX	025	98	B	-	217	217	-	217	
451	CAL MUX	025	48	A	-	-	154	-	-	
452	(DISCONNECTED)									△
453	LEMP T	025	66	A	333	435	435	435	333	*

△✱Table 4-3. MJS77 Engineering Telemetry Format (sheet 8 of 9)

E NO.	FUNCTION	SUBSYS	FDS ID	ENG HALF	LN40 LN12 LN72	CE40	MC40 MC12 MC72	MN40 MN12 MN72	EC40	CMNTS
	PHOTOPOLARIMETER SUBSYSTEM									
600	PPS T OP	027	26	A	-	316	316	-	350	
601	APERT POS	027	9E	B	-	352	352	-	209	
602	ANLYZ POS	027	3E	A	-	145	145	-	145	
603	FILTR POS	027	AE	B	-	149	149	-	149	
604	PPS HV	027	4E	A	-	152	210	-	152	
605	PPS LV	027	CE	B	-	157	213	-	322	*
606	SOL SEN	027	BE	B	-	331	331	-	158	*
607	PPS EL T	027	D8	B	459	459	459	459	459	
	PLASMA SUBSYSTEM									
620	PLS MUX	032	A2	B	-	219	219	-	219	
621	PLS EL T	032	F6	B	456	456	456	456	456	
622	PLS SEN T	032	70	A	457	457	457	457	457	
623	PLS MOD T	032	5B	A	449	449	449	449	449	
	UVS SUBSYSTEM									
640	UVS T	034	55	A	434	434	434	434	450	*
641	UVS HV	034	CD	B	-	334	334	-	157	
	MAGNETOMETER SUBSYSTEM									
660	MAG MUX	035	38	A	-	202	128	334	202	
661	OB LFM T	035	6E	A	206	206	206	216	305	
662	IB LFM T	035	EE	B	209	209	209	209	308	
663	OB HFM T	035	7E	A	211	211	211	217	309	
664	IB HFM T	035	FE	B	212	212	212	212	328	
	IMAGING SCIENCE SUBSYSTEM									
680	NA DATA	036	43	A	-	218	218	-	-	
681	WA DATA	036	B3	B	-	216	216	-	-	
682	NA VID T	036	F9	B	442	321	321	321	206	
683	WA VID T	036	69	A	443	322	322	322	207	
684	NA FOT	036	D9	B	444	305	305	305	208	
685	NA ROT	036	59	A	445	308	308	308	211	
686	WA OPT T	036	79	A	446	348	348	348	218	
687	NA PWR T	036	74	A	451	349	349	349	321	
688	WA PWR T	036	E9	B	453	350	350	350	453	*
	MIRIS SUBSYSTEM									
710	RAD ANA	039	4D	A	-	-	-	-	-	
711	RAD HI G	039	BD	B	-	-	-	-	-	
712	MRIS PM T	039	D3	B	203	203	203	203	203	*
713	MRIS PM H	039	A7	B	305	213	202	213	213	*
714	MRIS SM T	039	62	A	204	204	204	204	204	*
715	MRIS SM H	039	27	A	356	214	214	214	214	*
716	MRIS RS T	039	53	A	205	205	205	205	205	*
717	MRIS RS H	039	37	A	357	215	215	215	215	*

△*Table 4-3. MJS77 Engineering Telemetry Format (sheet 9 of 9)

E NO.	FUNCTION	SUBSYS	FDS ID	ENG HALF	LN40 LN12 LN72	CE40	MC40 MC12 MC72	MN40 MN12 MN72	EC40	CMNTS	
718	MRIS EL T	039	ED	B	424	424	424	424	424	*	
719	NEON ANA	039	97	B	-	-	-	-	-		
720	MRIS SBPW	039	C0	B	458	458	458	458	458	*	
	ATTITUDE AND ARTICULATION CONTROL SUBSYSTEM										△
750	MAM R OUT	007	00	A	-	-	-	-	-		△

NOTES

* DENOTES CHANGE.

** FOR COMMUTATOR A USE FDS IDENTIFIER 01, FOR COMMUTATOR B USE FDS IDENTIFIER 82.

AACS MEMORY READOUT NOTES

1) NOTE THAT COMMUTATOR POSITION 158 IS NOT USED IN THE AACS CRUISE AND ENCOUNTER MEMORY READOUT MODES.
2) IN AACS LAUNCH, MODIFIED CRUISE, AND MANEUVER MEMORY READOUT MODES, THE ABOVE READOUT MEMORY LOCATIONS REPLACE AACS ENG TLM READOUT LOCATIONS.
3) IN AACS CRUISE AND ENCOUNTER MEMORY READOUT MODES, THE ABOVE READOUT LOCATIONS ARE IN ADDITION TO THE AACS ENG TLM READOUT LOCATIONS.

△ ✱Table 4-4. MJS77 Telemetry Format Commuter Listing - LN-40, LN-12, and LN-72 Formats (sheet 1 of 6)

DECK	E NO.	FUNCTION	SUBSYS	FDS	ENG HALF	
100	160	FRAME SYNC CODE	0000	0011		
101	161	FRAME SYNC CODE	1001	0001		
102	162	FRAME SYNC CODE	0101	1110		
103	163	FRAME SYNC CODE	1101	0011		
104	164	FORMAT ID WORD				
105	165	MOD 16 COUNTER				
106	166	MOD 60 AND LINE COUNT (2 MSB)				
107	167	LINE COUNT (8 LSB)				
108+	172	P GYRO AP	007	**	**	
109	074	DC BUS I	004	36	A	*
110	072	2.4 INV I	004	41	A	
111+	179	Y GYRO AP	007	**	**	
112	073	DC BUS V	004	21	A	
113	075	SHUNT I	004	23	A	
114+	186	R GYRO AP	007	**	**	
115	070	INV IN I	004	C1	B	
116		300 DECK SC				
117+	182	Y RATE	007	**	**	
118	130	CCS OUT 1	005	04	A	
119	131	CCS OUT 2	005	05	A	
120+		A00 DECK SC				
121	022	VCO C V	002	9A	B	
122	085	RDM V	004	32	A	
123+	172	P GYRO AP	007	**	**	
124	060	MFP ST	003	07	A	
125		200 DECK SC				
126+	179	Y GYRO AP	007	**	**	
127	024	RCV AGC	002	3A	A	
128	300	MOTOR PC1	010	C3	B	
129+	186	R GYRO AP	007	**	**	
130		400 DECK SC				
131	035	S XMT I	002	3C	A	*
132+	175	P RATE	007	**	**	
133	331	D/C ST	012	02	A	
134	245	F/P/P ST	008	09	A	
135+	190	R RATE	007	**	**	
136	051	LGA DR	002	47	A	
137	146	FDS M WD	006	08	A	*
138+	172	P GYRO AP	007	**	**	
139	276	PROP C1MS	010	0C	A	
140	277	PROP C1LS	010	0D	A	
141+	179	Y GYRO AP	007	**	**	
142	278	PROP C2MS	010	0E	A	
143	279	PROP C2LS	010	0F	A	
144+	186	R GYRO AP	007	**	**	
145	246	BANK AV	008	39	A	

Δ *Table 4-4. MJS77 Telemetry Format Commutator Listing - LN-40, LN-12, and LN-72 Formats (sheet 2 of 6)

DECK	E NO.	FUNCTION	SUBSYS	FDS	ENG HALF	
146		300 DECK SC				
147+	182	Y RATE	007	**	**	
148	280	PROP C3MS	010	80	B	
149	281	PROP C3LS	010	81	B	
150+		B00 DECK SC				
151	282	PROP C4MS	010	83	B	
152	283	PROP C4LS	010	86	B	
153+	172	P GYRO AP	007	**	**	
154	247	BANK BV	008	A9	B	
155		200 DECK SC				
156+	179	Y GYRO AP	007	**	**	
157	038	S EXC I	002	4C	A	
158	301	MOTOR PC2	010	22	A	
159+	186	R GYRO AP	007	**	**	
200	034	S XMT DR	002	2D	A	*
201	340	DSS MV	016	2A	A	
202	271	PRESS BR1	010	94	B	
203	712	MRIS PM T	039	D3	B	*
204	714	MRIS SM T	039	62	A	*
205	716	MRIS RS T	039	53	A	*
206	661	OB LFM T	035	6E	A	
207	270	HELIUM P	010	24	A	
208	320	SCI PS T1	011	E2	B	
209	662	IB LFM T	035	EE	B	
210	330	SCI LP	012	B9	B	
211	663	OB HFM T	035	7E	A	
212	664	IB HFM T	035	FE	B	
213	027	RCV I	002	BA	B	*
214	342	MODE ST	016	88	B	*
215	343	PLAYB ST	016	89	B	*
216	023	VCO F V	002	2B	A	*
217	321	SCI PS T2	011	F0	B	
218	308	MOTOR T1	010	5E	A	
219	309	MOTOR T2	010	DE	B	
A00	176	P ES POSN	007	**	**	
A01	191	R ES POSN	007	**	**	
A02	227	CYC E CTR	007	**	**	Δ
A03	180	BDPAR CTR	007	**	**	Δ
A04	173	PC Q CTR	007	**	**	Δ
A05	176	P ES POSN	007	**	**	
A06	191	R ES POSN	007	**	**	
A07	213	AC/FDS HC	007	**	**	

Δ❋Table 4-4. MJS77 Telemetry Format Commutator Listing - LN-40, LN-12, and LN-72 Formats (sheet 3 of 6)

DECK	E NO.	FUNCTION	SUBSYS	FDS	ENG HALF	
A08	192	SCA AZ C	007	**	**	
A09	194	SCA EL C	007	**	**	
A10	176	P ES POSN	007	**	**	
A11	191	R ES POSN	007	**	**	
A12	206	CONF1 1ST	007	**	**	
A13	207	CONF1 2ND	007	**	**	
A14	208	CONF1 3RD	007	**	**	
B00	183	Y ES POSN	007	**	**	
B01	200	STAT 1	007	**	**	
B02	201	STAT 2	007	**	**	
B03	202	STAT 3	007	**	**	
B04	203	STAT 4	007	**	**	
B05	183	Y ES POSN	007	**	**	
B06	204	STAT MODE	007	**	**	
B07	205	STAT GYRO	007	**	**	
B08	193	SCA AZ F	007	**	**	
B09	195	SCA EL F	007	**	**	
B10	183	Y ES POSN	007	**	**	
B11	228	INT 1 CTR	007	**	**	Δ
B12	220	CONF2 1ST	007	**	**	
B13	221	CONF2 2ND	007	**	**	
B14	222	CONF2 3RD	007	**	**	
300	071	2.4 INV V	004	33	A	*
301	286	-Y THR1 T	010	D1	B	
302	030	USO OV I	002	CA	B	
303	155	3V ADC A	006	A8	B	
304	156	3V ADC B	006	28	A	
305	713	MRIS PM H	039	A7	B	*
306	109	RTG 1T3	004	5A	A	
307	110	RTG 1T2	004	DA	B	
308	061	TMU ST1	003	8B	B	
309	062	TMU ST2	003	8C	B	
310	289	-R THR1 T	010	52	A	
311	153	PWR CON A	006	35	A	
312	078	2.4 INV I	004	B1	B	
313	292	SURF T1	010	7B	A	
314	293	SURF T2	010	F4	B	
315	294	TANK T1	010	6D	A	
316	297	FEED T2	010	FB	B	
317	298	ISO VAL 1	010	C8	B	
318	299	ISO VAL 2	010	C9	B	
319	362	CRS TEL T	021	D7	B	
320	SPARE					Δ

△ ❀Table 4-4. MJS77 Telemetry Format Commutator Listing - LN-40, LN-12, and LN-72 Formats (sheet 4 of 6)

DECK	E NO.	FUNCTION	SUBSYS	FDS	ENG HALF
321	306	LINE T1	010	75	A
322	307	LINE T2	010	F5	B
323	103	RTG 1I	004	A0	B
324	104	RTG 2I	004	40	A
325	105	RTG 3I	004	B0	B
326	111	RTG 2T1	004	6A	A
327	112	RTG 2T3	004	EA	B
328	115	BAT T	004	EB	B
329	435	PWS T	023	58	A
330	296	FEED T1	010	68	A
331	080	DC BUS I	004	A6	B
332	361	CRS EL T	021	57	A
333	453	LEMP T	025	66	A
334	081	SHUNT I	004	96	B
335	302	+R ENG 1T	010	50	A
336	303	-R ENG 1T	010	D0	B
337	140	FDS ST1	006	8E	B
338	141	FDS ST2	006	16	A
339	142	FDS ST3	006	17	A
340	143	FDS ST4	006	8D	B
341	144	FDS ST5	006	15	A
342	145	FDS ST6	006	8F	B
343	352	HGA XBF T	017	F2	B
344	078	2.4 INV I	004	B1	B
345	295	TANK T2	010	E8	B
346	113	RTG 3T1	004	7A	A
347	114	RTG 3T2	004	FA	B
348	020	RFS ST1	002	06	A
349	021	RFS ST2	002	8A	B
350	151	30V INV	006	45	A
351	152	10V BUS	006	85	B
352	SPARE				
353	100	RTG 1V	004	3D	A
354	101	RTG 2V	004	90	B
355	102	RTG 3V	004	49	A
356	715	MRIS SM H	039	27	A
357	717	MRIS RS H	039	37	A
358	304	+R ENG 2T	010	60	A
359	305	-R ENG 2T	010	E0	B
400	000	BAY 1T	001	67	A
401	001	BAY 2T	001	D4	B
402	002	BAY 3T	001	54	A
403	003	BAY 4T	001	E4	B
404	004	BAY 5T	001	64	A
405	005	BAY 6T	001	F8	B

△

△*Table 4-4. MJS77 Telemetry Format Commutator Listing - LN-40, LN-12, and LN-72 Formats (sheet 5 of 6)

DECK	E NO.	FUNCTION	SUBSYS	FDS	ENG HALF	
406	006	BAY 7T	001	76	A	
407	007	BAY 8T	001	D5	B	
408	008	BAY 9T	001	77	A	
409	009	BAY 10T	001	F7	B	
410	350	HGA MR T	017	63	A	
411	SPARE					△
412	284	+P THR2 T	010	51	A	
413	028	LOC OSC D	002	4A	A	
414	029	RCV VCO T	002	6C	A	
415	031	S XMT BT	002	7C	A	*
416	032	S HYB T	002	DC	B	
417	033	S XMT V	002	AC	B	*
418	154	PWR CON B	006	A5	B	
419	036	S HELIX I	002	BC	B	
420	285	-P THR2 T	010	E1	B	
421	287	+Y THR2 T	010	61	A	
422	288	-Y THR2 T	010	F1	B	
423	290	+R THR2 T	010	71	A	
424	718	MRIS EL T	039	ED	B	*
425	236	SUN SEN T	007	78	A	
426	081	SHUNT I	004	96	B	
427	150	SEL 50 V	006	25	A	
428	157	5V TIME	006	C5	B	
429	049	TRF SW T	002	5D	A	
430	050	AUX OSC T	002	EC	B	
431	082	SHNT RG T	004	6B	A	
432	083	RAD T1	004	73	A	
433	084	RAD T2	004	F3	B	
434	640	UVS T	034	55	A	
435	411	PRA EL T	022	DB	B	
436	230	GYRO A T	007	56	A	
437	231	GYRO B T	007	FD	B	
438	232	GYRO C T	007	7D	A	
439	233	CST 1 T	007	65	A	
440	234	CST 2 T	007	E5	B	
441	235	SCAN AZ T	007	D6	B	
442	682	NA VID T	036	F9	B	
443	683	WA VID T	036	69	A	
444	684	NA FOT	036	D9	B	
445	685	NA ROT	036	59	A	
446	686	WA OPT T	036	79	A	
447	076	INV IN V	004	46	A	
448	078	2.4 INV I	004	B1	B	
449	623	PLS MOD T	032	5B	A	
450	077	2.4 INV V	004	92	B	
451	687	NA PWR T	036	74	A	

△ ✱ Table 4-4. MJS77 Telemetry Format Commutator Listing - LN-40, LN-12, and LN-72 Formats (sheet 6 of 6)

DECK	E NO.	FUNCTION	SUBSYS	FDS	ENG HALF	
452	079	DC BUS V	004	C2	B	
453	688	WA PWR T	036	E9	B	
454	291	-R THR2 T	010	D2	B	
455	341	DSS P	016	99	B	
456	621	PLS EL T	032	F6	B	
457	622	PLS SEN T	032	70	A	
458	720	MRIS SBPW	039	C0	B	*
459	607	PPS EL T	027	D8	B	

NOTES

* DENOTES CHANGE

** FOR COMMUTATOR A USE FDS IDENTIFIER 01,
FOR COMMUTATOR B USE FDS IDENTIFIER 82.

\+ USED FOR AACS MEMORY READOUT IN THIS MODE.
DURING AACS MEMORY READOUT NO DATA IS OBTAINED FROM THE A00/B00 DECKS.

△✻ Table 4-5. MJS77 Telemetry Format Commutator Listing - CE-40 Format (sheet 1 of 6)

DECK	E NO.	FUNCTION	SUBSYS	FDS	ENG HALF
100	160	FRAME SYNC CODE 0000 0011			
101	161	FRAME SYNC CODE 1001 0001			
102	162	FRAME SYNC CODE 0101 1110			
103	163	FRAME SYNC CODE 1101 0011			
104	164	FORMAT ID WORD			
105	165	MOD 16 COUNTER			
106	166	MOD 60 AND LINE COUNT (2 MSB)			
107	167	LINE COUNT (8 LSB)			
108	177	P SS BA F	007	**	**
109+	071	2.4 INV V	004	33	A
110+	072	2.4 INV I	004	41	A
111	184	Y SS BA F	007	**	**
112+	073	DC BUS V	004	21	A
113+	075	SHUNT I	004	23	A
114	188	R CT INT	007	**	**
115+	074	DC BUS I	004	36	A
116+		300 DECK SC			
117	175	P RATE	007	**	**
118+	130	CCS OUT 1	005	04	A
119+	131	CCS OUT 2	005	05	A
120		A00 DECK SC			
121+	022	VCO C V	002	9A	B
122+	023	VCO F V	002	2B	A
123	182	Y RATE	007	**	**
124+	060	MFP ST	003	07	A
125+		200 DECK SC			
126	190	R RATE	007	**	**
127+	024	RCV AGC	002	3A	A
128	176	P ES POSN	007	**	**
129	188	R CT INT	007	**	**
130+		400 DECK SC			
131	183	Y ES POSN	007	**	**
132	192	SCA AZ C	007	**	**
133+	026	RNG AGC V	002	C6	B
134	191	R ES POSN	007	**	**
135	194	SCA EL C	007	**	**
136+	051	LGA DR	002	47	A
137+	027	RCV I	002	8A	B
138	193	SCA AZ F	007	**	**
139+	070	INV IN I	004	C1	B
140+	034	S XMT DR	002	2D	A
141	195	SCA EL F	007	**	**
142+	037	S HGA DR	002	9C	B
143+	038	S EXC I	002	4C	A
144	188	R CT INT	007	**	**

△✱Table 4-5. MJS77 Telemetry Format Commutator Listing - CE-40 Format (sheet 2 of 6)

DECK	E NO.	FUNCTION	SUBSYS	FDS	ENG HALF	
145+	602	ANLYZ POS	027	3E	A	
146+		300 DECK SC				
147	172	P GYRO AP	007	**	**	
148	174	P SS POSN	007	**	**	
149+	603	FILTR POS	027	AE	B	
150		800 DECK SC				
151	181	Y SS POSN	007	**	**	
152+	604	PPS HV	027	4E	A	
153	179	Y GYRO AP	007	**	**	
154	189	R CT POSN	007	**	**	
155+		200 DECK SC				
156	186	R GYRO AP	007	**	**	
157+	605	PPS LV	027	CE	B	
158	146	FDS MEM WD	006	08	A	*
159	188	R CT INT	007	**	**	
200	SPARE					△
201	360	CRS MUX	021	29	A	
202	660	MAG MUX	035	38	A	
203	712	MRIS PM T	039	D3	B	*
204	714	MRIS SM T	039	62	A	*
205	716	MRIS RS T	039	53	A	*
206	661	OB LFM T	035	6E	A	
207	270	HELIUM P	010	24	A	
208	362	CRS TEL T	021	07	B	
209	662	IB LFM T	035	EE	B	
210	410	PRA MUX	022	2E	A	
211	663	OB HFM T	035	7E	A	
212	664	IB HFM T	035	FE	B	
213	713	MRIS PM H	039	A7	B	*
214	715	MRIS SM H	039	27	A	*
215	717	MRIS RS H	039	37	A	*
216	681	WA DATA	036	B3	B	
217	450	ENGR MUX	025	98	B	
218	680	NA DATA	036	43	A	
219	620	PLS MUX	032	A2	B	
A00	173	PC Q CTR	007	**	**	*△
A01	180	BDPAR CTR	007	**	**	*△
A02	196	PY SS INT	007	**	**	
A03	197	R CT CA	007	**	**	
A04	206	CONF1 1ST	007	**	**	
A05	227	CYC E CTR	007	**	**	*△
A06	228	INT 1 CTR	007	**	**	*△
A07	213	AC/FDS HC	007	**	**	

Δ*Table 4-5. MJS77 Telemetry Format Commutator Listing - CE-40 Format (sheet 3 of 6)

DECK	E NO.	FUNCTION	SUBSYS	FDS	ENG HALF	
A08	207	CONF1 2ND	007	**	**	
A09	208	CONF1 3RD	007	**	**	
A10	178	P SS BA C	007	**	**	
A11	185	Y SS BA C	007	**	**	
A12	209	+P AP CTR	007	**	**	
A13	211	+Y AP CTR	007	**	**	
A14	214	+R AP CTR	007	**	**	
B00	223	AACSSPARE	007	**	**	
B01	200	STAT 1	007	**	**	
B02	201	STAT 2	007	**	**	
B03	202	STAT 3	007	**	**	
B04	203	STAT 4	007	**	**	
B05	223	AACSSPARE	007	**	**	
B06	204	STAT MODE	007	**	**	
B07	205	STAT GYRO	007	**	**	
B08	220	CONF2 1ST	007	**	**	
B09	221	CONF2 2ND	007	**	**	
B10	222	CONF2 3RD	007	**	**	
B11	223	AACSSPARE	007	**	**	
B12	210	-P AP CTR	007	**	**	
B13	212	-Y AP CTR	007	**	**	
B14	215	-R AP CTR	007	**	**	
300	048	X HGA DR	002	2C	A	
301	286	-Y THR1 T	010	D1	B	
302	030	USO OV I	002	CA	B	
303	155	3V ADC A	006	A8	B	
304	156	3V ADC B	006	28	A	
305	684	NA FOT	036	D9	B	
306	109	RTG 1T3	004	5A	A	
307	110	RTG 1T2	004	DA	B	
308	685	NA ROT	036	59	A	
309	434	PWS V	023	93	B	
310	289	-R THR1 T	010	52	A	
311	352	HGA XBF T	017	F2	B	
312	271	PRESS BR1	010	94	B	
313	292	SURF T1	010	7B	A	
314	293	SURF T2	010	F4	B	
315	294	TANK T1	010	6D	A	
316	600	PPS T OP	027	26	A	
317	298	ISO VAL 1	010	C8	B	
318	299	ISO VAL 2	010	C9	B	
319	033	S XMT V	002	AC	B	*
320	342	MODE ST	016	88	B	*

Δ*Table 4-5. MJS77 Telemetry Format Commutator Listing - CE-40 Format (sheet 4 of 6)

DECK	E NO.	FUNCTION	SUBSYS	FDS	ENG HALF	
321	682	NA VID T	036	F9	B	
322	683	WA VID T	036	69	A	
323	103	RTG 1I	004	A0	B	
324	104	RTG 2I	004	40	A	
325	105	RTG 3I	004	B0	B	
326	111	RTG 2T1	004	6A	A	
327	112	RTG 2T3	004	EA	B	
328	296	FEED T1	010	68	A	
329	297	FEED T2	010	FB	B	
330	028	LOC OSC D	002	4A	A	
331	606	SOL SEN	027	BE	B	*
332	361	CRS EL T	021	57	A	
333	SPARE					Δ
334	641	UVS HV	034	CD	B	
335	276	PROP C1MS	010	0C	A	
336	277	PROP C1LS	010	0D	A	
337	278	PROP C2MS	010	0E	A	
338	279	PROP C2LS	010	0F	A	
339	280	PROP C3MS	010	80	B	
340	281	PROP C3LS	010	81	B	
341	282	PROP C4MS	010	83	B	
342	283	PROP C4LS	010	86	B	
343	020	RFS ST1	002	06	A	
344	021	RFS ST2	002	8A	B	
345	295	TANK T2	010	E8	B	
346	113	RTG 3T1	004	7A	A	
347	114	RTG 3T2	004	FA	B	
348	686	WA OPT T	036	79	A	
349	687	NA PWR T	036	74	A	
350	688	WA PWR T	036	E9	B	
351	044	X TWT DR	002	9B	B	
352	601	APERT POS	027	9E	B	
353	100	RTG 1V	004	3D	A	
354	101	RTG 2V	004	90	B	
355	102	RTG 3V	004	49	A	
356	061	TMU ST1	003	8B	B	
357	062	TMU ST2	003	8C	B	
358	343	PLAYB ST	016	89	B	*
359	045	X HELIX I	002	4B	A	
400	000	BAY 1T	001	67	A	
401	001	BAY 2T	001	D4	B	
402	002	BAY 3T	001	54	A	
403	003	BAY 4T	001	E4	B	
404	004	BAY 5T	001	64	A	
405	005	BAY 6T	001	F8	B	

△*Table 4-5. MJS77 Telemetry Format Commutator Listing - CE-40 Format (sheet 5 of 6)

DECK	E NO.	FUNCTION	SUBSYS	FDS	ENG HALF
406	006	BAY 7T	001	76	A
407	007	BAY 8T	001	D5	B
408	008	BAY 9T	001	77	A
409	009	BAY 10T	001	F7	B
410	350	HGA MR T	017	63	A
411	SPARE				
412	284	+P THR2 T	010	51	A
413	411	PRA EL T	022	DB	B
414	029	RCV VCO T	002	6C	A
415	031	S XMT BT	002	7C	A
416	032	S HYB T	002	DC	B
417	287	+Y THR2 T	010	61	A
418	285	-P THR2 T	010	E1	B
419	036	S HELIX I	002	BC	B
420	039	X TWT BT	002	FC	B
421	040	X HYB T	002	5C	A
422	041	X RFM T	002	E7	B
423	042	X EXC T	002	DD	B
424	718	MRIS EL T	039	ED	B
425	236	SUN SEN T	007	78	A
426	043	X TWT V	002	3B	A
427	046	X CAT I	002	AB	B
428	047	X EXC I	002	BB	B
429	049	TRF SW T	002	5D	A
430	050	AUX OSC T	002	EC	B
431	062	SHNT RG T	004	6B	A
432	063	RAD T1	004	73	A
433	084	RAD T2	004	F3	B
434	640	UVS T	034	55	A
435	453	LEMP T	025	66	A
436	230	GYRO A T	007	56	A
437	231	GYRO B T	007	FD	B
438	232	GYRO C T	007	7D	A
439	233	CST 1 T	007	65	A
440	234	CST 2 T	007	E5	B
441	235	SCAN AZ T	007	D6	B
442	140	FDS ST1	006	8E	B
443	141	FDS ST2	006	16	A
444	142	FDS ST3	006	17	A
445	143	FDS ST4	006	8D	B
446	144	FDS ST5	006	15	A
447	145	FDS ST6	006	8F	B
448	035	S XMT I	002	3C	A
449	623	PLS MOD T	032	5B	A
450	268	-Y THR2 T	010	F1	B
451	435	PWS T	023	58	A

△* Table 4-5. MJS77 Telemetry Format Commutator Listing - CE-40 Format (sheet 6 of 6)

DECK	E NO.	FUNCTION	SUBSYS	FDS	ENG HALF	
452	290	+R THR2 T	010	71	A	
453	153	PWR CON A	006	35	A	*
454	291	-R THR2 T	010	D2	B	
455	245	F/P/P ST	008	09	A	
456	621	PLS EL T	032	F6	B	
457	622	PLS SEN T	032	70	A	
458	720	MRIS SBPW	039	C0	B	*
459	607	PPS EL T	027	D8	B	

NOTES

* DENOTES CHANGE

** FOR COMMUTATOR A USE FDS IDENTIFIER 01,
FOR COMMUTATOR B USE FDS IDENTIFIER 82.

\+ USED FOR AACS MEMORY READOUT IN THIS MODE.
DURING AACS MEMORY READOUT NO DATA IS OBTAINED
FROM THE 200, 300 AND 400 DECKS.

△✱Table 4-6. MJS77 Telemetry Format Commutator Listing - MC-40, MC-12, and MC-72 Formats (sheet 1 of 6)

DECK	E NO.	FUNCTION	SUBSYS	FDS	ENG HALF
100	160	FRAME SYNC CODE	0000 0011		
101	161	FRAME SYNC CODE	1001 0001		
102	162	FRAME SYNC CODE	0101 1110		
103	163	FRAME SYNC CODE	1101 0011		
104	164	FORMAT ID WORD			
105	165	MOD 16 COUNTER			
106	166	MOD 60 AND LINE COUNT (2 MSB)			
107	167	LINE COUNT (8 LSB)			
108+	172	P GYRO AP	007	**	**
109	071	2.4 INV V	004	33	A
110	072	2.4 INV I	004	41	A
111+	179	Y GYRO AP	007	**	**
112	073	DC BUS V	004	21	A
113	075	SHUNT I	004	23	A
114+	186	R GYRO AP	007	**	**
115	074	DC BUS I	004	36	A
116		300 DECK SC			
117+	174	P SS POSN	007	**	**
118	130	CCS OUT 1	005	04	A
119	131	CCS OUT 2	005	05	A
120+		A00 DECK SC			
121	022	VCO C V	002	9A	B
122	023	VCO F V	002	2B	A
123+	181	Y SS POSN	007	**	**
124	060	MFP ST	003	07	A
125		200 DECK SC			
126+	189	R CT POSN	007	**	**
127	024	RCV AGC	002	3A	A
128	660	MAG MUX	035	38	A
129+	182	Y RATE	007	**	**
130		400 DECK SC			
131	030	USO OV I	002	CA	B
132+	175	P RATE	007	**	**
133	026	RNG AGC V	002	C6	B
134	146	FDS MEM WD	006	08	A
135+	190	R RATE	007	**	**
136	051	LGA DR	002	47	A
137	027	RCV I	002	BA	B
138+	172	P GYRO AP	007	**	**
139	070	INV IN I	004	C1	B
140	034	S XMT DR	002	2D	A
141+	179	Y GYRO AP	007	**	**
142	037	S HGA DR	002	9C	B
143	038	S EXC I	002	4C	A
144+	186	R GYRO AP	007	**	**

△ ✱ Table 4-6. MJS77 Telemetry Format Commutator Listing - MC-40, MC-12, and MC-72 Formats (sheet 2 of 6)

DECK	E NO.	FUNCTION	SUBSYS	FDS	ENG HALF
145	602	ANLYZ POS	027	3E	A
146		300 DECK SC			
147+	176	P ES POSN	007	**	**
148	410	PRA MUX	022	2E	A
149	603	FILTR POS	027	AE	B
150+		B00 DECK SC			
151	063	CDU SNR M	003	0A	A
152	064	CDU SNR L	003	0B	A
153+	183	Y ES POSN	007	**	**
154	451	CAL MUX	025	48	A
155		200 DECK SC			
156+	191	R ES POSN	007	**	**
157	063	CDU SNR M	003	0A	A
158	064	CDU SNR L	003	0B	A
159+	188	R CT INT	007	**	**
200	SPARE				
201	360	CRS MUX	021	29	A
202	713	MRIS PM H	039	A7	B
203	712	MRIS PM T	039	D3	B
204	714	MRIS SM T	039	62	A
205	716	MRIS RS T	039	53	A
206	661	OB LFM T	035	6E	A
207	270	HELIUM P	010	24	A
208	362	CRS TEL T	021	D7	B
209	662	IB LFM T	035	EE	B
210	604	PPS HV	027	4E	A
211	663	OB HFM T	035	7E	A
212	664	IB HFM T	035	FE	B
213	605	PPS LV	027	CE	B
214	715	MRIS SM H	039	27	A
215	717	MRIS RS H	039	37	A
216	681	WA DATA	036	B3	B
217	450	ENGR MUX	025	98	B
218	680	NA DATA	036	43	A
219	620	PLS MUX	032	A2	B
A00	216	+P TC CTR	007	**	**
A01	180	BDPAR CTR	007	**	**
A02	196	PY SS INT	007	**	**
A03	197	R CT CA	007	**	**
A04	206	CONF1 1ST	007	**	**
A05	218	+Y TC CTR	007	**	**
A06	226	R EST ACC	007	**	**
A07	213	AC/FDS HC	007	**	**

Δ✱Table 4-6. MJS77 Telemetry Format Commutator Listing - MC-40, MC-12, and MC-72 Formats (sheet 3 of 6)

DECK	E NO.	FUNCTION	SUBSYS	FDS	ENG HALF
A08	207	CONF1 2ND	007	**	**
A09	208	CONF1 3RD	007	**	**
A10	178	P SS BA C	007	**	**
A11	185	Y SS BA C	007	**	**
A12	209	+P AP CTR	007	**	**
A13	211	+Y AP CTR	007	**	**
A14	214	+R AP CTR	007	**	**
B00	217	-P TC CTR	007	**	**
B01	200	STAT 1	007	**	**
B02	201	STAT 2	007	**	**
B03	202	STAT 3	007	**	**
B04	203	STAT 4	007	**	**
B05	219	-Y TC CTR	007	**	**
B06	204	STAT MODE	007	**	**
B07	205	STAT GYRO	007	**	**
B08	225	Y EST ACC	007	**	**
B09	224	P EST ACC	007	**	**
B10	177	P SS BA F	007	**	**
B11	184	Y SS BA F	007	**	**
B12	210	-P AP CTR	007	**	**
B13	212	-Y AP CTR	007	**	**
B14	215	-R AP CTR	007	**	**
300	048	X HGA DR	002	2C	A
301	286	-Y THR1 T	010	D1	B
302	111	RTG 2T1	004	6A	A
303	155	3V ADC A	006	A8	B
304	156	3V ADC B	006	28	A
305	684	MA POT	036	D9	B
306	109	RTG 1T3	004	5A	A
307	110	RTG 1T2	004	DA	B
308	685	MA ROT	036	59	A
309	434	PWS V	023	93	B
310	289	-R THR1 T	010	52	A
311	352	HGA XBF T	017	F2	B
312	271	PRESS BR1	010	94	B
313	292	SURF T1	010	7B	A
314	293	SURF T2	010	F4	B
315	294	TANK T1	010	6D	A
316	600	PPS T OP	027	26	A
317	298	ISO VAL 1	010	C8	B
318	299	ISO VAL 2	010	C9	B
319	033	S XMT V	002	AC	B
320	342	MODE ST	016	88	B

△✱ Table 4-6. MJS77 Telemetry Format Commutator Listing - MC-40, MC-12, and MC-72 Formats (sheet 4 of 6)

DECK	E NO.	FUNCTION	SUBSYS	FDS	ENG HALF
321	682	NA VID T	036	F9	B
322	683	WA VID T	036	69	A
323	103	RTG 1I	004	A0	B
324	104	RTG 2I	004	40	A
325	105	RTG 3I	004	B0	B
326	150	SEL 50 V	006	25	A
327	151	30V INV	006	45	A
328	296	FEED T1	010	68	A
329	297	FEED T2	010	FB	B
330	028	LOC OSC D	002	4A	A
331	606	SOL SEN	027	BE	B
332	361	CRS EL T	021	57	A
333	SPARE				△
334	641	UVS HV	034	CD	B
335	276	PROP C1MS	010	0C	A
336	277	PROP C1LS	010	0D	A
337	278	PROP C2MS	010	0E	A
338	279	PROP C2LS	010	0F	A
339	280	PROP C3MS	010	80	B
340	281	PROP C3LS	010	81	B
341	282	PROP C4MS	010	83	B
342	283	PROP C4LS	010	86	B
343	020	RFS ST1	002	06	A
344	021	RFS ST2	002	8A	B
345	295	TANK T2	010	E8	B
346	152	10V BUS	006	B5	B
347	157	5V TIME	006	C5	B
348	686	WA OPT T	036	79	A
349	687	NA PWR T	036	74	A
350	688	WA PWR T	036	E9	B
351	044	X TWT DR	002	9B	B
352	601	APERT POS	027	9F	B
353	100	RTG 1V	004	3D	A
354	101	RTG 2V	004	90	B
355	102	RTG 3V	004	49	A
356	061	TMU ST1	003	8B	B
357	062	TMU ST2	003	8C	B
358	343	PLAYB ST	016	89	B
359	045	X HELIX I	002	4B	A
400	000	BAY 1T	001	67	A
401	001	BAY 2T	001	D4	B
402	002	BAY 3T	001	54	A
403	003	BAY 4T	001	E4	B
404	004	BAY 5T	001	64	A
405	005	BAY 6T	001	F8	B

△✱Table 4-6. MJS77 Telemetry Format Commutator Listing - MC-40, MC-12, and MC-72 Formats (sheet 5 of 6)

DECK	E NO.	FUNCTION	SUBSYS	FDS	ENG HALF
406	006	BAY 7T	001	76	A
407	007	BAY 8T	001	D5	B
408	008	BAY 9T	001	77	A
409	009	BAY 10T	001	F7	B
410	350	HGA MR T	017	63	A
411	SPARE				
412	284	+P THR2 T	010	51	A
413	411	PRA EL T	022	DB	B
414	029	RCV VCO T	002	6C	A
415	031	S XMT BT	002	7C	A
416	032	S HYB T	002	DC	B
417	287	+Y THR2 T	010	61	A
418	285	-P THR2 T	010	E1	B
419	036	S HELIX I	002	BC	B
420	039	X XMT BT	002	FC	B
421	040	X HYB T	002	5C	A
422	041	X RFM T	002	E7	B
423	042	X EXC T	002	DD	B
424	718	MRIS EL T	039	ED	B
425	236	SUN SEN T	007	78	A
426	043	X TWT V	002	3B	A
427	046	X CAT I	002	AB	B
428	047	X EXC I	002	BB	B
429	049	TRF SW T	002	5D	A
430	050	AUX OSC T	002	EC	B
431	082	SHNT RG T	004	6B	A
432	083	RAD T1	004	73	A
433	084	RAD T2	004	F3	B
434	640	UVS T	034	55	A
435	453	LEMP T	025	66	A
436	230	GYRO A T	007	56	A
437	231	GYRO B T	007	FD	B
438	232	GYRO C T	007	7D	A
439	233	CST 1 T	007	65	A
440	234	CST 2 T	007	E5	B
441	235	SCAN AZ T	007	D6	B
442	140	FDS ST1	006	8E	B
443	141	FDS ST2	006	16	A
444	142	FDS ST3	006	17	A
445	143	FDS ST4	006	8D	B
446	144	FDS ST5	006	15	A
447	145	FDS ST6	006	8F	B
448	035	S XMT I	002	3C	A
449	623	PLS MOD T	032	5B	A
450	288	-Y THR2 T	010	F1	B
451	435	PWS T	023	5B	A

△

△ ⁂Table 4-6. MJS77 Telemetry Format Commutator Listing - MC-40, MC-12, and MC-72 Formats (sheet 6 of 6)

DECK	E NO.	FUNCTION	SUBSYS	FDS	ENG HALF
452	290	+R THR2 T	010	71	A
453	153	PWR CON A	006	35	A
454	291	-R THR2 T	010	D2	B
455	245	F/P/P ST	008	09	A
456	621	PLS EL T	032	F6	B
457	622	PLS SEN T	032	70	A
458	720	MRIS SBPW	039	C0	B
459	607	PPS EL T	027	D8	B

NOTES

** FOR COMMUTATOR A USE FDS IDENTIFIER 01, FOR COMMUTATOR B USE FDS IDENTIFIER 82.

\+ USED FOR AACS MEMORY READOUT IN THE MC-12 AND MC-72 FORMATS. DURING AACS MEMORY READOUT, NO DATA IS OBTAINED FROM THE A00/B00 DECKS.

Δ* Table 4-7. MJS77 Telemetry Format Commutator Listing - MN-40, MN-12, and MN-72 Formats (sheet 1 of 6)

DECK	E NO.	FUNCTION	SUBSYS	FDS	ENG HALF	
100	160	FRAME SYNC CODE		0000	0011	
101	161	FRAME SYNC CODE		1001	0001	
102	162	FRAME SYNC CODE		0101	1110	
103	163	FRAME SYNC CODE		1101	0011	
104	164	FORMAT ID WORD				
105	165	MOD 16 COUNTER				
106	166	MOD 60 AND LINE COUNT (2 MSB)				
107	167	LINE COUNT (8 LSB)				
108+	172	P GYRO AP	007	**	**	
109	071	2.4 INV V	004	33	A	
110	072	2.4 INV I	004	41	A	
111+	179	Y GYRO AP	007	**	**	
112	073	DC BUS V	004	21	A	
113	075	SHUNT I	004	23	A	
114+	186	R GYRO AP	007	**	**	
115	074	DC BUS I	004	36	A	
116		300 DECK SC				
117+	174	P SS POSN	007	**	**	
118	130	CCS OUT 1	005	04	A	
119	131	CCS OUT 2	005	05	A	
120+		A00 DECK SC				
121	022	VCO C V	002	9A	B	
122	023	VCO F V	002	2B	A	
123+	181	Y SS POSN	007	**	**	
124	060	MFP ST	003	07	A	
125		200 DECK SC				
126+	189	R CT POSN	007	**	**	
127	024	RCV AGC	002	3A	A	
128	026	RNG AGC V	002	C6	B	
129+	182	Y RATE	007	**	**	
130		400 DECK SC				
131	034	S XMT DR	002	2D	A	*
132+	175	P RATE	007	**	**	
133	080	DC BUS I	004	A6	B	
134	037	S HGA DR	002	9C	B	
135+	190	R RATE	007	**	**	
136	051	LGA DR	002	47	A	
137	027	RCV I	002	BA	B	
138+	172	P GYRO AP	007	**	**	
139	070	INV IN I	004	C1	B	
140	270	HELIUM P	010	24	A	
141+	179	Y GYRO AP	007	**	**	
142	272	+P TCM PC	010	34	A	
143	273	-P TCM PC	010	A4	B	
144+	186	P GYRO AP	007	**	**	
145	274	+Y TCM PC	010	44	A	

△* Table 4-7. MJS77 Telemetry Format Commutator Listing - MN-40, MN-12, and MN-72 Formats (sheet 2 of 6)

DECK	E NO.	FUNCTION	SUBSYS	FDS	ENG HALF	
146		300 DECK SC				
147+	176	P ES POSN	007	**	**	
148	275	-Y TCM PC	010	B4	B	
149	271	PRESS BR1	010	94	B	
150+		800 DECK SC				
151	078	2.4 INV I	004	B1	B	
152	081	SHUNT I	004	96	B	
153+	183	Y ES POSN	007	**	**	
154	077	2.4 INV V	004	92	B	
155		200 DECK SC				
156+	191	R ES POSN	007	**	**	
157	298	ISO VAL 1	010	C8	B	
158	299	ISO VAL 2	010	C9	B	
159+	168	R CT INT	007	**	**	
200	297	FEED T2	010	FB	B	
201	294	TANK T1	010	6D	A	
202	080	DC BUS I	004	A6	B	
203	712	MRIS PM T	039	D3	B	*
204	714	MRIS SM T	039	62	A	*
205	716	MRIS RS T	039	53	A	*
206	079	DC BUS V	004	C2	B	
207	340	DSS MV	016	2A	A	
208	271	PRESS BR1	010	94	B	
209	662	IB LFM T	035	EE	B	
210	410	PRA MUX	022	2E	A	
211	295	TANK T2	010	E8	B	
212	664	IB HFM T	035	FE	B	
213	713	MRIS PM H	039	A7	B	*
214	715	MRIS SM H	039	27	A	*
215	717	MRIS RS H	039	37	A	*
216	661	OB LFM T	035	6E	A	
217	663	OB HFM T	035	7E	A	
218	079	DC BUS V	004	C2	B	
219	296	FEED T1	010	68	A	
A00	216	+P TC CTR	007	**	**	
A01	180	BDPAR CTR	007	**	**	* △
A02	196	PY SS INT	007	**	**	
A03	197	R CT CA	007	**	**	
A04	206	CONF1 1ST	007	**	**	
A05	218	+Y TC CTR	007	**	**	
A06	226	R EST ACC	007	**	**	*
A07	213	AC/FDS HC	007	**	**	

△ * Table 4-7. MJS77 Telemetry Format Commutator Listing - MN-40, MN-12, and MN-72 Formats (sheet 3 of 6)

DECK	E NO.	FUNCTION	SUBSYS	FDS	ENG HALF	
A08	207	CONF1 2ND	007	**	**	
A09	208	CONF1 3RD	007	**	**	
A10	178	P SS BA C	007	**	**	
A11	185	Y SS BA C	007	**	**	
A12	209	+P AP CTR	007	**	**	
A13	211	+Y AP CTR	007	**	**	
A14	214	+R AP CTR	007	**	**	
B00	217	-P TC CTR	007	**	**	
B01	200	STAT 1	007	**	**	
B02	201	STAT 2	007	**	**	
B03	202	STAT 3	007	**	**	
B04	203	STAT 4	007	**	**	
B05	219	-Y TC CTR	007	**	**	
B06	204	STAT MODE	007	**	**	
B07	205	STAT GYRO	007	**	**	
B08	225	Y EST ACC	007	**	**	*
B09	224	P EST ACC	007	**	**	*
B10	177	P SS BA F	007	**	**	
B11	184	Y SS BA F	007	**	**	
B12	210	-P AP CTR	007	**	**	
B13	212	-Y AP CTR	007	**	**	
B14	215	-R AP CTR	007	**	**	
300	411	PRA EL T	022	DB	B	
301	286	-Y THR1 T	010	D1	B	
302	030	USO OV I	002	CA	B	
303	155	3V ADC A	006	A8	B	
304	156	3V ADC B	006	28	A	
305	684	NA FOT	036	D9	B	
306	109	RTG 1T3	004	5A	A	
307	110	RTG 1T2	004	DA	B	
308	685	NA ROT	036	59	A	
309	154	PWR CON B	006	A5	B	
310	289	-R THR1 T	010	52	A	
311	361	CRS EL T	021	57	A	
312	362	CRS TEL T	021	D7	B	
313	292	SURF T1	010	7B	A	
314	293	SURF T2	010	F4	B	
315	061	TMU ST1	003	8B	B	
316	062	TMU ST2	003	8C	B	
317	245	F/P/P ST	008	09	A	
318	146	FDS MEM WD	006	08	A	*
319	107	RTG 2I	004	91	B	
320	352	HGA XBF T	017	F2	B	

△* Table 4-7. MJS77 Telemetry Format Commutator Listing - MN-40, MN-12, and MN-72 Formats (sheet 4 of 6)

DECK	E NO.	FUNCTION	SUBSYS	FDS	ENG HALF	
321	682	NA VID T	036	F9	B	
322	683	WA VID T	036	69	A	
323	103	RTG 1I	004	A0	B	
324	104	RTG 2I	004	40	A	
325	105	RTG 3I	004	B0	B	
326	111	RTG 2T1	004	6A	A	
327	112	RTG 2T3	004	EA	B	
328	434	PWS V	023	93	B	
329	435	PWS T	023	58	A	
330	SPARE					△
331	151	30V INV	006	45	A	
332	152	10V BUS	006	B5	B	
333	035	S XMT I	002	3C	A	*
334	660	MAG MUX	035	38	A	
335	276	PROP C1MS	010	0C	A	
336	277	PROP C1LS	010	0D	A	
337	278	PROP C2MS	010	0E	A	
338	279	PROP C2LS	010	0F	A	
339	280	PROP C3MS	010	80	B	
340	281	PROP C3LS	010	81	B	
341	282	PROP C4MS	010	83	B	
342	283	PROP C4LS	010	86	B	
343	038	S EXC I	002	4C	A	
344	020	RFS ST1	002	06	A	
345	021	RFS ST2	002	8A	B	
346	113	RTG 3T1	004	7A	A	
347	114	RTG 3T2	004	FA	B	
348	686	WA OPT T	036	79	A	
349	687	NA PWR T	036	74	A	
350	688	WA PWR T	036	E9	B	
351	153	PWR CON A	006	35	A	
352	SPARE					△
353	100	RTG 1V	004	3D	A	
354	101	RTG 2V	004	90	B	
355	102	RTG 3V	004	49	A	
356	342	MODE ST	016	88	B	
357	343	PLAYB ST	016	89	B	
358	157	5V TIME	006	C5	B	
359	108	RTG 3I	004	30	A	
400	000	BAY 1T	001	67	A	
401	001	BAY 2T	001	D4	B	
402	002	BAY 3T	001	54	A	
403	003	BAY 4T	001	E4	B	
404	004	BAY 5T	001	64	A	
405	005	BAY 6T	001	F8	B	

Δ* Table 4-7. MJS77 Telemetry Format Commutator Listing - MN-40, MN-12, and MN-72 Formats (sheet 5 of 6)

DECK	E NO.	FUNCTION	SUBSYS	FDS	ENG HALF	
406	006	BAY 7T	001	76	A	
407	007	BAY 8T	001	D5	B	
408	008	BAY 9T	001	77	A	
409	009	BAY 10T	001	F7	B	
410	350	HGA MR T	017	63	A	
411	SPARE					Δ
412	284	+P THR2 T	010	51	A	
413	028	LOC OSC D	002	4A	A	
414	029	RCV VCO T	002	6C	A	
415	031	S XMT BT	002	7C	A	*
416	032	S HYB T	002	DC	B	
417	033	S XMT V	002	AC	B	*
418	285	-P THR2 T	010	E1	B	
419	036	S HELIX I	002	BC	B	
420	287	+Y THR2 T	010	61	A	
421	288	-Y THR2 T	010	F1	B	
422	290	+R THR2 T	010	71	A	
423	291	-R THR2 T	010	D2	B	
424	718	MRIS EL T	039	ED	B	*
425	236	SUN SEN T	007	78	A	
426	284	+P THR2 T	010	51	A	
427	285	-P THR2 T	010	E1	B	
428	293	SURF T2	010	F4	B	
429	049	TRF SW T	002	5D	A	
430	050	AUX OSC T	002	EC	B	
431	082	SHNT RG T	004	6B	A	
432	083	RAD T1	004	73	A	
433	084	RAD T2	004	F3	B	
434	640	UVS T	034	55	A	
435	453	LEMP T	025	66	A	*
436	230	GYRO A T	007	56	A	
437	231	GYRO B T	007	FD	B	
438	232	GYRO C T	007	7D	A	
439	233	CST 1 T	007	65	A	
440	234	CST 2 T	007	E5	B	
441	235	SCAN AZ T	007	D6	B	
442	140	FDS ST1	006	8E	B	
443	141	FDS ST2	006	16	A	
444	142	FDS ST3	006	17	A	
445	143	FDS ST4	006	8D	B	
446	144	FDS ST5	006	15	A	
447	145	FDS ST6	006	8F	B	
448	287	+Y THR2 T	010	61	A	
449	623	PLS MOD T	032	5B	A	
450	288	-Y THR2 T	010	F1	B	
451	150	SEL 30 V	006	25	A	

ΔＸ Table 4-7. MJS77 Telemetry Format Commutator Listing - MN-40, MN-12, and MN-72 Formats (sheet 6 of 6)

DECK	E NO.	FUNCTION	SUBSYS	FDS	ENG HALF	
452	076	INV IN I	004	46	A	
453	290	+R THR2 T	010	71	A	
454	291	-R THR2 T	010	D2	B	
455	341	DSS P	016	99	B	
456	621	PLS EL T	032	F6	B	
457	622	PLS SEN T	032	70	A	
458	720	MRIS SBPW	039	C0	B	*
459	607	PPS EL T	027	D8	B	

NOTES

* DENOTES CHANGE

** FOR COMMUTATOR A USE FDS IDENTIFIER 01, FOR COMMUTATOR B USE FDS IDENTIFIER 82.

\+ USED FOR AACS MEMORY READOUT IN THIS MODE. DURING AACS MEMORY READOUT NO DATA IS OBTAINED FROM THE A00/B00 DECKS.

△✻ Table 4-8. MJS77 Telemetry Format Commutator Listing - EC-40 Format (sheet 1 of 6)

DECK	E NO.	FUNCTION	SUBSYS	FDS	ENG HALF	
100	160	FRAME SYNC CODE	0000 0011			
101	161	FRAME SYNC CODE	1001 0001			
102	162	FRAME SYNC CODE	0101 1110			
103	163	FRAME SYNC CODE	1101 0011			
104	164	FORMAT ID WORD				
105	165	MOD 16 COUNTER				
106	166	MOD 60 AND LINE COUNT (2 MSB)				
107	167	LINE COUNT (8 LSB)				
108	174	P SS POSN	007	**	**	
109+	071	2.4 INV V	004	33	A	
110+	072	2.4 INV I	004	41	A	
111	181	Y SS POSN	007	**	**	
112+	073	DC BUS V	004	21	A	
113+	075	SHUNT I	004	23	A	
114	189	R CT POSN	007	**	**	
115+	074	DC BUS I	004	36	A	
116+		300 DECK SC				
117	175	P RATE	007	**	**	
118+	130	CCS OUT 1	005	04	A	
119+	131	CCS OUT 2	005	05	A	
120		A00 DECK SC				
121+	022	VCO C V	002	9A	B	
122+	023	VCO F V	002	2B	A	
123	182	Y RATE	007	**	**	
124+	060	MFP ST	003	07	A	
125+		200 DECK SC				
126	190	R RATE	007	**	**	
127+	024	RCV AGC	002	3A	A	
128	174	P SS POSN	007	**	**	
129	177	P SS BA F	007	**	**	
130+		400 DECK SC				
131	181	Y SS POSN	007	**	**	
132	184	Y SS BA F	007	**	**	
133+	026	RNG AGC V	002	C6	B	
134	189	R CT POSN	007	**	**	
135	194	SCA EL C	007	**	**	
136+	146	FDS MEM WD	006	08	A	*
137+	027	RCV I	002	BA	B	
138	192	SCA AZ C	007	**	**	
139+	044	X TWT DR	002	9B	B	
140+	034	S XMT DR	002	2D	A	*
141	195	SCA EL F	007	**	**	
142+	037	S HGA DR	002	9C	B	
143+	048	X HGA DR	002	2C	A	
144	193	SCA AZ F	007	**	**	

Δ* Table 4-8. MJS77 Telemetry Format Commutator Listing - EC-40 Format (sheet 2 of 6)

DECK	E NO.	FUNCTION	SUBSYS	FDS	ENG HALF	
145+	602	ANLYZ POS	027	3E	A	
146+		300 DECK SC				
147	172	P GYRO AP	007	**	**	
148	174	P SS POSN	007	**	**	
149+	603	FILTR POS	027	AE	B	
150		800 DECK SC				
151	181	Y SS POSN	007	**	**	
152+	604	PPS HV	027	4E	A	
153	179	Y GYRO AP	007	**	**	
154	189	R CT POSN	007	**	**	
155+		200 DECK SC				
156	186	R GYRO AP	007	**	**	
157+	641	UVS HV	034	CD	B	
158	606	SOL SEN	027	BE	B	
159	188	R CT INT	007	**	**	
200	SPARE					Δ
201	360	CRS MUX	021	29	A	
202	660	MAG MUX	035	38	A	
203	712	MRIS PM T	039	D3	B	*
204	714	MRIS SM T	039	62	A	*
205	716	MRIS RS T	039	53	A	*
206	682	NA VID T	036	F9	B	
207	683	WA VID T	036	69	A	
208	684	NA FOT	036	D9	B	
209	601	APERT POS	027	9E	B	
210	410	PRA MUX	022	2E	A	
211	685	NA ROT	036	59	A	
212	153	PWR CON A	006	35	A	*
213	713	MRIS PM H	039	A7	B	*
214	715	MRIS SM H	039	27	A	*
215	717	MRIS RS H	039	37	A	*
216	070	INV IN I	004	C1	B	
217	450	ENGR MUX	025	98	B	
218	686	WA OPT T	036	79	A	
219	620	PLS MUX	032	A2	B	
A00	176	P ES POSN	007	**	**	
A01	191	R ES POSN	007	**	**	
A02	196	PY SS INT	007	**	**	
A03	197	R CT CA	007	**	**	
A04	206	CONF1 1ST	007	**	**	
A05	176	P ES POSN	007	**	**	
A06	191	R ES POSN	007	**	**	
A07	213	AC/FDS HC	007	**	**	

Δ* Table 4-8. MJS77 Telemetry Format Commutator Listing - EC-40 Format (sheet 3 of 6)

DECK	E NO.	FUNCTION	SUBSYS	FDS	ENG HALF	
A08	207	CONF1 2ND	007	**	**	
A09	208	CONF1 3RD	007	**	**	
A10	178	P SS BA C	007	**	**	
A11	185	Y SS BA C	007	**	**	
A12	209	+P AP CTR	007	**	**	
A13	211	+Y AP CTR	007	**	**	
A14	214	+R AP CTR	007	**	**	
B00	183	Y LS POSN	007	**	**	
B01	200	STAT 1	007	**	**	
B02	201	STAT 2	007	**	**	
B03	202	STAT 3	007	**	**	
B04	203	STAT 4	007	**	**	
B05	183	Y ES POSN	007	**	**	
B06	204	STAT MODE	007	**	**	
B07	205	STAT GYRO	007	**	**	
B08	228	INT 1 CTR	007	**	**	* Δ
B09	227	CYC L CTR	007	**	**	* Δ
B10	173	PC O CTR	007	**	**	* Δ
B11	180	BDPAR CTR	007	**	**	* Δ
B12	210	-P AP CTR	007	**	**	
B13	212	-Y AP CTR	007	**	**	
B14	215	-R AP CTR	007	**	**	
300	270	HELIUM P	010	24	A	
301	286	-Y THR1 T	010	D1	B	
302	030	USO OV I	002	CA	B	
303	155	3V ADC A	006	A8	B	
304	156	3V ADC B	006	28	A	
305	661	OB LFM T	035	6E	A	
306	109	RTG 1T3	004	5A	A	
307	110	RTG 1T2	004	DA	B	
308	662	IB LFM T	035	EE	B	
309	663	OB HFM T	035	7E	A	
310	289	-R THR1 T	010	52	A	
311	047	X EXC I	002	BB	B	
312	043	X TWT V	002	3B	A	
313	292	SURF T1	010	7B	A	
314	293	SURF T2	010	F4	B	
315	434	PWS V	023	93	B	*
316	297	FEED T2	010	FB	B	
317	298	ISO VAL 1	010	C8	B	
318	299	ISO VAL 2	010	C9	B	
319	362	CRS TEL T	021	D7	B	
320	294	TANK T1	010	6D	A	

✽ Table 4-8. MJS77 Telemetry Format Commutator Listing - EC-40 Format (sheet 4 of 6)

DECK	E NO.	FUNCTION	SUBSYS	FDS	ENG HALF	
321	667	NA PWR T	036	74	A	
322	605	PPS LV	027	CE	B	*
323	103	RTG 1I	004	A0	B	
324	104	RTG 2I	004	40	A	
325	105	RTG 3I	004	B0	B	
326	111	RTG 2T1	004	6A	A	
327	112	RTG 2T3	004	EA	B	
328	664	IB HFM T	035	FE	B	
329	340	DSS MV	016	2A	A	
330	035	S XMT I	002	3C	A	*
331	352	HGA XBF T	017	F2	B	
332	361	CRS EL T	021	57	A	
333	453	LEMP T	025	66	A	*
334	SPARE					Δ
335	276	PROP C1MS	010	0C	A	
336	277	PROP C1LS	010	0D	A	
337	278	PROP C2MS	010	0E	A	
338	279	PROP C2LS	010	0F	A	
339	280	PROP C3MS	010	80	B	
340	281	PROP C3LS	010	81	B	
341	282	PROP C4MS	010	83	B	
342	283	PROP C4LS	010	86	B	
343	038	S EXC I	002	4C	A	
344	020	RFS ST1	002	06	A	
345	021	RFS ST2	002	8A	B	
346	113	RTG 3T1	004	7A	A	
347	114	RTG 3T2	004	FA	B	
348	061	TMU ST1	003	8B	B	
349	062	TMU ST2	003	8C	B	
350	600	PPS T OP	027	26	A	
351	296	FEED T1	010	68	A	
352	046	X CAT I	002	AB	B	
353	100	RTG 1V	004	3D	A	
354	101	RTG 2V	004	90	B	
355	102	RTG 3V	004	49	A	
356	342	MODE ST	016	88	B	
357	343	PLAYB ST	016	89	B	
358	271	PRESS BR1	010	94	B	
359	045	X HELIX I	002	4B	A	
400	000	BAY 1T	001	67	A	
401	001	BAY 2T	001	D4	B	
402	002	BAY 3T	001	54	A	
403	003	BAY 4T	001	E4	B	
404	004	BAY 5T	001	64	A	
405	005	BAY 6T	001	F8	B	

* Table 4-8. MJS77 Telemetry Format Commutator Listing - EC-40 Format (sheet 5 of 6)

DECK	E NO.	FUNCTION	SUBSYS	FDS	ENG HALF	
406	006	BAY 7T	001	76	A	
407	007	BAY 8T	001	D5	B	
408	008	BAY 9T	001	77	A	
409	009	BAY 10T	001	F7	B	
410	350	HGA MR T	017	63	A	
411	SPARE					△
412	284	+P THR2 T	010	51	A	
413	028	LOC OSC D	002	4A	A	
414	029	RCV VCO T	002	6C	A	
415	031	S XMT BT	002	7C	A	*
416	032	S HYB T	002	DC	B	
417	033	S XMT V	002	AC	B	*
418	285	-P THR2 T	010	E1	B	
419	036	S HELIX I	002	BC	B	
420	039	X TWT BT	002	FC	B	
421	040	X HYB T	002	5C	A	
422	041	X RFM T	002	E7	B	
423	042	X EXC T	002	DD	B	
424	719	MRIS EL T	039	ED	B	*
425	236	SUN SEN T	007	78	A	
426	287	+Y THR2 T	010	61	A	
427	288	-Y THR2 T	010	F1	B	
428	290	+R THR2 T	010	71	A	
429	049	TRF SW T	002	5D	A	
430	050	AUX OSC T	002	EC	B	
431	082	SHNT RG T	004	6B	A	
432	083	RAD T1	004	73	A	
433	084	RAD T2	004	F3	B	
434	435	PWS T	023	58	A	
435	411	PRA EL T	022	DB	B	
436	230	GYRO A T	007	56	A	
437	231	GYRO B T	007	FD	B	
438	232	GYRO C T	007	7D	A	
439	233	CST 1 T	007	65	A	
440	234	CST 2 T	007	E5	B	
441	235	SCAN AZ T	007	D6	B	
442	140	FDS ST1	006	8E	B	
443	141	FDS ST2	006	16	A	
444	142	FDS ST3	006	17	A	
445	143	FDS ST4	006	8D	B	
446	144	FDS ST5	006	15	A	
447	145	FDS ST6	006	8F	B	
448	245	F/P/P ST	008	09	A	
449	623	PLS MOD T	032	5B	A	
450	640	UVS T	034	55	A	*
451	295	TANK T2	010	E8	B	

△✱ Table 4-8. MJS77 Telemetry Format Commutator Listing - EC-40 Format (sheet 6 of 6)

DECK	E NO.	FUNCTION	SUBSYS	FDS	ENG HALF	
452	065	CDU OSC M	003	87	B	*
453	688	WA PWR T	036	E9	B	*
454	291	-R THR2 T	010	D2	B	
455	341	DSS P	016	99	B	
456	621	PLS EL T	032	F6	B	
457	622	PLS SEN T	032	70	A	
458	720	MRIS SBPW	039	C0	B	*
459	607	PPS EL T	027	D8	B	

NOTES

* DENOTES CHANGE

** FOR COMMUTATOR A USE FDS IDENTIFIER 01, FOR COMMUTATOR B USE FDS IDENTIFIER 82.

\+ USED FOR AACS MEMORY READOUT IN THIS MODE. DURING AACS MEMORY READOUT NO DATA IS OBTAINED FROM THE 200, 300 AND 400 DECKS.

4.1.4 Sampling Periods

The following table defines the sampling period of engineering data for each deck at each of the engineering bit rates; 10, 40, and 1200 bps.

Sampling Period, Engineering

Engr. Rate (bps) \ Deck	100	200	A00 B00	300	400
10	48 s	8 m	12 m	24 m	48 m
40	12 s	2 m	3 m	6 m	12 m
1200	0.4 s	4 s	6 s	12 s	24 s

4.1.5 Resolution

Each temperature or 0-3 volt engineering measurement is converted into a 8-bit digital word for a data number (DN) range of 0 to 255 DN. Therefore each word has a maximum resolution of 1/256 (±0.39 percent).

4.1.6 Bit Order

All words are inserted into the telemetry stream MSB first. Bit 1 is MSB.

4.2 Engineering Frame Structure

4.2.1 Frame Synchronization Code (Bits 1-32)

Frame synchronization code is the same as described in paragraph 3.1.1.

4.2.2 Format ID Word (Bits 33-40)

Format ID is described in paragraph 3.1.2.

4.2.3 Flight Data System Count (Bits 41-64)

FDSC is described in paragraph 3.1.3. For engineering data frames the time count provided in this field is dependent upon the data rate as follows:

a) FDSC at 1200 bps:

Major Frame	Minor Frame (1-60)	MOD 16 Counter	MOD 60 Counter (0-59)	Line Count (1-800)
1	1	8 LSB*	0	1
1	2	8 MSB		7
1	3	8 LSB		14
1	4	8 MSB		21
1	5	8 LSB		27
1	6	8 MSB		34
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
1	60	8 MSB		394
2	1	8 LSB		401
.	.			.
.	.			.
.	.			.
2	60	8 MSB		794
3	1	8 LSB	1	1

etc.

*Odd numbered minor frames (Line Count = 1 or 14 or 27 MOD 40). Output is 8 LSBs.

Even numbered minor frames (Line Count = 7 or 21 or 34 MOD 40). Output is 8 MSBs.

b) FDSC at 40 bps:

Major Frame	Minor Frame (1-60)	MOD 16 Counter	MOD 60 Counter (0-59)	Line Count (1-800)
1	1	8 LSB*	0	1
1	2	8 MSB	0	201
1	3	8 LSB	0	401
1	4	8 MSB	0	601
1	5	8 LSB	0	1
.	.		.	.
.	.		.	.
.	.		.	.
1	60		59	601
2	1		0	1

*Odd numbered minor frames (Line Count = 1 or 401). Output is 8 LSBs.

Even numbered minor frames (Line Count = 201 or 601). Output is 8 MSBs.

4.2.4 Engineering Data Sample Time

The following paragraphs describe the relationship between the FDSC time in engineering minor frames and data sample time.

a) Sample time at 1200 bps:

Calling the beginning of Line Count MOD 20 the reference point and referring only to samples 9 through 60 of each minor frame, the delay (D) between FDSC time in that minor frame and sample time is:

Case 1: Relative to beginning of (Line Count = 1) MOD 20,

$D = 20 \text{ ms} + n(6\ 2/3 \text{ ms}) \mid n = 0, 51$

$n = 0$ => the 9th word of the minor frame

Case 2: Relative to beginning of (Line Count = 7) MOD 20,

$D = 60 \text{ ms} + n(6\ 2/3 \text{ ms}) \mid n = 0, 51$

$n = 0$ => the 9th word of the minor frame

Case 3: Relative to beginning of (Line Count = 14) MOD 20,

$D = 40 \text{ ms} + n(6\ 2/3 \text{ ms}) \mid n = 0, 51$

$n = 0$ => the 9th word of the minor frame.

b) Sample time at 40 bps:

Relative to the beginning of a line whose number appears in Line Count, the delay (D) between FDSC time in that minor frame and sample time (samples 9 through 60) is:

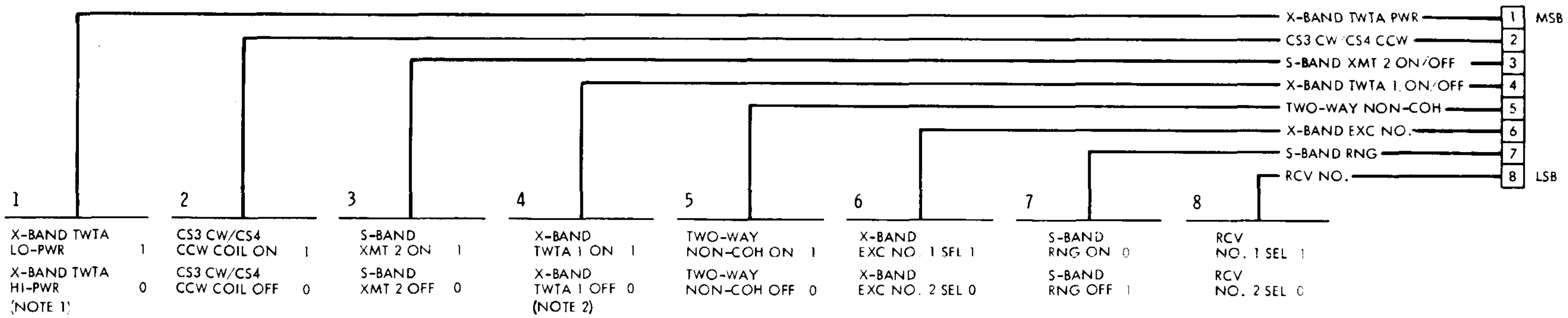
$D = 1.17 \text{ sec} + n(0.2 \text{ sec}) \mid n = 0, 51$

$n = 0$ => the 9th word of the minor frame

4.3 Special Processing Requirements

4.3.1 Status Words

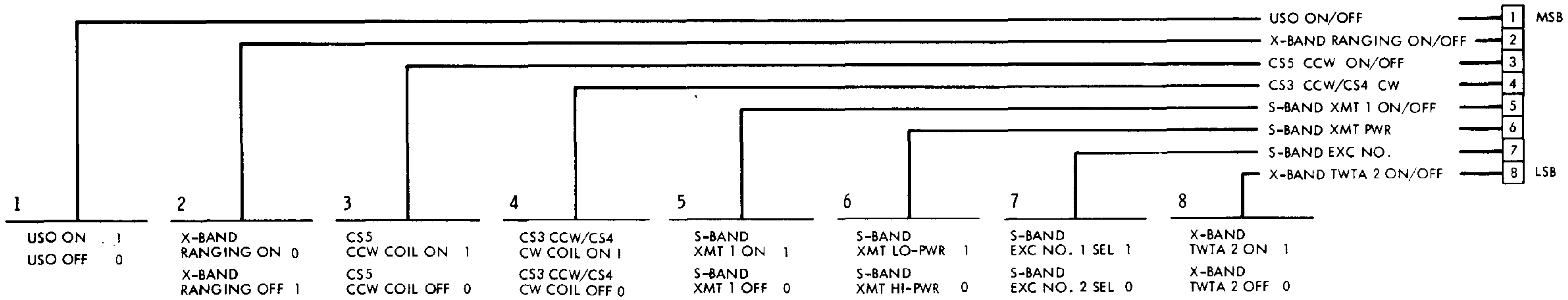
Status words are digital words reporting the state of discrete events or conditions. The information content for each bit of these words is shown in Figures 4-2 through 4-22.



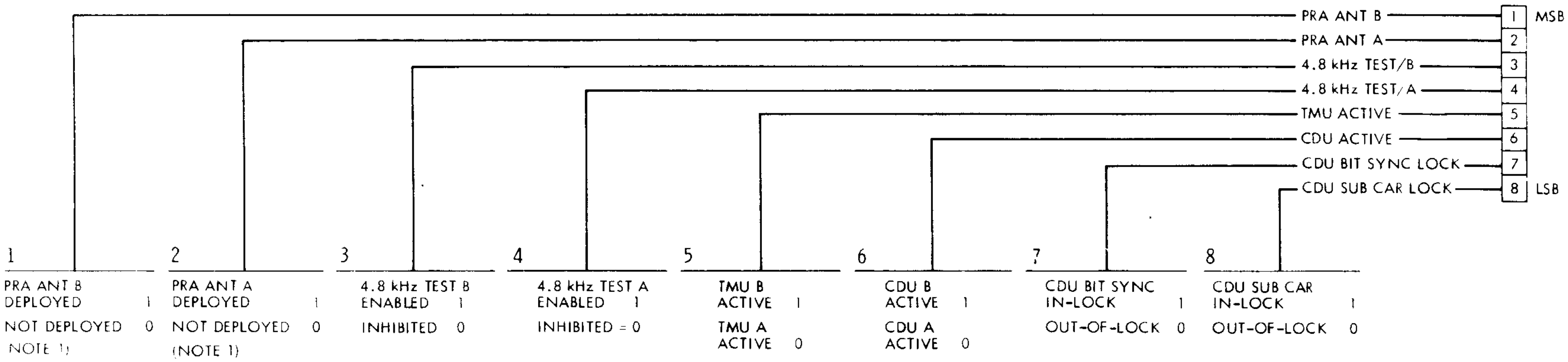
NOTE 1: BIT 1 WILL ALWAYS READ "O" WHEN X-BAND TWTA-1 IS ON IF THE HUGHES AIRCRAFT ALTERNATE X-BAND TWTA ASSEMBLY (2002 XB 1) IS FLOWN.

NOTE 2: HUGHES TUBE, IF FLOWN.

△ * Figure 4-2. Measurement No. E-020, RFS Status Word 1 (FDS Identifier 06)



* Figure 4-3. Measurement No. E-021, RFS Status Word 2 (FDS Identifier 8A)



NOTE 1: FOR PROPER ANTENNA DEPLOY INDICATION, 30 VDC POWER MUST BE APPLIED TO THE PRA.

* Figure 4-4. Measurement No. E-060, MDS/FDS/PRA Status (FDS Identifier 07)

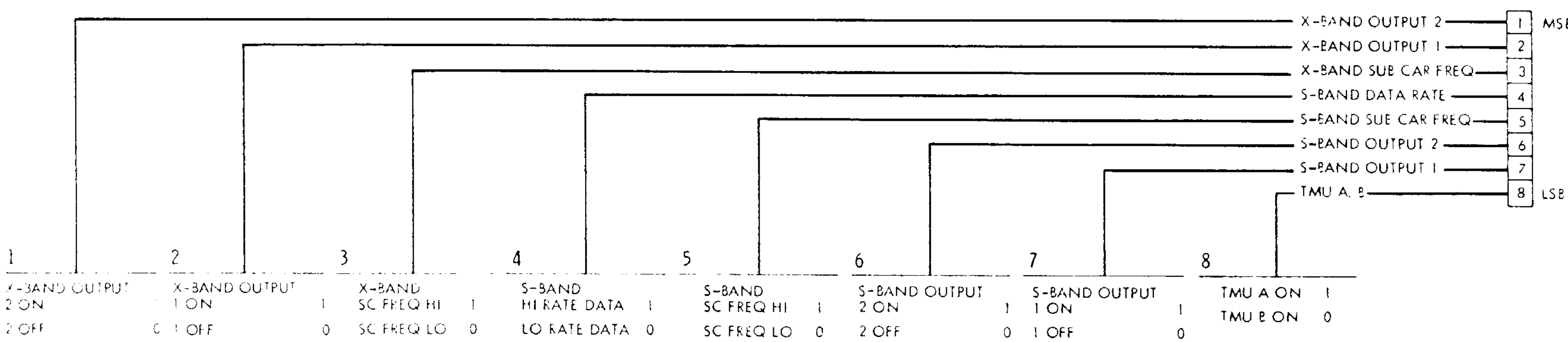
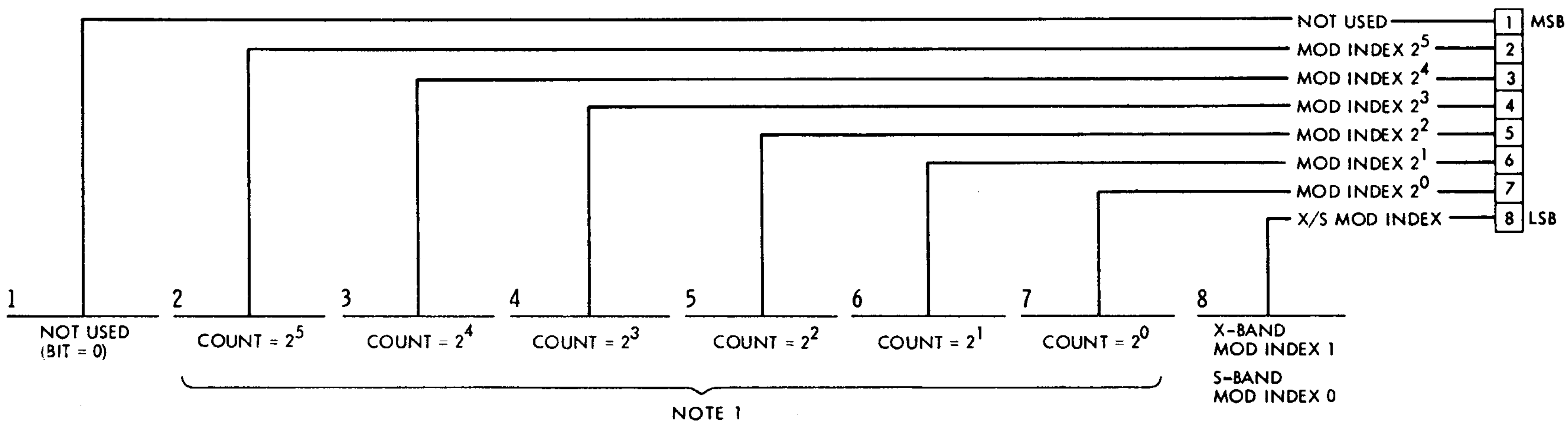


Figure 4-5. Measurement No. E-061, TMU Status 1 (FDS Identifier 8B)



NOTE 1:

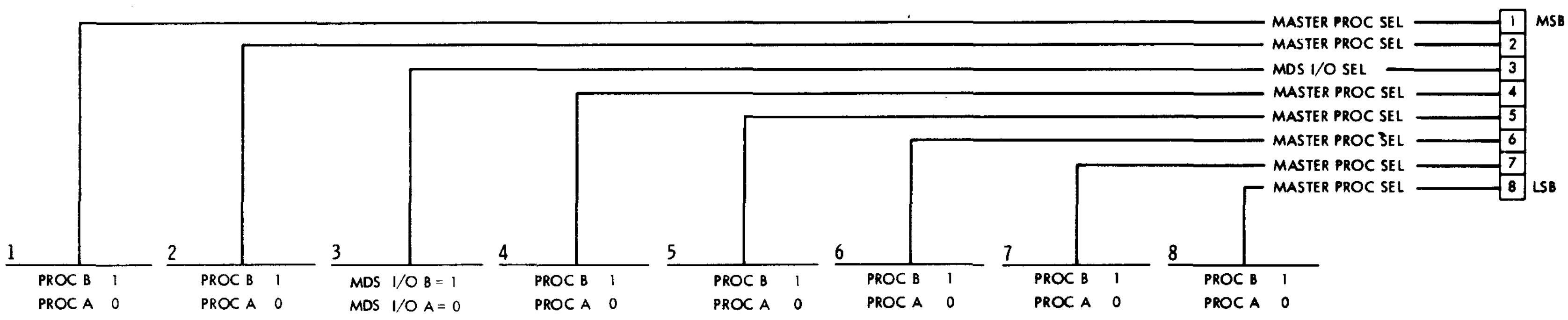
MODULATION INDEX IS MEASUREMENT OF SIGNAL AMPLITUDE AT RFS. COUNT IS 0 TO 63.

0 = 350 MVPP

63 = 1750 MVPP

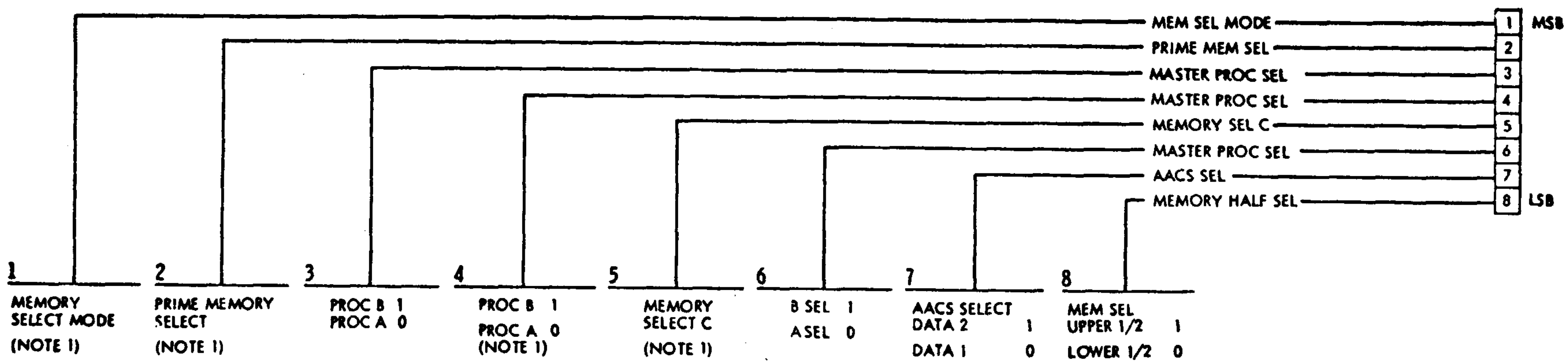
SCALE IS 22.22 MV PER UNIT

Figure 4-6. Measurement No. E-062, TMU Status 2 (FDS Identifier 8C)



NOTE: ALL PROCESSOR SELECTS WILL EITHER BE A("0") OR B("1")

Figure 4-7. Measurement No. E-140, FDS Status Word 1 (FDS **Identifier 8E)**



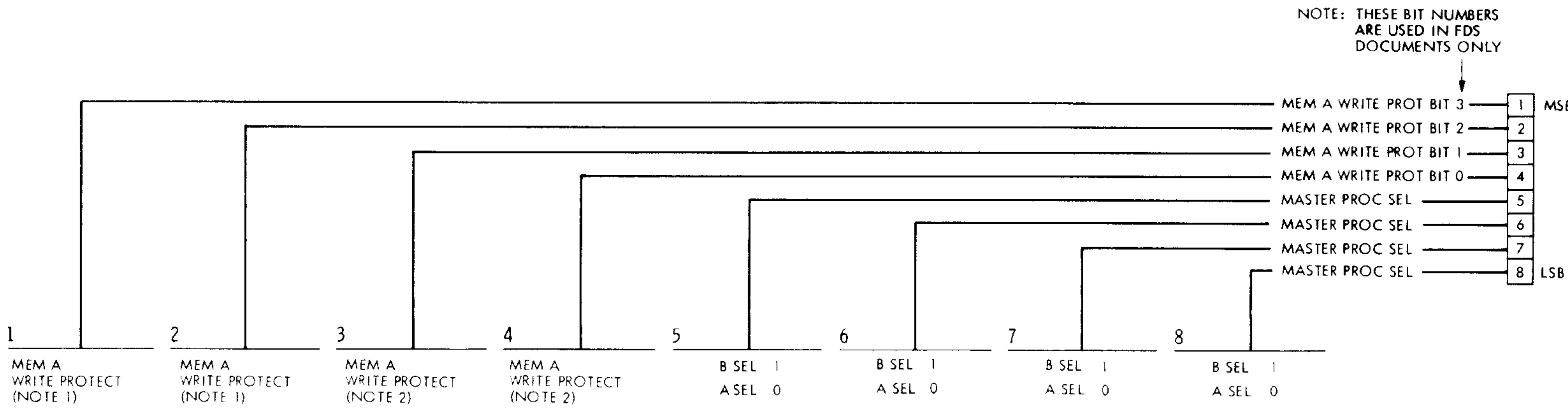
NOTE 1

BIT 1	BIT 2	BIT 4	BIT 5	ACTIVE PROC	PRIMARY MEMORY	SECONDARY MEMORY
0	0	0	1	A	B	A
0	1	0	0	A	A	B
0	0	1	1	B	A	B
0	1	1	0	B	B	A
1	0	0	•	A	•	•
1	1	0	•	A	•	•
1	0	1	•	B	•	•
1	1	1	•	B	•	•

*DETERMINED BY FDS PROGRAM

△ Figure 4-8. Measurement No. E-141, FDS Status Word 2 (FDS Identifier 16)

MJS77-3-280 B



NOTE 1 UPPER HALF

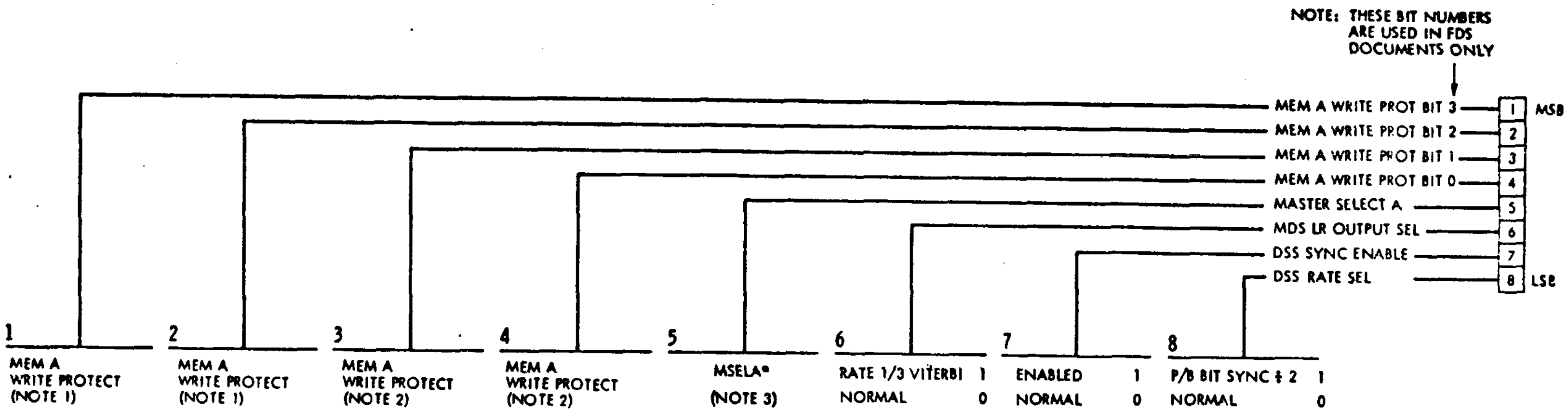
BIT 1 2	AREA PROTECTED (HEX ADDRESS)
0 0	NONE
0 1	1000 - 19FF
1 0	1000 - 1BFF
1 1	1000 - 1DFF

NOTE 2 LOWER HALF

BIT 3 4	AREA PROTECTED (HEX ADDRESS)
0 0	NONE
0 1	0 - 9FF
1 0	0 - BFF
1 1	0 - DFF

NOTE: ALL PROCESSOR SELECT BITS WILL EITHER BE A("0") OR B("1")

Figure 4-9. Measurement No. E-142, FDS Status Word 3 (FDS Identifier 17)



NOTE 1 UPPER HALF

BIT 1 2	AREA PROTECTED (HEX ADDRESS)
0 0	NONE
0 1	1000 - 19FF
1 0	1000 - 1BFF
1 1	1000 - 1DFF

NOTE 2 LOWER HALF

BIT 3 4	AREA PROTECTED (HEX ADDRESS)
0 0	NONE
0 1	0 - 9FF
1 0	0 - BFF
1 1	0 - DFF

NOTE 3

BIT 4 OF FDS SW 2	BIT 5 OF FDS SW 4	DEFINITION
0	0	SINGLE PROC MODE, PROC A
1	1	SINGLE PROC MODE, PROC B
0	1	DUAL PROC MODE, PROC A
1	0	DUAL PROC MODE, PROC B

NOTE: BITS 6-8 ARE ALL "0" IN SINGLE PROCESSOR MODE

△ * Figure 4-10. Measurement No. E-143, FDS Status Word 4 (FDS Identifier 8D)

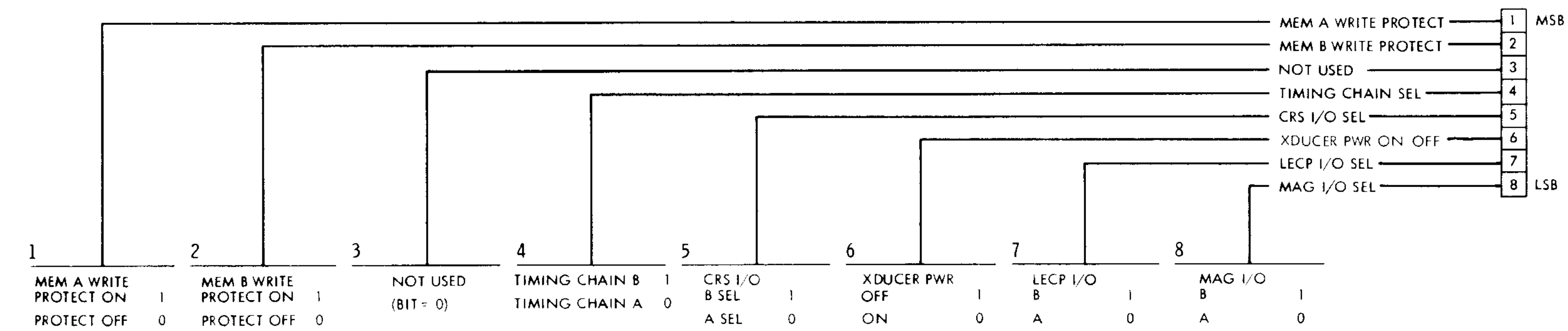


Figure 4-11. Measurement No. E-144, FDS Status Word 5 (FDS Identifier 15)

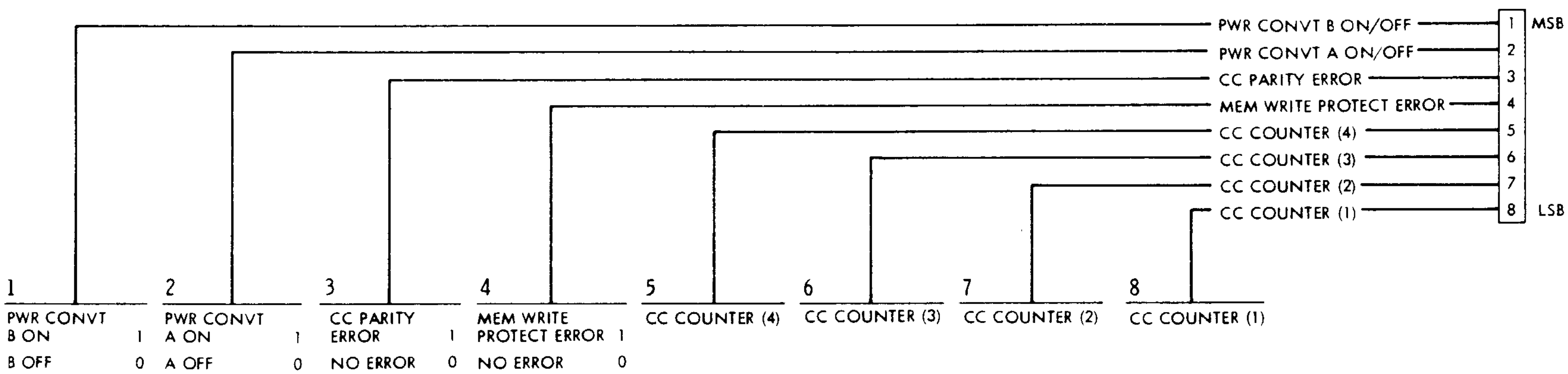


Figure 4-12. Measurement No. E-145, FDS Status Word 6 (FDS Identifier 8F)

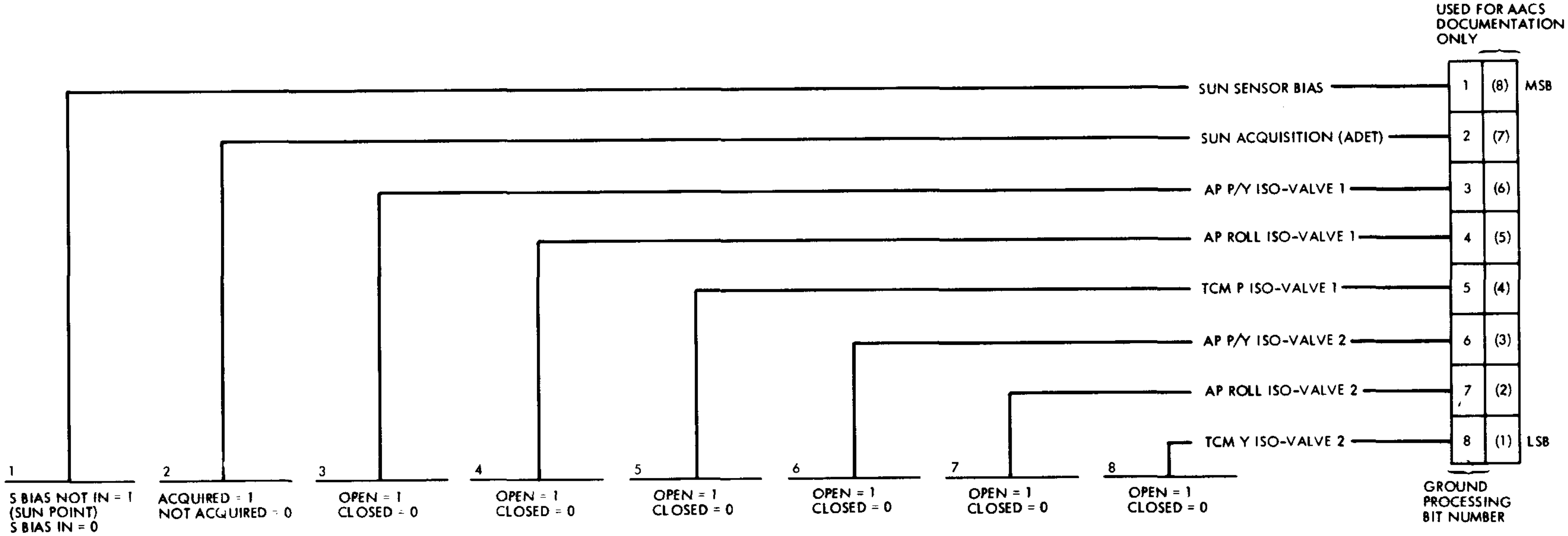


Figure 4-13. Measurement No. E-200 AACS Status Word 1

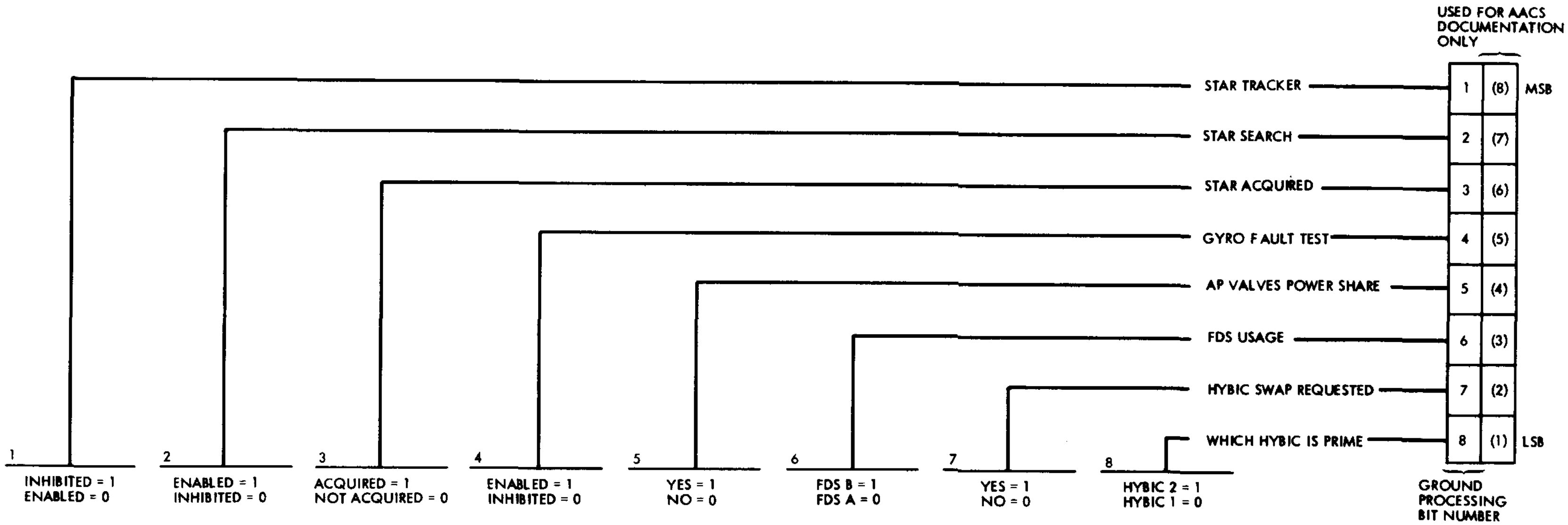


Figure 4-14. Measurement No. E-201 AACS Status Word 2

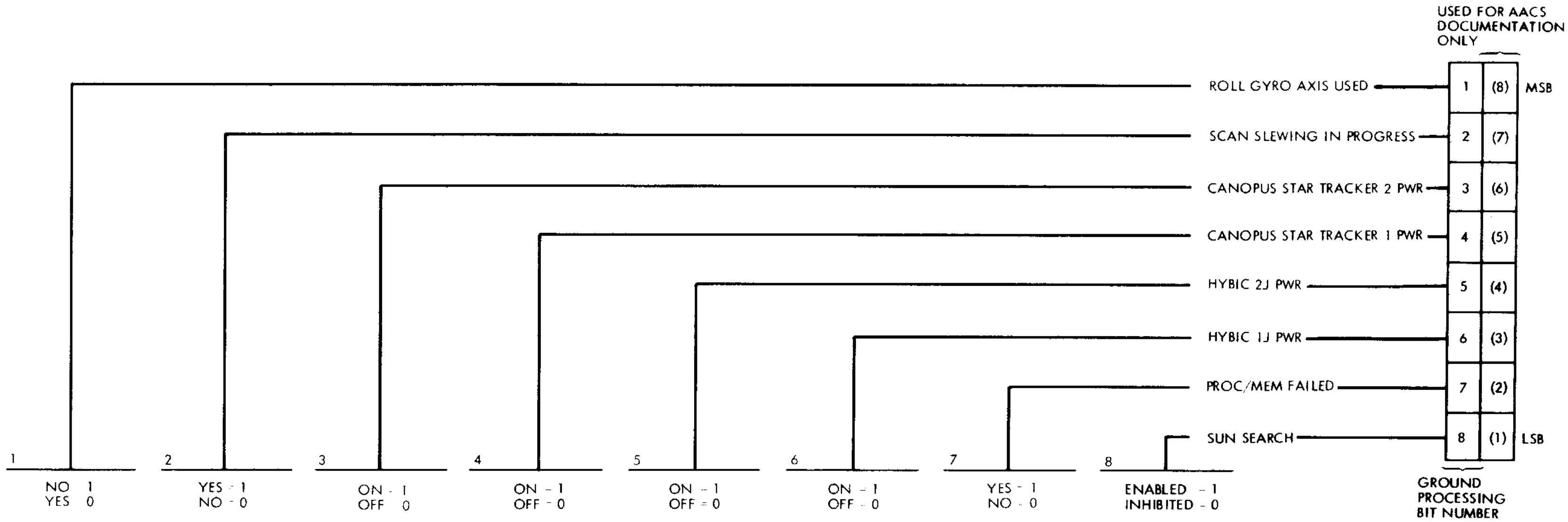


*Figure 4-15. Measurement No. E-202, AACS Status Word 3

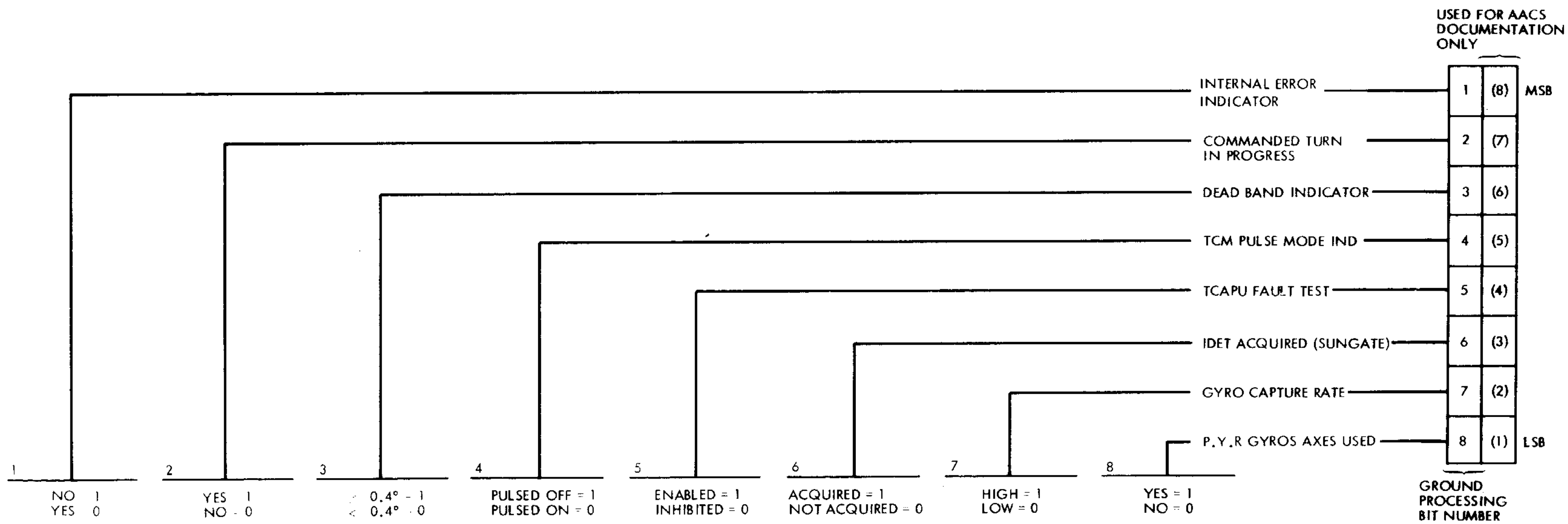


*Figure 4-16. Measurement No. E-203, AACS Status Word 4

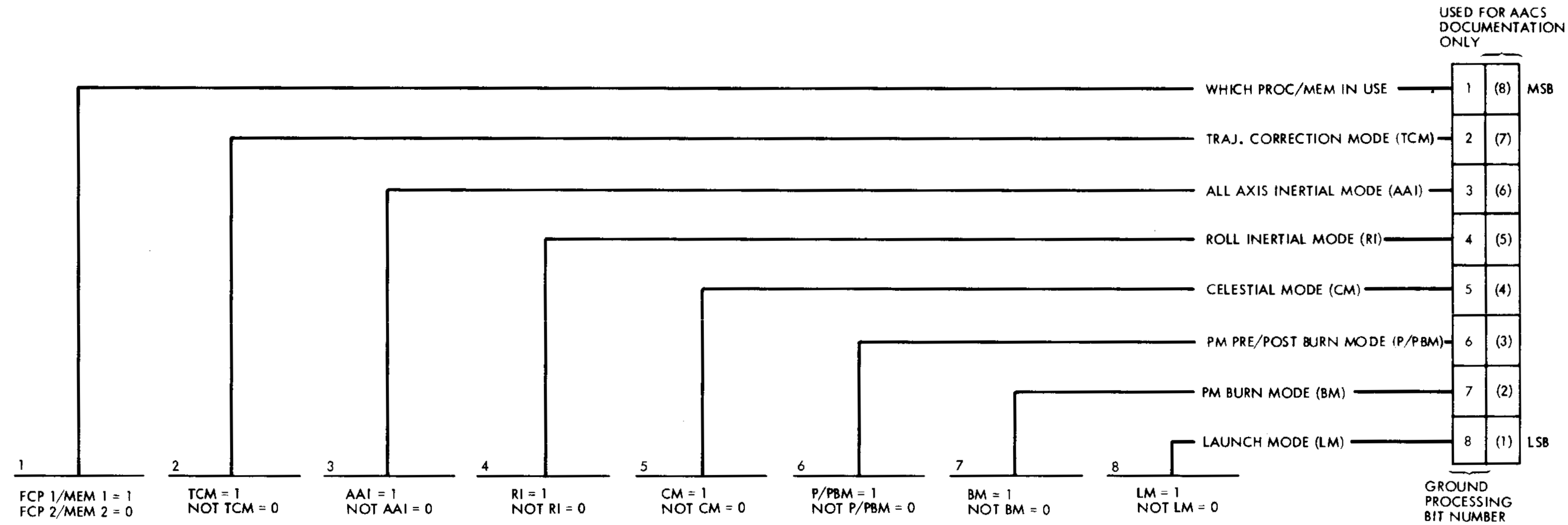


Figure 4-17. Measurement No. E-204 AACS Status Word 5 (Mode Status)

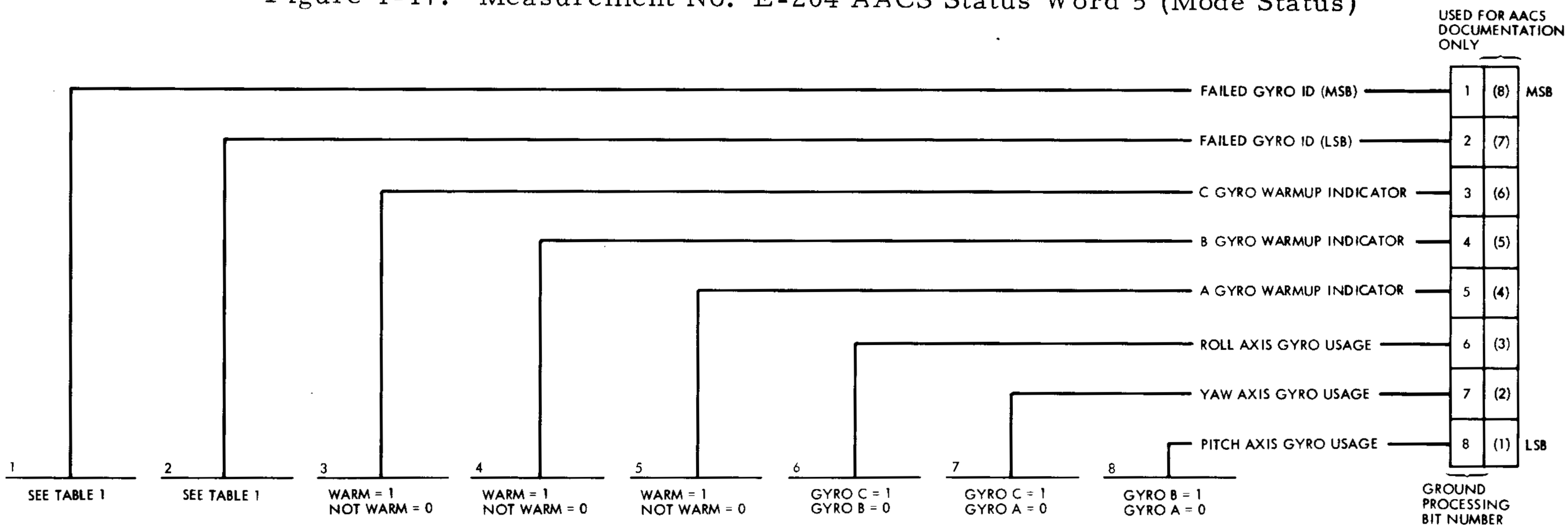
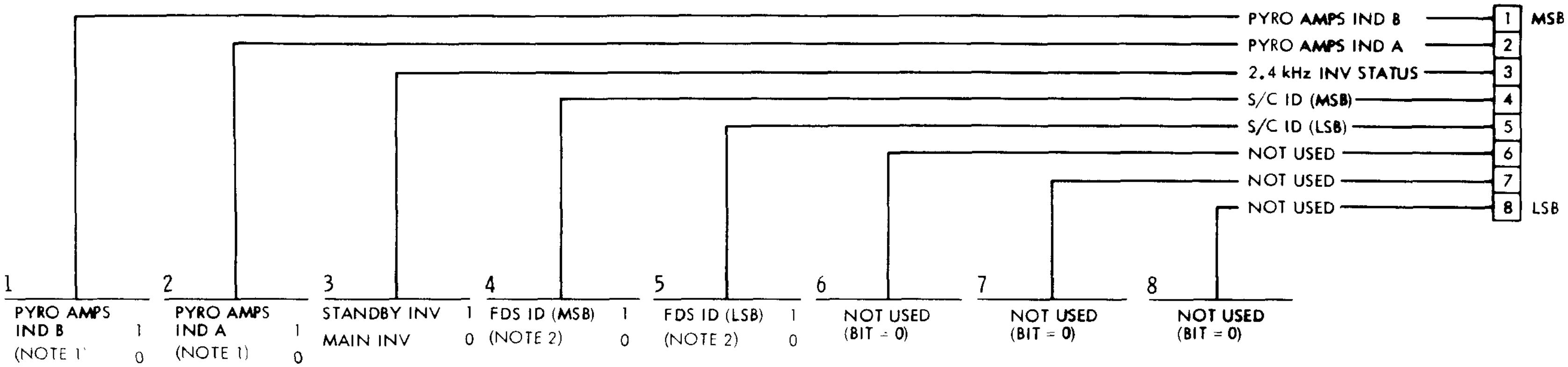


TABLE 1

BIT 1	2	FAILED GYRO
0	0	B
0	1	C
1	0	NONE
1	1	A

Figure 4-18. Measurement No. E-205 AACS Status Word 6 (Gyro Status)



NOTE 1:

PYRO AMPS IND AT POR = 00

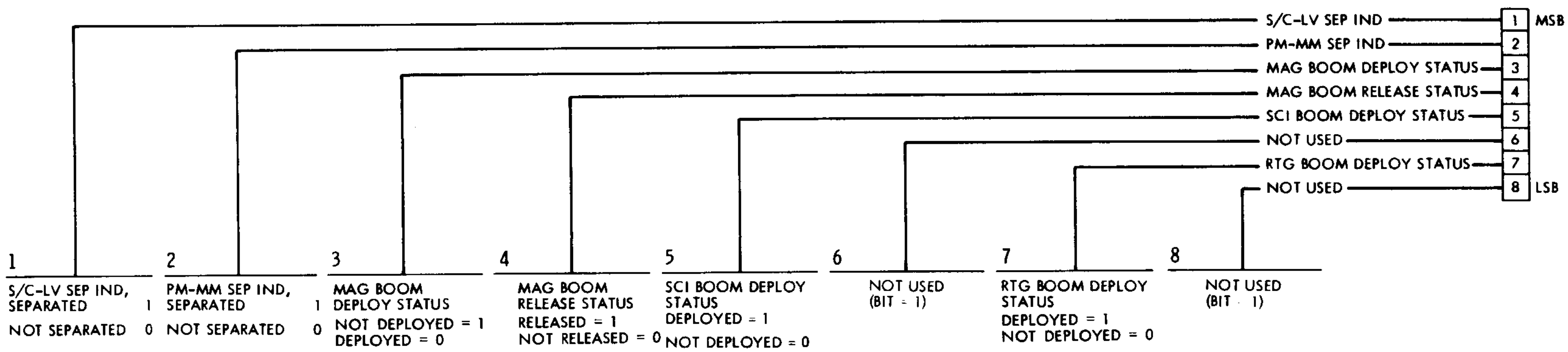
FOR SPACECRAFT EVENTS WHICH USE TWO BRIDGEWIRES PER SQUIB, ONLY ONE OF THESE BITS MAY INDICATE A BIT STATE CHANGE EVEN THOUGH BOTH CAPACITOR BANK VOLTAGE INDICATORS (E-246 & E-247) SHOW BANKS DISCHARGED.

NOTE 2: FDS ID

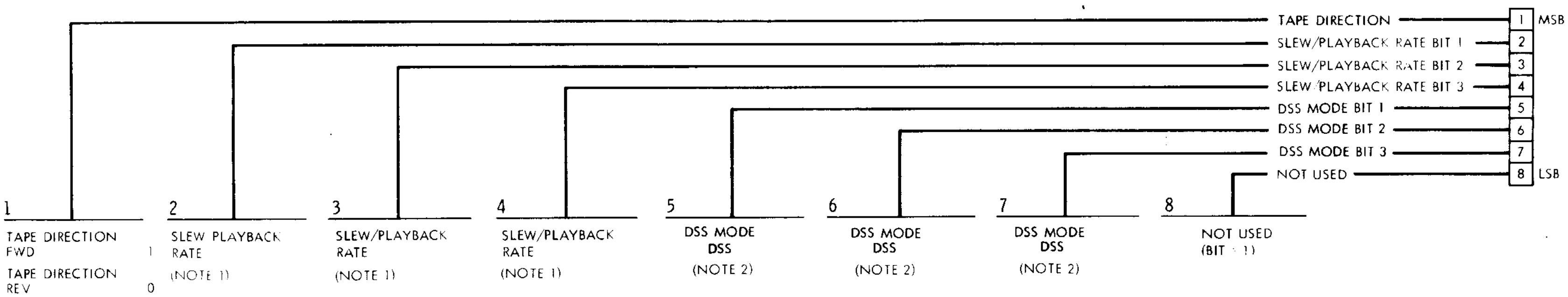
BIT 4	BIT 5	FDS
0	0	BREADBOARD AND PTM
1	0	FLT 1
0	1	FLT 2
1	1	NOT USED

Δ Figure 4-19. Measurement No. E-245, FDS/PWR/PYRO Status (Pyro Amps Ind) (FDS Identifier 09)

Δ



* Figure 4-20. Measurement No. E-331, Devices/Cabling Status (FDS Identifier 02)



NOTE 1

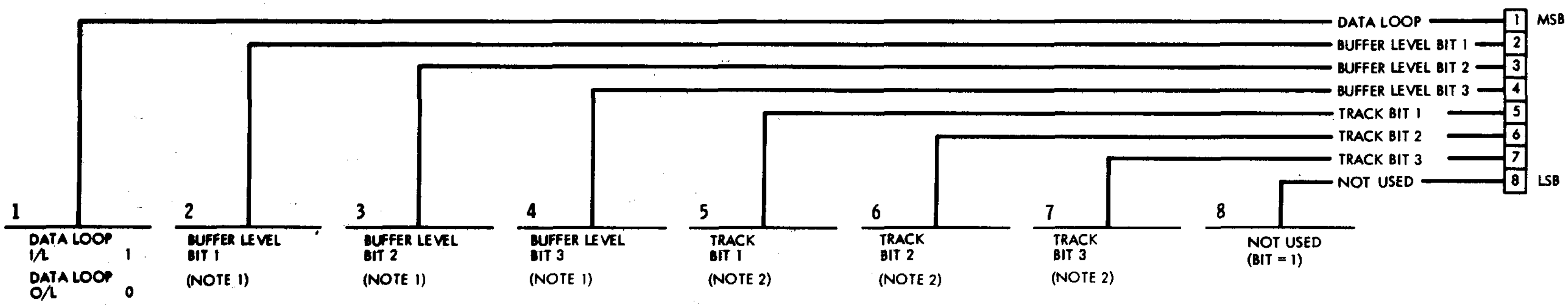
BIT 2 3 4	SLEW/PLAYBACK RATE
0 0 0	NO CHANGE
1 0 0	33.6 KBPS
0 1 0	7.2 KBPS
1 1 0	115.2 KBPS
0 0 1	NO CHANGE
1 0 1	57.6 KBPS
0 1 1	NO CHANGE
1 1 1	21.6 KBPS

NOTE 2

BIT 5 6 7	DSS MODE
0 0 0	NO CHANGE
1 0 0	PLAYBACK
0 1 0	SLEW
1 1 0	RECORD FDS 115.2 KBPS
0 0 1	RECORD FDS 7.2 KBPS
1 0 1	NO CHANGE
0 1 1	NO CHANGE
1 1 1	READY

NOTE: ALL BITS ARE "0"s OR "1"s WHEN DSS IS OFF

* Figure 4-21. Measurement No. E-342, Mode Status (FDS Identifier 88)



NOTE 1

BIT 2 3 4	BUFFER LEVEL
0 0 0	EMPTY
1 0 0	EMPTY TO 1/6
0 1 0	1/6 TO 1/3
1 1 0	1/3 TO 1/2
0 0 1	1/2 TO 2/3
1 0 1	2/3 TO 5/6
0 1 1	5/6 TO FULL
1 1 1	SPILLED

NOTE 2

BIT 5 6 7	TRACK
0 0 0	TRACK 8
1 0 0	TRACK 1
0 1 0	TRACK 2
1 1 0	TRACK 3
0 0 1	TRACK 4
1 0 1	TRACK 5
0 1 1	TRACK 6
1 1 1	TRACK 7

NOTE: ALL BITS ARE "0"s OR "1"s WHEN DSS IS OFF

* **Figure 4-22.** Measurement No. E-343, Playback Status (FDS Identifier 89)

4.3.2 Science Multiplexers

Several science instruments require additional measurements other than those made directly by the FDS. These measurements are routed to analog multiplexers located in the instruments and controlled by the FDS. Each multiplexer output is assigned to one position of the engineering tree. Instruments utilizing this technique are CRS, PRA, LECP, PLS, MAG, and ISS. Multiplexer timing for set and reset is detailed in Table 4-9.

4.3.2.1 PRA MUX. PRA MUX is normally sampled in position 210. Because of the stepping from the FDS, only words 1 and 3 will be sampled. It is required that once every 7 days the PRA MUX be changed to the 100 deck, by ground command, and sampled for a minimum of 10 consecutive samples for all 4 multiplexer measurements. At this time sampling order will be positions 1, 2, 3, 4, 1, 2 ..... Table 4-10 shows measurements and sampling order.

4.3.2.2 MAG MUX. MAG MUX is normally sampled in position 334 or 202 depending upon the format selected. Because of FDS stepping, only words 0, 2, 4 and 6 will be sampled during normal operations. It is required that once every 7 days the MAG MUX be changed to the 100 deck, by ground command, and each multiplexer position be sampled for a minimum of 10 consecutive samples. At this time sampling order will be 0, 1, 2.....7. Tables 4-11 and 4-12 show measurements and sampling order.

*4.3.2.3 LECP CAL MUX and LECP ENGR MUX. The LECP has two analog multiplexers: 1) a 120 channel calibrate multiplexer (CAL MUX), and 2) a 23 position engineering multiplexer (ENGR MUX). Both multiplexers are stepped every 12 s at 40 bps. Normally only the engineering multiplexer is included in the format in position 217. This results in the readout order as shown in Tables 4-13, 4-14, and 4-15.

Approximately once per week the calibrate multiplexer output (CAL MUX) is assigned a position in the 100 deck for the purpose of performing an LECP internal calibration sequence. This 120 measurement sequence consists of 52 pairs of discriminator level measurements and 16 undefined measurements. All 120 measurements are read out in two major frames. To permit proper timing CAL MUX must be sampled on position 152 or higher.

*4.3.2.4 PLS MUX. PLS MUX is normally sampled in position 219 for the CE-40 and EC-40 formats. This measurement is not included in the LN-40, LN-12, LN-72, MN-40, MN-12, or MN-72 formats.

Table 4-16 shows the measurements and multiplexer position. During an engineering major frame the sampling sequence will be Suppressor Voltage in the M, L, or E_2 mode (-100 V), Backup Science Data, DC Voltage, Voltage Reference, Backup Science Data, Suppressor Voltage in the E_1 mode (-6 V) and repeats.

Table 4-9. Multiplexer Timing

Instrument MUX Signal \ Telemetry Mode	GS-2, GS-3, GS-4, OC-1 All Imaging, PB-1, PB-2, PB-3
PRA MUX Step	Occurs at t = 20 ms and every 12 seconds thereafter ①
PRA MUX Reset	Occurs at t = 80 ms and every 48 seconds thereafter
MAG MUX Step	Occurs at t = 20 ms and every 12 seconds thereafter ①
MAG MUX Reset	Occurs at t = 80 ms and every 96 seconds thereafter
PLS MUX Step	Occurs at t = 20 ms and every 12 seconds thereafter ①
PLS MUX Reset	Occurs at t = 80 ms and every 12 minutes thereafter
CRS MUX Step	Occurs at t = 20 ms and every 12 seconds thereafter ①
CRS MUX Reset	Occurs at t = 80 ms and every 48 minutes thereafter
LECP MUX Step	Occurs at t = 20 ms and every 12 seconds thereafter ①
LECP MUX Reset	Occurs at t = 80 ms and every 48 minutes thereafter
ISS NA MUX Step	Occurs at t = 597. 5 ms and every 9. 6 seconds thereafter ②
ISS NA MUX Reset	Occurs during the Prepare cycle at t = 29. 4 seconds
ISS WA MUX Step	Occurs at t = 597. 5 ms and every 9. 6 seconds thereafter ②
ISS WA MUX Reset	Occurs during the Prepare cycle at t = 29. 4 seconds

① t = 0 is the beginning of a 96-second interval when LC = 1 and MOD 60 is even.

② t = 0 is the beginning of a 48-second interval when LC = 1. When MOD 60 is even, the ISS-NA is in the Prepare cycle and the ISS-WA is in the Read-Out cycle; when MOD 60 is odd, the ISS-NA is in the Read-Out cycle and the ISS-WA is the Prepare cycle.

* Table 4-10. PRA Multiplexer Sequence (40 bps)

MUX at Deck Position 210		MUX Anywhere on 100 Deck		Engineering Number	Measurement
MUX Pos.	MOD 60/LC	MUX Pos.	MOD 60/LC		
1	0+5N/001	1	All/001	E-412	PRA Receiver Coarse Frequency
2	–	2	All/201	E-413	PRA Power Supply 1 Voltage
3	2+5N/401	3	All/401	E-414	PRA Power Supply Current
4	–	4	All/601	E-415	PRA Power Supply 2 Voltage
	N = 0, 1, 2, . . . , 11				

* Table 4-11. MAG Multiplexer Sequence

MUX Pos.	Engineering Number	Measurement
0	E-665	MAG Instrument Serial Number
1	E-666	+12 Vdc Voltage
2	E-667	MAG Inboard Electronics Temperature
3	E-668	-12 Vdc Voltage
4	E-669	MAG Outboard Electronics Temperature
5	E-670	A ADC Reference Voltage
6	E-671	Power Converter Temperature
7	E-672	B ADC Reference Voltage

Table 4-12. MAG MUX Position (40 bps)

Readout Order	MUX at Deck Position 334		MUX at Deck Position 202		MUX at any 100 Deck Position	
	MUX Pos.	MOD 60/LC	MUX Pos.	MOD 60/LC	MUX Pos.	MOD 60/LC
1	4	1/1	2	0/401	0	0/1
2	2	8/401	4	3/1	1	0/201
3	0	16/1	6	5/401	2	0/401
4	6	23/401	0	8/1	3	0/601
5	4	31/1	2	10/401	4	1/1
6	2	38/401	4	13/1	5	1/201
7	0	46/1	6	15/401	6	1/401
8	6	53/401	0	18/1	7	1/601
			2	20/401	0	2/1
			4	23/1	1	2/201
			. . .		. . .	
			6	55/401	6	59/401
			0	58/1	7	59/601

Δ* Table 4-13. LECP Engineering Multiplexer Measurements

MUX Position	Engineering Number	Measurement
1	E-454	-6 V LEPT
2	E-455	-6 V
Δ 3	E-456	Spare
Δ 4	E-457	Spare
5	E-458	-12 V Data System
6	E-459	Motor Temperature
7	E-460	-Stepper Base Power
8	E-461	Log. Amp. Temperature
9	E-462	+8 V Data System
Δ 10	E-463	Spare
11	E-464	+Stepper Base Power
12	E-465	+6 V Data System
13	E-466	Bias Monitor 1
14	E-467	+12 V LEPT
15	E-468	Bias Monitor 2
16	E-469	+12 V Data System
17	E-470	+5 V
18	E-471	+6 V
19	E-472	+30 V
20	E-473	+8 V
21	E-474	+6 V LEPT
22	E-475	+12 V
Δ 23	E-476	Spare

Table 4-14. LECP Engineering Multiplexer Sequence

MUX Sampled at Position 152 or Higher		
LECP MUX Pos.	Eng MF	MOD 60/LC
1	1	6N/001
2	2	6N/201
3	3	6N/401
4	4	6N/601
5	5	1+6N/001
6	6	1+6N/201
7	7	1+6N/401
8	8	1+6N/601
9	9	2+6N/001
10	10	2+6N/201
11	11	2+6N/401
12	12	2+6N/601
13	13	3+6N/001
14	14	3+6N/201
15	15	3+6N/401
16	16	3+6N/601
17	17	4+6N/001
18	18	4+6N/201
19	19	4+6N/401
20	20	4+6N/601
21	21	5+6N/001
22	22	5+6N/201
23	23	5+6N/401
1	24	5+6N/601
N = 0, 1, 2, 3, 4, 5, 6, 7, 8, 9.		

MUX at Deck Position 217		
LECP MUX Pos.	Eng MF	MOD 60/LC
8	8	1/601
18	18	4/201
5	28	6/601
15	38	9/201
2	48	11/601
12	58	14/201
22	8	16/601
9	18	19/201
19	28	21/601
6	38	24/201
16	48	26/601
3	58	29/201
13	8	31/601
23	18	34/201
10	28	36/601
20	38	39/201
7	48	41/601
17	58	44/201
4	8	46/601
14	18	49/201
1	28	51/601
11	38	54/201
21	48	56/601
8	58	59/201
LECP Eng MUX reset at MOD 60 = 0, LC = 001.		

Table 4-15. LECP Calibration Multiplexer Sequence (For 40 bps Only) (sheet 1 of 5)

TTS Measurement CAL MUX Position	Discriminator Function	Threshold Level (%)	Nominal Output [1]	Calibration Autorange [2]	Function Name [3]	MUX on 100 Deck Eng MF	MUX on 100 Deck MOD 60/LC (N = 0, 1)
E-477/0	E2	12	2.32 mV	100:1	E2 LO	1	30N/001
E-478/1	E2	88			E2 HI	2	30N/201
E-479/2	E5	12	4.14 mV		E5 LO	3	30N/401
E-480/3	E5	88			E5 HI	4	30N/601
E-481/4	E4	12	1.22 mV		E4 LO	5	1+30N/001
E-482/5	E4	88			E4 HI	6	1+30N/201
E-483/6	E5A	12	4.96 mV		E5A LO	7	1+30N/401
E-484/7	E5A	88			E5A HI	8	1+30N/601
E-485/8	β - 0	12	1.33 mV (low disc)		BE0 LO	9	2+30N/001
E-486/9	β - 0	88	1.91 mV (high disc)		BE0 HI	10	2+30N/201
E-487/10	αl - 0	12	1.14 mV (low disc)		AL10 LO	11	2+30N/401
E-488/11	αl - 0	88	1.85 mV (high disc)		AL10 HI	12	2+30N/601
E-489/12	E4A	12	7.31 mV		E4A LO	13	3+30N/001
E-490/13	E4A	88			E4A HI	14	3+30N/201
E-491/14	β - 1	12	3.15 mV		BE1 LO	15	3+30N/401
E-492/15	β - 1	88			BE1 HI	16	3+30N/601
E-493/16	E5B	12	14.32 mV		E5B LO	17	4+30N/001
E-494/17	E5B	88			E5B HI	18	4+30N/201
E-495/18	E0	12	17.73 mV		E0 LO	19	4+30N/401
E-496/19	E0	88			E0 HI	20	4+30N/601
E-497/20	E1 SYNC	12	9.0 mV (low disc)		E1 LO	21	5+30N/001
E-498/21	E1 SYNC	88	15.40 mV (high disc)		E1 HI	22	5+30N/201
E-499/22	αl - 1	12	1.57 mV		AL11 LO	23	5+30N/401
E-500/23	αl - 1	88		100:1	AL11 HI	24	5+30N/601
E-501/24	E0A	12	5.0 mV	10:1	EOA LO	25	6+30N/001
E-502/25	E0A	88			EOA HI	26	6+30N/201
E-503/26	AC1	12	13.0 mV		ACI LO	27	6+30N/401
E-504/27	AC1	88		10:1	ACI HI	28	6+30N/601

Δ * Table 4-15. LECP Calibration Multiplexer Sequence (For 40 bps Only) (sheet 2 of 5)

TTS Measurement CAL MUX Position	Discriminator Function	Threshold Level (%)	Nominal[1] Output	Calibration[2] Autorange	Function[3] Name	MUX on 100 Deck Eng MF	MUX on 100 Deck MOD 60/LC (N = 0, 1)	
E-505/28	AC2	12	14.9 mV	10:1	AC2 LO	29	7+30N/001	Δ
E-506/29	AC2	88		↓	AC2 HI	30	7+30N/201	
E-507/30	α1-4	12	14.9 mV		AL14 LO	31	7+30N/401	Δ
E-508/31	α1-4	88			AL14 HI	32	7+30N/601	
E-509/32	E2B	12	94.6 mV		E2B LO	33	8+30N/001	Δ
E-510/33	E2B	88			E2B HI	34	8+30N/201	
E-511/34	L12B	12	39.2 mV		L12B LO	35	8+30N/401	Δ
E-512/35	L12B	88			L12B HI	36	8+30N/601	
E-513/36	Blank	12				37	9+30N/001	
E-514/37	Blank	88				38	9+30N/201	
E-515/38	β-4	12	17.9 mV		BE4 LO	39	9+30N/401	Δ
E-516/39	β-4	88			BE4 HI	40	9+30N/601	
E-517/40	EOB	12	10.1 mV		E0B LO	41	10+30N/001	Δ
E-518/41	EOB	88			E0B HI	42	10+30N/201	
E-519/42	α1-3	12	9.8 mV		AL13 LO	43	10+30N/401	Δ
E-520/43	α1-3				AL13 HI	44	10+30N/601	
E-521/44	Blank	12				45	11+30N/001	
E-522/45	Blank	88				46	11+30N/201	
E-523/46	L54B	12	15.42 mV		L54B LO	47	11+30N/401	Δ
E-524/47	L54B	88			L54B HI	48	11+30N/601	
E-525/48	α2-0	12	37.0 mV		AL02 LO	49	12+30N/001	Δ
E-526/49	α2-0	88			AL02 HI	50	12+30N/201	
E-527/50	α2-1	12	72.7 mV		AL21 LO	51	12+30N/401	Δ
E-528/51	α2-1	88			AL21 HI	52	12+30N/601	
E-529/52	E0C	12	28.4 mV		E0A LO	53	13+30N/001	Δ
E-530/53	E0C	88			E0A HI	54	13+30N/201	
E-531/54	Blank	12	———	↓		55	13+30N/401	
E-532/55	Blank	88		10:1		56	13+30N/601	

Δ✱ Table 4-15. LECP Calibration Multiplexer Sequence (For 40 bps Only) (sheet 3 of 5)

TTS Measurement CAL MUX Position	Discriminator Function	Threshold Level (%)	Nominal[1] Output	Calibration[2] Autorange	Function[3] Name	MUX on 100 Deck Eng MF	MUX on 100 Deck MOD 60/LC (N = 0, 1)
Δ E-533/56	E3A	12	98.5 mV	10:1	E3A LO	57	14+30N/001
E-534/57	E3A	88		↓	E3A HI	58	14+30N/201
Δ E-535/58	E1A	12	41.4 mV		E1A LO	59	14+30N/401
E-536/59	E1A	88			E1A HI	60	14+30N/601
E-537/60	Blank					1	15+30N/001
E-538/61	Blank					2	15+30N/201
E-539/62	Blank					3	15+30N/401
E-540/63	Blank			10:1		4	15+30N/601
Δ E-541/64	L12C	12	157 mV	1:1	L12C LO	5	16+30N/001
E-542/65	L12C	88		↓	L12C HI	6	16+30N/201
Δ E-543/66	L54C	12	376 mV		L54C LO	7	16+30N/401
E-544/67	L54C	88			L54C HI	8	16+30N/601
Δ E-545/68	L23A	12	310 mV		L23A LO	9	17+30N/001
E-546/69	L23A	88			L23A HI	10	17+30N/201
Δ E-547/70	E4B	12	304 mV		E4B LO	11	17+30N/401
E-548/71	E4B	88			E4B HI	12	17+30N/601
Δ E-549/72	E5C	12	419 mV		E5C LO	13	18+30N/001
E-550/73	E5C	88			E5C HI	14	18+30N/201
Δ E-551/74	EOD	12	81 mV		EOD LO	15	18+30N/401
E-552/75	EOD	88			EOD HI	16	18+30N/601
Δ E-553/76	E1B	12	122 mV		E1B LO	17	19+30N/001
E-554/77	E1B	88			E1B HI	18	19+30N/201
Δ E-555/78	E3C	12	218 mV		E3C LO	19	19+30N/401
E-556/79	E3C	88			E3C HI	20	19+30N/601
Δ E-557/80	L54D	12	888 mV		L54D LO	21	20+30N/001
E-558/81	L54D	88			L54D HI	22	20+30N/201
Δ E-559/82	L23B	12	84 mV	↓	L23B LO	23	20+30N/401
E-560/83	L23B	88		1:1	L23B HI	24	20+30N/601

Δ* Table 4-15. LECP Calibration Multiplexer Sequence (For 40 bps Only) (sheet 4 of 5)

TTS Measurement CAL MUX Position	Discriminator Function	Threshold Level (%)	Nominal[1] Output	Calibration[2] Autorange	Function[3] Name	MUX on 100 Deck		
						Eng MF	MOD 60/LC (N = 0, 1)	
E-561/84	E1C	12	272 mV	1:1	E1C LO	25	21+30N/001	Δ
E-562/85	E1C	88			E1C HI	26	21+30N/201	
E-563/86	E2C	12	1340 mV		E2C LO	27	21+30N/401	Δ
E-564/87	E2C	88			E2C HI	28	21+30N/601	
E-565/88	E3B	12	949 mV		E3B LO	29	22+30N/001	Δ
E-566/89	E3B	88			E3B HI	30	22+30N/201	
E-567/90	E4C	12	2.7 V		E4C LO	31	22+30N/401	
E-568/91	E4C	88			E4C HI	32	22+30N/601	
E-569/92	L23C	12	1994 mV		L23C LO	33	23+30N/001	Δ
E-570/93	L23C	88			L23C HI	34	23+30N/201	
E-571/94	E5D	12	2.7 V		E5D LO	35	23+30N/401	
E-572/95	E5D	88		1:1	E5D HI	36	23+30N/601	
E-573/96	β-2	12	4.96 mV	100:1	BE2 LO	37	24+30N/001	Δ
E-574/97	β-2	88			BE2 HI	38	24+30N/201	
E-575/98	E2A	12	22.6 mV		E2A LO	39	24+30N/401	Δ
E-576/99	E2A	88			E2A HI	40	24+30N/601	
E-577/100	α1-2	12	4.7 mV		AL12 LO	41	25+30N/001	Δ
E-578/101	α1-2	88			AL12 HI	42	25+30N/201	
E-579/102	L12A	12	7.94 mV		L12A LO	43	25+30N/401	Δ
E-580/103	L12A	88			L12A HI	44	25+30N/601	
E-581/104	Blank					45	26+30N/001	
E-582/105	Blank					46	26+30N/201	
E-583/106	E3	12	15.23 mV		E3 LO	47	26+30N/401	Δ
E-584/107	E3	88		100:1	E3 HI	48	26+30N/601	

Table 4-15. LECP Calibration Multiplexer Sequence (For 40 bps Only) (sheet 5 of 5)

TTS Measurement CAL MUX Position	Discriminator Function	Threshold Level (%)	Nominal[1] Output	Calibration[2] Autorange	Function[3] Name	MUX on 100 Deck	
						Eng MF	MOD 60/LC (N = 0, 1)
E-585/108	β-3	12	9.86 mV	100:1	BE3 LO	49	27+30N/001
E-586/109	β-3	88		↓	BE3 HI	50	27+30N/201
E-587/110	L54A	12	21.6 mV	↓	L54A LO	51	27+30N/401
E-588/111	L54A	88		100:1	L54A HI	52	27+30N/601

Notes:

1. This is the nominal output of the instrument in volts. The voltages are digitized to 8 bits by the FDS. Engineering data should reflect these after EU conversion.
2. Calibrate autorange indicates the multiplier used to bring the instrument outputs listed under nominal output up to a level allowing 8-bit digitation. The discriminator function voltages marked 100:1 are multiplied by 100, the 10:1 are multiplied by 10 and the 1:1 are direct levels.
3. Channel titles are formed by preceding the listed name with "LECP".

* Table 4-16. PLS Engineering Multiplexer Sequence

Readout Order	MOD 60/LC	MUX Pos.*	Engineering Number	Measurement
1	2+15N/201	3	E-626	PLS Suppressor Voltage (M, L, or E_2 Mode, -100 V)
2	4+15N/601	1	E-624	PLS Backup Science Data
3	7+15N/201	4	E-627	PLS DC Voltage
4	9+15N/601	2	E-625	PLS Voltage Reference
5	12+15N/201	1	E-624	PLS Backup Science Data
6	14+15N/601	3	E-626	PLS Suppressor Voltage (E_1 Mode, -6V)
	N = 0, 1, 2, 3			*Eng Deck Position 219

* 4.3.2.5 CRS MUX. CRS MUX is sampled in position 201 for the CE-40 and EC-40 formats only. No data is sampled during the LN-40, LN-12, LN-72, MN-40, MN-12, or MN-72 formats. Tables 4-17 and 4-18 show the CRS MUX measurements and their sampling order.

* 4.3.2.6 ISS MUX. The ISS WA and NA cameras each contain a ten position analog multiplexer. The measurements contained in and position on the multiplexer (the same for both WA and NA cameras) are shown in Table 4-19. These measurements are inserted in the subcom field of all encounter general science data formats as shown in Table 6-2 of this document. In addition, these measurements are included in the ISS Status/Engr field of all imaging formats as shown in Table 7-1 of this document. As a result, these multiplexer outputs are not included in the EC-40 engineering format. However, these measurements are included in the CE-40 engineering format. The FDS resets the multiplexers sufficiently often so as to always monitor the input currents (position 1) of both cameras.

* 4.3.3 MDS Signal-to-noise Ratio (SNR) Measurement

The MDS will shift a 20-bit serial word, MSB first, to the FDS every 62.5 ms which is related to the ST_B/N_O at the input to the command detector unit (CDU). The FDS shall transfer the 16 LSBs

* Table 4-17. CRS Engineering Multiplexer Data

Engineering Number	MUX Position	Measurement
E-363	1	+10 V Power Supply Voltage
E-364	2	Unused
E-365	3	+6 V Power Supply Voltage
E-366	4	+3 V Power Supply Voltage
E-367	5	-3 V Power Supply Voltage
E-368	6	-6 V Power Supply Voltage
E-369	7	-12 V Power Supply Voltage
E-370	8	Unused
E-371	9	Unused
E-372	10	LET A Temperature
E-373	11	LET B Temperature
E-374	12	LET C Temperature
E-375	13	LET D Temperature
E-376	14	HET A Temperature
E-377	15	HET B Temperature
E-378	16	TET Temperature
E-379	17	Power Converter Temperature
E-380	18	Baseplate Temperature
E-381	19	PHA Electronics Temperature
E-382	20	Supp/Repl Heater Temperature A
E-383	21	Supp/Repl Heater Temperature B
E-384	22	Unused
E-385	23	Unused
E-386	24	Unused

Table 4-18. CRS Multiplexer Sequence (40 bps)

MUX at Deck Position 201			MUX Anywhere on 100 Deck		
CRS MUX Position	Eng MF	MOD 60/LC	CRS MUX Position	Eng MF*	MOD 60/LC**
1	2	0/201	1	1, 2	0/001, 201
6	12	2/601	2	3, 4	0/401, 601
11	22	5/201	3	5, 6	1/001, 201
16	32	7/601	4	7, 8	1/401, 601
21	42	10/201	5	9, 10	2/001, 201
2	52	12/601	6	11, 12	2/401, 601
7	2	15/201	7	13, 14	3/001, 201
12	12	17/601	8	15, 16	3/401, 601
17	22	20/201	9	17, 18	4/001, 201
22	32	22/601	10	19, 20	4/401/601
3	42	25/201	11	21, 22	5/001, 201
8	52	27/601	12	23, 24	5/401, 601
13	2	30/201	13	25, 26	6/001, 201
18	12	32/601	14	27, 28	6/401, 601
23	22	35/201	15	29, 30	7/001, 201
4	32	37/601	16	31, 32	7/401, 601
9	42	40/201	17	33, 34	8/001, 201
14	52	42/601	18	35, 36	8/401, 601
19	2	45/201	19	37, 38	9/001, 201
24	12	47/601	20	39, 40	9/401, 601
5	22	50/201	21	41, 42	10/001, 201
10	32	52/601	22	43, 44	10/401, 601
15	42	55/201	23	45, 46	11/001, 201
20	52	57/601	24	47, 48	11/401, 601

*These values for Eng MF apply for N = 0 in MOD 60 Count. This will be the first pass of the 48 m CRS MUX major frame.

**To all values of MOD 60 Count in 100 deck column add +12 N where N = 0, 1, 2, 3, 4.

✱ Table 4-19. ISS Engineering Multiplexer Sequence

MUX Pos.	Engineering Number — NA	Engineering Number — WA	Measurement
1	E-689	E-699	ISS Input Current
2	E-690	E-700	ISS Focus Current
3	E-691	E-701	ISS Event Ladder
4	E-692	E-702	ISS G1 Voltage
5	E-693	E-703	ISS G2 Voltage
6	E-694	E-704	ISS Cathode Read Current
7	E-695	E-705	ISS Average Video
8	E-696	E-706	ISS +5Vdc
9	E-697	E-707	ISS Filament Current
10	E-698	E-708	ISS Cathode Erase Current

of the 20-bit SNR word into a storage register upon receipt of an alert pulse supplied by the MDS. The contents of this storage register are inserted into the telemetry stream with the next two samples of the SNR measurement. The storage register shall be reset to zero upon being read out.

4.3.4 <u>MDS Oscillator Monitor</u>

The MDS will provide the FDS a 1638.4 Hz squarewave signal which is related to the CDU oscillator frequency. The FDS shall count this signal over intervals of 96 s and generate an 8-bit word which defines the signal frequency. The oscillator monitor frequency and counter interval are chosen so that each count represents a frequency change of 6.35 ppm; and so that the residue remaining in the 7 LSBs of the register is centered at midrange when the MDS and FDS oscillator frequencies are at their design values. The MSB of the register shall be set to "1" when the correct number of overflows have occurred and "0" otherwise. At the end of the count interval, the data in the counting register shall be transferred to an 8-bit storage register and the count register shall be reset. The storage register shall hold the telemetry sample until readout or updated with a later sample. The storage register shall be reset upon readout. If the storage register is interrogated after being read, but prior to being updated with a new sample the telemetry word shall be all zeros.

4.4 Memory Readout Formats

The following section describes memory readout modes for AACS, CCS, and FDS using engineering formats AA-12, AA-40, FD-12, FD-40, CC-12, and CC-40.

4.4.1 AACS Memory Readout

4.4.1.1 High Rate AACS Memory Readout (1200 bps). High rate AACS memory readout is accomplished by using the AA-12 engineering format. The organization of this format is similar to LN-12 or MN-12 engineering formats except the AACS memory readout data utilizes the 18 locations as were used for normal AACS engineering telemetry data. These positions are listed in Table 4-20. All other engineering commutator locations will contain those engineering measurements as specified for the format defined by bits 5, 6, and 7 of the format ID field. Each minor frame will contain the AACS data words. Both the AACS address word and the data word will be broken into three 8-bit bytes as follows:

a) Most significant byte (1) 000000XX

b) Second significant byte (2) XXXXXXXX

c) Least significant byte (3) XXXXXXXX

Note that the AACS address field is only 12 bits. This means the most significant byte of an address word will be all zeros. Table 21 shows what data will be contained in each word during high rate memory readout. The readout is generated by FDS sending AACS a command sequence consisting of six telemetry addresses (one for each byte of the address and one for each byte of the data word). During memory readout the format ID word will change to identify the memory readout operation. See Section 3.1.2 of this document for format ID description.

4.4.1.2 Low Rate AACS Memory Readout (40 bps). Low rate AACS memory readout is accomplished by using the AA-40 engineering format. The organization of this format is similar to the other 40 bps engineering formats; however, AACS data will utilize the entire engineering system. AACS engineering data (using the appropriate AACS identifier table as specified by bits 5, 6, and 7 of the format ID field) will continue to be transmitted over the 24 positions used for normal telemetry operations, and the remaining non-FSC positions will be used for AACS memory readout. These are listed in Table 4-21. This table also shows the method of identifying the AACS memory readout data. When operating at either 10 or 40 bps the FDS is always requesting memory readout (even in the engineering telemetry mode) but only picks up readout data from the HYBIC FDS register when in the memory readout mode.

During memory readout the format ID word will change to identify the memory readout operation. See Section 3.1.2 of this document for format ID description.

Table 4-20. AACS Memory Readout at 1200 bps (AA-12 Engineering Format)

AACS Memory Readout Words*	8-bit Byte 1	8-bit Byte 2	8-bit Byte 3
108, 111, 114	0 0 0 0 0 0 0 0 0 0 0 0 A_1 ——— A_1		
117, 120, 123	0 0 0 0 0 0 D_1 ——— D_1		
126, 129, 132	0 0 0 0 0 0 D_2 ——— D_2		
135, 138, 141	0 0 0 0 0 0 D_3 ——— D_3		
144, 147, 150	0 0 0 0 0 0 D_4 ——— D_4		
153, 156, 159	0 0 0 0 0 0 D_5 ——— D_5		

A_1 = Address whose contents are read out as D_1

D_1 = Contents of Address A_1

D_2 = Contents of Address (A_1 plus 1)

D_n = Contents of Address (A_1 plus n-1)

This sequence repeats every minor frame.

*Remaining words in ENG TLM format are being used for S/C engineering telemetry.

Δ4.4.1.3 AACS Memory Readout Via the Memory Access Module (MAM). The capability also exists to read out the AACS memory on E-750 nominally by placing this measurement, which requires three positions, each separated by 30 ms or more, on the 100 deck. This allows readout of the inactive AACS memory. The readout may be be obtained in any format, may be obtained by utilizing positions on a lower rate deck, and could be obtained by utilizing any multiple of the three required positions provided that the 30 ms constraint is not violated. Each read of E-750 generates one 8-bit measurement and three successive measurements contain one 18-bit AACS memory word, Z, and the six least significant bits of the address, M, of Z. These three measurements are formatted as follows:

FDS Bit Position	8	7	6	5	4	3	2	1
First Measurement	Z_1	Z_2	Z_3	Z_4	Z_5	Z_6	M_1	M_2
Second Measurement	Z_7	Z_8	Z_9	Z_{10}	Z_{11}	Z_{12}	M_3	M_4
Third Measurement	Z_{13}	Z_{14}	Z_{15}	Z_{16}	Z_{17}	Z_{18}	M_5	M_6

where $Z = Z_{18}, Z_{17}, \ldots, Z_1$ and $M = M_{12}, M_{11}, \ldots, M_6, \ldots M_1$.

The address M is incremented after every third FDS read. Identification of first, second, and third parts of one word may be achieved by synchronizing with the alternating 1, 0, 1, 0, . . . pattern of bit 2 for sequential first measurements.

The six least significant bits identify a memory word within a block of 64. Unique identification of a block may be obtained from memory context and/or knowledge of memory readout starting time and address which are extablished by command.

Table 4-21. AACS Memory Readout at 10 and 40 bps (AA-40 Engineering Format)

AACS Memory Readout Words*	8-bit Byte 1	8-bit Byte 2	8-bit Byte 3
109, 110, 112	0 0 0 0 0 0 0 0 0 0 0 0 A_1 ———— A_1		
113, 115, 116	0 0 0 0 0 0 D_1 ———— D_1		
118, 119, 121	0 0 0 0 0 0 D_2 ———— D_2		
122, 124, 125	0 0 0 0 0 0 D_3 ———— D_3		
127, 130, 133	0 0 0 0 0 0 D_4 ———— D_4		
136, 137, 139	0 0 0 0 0 0 D_5 ———— D_5		
140, 142, 143	0 0 0 0 0 0 D_6 ———— D_6		
145, 146, 149	0 0 0 0 0 0 D_7 ———— D_7		
152, 155, 157	0 0 0 0 0 0 D_8 ———— D_8		
158	W_x ———— W_x	N/A	N/A

A_1 = Address whose contents are read out as D_1

D_1 = Contents of Address A_1

D_n = Contents of Address (A_1 plus n-1)

W_x = Spare

*Remaining words on 100 deck are being used for AACS engineering telemetry.

4.4.2 CCS Memory Readout

High rate (1200 bps) and low rate (40 bps) CCS memory readouts are accomplished by using CC-12 and CC-40 engineering formats respectively, each with unique format identifiers. In these formats CCS memory address/data replaces all engineering data with the exception of the 64-bit header. CCS memory readout is normally accomplished on one-half of the CCS at a time. Output will be provided from either output Unit 1 or 2. The first four 8-bit words following the header contains the memory section start address for the readout. Following this address are 8 blocks of 32 bits each. The first block contains the data in the start address, and the following 7 blocks contain the data in the next 7 CCS memory position. This sequence will repeat until the requested portion has been readout. After the readout is completed the CCS will continue to output CCS telemetry data until a mode change is commanded. Identification of the memory readout words and bit significance is shown in Table 4-22.

4.4.3 FDS Memory Readout

High rate (1200 bps) and low rate (40 bps) FDS memory readouts are accomplished by using the FD-12 and FD-40 engineering formats respectively, each with unique format identifiers. In these formats FDS memory address/data replaces all engineering data with the exception of the 64-bit header. The starting address of the readout (any may be chosen) is specified by an FDS block load. The starting address occupies the first two 8-bit words following the header, followed by 25 16-bit memory words. Consequtive 25 word blocks of FDS memory will continue to be readout until the memory readout mode is terminated by switching to another data mode. Note that since data mode changes are constrained to occur on 48-second centers, FDS memory readouts will occur in multiples of 25 words.

* 4.4.4 Memory Readout Times

Table 4-23 identifies the times required for the AACS, CCS, and FDS memory readouts described in paragraphs 4.4.1, 4.4.2, and 4.4.3 above.

4.5 CCS Output

CCS outputs 1 and 2 are readout in the engineering telemetry by use of engineering measurements E-130 through E-133. CCS has two output registers, one associated with each output unit. Output Unit 1 uses E-130 with E-132 being redundant. Output Unit 2 uses E-131 with E-133 being redundant.

Three types of CCS output words may be transmitted. These are shown by Tables 4-22, 4-24, and 4-25.

CCS output is a 32-bit binary word transmitted in four 8-bit engineering words. Note that the ground data processing bit order is reversed from the CCS output register bit number order. Ground processing bits 9, 17, and 25 identify the type of CCS output word being transmitted.

Δ* Table 4-22. CCS Processor Word

	WORD 1 (MSB)								WORD 2								WORD 3								WORD 4							(LSB)
GROUND PROCESSING BIT NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
OUTPUT REGISTER BIT NUMBER	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
OUTPUT REGISTER CONTENTS	1							T_D	1							T_D	1							T_D	0							T_D
PROCESSOR WORD BIT NUMBER										18	17	16	15	14	13			12	11	10	9	8	7			6	5	4	3	2	1	

PROCESSOR (A 1, B 0)

DON'T CARE

OUTPUT EVENT COUNTER (MSB … LSB)

TOLERANCE DETECTOR (4 PLACES) (ENABLED 0, DISABLED 1)

NOTES:

1. THE PROCESSOR WORD MAY CONTAIN ONE OF SEVERAL DATA STATEMENTS INCLUDING THE FOLLOWING:

PROCESSOR WORD BIT NUMBER	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
BASE COMMAND (1)(3)	T	ID	E	C	BITS 18-11 OF ACC								0	0	0	0	0	1
BLOCK COMMAND (1)(3)	R	ID	E	CB	C	SEQ	SEQ NO.				BLK ID		0	0	0	0	1	0
CCS MEMORY DUMP (5)	SECTION START ADDRESS												0	0	0	1	0	0
	CCS WORD 1																	
	CCS WORD 2																	
	CCS WORD 3																	
	CCS WORD 8																	
MSH OF CHECKSUM (4)	12 MSB OF CHECKSUM												0	0	0	1	1	1
LSH OF CHECKSUM (4)	12 LSB OF CHECKSUM												0	0	1	0	0	0
MASTER AUTOMATIC ENTRY COUNT (2)	AUTO ENTRY												0	0	1	1	1	0
TOTAL (BLOCK & BASE) COMMANDS EXECUTED (2)	COMMAND COUNT												0	0	1	0	1	1
TOTAL (CC & DC) EVENTS EXECUTED (2)	EVENT COUNT												0	0	1	1	0	1
TELEMETRY BUFFER FULL (4)	WORDS LOST												1	0	0	1	1	0
CDU LOCK CHANGE COUNT (2)	LOCK CHANGE COUNT												1	0	0	1	0	1
DTR TIC POSITION (2)	DTR TIC COUNT												0	1	1	1	1	1

Δ

2. SYMBOLS

T*	SET TO 1	IF COMMAND CAUSED TERMINATION (4)
R*	SET TO 1	IF COMMAND WAS REJECTED (4)
C	SET TO 1	IF BASE COMMAND WAS CORRECTED
CB	SET TO 1	IF BLOCK COMMAND WAS CORRECTED
ID*	SET TO 1	IF PROCESSOR OR S/C ID WAS INCORRECT
E	SET TO 1	IF COMMAND START HAD ONE ERROR
SEQ	SET TO 1	IF COMMAND BLOCK WAS OUT-OF-SEQUENCE
BLK ID	BITS 8-7 OF ACCUMULATOR	
SEQ NO.	BITS 4-1 OF ACCUMULATOR	

(1) ISSUED 10 BIT TIMES AFTER LAST BIT OF COMMAND UNLESS THE T OR R BIT IS SET THEN IT IS ISSUED AFTER THE LAST BIT OF THE COMMAND

(2) ISSUED EVERY HOUR PULSE

(3) INCLUDED IN CRITICAL TELEMETRY BUFFER IF COMMAND CAUSED TERMINATION OR WAS REJECTED

(4) INCLUDED IN CRITICAL TELEMETRY BUFFER

(5) MEMORY IS READ OUT IN 8-WORD SECTIONS. THE THREE LSBs OF THE SECTION START ADDRESS ARE ALWAYS ZERO

* IF SET, COMMAND WAS NOT EXECUTED

3. TOLERANCE DETECTOR STATUS.

   IF WORD IS FROM OUT1, TOLERANCE DETECTOR STATUS IN PWR SUPPLY B IS INDICATED

   IF WORD IS FROM OUT2, TOLERANCE DETECTOR STATUS IN PWR SUPPLY A IS INDICATED

4. FOR DATA TRANSMISSION PROCESSOR WORD HAS HIGHEST PRIORITY

* Table 4-23. Memory Readout Times

Data Rate \ Subsystem	AACS	CCS	FDS
10 bps	24,576 s (6.87 h)	NA	NA
40 bps	6144 s (1.707 h)	6144 s (1.707 h)	3936 s (1.093 h)
1200 bps	328 s	204.8 s	131.2 s

* Table new this issue (Amendment B, 8 April 1977)

Table 4-24. CCS Output Event Word

	WORD 1 (MSB)								WORD 2								WORD 3								WORD 4							(LSB)
GROUND PROCESSING BIT NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
OUTPUT REGISTER BIT NUMBER	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
OUTPUT REGISTER CONTENTS	1							T_D	1							T_D	0							T_D	0							T_D
OUTPUT EVENT WORD BIT NUMBER										18	17	16	15	14	13			12	11	10	9	8	7			6	5	4	3	2	1	

PROCESSOR (bit 2)
A 1
B 0

EVENT EXECUTION (bit 3)
YES 1
NO 0

OUTPUT EVENT COUNTER (bits 4–7, MSB to LSB)

TOLERANCE DETECTOR (4 PLACES)
ENABLED 0
DISABLED 1

Output event word bit 1: ODD PARITY

NOTES:

1. THE OUTPUT EVENT WORD IS EQUIVALENT TO THE 18-BIT ACCUMULATOR WORDS ILLUSTRATED IN MJS77-3-290, EXCEPT FOR LSB WHICH IS ODD PARITY
2. TOLERANCE DETECTOR STATUS:

   IF WORD IS FROM OU1, TOLERANCE DETECTOR STATUS IN PWR SUPPLY B IS INDICATED

   IF WORD IS FROM OU2, TOLERANCE DETECTOR STATUS IN PWR SUPPLY A IS INDICATED
3. FOR DATA TRANSMISSION OUTPUT EVENT WORD HAS SECOND PRIORITY

Table 4-25. CCS Status Word

	MSB WORD 1								WORD 2								WORD 3								WORD 4							LSB
GROUND PROCESSING BIT NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
OUTPUT REGISTER BIT NUMBER	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
OUTPUT REGISTER CONTENTS	1							T_D	0							T_D	0							T_D	0							T_D
CCS STATUS WORD BIT NUMBER										18	17	16	15	14	13			12	11	10	9	8	7			6	5	4	3	2	1	

DON'T CARE (ground processing bits 2–3)

OUTPUT EVENT COUNTER (ground processing bits 4–7, MSB … LSB)

TOLERANCE DETECTOR (4 PLACES)

ENABLED 0
DISABLED 1

NOTES:

1. THE STATUS WORD BITS DESCRIBE THE FOLLOWING CONDITIONS AND THE TITLE IS DENOTED BY A "1" STATE.

GROUND PROCESSOR BIT	OUTPUT REGISTER BIT	CCS BIT	
21	12	9	B - ENABLED BY A
22	11	8	B - ENABLED TO THIS OU
23	10	7	B - ENABLED TO OTHER OU
26	7	6	A - MEMORY PROTECT ACCESS
27	6	5	A - 2-8 INTERRUPT OVERRIDE ENABLED
28	5	4	A - ACTIVE
29	4	3	B - MEMORY PROTECT ACCESS
30	3	2	B - 2-8 INTERRUPT OVERRIDE ENABLED
31	2	1	B - ACTIVE

GROUND PROCESSOR BIT	OUTPUT REGISTER BIT	CCS BIT	
10	23	18	A - INTERNAL ERROR
11	22	17	A - POWER FAILURE
12	21	16	A - COMMAND ERROR (P)
13	20	15	B - INTERNAL ERROR
14	19	14	B - POWER FAILURE
15	18	13	B - COMMAND ERROR (P)
18	15	12	A - ENABLED BY B
19	14	11	A - ENABLED TO THIS OU
20	13	10	A - ENABLED TO OTHER OU

2. TOLERANCE DETECTOR STATUS:

   IF WORD IS FROM OU1, TOLERANCE DETECTOR STATUS IN PWR SUPPLY B IS INDICATED

   IF WORD IS FROM OU2, TOLERANCE DETECTOR STATUS IN PWR SUPPLY A IS INDICATED

3. FOR DATA TRANSMISSION STATUS WORD HAS LOWEST PRIORITY

4.6 AACS Engineering Data Limitations

Access to AACS data is limited by a 20 ms per 8-bit word limit to the HYBIC FDS register. Thus 1200 bps data rates are limited to 18 data words per MF.

5.0 CRUISE DATA FORMATS

* 5.1 CR-1

5.1.1 Data Content

The CR-1 format includes measurements for the following instruments:

PWS	UVS	LECP	MAG
PPS	CRS	PLS	PRA

This format also contains S/C engineering and S/C time.

5.1.2 CR-1 Frame Structure

Figure 5-1 shows one minor frame (MF) of CR-1 data. As indicated, one MF comprises a time period of 0.6 s, equivalent to 16 line counts, and has a frame length of 1,536 bits. Information is transmitted at a data rate of 2560 bps.

1,536 BITS

HEADER	ENGR	PWS	STATUS	PPS	UVS	CRS	LECP	PLS	MAG	PRA
(64)	(24)	(24)	(16)	(24)	(70)	(156)	(150)	(128)	(720)	(160)

0.6 s

Figure 5-1. One Minor Frame of CR-1 Data

5.1.3 Frame Synchronization and Time (Bits 1-32, 41-64)

Frame and time identification description is delineated in Section 3 of this document.

5.1.4 Format Identification (Bits 33-40)

Format identification word for CR-1 is shown in paragraph 3.1.2 of this document.

5.1.5 Engineering (Bits 65-88)

Each CR-1 MF contains 3 8-bit engineering words which are generated at 40 bps. The engineering MF output (the first 3 words) is output in CR-1 MFs 1, 21, 41, and 61 (which contain LC values of 1, 201, 401, and 601, respectively). This algorithm is the same as GS-3 and OC-1.

* Paragraph 5.1 new this issue (Amendment B, 8 April 1977)

5.1.6 PWS Data (Bits 89-112)

PWS sampling is identical to GS-3. PWS B (HFLC) and PWS A (LFLC) are each sampled every 0.5 s. A complete scan of 16 samples is taken every 4 s. The PWS vs. CR-1 MF repeats every 20 MFs. Each scan is preceeded by four filler words. The PWS data is shown in Table 5-1.

Table 5-1. PWS Data

CR-1 MF	Function		
1 of 20	XX	XX	XX
2 of 20	XX	9	1
3 of 20	10	2	11
4 of 20	3	12	4
5 of 20	13	5	14
6 of 20	6	15	7
7 of 20	16	8	XX
8 of 20	XX	XX	XX
9 of 20	9	1	10
10 of 20	2	11	3
11 of 20	12	4	13
12 of 20	5	14	6
13 of 20	15	7	16
14 of 20	8	XX	XX
15 of 20	XX	XX	9
16 of 20	1	10	2
17 of 20	11	3	12
18 of 20	4	13	5
19 of 20	14	6	15
20 of 20	7	16	8

5.1.7 Status (Bits 113-128)

This field contains instrument status and command words in addition to FDS command status, as shown in Table 5-2. It is commutated between ten sources with positions 8 and 9 being further subcommutated. All words are right justified when less than 16 bits except the FDS 12-bit commands received from CCS which are left justified. The status and command definitions are exactly as defined in GS-3.

Table 5-2. CR-1 Status Data (Sheet 1 of 2)

Position	CR-1 MF	Function
1	1, 11, 21...71	MAG Status Word 1
2	2, 12, 22...72	MAG Status Word 2
3	3, 13, 23...73	CRS Status Words
	3(SCT60=0)	Word 0
	13(SCT60=0)	Word 1
	. .	. .
	. .	. .
	73(SCT60=0)	Word 7
	3(SCT60=1)	Word 8
	. .	. .
	. .	. .
4	4, 14, 24...74	PRA Mode Command (one for each scan)
5	5, 15, 25...75	PRA Configuration Command (one for each scan)
6	6, 16, 26...76	PPSCT ENTRY
	6	6
	16	16
	26	26
	36	36
	46	46
	56	56
	66	66
	76	76
7	7, 17, 27...77	LECP R/S Commands (the last one sent before each readout)
8	8, 18, 28...78	Subcommutated
	8	PWS Bi-Level Command
	18	PWS Status
	28	MAG Command 1
	38	MAG Command 2
	48	UVS Bi-Level Command
	58	UVS Readout Flag
	68	PLS M-Mode Command
	78	PLS E1-Mode Command

Table 5-2. CR-1 Status Data (Sheet 2 of 2)

Position	CR-1 MF	Function
9	9, 19, 29...79	Subcommutated
	9	LECP Command
	19	CRS Command
	29	Spare
	39	Spare
	49	Spare
	59	Spare
	69	Spare
	79	FDS Command Count (The number of 12-bit commands FDS received from CCS in the previous 48 s between frame starts).
10	10, 20, 30...80	FDS Coded Commands (The 1st 8 commands received from CCS in the previous 48 s between frame starts).

5.1.8 PPS Data (Bits 129-152)

The PPS sampling and data output is identical to GS-3. One 24-bit sample is output every CR-1 MF (MF 1 contains data from the PPS 80-word table entry number 79; MF 2, entry 80; MF 3, entry 1; etc). The PPS serial command is output in status field position 6.

5.1.9 UVS Data (Bits 153-222)

A UVS snapshot is taken every 12 s at an instantaneous rate of one diode pair every 60 ms. The snapshot takes 3.84 s. The data is output in 18-2/7 CR-1 MFs. The remaining 1-5/7 MFs contain filler. The UVS vs. CR-1 MF readout is shown in Table 5-3.

Table 5-3. UVS Data

CR-1 MF	Function						
1 of 20	D127	D128	D1	D2	D3	D4	D5
2 of 20	D6	D7	D8	D9	D10	D11	D12
. . .	.	.	.	.	.	.	.
. . .	.	.	.	.	.	.	.
18 of 20	D118	D119	D120	D121	D122	D123	D124
19 of 20	D125	D126	XX	XX	XX	XX	XX
20 of 20	XX	XX	XX	XX	XX	XX	XX

5.1.10 CRS Data (Bits 223-378)

CRS sampling and data output is identical to GS-3. CRS is sampled every 6 s and output in status field position 3.

5.1.11 LECP Data (Bits 379-528)

The LECP data mix is 2:1 PHA to Rate/Status (R/S). A PHA burst of 4 words is sampled every 0.24 s (4 lines). Rate/Status data is also sampled in 4 word bursts once every 0.48 s (8 lines). Each CR-1 MF contains 15 10-bit LECP words. The readout pattern of LECP data vs. CR-1 MFs repeats every 4 MFs as shown in Table 5-4. The start of the R/S cycle occurs in MF 1 when SCT60 = 0.

Δ 5.1.12 PLS Data (Bits 529-656)

A PLS scan is output every 12 s (every 20 CR-1 MFs) and consists of 320 8-bit words. This includes 16 E1 samples, 300 M samples, 2 status words, and 2 M start words. Different subsets of M mode data are output in alternate scans. Only 100 sample groups (A, B, and C cups) of the 128 M-mode sample groups are output each scan. In the PLS data readout order shown in Table 5-5, X is equal to the M Start Word divided by 3. The M data output starting in CR-1 MFs 11 and 51 use M Start Word 1. M data output starting in CR-1 MFs 31 and 71 use M Start Word 2. Only M data from CUPS A, B, and C are output in CR-1.

Table 5-4. LECP Data

CR-2 MF \ LECP Words	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1 of 4	PHA	PHA	PHA	PHA	R/S	R/S	R/S	R/S	PHA	PHA	PHA	PHA	PHA	PHA	PHA
2 of 4	PHA	R/S	R/S	R/S	R/S	PHA	PHA	PHA	PHA	PHA	PHA	PHA	PHA	R/S	R/S
3 of 4	R/S	R/S	PHA	PHA	PHA	PHA	PHA	PHA	PHA	PHA	R/S	R/S	R/S	R/S	PHA
4 of 4	PHA	PHA	PHA	PHA	PHA	PHA	PHA	R/S	R/S	R/S	R/S	PHA	PHA	PHA	PHA

△ Table 5-5. PLS Data

CR-1 MF	Function
1 of 20	M Sample (BX+52) thru M Sample (BX+57)
2 of 20	M Sample (CX+56) thru M Sample (CX+62)
3 of 20	M Sample (AX+63) thru M Sample (AX+68)
4 of 20	M Sample (BX+68) thru M Sample (BX+73)
5 of 20	M Sample (CX+73) thru M Sample (CX+78)
6 of 20	M Sample (AX+79) thru M Sample (AX+84)
7 of 20	M Sample (BX+84) thru M Sample (BX+89)
8 of 20	M Sample (CX+89) thru M Sample (CX+94)
9 of 20	M Sample (AX+95) thru M Sample (CX+99) and E1 Status
10 of 20	E_1 Samples (D01) thru (D16)
11 of 20	M Start Words 1 and 2, M Status, and M Sample (AX) thru M Sample (AX+4)
12 of 20	M Sample (BX+4) thru M Sample (BX+9)
13 of 20	M Sample (CX+9) thru M Sample (CX+14)
14 of 20	M Sample (AX+15) thru M Sample (AX+20)
15 of 20	M Sample (BX+20) thru M Sample (BX+24)
16 of 20	M Sample (CX+25) thru M Sample (CX+30)
17 of 20	M Sample (AX+31) thru M Sample (AX+36)
18 of 20	M Sample (BX+36) thru M Sample (BX+41)
19 of 20	M Sample (CX+41) thru M Sample (CX+46)
20 of 20	M Sample (AX+47) thru M Sample (AX+52)

5.1.13 MAG Data (Bits 657-1376)

Only LFM data is output in CR-1. Both primary and secondary LFMs are sampled every 60 ms with the full 12-bit word from each axis being output directly without processing. Each MF contains 10 groups of the following data: PLFMX, PLFMY, PLFMZ, SLFMX, SLFMY, and SLFMZ. MAG status (both words) is sampled every 9.6 s and output in status field positions 1 and 2.

5.1.14 PRA Data (Bits 1377-1576)

PRA sampling and data output is identical to GS-3. PRA mode and configuration commands are both sampled and output every 6 s in status field positions 4 and 5, respectively.

* 5.2 CR-2

5.2.1 Data Content

The CR-2 format includes measurements for the following instruments:

PLS	UVS	CRS	PRA
PWS	MAG	LECP	PPS

This format also contains S/C engineering and time.

* Paragraph 5.2 new this issue (Amendment B, 8 April 1977).

Δ 5.2.2 CR-2 Frame Structure

Figure 5-2 shows one minor frame (MF) of CR-2 data. As indicated, one minor frame comprises a time period of 1.2 seconds, equivalent to 20 line counts, and has a frame length of 1,536 bits. Information is transmitted at a data rate of 1,280 bps.

|←———— 1,536 BITS ————→|

HEADER	ENGR	SUBCOM	CRS	MAG	LECP	PRA	PPS
(64)	(48)	(124)	(312)	(540)	(80)	(320)	(48)

|←———— 1.2 s ————→|

Figure 5-2. One Minor Frame of CR-2 Data

5.2.3 Frame Synchronization and Time (Bits 1-32, 41-64)

Frame and time identification description is delineated in Section 3 of this document.

5.2.4 Format Identification (Bits 33-40)

Format identification word for CR-2 is shown in paragraph 3.1.2 of this document.

5.2.5 Engineering (Bits 65-112)

Six 8-bit engineering words are output in each CR-2 MF as shown below (starting with SCT60 = 0). An engineering major frame is output every 600 CR-2 MFs (15 counts of SCT60).

CR-2 MF	Engineering Word	Engineering MF
1 of 600	1-6	1 of 60
2 of 600	7-12	1 of 60
. . .	.	.
. . .	.	.
10 of 600	55-60	1 of 60
11 of 600	1-6	2 of 60
. . .	.	.
. . .	.	.
599 of 600	49-54	60 of 60
600 of 600	55-60	60 of 60

5.2.6 Subcom (Bits 113-236)

This field contains UVS, PWS, PLS, instrument status, and command status data. It is 40 MFs long and repeats every 800 lines (48 s). The data content of the field is shown in Table 5-6.

Table 5-6. CR-2 Subcom Data

CR-2 MF	Function	Number of Words
1	12-bit MAG Status Words	5
	10-bit UVS Words	6
2-11	10-bit UVS Words	12
12	10-bit UVS Words	2
	8-bit PWS Words	13
13-23	8-bit PWS Words	15
24	8-bit PWS Words	14
25-37	8-bit PLS Words	15
38	16-bit Command Words	7
	12-bit Status Words	1
39	16-bit Command Words	1
	12-bit FDS Status Words	9
40	16-bit Command	1
	12-bit Status	9

5.2.6.1 Subcom-UVS Data

A UVS snapshot is taken every 48 s during lines 1 through 64 and takes 3.84 s. The instantaneous rate of one diode pair every 60 ms is the same as for GS-3. The subcom contains one UVS snapshot per cycle.

The UVS data read out in the subcom is shown in Table 5-7. Only bits 113 through 232 are used and bits 233 through 236 are always spares. In MF 12 only bits 113 through 132 contain UVS. Each 10-bit UVS sample consists of a 4-bit exponent and a 6-bit mantissa.

Table 5-7. UVS Data

CR-2 MF	Function
1	Diodes 127, 128, and 1 through 4; spares
2	D5 through D16; spares
3	D17 through D28; spares
4	D29 through D40; spares
5	D41 through D52; spares
6	D53 through D64; spares
7	D65 through D76; spares
8	D77 through D88; spares
9	D89 through D100; spares
10	D101 through D112; spares
11	D113 through D124; spares
12	D125 and D126

5.2.6.2 Subcom-PWS Data

PWS sampling is identical to GS-3. PSW B (HFLC) and PSW A (LFLC) are each sampled ever 0.5 s through the engineering tree. A complete scan of 16 samples takes 4.0 s. The 12 scans taken every 48 s are buffered and output in MFs 12 through 24. The scan output in MF12 and the first part of MF13 is the 8th scan taken in the previous 48 s. The last scan output is, therefore, the 7th scan taken within the 48 s the data is being output. MF 12 uses bits 133 through 236, and all other MFs use bits 113 through 232 except MF 24 which has spares in bits 225 through 236. MF 13 through 23 has spares in bits 233 through 236.

5.2.6.3 Subcom-PLS Data

A PLS scan is output every 96 s (twice through this subcom) and consists of 390 8-bit words. This includes 64 L samples, 16 E1 samples, 288 M samples, 16 E2 samples, 4 status words, and 2M start words. The sampling of PLS data is identical to the GS-3 mode although the data is processed differently. Different subsets of M mode data are output in alternate scans. Only 96 sample groups (A, B, and C cups) of the 128 M-mode sample groups are output each scan. The location of the PLS words within the 13 MFs is shown in Table 5-8 when X denotes the value of the M start word in use. Bits 113 through 232 always contain PLS data while 233 through 236 are always spares.

Table 5-8. Subcom - PLS Data

CR-2 MF	SCT60 MOD 2	Function
25	0	E1 Status
		E1 (D01) thru E1 (D14)
26	0	E1 (D15) thru E1 (D16)
		L Status
		L (A01) thru L(D03)
27	0	L (A04) thru L (C07)
28	0	L (D07) thru L (B11)
29	0	L (C11) thru L (A15)
30	0	L (B15) thru L (D16)
		E2 Status
		E2 (D01) thru E2 (D07)
31	0	E2 (D08) thru E2 (D16)
		M Start Word 1
		M Start Word 2
		M Status
		M(AX) thru M(CX + 1)
32	0	M (AX + 2) thru M (CS + 6)
33	0	M (AX + 7) thru M (CX + 11)
34	0	M (AX + 12) thru M (CX + 16)
35	0	M (AX + 17) thru M (CX + 21)
36	0	M (AX + 22) thru M (CX + 26)
37	0	M (AX + 27) thru M (CX + 31)
25	1	M (AX + 32) thru M (CX + 36)
26	1	M (AX + 37) thru M (CX + 41)
27	1	M (AX + 42) thru M (CX + 46)
28	1	M (AX + 47) thru M (CX + 51)
29	1	M (AX + 52) thru M (CX + 56)
30	1	M (AX + 57) thru M (CX + 61)
31	1	M (AX + 62) thru M (CX + 66)
32	1	M (AX + 67) thru M (CX + 71)
33	1	M (AX + 72) thru M (CX + 76)
34	1	M (AX + 77) thru M (CX + 81)
35	1	M (AX + 82) thru M (CX + 86)
36	1	M (AX + 87) thru M (CX + 91)
37	1	M (AX + 92) thru M (CX + 96)

5.2.6.4 Subcom-Status

Subcom status data consists of status words for MAG, FDS, CRS, PWS, and UVS contained in three subcom MFs. These status words are shown in Table 5-9.

Table 5-9. CR-2 Subcom Status Data

CR-2 MF	CR-2 Bits	Function
1	113-124	MAG Status Word 2
	125-136	Spare
	137-148	Spare
	149-160	Spare
	161-172	Spare
39	129-140	FDS Command Counter (The number of 12-bit FDS command words received during lines 1 thru 48 of the previous 48 s interval.)
	141-236	FDS Command Words (The first 8 12-bit FDS command words the FDS received during the previous 48 s interval. If none received, previous commands will be read out again.)
40	129-140	CRS Status
	141-152	CRS Status
	153-164	CRS Status
	165-176	CRS Status
	177-188	CRS Status
	189-200	CRS Status
	201-212	CRS Status
	213-224	CRS Status
	225-230	PWS Status (3 MSBs are spares)
	231-236	UVS Readout Flag "0"=Enable, "1"= Inhibit (The "1" to inhibit is contained in bit 236)

5.2.6.5 Subcom-Command Status

Three subcom MFs contain command status for MAG, LECP, UVS, PLS, PRA, PPS, and CRS as shown in Table 5-10. Serial commands include the 4-bit destination code in the LS byte position of the 16-bit word output. Bilevel commands include the entire 16-bit OUT instruction.

Table 5-10. CR-2 Subcom Command Status

CR-2 MF	CR-2 Bits	Function
38	113-128	MAG Command 1
	129-144	MAG Command 2
	145-160	LECP Configuration Command
	161-176	UVS Bilevel Command
	177-192	PLS Command
	193-208	PRA Mode Command
	209-224	PRA Configuration Command
39	113-128	PPS Command Word (Set Data/Count Control)
40	113-128	CRS Command

5.2.7 CRS Data (Bits 237-548)

CRS is sampled and processed as in GS-3. Each CR-2 MF contains the same data, in the same order, output in two GS-3 MFs. PHA data is sampled in bursts of four words every 0.24 s starting at t = 0.0475 s. The four PHA words output characterize one PHA event. A single rate sample is taken every 200 ms. A complete sequence of 480 rate samples is output every 80 MFs (96 s). Rate Word 1 of 480 is output in MF 1 when SCT60 = Even. All CRS words are 12 bits. The location of PHA and Rate Words within the MF is:

Four 12-Bit PHA words (one event)

Two 12-Bit Rate words

Four 12-Bit PHA words

One 12-Bit Rate word

Four 12-Bit PHA words

One 12-Bit Rate word

Four 12-Bit PHA words

One 12-Bit Rate word

Four 12-Bit PHA words

One 12-Bit Rate word

5.2.8 MAG Data (Bits 549-1088)

Only LFM data is output. The 12-bit words represent averages for samples taken from all axes of both primary (P) and secondary (S) LFMs every 60 ms starting at t_o = 10 ms. Two samples are averaged for PLFM and 4 for SLFM. The readout order is always X, Y, and Z. The MF data content is shown in Table 5-11.

Table 5-11. Mag Data

CR-2 Bits	Function	Line Numbers of Samples Averaged
549-584	PLFM	L1 and L2 of 20
585-620	PLFM	L3 and L4 of 20
621-656*	SLFM	L1 through L4 of 20
657-692	PLFM	L5 and L6 of 20
693-728	PLFM	L7 and L8 of 20
729-764	SLFM	L5 through L8 of 20
765-800	PLFM	L9 and L10 of 20
801-836	PLFM	L11 andL12 of 20
837-872	SLFM	L9 through L12 of 20
873-908	PLFM	L13 and L14 of 20
909-944	PLFM	L15 and L16 of 20
945-980	SLFM	L13 through L16 of 20
981-1016	PLFM	L17 and L18 of 20
1017-1052	PLFM	L19 and L20 of 20
1053-1088	SLFM	L17 through L20 of 20

*MAG Status Word 1, sampled at t = 45.0 ms of MF1 x 8, replaces the first SLFM Z-axis data average (bits 645-656) in each MF1 x 8.

5.2.9 LECP Data (Bits 1089-1168)

The LECP data mix is 2:1 PHA to Rate/Status. A PHA burst of four words is sampled every 0.9 s starting at t = 0.075 s. The four PHA words output characterize one PHA event. Rate/Status data is also sampled in four word bursts at one burst every 1.8 s starting at t = 0.7075 s. The Rate/Status readout sequence length is 200 bursts or 800 words and repeats every 300 MFs (7-1/2 counts of SCT60). Rate/Status burst 1 of 200 is the first Rate/Status group output in CR-2 MF 1 when SCT60 = 0. All LECP words are 10-bit. The sequence of PHA and Rate/Status words repeats every 3 MFs as shown in Table 5-12.

Table 5-12. LECP Data

CR-2 MF \ LECP Words	1	2	3	4	5	6	7	8
1 of 3	PHA	PHA	PHA	PHA	R/S	R/S	R/S	R/S
2 of 3	PHA	PHA	PHA	PHA	PHA	PHA	PHA	PHA
3 of 3	R/S	R/S	R/S	R/S	PHA	PHA	PHA	PHA

5.2.10 PRA Data (Bits 1169-1488)

PRA data is sampled and processed exactly as in GS-3 (one snapshot, equivalent to a 200-word PRA scan, every 6 s). Each PRA snapshot is output in five consecutive MFs. The two status words are output first followed by 38 data words in MF 1. The next four MFs each have 40 data words.

5.2.11 PPS Data (Bits 1489-1536)

PPS data is sampled and processed exactly as in GS-3. A 24-bit sample, consisting of a 4-bit exponent, a 10-bit mantissa, and 10 bits of status in sequence, is taken every 600 ms.

5.3 CR-3

(To be supplied when developed.)

5.4 CR-4

(To be supplied when developed.)

5.5 CR-5

(To be supplied when developed.)

5.6 CR-6

5.6.1 Data Content

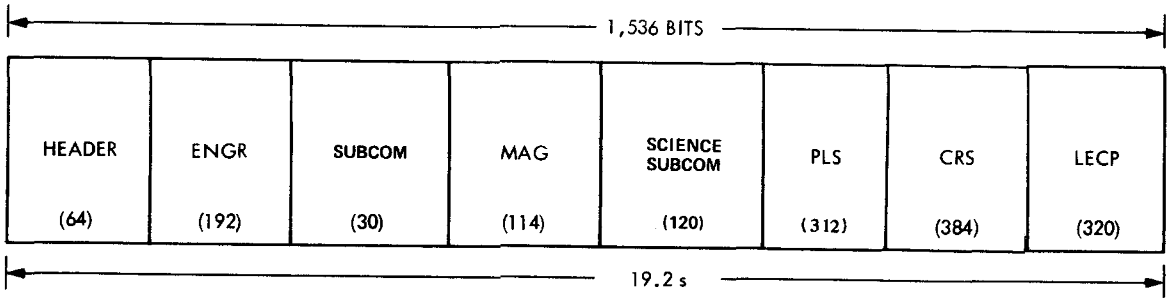
The CR-6 format includes measurements for the following instruments:

CRS	PWS	PPS	UVS
PRA	LECP	PLS	MAG

This format also contains S/C engineering and S/C time.

* 5.6.2 CR-6 Frame Structure

Figure 5-3 shows one minor frame (MF) of CR-6 data. As indicated one MF comprises a time period of 19.2 seconds with a frame length of 1,536 bits. This information is transmitted at a data rate of 80 bps.



* Figure 5-3. One Minor Frame CR-6 Data

The CR-6 minor frame time of 19.2 seconds is equal to 320 line counts. This results in five minor frames every 96 s (two counts of MOD 60) and 150 minor frames per cycle of the MOD 60 Counter. One revolution of the MOD 60 Counter is also the CR-6 major frame time; therefore, all data types will have an integer number of frames every major frame or 150 minor frames.

5.6.3 Frame Synchronization and Time (Bits 1-32, 41-64)

Frame and time identification description is delineated in Section 3 of this document.

5.6.4 Format Identification (Bits 33-40)

Format identification word for CR-6 is shown in paragraph 3.1.2 of this document.

5.6.5 Engineering (Bits 65-256)

The engineering structure is identical to the CR-40 mode. The minor frame time is 48 s and the major frame time is 48 m. This makes the MOD 60 Counter equal to an engineering minor frame counter. It can be used directly for engineering decommutation.

Line count in the engineering header will always read one since the minor frame time is equal to the line count cycle time. Engineering data will be imbedded as follows:

CR-6 MF	Engineering Word	Engineering MF
1 of 150	1 - 24	1 of 60
2 of 150	25 - 48	1 of 60
3 of 150	49 - 60	1 of 60
	1 - 12	2 of 60
4 of 150	13 - 36	2 of 60
5 of 150	37 - 60	2 of 60
...	...	...
...	...	...
149 of 150	13 - 36	60 of 60
150 of 150	37 - 60	60 of 60

*5.6.6 Subcom (Bits 257-286)

The CR-6 subcom contains both command status and instrument status information as described below.

*5.6.6.1 Subcom-Command (Bits 257-272)

The CR-6 command subcom is comprised of the commands shown in Table 5-13.

*5.6.6.2 Subcom-Status (Bits 273-286)

The CR-6 status subcom is comprised of the instrument status information shown in Table 5-14. Details of the CRS Status word sampling included in this field are shown in Table 5-15.

5.6.7 MAG Data (Bits 287-400)

MAG data is processed using a 2-bit delta modulation algorithm. This algorithm is detailed in MJS77-3-270. This results in 20 delta modulator (DM) samples for the primary LFM (a 2-bit DM for each axis or 6 bits per sample), ten DM samples for secondary LFM, one 12-bit primary reference, and one 12-bit secondary reference. The DM output is the same every minor frame; however, it takes three MFs to complete the reference readout since there are a total of six reference samples (three each for two MAGs). MAG Reset is sent every 288 seconds which is five cycles of the LFM secondary algorithm.

✱ Table 5-13. CR-6 Subcom Command Data

CR-6 MF (x10)	SCT60 MOD 4	Function
1	0	PRA Mode Command
2		PRA Configuration Command
3		PWS Level Control Command
4	1	PPS Set Data/Count Control
5		LECP Serial Command
6	2	CRS Serial Command
7		MAG Serial Command 1
8		MAG Serial Command 2
9	3	UVS Mode/High Voltage Control
10		PLS Serial Command

✱ Table new this issue (Amendment B, 8 April 1977)

△✱Table 5-14. CR-6 Subcom Status Data

SCT60 MOD 6	MF (x 15)	MSB ← FDS INTERNAL BITS → LSB 273 ← TLM BITS → 286				
0 ↓	1	S	S	MAG STATUS WORD 1		
	2	S	S	MAG STATUS WORD 2		
	3	S	S	FDS CMD COUNT		
1 ↓	4	1st CCS COMMAND RECEIVED			S	S
	5	2nd			S	S
2 ↓	6	3rd			S	S
	7	4th			S	S
	8	5th			S	S
3 ↓	9	6th			S	S
	10	7th			S	S
4 ↓	11	8th			S	S
	12	S	S	CRS STATUS WORD		
	13	S	S	CRS STATUS WORD		
5 ↓	14	S	S	CRS STATUS WORD		
	15	S ←→ S	U	P	S S	PWS

S = SPARE BIT (INDETERMINATE)
U = UVS READOUT FLAG
P = PLS INTEGRATION TIME

✱ Table new this issue (Amendment B, 8 April 1977)

✱ Table 5-15. CR-6 Subcom Status Data - CRS Status Words

CRS Status Word	Subcom Status Position	Output		Sampling	
		SCT60 MOD30	MF (x75)	SCT60 MOD30	MF (x75)
0	12	4	12	0	1
1	13	4	13	2	6
2	14	5	14	4	11
3	12	10	27	6	16
4	13	10	28	8	21
5	14	11	29	10	26
6	12	16	42	12	31
7	13	16	43	14	36
8	14	17	44	16	41
9	12	22	57	18	46
10	13	22	58	20	51
11	14	23	59	22	56
12	12	28	72	24	61
13	13	28	73	26	66
14	14	29	74	28	71

✱ Table new this issue (Amendment B, 8 April 1977)

*5.6.8 Science Subcom (Bits 401-520)

The science subcom contains UVS, PWS, PPS and PRA data, as shown in Figure 5-4. It is based on a 75-MF (24 min) complete cycle time. The science data provided for each instrument is described below.

*5.6.8.1 Science Subcom-UVS Data

Two snapshots are taken every 12 minutes. The data from each snapshot is output in 11 consecutive MFs. Each 3.84 s snapshot consists of 64 diode pair samples taken every 60 ms. The data consists of two 16-bit words which are log-compressed so that the data is stored as two 10-bit words. The UVS data vs. CR-6 MF readout is shown in Table 5-16.

*5.6.8.2 Science Subcom-PWS Data

A PWS data scan is repeated every 96 s. The data is output in eight consecutive MFs twice in a 75-MF sequence. Table 5-17 shows the PWS data vs. CR-6 MF readout.

*5.6.8.3 Science Subcom-PPS Data

One PPS sample is taken every 36 s. Each data word received from the PPS has 30 bits and takes 24 bits in the output data. 20-bit count values are log-compressed by the FDS to a 14-bit word which consists of a 4-bit exponent followed by a 10-bit mantissa. These 14 bits are followed by 10 bits of status to make up the 24 bits of PPS data in each MF. Table 5-18 shows the PWS data vs. CR-6 MF readout.

*5.6.8.4 Science Subcom-PRA Data

A 200-word PRA scan is taken every 37-1/2 MFs (12 min). A complete PRA scan sequence takes 51.2 h. All status and data words are 8-bit bytes. The first two data bytes are overlaid by status bytes and do not appear in the data. Table 5-19 shows the PRA data vs. CR-6 MF readout.

*5.6.8.5 Science Subcom-Filler Data

The 120-bit science subcom field contains no valid data in MF 75 (line count = 481).

SCT60 MOD 30	MF	SCT60 EVEN n 1	SCT60 EVEN n 2	SCT60 EVEN/ODD n 3	SCT60 ODD n 4	SCT60 ODD n 5
0, 1	0 + n			UVS		
2, 3	5 + n					
4, 5	10 + n					
6, 7	15 + n			PRA		
8, 9	20 + n					
10, 11	25 + n			PPS		
12, 13	30 + n			PWS		
14, 15	35 + n					
16, 17	40 + n			UVS		
18, 19	45 + n					
20, 21	50 + n			PRA		
22, 23	55 + n					
24, 25	60 + n			PPS		
26, 27	65 + n	PPS		PWS		
28, 29	70 + n					

NOTE: SHADING INDICATES SPARE BITS.

Figure 5-4. CR-6 Science Subcom Data

✱ Figure new this issue (Amendment B, 8 April 1977)

* Table 5-16. UVS Science Subcom Data

CR-6 MF	(x75)	Function
1	38	D_{127}, D_{128}, D_1, D_2, ..., D_9, D_{10}
2	39	D_{11}, D_{12}, D_{13}, D_{14}, ..., D_{21}, D_{22}
3	40	D_{23}, D_{24}, D_{25}, D_{26}, ..., D_{33}, D_{34}
4	41	. .
5	42	. .
6	43	. .
7	44	. .
8	45	. .
9	46	D_{95}, D_{96}, D_{97}, D_{98}, ..., D_{105}, D_{106}
10	47	D_{107}, D_{108}, D_{109}, D_{110}, ..., D_{117}, D_{118}
11	48	D_{119}, ..., D_{126}, 40 Filler Bits

* Table new this issue (Amendment B, 8 April 1977)

* Table 5-17. PWS Science Subcom Data

SCT60 MOD30	MF (x75)	Data Bits 401-408	409-416	417-424	425-432	433-440	441-448	449-456	457-464	465-472	473-480	481-488	489-496	497-504	505-512	513-520
11	30	9	1	10	2	11	3	12	4	13	5	14	6	15	7	16
12	31	8	9	1	10	2	11	3	12	4	13	5	14	6	15	7
	32	16	8	9	1	10	2	11	3	12	4	13	5	14	6	15
	33	7	16	8	9	1	10	2	11	3	12	4	13	5	14	6
13	34	15	7	16	8	9	1	10	2	11	3	12	4	13	5	14
	35	6	15	7	16	8	9	1	10	2	11	3	12	4	13	5
14	36	14	6	15	7	16	8	9	1	10	2	11	3	12	4	13
	37	5	14	6	15	7	16	8	9	1	10	2	11	3	12	4
26	67	13	5	14	6	15	7	16	8	9	1	10	2	11	3	12
	68	4	13	5	14	6	15	7	16	8	9	1	10	2	11	3
27	69	12	4	13	5	14	6	15	7	16	8	9	1	10	2	11
	70	3	12	4	13	5	14	6	15	7	16	8	9	1	10	2
28	71	11	3	12	4	13	5	14	6	15	7	16	8	9	1	10
	72	2	11	3	12	4	13	5	14	6	15	7	16	8	9	1
	73	10	2	11	3	12	4	13	5	14	6	15	7	16	8	9
29	74	1	10	2	11	3	12	4	13	5	14	6	15	7	X	X
	75	16	8	X	X	X	X	X	X	X	X	X	X	X	X	X

Note: Table entries are filter numbers. X indicates spare.

*Table new this issue (Amendment B, 8 April 1977)

*Table 5-18. PPS Science Subcom Data

CR-6 MF	SCT60 MOD30	LC	Bits	PPS Data Sample No.
27	10	1	425-448	1
			449-472	2
			473-496	3
			497-570	4
28	10	641	401-424	5
			425-228	6
			449-472	7
			473-496	8
			497-520	9
29	11	161	401-424	10
			425-448	11
			449-472	12
			473-496	13
			497-520	14
63	24	641	401-424	15
			425-448	16
			449-472	17
			473-496	18
			497-520	19
64	25	161	401-424	20
			425-448	21
			449-472	22
			473-496	23
			497-520	24
65	25	481	401-424	25
			425-448	26
			449-472	27
			473-496	28
			497-520	29
66	25	1	401-424	30
			425-448	31
			449-472	32
			473-496	33
			497-520	34
26	10	1	401-424	35
			425-448	36
			449-472	37
			473-496	38
			497-520	39
27	10	321	401-424	40

*Table new this issue (Amendment B, 8 April 1977)

*Table 5-19. PRA Science Subcom Data

Bits	MF (X75) 12, 49	13, 50	14, 51	15, 52	16, 53	17, 54	18, 55	19, 56	20, 57	21, 58	22, 59	23, 60	24, 61	25, 62
401-408	SW1	16	31	46	61	76	91	106	121	136	151	166	181	196
409-416	SW2	17	32	47	62	77	92	107	122	137	152	167	182	197
417-424	3	18	33	68	63	78	93	108	123	138	153	168	183	198
425-432	4	19	34	69	64	79	94	109	124	139	154	169	184	199
433-440	5	20	35	50	65	80	98	110	125	140	155	170	185	200
441-448	6	21	36	57	66	81	96	111	126	144	156	171	186	80 SPARE BITS (Indeterminate)
449-456	7	22	37	52	67	82	97	112	127	142	157	172	189	
457-464	8	23	38	53	68	83	98	113	128	143	158	173	188	
465-472	9	24	39	54	69	84	99	114	129	144	159	174	189	
473-480	10	25	40	55	70	85	100	115	130	145	160	175	190	
481-488	11	26	41	56	71	86	101	116	131	196	161	176	191	
489-496	12	27	42	57	72	89	102	117	132	149	162	177	192	
497-504	13	28	43	58	73	88	103	118	133	148	163	178	193	
505-512	14	29	44	59	74	89	104	119	134	149	164	179	194	
513-520	15	30	45	60	75	90	105	120	135	150	165	180	195	

Note: SW1 and SW2 are PRA Status Words 1 and 2, respectively.

* Table new this issue (Amendment B, 8 April 1977)

*5.6.9 PLS Data (Bits 521-832)

A complete PLS scan takes 384 s (20 MFs or eight counts of the SCT60 counter). This consists of two basic 192 s (10 MF) scans. However, in the odd (MF 11-20 x 20) scan, M-mode sampling is normally delayed. The data output vs. MF is shown in Table 5-20. Each status word, M-Start Word, or data sample is an 8-bit byte; each MF contains 39 bytes. Group numbers (n) have a z-range from 1 to 128 for M data and from 1 to 16 for E1, L, and E2 data.

*5.6.10 CRS data (Bits 833-1216)

The CRS operates on a 24-minute complete cycle time. During this time the CRS outpus 480 12-bit Rate words and 480 bursts of four 12-bit PHA words. The Rate and PHA words are both 12-bit words. 32 of these words are packed into the 384-bit CRS data field of each MF. The pattern of Rate and PHA words repeats every 5 MFs (192 s) as shown in Table 5-21.

*5.6.11 LECP Data (Bits 1217-1536)

Bursts of four word gates acquire four 10-bit data words each; these 40 bits are four 10-bit Rate/Status (R/S) data words or five 8-bit PHA (and ID) words. The PHA word Gate burst frequency is twice the R/S word Gate burst frequency. A complete cycle through the Rate/Status command tables takes 24 minutes. Each MF has 320 bits of data, consisting of the data samples obtained by the eight PHA and R/S word Gate bursts, each of which acquires 40 bits of LECP data. Table 5-22 shows the LECP data output vs. MF.

* Table 5-20. PLS Data

SCT60 MOD 4	CR-6 MF (x10)	Data Bytes	Byte Count	SCT60-MOD 4 When Sampled	
				Short Integration	Long Integration
0	1	E1 Status	1	Previous 1	Previous 2
		E1 (D01), E1 (D02),...,E1 (D16)	16	Previous 1	Previous 2
		L Status	1	Previous 2	Previous 3
		L(A01), L(B01),...,L(A06)	21	↓	↓
0	2	L(B06), L(C06),...,L(D15)	39	↓	↓
0	3	L(A16), L(B16),...,L(D16)	4	↓	↓
		E2 Status	1	Previous 3	↓
		E2(D01), E2(D02),...,E2(D16)	16	Previous 3	↓
		M Start Word - 1	1	Current 0	Current 0
		M Start Word - 2	1	↓	↓
		M Status	1	↓	↓
		M(A1+d), M(B1+d),...,M(C5+D)	15	↓	↓
1	4	M(A6+d), M(B6+d),...,M(C18+d)	39	Previous 0	Previous 0 or Current 1
1	5	M(A19+d), M(B19+d),...,M(C31+d)	39	↓	↓
2	6	M(A32+d), M(B32+d),...,M(C44+d)	39	↓	Previous 0-1
2	7	M(A45+d), M(B45+d),...,M(C57+d)	39	↓	Previous 0-1
2	8	M(A58+d), M(B58+d),...,M(C70+d)	39	↓	Previous 1
3	9	M(A71+d), M(B71+d),...,M(C83+d)	39	↓	Previous 1-2
3	10	M(A84+d), M(B84+d),...,M(C96+d)	39	↓	Previous 1-2

Note: d = M Start Word in use ÷ 3.

* Table new this issue (Amendment B, 8 April 1977)

* Table 5-21. CRS Data

CR-6 MF Bits	Sampling Time (s) MF/LC 1 x 5 1	2 x 5 321	3 x 5 641	4 x 5 161	5 x 5 481
833-844	R-0.0425	18.0475	36.0525	57.0450	75.0500
845-856	0.0450	18.0500	R-39.0425	57.0475	75.0575
857-868	0.0475	18.0525	39.0450	57.0500	R-78-0425
869-880	0.0500	R-21.0425	39.0475	57.0525	78.0450
881-892	0.0525	21.0450	39.0500	R-60.0425	78.0475
893-904	R-3.0425	21.0475	39.0525	60.0450	78.0500
905-916	3.0450	21.0500	R-42.0425	60.0475	78.0525
917-928	3.0475	21.0525	42.0450	60.0500	R-81.0425
929-940	3.0500	R-24.0425	42.0475	60.0525	81.00450
941-952	3.0525	24.0450	42.0500	R-63.0425	81.0475
953-964	R-6.0425	24.0475	42.0525	63.0450	81.0500
965-976	6.0450	24.0500	R-45.0425	63.0475	81.0525
. . .	. . .	. . .	. . .	. . .	. . .
1145-1156	15.0450	33.0500	R-54.0425	72.0425	90.0525
1157-1168	15.0475	33.0525	54.0450	72.0500	R-93.00425
1169-1180	15.0500	R-36.0425	54.0475	72.0525	93.00450
1181-1192	15.0525	36.0450	54.0500	R-75.0425	93.0475
1193-1204	R-18.0425	36.0475	54.0525	75.0450	93.00500
1205-1216	18.0450	36.0500	R-57.0425	75.0475	93.0525

Notes:

1. 'R' indicates Rate Data.
2. Bracketed 4-word groups are the 4 PHA words for 1 PHA event.
3. Sample times are from t_o when $(SCT60)_{MOD4}$ becomes 0.

* Table new this issue (Amendment B, 8 April 1977)

✻ Table 5-22. LECP Data

Output		Data		
		First Sample Time		Sample Type
MF (x3)	Bits	MF (x3)	t_o + (s)	
1	1217-1256	1	0.0275	PHA
	1257-1296		0.0875	R/S
	1297-1336		3.6275	PHA
	1337-1376		7.2275	PHA
	1377-1416		7.2875	R/S
	1417-1456		10.8275	PHA
	1457-1496		14.4275	PHA
	1497-1536		14.4875	R/S
2	1217-1256		18.0275	PHA
	1257-1296	2	2.4275	PHA
	1297-1336		2.4875	R/S
	1337-1376		6.0275	PHA
	1377-1416		9.6275	PHA
	1417-1456		9.6875	R/S
	1457-1496		13.2275	PHA
	1497-1536		16.8275	PHA
3	1217-1256		16.8875	R/S
	1257-1296		20.4275	PHA
	1297-1336	3	4.8275	PHA
	1337-1376		4.8875	R/S
	1377-1416		8.4275	PHA
	1417-1456		12.0275	PHA
	1457-1496		12.0875	R/S
	1497-1536		15.6275	PHA

✻ Table new this issue (Amendment B, 8April 1977)

*5.7 CR-7

At the present time, the Project has no plans to develop this format.

*5.8 CR-8

At the present time, the Project has no plans to develop this format.

*5.9 CR-9

At the present time, the Project has no plans to develop this format.

6.0 ENCOUNTER GENERAL SCIENCE DATA FORMATS

6.1 General Science and Engineering Format (GS-3)

The GS-3 format is used during encounter to acquire general science data in real time when imaging data is not being acquired.

6.1.1 Data Content

The GS-3 format includes measurements for the following instruments:

CRS	PWS	PPS	UVS	MIRIS
PRA	LECP	PLS	MAG	

This format also contains S/C engineering data using the encounter format and S/C time.

6.1.2 GS-3 Frame Structure

Figure 6-1 shows one MF of GS-3 data. As indicated one MF comprises a time period of 0.6 s with a frame length of 2160 bits.

2160 BITS

FSC	FORMAT ID	MOD 16 COUNTER	MOD 60 COUNTER	LINE COUNT	SUBCOM	ENGRG	LECP	MAG	FILLER	CRS	PRA	MIRIS	PPS	UVS
(32)	(8)	(8)	(6)	(10)	(48)	(24)	(360)	(450)	(2)	(156)	(160)	(672)	(24)	(200)

0.6 s (10 ISS LINES) (COMBINED WITH 2160 BITS OF GOLAY CODE FOR 7200 bps)

Figure 6-1. One Minor Frame of GS-3 Data

This results in an overall data rate of 3600 bps. This information is Golay coded and transmitted at a bit rate of 7200 bps. One MF covers 10 ISS lines. Since there are 800 ISS lines per picture (48 s), there are 80 GS-3 MFs per 48 s. A major frame is defined as 80 MFs (800 line counts). A major frame start is indicated by a one count in line count field. The following sections describe each data field of the GS-3 frame.

6.1.2.1 Frame Synchronization and Time (Bits 1-32, 41-64). Frame and time identification description is delineated in Section 3 of this document.

* 6.1.2.2 Format Identification (Bits 33-40). Format identification word for GS-3 is shown in paragraph 3.1.2 of this document.

* 6.1.2.3 Subcom (Bits 65-112). Subcom data is provided in a 48-bit field The major frame (80 minor frames) is subcommutated as shown in Table 6-1 to transmit instrument commands, status (ISS and non-ISS), PLS, and PWS data. This field is used to transmit subcommutated data as follows.

* 6.1.2.3.1 Subcom-Status. The GS-3 major frame is composed of 80 MFs. Of these 80 MFs, 16 48-bit fields have been assigned to status as shown in Table 6-1. This status consists of ISS status and non-ISS status. The data content of these fields is shown in Table 6-2.

* 6.1.2.3.2 Subcom-PLS Data. The GS-3 major frame has 32 48-bit fields assigned to PLS science data as shown by Table 6-1. The data sampled in these fields is shown in Table 6-3. Figure 6-19 provides additional detail of the data sampling and FDS processing. A PLS sequence scan results in 384 8-bit words outputted every 96 s. The data is divided into the following types:

Mode	Number of 8-bit Words in Format
M	288 (4 groups of 72 each)
E_1	16
L	64
E_2	16
	384

The bottom line of Figure 6-19 shows the relationship of time in seconds to the data sequence sampling. The top three lines show the relationship of status words, command words, and data words to MFs. Between the top three lines and bottom line is the FDS processing. Processing for E_1, L, and E_2 data sequences is direct as shown with 16, 64, and 16 words being sampled and output. Processing of M data involves a truncation process. On every other major frame (48 s), 128 readings are taken on four sensors, totaling 512 words. When the 2nd LSB of the MOD 60 count is even the data from readings 1 through 72 are transmitted. When the 2nd LSB of the MOD 60 count is odd the data from readings 57 through 128 are transmitted. Since the scan is 96 s long, both MOD 60 Count and Line Count must be used for decommutation. Commands are transferred to the PLS 2.5 ms prior to the first sample, as shown in Figure 6-19.

*Table 6-1. GS-3 Subcom Data

GS-3 MF	Line Count	Subcom Contents	GS-3 MF	Line Count	Subcom Contents	GS-3 MF	Line Count	Subcom Contents
1	1	Status	27	261	PLS	54	531	PWS
2	11	Status	28	271	PWS	55	541	PLS
3	21	PLS	29	281	PLS	56	551	PWS
4	31	PWS	30	291	PWS	57	561	PLS
5	41	PLS	31	301	Status	58	571	PWS
6	51	PWS	32	311	Status	59	581	PLS
7	61	PLS	33	321	PLS	60	591	PWS
8	71	PWS	34	331	PWS	61	601	Status
9	81	PLS	35	341	PLS	62	611	Status
10	91	PWS	36	351	PWS	63	621	PLS
11	101	Status	37	361	PLS	64	631	PWS
12	111	Status	38	371	PWS	65	641	PLS
13	121	PLS	39	381	PLS	66	651	PWS
14	131	PWS	40	391	PWS	67	661	PLS
15	141	PLS	41	401	Status	68	671	PWS
16	151	PWS	42	411	Status	69	681	PLS
17	161	PLS	43	421	PLS	70	691	PWS
18	171	PWS	44	431	PWS	71	701	Status
19	181	PLS	45	441	PLS	72	711	Status
20	191	PWS	46	451	PWS	73	721	PLS
21	201	Status	47	461	PLS	74	731	PWS
22	211	Status	48	471	PWS	75	741	PLS
23	221	PLS	49	481	PLS	76	751	PWS
24	231	PWS	50	491	PWS	77	761	PLS
25	241	PLS	51	501	Status	78	771	PWS
26	251	PWS	52	511	Status	79	781	PLS
			53	521	PLS	80	791	PWS

Δ * Table 6-2. GS-3 Subcom Status Data (sheet 1 of 6)

GS-3 MF	MOD 60	Line Count	Bit No.	Function
				ISS Status
1	-	1	65	Camera ID: "0" = WA, "1" = NA.
			66-80	Shuttered Picture Indicator: All ones indicate shuttered picture. All zeros indicate no shuttering.
			81-96	Slow Scan Status.
			97-101	Spare (bits = "0")
			102	NA Electronics Cal Status: "1" = ON, "0" = OFF
			103	WA Electronics Cal Status: "1" = ON "0" = OFF
			104-108	Actual Exposure Time: This word identifies the number that corresponds to an exposure time and the camera used during the prepare cycle. Bit 104 is MSB. This word does not indicate long exposures.
			109-112	Actual Filter Position: 4-bit word indicates the filter wheel position for picture being read out as shown in the following table. Bit 112 is odd parity.

Filter Position	Bit No. 109	110	111	112
1	0	0	1	0
2	0	1	0	0
3	0	1	1	1
4	1	0	0	0
5	1	0	1	1
6	1	1	0	1
7	1	1	1	0
8	0	0	0	1

△ * Table 6-2. GS-3 Subcom Status Data (sheet 2 of 6)

GS-3 MF	MOD 60	Line Count	Bit No.	Function
2	-	11	65-80	Picture Count: Count is incremented once for each shuttered picture and is reset only by command from CCS.
			81-96	Parameter Word A: Present value as used in the current ISS frame.
			97-98	Spare (bits = "0")
			99-112	Parameter A Indicator Bits: Indicator bits used in the current ISS frame.
11	-	101	65-66	Spare (bits = "0")
			67-80	Parameter Word A Pointer: The address in FDS memory where the next parameter A word pair is stored.
			81-96	Parameter Word B: Present value used in current ISS frame.
			97-98	Spare (bits = "0")
			99-112	Parameter Word B Pointer: The address in FDS memory where next parameter B word is stored.
12	-	111	65-80	Parameter Word C: Present value used in current ISS frame.
			81-82	Spare (bits = "0")
			83-96	Parameter Word C Pointer: The address in FDS memory where next parameter C word is stored.
			97-112	Parameter Word D: Present values used in current ISS frame.
21	-	201	65-68	Spare (bits = "0")
			69-80	Parameter D Indicator Bits: Indicator bits used in current ISS frame.
			81-82	Spare (bits = "0")
			83-96	Parameter Word D Pointer: The address in FDS memory where next parameter word D is stored.
			97-112	ISS Analog Engineering Telemetry
			97-104	First WA sample taken in previous ISS frame.
			105-112	First NA sample taken in previous ISS frame.

△ * Table 6-2. GS-3 Subcom Status Data (sheet 3 of 6)

GS-3 MF	MOD 60	Line Count	Bit No.	Function
22	-	211	65-72	Second WA sample taken in previous ISS frame.
			73-80	Second NA sample taken in previous ISS frame.
			81-88	Third WA sample taken in previous ISS frame.
			89-96	Third NA sample taken in previous ISS frame.
			97-104	Fourth WA sample taken in previous ISS frame.
			105-112	Fourth NA sample taken in previous ISS frame.
31	-	301	65-72	Fifth WA sample taken in previous ISS frame.
			73-80	Fifth NA sample taken in previous ISS frame.
			81-83	Pixel Average Status: A "1" indicates more than the minimum number of pixels were used in the pixel average calculation and the exposure time can be modified based on this average if in the auto exposure mode. A "0" indicates less than the minimum was used and the exposure time cannot be modified based on this average.
			84-88	Pixel Average: Is based on a sum of the 5 MSBs of all pixels exceeding the programmed threshold of the camera read out in the previous ISS frame.
			89-91	ISS G1 Voltage "000" = Least Negative G1 Voltage 100 010 110 001 101 011 "111" = Most Negative G1 Voltage
			92	ISS Gain Status ("0" = Low gain, "1" = High Gain)
			93-96	FDS Destination Code 5 WA Camera 6 NA Camera

Δ* Table 6-2. GS-3 Subcom Status Data (sheet 4 of 6)

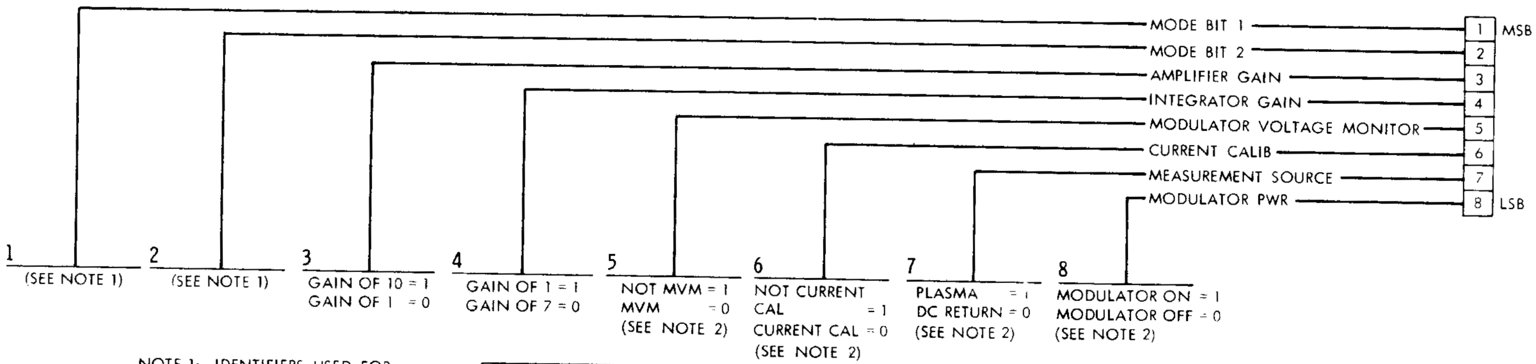
GS-3 MF	MOD 60	Line Count	Bit No.	Function
				Non-ISS Status
			97-112	PPS Command (Set Data/Count Control)
32	-	311	65-80	MAG Command 1
			81-96	MAG Command 2
			97-112	LECP Command (Configuration)
41	-	401	65-80	UVS Command
	Even		81-96	PLS M Command
	Even		97-104	PLS E_2 Status (defined by Figure 6-2)
	Even		105-112	PLS M Status (defined by Figure 6-2)
41	Odd	401	81-96	PLS L Command
	Odd		97-104	PLS E_1 Status (defined by Figure 6-2)
	Odd		105-112	PLS L Status (defined by Figure 6-2)
42	-	411	65-80	PRA Mode Command
			81-96	PRA Configuration Command
			97-112	FDS Command Counter: Counts the number of 12-bit FDS commands received during the previous 48 s.
51	-	501	65-76	First FDS command received in the previous 48 s frame.
			77-80	Spare (bits = "0")
			81-92	Second FDS command received in the previous 48 s frame.
			93-96	Spare (bits = "0")
			97-108	Third FDS command received in the previous 48 s frame.
			109-112	Spare (bits = "0")

△* Table 6-2. GS-3 Subcom Status Data (sheet 5 of 6)

GS-3 MF	MOD 60	Line Count	Bit No.	Function
52	-	511	65-76	Fourth FDS command received in the previous 48 s frame.
			77-80	Spare (bits = "0")
			81-92	Fifth FDS command received in the previous 48 s frame.
			93-96	Spare (bits = "0")
			97-108	Sixth FDS command received in the previous 48 s frame.
			109-112	Spare (bits = "0")
61		601	65-77	Seventh FDS command received in the previous 48 s frame.
			78-80	Spare (bits = "0")
			81-92	Eighth FDS command received in the previous 48 s frame.
			93-96	Spare (bits = "0")
			97-112	CRS Command
62	Even	611	65-76	CRS Status 0 (defined by Figure 6-3)
	Even		77-88	CRS Status 1 (defined by Figure 6-4)
	Even		89-100	CRS Status 2 (defined by Figure 6-5)
	Even		101-112	CRS Status 3 (defined by Figure 6-6)
62	Odd	611	65-77	CRS Status 8 (defined by Figure 6-11)
	Odd		78-83	CRS Status 9 (defined by Figure 6-12)
	Odd		89-100	CRS Status 10 (defined by Figure 6-13)
	Odd		101-112	CRS Status 11 (defined by Figure 6-14)

△* Table 6-2. GS-3 Subcom Status Data (sheet 6 of 6)

GS-3 MF	MOD 60	Line Count	Bit No.	Function
71	Even	701	65-76	CRS Status 4 (defined by Figure 6-7)
	Even		77-88	CRS Status 5 (defined by Figure 6-8)
	Even		89-100	CRS Status 6 (defined by Figure 6-9)
	Even		101-112	CRS Status 7 (defined by Figure 6-10)
71	Odd	701	65-76	CRS Status 12 (defined by Figure 6-15)
	Odd		77-88	CRS Status 13 (defined by Figure 6-16)
	Odd		89-100	CRS Status 14 (defined by Figure 6-17)
	Odd		101-112	CRS Status 15 (defined by Figure 6-18)
72	-	711	65-72	Spare (bits = "0")
			73-80	PWS Status Word (defined by Figure 6-19a) △
			81-96	MIRIS Command
			97-98	LECP Motor Step Flag BIT 97 / BIT 98 / Motor Step Period: 0 0 — 24 s 0 1 — 48 s 1 0 — 144 s
			99-111	Spare (bits = "0")
			112	LECP Mode Far Encounter = "0" Near Encounter = "1"



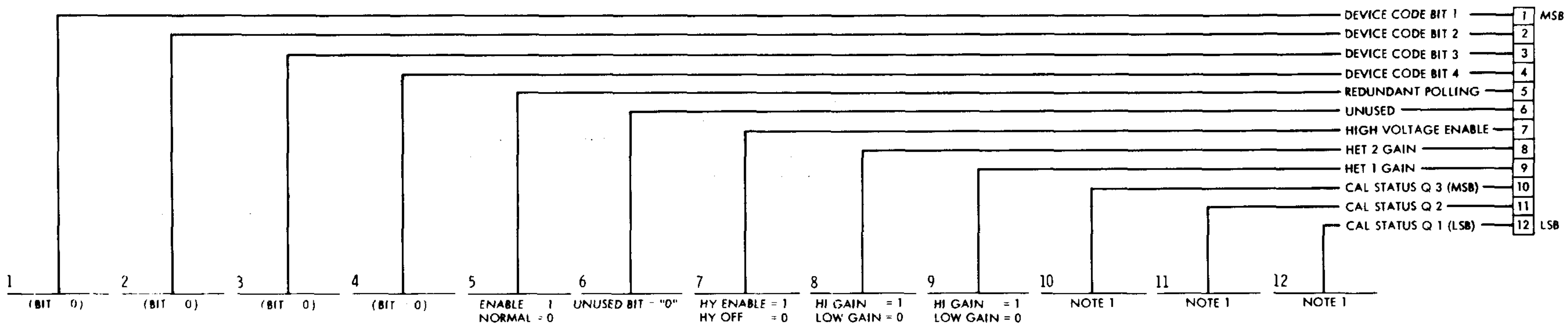
NOTE 1: IDENTIFIERS USED FOR 4 WORDS IN FORMAT

BIT 1 2	MODE
0 0	L
0 1	E_1
1 0	E_2
1 1	M

NOTE 2: BITS 5, 6, 7, AND 8 DECODE TO THE CONFIGURATIONS SHOWN IN THE TABLE BELOW.

BIT 5 6 7 8	CONFIGURATION
0 0 0 0	POWER ON STATE
0 0 0 1	DC RETURN CURRENT (REV. SUPPR.)
0 0 1 1	SECONDARIES CALIBRATION
0 0 1 0	PLASMA REVERSE SUPPRESSION MODULATOR OFF
1 1 1 1	PLASMA MEASUREMENT
1 1 1 0	PLASMA MEASUREMENT MOD. OFF
1 1 0 1	DC RETURN MEASUREMENT
1 1 0 0	DC RETURN MEASUREMENT MOD. OFF
1 0 1 0	CURRENT CALIBRATION
1 0 1 1	MODULATOR PICKUP MEASUREMENT
0 1 1 1	MODULATOR VOLTAGE MONITOR

* Figure 6-2. PLS Status Words - E2, M, E1, and L

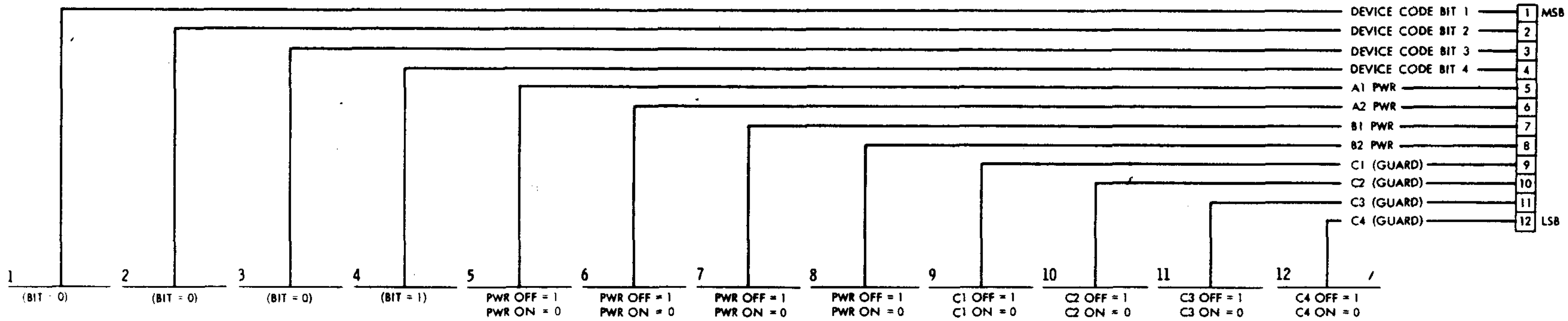


DEVICE CODE 0000

NOTE 1: BITS 10, 11, AND 12 ARE A 3 BIT COUNTER USED TO IDENTIFY CALIBRATION SEQUENCE.

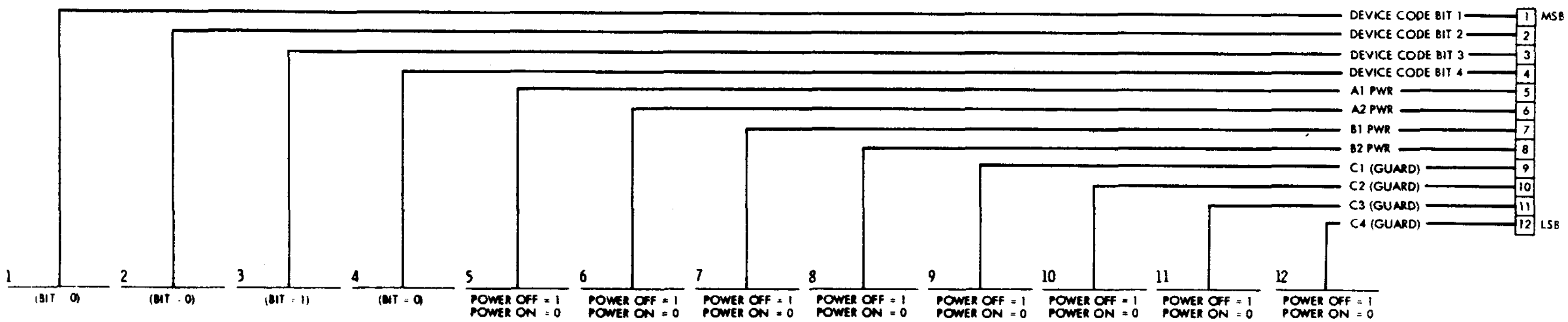
BIT 10	BIT 11	BIT 12	CAL SEQUENCE
0	0	0	1
0	0	1	2
0	1	0	3
0	1	1	4
1	0	0	5
1	0	1	6
1	1	0	7
1	1	1	8

* Figure 6-3. CRS Status Word 0, CAL and High/Low Gain



DEVICE CODE 0001

Figure 6-4. CRS Status Word 1, HET 1 Preamp



DEVICE CODE 0010

Figure 6-5. CRS Status Word 2, HET 2 Preamp

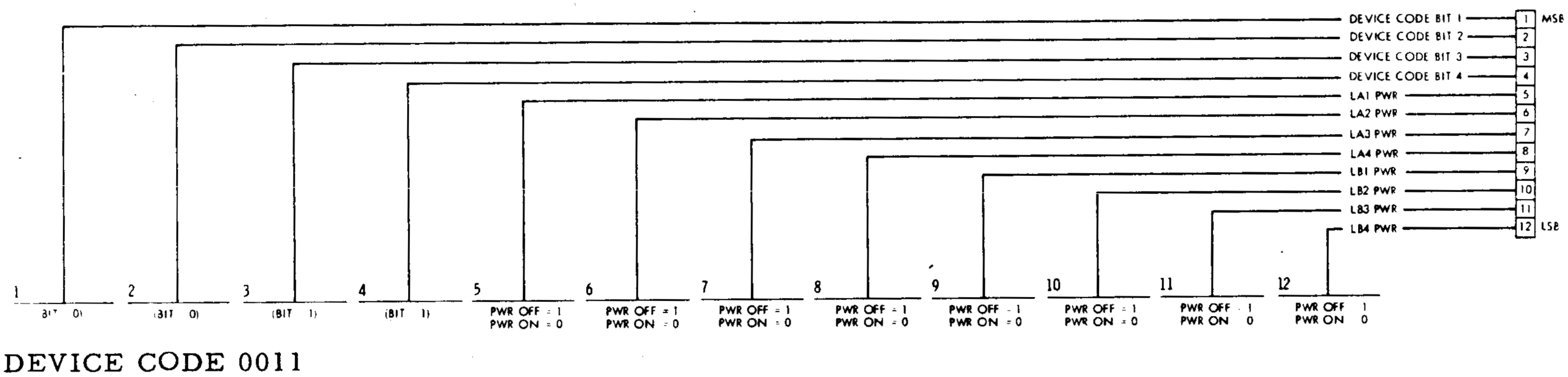


Figure 6-6. CRS Status Word 3, LET A/B Preamp

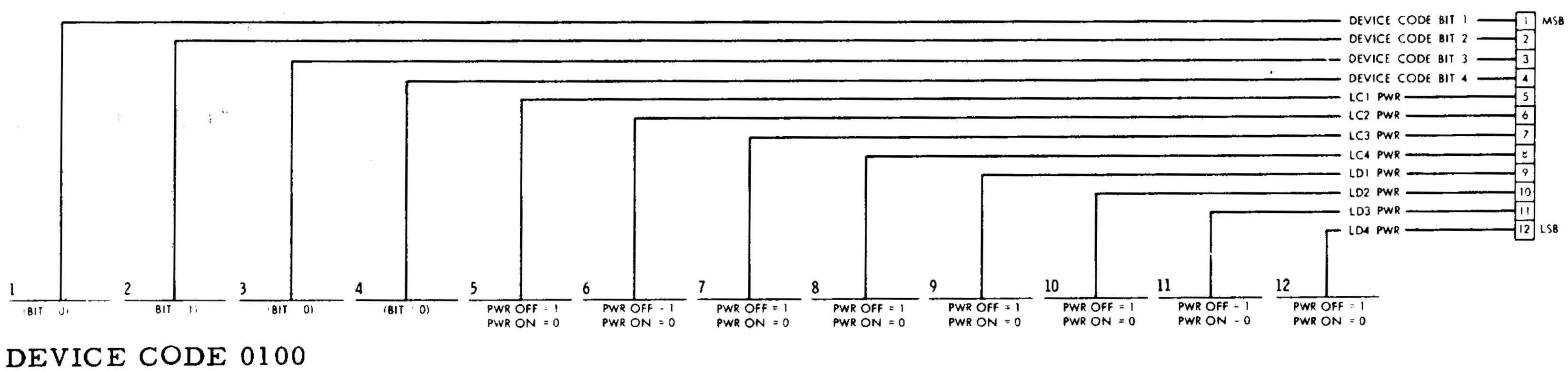
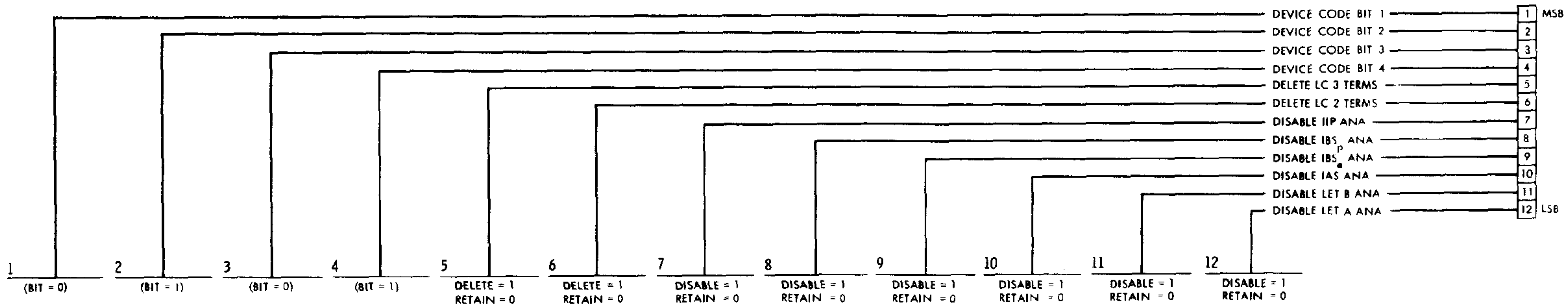
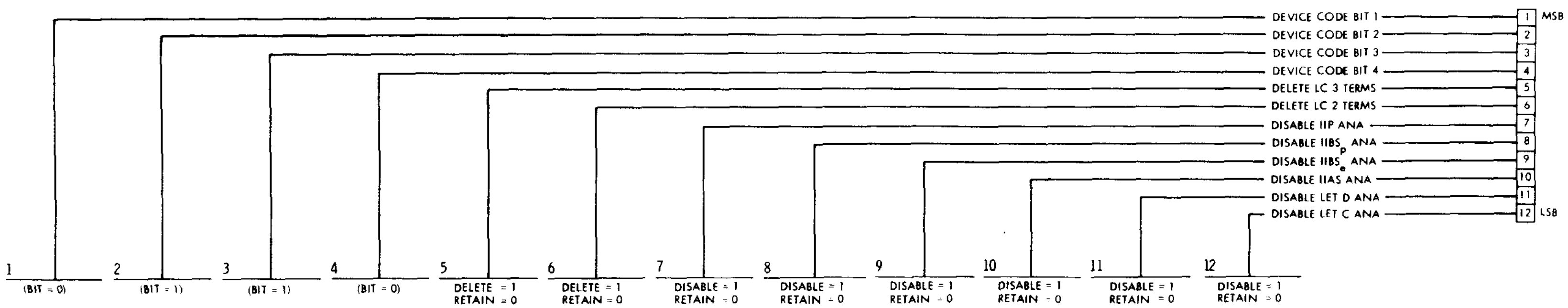


Figure 6-7. CRS Status Word 4, LET C/D Preamp



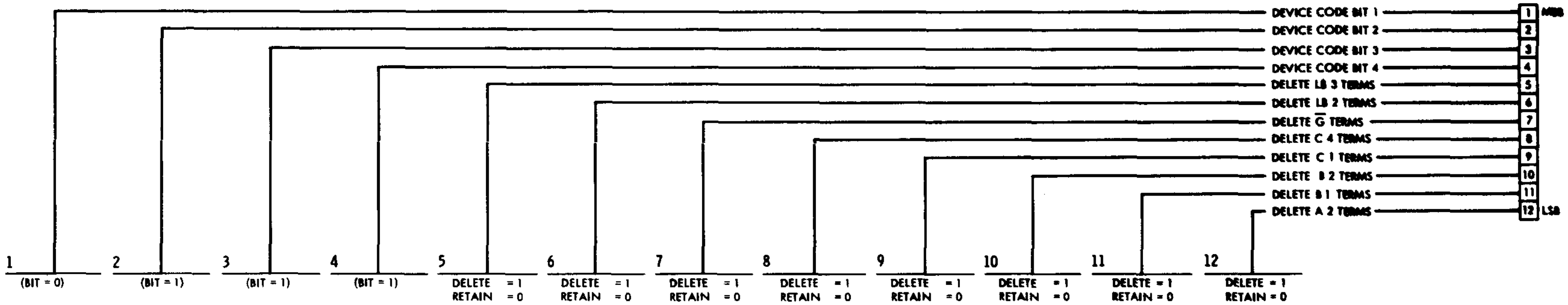
DEVICE CODE 0101

Figure 6-8. CRS Status Word 5, LET A/B and Block 1 PHA Control



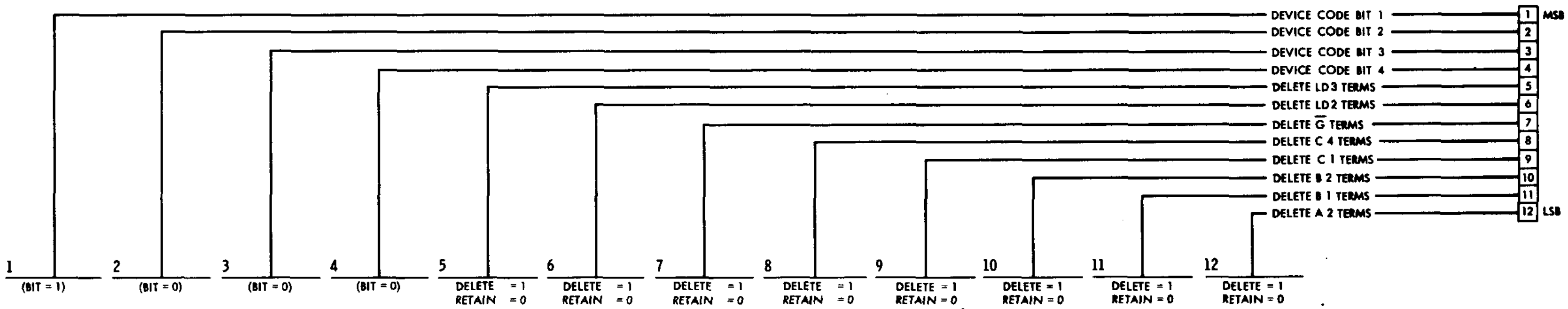
DEVICE CODE 0110

Figure 6-9. CRS Status Word 6, LET C/D and Block 2 PHA Control



DEVICE CODE 0111

Figure 6-10. CRS Status Word 7, LET A/B and HET I



DEVICE CODE 1000

Figure 6-11. CRS Status Word 8, LET C/D and HET II

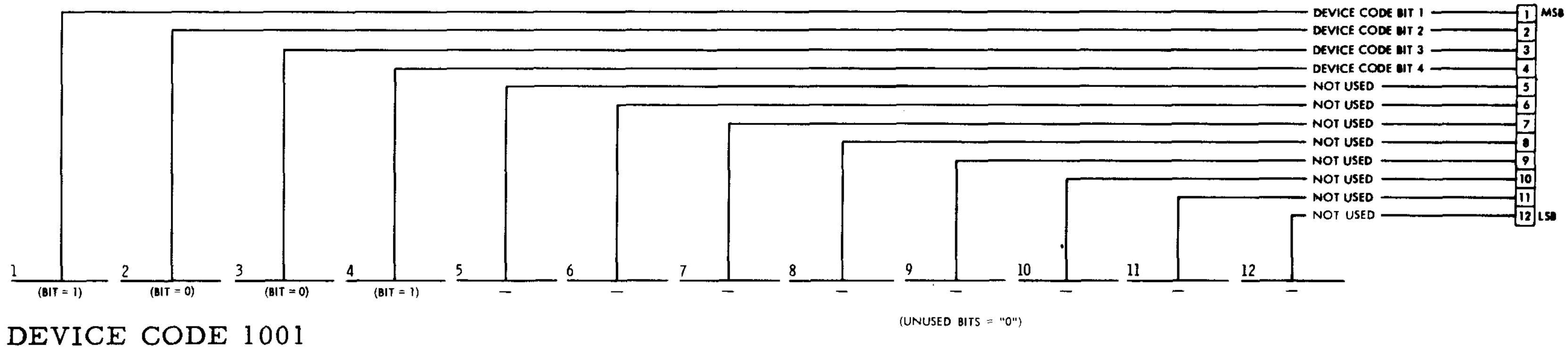


Figure 6-12. CRS Status Word 9, Unused

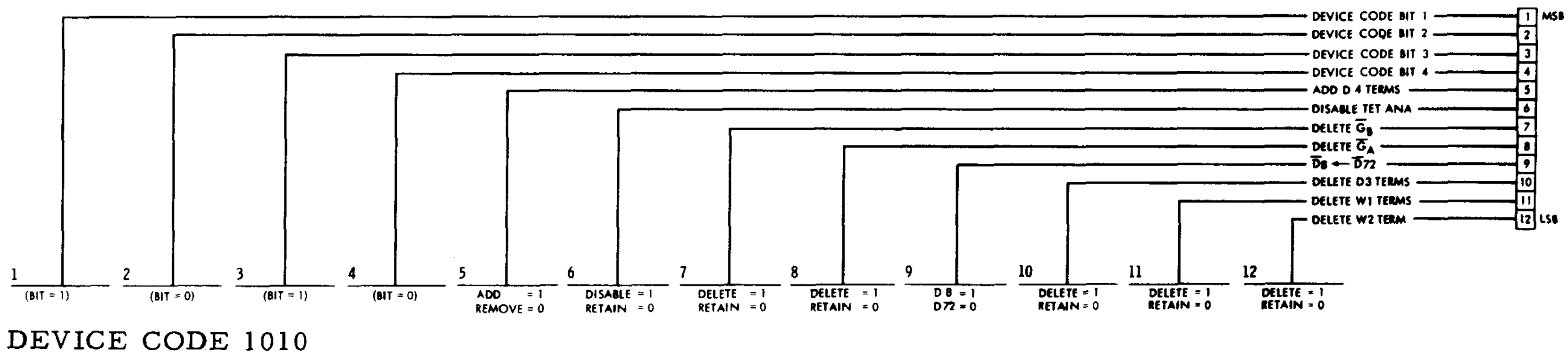
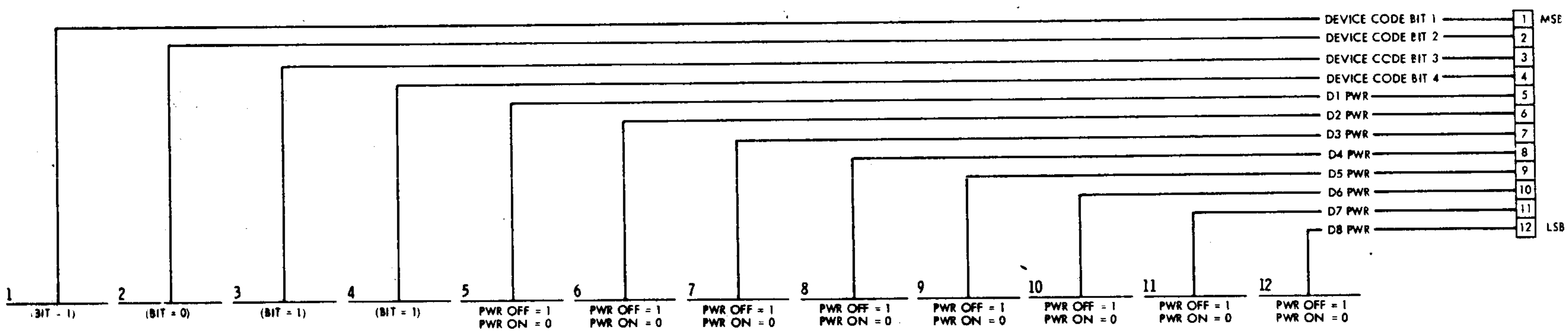
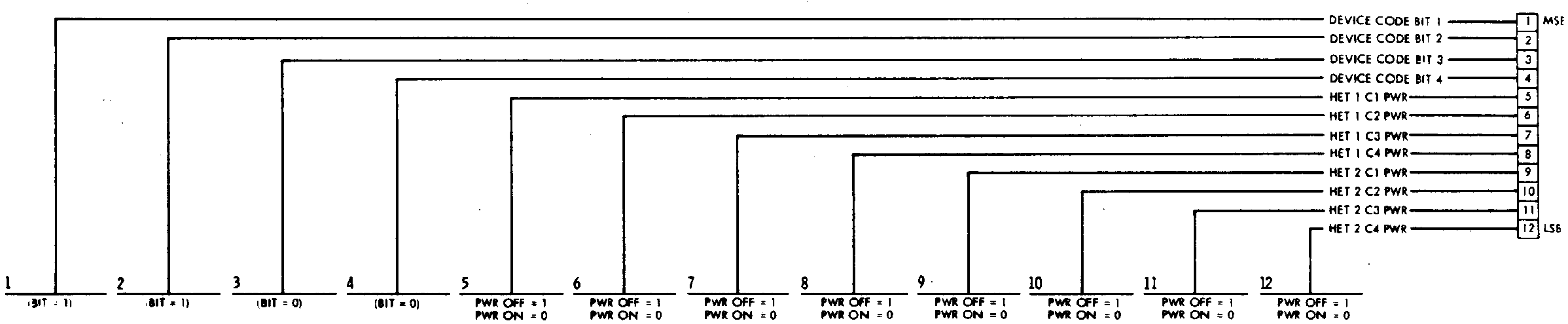


Figure 6-13. CRS Status Word 10, TET Coincidence



DEVICE CODE 1011

Figure 6-14. CRS Status Word 11, TET Preamps



DEVICE CODE 1100

Figure 6-15. CRS Status Word 12, HET C Preamps

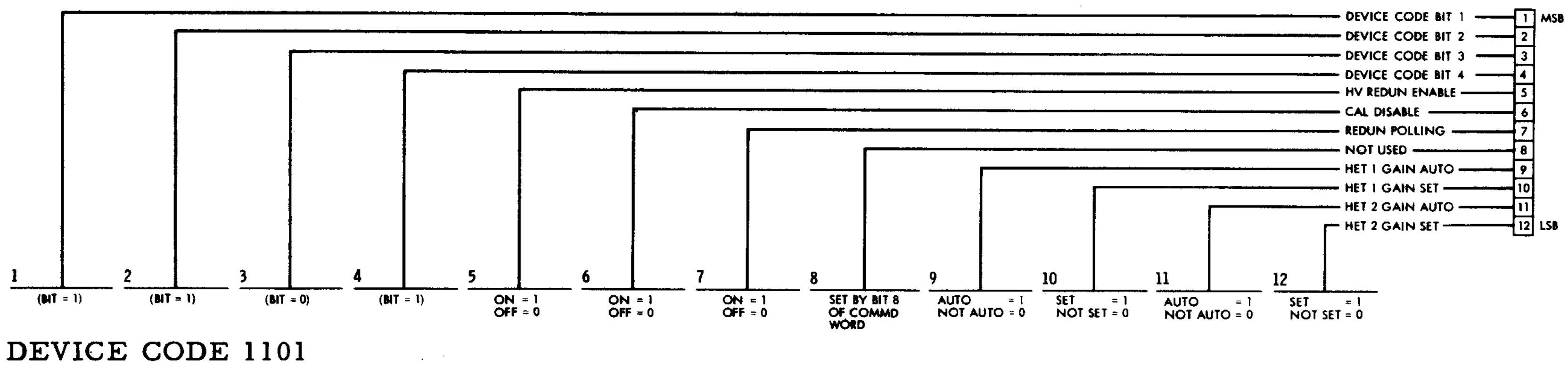


Figure 6-16. CRS Status Word 13, CRS Misc Control

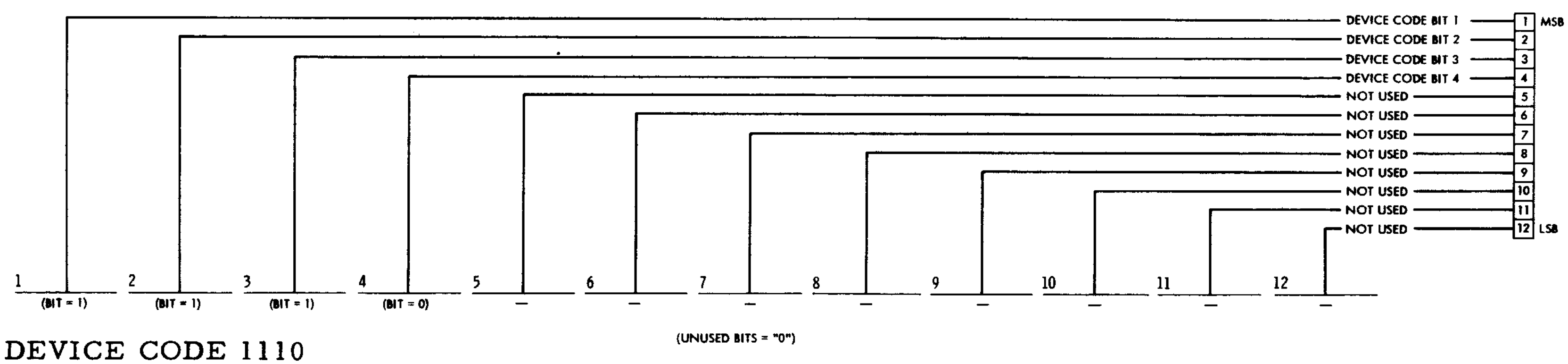
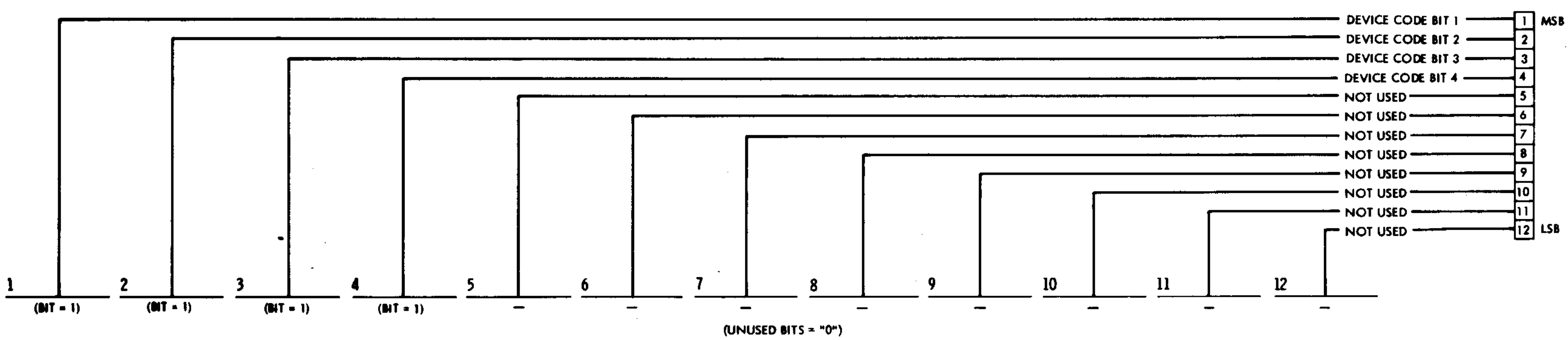


Figure 6-17. CRS Status Word 14, Not Used



DEVICE CODE 1111

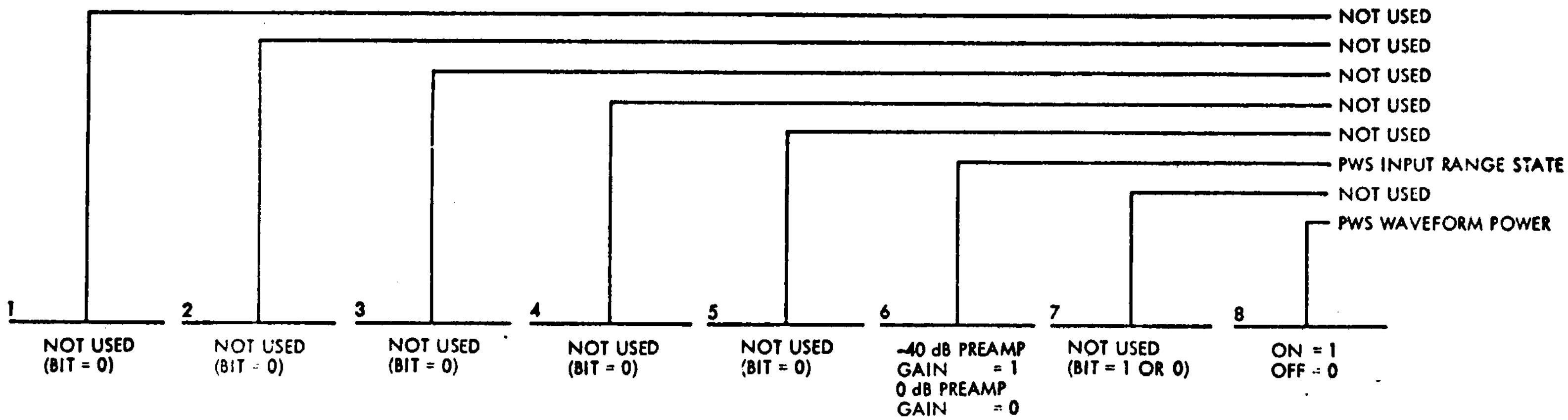
Figure 6-18. CRS Status Word 15, Not Used

✱ Table 6-3. Subcom-PLS Data

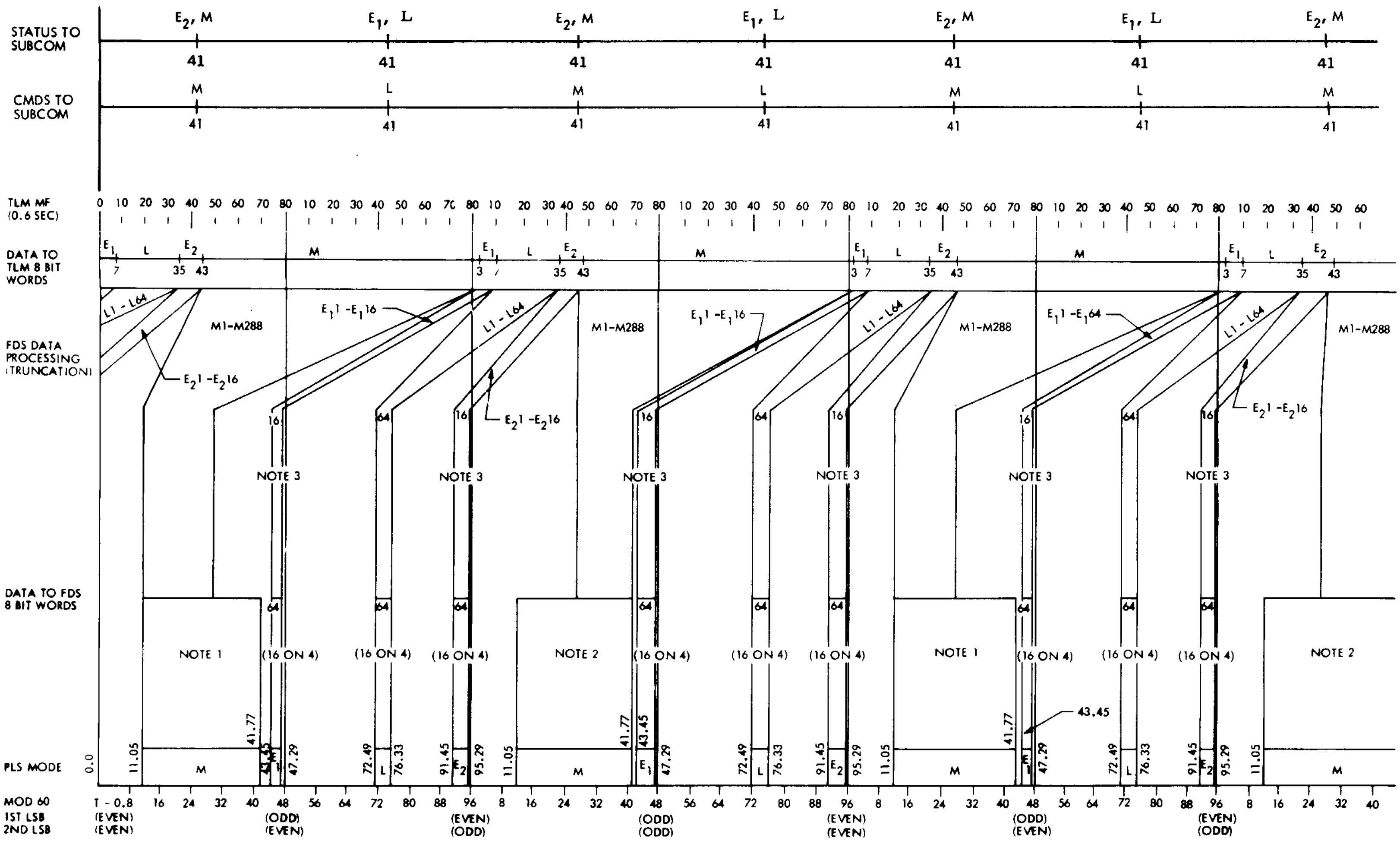
SCT60 MOD 4	CR-6 MF*	Function
0	3-39	$E_1$1 - $E_1$16 from previous SCT60 MOD 4 = 2
		L_1 - L_{64} from previous SCT60 MOD 4 = 3
		$E_2$1 - $E_2$16 from previous SCT60 MOD 4 = 3
	43-79	M1 - M96 from current SCT60 MOD 4 = 0
1	3-79	M97 - M288 from previous SCT60 MOD 4 = 0
2	3-39	$E_1$1 - $E_1$16 from previous SCT60 MOD 4 = 0
		L1 - L64 from previous SCT60 MOD 4 = 1
		$E_2$1 - $E_2$16 from previous SCT60 MOD 4 = 1
	43-79	M225 - M320 from current SCT60 MOD 4 = 2
3	3-79	M321 - M512 from previous SCT60 MOD 4 = 2

*PLS data is output for odd MF numbers only and is not output for MF numbers of nl.

✱ Table new this issue (Amendment B, 8 April 1977). Table 28, "PLS Science Data", from MJS77-3-280A is now deleted.



△ Figure 6-19a. PWS Status Word



NOTE 1: INPUT TO FDS 128 READINGS ON 4 SENSORS = 512 WORDS. READINGS 1-72 ON 4 SENSORS (288 WORDS) ARE TRANSMITTED WHEN 2ND LSB IS EVEN.

NOTE 2 INPUT TO FDS 128 READINGS ON 4 SENSORS = 512 WORDS. READINGS 57-128 ON 4 SENSORS (288 WORDS) ARE TRANSMITTED WHEN 2ND LSB IS ODD.

NOTE 3: INPUT TO FDS 16 READINGS EACH ON SENSORS A, B, C AND D. READINGS ON SENSOR D ONLY ARE TRANSMITTED.

NOTE 4: COMMANDS TO PLS FROM FDS OCCUR 2.5 ms BEFORE THE START OF THE MODES SHOWN ABOVE; e.g., AT 11.0475S FOR THE M MODE WHICH STARTS AT 11.05S.

Δ ✻ Figure 6-19. PLS Science Data Processing (EC Mode)

*6.1.2.3.3 Subcom-PWS Data. The GS-3 major frame has 32 48-bit blocks in the subcom field assigned to PWS data as shown by Table 6-1. Time relationship and data content for these words are shown in Table 6-4. A PWS sequence consists of 16 8-bit words outputted every 4 s. Six 8-bit words are transmitted in each MF.

a) PWS A (Filter Nos. 1-8) is equivalent to LFLC (Filter Nos. 1-8)

b) PWS B (Filter Nos. 9-16) is equivalent to HFLC (Filter Nos. 1-8)

1) The PWS scan of 16 8-bit samples repeats 12 times in 48 s (4 s per scan).

2) PWS is stepped every 0.5 s starting at filter 1 for output A (LFLC) and filter 9 for output B (HFLC) at t = 0.005 s (5 ms into line 1).

3) The first PWS B (9) sample is taken at t = 0.4325 s (12.5 ms into line 8). B is sampled every 0.5 s thereafter. This sample is output as the MS 8-bit byte in MF 4 (LC = 31).

4) The first PWS A (1) sample is taken at t = 0.44 s (20 ms into line 8). A is sampled every 0.5 s thereafter. This sample is output as the 2nd MS 8-bit byte in MF 4 (LC = 31).

c) Three bits of status are sampled every 48 s at t = 0.4925 (12.5 ms into line 9). It is output in MF 72 of the GS-3 subcom as part of the first 16 bits of the subcom.

*6.1.2.4 Engineering Data (Bits 113-136). In the GS-3 MF there is a 24-bit field for encounter engineering data.

*6.1.2.5 LECP Data (Bits 137-496). LECP data is provided in a 360-bit field and is sampled differently during far encounter and near encounter. Far encounter operation includes the acquisition of both Rate/Status and PHA data and, based on one complete cycle through its Rate/Status command word table, takes 24 s for a complete cycle. Near encounter operation acquires Rate/Status data only and requires 12 s for a complete cycle. Operation in each of the two modes is described below.

*6.1.2.5.1 LECP Data - Far Encounter. LECP Rate/Status data acquired during far encounter is shown in Table 6-5. The sequence is 960 10-bit words which are outputted every 24 s. Each MF contains 24 Rate/Status words and the scan repeats every 40 MF. PHA data consists of four 10-bit PHA words every 200 ms. Each MF contains 12 PHA words.

Both PHA and Rate/Status data are sampled in bursts of four words separated by 2.5 ms. A burst of PHA is read every 200 ms. Rate/Status bursts are read every 100 ms. A LECP Rate/Status command

✱ Table 6-4. Subcom-PWS Data

GS-3 MF	Line Count	Function	No. of Bits	Scan No.
4	31	PWS B, A Data (Filters 9, 1, 10, 2, 11, 3)	48	
6	51	PWS B, A Data (Filters 12, 4, 13, 5, 14, 6	48	1
8	71	PWS B, A Data (Filters 15, 7, 16, 8, 9, 1)	48	
10	91	PWS B, A Data (Filters 10, 2, 11, 3, 12, 4)	48	
14	131	PWS B, A Data (Filters 13, 5, 14, 6, 15, 7)	48	2
16	151	PWS B, A Data (Filters 16, 8, 9, 1, 10, 2)	48	
18	171	PWS B, A Data (Filters 11, 3, 12, 4, 13, 5)	48	
20	191	PWS B, A Data (Filters 14, 6, 15, 7, 16, 8)	48	3
24	231	PWS B, A Data (Filters 9, 1, 10, 2, 11, 3)	48	
. . .	. . .	. . .	. . .	. . .
80	791	PWS B, A Data (Filters 14, 6, 15, 7, 16, 8)	48	12

Note: PWS A is low-frequency log compressor.
PWS B is high-frequency log compressor.

Table 6-5. LECP Far Encounter Data

1. IN THE SEQUENCE BELOW, EACH PHA EVENT READOUT (40 BITS) IS INDICATED BY "P" AND EACH RATE/STATUS WORD GROUP READOUT (40 BITS) IS GIVEN BY A NUMBER INDICATING THE GROUP.
2. EACH P.H.A. EVENT CONSISTS OF 40 BITS. THESE 40 BITS ARE READ AS 4 CONTIGUOUS 10 BIT WORDS.
3. THERE ARE 72 RATE AND STATUS WORDS. EACH WORD CONTAINS 10 BITS. THESE WORDS ARE GROUPED INTO BLOCKS OF 4 AS SHOWN ON TABLE 6-6
4. AT LECP BIT RATE OF 600 BPS (GS-3), THE SEQUENCE LASTS 24 SECONDS (TWO MINOR FRAMES).

MF (ODD NUMBERED)

1	1	P	2	3	P	4	1	P	2
3	1	P	2	9	P	4	1	P	2
5	1	P	2	3	P	4	1	P	2
7	1	P	2	10	P	4	1	P	2
9	1	P	2	3	P	4	1	P	2
11	1	P	2	9	P	4	1	P	2
13	1	P	2	3	P	4	1	P	2
15	1	P	2	10	P	4	1	P	2
17	1	P	2	3	P	4	1	P	2
19	1	P	2	9	P	4	1	P	2
21	1	P	2	3	P	4	1	P	2
23	1	P	2	10	P	4	1	P	2
25	1	P	2	3	P	4	1	P	2
27	1	P	2	9	P	4	1	P	2
29	1	P	2	3	P	4	1	P	2
31	1	P	2	10	P	4	1	P	2
33	1	P	2	3	P	4	1	P	2
35	1	P	2	9	P	4	1	P	2
37	1	P	2	3	P	4	1	P	2
39	1	P	2	10	P	4	1	P	2

MF (EVEN NUMBERED)

2	7	P	5	1	P	2	3	P	6
4	3	P	5	1	P	2	11	P	6
6	8	P	5	1	P	2	3	P	6
8	3	P	5	1	P	2	12	P	6
10	7	P	5	1	P	2	3	P	6
12	3	P	4	1	P	2	13	P	6
14	8	P	5	1	P	2	3	P	6
16	3	P	5	1	P	2	14	P	6
18	7	P	5	1	P	2	3	P	6
20	3	P	5	1	P	2	15	P	6
22	8	P	5	1	P	2	3	P	6
24	3	P	5	1	P	2	11	P	6
26	7	P	5	1	P	2	3	P	6
28	3	P	5	1	P	2	12	P	6
30	8	P	5	1	P	2	3	P	6
32	3	P	5	1	P	2	13	P	6
34	7	P	5	1	P	2	3	P	6
36	3	P	5	1	P	2	16	P	6
38	8	P	5	1	P	2	3	P	6
40	3	P	5	1	P	2	17	P	6

ALL STATUS WORDS ARE IN GROUPS 16 AND 17.

9 HORIZONTAL BLOCKS = MF

*Table 6-6. LECP Far Encounter Mode Rate Group Arrangement

Rate Group	Rate Channels in Rate Group			
1	$P\alpha 1$	$P\alpha 2$	$P\alpha 3$	$E\beta 5$
2	$E\beta 1$	$E\beta 2$	$E\beta 3$	$E\gamma 6$
3	39	33	32	31
4	$E\gamma 7$	$E\gamma 8$/44*	$E\gamma 9$/45*	$E\beta 5$
5	1	44	3	10
6	$P\alpha 4$	$P\alpha 8$	42	16
7	11	23	27	4
8	13/46*	17/47*	28	38
9	35	$P\alpha 5$	$P\alpha 6$	$P\alpha 7$
10	45	41	12	24
11	34	5	18	14
12	6	7	19	36
13	8	43	25	9
14	29	22	26	30
15	$A\alpha 1$	$A\alpha 2$	37	21
16	15	20	S_5	S_6
17	S_1	S_2	S_3	S_4

1 Group = 40 bits; 1 Rate/Status Word = 10 bits;
1 Rate Channel = 10 bits.
* Two channels listed can be multiplexed together. Each measurement would then appear in alternate occurences of the rate group; otherwise, the first measurement will appear all the time.

is sent 2.5 ms before the first word of a Rate/Status burst is read by FDS. The bit organization for LECP status words is shown in Figures 6-20 through 6-25. Far encounter uses a sequence of 240 R/S commands. Data readout, sampling, and reference to R/S command is given below. The format structure repeats every MF. The R/S command sequence repeats every 40 MFs (24 s).

MF 1 (bits)	Type Burst	First Word Sample Time	R/S CMD Number
137-176	R/S	7.5 ms into line 2 of 10	1
177-216	PHA	7.5 ms into line 3 of 10	—
217-256	R/S	47.5 ms into line 3 of 10	2
257-296	R/S	27.5 ms into line 5 of 10	3
297-336	PHA	27.5 ms into line 6 of 10	—
337-376	R/S	7.5 ms into line 7 of 10	4
377-416	R/S	47.5 ms into line 8 of 10	5
417-456	PHA	47.5 ms into line 9 of 10	—
457-496	R/S	27.5 ms into line 10 of 10	6

This repeats in MF 2 using R/S Commands 7-12, MF 3 uses 13-18, etc. . . . MF 40 uses 235-240. MF 41 is a repeat of MF 1.

*6.1.2.5.2 LECP Data - Near Encounter. LECP Rate/Status data during near encounter is shown in Table 6-7. The basic sequence is 720 10-bit words which are outputted every 12 s. Each MF contains 35 Rate/Status words, and the scan repeats every 20 MFs. Only the R/S data is sampled, and there are no PHA data. Three additional bursts are read at the times PHA was read in far encounter (FE R/S burst remains the same). Additional Rate/Status commands are sent prior to these three R/S bursts. Near encounter uses a sequence of 180 R/S commands. Data readout is:

MF 1	R/S Commands 1-9.
MF 2	R/S Commands 10-18.
MF 20	R/S Commands 172-180.

This sequence repeats every 12 s.

*6.1.2.5.3 LECP Command. The LECP configuration command is in bits 67-112 of the subcom field of MF 32 (LC=311). The LECP Rate/Status command is not sampled as status.

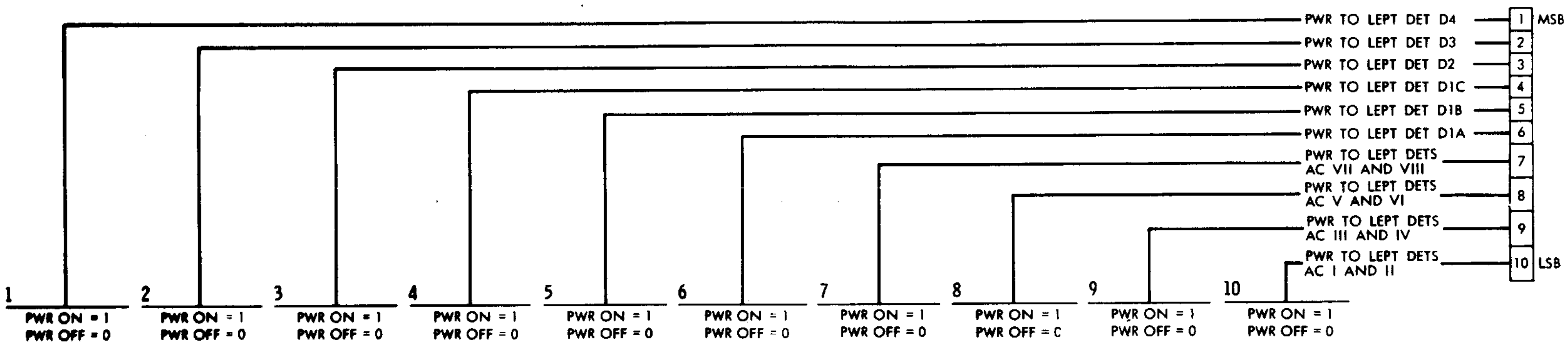
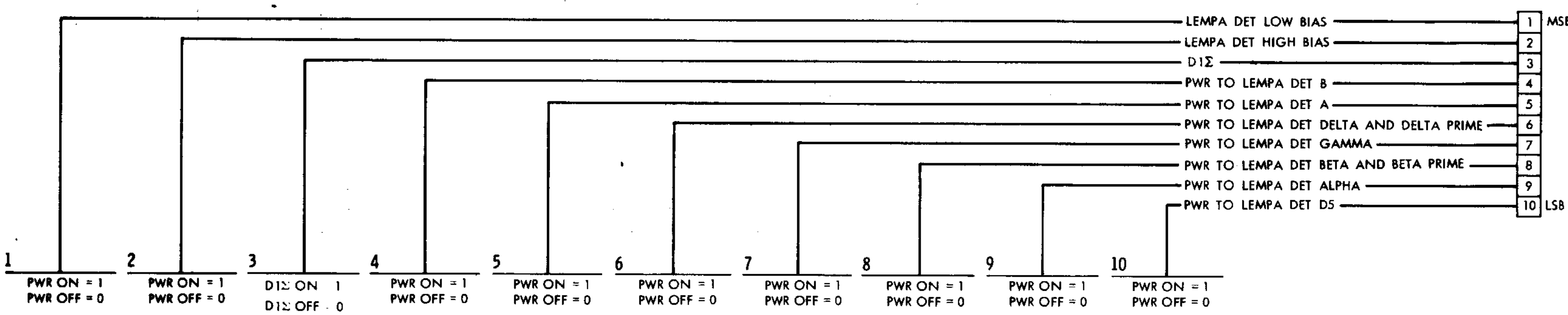
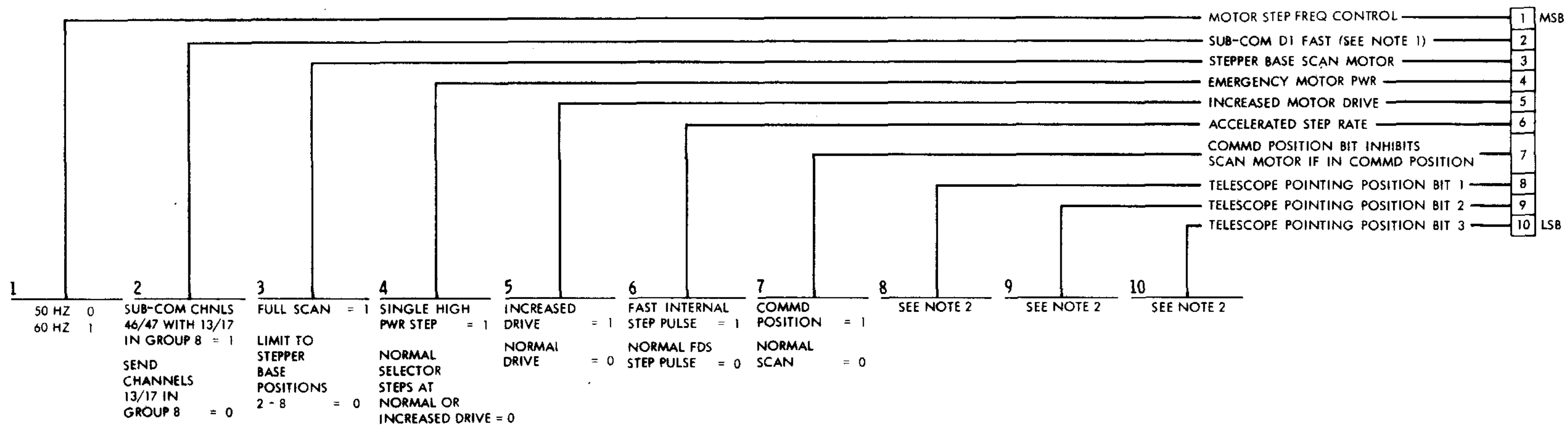


Figure 6-20. LECP Status Word 1



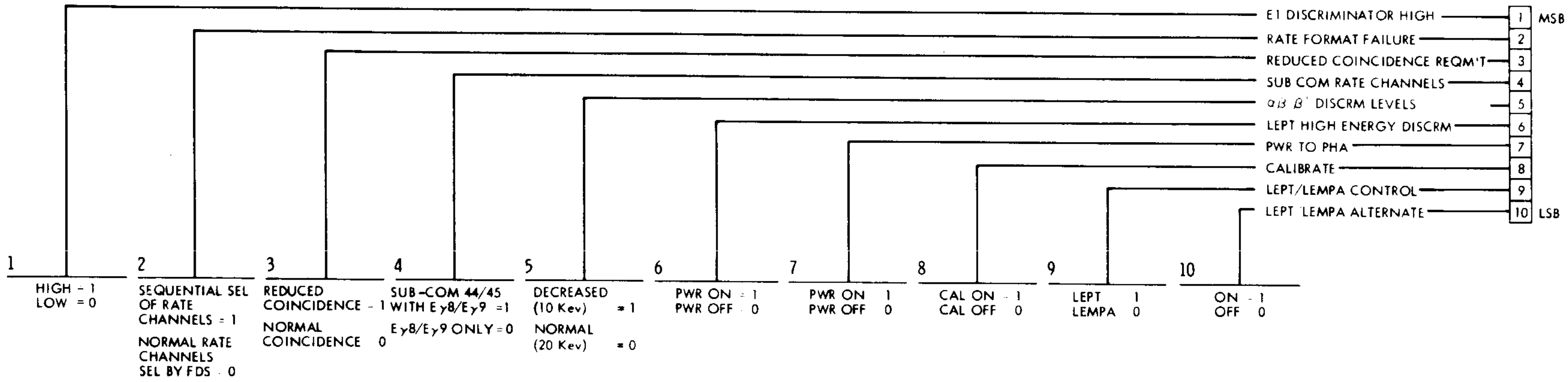
* Figure 6-21. LECP Status Word 2



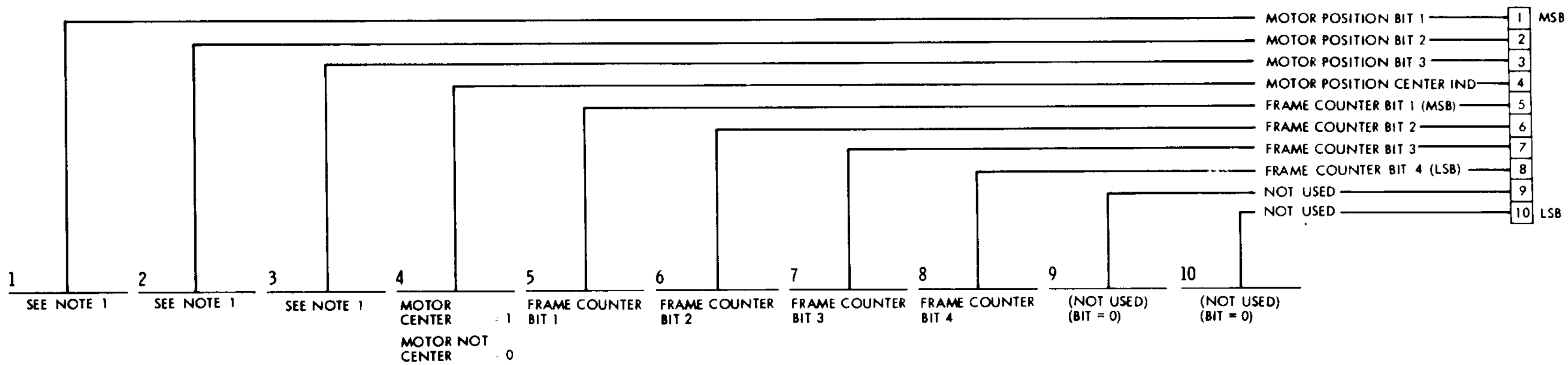
NOTE 1: DURING CRUISE AND FAR ENCOUNTER
NOTE 2: TELESCOPE POINTING POSITION

BITS 8	9	10	SECTOR NO.
1	1	0	1
1	0	1	2
1	0	0	3
0	0	0	4
0	0	1	5
0	1	0	6
0	1	1	7
1	1	1	8

✱ Figure 6-22. LECP Status Word 3



✱ Figure 6-23. LECP Status Word 4

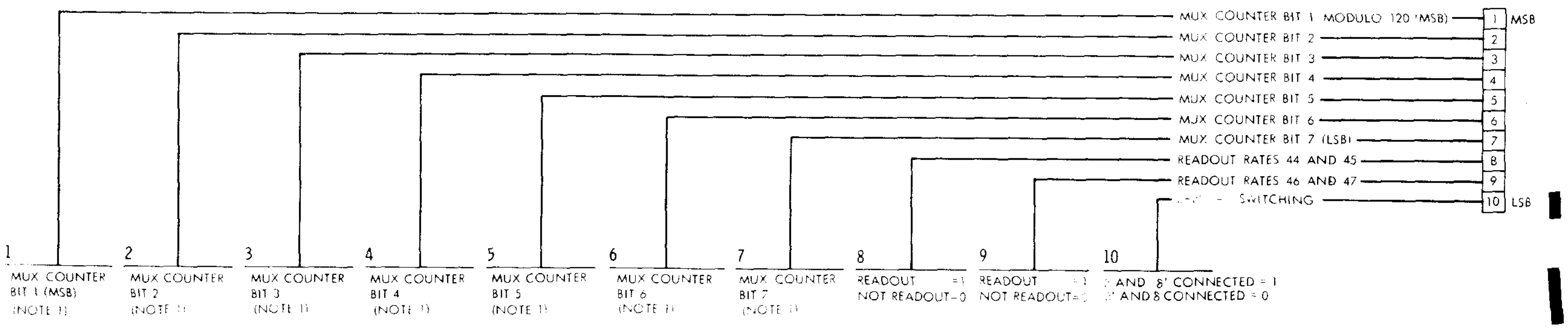


NOTE 1:

BITS 1 2 3	MOTOR POSITION SECTOR
1 1 0	1
1 0 1	2
1 0 0	3
0 0 0	4
0 0 1	5
0 1 0	6
0 1 1	7
1 1 1	8

NOTE 2: USE OF FRAME COUNTER IS DESCRIBED IN NOTE 3 OF TABLE 6-6.

△✱ Figure 6-24. LECP Status Word 5



NOTE 1 REFER TO TABLE 4-15 FOR CORRELATION OF MUX COUNTER READING (BITS 1 - 7) WITH MUX MEASUREMENT.

* Figure 6-25. LECP Status Word 6

Table 6-7. LECP Near Encounter Data

1. THERE ARE 44 RATE/STATUS WORDS. EACH WORD HAS 10 DATA BITS. THESE WORDS ARE GROUPED INTO GROUPS OF 4 AS SHOWN ON TABLE 6-8
2. NO P.H.A. DATA READOUT.
3. AT LECP BIT RATE OF 600 B.P.S., THE SEQUENCE LASTS 12 SECONDS (20 MINOR FRAMES).

MF (ODD NUMBERED)

T = 0 1	1	2	3	4	5	6	1	2	3
3	1	2	3	4	5	6	1	2	3
5	1	2	3	4	5	6	1	2	3
7	1	2	3	4	5	6	1	2	3
9	1	2	3	4	5	6	1	2	3
11	1	2	3	4	5	6	1	2	3
13	1	2	3	4	5	6	1	2	3
15	1	2	3	4	5	6	1	2	3
17	1	2	3	4	5	6	1	2	3
19	18	18	18	18	18	18	18	18	18

MF (EVEN NUMBERED) T = 1.2s

2	4	7	9	1	2	3	4	15	17
4	4	7	9	1	2	3	4	15	17
6	4	7	9	1	2	3	4	15	17
8	4	7	9	1	2	3	4	15	17
10	4	7	9	1	2	3	4	15	17
12	4	7	9	1	2	3	4	15	17
14	4	7	9	1	2	3	4	15	17
16	4	7	9	1	2	3	4	15	17
18	4	7	9	1	2	3	4	15	17
20	18	18	18	18	18	18	18	18	18

T = 12s

Table 6-8. Near Encounter Mode Group Arrangement (Rate Channels in Group) (sheet 1 of 3)

RATE GROUP					
1	$P\alpha_1$	$P\alpha_2$	$P\alpha_3$	$E\beta_4$	
2	$E\beta_1$	$E\beta_2$	$E\beta_3$	$E\gamma_6$	
3	$P\delta_9$ △1	$P\delta_{10}$ △1	$P\delta_{11}$ △1	$A\delta_3$ △1	
4	$E\gamma_7$	$E\gamma_8$	$E\gamma_9$	$E\beta_5$	
5	PSA_3 △1	PSB_3 △1	PAB_{12} △1	PAB_{13} △1	
6	$P\alpha_4$	$P\alpha_8$	$E\delta A0$ △1	$E\delta B0$ △1	
7	PSA_1 △1	PSB_1 △1	PSA_2 △1	PSB_2 △1	
9	EAB_{10} △1	$P\alpha_5$	$P\alpha_6$	$P\alpha_7$	
15	$A\alpha_1$	$A\alpha_2$	$Z\alpha_1$ △1	$A\delta_4$	
17	1β	1α	S_5, S_1, S_6, S_2	S_5, S_3, S_6, S_4	△2

SEE NOTE △3

* Table 6-8. Near Encounter Mode Group Arrangement (Rate Channels in Group) (sheet 2 of 3)

Notes

(1) Rate accumulators shared with cruise mode rates.

* (2) Status words in group 17 are subcommutated as follows:

During the first 12 s period (the first time through Table 6-7 starting at t = 0) all group 17 words will be:

I_β, I_α, S_5, S_5.

During the second 12 s period all group 17 words will be:

I_β, I_α, S_1, S_3.

During the third 12 s period all group 17 words will be:

I_β, I_α, S_6, S_6.

During the fourth 12 s period all group 17 words will be:

I_β, I_α, S_2, S_4.

At the end of the 48 s period the sequence will repeat.

All status words are contained in Rate Group 17. They are multiplexed by the internal frame counter such that the same two status words appear each time Rate Group 17 is addressed within one 12 s block (20 minor frames). When Rate Group 17 is addressed in the next 12 s block, the next two status words appear. Again, they repeat throughout the entire block. Four complete 12 s blocks are required to cover all six status words. The leakage currents I_α and I_β occur each and every time that Rate Group 17 is addressed.

* (3) When Rate Group 18 is addressed, a single rate group is repeatedly read out for 1.2 s (2 minor frames). Which rate group is being read out is indicated by frame counter bits 1 through 4 (refer to LECP Status Word 5, bits 5-8).

* Table 6-8. Near Encounter Mode Group Arrangement (Rate Channels in Group) (sheet 3 of 3)

Notes (contd)

The frame counter bits indicate which group is being read out as follows:

bits 1	2	3	4		Rate Group
0	0	0	0	=	1
0	0	0	1	=	2
0	0	1	0	=	3
0	0	1	1	=	4
0	1	0	0	=	5
0	1	0	1	=	6
0	1	1	0	=	7
0	1	1	1	=	15
1	0	0	0	=	9

System logic causes Rate Group 15 to be read out before Rate Group 9. Rate Group 17 (status words) does not appear in the Rate Group 18 rotation.

* 6.1.2.6 MAG Data (Bits 497-946). MAG data is contained within a 450-bit field in the GS-3 MF. The basic MAG sequence takes 4.8 s which is the time between reset signals sent to MAG. During this time the FDS acquires and processes data as follows:

a) FDS sends Reset to MAG. This clears the data readout buffer and loads two status words into the status register.

b) FDS sends Sample command to MAG.

c) MAG loads its 144 bit data readout buffer with twelve 12-bit words. These words are for the functions of inboard LFM (IB LFM), inboard HFM (IB HFM), outboard LFM (OB LFM), and outboard HFM (OB HFM) in that order. Each of these functions fill a 36-bit field. The 36-bit fields each contain three 12-bit words for each of the three axes. Detailed description of MAG data is shown in Table 6-9.

d) FDS reads in data in this order: Prime LFM X, Y, Z; Secondary LFM X, Y, Z; OB HFM X, Y, Z; IB HFM X, Y, Z.

e) FDS performs the following processing:

1) Prime LFM. FDS subtracts the previous LFM X, Y, Z samples from the present LFM X, Y, Z samples respectively, i.e., Xnew -Xold, Ynew -Yold, Znew -Zold. This results in three 12-bit differences of which the FDS saves the 6 LSBs from each for output (all differences in 2's complement). Every 5th X, Y, Z sample is saved and outputted as a reference sample.

2) Secondary LFM. FDS adds the previous LFM X, Y, Z samples to the present LFM X, Y, Z samples respectively and averages each sum, i.e.,

$$\frac{Xnew\ +Xold}{2},\ \frac{Ynew\ +Yold}{2},\ \frac{Znew\ +Zold}{2},$$

This results in three 12-bit averages which are differenced with the previous averages and the 6 bit difference is output. Every 5th X, Y, Z 12 bit average is saved for output as a reference average.

3) OB HFM. The X, Y, Z axis (three 12-bit words) are output every 600 ms in the same form as they are received from MAG.

4) IB HFM. Same as OB HFM except that every 4.8 s the last 2 of 3 (Y and Z axis) samples are replaced by two 12-bit status words.

*Table 6-9. MAG Data (sheet 1 of 3)

Bit No.	No. of Bits	Function
497-502	6	Prime LFM X Difference, i.e., data acquired at line 1 of 10 minus data acquired at the preceding line 10 of 10.
503-514	12	Prime LFM X Reference, i.e., data acquired at line 1 of 10.
515-520	6	Prime LFM Y Difference, i.e., data acquired at line 1 of 10 minus data acquired at the preceding line 10 of 10.
521-532	12	Prime LFM Y Reference, i.e., data acquired at line 1 of 10.
533-538	6	Prime LFM Z Difference, i.e., data acquired at line 1 of 10 minus data acquired at the preceding line 10 of 10.
539-550	12	Prime LFM Z Reference, i.e., data acquired at line 1 of 10.
551-586	36	OB HFM data acquired at line 1 of 10.
587-622 MF (1 + 8N)* Contain Status	36	For 7 of 8 general science frames, these bits are IB HFM data (X, Y, and Z) acquired at line 1 of 10 (except 1 of 80). For 1 of 8 general science frames, these bits are IB HFM X data (12 bits) and status data (24 bits) acquired at line 1 of 80. (Status replaces Y and Z.)
623-640	18	Prime LFM Difference, i.e., data acquired at line 2 of 10 minus data acquired at line 1 of 10.
641-646	6	Secondary LFM X Difference, i.e., average of data acquired at lines 1 and 2 of 10 minus average of data acquired at the preceding lines 9 and 10 of 10.

*Where N = 0, 9.

* Table 6-9. MAG Data (sheet 2 of 3)

Bit No.	No. of Bits	Function
647-658	12	Secondary LFM X **Reference,** i.e., average of data acquired at lines 1 and 2 of 10.
659-664	6	Secondary LFM Y **Difference,** i.e., averages of data acquired at lines 1 and 2 of 10 minus average of data acquired at the preceding lines 9 and 10 of 10.
665-676	12	Secondary LFM Y **Reference,** i.e., average of data acquired at lines 1 and 2 of 10.
677-682	6	Secondary LFM Z **Difference,** i.e., average of data acquired at lines 1 and 2 of 10 minus average of data acquired at the preceding lines 9 and 10 of 10.
683-694	12	Secondary LFM Z **Reference,** i.e., average of data acquired at lines 1 and 2 of 10.
695-712	18	Prime LFM **Difference,** i.e., data acquired at line 3 of 10 minus data acquired at line 2 of 10.
713-730	18	Prime LFM **Difference,** i.e., data acquired at line 4 of 10 minus data acquired at line 3 of 10.
731-748	18	Secondary LFM **Difference,** i.e., averages of data acquired at lines 3 and 4 of 10 minus averages of data acquired at lines 1 and 2 of 10.
749-766	18	Prime LFM **Difference,** i.e., data acquired at line 5 of 10 minus data acquired at line 4 of 10.
767-772	6	Prime LFM X **Difference,** i.e., data acquired at line 6 of 10 minus data acquired at line 5 of 10.
773-784	12	Prime LFM X **Reference,** i.e., data acquired at line 6 of 10.

* Table 6-9. MAG Data (sheet 3 of 3)

Bit No.	No. of Bits	Function
785-790	6	Prime LFM Y **Difference,** i.e., data acquired at line 6 of 10 minus data acquired at line 5 of 10.
791-802	12	Prime LFM Y **Reference,** i.e., data acquired at line 6 of 10.
803-808	6	Prime LFM Z **Difference,** i.e., data acquired at line 6 of 10 minus data acquired at line 5 of 10.
809-820	12	Prime LFM Z **Reference,** i.e., data acquired at line 6 of 10.
821-838	18	Secondary LFM **Difference,** i.e., averages of data acquired at lines 5 and 6 of 10 minus averages of data acquired at lines 3 and 4 of 10.
839-856	18	Prime LFM **Difference,** i.e., data acquired at line 7 of 10 minus data acquired at line 6 of 10.
857-874	18	Prime LFM **Difference,** i.e., data acquired at line 8 of 10 minus data acquired at line 7 of 10.
875-892	18	Secondary LFM **Difference,** i.e., averages of data acquired at lines 7 and 8 of 10 minus averages of data acquired at lines 5 and 6 of 10.
893-910	18	Prime LFM **Difference,** i.e., data acquired at line 9 of 10 minus data acquired at line 8 of 10.
911-928	18	Prime LFM **Difference,** i.e., data acquired at line 10 of 10 minus data acquired at line 9 of 10.
929-946	18	Secondary LFM **Difference,** i.e., averages of data acquired at lines 9 and 10 of 10 minus averages of data acquired at lines 7 and 8 of 10.

f) FDS outputs in each MF:

1)	Prime LFM.	30 6-bit differences 6 12-bit references
2)	Secondary LFM.	15 6-bit differences 3 12-bit reference averages
3)	OB HFM.	3 12 X, Y, Z words
4)	IB HFM.	3 12 X, Y, Z words except every 4.8 s (8 MFs) when Y and Z are replaced by two 12-bit status words.

The bit definitions for each MF are as shown in Table 6-9.

The MAG data sequence repeats every 4.8 s (every 8 GS-3 frames). Science data is sampled when MAG Sample is sent (every 60 ms starting 10 ms into the format interval). All LFM data are processed from every sample; however, only HFM data from the first MAG Sample of each format interval is processed. Status data is sampled when MAG Reset is sent (every 4.8 s, 7.5 ms into every 8th GS-3 frame starting with frame 1).

Examples using FDS Count in the GS-3 format and t_s = sample time are:

a) MAG Field Bits (add 496 to obtain GS-3 bit no.)

1-6	Six LSBs of LFM PRI x (t_s = FDS Count + 10 ms) minus LFM PRI x (t_s = FDS Count - 50 ms, i.e., previous sample).
133-138	Six LSBs of LFM PRI y (t_s = FDS Count + 70 ms) minus LFM PRI y(t_s = FDS Count + 10 ms).
145-150	Six LSBs of 1/2 [LFM s x (t_s = FDS Count +10 ms) + LFM s x (t_s = FDS Count +70 ms)] - 1/2 [LFM s x (t_s = FDS Count - 110 ms) + LFM s x (t_s = FDS Count -50 ms)].

b) MAG Status is sampled every 4.8 s (every 80 lines) when MAG Reset is received from FDS. The first status measurement of two 12-bit words is sampled at t = 0.0075 s (7.5 ms into line 1). These words are output in MF 1, bits 599-622. MF 9, bits 599-622, contain status sampled at t = 4.8075 s (7.5 ms into line 81). Bit assignments for MAG status are shown in Figures 6-26 and 6-27.

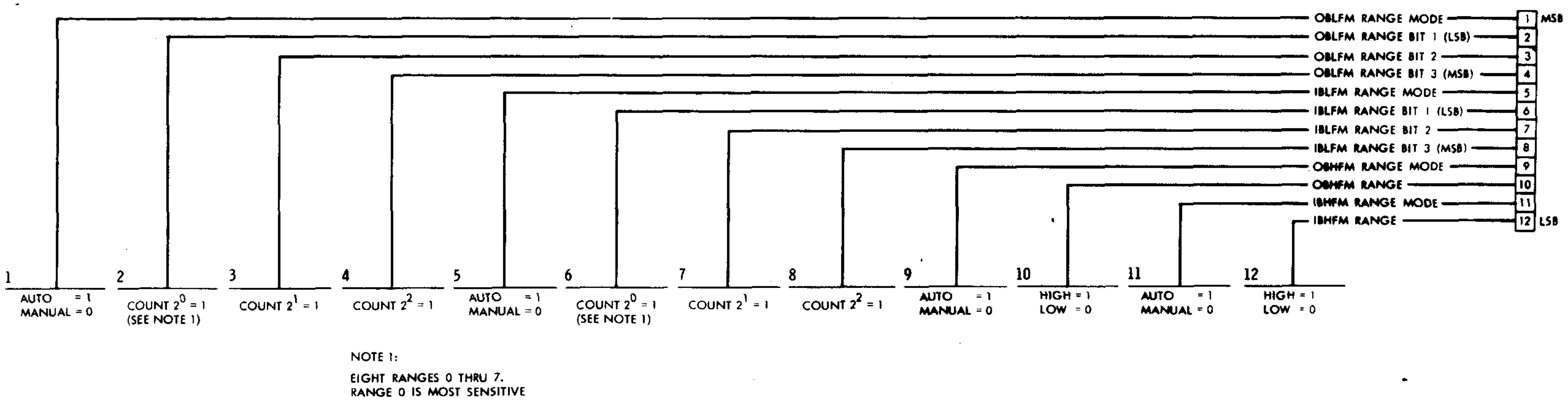


Figure 6-26. MAG Status Word 1

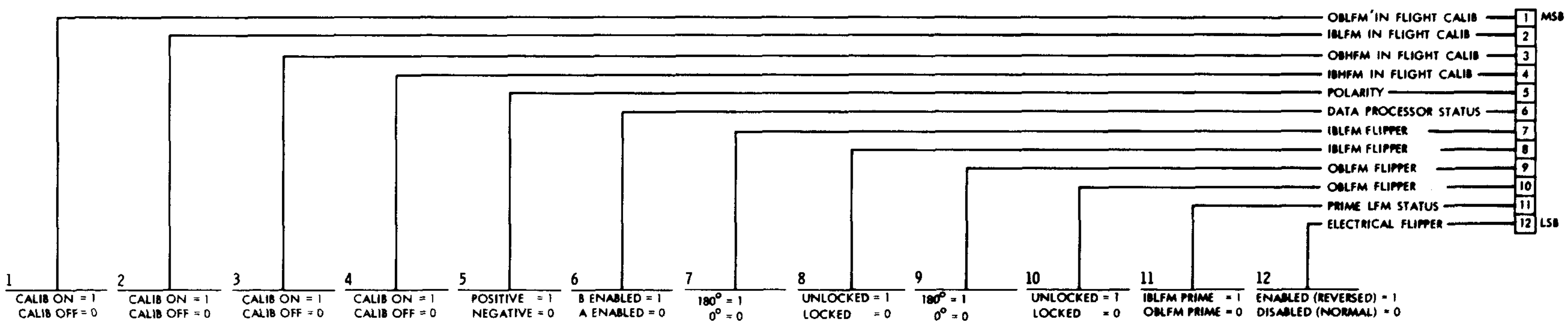


Figure 6-27. MAG Status Word 2

c) MAG Cmd Status (MF 32 of subcom status). Bits 65-80 show the command sent at t = 4.8025 s (2.5 ms into line 81). Bits 81-96 show the command sent at t = 4.805 s (5.0 ms into line 81).

6.1.2.7 Filler (Bits 947-948). Two filler bits are required to make the sum of MAG and CRS bit fields an integer multiple of 8 bits.

* 6.1.2.8 CRS Data (Bits 949-1104). CRS data is provided in a 156-bit field. The complete CRS data sequence is shown in Table 6-10. Two types of data are included in the format as follows:

PHA: PHA words are sampled in bursts of every 240 ms separated by 2.5 ms. The first word read out in MF 1 is sampled at t = 47.5 ms (47.5 ms into line 1). The output sequence repeats every 2 MFs.

RATE: Rate words are sampled every 200 ms. The first rate word is read out in MF 1 (bits 113-124) and is sampled at t = 62.5 ms (2.5 ms into line 2). Each MF contains three 12-bit Rate words. A complete rate sequence is 480 words and requires 96 s.

CRS status data is transmitted in the subcom status field. Status is sampled every 6 s starting at t = 0.015 s (15 ms into line 1). Status is output in MF 62 and MF 71. The first status word is read out as bits 65-72 of the MF 62 subcom status data. Bit assignments for CRS status data are as shown in Figures 6-3 through 6-18.

MF 62	Status sampled at:
Bits 65-76	15 ms into line 1
Bits 77-88	15 ms into line 101
Bits 89-100	15 ms into line 201
Bits 101-112	15 ms into line 301

MF 71	Status sampled at:
Bits 65-76	15 ms into line 401
Bits 77-88	15 ms into line 501
Bits 89-100	15 ms into line 601
Bits 101-112	15 ms into line 701

The CRS Command is transmitted in the 16 LSBs (bits 97-112) of MF 61 of the subcom status field.

Table 6-10. CRS Data

Time	GS-3 MF	MOD 60 Counter (n = 0-59)	Line Count	Function	No. of Bits
t=0	1	n (even values)	1	4 12-bit PHA words	48
				2 12-bit Rate words (1&2)	24
				4 12-bit PHA words	48
				1 12-bit Rate word (3)	12
				2 12-bit PHA words	24
					156
	2	n	11	2 12-bit PHA words	24
	.	.		1 12-bit Rate word (4)	12
	.	.		4 12-bit PHA words	48
	.	.		1 12-bit Rate word (5)	12
	.	.		4 12-bit PHA words	48
	.	.		1 12-bit Rate word (6)	12
		.			156
	79				
	80	n	791		
t=48s	1	n+1 (odd values)	1		
	.	.			
	.	.			
	.	.			
	.	.			
	80	n+1	791	2 12-bit PHA words	24
				1 12-bit Rate word (478)	12
				4 12-bit PHA words	48
				1 12-bit Rate word (479)	12
				4 12-bit PHA words	48
				1 12-bit Rate word (480)	12
					156

*6.1.2.9 PRA Data (Bits 1105-1264). PRA data is provided in a 160-bit field. The PRA scan is 6 s during which the FDS acquires two 8-bit status words and 198 8-bit data words. A mode sequence consists of 240 scans of 1440 s. Since the mode sequence requires more than 48 s, both MOD 60 Counter and Line Count must be used for decommutation. Each MF contains twenty 8-bit words. One mode sequence is as shown in Table 6-11.

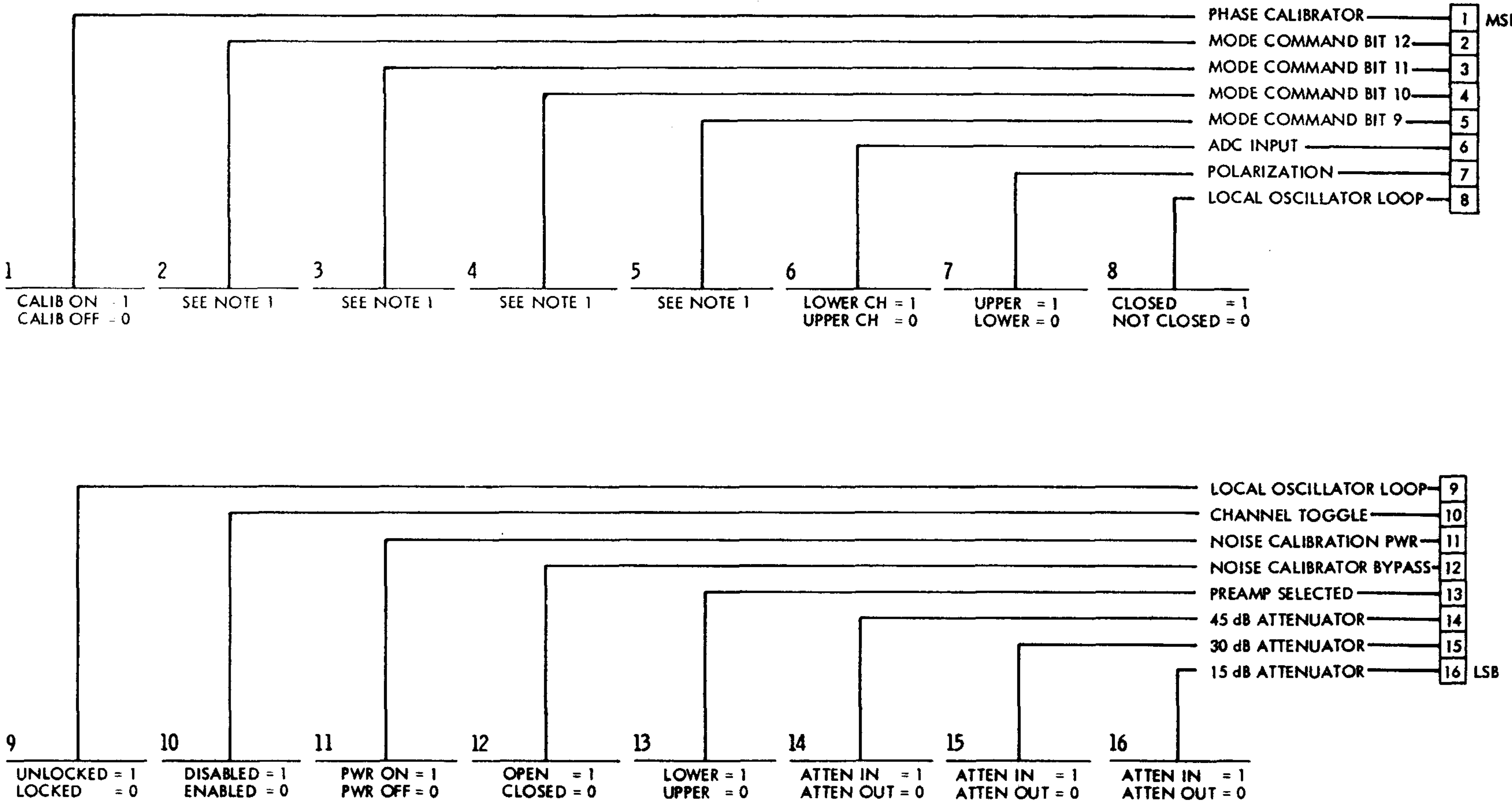
Table 6-11. PRA Data

GS-3 MF	MOD 60 Counter (n = 0-59)	S/C Time Line Count	Function	No. of Bits	Time Elapsed (s)
1	0	1	Two 8-bit status words	16	0.6
			18 8-bit POLLO words	144	
2	0	11	20 8-bit POLLO words	160	1.2
.			.		
.			.		
.			.		
10	0	91	20 8-bit POLLO words	160	6.0
.	.	.	.		
.	.	.	.		
.	.	.	.		
80	29	791	20 8-bit POLHI words	160	1440.0

Bit assignments for PRA status words are as shown on Figure 6-28.

In all PRA modes except POLHI, data are sampled every 30 ms. The first word output after the status is at FDS Count in GS-3 format plus 0.08756944 s (27.56944 ms into line 2 of 100). For POLHI the first word output is sampled at FDS Count in GS-3 format plus 0.05756944 s (57.56944 ms into line 1 of 100). Remaining are sampled every 69.44 ms thereafter.

PRA command status is transmitted in MF 42. The MS 16-bit word is 12-bit Mode Command sent to PRA at line 401 (5th PRA scan of a 48 s interval). The second MS 16-bit word is the 12-bit Configuration Command last sent to PRA as of the end of line 420.



NOTE 1:

BIT 2345		BIT 2345	
0000	POLLO, ALTERNATING POLARIZATION	1000	FIXLO, LOW BAND
0001	HARAD, ALTERNATING POLARIZATION	1001	FIXLO, HIGH BAND
0010	POLLO, DOES NOT ALTERNATE	1010	VLOBR, LOW BAND
0011	HARAD, DOES NOT ALTERNATE	1011	VLOBR, HIGH BAND
0100	LEVEL, ALTERNATING POLARIZATION, HARAD OFF	1100	POLHI, LOW BAND, ALTERNATING POLARIZATION
0101	LEVEL, ALTERNATING POLARIZATION, HARAD ON	1101	POLHI, HIGH BAND, ALTERNATING POLARIZATION
0110	LEVEL, DOES NOT ALTERNATE, HARAD OFF	1110	POLHI, LOW BAND, DOES NOT ALTERNATE
0111	LEVEL, DOES NOT ALTERNATE, HARAD ON	1111	POLHI, HIGH BAND, DOES NOT ALTERNATE

Figure 6-28. PRA Status Word

The mode Command is sent every 6 s starting at t = 0.0025 s (2.5 ms into line 1). One out of every eight Mode Commands is transmitted in the telemetry in MF 42. Configuration Command is sent only when a change has been made (FDS stored location updated by CCS or ground or when in Level) 20 ms after the command. The configuration command is also transmitted in MF 42.

* 6.1.2.10 MIRIS Data (Bits 1265-1936). MIRIS data is provided in a 672-bit field. The MIRIS Frame is 48 s long in Mode 1 (48 s interferogram) and 144 s long in Mode 2 (144 s interferogram) and begins 10 s after the beginning of a normal ISS Frame Start. Time t_o is the start of the 48 s period when SCT60 MOD 3 is zero. The contents of the MIRIS data field is shown in Table 6-12. Included in MFs 15 and 18 of this field is the MIRIS housekeeping (HK) data shown in Table 6-13 which includes, as word 17, the MIRIS Status Word shown in Figure 6-29. When SCT60 MOD 3=0, 8-bit MIRIS engineering data, consisting of RAD HI GAIN, RAD ANALOG, and NEON ANALOG, is output in MF 16 as shown in Table 6-14. During this period, the complete content of MF 16 is as shown in Figure 6-30.

* 6.1.2.11 PPS Data (Bits 1937-1960). PPS data is provided in a 24-bit field. The first 14 bits 4 bit exponent and 10 bit mantissa, are the log compressed value of a 20-bit word. The last 10 bits are status. Information contained in the PPS status word is shown on Figure 6-31.

For converting the received log compressed value to DN (A, B, DN expressed in decimal):

If A = 0, DN = B

If A ≠ 0, $DN = \left[2^{(A-1)}\right]\left[B+1024\right] + 1/2\left[2^{(A-1)}-1\right]$

The 80 sample PPS scan is controlled by a table stored in FDS. Sample 1, S_1, corresponds to the filter and analyzer wheel positions stored in location 1 of the 80 word mode table.

The table is first stepped through in the forward direction giving S_1, S_2, ... S_{39} and S_{40}. Then it is stepped through the reverse direction giving S_{40}, S_{39}, ... S_2 and S_1. These will be referred to as: S_{1F}, S_{2F}, ... S_{39F}, S_{40F}, S_{40R}, S_{39R}, ... S_{2R}, S_{1R}. The complete sequence takes 48 s.

The beginning of line 1 is t_o. Samples are taken every 600 ms, starting with S_{1F} whose sample interval is 0.0675 s to 0.4675 s. The output format is as follows:

MF 1, LC 1 is S_{1R} of previous sequence N-1

MF 2, LC 11 is S_{1F} sequence N

. .

. .

. .

MF 40, LC 391 is S_{39F} sequence N

MF 41, LC 401 is S_{40F} sequence N

✱ Table 6-12. MIRIS Data

MF	Contents (672 Bits)
61	Interferogram 2024 - 2071
62	Interferogram 2072 - 2119
63	Interferogram 2120 - 2167
.	. . .
.	. . .
.	. . .
14	Interferogram 3653 - 3600
15	Interferogram 3601 - 3648, 18HK3, 18HK4, 19 Off-Time
16*	48 Off-Time*
17	32 Off-Time/16 Off-Time
18	5 Off-Time, 18HK1, 18HK2, Interferogram 1 - 7
19	Interferogram 8 - 55
.	. . .
.	. . .
.	. . .
59	Interferogram 1928 - 1975
60	Interferogram 1976 - 2023

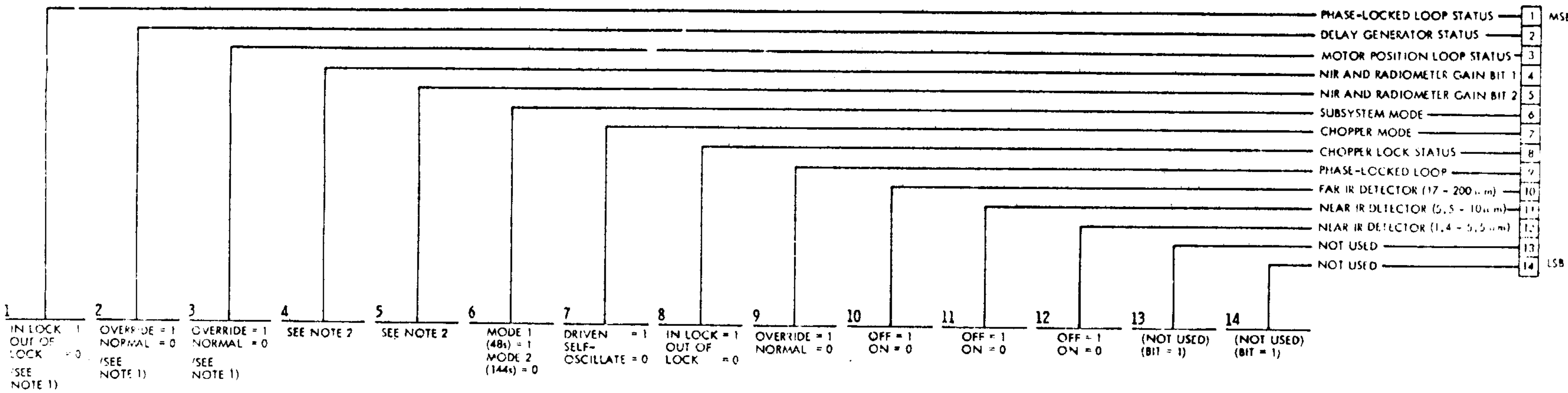
*See Table 6-14 for MIRIS data field contents when SCT60 MOD 3 = 0; see Figure 6-30 for complete MF16 data at this time

✱ Table new this issue (Amendment B, 8 April 1977)

Δ* Table 6-13. MIRIS Housekeeping Data

Word No.	Function	
1	Frame Sync	
2	Radiometer Data	Δ
3	Primary Mirror Temperature (Center)	
4	Far IR Temperature	Δ
5	Radiometer Detector Temperature	
6	Primary Mirror Temperature (Edge)	
7	Optics Housing Temperature	
8	Michelson Motor Temperature	
9	Interferometer Temperature	
10	Secondary Mirror Temperature	
11	Near IR Detector Temperature	
12	Electronics Temperature	
13	Positive Reference Volts	
14	Zero Reference Volts	Δ
15	Negative Reference Volts	
16	Thermistor Reference Voltage	Δ
17	Status Word	
18	Frame Sync	

* Table new this issue (Amendment B, 8 April 1977)



NOTE 1: IRIS STATUS WORD IS BITS 1, 2, AND 3 ONLY

NOTE 2:

BITS 4	BITS 5	GAIN
0	0	GAIN 1 (LOW DEFAULT)
0	1	GAIN 1 (LOW)
1	0	GAIN 2 (MEDIUM)
1	1	GAIN 3 (HIGH)

Δ

Δ ✻ Figure 6-29. MIRIS/IRIS Status Word (S-727)

✻ Figure new this issue (Amendment B, 8 April 1977)

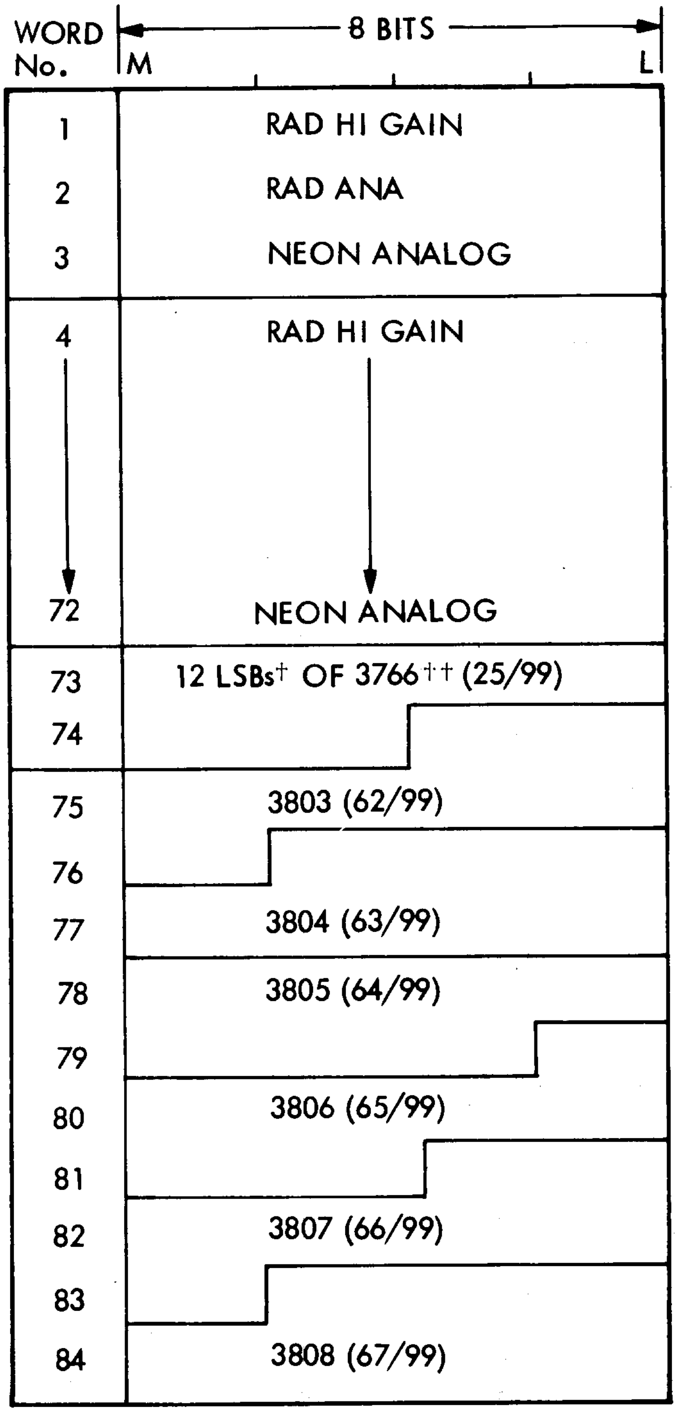
* Table 6-14. MIRIS Engineering Data

Data	Bits	Sample Time: SCT60 MOD 3	Sample Time: Line	Sample Time: t_o + (s)
RAD HI GAIN	1265 - 1272	0		13.000
RAD ANA	1273 - 1280	↓	217	13.0075
NEON ANALOG	1281 - 1288	↓		13.015
RAD HI GAIN	1289 - 1296	↓		19.000
RAD ANA	1297 - 1304	↓	317	19.0075
NEON ANALOG	1305 - 1312	↓		19.015
RAD HI GAIN	1313 - 1320	↓		25.00
RAD ANA	1321 - 1328	↓	417	25.0075
NEON ANALOG	1329 - 1336	↓		25.015
.	.	↓		31.000
.	.	↓	517	31.0075
.	.	↓		31.015
.	.	1		37.000
.	.	↓	617	37.0075
.	.	↓		37.015
.	.	↓	.	.
.	.	↓	.	.
.	.	↓	.	.

* Table new this issue (Amendment B, 8 April 1977)

* Table 6-14. MIRIS Engineering Data (contd)

Data	Bits	Sample Time		
		SCT60 MOD 3	Line	t_o + (s)
.	.	1		79.000
.	.	↓	517	79.0075
.	.			79.015
.	.	.		.
.	.	.		.
.	.	.		.
RAD HI GAIN	1817 - 1824			151.000
RAD ANA	1825 - 1832	0	117	151.0075
NEON ANALOG	1833 - 1840			151.015

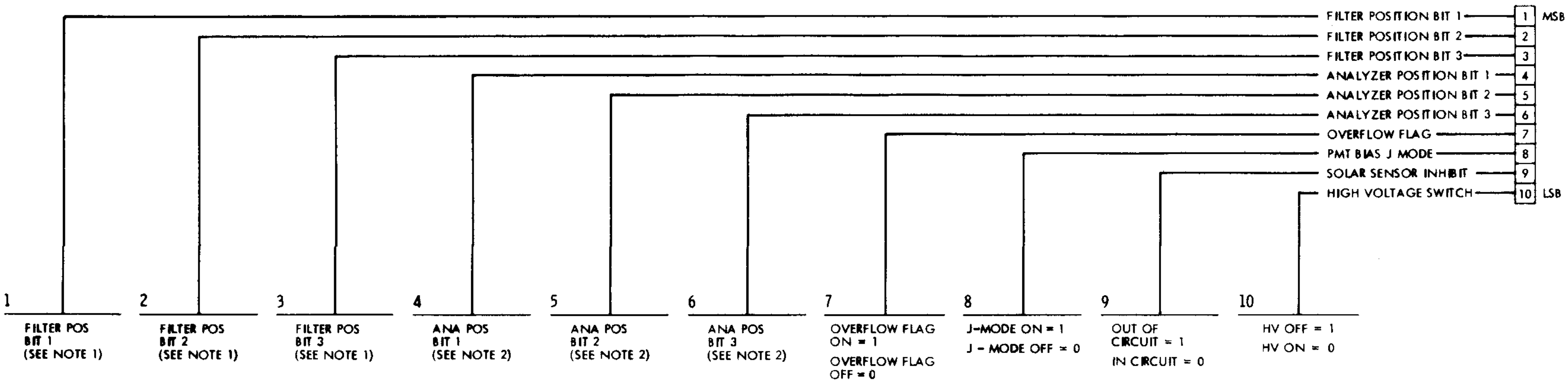


† Repeat of off-time data bits from previous frame used to make the length of the engineering data block equivalent to the off-time data block.

†† Entry indicates word number of 3840 words (with the number of 99 off-time words at end of MIRIS data)

* Figure 6-30. MF16 with MIRIS Engineering Data

* Figure new this issue (Amendment B, 8 April 1977)



NOTE 1 FILTER POSITION

BIT 1	BIT 2	BIT 3	FILTER
0	0	0	1
0	0	1	2
0	1	0	3
0	1	1	4
1	0	0	5
1	0	1	6
1	1	0	7
1	1	1	8

NOTE 2 ANALYZER POSITION

BIT 1	BIT 2	BIT 3	ANALYZER
0	0	0	1
0	0	1	2
0	1	0	3
0	1	1	4
1	0	0	5
1	0	1	6
1	1	0	7
1	1	1	8

Figure 6-31. PPS Status Word

MF 42, LC 411 is S_{40R} sequence N

. .

. .

. .

MF 79, LC 781 is S_{3R} sequence N

MF 80, LC 791 is S_{2R} sequence N

The PPS Command is in MF 31, LC = 301 (bits 97-112).

*6.1.2.12 UVS Data (Bits 1961-2160). A dual 64-word register accumulates counts from the 128 diode (D_1 - D_{128}) detector. The FDS samples these two registers by taking one 16-bit word from each register every 60 ms. The Register Load Gate performs this function. All 64 word pairs are read out every 3.84 s. In 96 s, the 64 word pair scan will be read out 25 times. Each 16-bit word is log-compressed to 10 bits by the FDS. The 10 bits comprise a 4-bit exponent "A", and a 6-bit mantissa "B".

For converting the received log compressed value to DN (A, B, DN expressed in decimal):

If A = 0, DN = B

If $A \neq 0$, $DN = 2^{(A-1)} (B+64) + 1/2 \; 2^{(A-1)} - 1$

The Word Address Reset (WAR) signal from the FDS synchronizes the sampling by setting the UVS word address counter to word pair 1 (samples D1 and D1). The WAR occurs twice in a 96 s cycle: at t = 5 ms (5 ms into MF1, MOD 60 = EVEN) and at t = 49.925 s (at the start of the 14th scan). The first word pair transferred to FDS is word pair in MF1 is word pair 64 (D_{127} and D_{128}) of the previous scan. Thus the first MF consists of twenty 10-bit words (200 bit field) as follows:

D_{127}, D_{128} (from previous scan), D1, D2, D3, ... D16, D17, D18.

Each MF contains ten pairs of 10-bit words or twenty 10-bit words total. The sequences repeat every 96 s and, being longer than 48 s, require both MOD 60 counter and line count for decommutation. UVS data format is shown in Table 6-15.

Table 6-15. UVS Data

MF	MOD 60 Counter (n = 0-59)	Line Count	Function	No. of Bits
1	n	1	Twenty 10-bit words ($D_{127}, D_{128}, D_1, D_2, \ldots D_{16}, D_{17}, D_{18}$)	200
2	n	11	Twenty 10-bit words ($D_{19}, D_{20}, D_{21}, \ldots D_{37}, D_{38}$)	200
. . .				
80	n+1	791	Twenty 10-bit words ($D_{107}, D_{108}, D_{109}, \ldots D_{124}, D_{125}, D_{126}$)	200
1	n+2	1	($D_{127}, D_{128}, D_1, D_2, \ldots D_{16}, D_{17}, D_{18}$)	200

The UVS Command is in MF 41, LC = 401 (bits 65-80). This word contains the status of the 4 bilevel command lines the FDS is sending to UVS as of t = 0.010 s (10 ms into line 1) when FDS updates these lines.

* 6.2 General Science and Engineering Format (GS-2)

The GS-2 format, shown in Figure 6-32, is used to acquire high rate PRA data. The data consists of 800 8-bit samples taken at 115.2 kbps. The PRA is operated in the POLHI mode when using this format.

6912 BITS

FSC	FORMAT ID	MOD 16 COUNTER	MOD 60 COUNTER	LINE COUNT	ISS STATUS/ ENGRG	GS&E (GS3)	PRA DATA 800 8-BIT WORDS
(32)	(8)	(8)	(6)	(10)	(16)	(432)	(6400)

60 ms

Figure 6-32. GS-2 Format

This format is identical to the IM-3 format (described in paragraph 7.1) with the following exceptions:

a) GS-2 format ID word is defined in Section 3.1.2 of this document.

b) Pixel data is replaced by 800 8-bit PRA data words.

c) Only the status part of the PRA data field in the imbedded GS-3 format is meaningful. It is updated every 6 s (normal rate). The remaining PRA bits represent a re-readout of the last scan prior to entering this mode.

PRA will operate the first 24 s (lines 1-400) using stored frequency F_1 and the last 24 s of each 48 s interval using frequency F_2. F_1 and F_2 are special frequencies stored for the GS-2 mode that are not used in other modes.

The intended operational use of the GS-2 and GS-4 formats is to alternate collection of PRA and PWS data for 48 s periods.

* 6.3 General Science and Engineering Format (GS-4)

The GS-4 format, shown in Figure 6-33, is used to acquire high rate PWS data. The data consists of 1600 4-bit samples taken at 115.2 kbps, and the format is identical to that of the IM-3 format (described in paragraph 7.1) with the following exceptions:

a) GS-4 format ID word is defined in Section 3.1.2 of this document.

b) Pixel data is replaced by 1600 4-bit PWS ADC data words. PWS data in the GS-3 imbedded format is not changed.

The intended operational use of the GS-4 and GS-2 formats is to alternate collection of PRA and PWS data for 48 s periods.

6912 BITS

FSC	FORMAT ID	MOD 16 COUNTER	MOD 60 COUNTER	LINE COUNT	ISS STATUS/ ENGR	GS&E (GS3)	PWS DATA 1600 4-BIT WORDS
(32)	(8)	(8)	(6)	(10)	(16)	(432)	(6400)

60 ms

✱ Figure 6-33. GS-4 Format

✱ 6.4 Special Occultation Format (OC-1)

The OC-1 format is used during solar and stellar occultation periods to acquire general science and engineering data. To provide the higher data rates required by the PPS and UVS in this format, the data is not Golay coded and the MIRIS allocation is reduced. The data is routed to the MDS and DSS for optional recording.

✱ 6.4.1 Data Content

The OC-1 format includes measurements for the following instruments:

CRS	PWS	UVS	MIRIS	PLS
PRA	LECP	MAG	PPS	

This format also contains S/C engineering data and S/C time.

6.4.2 OC-1 Frame Structure

Figure 6-34 shows one minor frame (MF) of OC-1 data. As indicated one MF is a time period of 0.6 s with a frame length of 4320 bits. This information is transmitted at a data rate of 7200 bps. One MF covers 10 ISS lines. Since there are 800 ISS lines per picture (48 s), there are 80 OC-1 MFs per 48 seconds.

6.4.2.1 Frame Synchronization and Time (Bits 1-32, 41-64). Format and time identification are described in Section 3 of this document.

6.4.2.2 Format ID (Bits 33-40).

Format ID word for OC-1 is defined in Section 3.1.2 of this document.

✱ Figure new this issue (Amendment B, 8 April 1977)

4320 BITS

FSC	FORMAT ID	MOD 16 COUNTER	MOD 60 COUNTER	LINE COUNT	SUBCOM	ENGRG	LECP	MAG	FILLER	CRS	PRA	MIRIS	FILLER	PPS	UVS
(32)	(8)	(8)	(6)	(10)	(48)	(24)	(360)	(450)	(2)	(156)	(160)	(24)	(18)	(614)	(2400)

0.6 s
(10 ISS LINES)

* Figure 6-34. One Minor Frame of OC-1

6.4.2.3 GS-3 Data (Bits 65-1264). With the exception of format ID, the first 1264 bits of OC-1 are the same format as GS-3.

* 6.4.2.4 MIRIS Engineering Data (Bits 1265-1288). MIRIS engineering data is provided in a 24-bit field. This is used to transmit three 8-bit words, RAD HI GAIN, RAD ANALOG, and NEON ANALOG in that order. Sampling of these words is the same as for GS-3.

* 6.4.2.5 Filler (Bits 1289-1306). Eighteen filler bits are required to make the sum of MIRIS and PPS bit fields an integer multiple of 16 bits.

6.4.2.6 PPS Data (Bits 1307-1920). Every 10 ms the FDS will load a 30-bit sample from PPS. The first 20 bits are log compressed to 14 bits, a 4 bit exponent called A and a 10 bit mantissa called B. The last 10 bits of the 30-bit sample are status. This results in a complete sample being 24 bits. In each MF the FDS will output:

a) Bits 1307-1330. One complete 24-bit sample (each is a 4-bit exponent, 10-bit mantissa, 10-bit status).

b) Bits 1331-1920. Fifty-nine 10-bit log-compressed samples where each sample is comprised of the 3 LSBs of the exponent and the 7 MSBs of the mantissa.

For converting the received log compressed value to DN (A, B, DN expressed in decimal):

$$\text{If } A = 0,\ DN = B$$

$$\text{If } A \neq 0,\ DN = \left[2^{(A-1)}\right]\left[B+1024\right] + 1/2\left[2^{(A-1)} - 1\right].$$

* 6.4.2.7 UVS Data (Bits 1921-4320). Content of the UVS data is shown in Table 6-16. A dual 64-word register accumulates counts from the 128 diode (D_1 - D_{128}) detector, and the FDS samples these two registers by taking one 16-bit word each 5 ms. Each 16-bit word

* Table 6-16. UVS Data

MF	Line Count	Scan	Function	No. of Bits
1	1	1	240 10-bit words ($D_{125}, \ldots, D_{128}, D_1, D_2, \ldots, D_{128}, D_1, D_2, \ldots, D_{108}$)	2400
2	11	2	240 10-bit words ($D_{109}, D_{110}, \ldots, D_{128}, D_1, D_2, \ldots, D_{128}, D_1, \ldots, D_{92}$)	2400
.				
.				
.				
8	71	15	240 10-bit words ($D_{13}, D_{14}, \ldots, D_{128}, D_1, D_2, \ldots, D_{124}$)	2400

is log-compressed to 10 bits by the FDS. The 10 bits comprise a 4-bit exponent, A, and a 6-bit mantissa, B. Each MF contains 120 pairs of 10-bit words, or nearly two full UVS scans. The sequence repeats itself in time every 4.8 s (8 MFs or 15 scans).

The Word Address Reset (WAR) signal from the FDS synchronizes the sampling by setting the UVS word address counter to word pair 1 (samples D1 and D2). Since the first sample occurs at t = 2.5 ms and the first Word Address Reset occurs at t = 5.0 ms, D1 and D2 are the second pair of words read out of the UVS. Due to a throughput delay in the FDS, the first two words read out in MF1 are D_{125} and D_{126} of the previous scan. Time reference t = 0 is LC = 1 and MOD 60 = even.

For converting the received log compressed value to DN (A, B, DN expressed in decimal):

If A = 0, DN = B

If $A \neq 0$, $DN = \left[2^{(A-1)}\right] (B+64) + 1/2 \left[2^{(A-1)} - 1\right]$.

7.0 ENCOUNTER IMAGING DATA FORMATS

7.1 Imaging Mode 3 (IM-3)

The IM-3 format is used for the real-time transmission and recording (optional) of full resolution imaging data with a frame time of 48 s. Five types of camera operation are possible:

1) Alternating camera

2) NA only

3) WA only

4) Simultaneous exposure

5) Long exposure.

7.1.1 Data Content

The IM-3 format includes imaging science data as well as imbedded GS&E data using the GS-3 format.

7.1.2 IM-3 Frame Structure

Figure 7-1 shows one minor frame (MF) of IM-3 data. As indicated one MF comprises a time period of 60 ms with a frame length of 6912 bits corresponding to a data rate of 115.2 kbps. The following sections describe each field of the IM-3 frame.

6912 BITS

FSC	FORMAT ID	MOD 16 COUNTER	MOD 60 COUNTER	LINE COUNT	ISS STATUS/ ENGRG	GS&E (GS3)	ISS PIXEL DATA 800, 8-BIT PIXELS
(32)	(8)	(8)	(6)	(10)	(16)	(432)	(6400)

60 ms

Figure 7-1. One Minor Frame of IM-3

7.1.3 Frame Synchronization and Time (Bits 1-32, 41-64)

Frame and time identification are described in Section 3 of this document.

7.1.4 Format ID Word (Bits 33-40)

Format ID word for IM-3 is defined in Section 3.1.2 of this document.

7.1.5 ISS Status/Engineering Data (Bits 65-80)

ISS status and engineering data is provided in a 16-bit field as shown in Table 7-1. This field is time shared to transmit 20 different fields as shown in the table. Line count one and subcom position one is the start of the subcommand sequence. The sequence will repeat 40 times before line count returns to one. This field will be modified to include which type of camera operation is being performed as well as whether actual video data or filler is being transmitted. These data are the same as the first 20 words of the GS-3 subcom.

7.1.6 General Science and Engineering (Bits 81-512)

The GS-3 frame of data is multiplexed into the IM-3 frame in this field. This is accomplished in ten lines as shown in Table 7-2. Note that five of these 432-bit fields contain parts of the GS-3 frame while the other five contain Golay code bits. The imbedded GS-3 time relationship to IM-3 MF time is -10 line counts.

7.1.7 Pixel Data (Bits 513-6912)

This is a 6400-bit field used to transmit 800 8-bit pixels. Depending on the type of camera operation involved, consecutive 48 s MF's may, or may not, contain actual video data.

7.2 Imaging Mode 2 (IM-2)

The IM-2 format is used to record full resolution imaging data with a frame time of 48 s (using the IM-3 format) while simultaneously transmitting the GS-3 format in real time. Five types of camera operation are possible as in IM-3. Data format is identical to IM-3 except for Format ID. Format ID for IM-2 is defined in Section 3.1.2 of this document.

7.3 Imaging Mode 4 (IM-4)

IM-4 is a 3/4 edited version of IM-3. The data rate for this format is 89.6 kbps and it is intended to be used when the telecommunication link capability will not support real time imaging data transmission at a higher rate. This format is identical to IM-3 except for a smaller pixel field, specifically:

a) Format ID for IM-4 is defined in Section 3.1.2 of this document. This is the only exception in the first 512 bits of the format including the imbedded GS-3 data.

Table 7-1. ISS Status/Engineering Data (sheet 1 of 3)

Line Count	Bit No.	Function
1	65	Camera ID: "0" = WA, "1" = NA
	66-80	Shuttered Picture Indicator: All ones indicate shuttered picture. All zeros indicate no shuttering
2	65-80	Slow Scan Status
3	65-69	Spare (bits = "0")
	70	NA Electronics Cal Status: "1" = ON, "0" = OFF
	71	WA Electronics Cal Status: "1" = ON, "0" = OFF
	72-76	Actual Exposure Time: This word identifies the number that corresponds to an exposure time and the camera used during the prepare cycle. Bit 8 is MSB. This word does not indicate long exposures. WA Camera: "0" } from bit 65 NA Camera: "1" } from bit 65
	77-80	Actual Filter Position: This word indicates the filter wheel position for the picture being read out. Bits 13-15 are the 3-bit filter position number and bit 16 is odd parity bit.

Position	Bits 77	78	79	80
1	0	0	1	0
2	0	1	0	0
3	0	1	1	1
4	1	0	0	0
5	1	0	1	1
6	1	1	0	1
7	1	1	1	0
8	0	0	0	1

*Table 7-1. ISS Status/Engineering Data (sheet 2 of 3)

Line Count	Bit No.	Function
4	65-80	Picture Count: This word is incremented once for each shuttered picture and is reset by command frame CCS
5	65-80	Parameter Word A: Present value used in current ISS frame
6	65-68	Spare (bits = "0")
	68-80	Parameter A Indicator Bits: Indicator bits used in current ISS frame
7	65-66	Spare (bits = "0")
	67-80	Parameter A Word Pointer: Address in FDS memory where next parameter A word pair is stored
8	65-80	Parameter Word B: Present value used in current ISS frame
9	65-66	Spare (bits = "0")
	67-80	Parameter Word B Pointer: Address in FDS memory where next parameter B word pair is stored
10	65-80	Parameter Word C: Present value used in current ISS frame
11	65-66	Spare (bits = "0")
	66-80	Parameter Word C Pointer: Address in FDS memory where next parameter C word pair is stored
12	65-80	Parameter Word D: Present value used in current ISS frame.
13	65-68	Spare (bits = "0")
	69-80	Parameter D Indicator Bits: Indicator bits used in current ISS frame.
14	65-66	Spare (bits = "0")
	67-80	Parameter Word D Pointer: Address in FDS memory where the next parameter D word is stored
15	65-80	ISS Analog Engineering Telemetry
	65-72	First WA sample taken in previous ISS frame
	73-80	First NA sample taken in previous ISS frame
16	65-72	Second WA sample taken in previous ISS frame
	73-80	Second NA sample taken in previous ISS frame

* Table 7-1. ISS Status/Engineering Data (sheet 3 of 3)

Line Count	Bit No.	Function
17	65-72	Third WA sample taken in previous ISS frame
	73-80	Third NA sample taken in previous ISS frame
18	65-72	Fourth WA sample taken in previous ISS frame
	73-80	Fourth NA sample taken in previous ISS frame
19	65-72	Fifth WA sample taken in previous ISS frame
	73-80	Fifth NA sample taken in previous ISS frame
	65-67	Pixel Average Status: A "1" indicates more than the minimum number of pixels were used in the pixel average calculation and the exposure time can be modified based on this average if in the auto exposure mode. A "0" indicates less than the minimum was used ana the exposure time cannot be modified based on this average
	68-72	Pixel Average: Is based on a sum of the 5 MSBs of all pixels exceeding the programmed threshold of the camera read out in the previous ISS frame
	73-75	ISS G1 Voltage "000" = Least Negative G1 Voltage 100 010 110 001 101 011 "111" = Most Negative G1 Voltage
	76	ISS Gain Status ("0" = Low Gain, "1" = High Gain)
	77-80	FDS Destination Code 5 WA Camera 6 NA Camera

*Table 7-2. GS&E Data

	IM-3 Line Count	Contents
Sequence repeats every 10 lines	1	1st 432 bits of 2160 bit GS-3 MF.
	2	Golay code bits (432) for GS-3 bits output in line 1.
	3	2nd 432 bits of 2160 bit GS-3 MF.
	4	Golay code bits (432) for GS-3 bits output in line 3.
	5	3rd 432 bits of 2160 bit GS-3 MF.
	6	Golay code bits (432) for GS-3 bits output in line 5.
	7	4th 432 bits of 2160 bit GS-3 MF.
	8	Golay code bits (432) for GS-3 bits output in line 7.
	9	5th 432 bits of 2160 bit GS-3 minor frame.
	10	Golay code bits (432) for GS-3 bits output in line 9.

b) The frame length is 5376 bits.

c) The pixel field is 4864 bits (rather than 6400 bits as in IM-3). Eight-bit pixels 97 through 704 (the center 608) are output in every line.

The ISS frame time remains the same at 48 s.

7.4 Imaging Mode 5 (IM-5) 2:1 Slow Scan

IM-5 is used to transmit full resolution imaging data with a frame time of 96 s. The data rate for this format is 67.2 kbps. In this mode a line of ISS data (6400 bits or 800 8-bit pixels) is read into the FDS in one line time (60 ms) and read out in two line times. Four types of camera operation are possible: 1) alternating camera, 2) NA only, 3) WA only or, 4) simultaneous exposure. The format is identical to IM-3 except for the following:

a) Format ID for IM-5 is defined in Section 3.1.2 of this document.

b) ISS Status/Engr field will be modified to include which one-half of the picture is being read out, the type of camera operation involved, and whether actual video data or filler is being transmitted.

c) Except as noted in a) and b) the first 512 bits of the IM-5 format are identical to the first 512 bits of the IM-3 format.

d) The pixel field readout comprises 3520 bits and repeats every two increments of the line count field:

1) 8-bit pixels 1-440 of line N.

2) 8-bit pixels 441-800 of line N + 640 filler bits.

3) 8-bit pixels 1-440 of line N + 1.

4) Etc. . . .

7.5 Imaging Mode 6 (IM-6) 1/2 Edit

IM-6 is used to transmit a nearly 1/2 edited version of IM-3. The data rate for this format is 67.2 kbps. This format is identical to IM-3 except for the following:

a) Format ID for IM-6 is defined in Section 3.1.2 of this document.

b) The frame length is 4032 bits.

c) The pixel field is 3520 bits. Eight-bit pixels 181 through 620 (the center 440) are output every line.

The ISS frame time remains the same at 48 s.

7.6 Imaging Mode 7 (IM-7) 3:1 Slow Scan

IM-7 is used to transmit full resolution imaging data with a frame time of 144 s. The data rate for this format is 44.8 kbps. In this mode a line of ISS data (6400 bits or 800 8-bit pixels) is read into the FDS in one line time (60 ms) and read out in three line times. Four types of camera operation are possible: 1) alternating camera, 2) NA asymmetric, 3) WA asymmetric or, 4) asymmetric simultaneous exposure. The format is identical to IM-3 except for the following:

a) Format ID for IM-7 is defined in Section 3.1.2 of this document.

b) ISS Status/Engr field will be modified to include which one-third of the picture is being read out, the type of camera operation involved, and whether actual video data or filler is being transmitted.

c) Except as noted in a) and b), the first 512 bits of the IM-7 format are identical to the first 512 bits of the IM-3 format.

d) The pixel field readout comprises 2176 bits and repeats every three increments of the line count field:

   1) 8-bit pixels 1-272 of line N.

   2) 8-bit pixels 273-544 of line N.

   3) 8-bit pixels 545-800 of line N + 128 filler bits.

   4) 8-bit pixels 1-272 of line N + 1.

   5) Etc....

7.7 <u>Imaging Mode 8 (IM-8) 1/3 Edit</u>

IM-8 is used to transmit a 1/3 edited version of IM-3. The data rate for this format is 44.8 kbps. This format is identical to IM-3 except for the following:

a) Format ID for IM-8 is defined in Section 3.1.2 of this document. This is the only exception in the first 512 bits of the format including the imbedded GS-3 data.

b) The frame length is 2688 bits.

c) The pixel field is 2176 bits. Eight-bit pixels 265 through 536 (the center 272, or approximately the center 1/3) are output in every line.

The ISS frame time remains the same at 48 s.

7.8 <u>Imaging Mode 9 (IM-9) 3:1 Slow Scan Edited to 29.9 kbps</u>

(To be supplied when developed.)

7.9 Imaging Mode 10 (IM-10) 1/5 Edit

(To be supplied when developed.)

7.10 Imaging Mode 11 (IM-11) 5:1 Slow Scan

(To be supplied when developed.)

7.11 Imaging Mode 12 (IM-12) 5:1 Slow Scan, 1/2 Edit

(To be supplied when developed.)

7.12 Imaging Mode 13 (IM-13) 10:1 Slow Scan

(To be supplied when developed.)

7.13 Imaging Mode 14 (IM-14) 1/10 Edit

(To be supplied when developed.)

8.0 PLAYBACK FORMATS

There are three playback formats each of which allows playback of the tape recorder with simultaneous transmission of the GS-3 format (PB-1, 2, and 3). There are also two additional formats, PB-4 and 5, which the Project has chosen not to develop at this time.

8.1 Playback Mode 1 (PB-1)

The PB-1 format includes imbedded GS-3 data and 57.6 kbps of DSS playback data as shown in Figure 8-1. The data rate for this format is 67.2 kbps.

4032 BITS

FSC	FORMAT ID	MOD 16 COUNTER	MOD 60 COUNTER	LINE COUNT	GS&E (GS3)	PLAYBACK DATA	FILLER
(32)	(8)	(8)	(6)	(10)	(432)	(3456)	(80)

60 ms

Figure 8-1. PB-1 Format

This format is identical to IM-3 with the following exceptions:

a) Format ID for PB-1 is defined in Section 3.1.2 of this document.

b) Frame length is 4032 bits.

c) The imbedded GS-3 data field (432 bits) immediately follows the 64-bit header field. As a consequence, 16 must be subtracted from all bit designations (greater than 64) described for the IM-3 format to obtain the playback mode bit designations.

d) 3456 bits of playback data immediately follow the imbedded GS-3 field. This serial data from the tape recorder. It is not synchronized in any way with the playback lines.

e) The last 80 bits of the frame are filler which are necessary because data rates that exactly match are not available.

8.2 Playback Mode 2 (PB-2)

The PB-2 format includes imbedded GS-3 data, 33.6 kbps of DSS playback data, and required filler bits as shown in Figure 8-2. The data rate for this format is 44.8 kbps.

2688 BITS

FSC	FORMAT ID	MOD 16 COUNTER	MOD 60 COUNTER	LINE COUNT	GS&E (GS3)	PLAYBACK DATA	FILLER
(32)	(8)	(8)	(6)	(10)	(432)	(2016)	(176)

60 ms

*Figure 8-2. PB-2 Format

This format is identical to IM-3 with the following exceptions:

a) Format ID for PB-2 is defined in Section 3.1.2 of this document.

b) Frame length is 2688 bits.

c) The imbedded GS-3 data field (432 bits) immediately follows the 64-bit header field. As a consequence, 16 must be subtracted from all bit designations (greater than 64) described for the IM-3 format to obtain the playback mode bit designations.

d) 2016 bits of playback data immediately follow the imbedded GS-3 field. This is serial data from the tape recorder. It contains whatever was on the recorder. It is not synchronized in any way with the playback lines.

e) The last 176 bits of the frame are filler which are necessary because data rates that exactly match are not available.

* 8.3 Playback Mode 3 (PB-3)

The PB-3 format includes imbedded GS-3 data and 21.6 kbps of DSS playback data as shown in Figure 8-3. The data rate for this format is 29,866-2/3 bps.

1792 BITS

FSC	FORMAT ID	MOD 16 COUNTER	MOD 60 COUNTER	LINE COUNT	GS&E (GS3)	PLAYBACK DATA
(32)	(8)	(8)	(6)	(10)	(432)	(1296)

60 ms

Figure 8-3. PB-3 Format

This format is identical to IM-3 with the following exceptions:

a) Format ID for PB-3 is defined in Section 3.1.2 of this document.

b) Frame length is 1792 bits.

c) The imbedded GS-3 data field (432 bits) immediately follows the 64-bit header field. As a consequence, 16 must be subtracted from all bit designations (greater than 64) described for the IM-3 format to obtain the playback mode bit designations.

d) 1296 bits of playback data immediately follow the imbedded GS-3 field. This is serial data from the tape recorder. It contains whatever was on the recorder. It is not synchronized in any way with the playback lines.

* 8.4 Playback Mode 4 (PB-4)

PB-4 allows for uninterrupted tape recorder playback at 21.6 kbps. The transmission format is that which was recorded. At the present time, the Project has no plans to develop this format.

* 8.5 Playback Mode 5 (PB-5)

PB-5 allows for uninterrupted tape recorder playback at 7.2 kbps. The transmission format is that which was recorded. At the present time, the Project has no plans to develop this format.

REVISION PAGE

Revision	Date	ECRs Incorporated	Comments
Original	3 Sept 1975		
A	18 Feb 1976	36069 36097 36134 36172	Accommodate additional temperature measurements Change MAG multiplexer sequence General update of document Implement single processor select bit
Amend 1	26 July 1976	36267, 36292, 36314	Update per ECRs listed
B	8 April 1977	36146, 36326, 36353, 36354, 36360, 36420, 36431, 36452, 36457, 36467, 36497, 36501, 36504, 36551, 36574, 36582, 36597, 36603, 36604, 36607, *36620, 36653,* 36664, 36707,* 36709, 36710,* *36742, 36753, 36764, 36804 *	Revise document per ECRs listed * Released Waiver 40876 allows release of this FR update prior to approval of six ECR's noted. RFD/NEW
Amend 2	26 August 1977	36721, 36757, 36772, 36773, 36800, 36833, 36856, 36858, 36877*, 36887, 36898, 36917	Update per ECRs listed. The following unapproved ECRs incorporated in Revision B have now been approved: 36620, 36653 36710, 36742 36804 * Released Waiver 40951 allows release of this FR update prior to approval of the ECR noted.

FUNCTIONAL REQUIREMENT AMENDMENT

(Insert in 618 -205, MJS77 Functional Requirements Book)

TITLE:

FUNCTIONAL REQUIREMENT
MARINER JUPITER/SATURN 1977
FLIGHT EQUIPMENT
COMMAND STRUCTURE AND ASSIGNMENTS

FR No. MJS77-3-290C

AMENDMENT No. 2

PAGE 1 **OF** 1

DATE: 14 February 1979

PER ECR No. N/A

DESCRIPTION OF CHANGE:

A. This document has been removed from control and placed in a non-maintenance category.

B. Changes authorized by the following ECRs will not be incorporated into this document:

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3 March 1977

FUNCTIONAL REQUIREMENT
MARINER JUPITER/SATURN 1977 FLIGHT EQUIPMENT
COMMAND STRUCTURE AND ASSIGNMENTS

Bar (▌) on the right margin identifies the changes from previous issue. Triangle (Δ) preceding the table captions designates as completely revised or new in its entirety.

CONTENTS

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TABLES

ILLUSTRATIONS

1.0 SCOPE

This document establishes the command structure, assigns commands and their identifiers, and establishes the coding necessary to send commands.

2.0 APPLICABLE DOCUMENTS

The following documents form a part of this Functional Requirement:

NOTE

MJS77-3-100A, Spacecraft Requirements and Constraints, applies to this document. Requirements of other MJS77 level 3 documents may also be applicable. It is the responsibility of the user to adequately acquaint himself with the organization and pertinent content of the level 3 documents, as well as with the material contained herein.

REQUIREMENTS

Jet Propulsion Laboratory

MJS77-1-100A	Functional Requirement Book, Mariner Jupiter/Saturn 1977, Introduction
MJS77-3-100A	Functional Requirement, Mariner Jupiter/Saturn 1977 Spacecraft Requirements and Constraints
MJS77-3-270	Functional Requirement, Mariner Jupiter/Saturn 1977 Telemetry and and Command Handling

3.0 COMMAND STRUCTURE AND ASSIGNMENTS

3.1 General

MJS77-3-270, Telemetry and Command Handling, establishes command philosophy, command requirements and constraints, and describes the command types necessary to carry out flight sequences and to counter unexpected events.

3.2 Command List

Tables 1 through 6 of this document tabulate the command structure and bit patterns as received by the CCS. Table 7 tabulates subsystem to subsystem command structure and bit patterns.

Operator words for the various command types are given in Table 1. All discrete commands (DC) and coded commands (CC) are delineated in Table 2. The required DC accumulator words are provided in Table 3 with the required CC accumulator words provided in Table 4. Table 5 contains the CC accumulator words for power switching. This table also delineates the commands for attitude and articulation control subsystem (AACS) power switching.

Table 2 delineates the attitude control (AC) commands. Table 6 tabulates the command structure for these words.

Science command words as received by the CCS, are delineated in Table 2. The command structure for these words is tabulated in Table 7. The flight data subsystem (FDS) to science subsystems commands are delineated in Table 7.

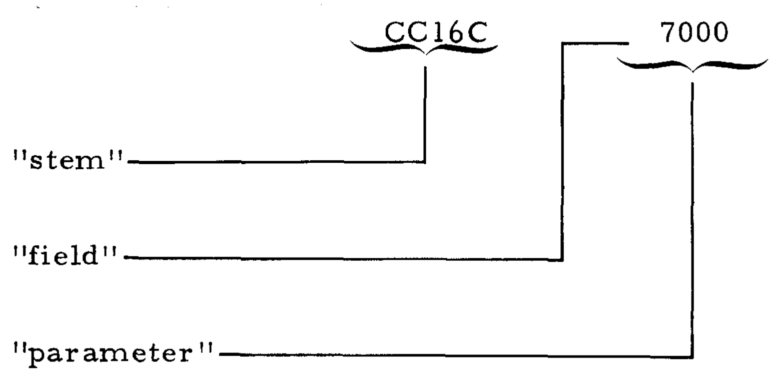
3.3 Command Mnemonic Guidelines

To ensure compatibility with flight, ground, and test software, the following guidelines shall be used to establish command mnemonics.

3.3.1 General Command Mnemonic Guidelines

The following guidelines shall be used for all commands:

a) The general command form is shown in the following example, with the parts of the mnemonic identified:



b) The stem shall consist of a maximum of six characters including the CC, DC, science commands (SC), science table commands (ST), AC, or processor commands (PC) command type designation. The only exception allowed is power switching commands to the power subsystem.

c) The decimal value of a parameter shall not exceed $2^{18} - 1 = 262,143$ or $\pm 2^{17} - 1 = \pm 131,071$ for parameters that have signs associated with them.

d) The maximum decimal value for a field shall be $2^{12} - 1 = 4095$ or $\pm 2^{11} - 1 = \pm 2047$ for fields with signs.

e) The maximum number of fields within a parameter is six.

f) For commands with two or more characters in a field, lead zeros are required in fields with fewer than the highest number of significant characters.

g) All commands requiring more than one word are specified as ACs, SCs, or STs.

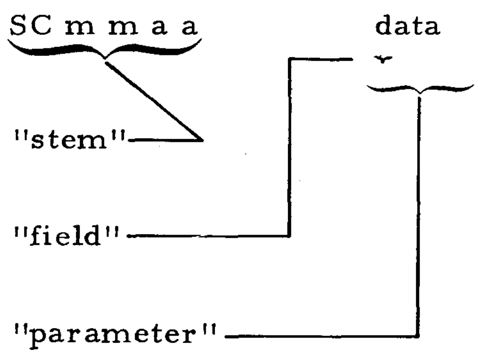
h) For operational purposes, all spare bits shall be zero.

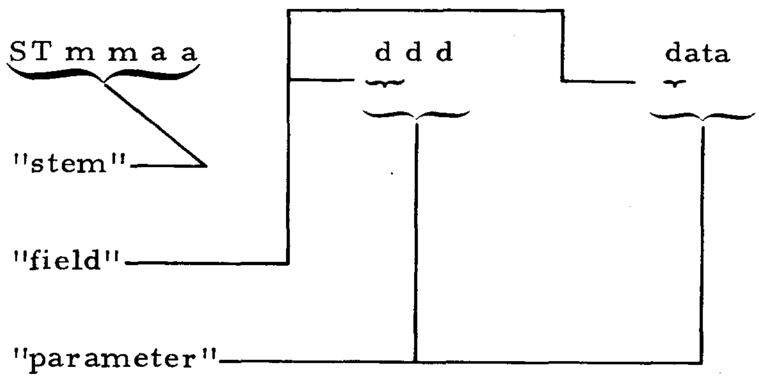
i) CMD IDs are fields which compose a single parameter in a CC. In Table 4 the CMD IDs are read from top to bottom.

3.3.2 Science Command Mnemonic Guidelines

The following guidelines shall be used for all SCs and STs:

a) The general form of SCs and STs shall be:





b) A SC implies a single word command.

c) A ST implies one element of a multi-element command table in the FDS memory.

d) "mm" is a two-character number identifying the science subsystem with which the command is associated.

e) "aa" are two alphabetic characters which complete the identification of the FDS address into which the data are to be loaded. If the first of these characters is A through M, the "data" parameter is decimal; if it is N through Z, the "data" parameter is hexadecimal. The second of the characters is merely a sequential listing of the several commands associated with a specific subsystem.

f) The "ddd" is a decimal number between 001 and 999 defining the element of a table into which the data are to be loaded.

g) The "data" parameters may be either decimal or hexadecimal, as specified by the first of the "aa" characters. If it is hexadecimal, four hexadecimal characters will define the 16 bits to be loaded into the specific FDS word, and this form is used for FDS functions and engineering identifier tables. If the "data" parameter is decimal, it will consist of up to six fields consisting of logical or functional groups of bits within the 16-bit FDS word.

h) Fields in the "data" parameter must appear in the same order in the SC or ST as they exist in the FDS word, reading from left to right.

i) The "data" parameter shall convert directly to the bit configuration of the FDS word with no lookup tables or special conversion algorithms.

3.3.3 AC Command Mnemonic Guidelines

a) The maximum number of characters in an AC, including stem, parameters, spaces, and delimiters, shall be 24.

b) The alphabetic characters following the subsystem number in the stem must be three characters in length; i.e., AC7XXX. Therefore, an AC command stem will always be six characters in length.

c) The first two alphabetic characters following the subsystem number in an AC shall be identical as the characters used in the associated control CC. For example, AC7CTG (CST gate control) is derived from CC7CT (CST control).

Table 1. CCS Operator Words

			GROUND CMD BIT NUMBER	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
			CCS BIT NUMBER	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
PC			STORE	1	MEM ADDRESS											0	1	1			
PC			TRANSFER	MEM ADDRESS												0	1	0			
PC			INTERNAL EXECUTE	OPERAND												1	0	0			
PC	BLOCK TYPE	0	COND. CCS EXECUTE	0	0	0	0	0	0	BLOCK SIZE						0	0	0			
PC	BLOCK TYPE	1	COND. EVENT EXEC	0	0	0	1														
PC	BLOCK TYPE	2/3	CCS LOAD	0	0	1	X														
PC	BLOCK TYPE	4/5	CCS LOAD	0	1	0	X														
PC	BLOCK TYPE	6	CCS EXECUTE	0	1	1	0														
PC	BLOCK TYPE	7	EVENT EXEC	0	1	1	1														
PC	BLOCK TYPE	8	AACS LOAD	1	0	0	0														
PC	BLOCK TYPE	11	FDS H/W LOAD	1	0	1	1														
PC	BLOCK TYPE	* 12	FCP/MEM LOAD	1	1	0	0														
PC	BLOCK TYPE	10/14	FDS PRI MEM LOAD	1	A	1	0														
PC	BLOCK TYPE	9/13	FDS SEC MEM LOAD	1	A	0	1														
PC			RETURN		MEM ADDRESS											1	0	1			
PC			STORE INDIRECT		MEM ADDRESS											1	1	0			
PC			EXECUTE		MEM ADDRESS											1	1	1			

A = 1 FOR MEM PROTECT OVERRIDE (bit 32)
X = DON'T CARE

MODIFIER (bits 33–42)

MODIFIER ID (bits 43–45)

PROCESSOR ID: 1 = PROCESSOR B (bit 46); 1 = PROCESSOR A (bit 47)

SPACECRAFT ID (bit 48): 1 = MJS77-2; 0 = MJS77-3

*NOTE: THIS BLOCK TYPE COMMAND SHALL ONLY BE USED PER SEQUENCE BLOCK (TBD)

Table 2. MJS77 Command List

NOTES:

1. The number associated with a command is the affected subsystem designator as specified in MJS77-1-100A, Introduction.

2. The letters and number following the designator differentiate between commands to a particular subsystem.

3. A command that is a complement of another is identified with the symbol R.

4. The suffix P or S in the command symbol represents primary or secondary power relays respectively.

Table 2. MJS77 Command List

Symbol	Command Type	Name	Destination	Comment
1C	CC	MAG CAL COIL ON	PWR	Switches 30 vdc power to magnetometer calibration coil
1CR	CC	MAG CAL COIL OFF	PWR	Removes 30 vdc power from magnetometer calibration coil
1D	CC	BAY 2 HTR ON	PWR	Switches 2.4 kHz power to bay 2 heater
1DR	CC	BAY 2 HTR OFF	PWR	Removes 2.4 kHz power from bay 2 heater
1PHP 1PHRP	CC CC	SCAN PLATFORM SUPPLEMENTAL HEATER ON	PWR	Switches 30 vdc power to scan platform supplemental heater
1PHS 1PHRS	CC CC	SCAN PLATFORM SUPPLEMENTAL HEATER OFF	PWR	Removes 30 vdc power from scan platform supplemental heater
1T	CC	BAY 1 HTR ON	PWR	Switches 2.4 kHz power to RFS bay 1 heater
1TR	CC	BAY 1 HTR OFF	PWR	Removes 2.4 kHz power from RFS bay 1 heater

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
2A	DC	S-BAND RANGING ON	RFS	Turns on S-Band ranging
2AR	DC	S-BAND RANGING OFF	RFS	Turns off S-Band ranging
2BP	CC	S-BAND EXCITER 1 SELECT	PWR	Selects S-Band exciter 1
2BRP	CC			
2BS	CC	S-BAND EXCITER 2 SELECT	PWR	Selects S-Band exciter 2
2BRS	CC			
2CP	CC	S-BAND TRANS-MITTER 1 SELECT	PWR	Selects S-Band Transmitter 1
2CRP	CC			
2CS	CC	S-BAND TRANS-MITTER 2 SELECT	PWR	Selects S-Band Transmitter 2
2CRS	CC			
2D	DC	S-BAND TRANS-MITTER HIGH-POWER	RFS	Selects high-power output mode
2DR	DC	S-BAND TRANS-MITTER LOW-POWER	RFS	Selects low-power output mode
2E	DC	HGA SELECT - S BAND	RFS	Selects the high-gain antenna for transmitting and receiving

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
2ER	DC	LGA SELECT - S BAND	RFS	Selects the low-gain antenna for transmitting and receiving
2FP	CC	RCVR 1 SELECT	PWR	Selects Rcvr 1
2FRP	CC			
2FS	CC	RCVR 2 SELECT	PWR	Selects Rcvr 2
2FRS	CC			
2GP	CC	X-BAND TRANS-MITTER POWER ON	PWR	Switches 30 Vdc to the X-Band TWTA and exciter
2GRP	CC			
2GS	CC	X-BAND TRANS-MITTER POWER OFF	PWR	Removes 30 Vdc from the X-Band TWTA and exciter
2GRS	CC			
2H	DC	X-BAND TWT HIGH POWER	RFS	Selects high-power output mode
2HR	DC	X-BAND TWT LOW POWER	RFS	Selects low-power output mode
2JP	CC	X-BAND EXCITER 1 SELECT	PWR	Selects X-Band exciter 1
2JRP	CC			
2JS	CC	X-BAND EXCITER 2 SELECT	PWR	Selects X-Band exciter 2
2JRS	CC			

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
2KP	CC	S-BAND TRANSMITTER POWER ON	PWR	Switches 30 Vdc to the S-Band Transmitter
2KRP	CC			
2KS	CC			
2KRS	CC	S-BAND TRANSMITTER POWER OFF	PWR	Removes 30 Vdc from the S-Band Transmitter
2LP	CC	X-BAND TWTA 1 SELECT	PWR	Selects X-Band TWTA 1 (HAC/WJ)
2LRP	CC			
2LS	CC			
2LRS	CC	X-BAND TWTA 2 SELECT	PWR	Selects X-Band TWTA 2
2MP	CC	S-BAND EXCITER POWER ON	PWR	Switches 30 Vdc to S-Band exciter
2MRP	CC			
2MS	CC			
2MRS	CC	S-BAND EXCITER POWER OFF	PWR	Removes 30 Vdc from S-Band exciter
2N	DC	X-BAND RANGING ON	RFS	Turns on X-Band ranging
2NR	DC	X-BAND RANGING OFF	RFS	Turns off X-Band ranging

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
2P	DC	TWO-WAY NON-COHERENT ON	RFS	Disables VCO as source of downlink signal
2PR	DC	TWO-WAY NON-COHERENT OFF	RFS	Enables VCO as source of downlink signal
2Q	DC	USO ON	RFS	Turns on ultrastable oscillator.
2QR	DC	USO OFF	RFS	Turns off ultrastable oscillator.
2X	DC	RFS COMMAND ENABLE	CCS	Enables CCS outputs to RFS
2XR	DC	RFS COMMAND INHIBIT	CCS	Inhibits CCS outputs to RFS
3A	CC	TMU STATE SELECT	MDS	Coded command that selects the operating state of the TMUs
3BP	CC	TMU PWR ON	PWR	Switches 2.4 kHz power to TMUs
3BRP	CC			
3BS	CC			
3BRS	CC	TMU PWR OFF	PWR	Removes 2.4 kHz power from TMUs
3GP	CC	TMU-A SELECT	PWR	Turns on TMU-A and turns off TMU-B
3GRP	CC			
3GS	CC			
3GRS	CC	TMU-B SELECT	PWR	Turns on TMU-B and turns off TMU-A

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
3HP	CC	CDU A SELECT	PWR	Turns on CDU A- turns off CDU B
3HRP	CC			
3HS	CC			
3HRS	CC	CDU B SELECT	PWR	Turns on CDU B - turns off CDU A
3X	DC	MDS COMMAND ENABLE	CCS	Enables CCS outputs to MDS
3XR	DC	MDS COMMAND DISABLE	CCS	Disables CCS outputs to MDS
4A	CC	UNDERVOLTAGE TRIP RESET	PWR	Resets AC2 and DC2 power buses
4K	CC	RTG 1 DIODE BYPASS ON	PWR	Shorts out RTG 1 isolation diode
4KR	CC	RTG 1 DIODE BYPASS OFF	PWR	Removes RTG 1 diode bypass
4L	CC	RTG 2 DIODE BYPASS ON	PWR	Shorts out RTG 2 isolation diode
4LR	CC	RTG 2 DIODE BYPASS OFF	PWR	Removes RTG 2 diode bypass
4M	CC	RTG 3 DIODE BYPASS ON	PWR	Shorts out RTG 3 isolation diode
4MR	CC	RTG 3 DIODE BYPASS OFF	PWR	Removes RTG 3 diode bypass
4T	DC	ACTIVATE BAT-TERIES A & B	PYRO	Selects electrolyte injection squib.
4X	DC	PWR COMMAND ENABLE	CCS	Enables CCS outputs to PWR

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
4XR	DC	PWR COMMAND DISABLE	CCS	Disables CCS outputs to PWR
5A	DC	CCS TOLERANCE DET. DISABLE	CCS	Disables tolerance detector
5AR	DC	CCS TOLERANCE DET. ENABLE	CCS	Enables tolerance detector
6AA	CC	SVC-W1 FDS MDS I/O SELECT	FDS	State vector command which selects MDS I/O logic
6AB	CC	SVC-W2 FDS MEM/PROC SELECT + AACS SELECT	FDS	State vector command which determines proc/mem configuration and AACS data interface
6AC	CC	SVC-W3 FDS MEMORY A WRITE PROTECT	FDS	State vector command that determines amount of FDS memory A that will be under write-protect control
6AD	CC	SVC-W4 FDS MEMORY B WRITE PROTECT	FDS	State vector command that determines amount of FDS memory B that will be under write-protect control
6AE	CC	SVC-W5 FDS PROTECT; TIMING; TD PWR; I/O SELECT	FDS	State vector command that enables or disables write protect; determines timing chain; determines CRS, MAG, and LECP I/O logics; and disables or enables transducer power

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
6AF	CC	FDS SOFTWARE BLOCK LOAD, WITHOUT PRIMARY MEMORY, WRITE PROTECT OVERRIDE	FDS	See CC6AK, CC6AL, or CC6AM
06AG	SC	SPACECRAFT TIME (16-BIT STAGE COUNTER)	FDS	Command word which updates or modifies S/C time. Counter increments every 48 minutes.
06AH	SC	SPACECRAFT TIME 60-FRAME COUNTER	FDS	Command word which updates or modifies frame counter. Counter increments every 48 sec.
06AJ	SC	SPACECRAFT TIME 800-LINE COUNTER	FDS	Command word which updates or modifies line counter. Counter increments every 60 msec.
6AK	CC	FDS SOFTWARE BLOCK LOAD, PRIMARY MEMORY, WITH WRITE PROTECT OVERRIDE	FDS	These commands are automatically issued by the CCS to FDS and should not be used by ground control
6AL	CC	FDS SOFTWARE BLOCK LOAD, SECONDARY MEMORY, WITHOUT WRITE PROTECT OVERRIDE	FDS	
6AM	CC	FDS SOFTWARE BLOCK LOAD, SECONDARY MEMORY, WITH WRITE PROTECT OVERRIDE	FDS	

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
6AN	CC	PARAMETER TABLE A POINTER COMMAND	FDS	Controls parameter table A pointer
6AP	CC	FDS POWER CONVERTER A SELECT	PWR	Switches 2.4 kHz power to FDS power converter A and removes power from converter B if enabled by CC6CP or CC6CS
6ARP	CC			
6AS	CC	FDS POWER CONVERTER B SELECT	PWR	Switches 2.4 kHz power to FDS power converter B and removes power from converter A if enabled by CC6CP or CC6CS
6ARS	CC			
6AQ	CC	PARAMETER TABLE B POINTER COMMAND	FDS	Controls parameter table B pointer
6AR	CC	PARAMETER TABLE C POINTER COMMAND	FDS	Controls parameter table C pointer
6AT	CC	PARAMETER TABLE D POINTER COMMAND	FDS	Controls parameter table D pointer

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
6AU	CC	PARAMETER A USE COUNTER RESET	FDS	Sets parameter A USE field to zero
6AV	CC	PARAMETER B USE COUNTER RESET	FDS	Sets parameter B USE field to zero
06AW	SC	FDS ISS AEX NA/WA PIXEL SUM THRESHOLD	FDS	Sets pixel threshold to be used in the ISS auto-exposure algothrim (AEX)
06AX	SC	FDS ISS WA AEX MIN PIXEL COUNT	FDS	Sets minimal number of pixels which must exceed pixel threshold before AEX affects WA camera setting
6AY	CC	PARAMETER C USE COUNTER RESET	FDS	Sets parameter C USE field to zero
6AZ	CC	PARAMETER D USE COUNTER RESET	FDS	Sets parameter D USE field to zero
6BA	CC	FDS HARDWARE BLOCK LOAD	FDS	Command automatically generated by CCS upon acceptance of the H/W LOAD PC
06BB	SC	FDS MODE COMMAND	FDS	Command word which controls FDS mode

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
06BC	SC	PRIMARY TO SECONDARY MEMORY COPY	FDS	Copies primary memory contents into secondary memory
06BE	ST	FDS AACS ADDRESS TABLE - 1200 MEM R/O	FDS	Modifies an entry to AACS engineering telemetry table to affect change in format
06BF	ST	FDS AACS ADDRESS TABLE - 40 ENG + R/O	FDS	
06BG	SC	FDS ISS NA AEX MIN PIXEL COUNT	FDS	Same as SC06AX, only NA camera is affected
06BH	SC	FDS ISS WA AEX TRIP POINT LOW	FDS	Specifies trip points which is used by the auto exposure algothrim (AEX) in determining the exposure number for the next picture
06BJ	SC	FDS ISS WA AEX TRIP POINT MIDDLE	FDS	
06BK	SC	FDS ISS WA AEX TRIP POINT HIGH	FDS	
06BL	SC	FDS ISS NA AEX TRIP POINT LOW	FDS	Same as SC06BH, SC06BJ, and SC06BK
06BM	SC	FDS ISS NA AEX TRIP POINT HIGH	FDS	
06BN	SC	FDS ISS NA AEX TRIP POINT HIGH	FDS	

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
06BP	SC	FDS NORM/CROSS CONFIGURATION COMMAND	FDS	Command word which selects processor-memory configuration
06BQ	SC	FDS P/C VOLTAGE MUX	FDS	Positions multiplexer to monitor desired voltage within FDS power converter
06BR	ST	FDS AACS ADDRESS TABLE - LAUNCH	FDS	See ST06BE or ST06BF
06BS	ST	FDS AACS ADDRESS TABLE - MANEUVER	FDS	See ST06BE or ST06BF
06BT	ST	FDS AACS ADDRESS TABLE - CRUISE	FDS	See ST06BE or ST06BF
06BU	ST	FDS AACS ADDRESS TABLE - ENCOUNTER	FDS	See ST06BE or ST06BF
06BV	ST	FDS ISS NA/WA FILTER NUMBERS	FDS	Modifies or updates one of eight (8) entries to a table which specifies NA and WA camera filter numbers.
06BW	SC	FDS ISS PICTURE COUNT	FDS	Command word which modifies picture counter

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
6CP 6CRP	CC CC	FDS POWER ON/ ISS POWER ENABLE	PWR	Switches 2.4 kHz power to FDS and enables power to ISS power supplies
6CS 6CRS	CC	FDS POWER OFF/ ISS POWER INHIBIT	PWR	Removes 2.4 kHz power from FDS and disables power from ISS power supplies
06NB	SC	FDS PWS ANALOG A ENG ID	FDS	Specifies tree switch identifiers
06NC	SC	FDS 1-WD READOUT POINTER	FDS	Specifies any single location within FDS memory to be readout
06ND	SC	FDS PWS ANALOG B ENG ID	FDS	Same as SC06NB
06NG	ST	FDS ENG ID TABLE 1	FDS	Modifies an entry to the engineering identifier tables
06NH	ST	FDS ENG ID TABLE MODIFIED CRUISE	FDS	
06NJ	ST	FDS ENG ID TABLE ENCOUNTER	FDS	See ST06PW, ST06PX, or ST06PY
06NK	SC	FDS CHECK SUM FIRST LOWER PRIMARY MEMORY	FDS	These commands specify the boundaries over which FDS memory check sum is to be computed.

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
06NL	SC	FDS CHECK SUM LAST LOWER PRIMARY MEMORY	FDS	
06NM	SC	FDS CHECK SUM FIRST UPPER PRIMARY MEMORY	FDS	
06NN	SC	FDS CHECK SUM LAST UPPER PRIMARY MEMORY	FDS	
06NP	SC	FDS CHECK SUM FIRST LOWER SECONDARY MEMORY	FDS	
06NQ	SC	FDS CHECK SUM LAST LOWER SECONDARY MEMORY	FDS	
06NR	SC	FDS CHECK SUM FIRST UPPER SECONDARY MEMORY	FDS	
06NS	SC	FDS CHECK SUM LAST UPPER SECONDARY MEMORY	FDS	These commands specify the boundaries over which FDS memory check sum is to be computed.

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
06NT	SC	FDS ENGR. POINTER ENG MODE = 2	FDS	These commands specify the starting address in FDS memory for the engineering identifier and AACS address tables.
06NU	SC	FDS AACS POINTER ENG MODE = 2	FDS	
06NV	SC	FDS ENGR. POINTER ENG MODE = 3	FDS	
06NW	SC	FDS AACS POINTER ENG MODE = 3	FDS	
06NX	SC	FDS ENGR. POINTER ENG MODE = 4	FDS	
06NY	SC	FDS AACS POINTER ENG MODE = 4	FDS	
06NZ	SC	FDS ENGR. POINTER ENG MODE = 5	FDS	

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
06PA	SC	FDS AACS POINTER ENG MODE = 5	FDS	
06PB	SC	FDS ENGR. POINTER FDS MODE = 6	FDS	
06PC	SC	FDS AACS POINTER FDS MODE = 6	FDS	
06PD	SC	FDS ENGR. POINTER FDS MODE = 7	FDS	
06PE	SC	FDS AACS POINTER FDS MODE = 7	FDS	These commands specify the starting address in FDS memory for the engineering identifier and AACS address tables.
06PF	SC	FDS ISS PARAMETER A TABLE ORIGIN	FDS	
06PG	SC	FDS ISS PARAMETER B TABLE ORIGIN	FDS	Specifies starting address of respective ISS parameter tables.
06PH	SC	FDS ISS PARAMETER C TABLE ORIGIN	FDS	

Table 2. MJS77 Command List (Contd)

<table>
<tr><th>Symbol</th><th>Command Type</th><th>Name</th><th>Destination</th><th>Comment</th></tr>
<tr><td>06PJ</td><td>SC</td><td>FDS ISS PARAMETER D TABLE ORIGIN</td><td>FDS</td><td>Specifies starting address of respective ISS parameter tables.</td></tr>
<tr><td>06PK</td><td>SC</td><td>FDS ISS PARAMETER B TABLE POINTER</td><td>FDS</td><td rowspan="4">Specifies location of next parameter relative to the starting address which is specified by the origin command.</td></tr>
<tr><td>06PL</td><td>SC</td><td>FDS ISS PARAMETER B TABLE POINTER</td><td>FDS</td></tr>
<tr><td>06PM</td><td>SC</td><td>FDS ISS PARAMETER C TABLE POINTER</td><td>FDS</td></tr>
<tr><td>06PN</td><td>SC</td><td>FDS ISS PARAMETER D TABLE POINTER</td><td>FDS</td></tr>
<tr><td>06PT</td><td>SC</td><td>FDS NEXT ADDRESS TO READOUT - 40 BPS</td><td>FDS</td><td rowspan="2">Specifies starting address for FDS memory readout.</td></tr>
<tr><td>06PU</td><td>SC</td><td>FDS NEXT ADDRESS TO READOUT - 1200 BPS</td><td>FDS</td></tr>
<tr><td>06PV</td><td>SC</td><td>FDS CCS SINGLE ID</td><td>FDS</td><td>Specifies tree ID which is used for CCS memory readout.</td></tr>
</table>

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
06PW	ST	FDS ENGR. ID TABLE LAUNCH	FDS	Modifies one of 95 table entries whose contents determines the engineering format.
06PX	ST	FDS ENGR. ID TABLE MANEUVER	FDS	
06PY	ST	FDS ENGR. ID TABLE CRUISE	FDS	
06PZ	ST	FDS ISS PARAMETER A TABLE ORIGIN REGION 1	FDS	Modifies or updates an entry to one of two sets of parameter tables stored within the FDS.
06QA	ST	FDS ISS PARAMETER A TABLE ORIGIN REGION 2	FDS	
06QC	SC	FDS AACS SINGLE ID	FDS	Specifies tree switch ID which is used for AACS memory readout.
06QF	SC	FDS S/C ID NUMBER	FDS	Modifies the S/C ID which is part of the 64-bit header of each minor frame of tlm data.
6X	DC	FDS COMMAND ENABLE	CCS	Enables CCS outputs to FDS
6XR	DC	FDS COMMAND DISABLE	CCS	Inhibits CCS outputs to FDS

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
7AHP	CC	SUN SENSOR A HTR ON	PWR	Switches 30 Vdc power to
7AHRP	CC			
7AHS	CC			
7AHRS	CC	SUN SENSOR A HTR OFF	PWR	Removes 30 Vdc power from sun sensor B heater
7BAP	CC	AACS Bay 6 HTR A ON	PWR	Switches 2.4 kHz power to AACS bay 6 heater A
7BARP	CC			
7BAS	CC			
7BARS	CC	AACS Bay 6 HTR A OFF	PWR	Removes 2.4 kHz power from AACS bay 6 heater A
7BBP	CC	AACS Bay 6 HTR B ON	PWR	Switches 2.4 kHz power to AACS bay 6 heater B
7BBRP	CC			
7BBS	CC			
7BBRS	CC	AACS Bay 6 HTR B OFF	PWR	Removes 2.4 kHz power from AACS bay 6 heater B

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
7BHP	CC	SUN SENSOR B HTR ON	PWR	Switches 30 Vdc power to sun sensor B heater
7BHRP	CC			
7BHS	CC	SUN SENSOR B HTR OFF	PWR	Removed 30 Vdc power from sun sensor B heater
7BHRS	CC			
7CT	CC	CST CONTROL	AACS	Controls cone angle, roll override, flyback, Canopus search, and gate update. Gate updates require preceding data words (CC7FD and CC7SD).
7CTG	AC	CANOPUS STAR TRACKER GATE CONTROL	AACS	Command word which selects high and low gate updates

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
7DD	CC	DEADBAND/DRIFT CONTROL	AACS	Controls sun sensor deadband size and compensates for DRIRU drift. This command must be preceded by precursor command (CC7ML04).
7DDB	AC	DEADBAND UPDATE	AACS	Command word which updates sun sensor deadband
7DDC	AC	DRIRU DRIFT RATE CONTROL	AACS	Command word which compensates for DRIRU drift
7FA	CC	FIRST HALF ADDRESS	AACS	Command which specifies the 9 MSB of the selected memory location
7SA	CC	SECOND HALF ADDRESS	AACS	Command which specifies the 3 LSB of the selected memory location and the length of the block load
7FD	CC	FIRST HALF DATA	AACS	Command which specifies the 9 MSB of the data word
7SD	CC	SECOND HALF DATA	AACS	Command which specifies the 9 LSB of the data word

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
7GAP	CC	GYRO A ON	PWR	Turns on GYRO A
7GARP	CC			
7GAS	CC			
7GARS	CC	GYRO A OFF	PWR	Turns off GYRO A
7GBP	CC	GYRO B ON	PWR	Turns on GYRO B
7GBRP	CC			
7GBS	CC			
7GBRS	CC	GYRO B OFF	PWR	Turns off GYRO B
7GCP	CC	GYRO C ON	PWR	Turns on GYRO C
7GCRP	CC			
7GCS	CC			
7GCRS	CC	GYRO C OFF	PWR	Turns off GYRO C
7GY	CC	DRIRU CONTROL	AACS	Controls capture rate, initialization, fault testing, calibration, and usage pattern. Usage pattern requires preceding data word (CC7FD and CC7SD)

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
7GYP	AC	DRIRU PATTERN CONTROL	AACS	Command word which selects GYRO axis usage
7H1P	CC	HYBIC 1 MAJOR POWER SUPPLY ON	PWR	Switches 2.4 kHz power to HYBIC 1 major power supply and to the sun sensor powered by HYBIC 1
7H1RP	CC			
7H1S	CC	HYBIC 1 MAJOR POWER SUPPLY OFF	PWR	Removes 2.4 kHz power from HYBIC 1 major power supply and from the sun sensor powered by HYBIC 1
7H1RS	CC			
7H2P	CC	HYBIC 2 MAJOR POWER SUPPLY ON	PWR	Switches 2.4 kHz power to HYBIC 2 major power supply and to the sun sensor powered by HYBIC 2
7H2RP	CC			
7H2S	CC	HYBIC 2 MAJOR POWER SUPPLY OFF	PWR	Removes 2.4 kHz power from HYBIC 2 major power supply and from the sun sensor powered by HYBIC 2
7H2RS	CC			
7MD	CC	MODE CONTROL	AACS	Control various AACS modes
7MDP	AC	MODE CONTROL WITH PRECURSOR	AACS	Command word which selects AACS mode

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
7ML	CC	MISCELLANEOUS LOGIC CONTROL	AACS	Control miscellaneous AACS control functions. The precursor command is in CC7ML
7MLD	AC	MISCELLANEOUS LOGIC CONTROL - MEMORY DUMP	AACS	Command word which indicates starting address for memory dump
7MMP	CC	PROC/MEM 1 SELECT	PWR	Selects PROC/MEM 1
7MMRP	CC			
7MMS	CC	PROC/MEM 2 SELECT	PWR	Selects PROC/MEM 2
7MMRS	CC			
7PAR	AC	PARAMETER LOAD	AACS	Command word which updates one MEMORY location
7PC	CC	POWER CODE CONTROL	AACS	Controls AACS power codes. Ground initiated power codes must be preceded by precursor cmd (CC7ML04).
7PCG	AC	GROUND COMMANDED POWER CODE	AACS	Command word which updates power codes and initiates AACS power switching.

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
7RC	CC	REGISTER CONTROL	AACS	Controls opening of TCM ISO valves and loading of ISO valve register, configuration register, and propulsion register. Register loads must be preceded by data word (CC7FD and CC7SD) and precursor. Register loads are only loaded in the launch mode. TCM ISO valve cmd must be preceded by precursor command (CC7ML04).
7RCB	AC	REGISTER CONTROL - TCM BURN/PYRO EVENT	AACS	Command word which assures that selected TCM ISO valves are open (valves automatically close)
7RCR	AC	REGISTER CONTROL - REGISTERS	AACS	Command word which directly loads the HYBIC ISO valve, configuration, or propulsion registers
7SHP	CC	AZ SCAN ACTUATOR HTR ON	PWR	Switches 30 Vdc power to azimuth actuator heater
7SHRP	CC			
7SH	CC			
7SHRS	CC	AZ SCAN ACTUATOR HTR OFF	PWR	Removes 30 Vdc power from azimuth actuator heater

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
7SP	CC	SCIENCE PLATFORM CONTROL	AACS	Controls slew axis, slew rate, use of fine and coarse pots, and command stack. This cmd requires preceding data word.
7SPK	AC	SCIENCE PLATFORM CONTROL - STACK CMD WITH COARSE AND FINE POT	AACS	Command word which positions the science platform without causing the present platform slewing to be aborted.
7SPL	AC	SCIENCE PLATFORM CONTROL - STACK CMD WITH FINE POT ONLY	AACS	Command word which positions the science platform without causing the present platform slewing to be aborted.
7SPM	AC	SCIENCE - PLATFORM CONTROL - OVERRIDE STACK CMD WITH COARSE AND FINE POT	AACS	Command word which aborts the present platform slewing and repositions the science platform
7SPN	AC	SCIENCE PLATFORM CONTROL - OVERRIDE STACK CMD WITH FINE POT ONLY	AACS	

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
7SS	CC	SUN SENSOR CONTROL	AACS	Controls initial acquisition, reacquisition, bias, and gate updates. Bias and gate updates must be preceded by data words (CC7FD and CC7SD)
7SSB	AC	SUN SENSOR BIAS CONTROL	AACS	Command word which selects yaw or pitch bias update
7SSG	AC	SUN SENSOR GATE CONTROL	AACS	Command word which updates the sun sensor intensity gates
7ST	DC*	AACS SELF-TEST	AACS	Initiates self-test for AACS
7TC	CC	TURN COMMAND CONTROL	AACS	Controls turn axis, polarity, and scaling. This command must be preceded by data words (CC7FD and CC7SD)
7TCD	AC	TURN CONTROL COMMAND WITH DATA	AACS	Command word which controls spacecraft commanded turns

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
7TSP	CC	CST SUN SHUTTER ON	PWR	Switches 2.4 kHz power to both CST Sun Shutters
7TSRP	CC			
7TSS	CC			
7TSRS	CC	CST SUN SHUTTER OFF	PWR	Removes 2.4 kHz power from both CST Sun Shutters
7T1P	CC	CST 1 ON	PWR	Switches 2.4 kHz power to CST 1
7T1RP	CC			
7T1S	CC			
7T1RS	CC	CST 1 OFF	PWR	Removes 2.4 kHz power from CST 1
7T2P	CC	CST 2 ON	PWR	Switches 2.4 kHz power to CST 2
7T2RP	CC			
7T2S	CC			
7T2RS	CC	CST 2 OFF	PWR	Removes 2.4 kHz power from CST 2
7V1P	CC	ISO VALVES BRANCH 1 ON	PWR	Switches 30 Vdc power to ISO valves Branch 1.
7V1RP	CC			
7V1S	CC			
7V1RS	CC	ISO VALVES BRANCH 1 OFF	PWR	Removes 30 Vdc power from ISO valves Branch 1

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
7V2P	CC	ISO VALVES BRANCH 2 ON	PWR	Switches 30 Vdc power to ISO valves Branch 2
7V2RP	CC			
7V2S	CC			
7V2RS	CC	ISO VALVES BRANCH 2 OFF	PWR	Switches 30 Vdc power from ISO valves Branch 2
7X	DC	AACS COMMAND ENABLE	CCS	Enables CCS outputs to AACS
7XR	DC	AACS COMMAND INHIBIT	CCS	Inhibits CCS outputs to AACS
8A	CC	PSU A ON	PWR	Switches 2.4 kHz power to PSU A
8AR	CC	PSU A OFF	PWR	Removes 2.4 kHz power from PSU A
8B	CC	PSU B ON	PWR	Switches 2,4 kHz power to PSU B
8BR	CC	PSU B OFF	PWR	Removes 2.4 kHz power from PSU B
8D	CC	PSU INSTRUMENTATION ON	PWR	Switches 2.4 kHz power to PSU instrumentation tlm
8DR	CC	PSU INSTRUMENTATION OFF	PWR	Removes 2.4 kHz power from instrumentation tlm

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
8X	DC	PYRO COMMAND ENABLE	CCS	Enables CCS outputs to PYRO
8XR	DC	PYRO COMMAND INHIBIT	CCS	Inhibits CCS outputs to PYRO
10A	DC	START SOLID MOTOR	PYRO	Selects solid motor ignitor squibs
10B	DC	CLOSE IPU-REA ISOLATION VALVE	PYRO	Selects PM isolation valve squibs
10CP	CC	TCM HEATERS ON	PWR	Switches 30 Vdc power to TCM heaters
10CRP	CC			
10CS	CC			
10CRS	CC	TCM HEATERS OFF	PWR	Removes 30 Vdc power from TCM heaters
10D	CC	AP BR 1 HTRS ON	PWR	Switches 30 Vdc power to attitude propulsion Branch 1 backup heaters
10DR	CC	AP BR 1 HTRS OFF	PWR	Removes 30 Vdc power from attitude propulsion Branch 1 backup heaters
10E	CC	AP BR 2 HTRS ON	PWR	Switches 30 Vdc power to attitude propulsion Branch 2 backup heaters

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
10ER	CC	AP BR 2 HTRS OFF	PWR	Removes 30 Vdc power from attitude propulsion Branch 2 backup heaters
10F	CC	IPU VALVE HTRS ON	PWR	Switches 30 Vdc power to IPU heaters
10FR	CC	IPU VALVE HTRS OFF	PWR	Removes 30 Vdc power from IPU heaters
10G	CC	IPU THRUSTER HTRS ON	PWR	Switches 30 Vdc power to IPU thruster heaters
10GR	CC	IPU THRUSTER HTRS OFF	PWR	Removes 30 Vdc power from IPU thruster heaters
10H	CC	IPU REDUNDANT VALVE HTR ON	PWR	Switches 30 Vdc power to IPU redundant heater
10HR	CC	IPU REDUNDANT VALVE HTR OFF	PWR	Removes 30 Vdc power from IPU redundant heater
10TP 10TRP 10TS 10TRS	CC CC CC CC	TCM LINE HTRS ON TCM LINE HTRS OFF	PWR PWR	Switches 2.4 kHz power to TCM line and bracket heaters. Removes 2.4 kHz power from TCM line and bracket heaters.
12A1	DC	S/C - LV SEPARATION A	PYRO	Selects primary S/C - LV separation squibs
12A2	DC	S/C - LV SEPARATION B	PYRO	Selects secondary S/C - LV separation squibs
12B1	DC	RELEASE RTG BOOM, SET 1	PYRO	Selects Set 1 RTG boom release squibs

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
12B2	DC	RELEASE RTG BOOM, SET 2	PYRO	Selects SET 2 RTG boom release squibs
12C	DC	RELEASE MAG BOOM	PYRO	Selects MAG boom deployment squibs
12D	DC	RELEASE SCIENCE BOOM	PYRO	Selects science boom release squibs
12E	DC	JETTISON PROPULSION MODULE	PYRO	Selects final MM/PM release device squibs
16AP	CC	DSS ON	PWR	Switches 2.4 kHz power to DSS
16ARP	CC			
16AS	CC			
16ARS	CC	DSS OFF	PWR	Removes 2.4 kHz power from DSS
16B	CC	DSS REPLACEMENT HEATER ON	PWR	Switches 2.4 kHz power to DSS replacement heater
16BR	CC	DSS REPLACEMENT HEATER OFF	PWR	Removes 2.4 kHz power from DSS replacement heater
16C	CC	DSS STATE SELECT	DSS	Coded command that determines the DSS operating state
16DA	SC	DSS CODED COMMAND (via FDS)	FDS	DSS coded command that uses FDS-DSS command interface

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
16X	DC	DSS COMMAND ENABLE	CCS	Enables CCS outputs to DSS
16XR	DC	DSS COMMAND INHIBITS	CCS	Inhibits CCS outputs to DSS
21A	CC	CRS ON	PWR	Switches 30 Vdc power to CRS
21AR	CC	CRS OFF	PWR	Removes 30 Vdc power from CRS
21AF	SC	CRS COMMAND WORD	FDS	Command word which controls CRS internal functions
21AG	SC	CRS HV ON COMMAND	FDS	Command word which controls the HV flag
21AH	SC	CRS CAL-START COMMAND	FDS	Command word which controls the CAL-START flag
21B	CC	CRS REPLACEMENT HEATER ON	PWR	Switches 30 Vdc power to CRS replacement heater
21BR	CC	CRS REPLACEMENT HEATER OFF	PWR	Removes 30 Vdc power from CRS replacement heater
21C	CC	CRS SUPPLEMENTAL HEATER ON	PWR	Switches 30 Vdc power to CRS supplemental heater

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
21CR	CC	CRS SUPPLEMENTAL HEATER OFF	PWR	Removes 30 Vdc power from CRS supplemental heater
22A	CC	PRA ON	PWR	Switches 2.4 kHz power to PRA
22AR	CC	PRA OFF	PWR	Removes 2.4 kHz power from PRA
22AF	SC	PRA CONFIGURATION COMMAND	FDS	Command word which controls the PRA configuration
22AG 22AH 22AJ	SC SC SC	PRA FIXLO AND FREQUENCIES COMMAND	FDS FDS	Command word which selects frequencies and the FIXLO mode
22AK 22AL 22AM	SC SC SC	PRA POLHI AND FREQUENCIES COMMAND	FDS FDS FDS	Command word which selects frequencies and the POLHI mode
22AN 22AP	SC SC	PRA POLHI AND FREQUENCIES COMMAND	FDS FDS	Command word which selects frequencies and the POLHI mode for GS-2 only
22AQ	SC	PRA VLOBR AND FREQUENCIES COMMAND	FDS	Command word which selects frequency and the VLOBR mode (extended mission only)

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
22BP	CC	PRA/PWS ANTENNA DEPLOY MOTOR ON	PWR	Switches 30 Vdc power to deploy PRA/PWS antennas
22BPR	CC			
22BS	CC	PRA/PWS ANTENNA DEPLOY MOTOR OFF		
22BRS	CC			
22NJ	ST	PRA MODE COMMAND TABLE	FDS	Modifies an entry into a 30 word table containing PRA modes.
22NR	SC	PRA LEVEL COMMAND	FDS	Places PRA into LEVEL mode
22NS	SC	PRA POLLO COMMAND	FDS	Places PRA into POLLO mode
22NT	SC	PRA HARAD COMMAND	FDS	Places PRA into HARAD mode
23A	CC	PWS ON	PWR	Switches 2.4 kHz power to PWS
23AR	CC	PWS OFF	PWR	Removes 2.4 kHz power from PWS
23AD	SC	PWS COMMAND WORD	FDS	Command word which controls PWS internal functions
25A	CC	LECP ON	PWR	Switches 2.4 kHz power to LECP

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
25AR	CC	LECP OFF	PWR	Removes 2.4 kHz power from LECP
25AH	SC	LECP COMMAND WORD	FDS	Command word which controls LECP internal functions
25AJ	SC	LECP MOTOR STEP COMMAND	FDS	Specifies LECP motor step rate
25AK	ST	LECP FE RATE COMMAND	FDS	Modifies an entry into table which selects rate group
25AL	ST	LECP NE RATE COMMAND	FDS	Modifies an entry into table which selects rate group
25AM	ST	LECP CRUISE RATE COMMAND	FDS	Modifies an entry into table which selects rate group
25B	CC	LECP STEPPER MOTOR ON	PWR	Switches 30 Vdc power to stepper motor
25BR	CC	LECP STEPPER MOTOR OFF	PWR	Removes 30 Vdc power from stepper motor
25C	CC	LECP REPLACEMENT HEATER ON	PWR	Switches 30 Vdc power to LECP replacement heater
25CR	CC	LECP REPLACEMENT HEATER OFF	PWR	Removes 30 Vdc power from LECP replacement heater
25D	CC	LECP MAIN SUPPLEMENTAL HEATER ON	PWR	Switches 30 Vdc power to LEMPA telescope and main electronics supplemental heaters

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
25DR	CC	LECP MAIN SUPPLEMENTAL HEATER OFF	PWR	Removes 30 Vdc power from LEMPA telescope and main electronics supplemental heaters
25E	CC	LECP LEPT SUPPLEMENTAL HEATER ON	PWR	Switches 30 Vdc power to LEPT amplifier supplemental heater
25ER	CC	LECP LEPT SUPPLEMENTAL HEATER OFF	PWR	Removes 30 Vdc power from LEPT amplifier supplemental heater
27A	CC	PPS ON	PWR	Switches 30 Vdc power to PPS
27AR	CC	PPS OFF	PWR	Removes 30 Vdc power to PPS
27AE	SC	PPS CONFIGURATION COMMAND	FDS	Command word which controls PPS configuration
27AF	SC	PPS POSITION COMMAND	FDS	Command word which selects the filter and analyzer position
27AH	ST	PPS MODE TABLE	FDS	Modifies an entry into an 80 word table containing PPS modes
27AJ	ST	PPS FILTER TABLE	FDS	Selects filter position
27AK	ST	PPS ANALYZER TABLE	FDS	Selects analyzer position

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
27AL	SC	PPS FIXED FILTER WORD	FDS	Selects filter position
27AM	SC	PPS FIXED ANALYZER WORD	FDS	Selects analyzer position
27B	CC	PPS SUPPLEMENTAL HEATER ON	PWR	Switches 30 Vdc power to PPS supplemental heater
27BR	CC	PPS SUPPLEMENTAL HEATER OFF	PWR	Removes 30 Vdc power from PPS supplemental heater
32A	CC	PLS ON	PWR	Switches 2.4 kHz power to PLS
32AR	CC	PLS OFF	PWR	Removes 2.4 kHz power from PLS
32AF	SC	PLS E1 MODE COMMAND	FDS	Command word which selects E1 mode and the appropriate gains
32AG	SC	PLS E2 MODE COMMAND	FDS	Command word which selects E2 mode and the appropriate gains
32AH	SC	PLS M MODE COMMAND	FDS	Command word which selects M mode and the appropriate gains
32AJ	SC	PLS CONFIGURATION COMMAND	FDS	Command word which controls PLS configuration
32AK	SC	PLS L MODE COMMAND	FDS	Command word which selects L mode and the appropriate gains
32AL	SC	PLS M MODE START WORD 1	FDS	Determines sampling of PLS M mode during cruise Data Mode.

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
32AM	SC	PLS M MODE START WORD 2	FDS	Determines sampling of PLS M mode during cruise data mode.
32B	CC	PLS SUPPLEMENTAL HEATER ON	PWR	Switches 30 Vdc power to PLS supplemental heater
32BR	CC	PLS SUPPLEMENTAL HEATER OFF	PWR	Removes 30 Vdc power from PLS supplemental heater
32C	CC	PLS REPLACEMENT HEATER ON	PWR	Switches 30 Vdc power to PLS replacement heater
32CR	CC	PLS REPLACEMENT HEATER OFF	PWR	Removes 30 Vdc power from PLS replacement heater
34A	CC	UVS ON	PWR	Switches 2.4 kHz power to UVS
34AR	CC	UVS OFF	PWR	Removes 2.4 kHz power from UVS
34AE	SC	UVS COMMAND WORD	FDS	Command word which selects UVS voltage level and mode
34AF	SC	UVS READOUT FLAG	FDS	Enables/Inhibits UVS register load gate

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
34B	CC	UVS REPLACEMENT HEATER	PWR	Switches 30 Vdc power to UVS replacement heater
34BR	CC	UVS REPLACEMENT HEATER OFF	PWR	Removes 30 Vdc power from UVS replacement heater
35A	CC	MAG ON	PWR	Switches 2.4 kHz power to MAG
35AR	CC	MAG OFF	PWR	Removes 2.4 kHz power from MAG
35AI	SC	MAG INBOARD COMMAND	FDS	Command word which controls MAG internal inboard functions
35AO	SC	MAG OUTBOARD COMMAND	FDS	Command word which controls MAG internal outboard functions
35B	CC	MAG STANDBY ON	PWR	Switches 2.4 kHz standby power to MAG
35BR	CC	MAG STANDBY OFF	PWR	Removes 2.4 kHz standby power from MAG
35C	CC	MAG IBLFM FWD FLIPPER ON	PWR	Switches 2.4 kHz power to inboard low field forward flipper

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
35CR	CC	MAG IBLFM FWD FLIPPER OFF	PWR	Removes 2.4 kHz power to inboard low field forward flipper
35D	CC	MAG IBLFM REV FLIPPER ON	PWR	Switches 2.4 kHz power to inboard low field reverse flipper
35DR	CC	MAG IBLFM REV FLIPPER OFF	PWR	Removes 2.4 kHz power from inboard low field reverse flipper
35E	CC	MAG OBLFM FWD FLIPPER ON	PWR	Switches 2.4 kHz power to outboard low field forward flipper
35ER	CC	MAG OBLFM FWD FLIPPER OFF	PWR	Removes 2.4 kHz power from outboard low field forward flipper
35F	CC	MAG OBLFM REV FLIPPER ON	PWR	Switches 2.4 kHz power to outboard low field reverse flipper
35FR	CC	MAG OBLFM REV FLIPPER OFF	PWR	Removes 2.4 kHz power from outboard low field reverse flipper
35G	CC	MAG SENSOR HEATERS ON	PWR	Switches 2.4 kHz power to both OBLFM and IBLFM sensor heaters

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
35GR	CC	MAG SENSOR HEATERS OFF	PWR	Removes 2.4 kHz power from both OBLFM and IBLFM sensor heaters
36AM	SC	ISS-WA CMD WORD	FDS	Command word which controls WA gain state and GI voltage level
36AN	SC	ISS-NA CMD WORD	FDS	Command word which controls NA gain state and GI voltage level
36AQ	SC	ISS-WA ELECTRONICS CALIBRATE FLAG COMMAND	FDS	Command word which sets the ISS-WA electronic calibrate flag
36AT	SC	ISS-NA ELECTRONICS CALIBRATE FLAG COMMAND	FDS	Command word which sets the ISS-NA electronics calibrate flag

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
36B	CC	ISS WA ON	PWR	Switches 2.4 kHz power to wide-angle camera if enabled by CC6CP or CC6CS
36BR	CC	ISS WA OFF	PWR	Removes 2.4 kHz power from wide-angle camera
36CP	CC	ISS NA OPTICS HEATER ON	PWR	Switches 30 Vdc power to ISS NA optics heater
36CRP	CC			
36CS	CC			
36CRS	CC	ISS NA OPTICS HEATER OFF	PWR	Removes 30 Vdc power to ISS NA optics heater
36DP	CC	ISS NA ON	PWR	Switches 2.4 kHz power to narrow angle camera if enabled by CC6CP or CC6CS
36DRP	CC			
36DS	CC			
36DRS	CC	ISS NA OFF		Removes 2.4 kHz power from narrow angle
36FP	CC	ISS NA VID REPLACEMENT HEATER ON	PWR	Switches 30 Vdc power to ISS NA vidicon replacement heater
36FRP	CC			
36FS	CC	ISS NA VID REPLACEMENT HEATER OFF	PWR	Removes 30 Vdc power from ISS NA vidicon replacement heater
36FRS	CC			

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
36G	CC	ISS WA VID REPLACEMENT HEATER ON	PWR	Switches 30 Vdc power to ISS WA vidicon replacement heater
36GR	CC	ISS WA VID REPLACEMENT HEATER OFF	PWR	Removes 30 Vdc power from ISS WA vidicon replacement heater
36H	CC	ISS WA ELEC REPL HTR ON	PWR	Switches 30 Vdc power to ISS WA electronics replacement heater
36HR	CC	ISS WA ELEC REPL HTR OFF	PWR	Removes 30 Vdc power from ISS WA electronics replacement heater
36JP 36JRP 36JS 36JRS	CC CC CC CC	ISS NA ELEC REPL HTR ON	PWR	Switches 30 Vdc power to ISS NA electronics replacement heater
		ISS NA ELEC REPL HTR OFF	PWR	Removes 30 Vdc power from ISS NA electronics replacement heater
39A	CC	MIRIS ON	PWR	Switches 2.4 kHz power to MIRIS
39AR	CC	MIRIS OFF	PWR	Removes 2.4 kHz power from MIRIS
39AG	SC	MIRIS COMMAND WORD	FDS	Command word which selects MIRIS mode and gain

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
39B	CC	MIRIS STANDBY SUPPLY B ON	PWR	Removes 2.4 kHz power to MIRIS standby power supply B
39BR	CC	MIRIS STANDBY SUPPLY B OFF	PWR	Removes 2.4 kHz power from MIRIS standby power supply B
39C	CC	MIRIS FLASH OFF HEATER ON	PWR	Switches 30 Vdc power to Flash Off heater
39CR	CC	MIRIS FLASH OFF HEATER OFF	PWR	Removes 30 Vdc power from Flash Off heater
39D	CC	MIRIS REPLACE-MENT HEATERS ON	PWR	Switches 30 Vdc power to MIRIS replacement heaters
39DR	CC	MIRIS REPLACE-MENT HEATERS OFF	PWR	Removes 30 Vdc power from MIRIS replacement heaters
39E	DC	RELEASE MIRIS DUST COVER	PYRO	Selects MIRIS dust cover release squibs
39F	CC	MIRIS STANDBY SUPPLY A ON	PWR	Switches 2.4 kHz power to MIRIS standby power supply A
39FR	CC	MIRIS STANDBY SUPPLY A OFF	PWR	Removes 2.4 kHz power from MIRIS standby power supply A

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
77CW	CC	MAM CONTROL WORD	AACS (MAM)	Selects read/write mode and sets readout start address in MAM
77MP	CC	MAM ON	PWR	Switches 2.4 kHz power to MAM
77MRP	CC			
77MS	CC			
77MRS	CC	MAM OFF	PWR	Removes 2.4 kHz power from MAM
77P	DC	NON-PRIME FCP/ MEM ON	AACS (MAM)	Switches 2.4 kHz power from selected FCP/MEM to both units
77PR	DC	NON-PRIME FCP/ MEM OFF	AACS (MAM)	Removes 2.4 kHz power from non-selected FCP FCP/MEM
77WA	CC	WRITE WORD A	AACS (MAM)	These three commands sent in the order shown load one word into AACS non-prime memory via the MAM
77WB	CC	WRITE WORD B	AACS (MAM)	
77WC	CC	WRITE WORD C	AACS (MAM)	

Table 2. MJS77 Command List (Contd)

Symbol	Command Type	Name	Destination	Comment
77X	DC	MAM COMMAND ENABLE	CCS	Enables CCS outputs to MAM
77XR	DC	MAM COMMAND DISABLE	CCS	Disables CCS outputs to MAM

Table 3. Discrete Command Accumulator Words

NOTES:

1. The number associated with a DC is the affected subsystem designator as specified in MJS77-1-100A.

2. The letter and number following the designator differentiates between commands to a particular subsystem.

3. A command that is the complement of another is identified with the suffix R.

4. CCS COMMAND FIELDS A, B and C correspond to CCS Matrix Source drivers A and B, and Sink drivers C.

Table 3. Discrete Command Accumulator Words (Contd)

CMD SYMBOL	GROUND CMD BIT NUMBER	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
	CCS BIT NUMBER	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
	CCS COMMAND FIELDS	1	ADDRESS				A				B			C				0	1
2A	S-BAND RANGING ON		0	0	0	1	0	1	0	1	0	0	0	0	0	0	1		
2AR	S-BAND RANGING OFF		↑				0	1	1	0	0	0	0	0	0	0	1		
2D	S-BAND TRANSMITTER HIGH-POWER						0	1	1	1	0	0	0	0	0	0	1		
2DR	S-BAND TRANSMITTER LOW-POWER						1	0	0	0	0	0	0	0	0	0	1		
2E	S-BAND HGA SELECT						0	1	1	1	0	0	0	0	0	1	0		
2ER	S-BAND LGA SELECT						1	0	0	0	0	0	0	0	0	1	0		
2H	X-BAND TWT HIGH-POWER						0	1	0	1	0	0	0	0	0	1	0		
2HR	X-BAND TWT LOW-POWER						0	1	1	0	0	0	0	0	0	1	0		
2N	X-BAND RANGING ON						0	1	0	1	0	0	0	0	0	1	1		
2NR	X-BAND RANGING OFF						0	1	1	0	0	0	0	0	0	1	1		
2P	TWO-WAY NON-COHERENT ON						0	1	1	1	0	0	0	0	0	1	1		
2PR	TWO-WAY NON-COHERENT OFF						1	0	0	0	0	0	0	0	0	1	1		
2Q	USO ON		↓				0	1	0	1	0	0	0	0	1	0	0		
2QR	USO OFF		0	0	0	1	0	1	1	0	0	0	0	0	1	0	0		

Table 3. Discrete Command Accumulator Words (Contd)

CMD SYMBOL	GROUND CMD BIT NUMBER	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
	CCS BIT NUMBER	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
	CCS COMMAND FIELDS	1	ADDRESS				A				B			C				0	1
2X	RFS COMMAND ENABLE		1	1	1	0	0	0	0	0	0	0	1	0	0	1	1		
2XR	RFS COMMAND DISABLE		1	1	1	0	0	0	0	0	0	0	1	0	1	0	0		
3X	MDS COMMAND ENABLE		1	1	1	0	0	1	0	0	0	0	0	0	0	1	1		
3XR	MDS COMMAND DISABLE		1	1	1	0	0	1	0	0	0	0	0	0	1	0	0		
4T	ACTIVATE BATTERIES A&B		1	0	0	0	0	0	0	0	0	0	1	1	0	0	0		
4X	PWR COMMAND ENABLE		1	1	1	0	0	0	0	0	1	0	0	0	0	0	1		
4XR	PWR COMMAND DISABLE		1	1	1	0	0	0	0	0	1	0	0	0	0	1	0		
5A	CCS TOLERENCE DET. DISABLE		1	1	1	0	0	0	0	0	0	1	0	0	0	1	1		
5AR	CCS TOLERANCE DET. ENABLE		1	1	1	0	0	0	0	0	0	1	0	0	1	0	0		
6X	FDS COMMAND ENABLE		1	1	1	0	0	0	1	1	0	0	0	0	0	1	1		
6XR	FDS COMMAND DISABLE		1	1	1	0	0	0	1	1	0	0	0	0	1	0	0		
7ST	AACS SELF TEST		1	0	1	0	0	0	0	1	0	0	0	0	1	1	1		
7X	AACS COMMAND ENABLE		1	1	1	0	0	0	0	0	0	1	1	0	0	0	1		

Table 3. Discrete Command Accumulator Words (Contd)

CMD SYMBOL	GROUND CMD BIT NUMBER	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
	CCS BIT NUMBER	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
	CCS COMMAND FIELDS	1	ADDRESS				A				B			C				0	1
7XR	AACS COMMAND DISABLE		1	1	1	0	0	0	0	0	0	1	1	0	0	1	0		
8X	PYRO COMMAND ENABLE		1	1	1	0	0	0	0	0	0	0	1	0	0	0	1		
8XR	PYRO COMMAND DISABLE		1	1	1	0	0	0	0	0	0	0	1	0	0	1	0		
10A	START SOLID MOTOR		1	0	0	0	0	0	1	1	0	0	0	1	0	0	0		
10B	CLOSE IPU-REA ISO VALVE				↑		0	1	0	1	0	0	0	1	0	0	0		
12A1	S/C – LV SEPARATION A				│		0	0	0	1	0	0	0	1	0	0	0		
12A2	S/C – LV SEPARATION B				│		0	0	1	0	0	0	0	1	0	0	0		
12B1	RELEASE RTG BOOM, SET 1				│		0	0	0	0	0	1	0	1	0	0	0		
12B2	RELEASE RTG BOOM, SET 2				│		0	0	0	0	0	1	1	1	0	0	0		
12C	RELEASE MAG BOOM				│		0	1	1	1	0	0	0	1	0	0	0		
12D	RELEASE SCIENCE BOOM				↓		1	0	0	0	0	0	0	1	0	0	0		
12E	JETTISON PROPULSION MODULE		1	0	0	0	0	1	1	0	0	0	0	1	0	0	0		
16X	DSS COMMAND ENABLE		1	1	1	0	0	0	1	0	0	0	0	0	0	1	1		
16XR	DSS COMMAND DISABLE		1	1	1	0	0	0	1	0	0	0	0	0	1	0	0		
39E	RELEASE MIRIS DUST COVER		1	0	0	0	0	0	0	0	1	0	0	1	0	0	0		

△ Table 3. Discrete Command Accumulator Words (contd)

CMD ID	GROUND CMD BIT NUMBER	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
	CCS BIT NUMBER	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
	CCS COMMAND FIELDS	1	ADDRESS				A				B			C				0	1
77P	NON-PRIME FCP/MEM ON		0	1	1	0	0	1	0	1	0	0	0	0	1	1	0		
77PR	NON-PRIME FCP/MEM OFF		0	1	1	0	0	1	1	0	0	0	0	0	1	1	0		
77X	MAM COMMAND ENABLE		1	1	1	0	0	0	0	1	0	1	1	0	0	1	1		
77XR	MAM COMMAND DISABLE		1	1	1	0	0	0	0	1	0	1	1	0	1	0	0		

Table 4. Coded Command Accumulator Words

NOTES:

1. The number associated with a CC is the affected subsystem designator as specified in MJS77-1-100A.

2. The letters and number following the designator differentiate between commands to a particular subsystem.

3. CMD ID may be used as a quick reference to identify the various combinations within a particular coded command.

4. CMD IDs are fields which compose a single parameter in a CC. In Table 4 the CMD IDs are read from top to bottom.

5. Table 4 shows the bit pattern as received by the CCS. In transferring a command from CCS to all user subsystems, except for the AACS, the first user bit is always zero. The next user bit is set by CCS to provide odd parity on user bits 1 through 14. See Figure 1.

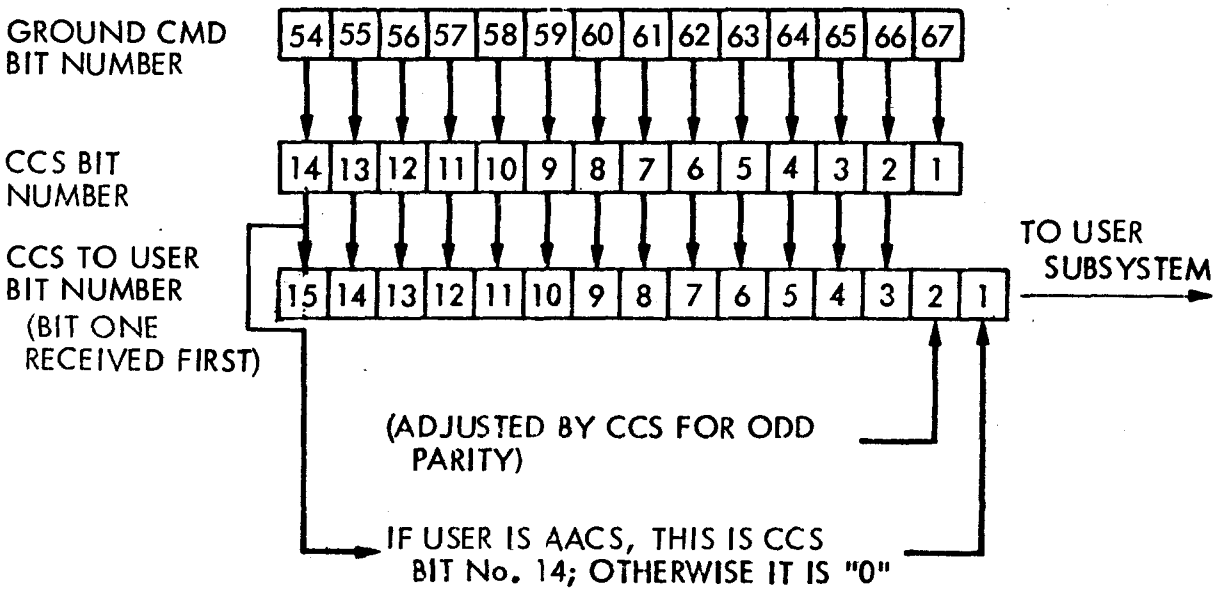


Figure 1. Bit Numbers for Coded Commands

Table 4. Coded Command Accumulator Words (Contd)

CMD ID		GROUND COMMAND BIT NUMBER	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
CMD ID		CCS BIT NUMBER	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
		MDS ADDRESS	0	0	0	1	1													1
00 through 63		MOD INDEX						(LSB)					(MSB)							
0	DRIVER SELECT	DRIVER 1 AND 2 OFF												0	0					
1	DRIVER SELECT	DRIVER 1 ON – DRIVER 2 OFF												0	1					
2	DRIVER SELECT	DRIVER 2 ON – DRIVER 1 OFF												1	0					
3	DRIVER SELECT	DRIVER 1 AND 2 ON												1	1					
0	SUBCARRIER DATA RATE	LOW FREQ, LOW RATE														0		0		
1	SUBCARRIER DATA RATE	LOW FREQ, HIGH RATE														0		1		
2	SUBCARRIER DATA RATE	HIGH FREQ, LOW RATE														1		0		
3	SUBCARRIER DATA RATE	HIGH FREQ, HIGH RATE														1		1		
		SPARE (MOS CMD SYSTEM ALWAYS SET TO ZERO)															0 1			
0	CMD ADDR	X-BAND																	0	
1	CMD ADDR	S-BAND																	1	

CC3A (TMU STATE SELECT)

Table 4. Coded Command Accumulator Words (contd)

CMD ID		FDS BIT NO.					1	2	3	4	5	6	7	8	9	10	11	12	
	GROUND BIT NO.	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
	CCS BIT NO.	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
	FDS ADDRESS	0	1	1	0	0													1
	CONTROL PATTERN						0	0	0	0	0		0	0	0	0	0	0	
0	MDS I/O A											0							
1	MDS I/O B											1							

CC6AA (SVC-W1 FDS MDS I/O SELECT)

CMD ID		FDS BIT NO.					1	2	3	4	5	6	7	8	9	10	11	12		
	GROUND BIT NO.	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	
	CCS BIT NO.	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
	FDS ADDRESS	0	1	1	0	0													1	
	CONTROL PATTERN								0	0		0			1	0	0	0		
	MEM SEL MODE																			SEE NOTE BELOW
0	HARDWARE													0						
1	SOFTWARE													1						
	PRIM MEM SEL																			
0	CROSS STRAP												0							
1	NORMAL												1							
	MASTER PROC SEL																			
0	PROC A										0									
1	PROC B										1									
0	AACS SEL: DATA 1							0												
1	DATA 2							1												
	MEM HALF SEL:																			
0	PROG HAS LOCATION 0 IN LOWER HALF						0													
1	PROG HAS LOCATION 0 IN UPPER HALF						1													

CC6AB (SVC-W2 FDS MEM/PROC SEL + AACS SELECT)

Table 4. Coded Command Accumulator Words (contd)

NOTE:

Mem Sel Mode	Prime Mem Sel	Master Proc Sel	Processor/Mem Config
0	0	0	Proc A ⟶ Mem B (Primary) Mem A (Secondary)
0	1	0	Proc A ⟶ Mem A (Primary) Mem B (Secondary)
0	0	1	Proc B ⟶ Mem A (Primary) Mem B (Secondary)
0	1	1	Proc B ⟶ Mem B (Primary) Mem A (Secondary)
1	0	0	Proc A ⟶ Primary and Secondary Mem determined by FDS Program
1	1	0	Proc A ⟶ Primary and Secondary Mem determined by FDS Program
1	0	1	Proc B ⟶ Primary and Secondary Mem determined by FDS Program
1	1	1	Proc B ⟶ Primary and Secondary Mem determined by FDS Program

Table 4. Coded Command Accumulator Words (contd)

	FDS BIT NO.						1	2	3	4	5	6	7	8	9	10	11	12	
CMD ID	GROUND BIT NO.	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
CMD ID	CCS BIT NO.	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
CMD ID	FDS ADDRESS	0	1	1	0	0													1
CMD ID	CONTROL PATTERN						0	0	0	0					0	1	0	0	
	MEM A WRITE PROTECT																		
0	UPPER HALF: NONE												0	0					
1	1000 → 19FF												1	0					
2	1000 → 1BFF												0	1					
3	1000 → 1DFF												1	1					
0	LOWER HALF: NONE										0	0							
1	0 → 09FF										1	0							
2	0 → 0BFF										0	1							
3	0 → 0DFF										1	1							

CC6AC (SVC-W3 FDS MEM A WRITE PROTECT)

△ Table 4. Coded Command Accumulator Words (contd)

							LSB											MSB	
	FDS BIT NO.						1	2	3	4	5	6	7	8	9	10	11	12	
CMD ID	GROUND BIT NO.	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
	CCS BIT NO.	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
	FDS ADDRESS	0	1	1	0	0													1
	CONTROL PATTERN														0	0	1	0	
	MEM B WRITE PROTECT																		
0	UPPER HALF: NONE												0	0					
1	1000 - 19FF												1	0					
2	1000 - 1BFF												0	1					
3	1000 - 1DFF												1	1					
0	LOWER HALF: NONE										0	0							
1	0 - 09FF										1	0							
2	0 - 0BFF										0	1							
3	0 - 0DFF										1	1							
	MEMORY SELECT A:																		
0	PROC A									0									
1	PROC B									1									
*	MDS LR OUTPUT SELECT:																		
0	40 BPS DATA								0										
↓	VITERBI RATE 1/3 SYMBOLS								1										
↓	DSS SYNC ENABLE:																		
↓	UNSYNCED							0											
↓	PN DETECT AND JUSTIFY							1											
↓	DSS RATE SEL																		
↓	PB SYNC						0												
7	HALF PB SYNC						1												

*Command ID is a decimal representation of the variable data with MSB on the right.

CC6AD (SVC-W4 FDS MEM B WRITE PROTECT)

Table 4. Coded Command Accumulator Words (contd)

CMD ID		50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
	FDS BIT NO.						1	2	3	4	5	6	7	8	9	10	11	12	
	GROUND BIT NO.	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
	CCS BIT NO.	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
	FDS ADDRESS	0	1	1	0	0													1
	CONTROL PATTERN											0			1	1	1	0	
	MEM/WRITE PROTECT																		
0	A, B/OFF, OFF												0	0					
1	A, B/OFF, ON												1	0					
2	A, B/ON, OFF												0	1					
3	A, B/ON, ON												1	1					
0	TIMING CHAIN A										0								
1	TIMING CHAIN B										1								
	CRS I/O SELECT:																		
0	I/O A									0									
1	I/O B									1									
	XDUCER PWR																		
0	PWR ON								0										
1	PWR OFF								1										
	MAG I/O SEL / LECP I/O SEL																		
0	A / A						0	0											
1	B / A						1	0											
2	A / B						0	1											
3	B / B						1	1											

CC6AE (SVC-W5 FDS PROTECT-TIM-TDPWR-I/O SEL)

Table 4. Coded Command Accumulator Words (Contd)

FDS BIT NUMBERS	1	2	3	4	5	6	7	8	9	10	11	12		
CCS TO FDS BIT NUMBERS	14	13	12	11	10	9	8	7	6	5	4	3	2	1
PARITY													P	0
SWL-A	0	0	1	1	1	1	0	0	1	0	1	0		

CC6AF (SWL-A FDS PRIMARY MEMORY SOFTWARE LOAD WITHOUT WRITE PROTECT OVERRIDE)

FDS BIT NUMBER	1	2	3	4	5	6	7	8	9	10	11	12		
CCS TO FDS BIT NUMBER	14	13	12	11	10	9	8	7	6	5	4	3	2	1
PARITY													P	0
SWL-B	0	0	1	1	1	1	0	1	1	0	1	0		

CC6AK (SWL-B FDS PRIMARY MEMORY SOFTWARE LOAD WITH WRITE PROTECT OVERRIDE)

FDS BIT NUMBER	1	2	3	4	5	6	7	8	9	10	11	12		
CCS TO FDS BIT NUMBER	14	13	12	11	10	9	8	7	6	5	4	3	2	1
PARITY													P	0
SWL-C	0	0	1	1	1	1	0	0	0	1	1	0		

CC6AL (SWL-C FDS SECONDARY SOFTWARE LOAD WITHOUT WRITE PROTECT OVERRIDE)

FDS BIT NUMBER	1	2	3	4	5	6	7	8	9	10	11	12		
CCS TO FDS BIT NUMBER	14	13	12	11	10	9	8	7	6	5	4	3	2	1
PARITY													P	0
SWL-D	0	0	1	1	1	1	0	1	0	1	1	0		

CC6AM (SWL-D FDS SECONDARY SOFTWARE LOAD WITH WRITE PROTECT OVERRIDE)

Table 4. **Coded Command Accumulator Words (contd)**

		FDS BIT NO.					1	2	3	4	5	6	7	8	9	10	11	12		
CMD ID	GROUND BIT NO.	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	
	CCS BIT NO.	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
	FDS ADDRESS	0	1	1	0	0													1	
	CONTROL PATTERN															0	1	1		
000 ↓ 511	REL ADDRESS						TABLE A REL ADDRESS													SEE NOTE BELOW

CC6AN (PARAMETER TABLE A POINTER COMMAND)

		FDS BIT NO.					1	2	3	4	5	6	7	8	9	10	11	12		
CMD ID	GROUND BIT NO.	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	
	CCS BIT NO.	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
	FDS ADDRESS	0	1	1	0	0													1	
	CONTROL PATTERN														1	0	0	1		
000 ↓ 255	REL ADDRESS						TABLE B REL ADDRESS													SEE NOTE BELOW

CC6AQ (PARAMETER TABLE B POINTER COMMAND)

		FDS BIT NO.					1	2	3	4	5	6	7	8	9	10	11	12		
CMD ID	GROUND BIT NO.	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	
	CCS BIT NO.	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
	FDS ADDRESS	0	1	1	0	0													1	
	CONTROL PATTERN														0	1	0	1		
000 ↓ 255	REL ADDRESS						TABLE C REL ADDRESS													SEE NOTE BELOW

CC6AR (PARAMETER TABLE C POINTER COMMAND)

NOTE: The bit pattern transmitted across the interface specifies the commanded pointer position relative to the origin of the FDS imaging parameter tables A, B, C, or D as appropriate; e. g., a displacement of 1 from the program load state would be commanded with CCS bits 13 ⟶ 5 as 100000000 respectively.

Table 4. Coded Command Accumulator Words (contd)

	FDS BIT NO.						1	2	3	4	5	6	7	8	9	10	11	12		
CMD ID	GROUND BIT NO.	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	
	CCS BIT NO.	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
	FDS ADDRESS	0	1	1	0	0													1	
	CONTROL PATTERN														1	1	0	1		
000 ↓ 255	REL ADDRESS						TABLE D REL ADDRESS													SEE NOTE BELOW

CC6AT (PARAMETER TABLE D POINTER COMMAND)

NOTE: The bit pattern transmitted across the interface specifies the commanded pointer position relative to the origin of the FDS imaging parameter tables A, B, C, or D as appropriate; e.g. a displacement of 1 from the program load state would be commanded with CCS bits 13⟶5 as 100000000 respectively.

FDS BIT NO.						1	2	3	4	5	6	7	8	9	10	11	12	
GROUND BIT NO.	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
CCS BIT NO.	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
FDS ADDRESS	0	1	1	0	0													1
PAR. A USE COUNTER RESET						0	0	0	0	0	0	0	0	0	0	0	1	

CC6AU (PARAMETER A USE COUNTER RESET)

FDS BIT NO.						1	2	3	4	5	6	7	8	9	10	11	12	
GROUND BIT NO.	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
CCS BIT NO.	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
FDS ADDRESS	0	1	1	0	0													1
PAR. B USE COUNTER RESET						1	0	0	0	0	0	0	0	0	0	0	1	

CC6AV (PARAMETER B USE COUNTER RESET)

Table 4. Coded Command Accumulator Words (contd)

	FDS BIT NO.					1	2	3	4	5	6	7	8	9	10	11	12	
GROUND BIT NO.	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
CCS BIT NO.	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
FDS ADDRESS	0	1	1	0	0													1
PAR. C USE COUNTER RESET						0	1	0	0	0	0	0	0	0	0	0	1	

CC6AY (PARAMETER C USE COUNTER RESET)

	FDS BIT NO.					1	2	3	4	5	6	7	8	9	10	11	12	
GROUND BIT NO.	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
CCS BIT NO.	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
FDS ADDRESS	0	1	1	0	0													1
PAR. D USE COUNTER RESET						1	1	0	0	0	0	0	0	0	0	0	1	

CC6AZ (PARAMETER D USE COUNTER RESET)

Table 4. Coded Command Accumulator Words (Contd)

FDS BIT NUMBER	1	2	3	4	5	6	7	8	9	10	11	12		
CCS TO FDS BIT NUMBER	14	13	12	11	10	9	8	7	6	5	4	3	2	1
PARITY													P	0
END OF MEMORY LOAD	1	1	1	1	1	1	1	1	1	1	1	1		

FDS END OF MEMORY LOAD

FDS BIT NUMBERS	1	2	3	4	5	6	7	8	9	10	11	12		
CCS TO FDS BIT NUMBERS	14	13	12	11	10	9	8	7	6	5	4	3	2	1
PARITY													P	0
FDS HARDWARE LOAD	0	0	1	1	1	1	0	0	1	1	0	0		

CC6BA (HWL FDS HARDWARE LOAD COMMAND)

Table 4. Coded Command Accumulator Words (Contd)

CMD ID		50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	
	GROUND CMD BIT NUMBER	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	
	CCS BIT NUMBER	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
	AACS ADDRESS	0	1	0	1														1	
						1										1	0	1		
00	NO CHANGE						0	0	0	0	0	0	0	0	0					
01	CONE ANGLE – C1						0	0	0	0	0	0	1	1	1					
02	CONE ANGLE – C2						0	0	0	0	0	0	0	1	1					
03	CONE ANGLE – C3						0	0	0	0	0	0	1	0	1					
04	CONE ANGLE – C4						0	0	0	0	0	0	0	0	1					
05	CONE ANGLE – C5						0	0	0	0	0	0	1	1	0					
06	ROLL OVERRIDE – DO						0	0	0	0	0	1	0	0	0					
07	FLYBACK – DO						0	0	0	0	1	0	0	0	0					
09	CANOPUS SEARCH - ENABLE						0	0	1	1	0	0	0	0	0					
10	HIGH GATE UPDATE						0	1	0	0	0	0	0	0	0					SEE NOTE BELOW
11	LOW GATE UPDATE						1	0	0	0	0	0	0	0	0					

	N	12	11	10	9	8	7	6	5	4	3	2	1	P	A
AACS SUBADDRESS	1										1	0	1	P	1
AACS BIT NUMBER	N	12	11	10	9	8	7	6	5	4	3	2	1	P	A

P: ADJUSTED BY CCS FOR ODD PARITY OVER ACCS BITS 12 THROUGH A, INCLUDING PARITY BIT P.

A: THIS IS CCS BIT NO. 14

NOTE: CC7CT10 AND CC7CT11 MUST BE PRECEDED BY CC7FD AND CC7SD AS SHOWN IN AC7CTG.

CC7CT (CST CONTROL)

Table 4. Coded Command Accumulator Words (contd)

CMD ID																				
	GROUND COMMAND BIT NUMBER	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	
	CCS BIT STRUCTURE	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
CMD ID	AACS ADDRESS	0	1	0	1														1	
						1										1	0	0		
1	DEADBAND UPDATE						0	0	0	0	0	0	0	0	1					SEE NOTE BELOW
2	DRIRU DRIFT RATE (PITCH A)						0	0	0	0	0	0	0	0	0					
3	DRIRU DRIFT RATE (PITCH B)						0	0	0	0	0	0	0	1	0					
4	DRIRU DRIFT RATE (YAW A)						0	0	0	0	0	0	1	0	0					
5	DRIRU DRIFT RATE (YAW C)						0	0	0	0	0	0	1	1	0					
6	DRIRU DRIFT RATE (ROLL B)						0	0	0	0	0	1	0	0	0					
7	DRIRU DRIFT RATE (ROLL C)						0	0	0	0	0	1	0	1	0					

AACS SUBADDRESS	1										1	0	0	P	1
AACS BIT NUMBER	N	12	11	10	9	8	7	6	5	4	3	2	1	P	A

P: ADJUSTED BY CCS FOR ODD PARITY OVER AACS BITS 12 THROUGH A, INCLUDING PARITY BIT A.

A: THIS IS CCS BIT NO. 14

NOTE: THIS CMD REQUIRES PRECEDING DATA WORD (CC7FD AND CC7SD) AS SHOWN IN AC7DDB AND AC7DDC.

CC7DD (DEADBAND/DRIFT CONTROL)

Table 4. Coded Command Accumulator Words (Contd)

	GROUND CMD BIT NUMBERS	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
	CCS BIT NUMBER	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
CMD ID	AACS ADDRESS	0	1	0	1														1
						1										1	1	1	
SEE NOTE BELOW	9 MSB ADDRESS BITS																		

AACS SUBADDRESS	1										1	1	1	P	1
AACS BIT NUMBER	N	12	11	10	9	8	7	6	5	4	3	2	1	P	A

ADJUSTED BY CCS FOR ODD PARITY OVER AACS BITS 12 THROUGH A, INCLUDING PARITY BIT P. → P

THIS IS CCS BIT NO. 14 → A

NOTE: CMD ID IS AN OCTAL REPRESENTATION OF THE 9 MSB ADDRESS BITS.

CC7FA (FIRST HALF ADDRESS)

Table 4. Coded Command Accumulator Words (Contd)

		50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
	GROUND CMD BIT NUMBER	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
	CCS BIT NUMBER	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
CMD ID	AACS ADDRESS	0	1	0	1														1
CMD ID						0										1	1	1	
SEE NOTE BELOW	3 LSB ADDRESS BITS																		
SEE NOTE BELOW	BLOCK LOAD LENGTH (0-63)																		

AACS SUBADDRESS	0									1	1	1	P	O
AACS BIT NUMBER	N	12	11	10	9	8	7	6	5	4	3	2	1	P	A

ADJUSTED BY CCS FOR ODD PARITY OVER AACS BITS 12 THROUGH A, INCLUDING PARITY BIT P. (→ P)

THIS IS CCS BIT NO. 14 (→ A)

NOTE: CMD ID IS AN OCTAL REPRESENTATION OF THE 3LSB OF THE ADDRESS AND BLOCK LOAD LENGTH.

CC7SA (SECOND HALF ADDRESS)

Table 4. Coded Command Accumulator Words (Contd)

		50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
	GROUND CMD BIT NUMBER	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
	CCS BIT NUMBER	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
CMD ID	AACS ADDRESS	0	1	0	1														1
						1										0	1	1	
SEE NOTE BELOW	9MSB DATA BITS																		

AACS SUBADDRESS	1										0	1	1	P	1
AACS BIT NUMBER	N	12	11	10	9	8	7	6	5	4	3	2	1	P	A

ADJUSTED BY CCS FOR ODD PARITY OVER AACS BITS 12 THROUGH A, INCLUDING PARITY BIT P. (→ P)

THIS IS CCS BIT NO. 14 (→ A)

NOTE: CMD ID IS AN OCTAL REPRESENTATION OF THE 9MSB DATA BITS.

CC7FD (FIRST HALF DATA)

Table 4. Coded Command Accumulator Words (Contd)

	GROUND CMD BIT NUMBER	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
	CCS BIT NUMBER	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
CMD ID	AACS ADDRESS	0	1	0	1														1
						0										0	1	1	
SEE NOTE BELOW	9 LSB DATA BITS																		

AACS SUBADDRESS	0										0	1	1	P	0
AACS BIT NUMBER	N	12	11	10	9	8	7	6	5	4	3	2	1	P	A

ADJUSTED BY CCS FOR ODD PARITY OVER AACS BITS 12 THROUGH A, INCLUDING PARITY BIT P. (→ P)

THIS IS CCS BIT NO. 14. (→ A)

NOTE: CMD ID IS AN OCTAL REPRESENTATION OF THE 9 LSB DATA BITS.

CC7SD (SECOND HALF DATA)

Table 4. Coded Command Accumulator Words (Contd)

CMD ID	GROUND CMD BIT NUMBER	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	
	CCS BIT NUMBER	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
	AACS ADDRESS	0	1	0	1														1	
						1										0	0	1		
1	CAPTURE RATE – LOW						0	0	0	0	0	0	0	0	1					
2	CAPTURE RATE – HIGH						0	0	0	0	0	0	0	1	1					
3	INITIALIZE (P, Y, R) ∡ = 0						0	0	0	0	0	0	1	0	0					
4	FAULT TEST – START						0	0	0	0	0	1	0	0	0					
5	FAULT TEST – STOP						0	0	0	0	1	1	0	0	0					
8	USAGE PATTERN – UPDATE						0	1	0	0	0	0	0	0	0					NOTE

AACS SUBADDRESS	1										0	0	1	P	1
AACS BIT NUMBER	N	12	11	10	9	8	7	6	5	4	3	2	1	P	A

P: ADJUSTED BY CCS FOR ODD PARITY OVER AACS BITS 12 THROUGH A, INCLUDING PARITY BIT P.

A: THIS IS CCS BIT NO. 14

NOTE: CC7GY8 MUST BE PRECEDED BY CC7FD AND CC7SD AS SHOWN IN AC7GYP.

CC7GY (DRIRU CONTROL)

Table 4. Coded Command Accumulator Words (Contd)

CMD ID		50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	
	GROUND CMD BIT NUMBER	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	
	CCS BIT NUMBER	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
CMD ID	AACS ADDRESS	0	1	0	1														1	
						0										1	1	0		
1	LAUNCH						0	0	0	0	0	0	0	0	1					SEE NOTE BELOW
2	PM – (BURN)						0	0	0	0	0	0	0	1	0					
3	PM – (POST BURN)						0	0	0	0	0	0	1	0	0					
5	ROLL INERTIAL						0	0	0	0	1	0	0	0	0					
6	ALL AXES INERTIAL						0	0	0	1	0	0	0	0	0					
7	MM TCM BURN						0	0	1	0	0	0	0	0	0					
8	PM – (PREBURN)						0	1	0	0	0	0	0	0	0					

AACS SUBADDRESS	0										1	1	0	P	O
AACS BIT NUMBER	N	12	11	10	9	8	7	6	5	4	3	2	1	P	A

ADJUSTED BY CCS FOR ODD PARITY OVER AACS BITS 12 THROUGH A, INCLUDING PARITY BIT P. (→ P)

THIS IS CCS BIT NO. 14 (→ A)

NOTE: THIS CMD MUST BE PRECEDED BY CC7ML04 AS SHOWN IN AC7MDP.

CC7MD (MODE CONTROL)

Table 4. Coded Command Accumulator Words (Contd)

CMD ID	GROUND CMD BIT NUMBER	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	
	CCS BIT NUMBER	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
	AACS ADDRESS	0	1	0	1														1	
						1										1	1	0		
01	FDS CHANNEL SELECT – A						0	0	0	0	0	0	0	0	1					
02	FDS CHANNEL SELECT – B						0	0	0	0	0	0	0	1	1					
03	MEMORY DUMP						0	0	0	0	0	0	1	0	0					SEE NOTE 1 BELOW
04	CMD PRECURSOR						0	0	0	0	0	1	0	0	0					SEE NOTE 2 BELOW
05	CST POWER ENABLE						0	0	0	0	1	0	0	0	0					
06	CST POWER DISABLE						0	0	0	1	1	0	0	0	0					
07	FCP REINITIALIZE						0	0	1	0	0	0	0	0	0					
08	TURN ABORT						0	1	0	0	0	0	0	0	0					
09	TCAPU FAULT TEST ENABLE						0	1	1	0	0	0	0	0	0					
10	TCAPU FAULT TEST DISABLE						1	0	0	0	0	0	0	0	0					

AACS SUBADDRESS	1									1	1	0	P	1
AACS BIT NUMBERS	N	12	11	10	9	8	7	6	5	4	3	2	1	P	A

ADJUSTED BY CCS FOR ODD PARITY OVER AACS BITS 12 THROUGH 14 INCLUDING PARITY BIT P (→ P)

THIS IS CCS BIT NUMBER 14 (→ A)

NOTES: 1. CC7ML03 MUST BE PRECEDED BY CC7FD AND CC7SD AS SHOWN IN AC7MLD.

2. CC7ML04 MUST PRECEDE ANY MODE, REGISTER CONTROL, OR GROUND INITIATED POWER CODE COMMAND.

CC7ML (MISCELLANEOUS LOGIC CONTROL)

Table 4. Coded Command Accumulator Words (Contd)

CMD ID	GROUND CMD BIT NUMBER	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	
	CCS BIT NUMBER	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
	AACS ADDRESS	0	1	0	1														1	
						0										0	1	0		
1	CCS INTERFACE CHECK												0	0	1					NOTE 2
2	GROUND CMD PC												0	1	0					
3	ECHO PC												1	0	0					
00	NO – OP						0	0	0	0	0	0								SEE NOTE 1 BELOW
01	DUMMY PWR CMD						0	0	0	0	0	1								
02	DUMMY PWR CMD						0	0	0	0	1	0								
03	DUMMY PWR CMD						0	0	0	0	1	1								
04	ADET NOT ACQUIRED ($\overline{\text{ADET}}$)						0	0	0	1	0	0								
05	ADET ACQ. (ADET)						0	0	0	1	0	1								
06	STAR NOT ACQUIRED ($\overline{\text{CA}}$)						0	0	0	1	1	0								
07	STAR ACQUIRED (CA)						0	0	0	1	1	1								
10	ISO VALVE PWR – BR1 – OFF						0	0	1	0	0	0								
11	ISO VALVE PWR – BR1 – ON						0	0	1	0	0	1								
12	DUMMY PWR CMD						0	0	1	0	1	0								
13	DUMMY PWR CMD						0	0	1	0	1	1								
14	HYBIC 1 OFF, 2 ON						0	0	1	1	0	0								
15	HYBIC 2 OFF, 1 ON						0	0	1	1	0	1								
16	HYBIC 1 OFF, 2 ON (REDT)						0	0	1	1	1	0								
17	HYBIC 2 OFF, 1 ON (REDT)						0	0	1	1	1	1								
20	ISO VALVE PWR – BR2 – OFF						0	1	0	0	0	0								
21	IOS VALVE PWR – BR2 – ON						0	1	0	0	0	1								
22	CST SUN SHUTTER – OFF						0	1	0	0	1	0								
23	CST SUN SHUTTER – ON						0	1	0	0	1	1								
24	POWER SUPPLY FAIL						0	1	0	1	0	0								
25	MEMORY REFRESH FAIL						0	1	0	1	0	1								
26	IDET NOT ACQUIRED ($\overline{\text{IDET}}$)						0	1	0	1	1	0								
27	IDET ACQ (IDET)						0	1	0	1	1	1								
30	DUMMY PWR CMD						0	1	1	0	0	0								
31	DUMMY PWR CMD						0	1	1	0	0	1								
32	CST 1 – OFF						0	1	1	0	1	0								
33	CST 1 – ON						0	1	1	0	1	1								
34	FCP SELF TEST PASSED						0	1	1	1	0	0								
35	FCP SELF TEST PASSED (REDT)						0	1	1	1	0	1								
36	FCP SELF TEST PASSED (REDT)						0	1	1	1	1	0								
37	HEART BEAT						0	1	1	1	1	1								
40	DUMMY PWR CMD						1	0	0	0	0	0								
41	DUMMY PWR CMD						1	0	0	0	0	1								
42	CST 2 – OFF						1	0	0	0	1	0								
43	CST 2 – ON						1	0	0	0	1	1								
44	TCM BURN ABORT						1	0	0	1	0	0								
45	MM/PM COMMANDED TURN COMPLETE						1	0	0	1	0	1								
46	SEQUENCE CHECK SPARE						1	0	0	1	1	0								
47	SEQUENCE CHECK SPARE						1	0	0	1	1	1								
50	DUMMY PWR CMD						1	0	1	0	0	0								
51	DUMMY PWR CMD						1	0	1	0	0	1								
52	GYRO A – OFF						1	0	1	0	1	0								
53	GYRO A – ON						1	0	1	0	1	1								
54	SCAN SLEW ABORT						1	0	1	1	0	0								
55	COMMAND PARITY ERROR						1	0	1	1	0	1								
56	BAD NO ECHO RESPONSE						1	0	1	1	1	0								
57	COMMAND SEQUENCE ERROR						1	0	1	1	1	1								
60	BAY 6 HTR A ON						1	1	0	0	0	0								
61	BAY 6 HTR A OFF						1	1	0	0	0	1								
62	GYRO B – OFF						1	1	0	0	1	0								
63	GYRO B – ON						1	1	0	0	1	1								
64	OMEN – PRECURSOR						1	1	0	1	0	0								
65	OMEN – PRECURSOR (REDT)						1	1	0	1	0	1								
66	TCAPU FAIL						1	1	0	1	1	0								
67	GYRO FAIL						1	1	0	1	1	1								
70	BAY 6 HTR B ON						1	1	1	0	0	0								
71	BAY 6 HTR B OFF						1	1	1	0	0	1								
72	GYRO C – OFF						1	1	1	0	1	0								
73	GYRO C – ON						1	1	1	0	1	1								
74	INTERFACE CHECK SPARE						1	1	1	1	0	0								
75	INTERFACE CHECK SPARE						1	1	1	1	0	1								
76	INTERFACE CHECK SPARE						1	1	1	1	1	0								
77	INTERFACE CHECK SPARE						1	1	1	1	1	1								
	AACS SUBADDRESS					0										0	1	0	P	0
	AACS BIT NUMBER					N	12	11	10	9	8	7	6	5	4	3	2	1	P	A

ADJUSTED BY CCS FOR ODD PARITY OVER AACS BITS 12 THROUGH A, INCLUDING PARITY BIT P. (→ P)

THIS IS CCS BIT NO. 14. (→ A)

NOTES: 1. CMD IDS ARE IN OCTAL.
2. CC7PC2 MUST BE PRECEDED BY CC7ML04 AS SHOWN IN AC7PCG.

CC7PC (POWER CODE CONTROL)

Table 4. Coded Command Accumulator Words (Contd)

CMD ID																				
	GROUND CMD BIT NUMBER	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	
	CCS BIT NUMBER	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
	AACS ADDRESS	0	1	0	1														1	
						0										1	0	0		
1	ISO VALVE RESET/ PYRO EVENT						0	0	0	0	0	0	0	0	1					SEE NOTE 1 BELOW
2	OPEN X TCM ISO VALVE						0	0	0	0	0	0	0	1	0					
3	OPEN Y TCM ISO VALVE						0	0	0	0	0	0	1	1	0					
4	LOAD ISO VALVE REGISTER						0	0	0	0	0	1	0	0	0					SEE NOTES 2 & 3 BELOW
5	LOAD CONFIGURATION REGISTER						0	0	0	0	1	0	0	0	0					
6	LOAD PROP REGISTER						0	0	0	1	0	0	0	0	0					

AACS SUBADDRESS	0										1	0	0	P	0
AACS BIT NUMBER	N	12	11	10	9	8	7	6	5	4	3	2	1	P	A

ADJUSTED BY CCS FOR ODD PARITY OVER AACS BITS 12 THROUGH A, INCLUDING PARITY BIT P. (→ P)

THIS IS CCS BIT NO. 14. (→ A)

NOTES:
1. CC7ML04 MUST PRECEDE CC7RC1, CC7RC2, AND CC7RC3 AS SHOWN IN AC7RCB.
2. CC7FD, CC7SD, AND CC7ML04 MUST PRECEDE CC7RC4, CC7RC5, AND CC7RC6 AS SHOWN IN AC7RCR.
3. CC7RC4, CC7RC5, AND CC7RC6 MUST ONLY BE USED IN THE LAUNCH MODE AND ONLY USED FOR GROUND TESTING.

CC7RC (REGISTER CONTROL)

Table 4. Coded Command Accumulator Words (Contd)

CMD ID	GROUND CMD BIT NUMBER	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
	CCS BIT NUMBER	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
	AACS ADDRESS	0	1	0	1														1
						0										0	0	1	
1 2	SLEW AXIS – EL SLEW AXIS – AZ														0 1				
1 2	FINE POT USED – A FINE POT USED – B													0 1					
SEE NOTE 2 & 3 BELOW	SLEW RATE									0 . . 1	0 . . 1	0 . . 1	0 . . 1						
	RATE SCALING – DON'T RATE SCALING – DO								0 1										
1 2	NO COARSE POT DATA COARSE POT USED							0 1											
1 2	STACK COMMANDS OVERRIDE STACK						0 1												

SEE NOTE 1 BELOW

	N	12	11	10	9	8	7	6	5	4	3	2	1	P	A
AACS SUBADDRESS	0										0	0	1	P	0
AACS BIT NUMBER	N	12	11	10	9	8	7	6	5	4	3	2	1	P	A

ADJUSTED BY CCS FOR ODD PARITY OVER AACS BITS 12 THROUGH A, INCLUDING PARITY BIT P. (→ P)

THIS IS CCS BIT NO. 14. (→ A)

NOTES:

1. THIS COMMAND REQUIRES PRECEDING DATA WORD AS SHOWN IN AC7SPK, AC7SPL, AC7SPM, AND AC7SPN.
2. IF RATE SCALE = 0 (CCS BIT NO. 11), SLEW RATE = 1/(CMD ID) WHERE CMD ID IS FROM 01 TO 15. CMD ID = 00 IS UNACCEPTABLE.
3. IF RATE SCALE = 1 (CCS BIT NO. 11), SLEW RATE = 1/(16(CMD ID - 15)) WHERE CMD ID IS FROM 16 TO 30.
4. (Deleted)

CC7SP (SCIENCE PLATFORM CONTROL)

Table 4. Coded Command Accumulator Words (Contd)

CMD ID		50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	
	GROUND CMD BIT NUMBER	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	
	CCS BIT NUMBER	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
	AACS ADDRESS	0	1	0	1														1	
						0										1	0	1		SEE NOTES BELOW
1	SEARCH ENABLE						0	0	0	0	0	0	0	0	1					
3	PITCH BIAS UPDATE						0	0	0	0	0	0	1	0	0					NOTE 1
4	YAW BIAS UPDATE						0	0	0	0	0	1	0	0	0					NOTE 1
5	INTENSITY GATE UPDATE						0	0	0	0	1	0	0	0	0					NOTE 2
6	SUN POINT ENABLE						0	0	0	1	0	0	0	0	0					
7	EARTH POINT ENABLE						0	0	1	1	0	0	0	0	0					

AACS SUBADDRESS	0										1	0	1	P	O
AACS BIT NUMBER	N	12	11	10	9	8	7	6	5	4	3	2	1	P	A

ADJUSTED BY CCS FOR ODD PARITY OVER AACS BITS 12 THROUGH A, INCLUDING PARITY BIT P. (→ P)

THIS IS CCS BIT NO. 14. (→ A)

NOTE: 1. CC7SS3 AND CC7SS4 MUST BE PRECEDED BY CC7FD AND CC7SD AS SHOWN IN AC7SSB.
2. CC7SS5 MUST BE PRECEDED BY CC7FD AND CC7SD AS SHOWN IN AC7SSG.

CC7SS (SUN SENSOR CONTROL)

Table 4. Coded Command Accumulator Words (Contd)

CMD ID		50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	
	GROUND CMD BIT NUMBER	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	
	CCS BIT NUMBER	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
	AACS ADDRESS	0	1	0	1														1	
						1										0	1	0		SEE NCTE BELOW
1 2 3	AXIS – PITCH AXIS – YAW AXIS – ROLL						0 0 0	0 0 0	0 0 0	0 0 0			0 0 1	0 1 0	1 0 0					
1 2	POLARITY – POSITIVE POLARITY – NEGATIVE						0 0	0 0	0 0	0 0		0 1								
1 2	RANGE SCALING – (X1) RANGE SCALING – (X10)						0 0	0 0	0 0	0 0	0 1									

AACS SUBADDRESS	1										0	1	0	P	1
AACS BIT NUMBER	N	12	11	10	9	8	7	6	5	4	3	2	1	P	A

ADJUSTED BY CCS FOR ODD PARITY OVER AACS BITS 12 THROUGH A, INCLUDING PARITY BIT P. (→ P)

THIS IS CCS BIT NO. 14. (→ A)

NOTE: THIS CMD REQUIRES PRECEDING DATA WORD (CC7FD AND CC7SD) AS SHOWN IN AC7TCD.

CC7TC (TURN COMMAND CONTROL)

Table 4. Coded Command Accumulator Words (Contd)

CMD ID		Ground CMD Bit Number	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
		CCS Bit Number	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
		DSS Address	0	1	0	0	1													1
0	Mode	No-Change						0	0	0										
1		Playback						0	0	1										
2		Slew						0	1	0										
3		Record 115.2 kbps						0	1	1										
4		Record FDS 7.2 kbps						1	0	0										
5		Spare						1	0	1										
6		Spare						1	1	0										
7		Ready						1	1	1										
0	Data Rate	No-Change									0	0	0							
1		No-Change									1	1	0							
2		7.2 kbps									0	1	0							
3		21.6 kbps									1	1	1							
4		33.6 kbps									0	0	1							
5		57.6 kbps									1	0	1							
6		Spare									1	0	0							
7		High Rate Record Speed									0	1	1							
0	Direc-tion	No-Change												0	0					
1		Forward												0	1					
2		Reverse												1	0					
3		No-Change (spare)												1	1					
0	Track Selection	No-Change														0	0	0	0	
1		Track 1														0	0	0	1	
2		Track 2														0	0	1	0	
3		Track 3														0	0	1	1	
4		Track 4														0	1	0	0	
5		Track 5														0	1	0	1	
6		Track 6														0	1	1	0	
7		Track 7														0	1	1	1	
8		Track 8														1	0	0	0	

CC16C (DSS STATE SELECT)

△ Table 4. Coded Command Accumulator Words (Contd)

	CMD ID		50	51	52	53	4	55	56	57	58	59	60	61	62	63	64	65	66	67
		GROUND CMD BIT NUMBER	50	51	52	53	4	55	56	57	58	59	60	61	62	63	64	65	66	67
		CCS BIT NUMBER	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
		AACS ADDRESS	0	0	1	1														1
							1	0	0	0	0	0	0						0	
(1)	1	MODE SELECT																0		
	2	READ WRITE																1		
(2)	0	NO CHANGE												0	0	0	0			
	1	Increment address by 1_{10}												0	0	0	1			
	2	Increment address by 16_{10}												0	0	1	0			
	3	Increment address by 17_{10}												0	0	1	1			
	4	Increment address by 256_{10}												0	1	0	0			
	5	Increment address by 257_{10}												0	1	0	1			
	6	Increment address by 272_{10}												0	1	1	0			
	7	Increment address by 273_{10}												0	1	1	1			
	8	Reset address to ZERO												1	0	0	0			

CC77CW (1)(2)

AACS SUBADDRESS	1	0	0	0	0	0	0						P	1
AACS BIT NUMBER	N	12	11	10	9	8	7	6	5	4	3	2	1	P	A

ADJUSTED BY CCS FOR ODD PARITY OVER AACS BITS 12 THROUGH A, INCLUDING PARITY BIT P

THIS IS CCS BIT NO. 14

CC77CW (MAM CONTROL WORD)

△ Table 4. Coded Command Accumulator Words (contd)

CMD ID																			
	GRN CMD BIT NO.	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
	CCS BIT NUMBER	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
CMD	AACS ADDRESS	0	0	1	1														1
ID						0											0	0	
0000 to 1777_8	WRITE WORD A						Z_{10}	Z_9	Z_8	Z_9	Z_{10}	Z_5	Z_4	Z_3	Z_2	Z_1			SEE NOTES BELOW

AACS SUBROUTINE	0											0	0	P	0
AACS BIT NUMBER	N	12	11	10	9	8	7	6	5	4	3	2	1	P	A

ADJUSTED BY CCS FOR ODD PARITY OVER AACS BITS 12 THROUGH A, INCLUDING PARITY BIT P → P

THIS CCS BIT NUMBER 14 → A

NOTES:
1. $Z_{18}\ Z_{17} \ldots Z_1$ = Z is the 18 bit memory word
2. $M_{12}\ M_{11} \ldots M_1$ = is the 12 bit address of Z
3. CMD IDs ARE AN OCTAL REPRESENTATION OF THE ADDRESS OR DATA WORD

CC77WA (WRITE WORD A)

△ Table 4. Coded Command Accumulator Words (contd)

CMD ID		50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	
	GRN CMD BIT NO.	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	
	CCS BIT NUMBER	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
CMD ID	AACS ADDRESS	0	0	1	1														1	
						0											0	1		
0000 to 177778	WRITE WORD B						M_2	M_1	Z_{18}	Z_{17}	Z_{16}	Z_{15}	Z_{14}	Z_{13}	Z_{12}	Z_{11}				SEE NOTES BELOW

AACS SUBADDRESS	0										0	1	P	0
AACS BIT NUMBER	N	12	11	10	9	8	7	6	5	4	3	2	1	P	A

ADJUSTED BY CCS FOR ODD PARITY OVER AACS BITS 12 THROUGH A, INCLUDING PARITY BIT P. → P

THIS CCS BIT NO. 14 → A

NOTES:
1. $Z_{18} Z_{17} \ldots Z_1$ = Z is the 18 bit memory word
2. $M_{12} M_{11} \ldots M_1$ = M is the 12 bit address of Z
3. CMD IDs ARE AN OCTAL REPRESENTATION OF THE ADDRESS OR DATA WORD

CC77WB (WRITE WORD B)

△ Table 4. Coded Command Accumulator Words (Contd)

CMD ID																			
	GRN CMD BIT NO.	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
	CCS BIT NUMBER	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
CMD ID	AACS ADDRESS	0	0	1	1														1
	X					0											1	0	
0000 to 1777_8	WRITE WORD C						M_{12}	M_{11}	M_{10}	M_9	M_8	M_7	M_6	M_5	M_4	M_3			SEE NOTES BELOW

AACS SUBADDRESS	0										1	0	P	0
AACS BIT NUMBER	N	12	11	10	9	8	7	6	5	4	3	2	1	P	A

P: ADJUSTED BY CCS FOR ODD PARITY OVER AACS BITS 12 THROUGH A, INCLUDING PARITY BIT P

A: THIS IS CCS BIT NO. 14

NOTES:
1. $Z_{18}\ Z_{17} \ldots Z_1 = Z$ is the 18 bit memory word.
2. $M_{12}\ M_{11} \ldots M_1 = M$ is the 12 bit address of Z.
3. CMD IDs are an octal representation of the address or data word.

CC77WC (WRITE WORD C)

Table 5. Coded Command Accumulator Words for Power Switching

NOTES:

1. The number associated with a CC is the affected subsystem designator as specified in MJS77-1-100A.
2. The letters and number following the designator differentiate between commands to a particular subsystem.
3. A command that is a complement of another is identified with the symbol R.
4. The suffix P or S in the command symbol represents primary or secondary power relays respectively.
5. CMD ID may be used as a quick reference to identify the various combinations within a particular coded command.
6. CMD IDs are fields which compose a single parameter in a CC. In Table 5 the CMD IDs are read from top to bottom.
7. Whenever an AACS power switching command is used, it must be followed by CC7PC (plus precursor command).
8. Table 5 shows the bit pattern as received by the CCS. In transferring a command from CCS to all user subsystems, except for the AACS, the first user bit is zero. The next bit is set by CCS to provide odd parity on user bits 1 through 14. See Figure 2.

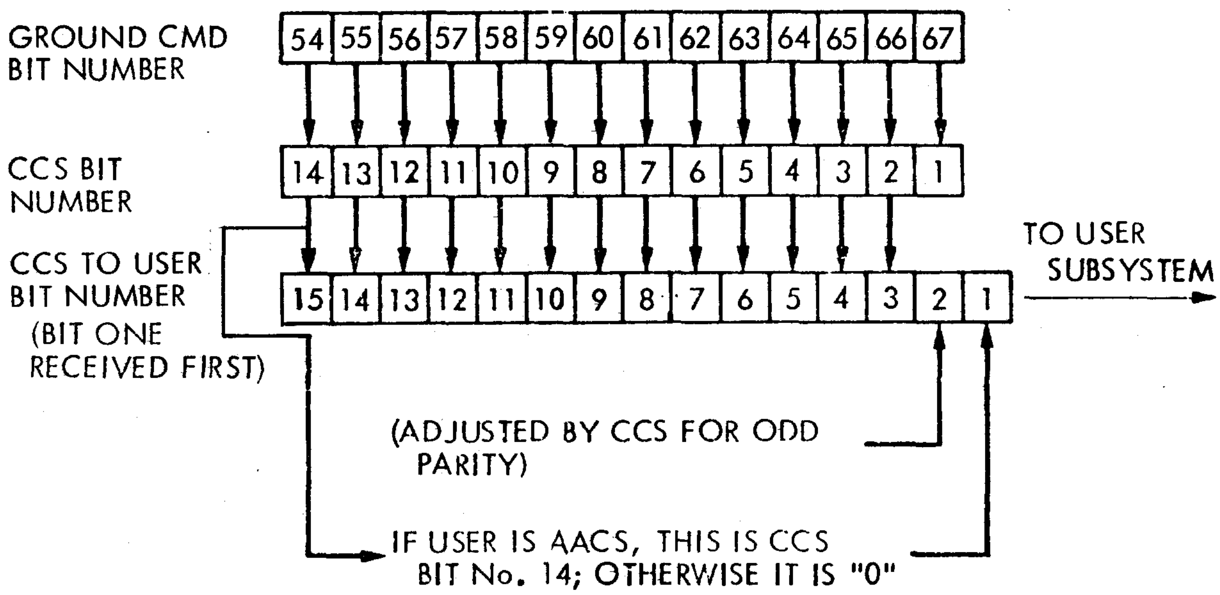


Figure 2. Bit Numbers for Coded Commands

Table 5. Coded Command Accumulator Words for Power Switching (Contd)

CMD ID			50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
		Ground CMD Bit Number	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
		CCS Bit Number	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
CMD ID		PWR Address	0	0	1	0	1													1
		Spare						0	0											
								0	1											
								1	0											
								1	1											
0	Decoder Select	Command Reject									0	0								
1	Decoder Select	Decoder A									0	1								
2	Decoder Select	Decoder B									1	0								
3	Decoder Select	Command Reject									1	1								

Command	57	60	61	62	63	64	65	66
1C (MAG CAL COIL ON)	0	1	0	1	1	0	1	0
1CR (MAG CAL COIL OFF)	0	1	0	1	1	0	1	1
1D (DSS BAY 2 HTR ON)	1	1	0	1	0	0	0	0
1DR (DSS BAY 2 HTR OFF)	1	1	0	1	0	0	0	1
1PHP (SCAN PLTFM SUP HTR ON; with CC1PHS)	0	0	0	0	1	1	1	0
1PHP (SCAN PLTFM SUP HTR OFF; with CC1PHRS)	0	0	0	0	1	1	1	0
1PHRP (SCAN PLTFM SUP HTR OFF; with CC1PHS)	0	0	0	0	1	1	1	1
1PHRP (SCAN PLTFM SUP HTR ON; with CC1PHRS)	0	0	0	0	1	1	1	1
1PHS (SCAN PLTFM SUP HTR ON; with CC1PHP)	0	1	0	0	1	0	1	0
1PHS (SCAN PLTFM SUP HTR OFF; with CC1PHRP)	0	1	0	0	1	0	1	0
1PHRS (SCAN PLTFM SUP HTR OFF; with CC1PHP)	0	1	0	0	1	0	1	1
1PHRS (SCAN PLTFM SUP HTR ON; with CC1PHRP)	0	1	0	0	1	0	1	1
1T (BAY 1 HTR ON)	0	1	1	0	1	0	1	1
1TR (BAY 1 HTR OFF)	0	1	1	0	1	0	1	0
2BP (S-BAND EXCITER 1 SELECT; with CC2BS)	1	0	0	0	1	0	0	0
2BP (S-BAND EXCITER 2 SELECT; with CC2BRS)	1	0	0	0	1	0	0	0
2BRP (S-BAND EXCITER 2 SELECT; with CC2BS)	1	0	0	0	1	0	0	1
2BRP (S-BAND EXCITER 1 SELECT; with CC2BRS)	1	0	0	0	1	0	0	1
2BS (S-BAND EXCITER 1 SELECT; with CC2BP)	1	1	0	0	1	1	0	0
2BS (S-BAND EXCITER 2 SELECT; with CC2BRP)	1	1	0	0	1	1	0	0
2BRS (S-BAND EXCITER 2 SELECT; with CC2BP)	1	1	0	0	1	1	0	1
2BRS (S-BAND EXCITER 1 SELECT; with CC2BRP)	1	1	0	0	1	1	0	1
2CP (S-BAND TRANSMITTER 1 SELECT; with CC2CS)	1	0	0	0	0	1	1	0
2CP (S-BAND TRANSMITTER 2 SELECT; with CC2CRS)	1	0	0	0	0	1	1	0
2CRP (S-BAND TRANSMITTER 2 SELECT; with CC2CS)	1	0	0	0	0	1	1	1
2CRP (S-BAND TRANSMITTER 1 SELECT; with CC2CRS)	1	0	0	0	0	1	1	1
2CS (S-BAND TRANSMITTER 1 SELECT; with CC2CP)	1	1	0	0	0	0	1	0
2CS (S-BAND TRANSMITTER 2 SELECT; with CC2CRP)	1	1	0	0	0	0	1	0
2CRS (S-BAND TRANSMITTER 2 SELECT; with 2CP)	1	1	0	0	0	0	1	1
2CRS (S-BAND TRANSMITTER 1 SELECT; with 2CRP)	1	1	0	0	0	0	1	1
2FP (RCVR 1 SELECT; with CC2FS)	1	0	1	1	0	0	0	0
2FP (RCVR 2 SELECT; with CC2FRS)	1	0	1	1	0	0	0	0
2FRP (RCVR 2 SELECT; with CC2FS)	1	0	1	1	0	0	0	1
2FRP (RCVR 1 SELECT; with CC2FRS)	1	0	1	1	0	0	0	1
2FS (RCVR 1 SELECT; with CC2FP)	1	1	1	1	0	1	0	0
2FS (RCVR 2 SELECT; with CC2FRP)	1	1	1	1	0	1	0	0
2FRS (RCVR 2 SELECT; with CC2FP)	1	1	1	1	0	1	0	1
2FRS (RCVR 1 SELECT; with CC2FRP)	1	1	1	1	0	1	0	1
2GP (X-BAND TRANSMITTER POWER ON; with CC2GS)	0	0	0	0	0	1	0	0
2GP (X-BAND TRANSMITTER POWER OFF; with CC2GRS)	0	0	0	0	0	1	0	0
2GRP (X-BAND TRANSMITTER POWER OFF; with CC2GS)	0	0	0	0	0	1	0	1
2GRP (X-BAND TRANSMITTER POWER ON; with CC2GRS)	0	0	0	0	0	1	0	1
2GS (X-BAND TRANSMITTER POWER ON; with CC2GP)	0	1	0	0	0	0	0	0
2GS (X-BAND TRANSMITTER POWER OFF: with CC2GRP)	0	1	0	0	0	0	0	0

Table 5. Coded Command Accumulator Words for Power Switching (Contd)

CMD ID		Ground CMD Bit Number	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
		CCS Bit Number	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
		PWR Address	0	0	1	0	1													1
		Spare						0	0											
								0	1											
								1	0											
								1	1											
0	Decoder Select	Command Reject									0	0								
1	Decoder Select	Decoder A									0	1								
2	Decoder Select	Decoder B									1	0								
3	Decoder Select	Command Reject									1	1								
		2GRS (X-BAND TRANSMITTER POWER OFF; with CC2GP)	0										1	0	0	0	0	0	1	
		2GRS (X-BAND TRANSMITTER POWER ON; with CC2GRP)	0										1	0	0	0	0	0	1	
		2JP (X-BAND EXCITER 1 SELECT; with CC2JS)	1										0	0	0	1	0	1	0	
		2JP (X-BAND EXCITER 2 SELECT; with CC2JRS)	1										0	0	0	1	0	1	0	
		2JRP (X-BAND EXCITER 2 SELECT; with CC2JS)	1										0	0	0	1	0	1	1	
		2JRP (X-BAND EXCITER 1 SELECT; with CC2JRS)	1										0	0	0	1	0	1	1	
		2JS (X-BAND EXCITER 1 SELECT; with CC2JP)	1										1	0	0	1	1	1	0	
		2JS (X-BAND EXCITER 2 SELECT; with CC2JRP)	1										1	0	0	1	1	1	0	
		2JRS (X-BAND EXCITER 2 SELECT; with CC2JP)	1										1	0	0	1	1	1	1	
		2JRS (X-BAND EXCITER 1 SELECT; with CC2JRP)	1										1	0	0	1	1	1	1	
		2KP (S-BAND TRANSMITTER POWER ON; with CC2KS)	1										0	0	0	0	1	0	0	
		2KP (S-BAND TRANSMITTER POWER OFF; with CC2KRS)	1										0	0	0	0	1	0	0	
		2KRP (S-BAND TRANSMITTER POWER OFF; with CC2KS)	1										0	0	0	0	1	0	1	
		2KRP (S-BAND TRANSMITTER POWER ON; with CC2KRS)	1										0	0	0	0	1	0	1	
		2KS (S-BAND TRANSMITTER POWER ON; with CC2KP)	1										1	0	0	0	0	0	0	
		2KS (S-BAND TRANSMITTER POWER OFF; with CC2KRP)	1										1	0	0	0	0	0	0	
		2KRS (S-BAND TRANSMITTER POWER OFF; with 2KP)	1										1	0	0	0	0	0	1	
		2KRS (S-BAND TRANSMITTER POWER ON; with 2KRP)	1										1	0	0	0	0	0	1	
		2LP (X-BAND TWTA 1 SELECT; with CC2LS)	0										0	0	0	0	1	1	0	
		2LP (X-BAND TWTA 2 SELECT; with CC2LRS)	0										0	0	0	0	1	1	0	
		2LRP (X-BAND TWTA 2 SELECT; with CC2LS)	0										0	0	0	0	1	1	1	
		2LRP (X-BAND TWTA 1 SELECT; with CC2LRS)	0										0	0	0	0	1	1	1	
		2LS (X-BAND TWTA 1 SELECT; with CC2LP)	0										1	0	0	0	0	1	0	
		2LS (X-BAND TWTA 2 SELECT; with CC2LRP)	0										1	0	0	0	0	1	0	
		2LRS (X-BAND TWTA 2 SELECT; with CC2LP)	0										1	0	0	0	0	1	1	
		2LRS (X-BAND TWTA 1 SELECT; with CC2LRP)	0										1	0	0	0	0	1	1	
		2MP (S-BAND EXCITER POWER ON; with CC2MS)	1										0	1	1	0	0	1	0	
		2MP (S-BAND EXCITER POWER OFF; with CC2MRS)	1										0	1	1	0	0	1	0	
		2MRP (S-BAND EXCITER POWER OFF; with CC2MS)	1										0	1	1	0	0	1	1	
		2MRP (S-BAND EXCITER POWER ON; with CC2MRS)	1										0	1	1	0	0	1	1	
		2MS (S-BAND EXCITER POWER ON; with CC2MP)	1										1	1	1	0	1	1	0	
		2MS (S-BAND EXCITER POWER OFF; with CC2 MRP)	1										1	1	1	0	1	1	0	
		2MRS (S-BAND EXCITER POWER OFF; with CC2MP)	1										1	1	1	0	1	1	1	
		2MRS (S-BAND EXCITER POWER ON; with CC2MRP)	1										1	1	1	0	1	1	1	

Table 5. Coded Command Accumulator Words for Power Switching (Contd)

CMD ID		Ground CMD Bit Number	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
		CCS Bit Number	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
		PWR Address	0	0	1	0	1													1
		Spare						0	0											
								0	1											
								1	0											
								1	1											
0	Decoder Select	Command Reject									0	0								
1		Decoder A									0	1								
2		Decoder B									1	0								
3		Command Reject									1	1								
		3BP (TMU POWER ON; with CC3BS)								1			0	0	0	0	0	0	0	
		3BP (TMU POWER OFF; with CC3BRS)								1			0	0	0	0	0	0	0	
		3BRP (TMU POWER OFF; with CC3BS)								1			0	0	0	0	0	0	1	
		3BRP (TMU ON; with CC3BRS)								1			0	0	0	0	0	0	1	
		3BS (TMU POWER ON; with CC3BP)								1			1	0	0	0	1	0	0	
		3BS (TMU POWER OFF; with CC3BRP)								1			1	0	0	0	1	0	0	
		3BRS (TMU POWER OFF; with CC3BP)								1			1	0	0	0	1	0	1	
		3BRS (TMU POWER ON; with CC3BRP)								1			1	0	0	0	1	0	1	
		3GP (TMU-A SELECT; with CC3GS)								1			0	0	0	0	0	1	0	
		3GP (TMU-B SELECT; with CC3GRS)								1			0	0	0	0	0	1	0	
		3GRP (TMU-B SELECT; with CC3GS)								1			0	0	0	0	0	1	1	
		3GRP (TMU-A SELECT; with CC3GRS)								1			0	0	0	0	0	1	1	
		3GS (TMU-A SELECT; with CC3GP)								1			1	0	0	0	1	1	0	
		3GS (TMU-B SELECT; with CC3GRP)								1			1	0	0	0	1	1	0	
		3GRS (TMU-B SELECT; with CC3GP)								1			1	0	0	0	1	1	1	
		3GRS (TMU-A SELECT; with CC3GRP)								1			1	0	0	0	1	1	1	
		3HP (CDU A SELECT; with CC3HS)								1			0	0	1	0	0	0	0	
		3HP (CDU B SELECT; with CC3HRS)								1			0	0	1	0	0	0	0	
		3HRP (CDU B SELECT; with CC3HS)								1			0	0	1	0	0	0	1	
		3HRP (CDU A SELECT; with CC3HRS)								1			0	0	1	0	0	0	1	
		3HS (CDU A SELECT; with CC3HP)								1			1	0	1	0	1	0	0	
		3HS (CDU B SELECT; with CC3HRP)								1			1	0	1	0	1	0	0	
		3HRS (CDU B SELECT; with CC3HP)								1			1	0	1	0	1	0	1	
		3HRS (CDU A SELECT; with CC3HRP)								1			1	0	1	0	1	0	1	
		4A (UNDER VOLTAGE RESET)								1			1	1	0	1	0	1	1	
		4K (RTG 1 DIODE BYPASS ON)								1			1	1	1	0	0	0	0	
		4KR (RTG 1 BYPASS OFF)								1			1	1	1	0	0	0	1	
		4L (RTG 2 DIODE BYPASS ON)								1			1	1	1	0	0	1	0	
		4LR (RTG 2 DIODE BYPASS OFF)								1			1	1	1	0	0	1	1	
		4M (RTG 3 DIODE BYPASS ON)								1			1	0	1	1	0	0	0	
		4MR (RTG 3 DIODE BYPASS OFF)								1			1	0	1	1	0	0	1	

Table 5. Coded Command Accumulator Words for Power Switching (Contd)

CMD ID			50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
		Ground CMD Bit Number	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
		CCS Bit Number	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
		PWR Address	0	0	1	0	1													1
		Spare						0	0											
								0	1											
								1	0											
								1	1											
0	Decoder Select	Command Reject									0	0								
1	Decoder Select	Decoder A									0	1								
2	Decoder Select	Decoder B									1	0								
3	Decoder Select	Command Reject									1	1								

Command	57	60	61	62	63	64	65	66
6AP (FDS POWER CONVERTER A SELECT; with CC6AS)	1	0	1	0	0	0	0	0
6AP (FDS POWER CONVERTER B SELECT; with CC6ARS)	1	0	1	0	0	0	0	0
6ARP (FDS POWER CONVERTER B SELECT; with CC6AS)	1	0	1	0	0	0	0	1
6ARP (FDS POWER CONVERTER A SELECT; with CC6ARS)	1	0	1	0	0	0	0	1
6AS (FDS POWER CONVERTER A SELECT; with CC6AP)	1	1	1	0	0	1	0	0
6AS (FDS POWER CONVERTER B SELECT; with CC6ARP)	1	1	1	0	0	1	0	0
6ARS (FDS POWER CONVERTER B SELECT; with CC6AP)	1	1	1	0	0	1	0	1
6ARS (FDS POWER CONVERTER A SELECT; with CC6ARP)	1	1	1	0	0	1	0	1
6CP (FDS POWER ON/ISS POWER ENABLE; with CC6CS)	1	0	0	1	0	0	1	0
6CP (FDS POWER OFF/ISS POWER DISABLE; with CC6CRS)	1	0	0	1	0	0	1	0
6CRP (FDS POWER OFF/ISS POWER DISABLE; with CC6CS)	1	0	0	1	0	0	1	1
6CRP (FDS POWER ON/ISS POWER ENABLE; with CC6CRS)	1	0	0	1	0	0	1	1
6CS (FDS POWER ON/ISS POWER ENABLE; with CC6CP)	1	1	0	1	0	1	1	0
6CS (FDS POWER OFF/ISS POWER DISABLE; with CC6CRP)	1	1	0	1	0	1	1	0
6CRS (FDS POWER OFF/ISS POWER DISABLE; with CC6CP)	1	1	0	1	0	1	1	1
6CRS (FDS POWER ON/ISS POWER ENABLE; with CC6CRP)	1	1	0	1	0	1	1	1
7AHP (SUN SENSOR HTR A ON, with CC7AHS)	1	0	0	0	1	1	0	0
7AHP (SUN SENSOR HTR A OFF, with CC7AHRS)	1	0	0	0	1	1	0	0
7AHRP (SUN SENSOR HTR A OFF, with CC7AHS)	1	0	0	0	1	1	0	1
7AHRP (SUN SENSOR HTR A ON, with CC7AHRS)	1	0	0	0	1	1	0	1
7AHS (SUN SENSOR HTR A ON, with CC7AHP)	1	1	0	0	1	0	0	0
7AHS (SUN SENSOR HTR A OFF, with CC7AHRP)	1	1	0	0	1	0	0	0
7AHRS (SUN SENSOR HTR A ON, with CC7AHRP)	1	1	0	0	1	0	0	1
7AHRS (SUN SENSOR HTR A OFF, with CC7AHP)	1	1	0	0	1	0	0	1
7BAP (HTR A ON; with CC7BAS)	0	0	1	1	0	0	0	0
7BAP (HTR A OFF; with CC7BARS)	0	0	1	1	0	0	0	0
7BARP (HTR A ON; with CC7BARS)	0	0	1	1	0	0	0	1
7BARP (HTR A OFF; with CC7BAS)	0	0	1	1	0	0	0	1
7BAS (HTR A ON; with CC7BAP)	0	1	1	1	0	1	0	0
7BAS (HTR A OFF; with CC7BARP)	0	1	1	1	0	1	0	0
7BARS (HTR A ON; with CC7BARP)	0	1	1	1	0	1	0	1
7BARS (HTR A OFF; with CC7BAP)	0	1	1	1	0	1	0	1
7BBP (HTR B ON; with CC7BBS)	0	0	1	1	1	0	0	0
7BBP (HTR B OFF; with CC7BBRS)	0	0	1	1	1	0	0	0
7BBRP (HTR B ON; with CC7BBRS)	0	0	1	1	1	0	0	1
7BBRP (HTR B OFF; with CC7BBS)	0	0	1	1	1	0	0	1
7BBS (HTR B ON; with CC7BBP)	0	1	1	1	1	1	0	0
7BBS (HTR B OFF; with CC7BBRP)	0	1	1	1	1	1	0	0
7BBRS (HTR B ON; with CC7BBRP)	0	1	1	1	1	1	0	1
7BBRS (HTR B OFF; with CC7BBP)	0	1	1	1	1	1	0	1
7BHP (SUN SENSOR HTR B ON, with CC7BHS)	1	0	0	0	1	1	1	0
7BHP (SUN SENSOR HTR B OFF, with CC7BHRS)	1	0	0	0	1	1	1	0

Table 5. Coded Command Accumulator Words for Power Switching (Contd)

CMD ID	Decoder Select	Ground CMD Bit Number	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
		CCS Bit Number	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
		PWR Address	0	0	1	0	1													1
		Spare						0	0											
								0	1											
								1	0											
								1	1											
0	Decoder Select	Command Reject									0	0								
1		Decoder A									0	1								
2		Decoder B									1	0								
3		Command Reject									1	1								
		7BHRP (SUN SENSOR HTR B ON, with CC7BHRS)								1			0	0	0	1	1	1	1	
		7BHRP (SUN SENSOR HTR B OFF, with CC7BHS)								1			0	0	0	1	1	1	1	
		7BHS (SUN SENSOR HTR B ON, with CC7BHP)								1			1	0	0	1	0	1	0	
		7BHS (SUN SENSOR HTR B OFF, with CC7BHRP)								1			1	0	0	1	0	1	0	
		7BHRS (SUN SENSOR HTR B ON, with CC7BHRP)								1			1	0	0	1	0	1	1	
		7BHRS (SUN SENSOR HTR B OFF, with CC7BHP)								1			1	0	0	1	0	1	1	
		7GAP (GYRO A ON; with CC7GAS)								0			0	1	0	1	0	1	1	
		7GAP (GYRO A OFF; with CC7GARS)								0			0	1	0	1	0	1	1	
		7GARP (GYRO A OFF; with CC7GAS)								0			0	1	0	1	0	1	0	
		7GARP (GYRO A ON; with CC7GARS)								0			0	1	0	1	0	1	0	
		7GAS (GYRO A ON; with CC7GAP)								0			1	1	0	1	1	1	1	
		7GAS (GYRO A OFF; with CC7GARP)								0			1	1	0	1	1	1	1	
		7GARS (GYRO A OFF; with CC7GAP)								0			1	1	0	1	1	1	0	
		7GARS (GYRO A ON; with CC7GARP)								0			1	1	0	1	1	1	0	
		7GBP (GYRO B ON; with CC7GBS)								0			0	1	1	0	0	1	1	
		7GBP (GYRO B OFF; with CC7GBRS)								0			0	1	1	0	0	1	1	
		7GBRP (GYRO B OFF; with CC7GBS)								0			0	1	1	0	0	1	0	
		7GBRP (GYRO B ON; with CC7GBRS)								0			0	1	1	0	0	1	0	
		7GBS (GYRO B ON; with CC7GBP)								0			1	1	1	0	1	1	1	
		7GBS (GYRO B OFF; with CC7GBRP)								0			1	1	1	0	1	1	1	
		7GBRS (GYRO B OFF; with CC7GBP)								0			1	1	1	0	1	1	0	
		7GBRS (GYRO B ON; with CC7GBRP)								0			1	1	1	0	1	1	0	
		7GCP (GYRO C ON; with CC7GCS)								0			0	1	1	1	0	1	1	
		7GCP (GYRO C OFF; with CC7GCRS)								0			0	1	1	1	0	1	1	
		7GCRP (GYRO C OFF; with CC7GCS)								0			0	1	1	1	0	1	0	
		7GCRP (GYRO C ON; with CC7GCRS)								0			0	1	1	1	0	1	0	
		7GCS (GYRO C ON; with CC7GCP)								0			1	1	1	1	1	1	1	
		7GCS (GYRO C OFF; with CC7GCRP)								0			1	1	1	1	1	1	1	
		7GCRS (GYRO C OFF; with CC7GCP)								0			1	1	1	1	1	1	0	
		7GCRS (GYRO C ON; with CC7GCRP)								0			1	1	1	1	1	1	0	
		7H1P (HYBIC 1 MAJOR POWER SUPPLY ON; with CC7H1S)								0			0	1	0	0	0	0	1	
		7H1P (HYBIC 1 MAJOR POWER SUPPLY OFF; with CC7H1RS)								0			0	1	0	0	0	0	1	
		7H1RP (HYBIC 1 MAJOR POWER SUPPLY OFF; with CC7H1S)								0			0	1	0	0	0	0	0	
		7H1RP (HYBIC 1 MAJOR POWER SUPPLY ON; with CC7H1RS)								0			0	1	0	0	0	0	0	
		7H1S (HYBIC 1 MAJOR SUPPLY ON; with CC7H1P)								0			1	1	0	0	1	0	1	
		7H1S (HYBIC 1 MAJOR SUPPLY OFF; with CC7H1RP)								0			1	1	0	0	1	0	1	
		7H1RS (HYBIC 1 MAJOR POWER SUPPLY OFF; with CC7H1P)								0			1	1	0	0	1	0	0	
		7H1RS (HYBIC 1 MAJOR POWER SUPPLY ON; with CC7H1RP)								0			1	1	0	0	1	0	0	

Table 5. Coded Command Accumulator Words for Power Switching (Contd)

CMD ID		Ground CMD Bit Number	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
		CCS Bit Number	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
		PWR Address	0	0	1	0	1													1
		Spare						0	0											
								0	1											
								1	0											
								1	1											
0	Decoder Select	Command Reject									0	0								
1		Decoder A									0	1								
2		Decoder B									1	0								
3		Command Reject									1	1								

Command	57	60	61	62	63	64	65	66
7H2P (HYBIC 2 MAJOR POWER SUPPLY ON; with CC7H2S)	0	0	1	0	1	0	0	1
7H2P (HYBIC 2 MAJOR POWER SUPPLY OFF; with CC7H2RS)	0	0	1	0	1	0	0	1
7H2RP (HYBIC 2 MAJOR POWER SUPPLY OFF; with CC7H2S)	0	0	1	0	1	0	0	0
7H2RP (HYBIC 1 MAJOR POWER SUPPLY ON; with CC7H2RS)	0	0	1	0	1	0	0	0
7H2S (HYBIC 2 MAJOR POWER SUPPLY ON; with CC7H2P)	0	1	1	0	1	1	0	1
7H2S (HYBIC 2 MAJOR POWER SUPPLY OFF; with CC7H2RP)	0	1	1	0	1	1	0	1
7H2RS (HYBIC 2 MAJOR POWER SUPPLY OFF; with CC7H2P)	0	1	1	0	1	1	0	0
7H2RS (HYBIC 2 MAJOR POWER SUPPLY ON; with CC7H2RP)	0	1	1	0	1	1	0	0
7MMP (PROC/MEM 1 SELECT; with CC7MMS)	0	0	0	1	1	0	0	1
7MMP (PROC/MEM 2 SELECT; with CC7MMRS)	0	0	0	1	1	0	0	1
7MMRP (PROC/MEM 2 SELECT; with CC7MMS)	0	0	0	1	1	0	0	0
7MMRP (PROC/MEM 1 SELECT; with CC7MMRS)	0	0	0	1	1	0	0	0
7MMS (PROC/MEM 1 SELECT; with CC7MMP)	0	1	0	1	1	1	0	1
7MMS (PROC/MEM 2 SELECT; with CC7MMRP)	0	1	0	1	1	1	0	1
7MMRS (PROC/MEM 2 SELECT; with CC7MMP)	0	1	0	1	1	1	0	0
7MMRS (PROC/MEM 1 SELECT; with CC7MMRP)	0	1	0	1	1	1	0	0
7SHP (AZIMUTH ACTUATOR HEATER ON; with CC7SHS)	1	0	0	1	1	0	0	0
7SHP AZIMUTH ACTUATOR HEATER OFF; with CC7SHRS)	1	0	0	1	1	0	0	0
7SHRP (AZIMUTH ACTUATOR HEATER OFF; with CC7SHS)	1	0	0	1	1	0	0	1
7SHRP (AZIMUTH ACTUATOR HEATER ON; with CC7SHRS)	1	0	0	1	1	0	0	1
7SHS (AZIMUTH ACTUATOR HEATER ON; with CC7SHP)	1	1	0	1	1	1	0	0
7SHS (AZIMUTH ACTUATOR HEATER OFF; with CC7SHRP)	1	1	0	1	1	1	0	0

Table 5. Coded Command Accumulator Words for Power Switching (Contd)

		Ground CMD Bit Number	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
		CCS Bit Number	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
CMD ID		PWR Address	0	0	1	0	1													1
		Spare						0	0											
								0	1											
								1	0											
								1	1											
0	Decoder Select	Command Reject									0	0								
1		Decoder A									0	1								
2		Decoder B									1	0								
3		Command Reject									1	1								
		7SHRS (AZIMUTH ACTUATOR HEATER OFF; with CC7SHP)								1			1	0	1	1	1	0	1	
		7SHRS (AZIMUTH ACTUATOR HEATER ON; with CC7SHRP)								1			1	0	1	1	1	0	1	
		7TSP (CST SUN SHUTTER ON; with CC7TSS)								0			0	0	1	0	0	1	1	
		7TSP (CST SUN SHUTTER OFF; with CC7TSRS)								0			0	0	1	0	0	1	1	
		7TSRP (CST SUN SHUTTER OFF; with CC7TSS)								0			0	0	1	0	0	1	0	
		7TSRP (CST SUN SHUTTER ON; with CC7TSRS)								0			0	0	1	0	0	1	0	
		7TSS (CST SUN SHUTTER ON; with CC7TSP)								0			1	0	1	0	1	1	1	
		7TSS (CST SUN SHUTTER OFF; with CC7TSRP)								0			1	0	1	0	1	1	1	
		7TSRS (CST SUN SHUTTER OFF; with CC7TSP)								0			1	0	1	0	1	1	0	
		7TSRS (CST SUN SHUTTER ON; with CC7TSRP)								0			1	0	1	0	1	1	0	
		7T1P (CST 1 ON; with CC7T1S)								0			0	0	1	1	0	1	1	
		7T1P (CST 1 OFF; with CC7T1RS)								0			0	0	1	1	0	1	1	
		7T1RP (CST 1 OFF; with CC7T1S)								0			0	0	1	1	0	1	0	
		7T1RP (CST 1 ON; with CC7T1RS)								0			0	0	1	1	0	1	0	
		7T1S (CST 1 ON; with CC7T1P)								0			1	0	1	1	1	1	1	
		7T1S (CST 1 OFF; with CC7T1RP)								0			1	0	1	1	1	1	1	
		7T1RS (CST 1 OFF; with CC7T1P)								0			1	0	1	1	1	1	0	
		7T1RS (CST 1 ON; with CC7T1RP)								0			1	0	1	1	1	1	0	
		7T2P (CST 2 ON; with CC7T2S)								0			0	1	0	0	0	1	1	
		7T2P (CST 2 OFF; with CC7T2RS)								0			0	1	0	0	0	1	1	
		7T2RP (CST 2 OFF; with CC7TS2)								0			0	1	0	0	0	1	0	
		7T2RP (CST 2 ON; with CC7T2RS)								0			0	1	0	0	0	1	0	
		7T2S (CST 2 ON; with CC7T2P)								0			1	1	0	0	1	1	1	
		7T2S (CST 2 OFF; with CC7T2RP)								0			1	1	0	0	1	1	1	
		7T2RS (CST 2 OFF; with CC7T2P)								0			1	1	0	0	1	1	0	
		7T2RS (CST 2 ON; with CC7T2RP)								0			1	1	0	0	1	1	0	

Table 5. Coded Command Accumulator Words for Power Switching (Contd)

CMD ID			50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
		Ground CMD Bit Number	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
		CCS Bit Number	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
		PWR Address	0	0	1	0	1													1
		Spare						0	0											
								0	1											
								1	0											
								1	1											
0	Decoder Select	Command Reject									0	0								
1	Decoder Select	Decoder A									0	1								
2	Decoder Select	Decoder B									1	0								
3	Decoder Select	Command Reject									1	1								

Command	57	60	61	62	63	64	65	66
7V1P (ISO VALVE BRANCH 1 ON; with CC7V1S)	0	0	0	0	1	0	0	1
7V1P (ISO VALVE BRANCH 1 OFF; with CC7V1RS)	0	0	0	0	1	0	0	1
7V1RP (ISO VALVE BRANCH 1 OFF; with CC7V1S)	0	0	0	0	1	0	0	0
7V1RP (ISO VALVE BRANCH 1 ON; with CC7V1RS)	0	0	0	0	1	0	0	0
7V1S (ISO VALVE BRANCH 1 ON; with CC7V1P)	0	1	0	0	1	1	0	1
7V1S (ISO VALVE BRANCH 1 OFF; with CC7V1RP)	0	1	0	0	1	1	0	1
7V1RS (ISO VALVE BRANCH 1 OFF; with CC7V1P)	0	1	0	0	1	1	0	0
7V1RS (ISO VALVE BRANCH 1 ON; with CC7V1RP)	0	1	0	0	1	1	0	0
7V2P (ISO VALVE BRANCH 2 ON; with CC7V2S)	0	0	0	1	0	0	0	1
7V2P (ISO VALVE BRANCH 2 OFF; with CC7V2RS)	0	0	0	1	0	0	0	1
7V2RP (ISO VALVE BRANCH 2 OFF; with CC7V2S)	0	0	0	1	0	0	0	0
7V2RP (ISO VALVE BRANCH 2 ON; with CC7V2RS)	0	0	0	1	0	0	0	0
7V2S (ISO VALVE BRANCH 2 ON; with CC7V2P)	0	1	0	1	0	1	0	1
7V2S (ISO VALVE BRANCH 2 OFF; with CC7V2RP)	0	1	0	1	0	1	0	1
7V2RS (ISO VALVE BRANCH 2 OFF; with CC7V2P)	0	1	0	1	0	1	0	0
7V2RS (ISO VALVE BRANCH 2 ON; with CC7V2RP)	0	1	0	1	0	1	0	0

Table 5. Coded Command Accumulator Words for Power Switching (Contd)

CMD ID			50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
		Ground CMD Bit Number	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
		CCS Bit Number	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
CMD ID		PWR Address	0	0	1	0	1													1
		Spare						0	0											
								0	1											
								1	0											
								1	1											
0	Decoder Select	Command Reject									0	0								
1	Decoder Select	Decoder A									0	1								
2	Decoder Select	Decoder B									1	0								
3	Decoder Select	Command Reject									1	1								
		8A (PSU A ON)								0			0	0	1	0	1	0	0	
		8AR (PSU A OFF)								0			0	0	1	0	1	0	1	
		8B (PSU B ON)								0			0	1	0	0	1	1	0	
		8BR (PSU B OFF)								0			0	1	0	0	1	1	1	
		8D (PSU INSTRUMENTATION ON)								0			0	0	1	0	1	1	0	
		8DR (PSU INSTRUMENTATION OFF)								0			0	0	1	0	1	1	1	
		10CP (TCM HEATER ON; with CC10CS)								0			0	0	0	1	0	1	1	
		10CP (TCM HEATER OFF; with CC10CRS)								0			0	0	0	1	0	1	1	
		10CRP (TCM HEATER OFF; with CC10CS)								0			0	0	0	1	0	1	0	
		10CRP (TCM HEATER ON; with CC10CRS)								0			0	0	0	1	0	1	0	
		10CS (TCM HEATER ON; with CC10CP)								0			1	0	0	1	1	1	1	
		10CS (TCM HEATER OFF; with CC10CRP)								0			1	0	0	1	1	1	1	
		10CRS (TCM HEATER OFF; with CC10CP)								0			1	0	0	1	1	1	0	
		10CRS (TCM HEATER ON; with CC10CRP)								0			1	0	0	1	1	1	0	
		10D (AP BR1 HTRS ON)								1			1	1	0	1	0	0	0	
		10DR (AP BR1 HTRS OFF)								1			1	1	0	1	0	0	1	
		10E (AP BR2 HTRS ON)								1			1	1	1	1	0	1	0	
		10ER (AP BR2 HTRS OFF)								1			1	1	1	1	0	1	1	
		10F (IPU VALVE HTRS ON)								1			1	0	1	1	0	1	0	
		10FR (IPU VALVE HTRS OFF)								1			1	0	1	1	0	1	1	
		10G (IPU THRUSTER HTRS ON)								1			1	1	1	1	0	0	0	
		10GR (IPU THRUSTER HTRS OFF)								1			1	1	1	1	0	0	1	
		10H (IPU REDUNDANT VALVE HTR ON)								1			1	1	0	0	0	1	0	
		10HR (IPU REDUNDANT VALVE HTR OFF)								1			1	1	0	0	0	1	1	

Table 5. Coded Command Accumulator Words for Power Switching (Contd)

CMD ID			50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
		Ground CMD Bit Number	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
		CCS Bit Number	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
CMD ID		PWR Address	0	0	1	0	1													1
		Spare						0	0											
								0	1											
								1	0											
								1	1											
0	Decoder Select	Command Reject									0	0								
1	Decoder Select	Decoder A									0	1								
2	Decoder Select	Decoder B									1	0								
3	Decoder Select	Command Reject									1	1								
		10TP (TCM LINE HTRS ON; with CC10DTS)								1			0	1	1	1	0	1	0	
		10TP (TCM LINE HTRS OFF; with CC10TRS)								1			0	1	1	1	0	1	0	
		10TRP (TCM LINE HTRS ON; with CC10TRS)								1			0	1	1	1	0	1	1	
		10TRP (TCM LINE HTRS OFF; with CC10TS)								1			0	1	1	1	0	1	1	
		10TS (TCM LINE HTRS ON; with CC10TP)								1			1	1	1	1	1	1	0	
		10TS (TCM LINE HTRS OFF; with CC10TRP)								1			1	1	1	1	1	1	0	
		10TRS (TCM LINE HTRS ON; with CC10TRP)								1			1	1	1	1	1	1	1	
		10TRS (TCM LINE HTRS OFF; with CC10TP)								1			1	1	1	1	1	1	1	
		15AP (DSS ON; with CC16AS)								0			0	0	0	1	1	0	0	
		16AP (DSS OFF; with CC16ARS)								0			0	0	0	1	1	0	0	
		16ARP (DSS OFF; with CC16AS)								0			0	0	0	1	1	0	1	
		16ARP (DSS ON; with CC16ARS)								0			0	0	0	1	1	0	1	
		16AS (DSS ON; with CC16AP)								0			1	0	0	1	0	0	0	
		16AS (DSS OFF; with CC16ARP)								0			1	0	0	1	0	0	0	
		16ARS (DSS OFF; with CC16AP)								0			1	0	0	1	0	0	1	
		16ARS (DSS ON; with CC16ARP)								0			1	0	0	1	0	0	1	
		16B (DSS REPLACEMENT HEATER ON)								0			1	1	1	0	0	0	0	
		16BR (DSS REPLACEMENT HEATER OFF)								0			1	1	1	0	0	0	1	
		21A (CRS ON)								0			1	1	1	1	0	0	0	
		21AR (CRS OFF)								0			1	1	1	1	0	.0	1	
		21B (CRS REPLACEMENT HEATER ON)								1			0	0	1	0	1	0	0	
		21BR (CRS REPLACEMENT HEATER OFF)								1			0	0	1	0	1	0	1	
		21C (CRS SUPPLEMENTAL HEATER ON)								0			1	1	1	1	0	1	0	
		21CR (CRS SUPPLEMENTAL HEATER OFF)								0			1	1	1	1	0	1	1	
		22A (PRA ON)								0			0	1	1	0	1	0	0	
		22AR (PRA OFF)								0			0	1	1	0	1	0	1	
		22BP (PRA/PWS ANTENNA DEPLOY MOTOR ON; with CC22BS)								1			0	0	1	1	0	1	0	
		22BP (PRA/PWS ANTENNA DEPLOY MOTOR OFF; with CC22BRS)								1			0	0	1	1	0	1	0	

Table 5. Coded Command Accumulator Words for Power Switching (Contd)

CMD ID			50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
		Ground CMD Bit Number	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
		CCS Bit Number	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
CMD ID		PWR Address	0	0	1	0	1													1
		Spare						0	0											
								0	1											
								1	0											
								1	1											
0	Decoder Select	Command Reject									0	0								
1	Decoder Select	Decoder A									0	1								
2	Decoder Select	Decoder B									1	0								
3	Decoder Select	Command Reject									1	1								
		22BRP (PRA/PWS ANTENNA DEPLOY MOTOR OFF; with CC22BS)								1			0	0	1	1	0	1	1	
		22BRP (PRA/PWS ANTENNA DEPLOY MOTOR ON; with CC22BRS)								1			0	0	1	1	0	1	1	
		22BS (PRA/PWS ANTENNA DEPLOY MOTOR ON; with CC22BP)								1			1	0	1	1	1	1	0	
		22BS (PRA/PWS ANTENNA DEPLOY MOTOR OFF; with CC22BRP)								1			1	0	1	1	1	1	0	
		22BRS (PRA/PWS ANTENNA DEPLOY MOTOR OFF; with CC22BP)								1			1	0	1	1	1	1	1	
		22BRS (PRA/PWS ANTENNA DEPLOY MOTOR ON; with CC22BRP)								1			1	0	1	1	1	1	1	
		23A (PWS ON)								0			0	1	1	0	1	1	0	
		23AR (PWS OFF)								0			0	1	1	0	1	1	1	
		25A (LECP ON)								0			0	0	1	1	1	0	0	
		25AR (LECP OFF)								0			0	0	1	1	1	0	1	
		25B (LECP STEPPER MOTOR ON)								1			0	0	1	0	1	1	0	
		25BR (LECP STEPPER MOTOR OFF)								1			0	0	1	0	1	1	1	
		25C (LECP REPLACEMENT HEATER ON)								1			0	1	1	0	1	0	0	
		25CR (LECP REPLACEMENT HEATER OFF)								1			0	1	1	0	1	0	1	
		25D (LECP MAIN SUPPLEMENTAL HEATER ON)								1			0	1	0	0	1	1	0	
		25DR (LECP MAIN SUPPLEMENTAL HEATER OFF)								1			0	1	0	0	1	1	1	
		25E (LECP LEPT SUPPLEMENTAL HEATER ON)								1			0	1	0	0	1	0	0	
		25ER (LECP LEPT SUPPLEMENTAL HEATER OFF)								1			0	1	0	0	1	0	1	
		27A (PPS ON)								1			0	1	1	0	1	1	0	
		27AR (PPS OFF)								1			0	1	1	0	1	1	1	
		27B (PPS SUPPLEMENTAL HEATER ON)								1			0	0	1	1	1	0	0	
		27BR (PPS SUPPLEMENTAL HEATER OFF)								1			0	0	1	1	1	0	1	

Table 5. Coded Command Accumulator Words for Power Switching (Contd)

CMD ID			50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
		Ground CMD Bit Number	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
		CCS Bit Number	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
		PWR Address	0	0	1	0	1													1
		Spare						0	0											
								0	1											
								1	0											
								1	1											
0	Decoder Select	Command Reject									0	0								
1	Decoder Select	Decoder A									0	1								
2	Decoder Select	Decoder B									1	0								
3	Decoder Select	Command Reject									1	1								
		32A (PLS ON)								0			0	0	1	1	1	1	0	
		32AR (PLS OFF)								0			0	0	1	1	1	1	1	
		32B (PLS SUPPLEMENTAL HEATER ON)								1			0	0	1	1	1	1	0	
		32BR (PLS SUPPLEMENTAL HEATER OFF)								1			0	0	1	1	1	1	1	
		32C (PLS REPLACEMENT HEATER ON)								1			0	1	0	1	1	0	0	
		32CR (PLS REPLACEMENT HEATER OFF)								1			0	1	0	1	1	0	1	
		34A (UVS ON)								0			0	1	0	1	1	0	0	
		34AR (UVS OFF)								0			0	1	0	1	1	0	1	
		34B (UVS REPLACEMENT HEATER ON)								1			0	1	0	1	1	1	0	
		34BR (UVS REPLACEMENT HEATER OFF)								1			0	1	0	1	1	1	1	
		35A (MAG ON)								0			0	1	0	1	1	1	0	
		35AR (MAG OFF)								0			0	1	0	1	1	1	1	
		35B (MAG STANDBY ON)								0			0	1	1	1	1	0	0	
		35BR (MAG STANDBY OFF)								0			0	1	1	1	1	0	1	
		35C (MAG IBLFM FWD FLIPPER ON)								0			1	1	0	0	0	0	0	
		35CR (MAG IBLFM FWD FLIPPER OFF)								0			1	1	0	0	0	0	1	
		35D (MAG IBLFM REV FLIPPER ON)								0			1	0	1	0	0	1	0	
		35DR (MAG IBLFM REV FLIPPER OFF)								0			1	0	1	0	0	1	1	
		35E (MAG OBLFM FWD FLIPPER ON)								0			1	0	1	0	0	0	0	
		35ER (MAG OBLFM FWD FLIPPER OFF)								0			1	0	1	0	0	0	1	
		35F (MAG OBLFM REV FLIPPER ON)								0			0	1	1	1	1	1	0	
		35FR (MAG OBLFM REV FLIPPER OFF)								0			0	1	1	1	1	1	1	
		35G (MAG SENSOR HEATERS ON)								0			1	1	0	0	0	1	0	
		35GR (MAG SENSOR HEATERS OFF)								0			1	1	0	0	0	1	1	
		36B (ISS WA ON)								0			1	1	1	0	0	1	0	
		36BR (ISS WA OFF)								0			1	1	1	0	0	1	1	

Table 5. Coded Command Accumulator Words for Power Switching (Contd)

CMD ID		Ground CMD Bit Number	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	6[illegible]
		CCS Bit Number	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
		PWR Address	0	0	1	0	1													1
		Spare						0	0											
								0	1											
								1	0											
								1	1											
0	Decoder Select	Command Reject									0	0								
1	Decoder Select	Decoder A									0	1								
2	Decoder Select	Decoder B									1	0								
3	Decoder Select	Command Reject									1	1								
		36CP (ISS NA OPTICS HEATER ON; with CC36CS)								1			0	1	0	1	0	0	0	
		36CP (ISS NA OPTICS HEATER OFF; with CC36CRS)								1			0	1	0	1	0	0	0	
		36CRP (ISS NA OPTICS HEATER OFF; with CC36CS)								1			0	1	0	1	0	0	1	
		36CRP (ISS NA OPTICS HEATER ON; with CC36CRS)								1			0	1	0	1	0	0	1	
		36CS (ISS NA OPTICS HEATER ON; with CC36CP)								1			1	1	0	1	1	0	0	
		36CS (ISS NA OPTICS HEATER OFF; with CC36CRP)								1			1	1	0	1	1	0	0	
		36CRS (ISS NA OPTICS HEATER OFF; with CC36CP								1			1	1	0	1	1	0	1	
		36CRS (ISS NA OPTICS HEATER ON; with CC36CRP)								1			1	1	0	1	1	0	1	
		36DP (ISS NA ON; with CC36DS)								1			0	1	0	0	0	1	0	
		36DP (ISS NA OFF; with CC36DRS)								1			0	1	0	0	0	1	0	
		36DRP (ISS NA OFF; with CC36DS)								1			0	1	0	0	0	1	1	
		36DRP (ISS NA ON; with CC36DRS)								1			0	1	0	0	0	1	1	
		36DS (ISS NA ON; with CC36DP)								1			1	1	0	0	1	1	0	
		36DS (ISS NA OFF; with CC36DRP)								1			1	1	0	0	1	1	0	
		36DRS (ISS NA OFF; with CC36DP)								1			1	1	0	0	1	1	1	
		36DRS (ISS NA ON; with CC36DRP)								1			1	1	0	0	1	1	1	
		36FP (ISS NA VID REPLACEMENT HEATER ON; with CC36FS)								1			0	1	0	1	0	1	0	
		36FP (ISS NA VID REPLACEMENT HEATER OFF; with CC36FRS)								1			0	1	0	1	0	1	0	
		36FRP (ISS NA VID REPLACEMENT HEATER OFF; with CC36FS)								1			0	1	0	1	0	1	1	
		36FRP (ISS NA VID REPLACEMENT HEATER ON; with CC36FRS)								1			0	1	0	1	0	1	1	
		36FS (ISS NA VID REPLACEMENT HEATER ON; with CC36FP)								1			1	1	0	1	1	1	0	
		36FS (ISS NA VID REPLACEMENT HEATER OFF; with CC36FRP)								1			1	1	0	1	1	1	0	
		36FRS (ISS NA VID REPLACEMENT HEATER OFF; with CC36FP)								1			1	1	0	1	1	1	1	
		36FRS (ISS NA VID REPLACEMENT HEATER ON; with CC36FRP)								1			1	1	0	1	1	1	1	

Table 5. Coded Command Accumulator Words for Power Switching (Contd)

CMD ID	Decoder Select		50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
		Ground CMD Bit Number	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
		CCS Bit Number	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
		PWR Address	0	0	1	0	1													1
		Spare						0	0											
								0	1											
								1	0											
								1	0											
0	Decoder Select	Command Reject									0	0								
1	Decoder Select	Decoder A									0	1								
2	Decoder Select	Decoder B									1	0								
3	Decoder Select	Command Reject									1	1								
		36G (ISS WA VID REPLACEMENT HEATER ON)								1			0	1	1	1	1	0	0	
		36GR (ISS WA VID REPLACEMENT HEATER OFF)								1			0	1	1	1	1	0	1	
		36H (ISS WA ELEC REPLACEMENT HEATER ON)								1			0	1	1	1	1	1	0	
		36HR (ISS WA ELEC REPLACEMENT HEATER OFF)								1			0	1	1	1	1	1	1	
		36JP (ISS NA ELEC REPLACEMENT HEATER ON; with CC36JS)								1			0	1	1	1	0	0	0	
		36JP (ISS NA ELEC REPLACEMENT HEATER OFF; with CC36JRS)								1			0	1	1	1	0	0	0	
		36JRP (ISS NA ELEC REPLACEMENT HEATER OFF; with CC36JS)								1			0	1	1	1	0	0	1	
		36JRP (ISS NA ELEC REPLACEMENT HEATER ON; with CC36JRS)								1			0	1	1	1	0	0	1	
		36JS (ISS NA ELEC REPLACEMENT HEATER ON; with CC36JP)								1			1	1	1	1	1	0	0	
		36JS (ISS NA ELEC REPLACEMENT HEATER OFF; with CC36JRP)								1			1	1	1	1	1	0	0	
		36JRS (ISS NA ELEC REPLACEMENT HEATER OFF; with CC36JP)								1			1	1	1	1	1	0	1	
		36JRS (ISS NA ELEC REPLACEMENT HEATER ON; with CC36JRP)								1			1	1	1	1	1	0	1	
		39A (MIRIS ON)								0			1	0	1	1	0	0	0	
		39AR (MIRIS OFF)								0			1	0	1	1	0	0	1	
		39B (MIRIS STANDBY SUPPLY B ON)								0			1	1	0	1	0	0	0	
		39BR (MIRIS STANDBY SUPPLY B OFF)								0			1	1	0	1	0	0	1	
		39C (MIRIS FLASH OFF HEATER ON)								1			1	1	0	0	0	0	0	
		39CR (MIRIS FLASH OFF HEATER OFF)								1			1	1	0	0	0	0	1	
		39D (MIRIS REPLACEMENT HEATER ON)								1			1	0	1	0	0	1	0	
		39DR (MIRIS REPLACEMENT HEATER OFF)								1			1	0	1	0	0	1	1	
		39F (MIRIS STANDBY SUPPLY A ON)								0			0	1	0	0	1	0	0	
		39FR (MIRIS STANDBY SUPPLY A OFF)								0			0	1	0	0	1	0	1	