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Functional Requirements
Voyager Interstellar Mission
Cruise Data System

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1. PURPOSE

The Voyager Interstellar Mission (VIM) Data System Functional Requirements Document (FRD) establishes the functional requirements for a two-program set of Flight Data Subsystem (FDS) software, associated FDS ground support hardware and software, and the Ground Data System (GDS) software to be used during the Voyager extended missions.

2. SCOPE

The VIM begins at the end of the Voyager Neptune Interstellar Mission (VNIM) on 1 January 1990 and continues until useful science data can no longer be returned from either of the Voyager Spacecraft. Barring an unexpected hardware failure, such a condition has been predicted to occur during the 2020s, based upon diminishing power and hydrazine reserves. The initial budget submittal to NASA Headquarters is for a VIM covering the first five years of the extended mission period.

This document covers not only the first five-year VIM, but also any VIM extensions to the limit of Spacecraft usefulness, which is a function of Spacecraft power availability, Spacecraft hydrazine reserves, and Spacecraft subsystem lifetime. Primarily as a result of the declining telecom performance with increasing Spacecraft distance, as well as the declining power availability with time, the VIM Data System contains two FDS flight programs. The first,VIM-5, incorporates a derivative of the CR05 data mode and is intended for use during the period when scan platform science and recorded data can be acquired and returned to Earth. The second, VIM-7, incorporates a derivative of the CR07 data mode and is intended for use when the VIM-5 cruise data rates can no longer be returned to Earth within acceptable BERs.

Requirements contained herein are also derived from other sources than physical or engineering limitations. These include budgetary limitations, Deep Space Network (DSN) resource limitations, institutional resource limitations, and judgments by the Project as to the relative worth of the various Voyager data types and sources to the overall extended mission objectives.

Not addressed in this document is the integration of the VIM into the Spaceflight Operations Center (SFOC) environment planned for the 1990s. The SFOC design is judged to be insufficiently mature at this time to allow a detailed

This document provides GDS Functional Requirements and high-level implementation plans for Project and Institutionally developed data processing elements in support of the FDS VIM-5 and VIM-7 programs. It is not intended to provide a complete restatement of GDS Functional Requirements; rather the approach will be to retain existing baseline capabilities, and then to provide a delta to that baseline. The Project plans a transition to a new Spaceflight Operations Center (SFOC)-based computing environment early in the VIM after demonstration of SFOC processing support for VIM requirements. Effort will be extended by the Project to provide a detailed requirements statement for SFOC developers that does not assume an existing baseline. These details of general processing and support requirements are beyond the scope of the VIM-5 and VIM-7 requirements provided by this document, and will be provided by release of an updated Software Requirements Document (SRD) at a later date.

In addition to the functional requirements, this document includes lists of priorities for the addition or removal of capabilities from the VIM Data System which are consistent with the VIM objectives. Final content of the FDS programs is determined by the exact flight subsystem configuration and by the final assembly versions of the programs.

Voyager Project change control procedures shall be in effect following the initial issuance of this document and shall apply to any addition to or revision of this document.

3. APPLICABLE DOCUMENTS

The following documents contain requirements or information which relate to or form a part of this Functional Requirements Document. The documents cited are applicable in the exact Revision or Issue where such are referenced, or in the latest version where no Revision or Issue reference is given.

(a) PD 618-5, Part 4, Voyager Project Plan, Part 4: Voyager Interstellar Mission, 1 October 1987.

(b) PD 618-123, Vol. V, Voyager Mission Design Guidelines and Constraints: Voyager Interstellar Mission, TBD.

(c) MJS-77-4-2006-1A, Functional Requirements: MJS77 Flight Data Subsystem - Hardware, 20 March 1978.

(d) MJS-77-4-2006-2, Functional Requirements: MJS77 Flight Data Subsystem - Software, 12 August 1975. (This document contains fundamental data about the FDS software, but it has not been maintained up to date.)

(e) PD 618-236, Vol. I, Change #7, Voyager Flight Data Subsystem: Flight Software Description, January 1988.

(f) IOM Voyager-APH-88-001, to Kohlhase from A. Harch, "Science Requirements for the VIM-5 FDS Program," dated 1 February 1988.

(g) IOM Voyager-ASD-88-005, to M. Urban from D. Miller, "FDS/DSS Playback Synchronizer", dated 09 March 1988.

(h) IOM Voyager-SCT-86-246, to Marderness from Harper/Barros, "Summary Report on the Operational Aspects of Loading the 07A8 Program (using MIN CMROT Routine) on S/C 31", dated 09 December 1986.

(i) IOM Voyager-PJS-88-6, to J. Gerschultz from P. Schulte, "Science Requirements for the VIM-7 FDS Program", dated 19 August, 1988.

4. GUIDELINES, CONSTRAINTS AND REQUIREMENTS

4.1 PROJECT GUIDELINES

4.1.1 Applicability

The Voyager Project has determined, in conjunction with NASA HQ Code E, that VIM shall be a limited scope extended mission for the two Voyager Spacecraft beginning on January 1, 1990. It shall be directed toward in situ measurements of the outer solar system environment, with particular interest in the heliopause region, the boundary between solar and galactic influence. The heliopause region may be remotely sensed by the PWS instrument. There shall also be consideration given to remote sensing of astronomical objects which are, at present, observable in certain ultraviolet (UV) spectral bandsonly by the Voyager spacecraft. VIM shall be conducted on a basis of reduced resources when compared with Voyager's history of planetary encounters and interplanetary cruise. Resources reduced shall include Project and Flight Team personnel, NASA funding levels, Investigator funding levels and scientific support, and JPL institutional support including some ground data and support resources.

To this end, the VIM Data System shall be capable of supporting all required Voyager Spacecraft and ground capabilities from early in the first VIM period until the last anticipated, useful period of a single Voyager Spacecraft. All Fields, Particles, and Waves (F&P&W) science instruments can be powered until about the year 2010, with FPA gyros-on protection, and until about the year 2015, without this protection. Furthermore, a subset (constant or changing) of these instruments can be powered into the 2020s. The design of the VIM Data System shall consider: the science data collection and processing desired, the FDS capabilities existing at present and anticipated to exist at the possible closing of the VIM period, reasonable failures and contingencies of flight or ground equipment, anticipated changes to ground data collection capabilities or ground data processing capabilities, and other changes to the Voyager Mission that can be reasonably accounted for.

4.1.1.1 The VIM Data System shall consist of two flight data systems which shall meet the above requirements for the VIM Mission. They shall be known as VIM-5 and VIM-7, with cruise science data rates of 160 b/s and 46-2/3 b/s, respectively.

4.1.1.2 The earliest need date for the VIM-5 Data System on the spacecraft shall be 7/1/90. The earliest need date for

VIM-7 shall be on 1/1/95, (assuming no onboard failures) although the actual need date will probably be later.

4.1.2 VIM Science Instruments

VIM shall be conducted as an F&P&W mission with periodic UV source observations. The instruments to be used during VIM are: Cosmic Ray Subsystem (CRS), Low-energy Charged Particle Subsystem (LECP), Magnetometer Subsystem (MAG), Plasma Science Subsystem (PLS), Planetary Radio Astronomy Subsystem (PRA), Plasma Wave Subsystem (PWS) and Ultraviolet Spectrometer Subsystem (UVS). The VIM FDS programs shall provide data formatting and instrument control functions for these instruments. Adequate power to support UVS and scan platform heaters is not available much beyond the year 2000.

Precluded from use during VIM by Project decision are: Infrared Interferometer Spectrometer and Radiometer Subsystem (IRIS), Imaging Science Subsystem (ISS), Photopolarimeter Subsystem (PPS), and Radio Science Subsystem (RSS). The VIM FDS programs are not required to provide any data formatting or instrument control functions for these instruments. Operation of these instruments during VIM will be only for the purpose of providing an adequate thermal environment for neighboring instruments.

4.1.3 Cruise Science Modes

CR05 (160 b/s) and CR07 (46-2/3 b/s) have been previously discussed in other project documents and represent the starting points for their counterparts in the VIM-5 and VIM-7 FDS programs. The CR05 mode has been a cornerstone in both the UNC and UBC FDS programs.

However, important instrument processing changes are necessary for more effective cruise science data return during the VIM era. Such an updated version of the CR05 data format shall be referred to as CR5a. When imbedded in the final RS-coded "transport frame", it shall be referred to as CR5T.

The updated version of CR07 shall be denoted by CR7a.

4.1.4 High Rate Science Modes

In accordance with subsection 4.3, high-rate science modes are required for GS&E (real-time and record/playback), PWS (record/playback), and UVS with embedded cruise science (real-time). The properties of these data mode candidates are summarized in Table 4.1.4-1, and covered in greater detail in Subsections 5.6 and 5.7.

Table 4.1.4-1

High-Rate Science Data Modes

Mnemonic	Downlink Data Rate (b/s)	FDS HR Format	FDS LR Format	DTR Record Format	DTR Rates (Kb/s)	Comments
UV5a	600	UV5a	---	---	---	Embedded CR5a and RS-coded
GS4b	2800	GS08	EL40	GS4b/ GS4c	115.2 115.2	GS4b HR PWS (every 5th line) PLBK using PB14; GS4c HR PWS (every line) PLBK using PB05
GS08	2800	GS08	EL40	GS08/ GS09	7.2 3.6	GS08 RS-coded normal sync, PLBK using PB15; GS09 3.6 Kb/s half sync, PLBK using PB12.
PB05	7200	async	EL40	---	---	used to PLBK GS4c.
PB12	4800	PB12	---	---	---	used to PLBK GS09, EHRH.
PB15	2800	GS08*/ EH24*	EL40	---	---	DTR H/W sync, use to PLBK GS08 & EH24.
PB14	1400	GS4b*	EL40	---	---	DTR H/W sync, use to PLBK GS4b.

* Recorded data defines downlink format.

4.1.5 Data Encoding

Reed-Solomon (RS) encoding shall be utilized in the VIM-5 FDS program without consideration of a possible RS-coder failure. The encoder high reliability,low encoding overhead, and bit error reduction effectivity warrant this posture. Use of RS encoding gains appreciable time extensions for all data rates (4 more years at 160 b/s). In the unlikely event of RS failure during the VIM-5 era, although non-RS-coded CR5a may be supportable for a few years, it will eventually be necessary to replace VIM-5 with VIM-7 sooner than would otherwise have been necessary. In any event, the VIM-7 non-RS cruise data rate should be acquirable until the early 2020s, when power and hydrazine reserves become insufficient for mission continuation.

4.1.6 RFS Strategy

The RFS strategy shall have the basic objective of returning VIM-5 cruise science data to 34m apertures for as long as possible (until a minimum of, say, 8hr/day at ≤5E-5 BER can no longer be supported), at which time comparable longevity goals shall be adopted for the VIM-7 cruise science data.

In satisfying the above objective, X-band TWT power level and spacecraft dead-band selection will be generally chosen (for information purposes) as follows:

(a) The Voyager-1 dead-band will be 0.05°, 0.10°, 0.25°. X-low will be used until the VIM-5 objective can no longer be met (≈2001), at which time X-high will be selected. VIM-5 will continue to be in use until the RS-coded CR5a at 160 b/s can no longer be supported by 34m apertures (≈2007), at which time X-low and VIM-7 will be initiated. This situation will continue until expiration of 46-2/3 b/s telecom capability at X-low power (≈2011), at which time X-high power will be used until mission termination in the early 2020s.

(b) The Voyager-2 dead-band will initially be 0.05°, 0.25°, 0.4°. X-low will be used until the VIM-5 objective can no longer be met (≈2004), at which time the dead-band will be reduced to 0.05°, 0.10°, 0.25°. VIM-5 will continue to be in use until telecom non-supportability (≈2007), at which time X-high power will be selected. VIM-5 will continue to be in use until the RS-coded 160 b/s can no longer be supported by 34m apertures (≈2013), at which time VIM-7 and "medium" dead band (0.05°, 0.25°, 0.4°) will be selected. (X-low could be chosen until possibly 2015,if desired). VIM-7 and its prime 46-2/3 b/s CR7a would then remain in use until mission termination in the early 2020s.

4.1.7 Ground Data Processing

GDS requirements and guidelines for development and modification of Project and Institutionally provided subsystems are further detailed in sections 5.9 and 6.9 of this document. A definition of requirements at the level of a SRD will be provided in conjunction with an approved Software Change Proposal (SCP) by the end of the first quarter of CY '89. Generation of this level of detail must follow finalization and Voyager Change Board approval of the spacecraft software design; however, a draft of the detailed requirements will be available by the end of CY '88.

In general, the GDS capabilities required for support of the VIM-5 FDS design will be provided within the existing baseline of MCCC/DSN/Project subsystems. This will require significant modification of Mission Sequence Software (MSS) and downlink Telemetry processing elements to support the new spacecraft block approach to sequence generation and new telemetry data modes and data formats. Transition to a SFOC based capability will be planned for late CY 91; thus, VIM-5 capability will be implemented in both the existing MCCC subsystems and in the to-be-developed SFOC subsystems.

MSS and Spacecraft Analysis System (SAS) software will be modified to support FDS designs and, where resources permit, to provide a more sustainable software baseline capability to assure minimal maintenance for the VIM and possible VIM extensions.

GDS implementation of VIM-7 capabilities will be required within the baseline Project and DSN subsystems, but not within the MCCC baseline. VIM-7 capabilities will be implemented within the SFOC subsystems. It is not anticipated that VIM-7 will be utilized prior to retirement of the existing MCCC subsystems.

4.1.8 Unique Data Format Identification

All VIM-5 and VIM-7 data formats shall have a unique 8-bit format identification (FID).

4.1.9 Contingency Provisions

4.1.9.1 FDS Memory Allocation

Voyager 1 has one and Voyager 2 has two usable FDS memories. Because of past faults, however, these memories are not identical in regard to their good and bad address regions. During the VIM era, it is undesirable to have to assemble and load spacecraft-specific FDS programs in slightly different address structures. For this reason, it shall be a requirement that both the VIM-5 and VIM-7 programs be designed and loaded into the common set of usable addresses where all three operable memories are concerned.

In addition, both the VIM-5 and VIM-7 programs shall be compatible with the Minimum CMROT routine (ref. IOM SCT 86-246), which permits the programs to be software loaded into primary FDS memory on S/C 31.

The long duration of the VIM era increases the probability of future memory faults or failures. For this reason, it is important to provide at least 256 spare memory locations in the VIM-5 program to facilitate programming around bad addresses without having to face the added difficulty of removing VIM-5 capabilities as well. VIM-7 does not require spare memory locations since it shall use only one-half of available memory space.

4.1.9.2 Developmental Problems

4.1.9.2.1 CR5a/CR7a Instrument Processing Changes

One development task is the modification or redesign of science instrument control, data collection, and data processing within the FDS programs. These modifications are referred to collectively as CR5a and CR7a. Development of CR5a and CR7a contains an inherent risk which must be addressed. Final FDS program validation is done in the Capability Demonstration Laboratory (CDL). The CDL does not contain the Science instruments, which limits the extent to which processing modifications can be tested. Specifically, CDL validation cannot uncover problems resulting in:

- o Unexpected instrument response to FDS commands for instrument control or data collection
- o Interference in the CR5a/CR7a instrument data caused by other instruments or spacecraft subsystems.

Processing anomalies of this sort will not be detectable until after uplink and first use of the CR5a/CR7a processing mods. To protect against science data loss due to CR5a/CR7a processing anomalies detected after uplink, Division-34 capability to troubleshoot and patch FDS flight software shall be available to the project until at least six months after uplink of the VIM-7 program to the spacecraft. Corrective action for a processing anomaly discovered after uplink of the FDS program to the spacecraft would consist of the most appropriate of the following:

- o Develop/Uplink a patch to the operating FDS program
- o Abandon the instrument returning anomalous data
- o VIM-5 FDS Program Only: Uplink UBC-5 (S/C 31) and UNC-5 (S/C 32) programs to replace the onboard FDS program

FDS patches are constrained to simple corrections to the onboard processing scheme only. FDS patches which either fundamentally alter the onboard instrument processing or replace it with the old CR05/CR07 processing for the anomalous instrument are considered too complex for the VIM time frame.

4.1.9.2.2 Data Storage Subsystem (DSS) Hardware (H/W) Sync

Playback data modes PB14 and PB15 require development of a new system of DSS control and telemetry processing for use onboard the spacecraft. Complications may occur which either preclude or make impractical the use of DSS H/W sync. Such complications could surface in one of two time frames:

- o During VIM-5 development/validation
- o After uplink of the VIM-5 FDS program

To protect against H/W sync development complications, the data recorded for playback using H/W sync shall be designed to be compatible with playback by an alternative playback data mode, as illustrated in the table below:

DATA TYPE	RECORD DAMODE	H/W SYNC PB DAMODE	ALTERNATIVE PB DAMODE
HR PWS	GS4b	PB14; 1.4 UNC D/L	PB05; 7.2 UNC D/L NORM PB SYNC
GS&E	GS08	PB15; 2.8 RS D/L	PB12; 4.8 RS D/L HALF PB SYNC
HR ENG	EH12	PB15; 2.8 RS D/L	PB12; 4.8 RS D/L HALF PB SYNC

Should an unrecoverable problem with H/W sync occur during VIM-5 development/validation, the PB14 and PB15 data modes will be replaced with PB05 and PB12, respectively. If no problem with H/W sync surfaces during VIM-5 development /validation, the PB05 and PB12 data modes may still be added if room is available in the FDS after all other requirements have been achieved. If a problem with H/W sync surfaces after uplink of the VIM-5 program, PB05 and PB12 become the prime VIM-5 playback data modes if they have been included in the program, and the playback capability shall be abandoned if they have not.

4.1.9.3 Future Memory Failures

The general tools available in VIM for FDS memory failures are Spacecraft configuration changes, patches to the operating program, and uplink of a different operating program (replacing VIM-5 with VIM-7).

The recovery strategy chosen for a specific FDS failure depends on the nature of the failure, the operating FDS program, and the spacecraft in which the failure occurs. Detail failure recovery strategies are beyond the scope of this document; however, the following requirements are levied on the VIM mission to facilitate FDS failure recovery:

- The capability to perform FDS hardware and software diagnostics, software patch design, and software validation shall be available to the project until at least six months after the uplink of VIM-7.

- Where possible, a patch made to an FDS program to recover from an FDS failure shall be made to both spacecraft in order to maintain commonality of the FDS program load for both spacecraft. However, if this proves unfeasible, it is preferred to implement a Spacecraft-unique FDS patch rather than to abandon a data type for that spacecraft.

- Design of the VIM-5 program shall maintain 256 spares to accommodate FDS patches necessary to bypass memory failures.

- If possible within the other requirements levied, the VIM-7 FDS program shall be designed to reside within a single FDS memory half (4096 memory locations less bad addresses).

4.2 Engineering Requirements (General)

A sufficient number of engineering formats shall be available to allow spacecraft health to be adequately monitored during both routine and special activities. Normally, engineering telemetry data are embedded within the science data modes. The following engineering formats shall be included in both the VIM-5 and VIM-7 FDS programs:

Cruise Engineering (CE)
CCS Memory Readout
FDS Memory Readout
AACS Memory Readout

In addition, a Modified Cruise (MC) format shall be included in the VIM-5 program. A maneuver engineering (MN) format shall not be required for VIM. Refer to Subsections 5.3 and 6.3 for specific format definitions, program address constraints, instrument safing commands, and other details.

4.3 Science Requirements (General)

At the most fundamental level, basic VIM science data mode capabilities must contain a low-bit-rate cruise science data mode for daily reception by 34m apertures; GS&E real-time and record/playback reduced data mode bit rates; and a capability to record and playback high-rate PWS data at reduced bit rates. Beyond these basic capabilities, enhancements have been identified for UVS stellar observations, several instrument processing modifications, and selected backup modes.

4.3.1 VIM-5 Requirements

The required science capabilities may be summarized as follows, where (a)-(d) represent the essential basic requirements, and (e)-(k) are enhancements desired to complement the basic capabilities:

(a) A low-rate ($\leq$186-2/3 bps) Reed-Solomon coded cruise science mode similar in format to CR05 with telecom performance capable of reception through the year 2000 using X-band low power over a 34-meter station.

(b) Real-time GS&E at a reduced data rate (less than or equal to 3.6 kbps).

(c) Record and playback of GS&E (reduced data rate if possible).

(d) Record and playback of high-rate PWS (reduced data rate if possible).

(e) Inhibit LECP Stepping during recording of high-rate PWS.

(f) MAG/PLS/LECP autocal capability.

(g) The capability of combining GS&E-rate UVS with data from the cruise science mode while maintaining a moderately low data rate (UV5a).

(h) Instrument processing modifications for six of the seven VIM instruments in the cruise science mode (CR5a).

(i) Reduction in data rate of the low-rate cruise science mode to 160 b/s by capitalizing on minor-frame bit reductions as part of CR5a processing modifications.

(j) Multiple transmission of the low-rate PWS embedded in the playback of high-rate PWS (PB14).

(k) Provide back-up data modes as possible, in the following order, to safeguard against hardware failure or implementation error: PB12, PB05, and CR05.

The science requirement specifics, including data mode priorities and detailed descriptions, are contained in Subsections 5.4.

4.3.2 VIM-7 Requirements

The required science capabilities are as follows, where (a)-(c) are essential requirements and (d)-(f) are enhancements:

(a) A low-rate (46-2/3 bps) cruise science mode similar in format to CR07 with telecom performance capable of reception through the functional lifetime of the Voyager spacecraft.

(b) Instrument processing for MAG, PLS, LECP, CRS, PWS, and PRA. Remove processing and telemetry for UVS and PPS from the CR07 baseline.

(c) PRA POR automatic recovery algorithm.

(d) Instrument processing modifications: MAG/PLS/PWS/PRA.

(e) MAG/PLS/LECP autocal capability suitable for the VIM-7 cruise data rate.

(f) A 16-position PRA frequency table.

The science requirements specifics are contained in Subsections 6.4 and 6.8.

4.4 Recording and Playback

Record and playback formats are interdependent and determined primarily by the DTR control strategy selected for VIM. With the deletion of ISS telemetry, three recorded data types are candidates for inclusion in the VIM-5 program: High-rate engineering, GS&E, and high-rate PWS. High-rate PWS utilizes a unique DTR control strategy.

For the recovery of high-rate engineering and GS&E, two options exist for DTR control which reduce the playback rate below the nominal minimum of 7.2 kb/s: DSS Half PB Sync and DSS H/W Sync. New record formats for high-rate engineering and GS&E are designed so that they can be played back using playback formats designed to use either method of DTR control. This makes it possible for both DTR control strategies to be incorporated in the VIM-5 FDS program, so that one can serve as a backup for the other.

4.4.1 Hardware-Sync Record and Playback

The first option for DTR control utilizes a previously unused hardware capability in the FDS to recognize a particular 24-bit pattern in the playback data and use it to select one of the 16 taps from the DTR to the FDS. Each tap's data stream is 1-bit shifted from the adjacent tap. This capability is referred to as DSS H/W Sync.

Playback for this option is a new capability still under study and, as a result, there is a developmental risk. There is a small possibility that something may surface during development which would make the playback capability not achievable.

In all previous playback formats, the record format was asynchronously embedded in the parent format minor frame and the record format frame start could be anywhere in the playback field. The DSS H/W Sync function word-justifies the playback data input to the FDS (which is a 16-bit word machine), provided the record format (recorded in Normal PB Sync) contains the 24-bit sync pattern discussed above. In the H/W Sync, a routine would then be implemented in FDS software (S/W) which detects, during playback, this 24-bit sync pattern and uses it as a reference point to determine the location of data in the record format minor frame. The FDS can then selectively process, during playback, different portions of the record minor frame, keeping the real data and throwing out the fill. This allows the downlink to be less than the playback rate. Note that, since bits are thrown out during playback in the H/W Sync option, the format which is recorded on the DTR is not identical to the format which is played back to the ground.

H/W Sync PB modes include PB15 at 2.8 kb/s (RS-coded, but no CR5a) and PB14 at 1.4 kb/s (every fifth line of PWS high-rate data; returns incomplete GS&E minor frame, but includes low-rate PWS portion). See also Table 4.1.4-1.

4.4.2 Half-Rate Record and Playback

The second option for DTR control utilizes the DSS Half PB Sync capability currently implemented in the UNC-5 and UBC-5 FDS programs. DSS Half PB Sync utilizes a flight hardware configuration in which the telemetry rate for recorded data is half the rate required by DSS hardware and each bit is recorded twice onto the tape recorder to achieve the required data rate. On playback, every second bit is deleted, so that the original recorded data are fully recovered and the playback bit rate is cut in half. With Half PB Sync the minimum playback data rate is 3.6 kb/s. Existing playback mode PB12 combines the 3.6 kb/s playback with real-time CR05, then RS encodes the entire minor frame for a 4.8 kb/s downlink bit rate. In VIM, the embedded CR05 data will be replaced by CR5a data.

4.5 Ground Data System Requirements

4.5.1 Mission Sequence System Requirements

The Mission Sequence System (MSS) software shall be able to select and simulate any new or modified data modes and SC commands incorporated in the VIM FDS programs. The use of DSS H/W Sync in VIM will require the MSS to generate and simulate sequences using command parameters and spacecraft configurations not previously used on the spacecraft. The following requirements pertaining to DSS control are levied on MSS software:

- The MSS S/W shall be able select the proper spacecraft configuration (DSS Normal, Half, or H/W sync) for record or playback of data.

- The MSS S/W shall be able to detect in simulation an incorrect configuration for record or playback of data.

Table 4.5.1-1 lists the appropriate spacecraft configuration for all record and playback data modes. Note that proper spacecraft configuration is not strictly a function of data mode, but sometimes also of the desired record format. Also note that sometimes more than one spacecraft configuration is acceptable for a given record or playback situation.

Table 4.5.1-1 Required Spacecraft Configuration for Record or Playback of Data

DATA MODE	MODE TYPE	DESIRED REC FMT	REQUIRED SPACECRAFT CONFIGURATION	
EH12	REC	EHRH	HALF PB SYNC:	CC6AD XXX1
		EH24	NORMAL SYNC:	CC6AD XXX0
			OR H/W SYNC:	CC6AD XXX2
GS4b	REC	----	NORMAL SYNC:	CC6AD XXX0
			OR H/W SYNC:	CC6AD XXX2
GS08	REC	GS09	HALF PB SYNC:	CC6AD XXX1
		GS08	NORMAL SYNC:	CC6AD XXX0
			OR H/W SYNC:	CC6AD XXX2
PB05	PB	----	NORMAL SYNC:	CC6AD XXX0
			OR H/W SYNC:	CC6AD XXX2
PB12	PB	----	HALF PB SYNC:	CC6AD XXX1
PB14	PB	----	H/W SYNC:	CC6AD XXX2
PB15	PB	----	H/W SYNC:	CC6AD XXX2

It will be the responsibility of the sequence designer to select the appropriate data mode for playback of a given data type. Table 4.5.1-2 lists the appropriate playback data mode for all record formats.

Table 4.5.1-2 Playback Data Modes for Record Formats

RECORD FORMAT	PLAYBACK DATA MODE
EH24	PB15
EHRH	PB12
GS4b	PB14
GS4c	PB05
GS08	PB15
GS09	PB12

The VIM FDS programs shall have all image control removed. The MSS software shall be able to operate in the absence of any ISS control or imaging-related SC/ST commands (including image parameter tables) in its FDS program data base. All VIM data modes will be non-image counting data modes.

4.5.2 Downlink Telemetry Processing Requirements

The Voyager Ground Data System (GDS) shall provide downlink telemetry data processing functions including data acquisition, block and frame synchronization, decoding, frame extraction, channelization, alarm monitoring, and logging. Display capability shall be provided to monitor performance of the spacecraft and the GDS. Refer to Subsection 4.1.7 for guidelines on TTS and NERT support.

The GDS shall provide Data Management functions to catalog and archive GS&E data, and provide generation of Experimenter Data Records, Supplementary Experimenter Data Records, tabular or plot formatted data displays, transfer to remote facilities, and processing of PWS high-rate data.

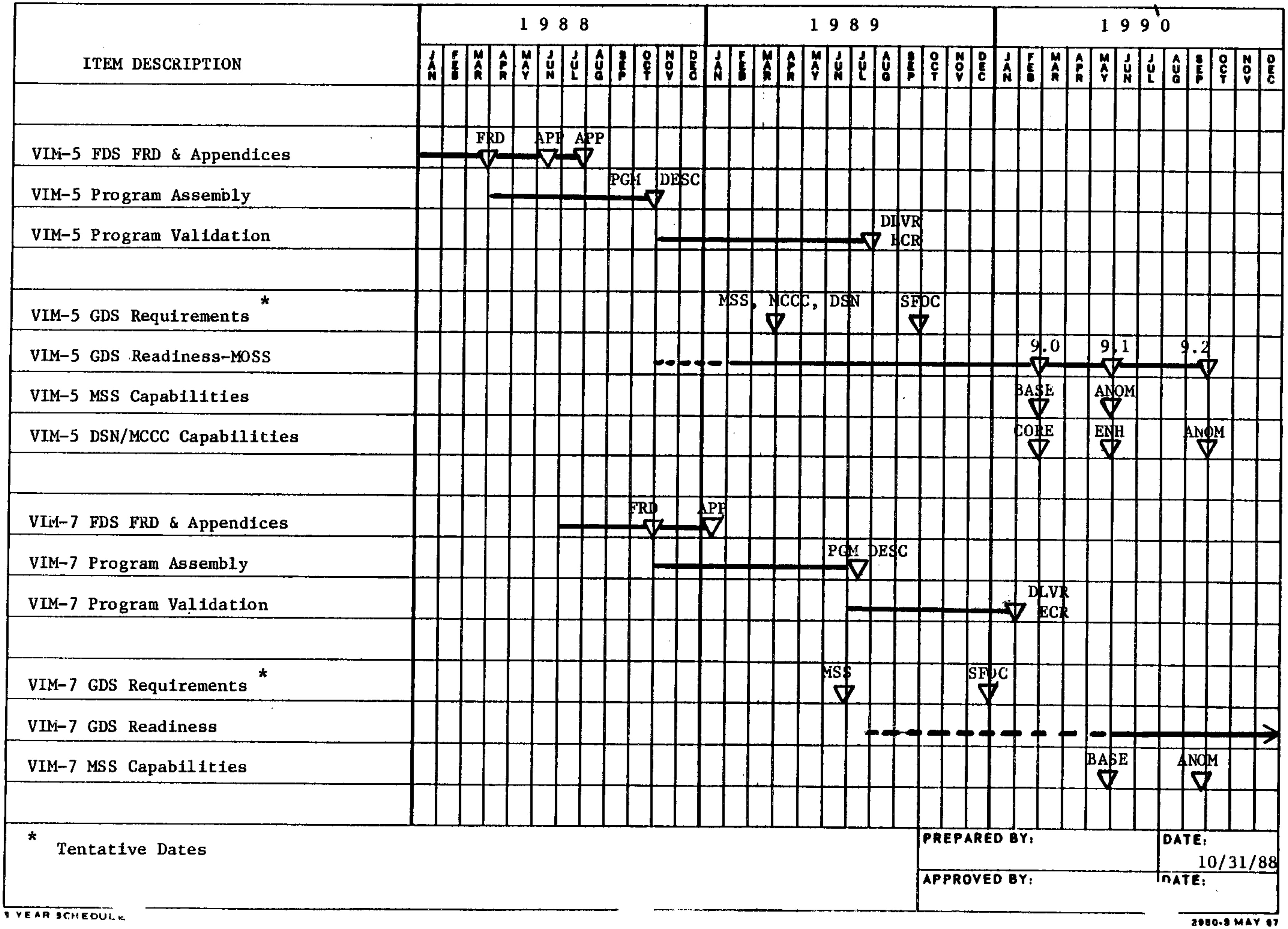
The GDS shall include simulation/test support capability to verify system functionality and performance, and to demonstrate new capability developed in response to evolving requirements.

4.6 Schedule

The VIM Data System development schedule is shown in Figure 4.6-1 with a resolution to the nearest half-month. The FRD specifies the project and science requirements on the end product data system. The FDS program assembly phase culminates with a detailed program description document. The program validation phase culminates with ECR delivery at the end of extensive testing in CDL. Note, however, that some anomalies may not be detected and fixed until after uplink (mid-1990 for VIM-5). Finally, VIM-5 MOSS deliveries by the GDS assume CR5a, GS08, PB15, EH24 for MOSS 9.0; fixes to 9.0 if necessary, UV5a, PB14, and GS4b for MOSS 9.1; fixes to 9.1 if necessary, and completion of core items and backup capabilities for MOSS 9.2.

In order to ensure that science data processing or format problems are detected soon after FDS-program uplink, if they should exist, it shall be a requirement that the VIM-participating PI teams have the necessary capabilities on-line to verify the acceptability of their data by 3/1/90 for VIM-5, and by uplink for VIM-7.

Figure 4.6-1 VIM Data System Development Schedule



4.7 Telecommunications Link Performance

This subsection contains (for information purposes) approximate telecom performance data at a level of accuracy that is useful for long range planning purposes. Figure 4.7-1 describes Voyager-1 performance and Figure 4.7-2 describes Voyager-2 performance from August 1, 1989 through December 31, 1994. Figure 4.7-3 describes Voyager-1 performance and Figure 4.7-4 describes Voyager-2 performance from January 1, 1990 to December 31, 2030. Figures 4.7-1 & 4.7-2 are nomograms, and describe telecom performance in much greater detail than the simple data rate versus time plots shown in Figures 4.7-3 and 4.7-4.

Voyager telecom performance for the first five years of VIM should be estimated using either Figure 4.7-1 or 4.7-2. These nomograms give telecom link performance for 80% confidence, yearly weather, X-band TWT in low power, and spacecraft deadband of .05, .10, and .25 degrees in the pitch, yaw, and roll axes for Voyager 1, and .05, .25, and .4 degrees for Voyager 2. Adjustments may be made for telecom link performance as a result of changes in deadband sizes, confidence levels, and for TWT high power. Bit error rates are either 5×10^{-5} or 5×10^{-3} as indicated on the nomograms for the various data rates available.

Either Figure 4.7-1 or 4.7-2 is used as follows. For a given date on the X-axis of the graph in the upper right hand corner, read vertically upward to the plotted curve. From this curve, read horizontally to the left to determine (for information) the additional range loss, in d.B., incurred after Neptune Encounter. Continue horizontally to the upper left hand corner graph, to the data rate of choice, then vertically downward to the DSN station combination of choice.

Next, read horizontally to the right to obtain performance margin, in d.B., for the date, data rate, and station combination chosen. Note for information the corresponding threshold signal strength (P_T/N_O) required to produce the performance margin. The daily tracking time available, in hours, at 80% confidence, may be determined by reading, from the matrix, the row corresponding to the given performance margin. Hours per pass are given for the DSN Goldstone (G), Canberra (C), and Madrid (M) complexes. The total tracking time per day accounts for time in overlapping passes. Performance margin adjustments, as a result of X-band TWT power, spacecraft deadband size, or confidence level changes are given in the lower right corner of Figures 4.7-1 and 4.7-2.

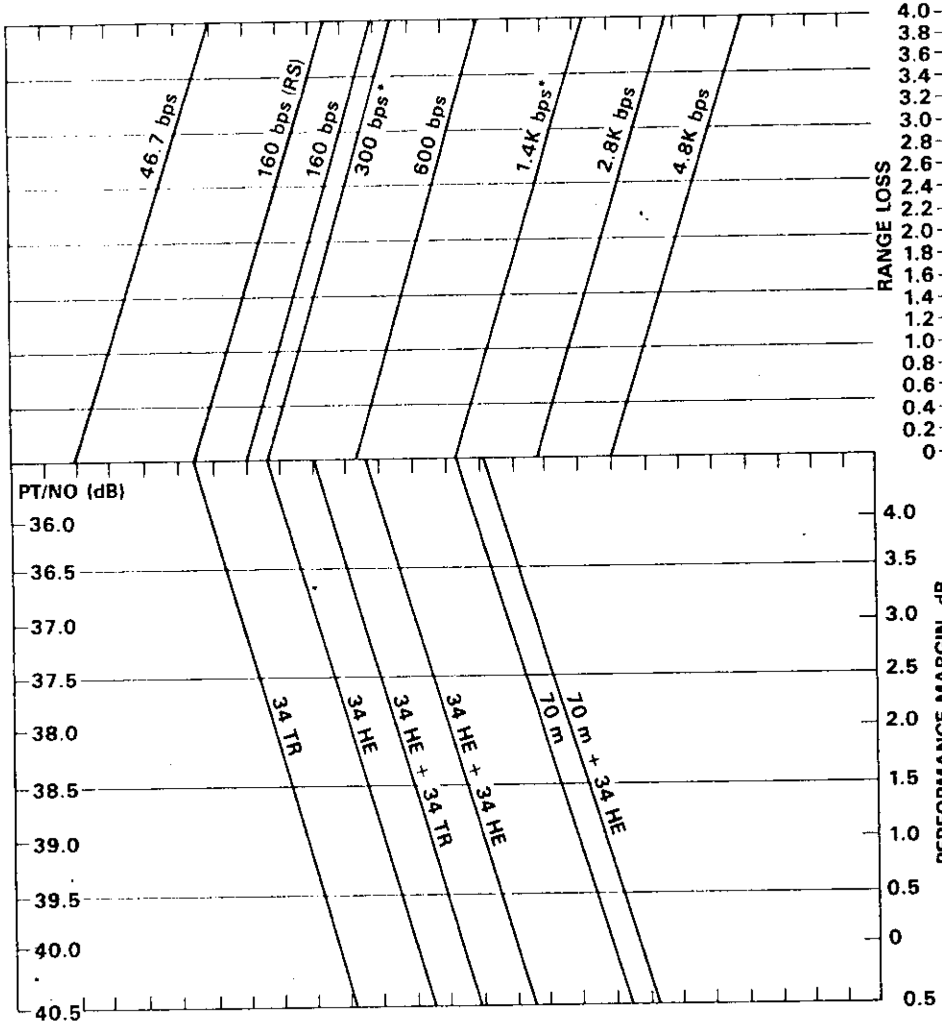
Figures 4.7-3 and 4.7-4 are read as follows. These figures are simple plots of available data rates, as a function of time, for the four possible combinations of DSN 70m antenna, 34m HE antenna, X-band TWT high power, and X-band TWT low power. Simply locate the time of interest on the X-axis, and read vertically upward to the antenna/power state of interest, to determine the available data rates (those below the appropriate curve).

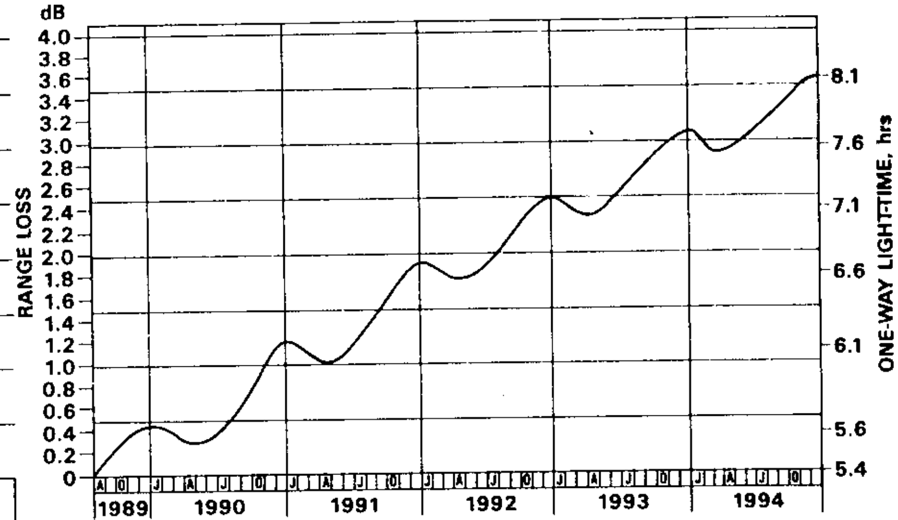
Figures 4.7-3 and 4.7-4 are plotted assuming 80% confidence, yearly weather, spacecraft deadband of .05, .10, and .25 degrees in the pitch, yaw, and roll axes for Voyager 1, and .05, .25, and .40 degrees for Voyager 2, and Goldstone peak performance for Voyager 1 and Canberra peak performance for Voyager 2. Link bit error rates are either $5x10^{-5}$ or $5x10^{-3}$ as indicated on the figures for the various data rates available. Performance margin adjustments may be made to any of the curves plotted, by referencing the table in the upper right hand corner of the figures. Note that an adjustment of -0.8db is necessary to go from nil hrs/day of coverage to 12 hr/day of coverage.

FIGURE 4.7-1

VOYAGER 1 VIM TELECOM

80% CONFIDENCE, X-LOW, YEARLY WEATHER, (.05, .10, .25) DDB





PASS LENGTH (hrs)

PERFORMANCE MARGIN, dB	G	C	M	TOTAL DAILY HOURS
0	0	0	0	0
0.5	7	0	6	13
1.0	8	4	8	20
1.5	9	6	9	21
2.0	10	7	9	22
2.5	11	8	10	23
3.0	12	9	11	24

MARGIN ADJUSTMENTS

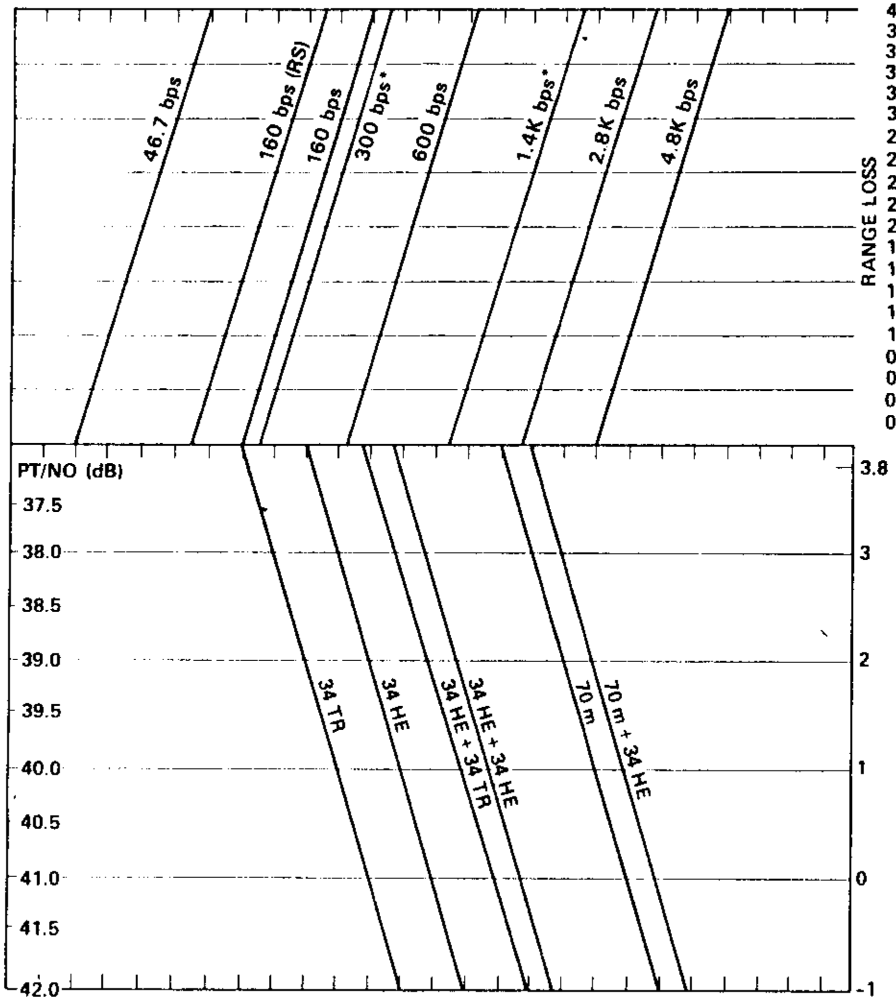
X-Hi, ADD 2.0 dB
90% CONFIDENCE, SUBTRACT 0.6 dB

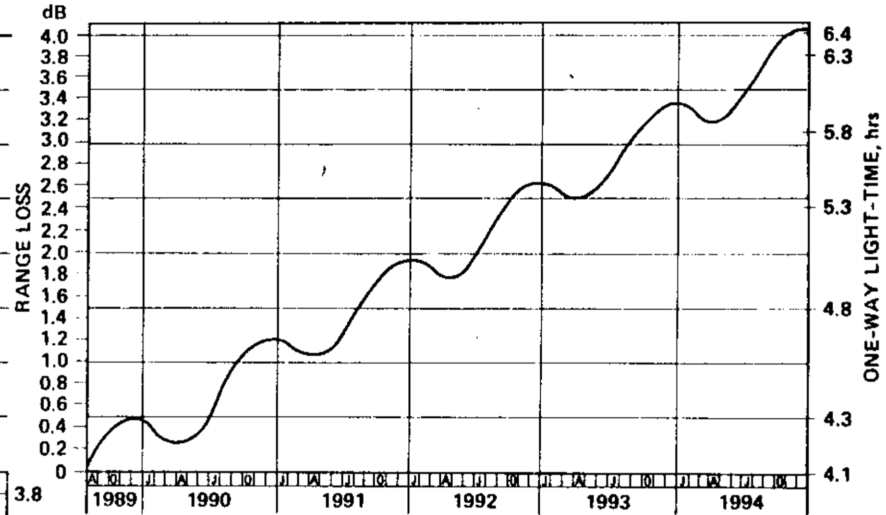
*FINAL BER = $5x10^{-3}$ (ALL OTHER DATA RATES HAVE FINAL BER = $5x10^{-5}$)

FIGURE 4.7-2

VOYAGER 2 VIM TELECOM

80% CONFIDENCE, X-LOW, YEARLY WEATHER, (.05, .25, .4) DDB





PASS LENGTH (hrs)

PERFORMANCE MARGIN, dB	G	C	M	TOTAL DAILY HOURS
0	0	0	0	0
0.5	0	7	0	7
1.0	4	9	0	13
1.5	6	10	3	17
2.0	6	11	5	20
2.5	7	11	6	21
3.0	8	11	6	22
3.5	8	12	7	23
4.0	9	13	7	24

MARGIN ADJUSTMENTS

X-Hi, ADD 2.0 dB
(0.05, 0.1, 0.25) DDB, ADD 1.8 dB
90% CONFIDENCE, SUBTRACT 0.6 dB

*FINAL BER = $5x10^{-3}$ (ALL OTHER DATA RATES HAVE FINAL BER = $5x10^{-5}$)

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FIGURE 4.7-3

VOYAGER 1 LONG-TERM VIM TELECOM PROJECTIONS

80% Confidence, Yearly Weather, (.05, .10, .25) Deadband, Goldstone Peak Capability

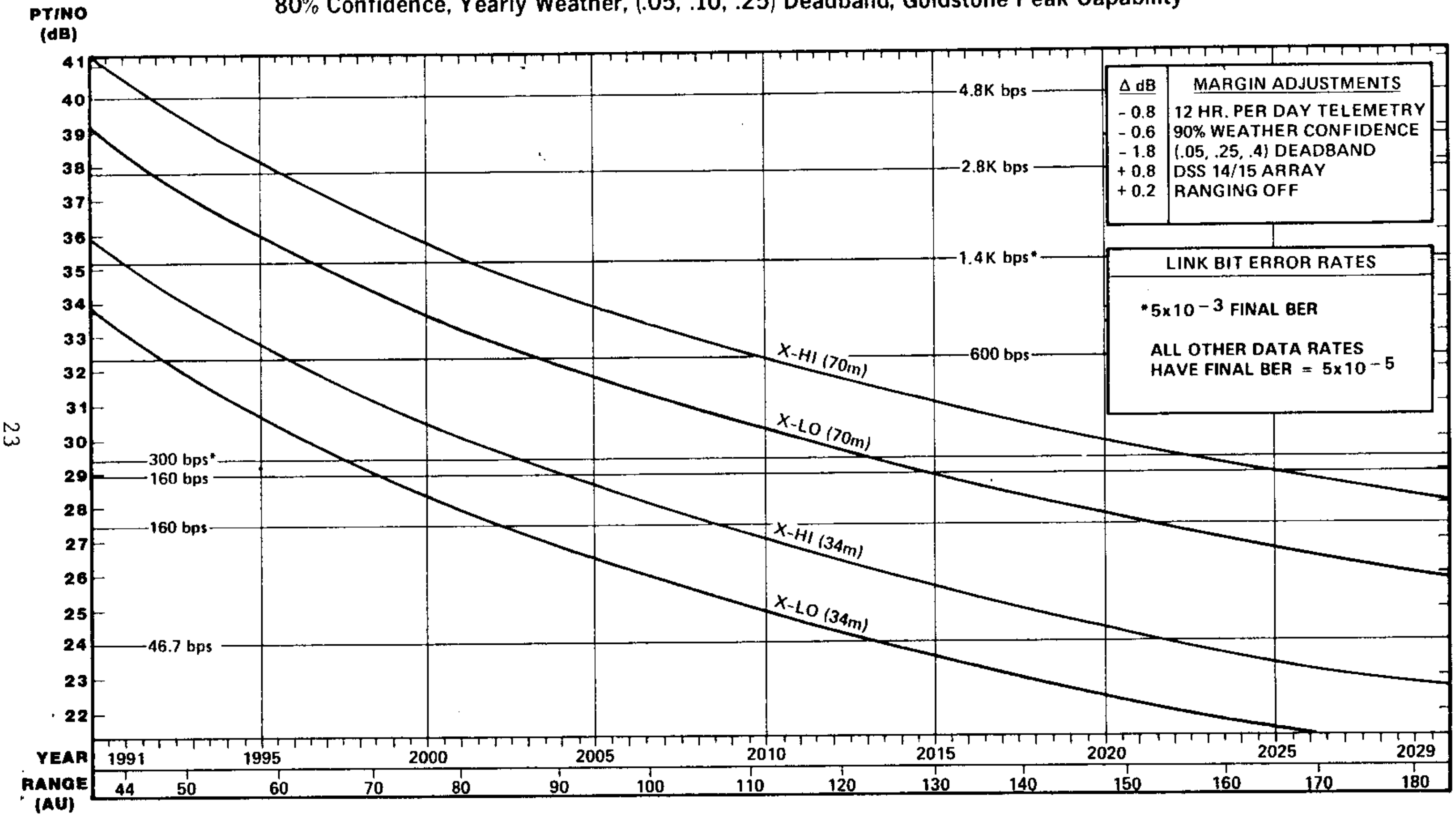
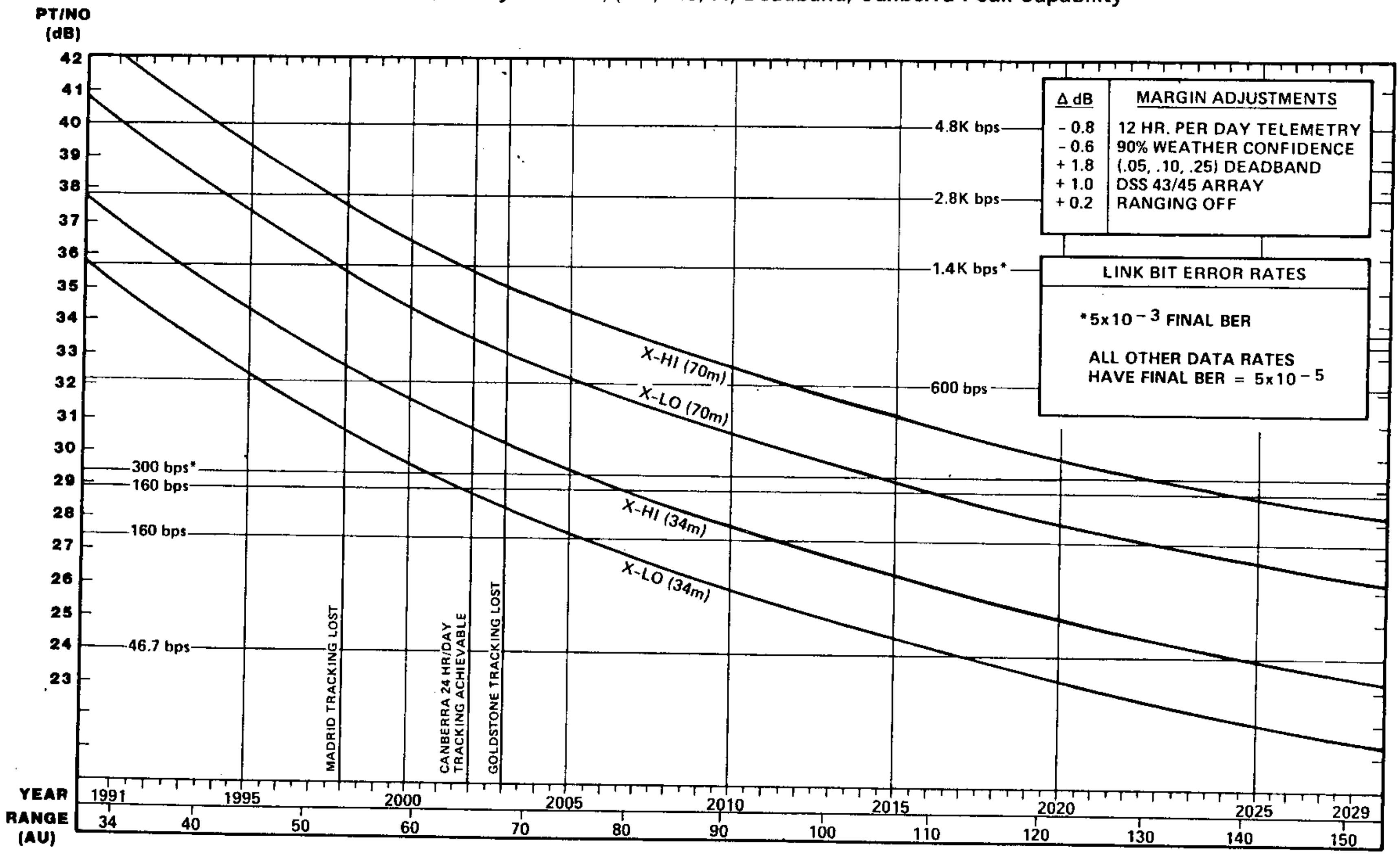


FIGURE 4.7-4

VOYAGER 2 LONG-TERM VIM TELECOM PROJECTIONS

80% Confidence, Yearly Weather, (.05, .25, .4) Deadband, Canberra Peak Capability



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5.0 VOYAGER INTERSTELLAR MISSION VIM-5 PROGRAM FUNCTIONAL REQUIREMENTS

5.1 Applicability

Whereas Sections 1-4 of this document are general in nature, usually applicable to the overall VIM Data System consisting of both the VIM-5 and VIM-7 FDS programs and supporting GDS requirements, Section 5 is specific to the VIM-5 program requirements.

5.2 Objectives

The objectives of Section 5, along with Appendices A-C, are to provide sufficient details on the functional requirements that must be satisfied by the VIM-5 science and engineering data modes and related capabilities that it will be possible to design, code, and test the necessary data system in time to meet the schedule milestones of Subsection 4.6 with a pre-negotiated and reliable product.

Regarding the organization of Section 5, it should be noted that the basic engineering and science requirements are set forth in Subsections 5.3 and 5.4, whereas the derived specific requirements may be found in Subsections 5.5 - 5.8, as well as in Appendices A - C.

From the standpoint of the overall developmental priorities on the VIM-5 FDS program, the order of importance (from highest to lowest) shall be to satisfy engineering requirements (spacecraft health and operations), 256 spare memory word requirements (4.1.9.1 and 4.1.9.3), and science requirements (see 5.4.1 for science priorities).

5.3 Engineering Requirements

5.3.1 Engineering Commutator Formats

Engineering commutator formats in VIM-5 shall be as listed in Table 5.3.1-1.

Table 5.3.1-1 VIM-5 Engineering Commutator Formats

COMMUTATOR FORMAT	GDS MNEMONIC
Cruise Engineering, AACS Telemetry Readout	CE
Cruise Engineering, AACS Memory Readout	CA
Modified Cruise, AACS Telemetry Readout	SM
Modified Cruise, AACS Memory Readout	SA
CCS Memory Readout	CC
FDS Memory Readout	FD

CE and CA shall be illegal in the EH12 data mode. All other combinations of data mode and engineering commutator formats shall be legal. Engineering commutator format command codes, as specified by the third field (fourth and fifth digits) of the SC06BB command, for commutator formats not in VIM-5, shall default to a compatible commutator format in VIM-5 as specified in Table 5.3.1-2.

Table 5.3.1-2 Engineering Commutator Format Defaults in VIM-5

SC06BB FIELD	COMMUTATOR FORMAT	VIM-5 DEFAULT
00	FDS Memory Readout	FDS Memory Readout
02	CCS Memory Readout	CCS Memory Readout
04	Launch	Modified Cruise
07	Cruise	Cruise
09	Encounter	Cruise
10	Maneuver	Modified Cruise
14	Modified Cruise	Modified Cruise

5.3.2 Engineering Data Formats

Engineering data formats in the VIM-5 program shall be EL10 (10 b/s engineering embedded in CR05 or CR5a), EL40 (40 b/s engineering stand-alone or embedded in GS08 and GS09), EH12 (1200 b/s engineering stand-alone or embedded in EHRH and EH24), EHRH (high rate engineering recorded in half PB Sync for playback in PB12, and EH24 (high rate engineering recorded for playback in PB15 with H/W Sync enabled). EHRH and EH24 are new recorded high-rate engineering transport frames and are described in detail in Subsection 5.6.

5.3.3 Engineering Data Modes

The engineering commutator shall be embedded in the CR05 (CR5a) data format at a rate of 10 b/s and embedded in the GS08 and GS09 data formats at a rate of 40 b/s. In addition, there shall be two stand-alone engineering data modes: EL40 (real-time engineering at 40 b/s) and EH12 (real-time engineering at 1200 b/s). The EH12 data mode shall in addition record EHRH at 3600 b/s when in half PB sync. High-rate engineering data recorded in normal PB sync in the EH12 data mode will be played back in PB15 with H/W sync enabled, which will allow deletion of some of the fill for a data rate of slightly less than 2400 b/s. PB15 will RS code the remaining data/fill, producing the EH24 format at a final playback rate of 2.8 kb/s (EH24).

5.3.4 Science Instrument Command Constraints

The science instrument housekeeping and safing commands that are currently used in the EL and EH data modes shall be retained in the VIM-5 program. The safing commands are listed in Table 5.3.4-1. Note however, that PPS and ISS safing commands may be deleted.

UVS word gates are not issued in the EL40 and EH12 data modes, inhibiting readout from the instrument. As a result, EL40 and EH12 data modes can be selected during a period when UVS readout is inhibited with an SC34AF (UVSROF-1) without interrupting the UVS count accumulation.

Table 5.3.4-1 Science Instrument Safing Commands (both S/C) in EL 40, EH 12

Instrument	FDS Command (Hex)	Instrument Configuration	
LECP	A802	Motor Frequency	60 HZ
		D1 Fast Channel	Not Subcom
		Motor Scan	Full
		Emergency Motor Power	OFF
		Motor DR Power	Normal
		Motor Step Rate	Normal
		Motor Scan	Normal
		Motor Position	Sector 4
PLS	0000	Power State	On
		Instrument Gain	7
		Amp Gain	1

5.3.5 Program Address Constraints

Addresses of certain "SC" commands are constrained so that their use on the spacecraft does not depend on which FDS program is prime. These SC commands and their required addresses are listed in Table 5.3.5-1. Program address constraints previously imposed on PPS commands no longer apply.

Table 5.3.5-1 Constrained Program Addresses

Mnemonic	Addr	Command	Function
MODE	0BE5	SC06BB	Data Mode Select
CPYFLG	0F81	SC06BC	Copy Flag
SVCFLG	0BE2	SC06BP	FDS Prime Memory Select
CRSHVF	0F80	SC21AG	CRS HV ON
LECPSC	0BEA	SC25AH	LECP CMD WD
SCIDNO	0BEF	SC06QF	Spacecraft ID

5.4 Science Requirements

5.4.1 Priorities

Because several science capabilities have been requested but may not all be implementable, it is important that priorities be established not only with respect to scientific rationale, but also to considerations regarding developmental complexity and GDS adaptability as well. Although inclusion of some form of low-rate cruise data collection (i.e., at least RS-coded CR05) for all seven VIM instruments is a hard requirement, it is requested that the high-rate formats be developed first to facilitate expedient construction of the program. They are relatively simple to construct and inexpensive (in terms of FDS memory space) compared to the instrument processing modifications. The CR5a processing mods are then to be addressed subsequently as a group. If either development resources or FDS memory space are depleted before all of the processing modifications have been incorporated, it is assumed that the original CR05 processing schemes will be used for the remaining instruments. With these considerations in mind, development should proceed in the following order:

(a) "Reduced rate" real-time GS&E (GS08)
(b) "Reduced rate" playback of GS&E (PB15); PB12 to be substituted only if PB15 not workable in development
(c) "Reduced rate" playback of high-rate PWS (PB14); PB05 to be substituted only if PB14 not workable in development
(d) Inhibited LECP stepping during recording of high-rate PWS
(e) Combined MAG/PLS/LECP Autocal
(f) GS&E-rate UVS plus CR5a (UV5a)
(g) RS-coded low-rate (160 b/s desired, 186-2/3 b/s max acceptable) cruise science (CR5a) with instrument processing modifications prioritized as follows: LECP, PLS, PRA, PWS, MAG.
(h) PB12 (back-up to PB15)
(i) UVS instrument processing mods for CR5a.
(j) Multiple transmission of the low-rate PWS data embedded in the playback of high-rate PWS (in PB14)
(k) PB05 (back-up to PB14)

5.4.3 Description of Basic Requirements and Enhancements

5.4.3.1 General Science and Engineering

A data mode capable of returning RS-coded GS&E in real-time at a "reduced data rate" is required. The basic format will be similar to the current UNC GS06 mode except that the minor frame may be further truncated by eliminating the PPS and Header fields in addition to the IRIS field. The predominant use for this mode will be to perform periodic MAG/PLS/LECP autocals and periodic high resolution F&P to augment the low-rate data. It will additionally be used to acquire high-rate UVS data if UV5a is not available. The Bit Error Rate (BER) requirement acceptable for these data is 5E-5.

5.4.3.2 Recording and Playback of GS&E

The capability to record and playback the GS&E frame discussed in 5.4.3.1 is also required. The principal use for this capability will be to record and playback Cruise Maneuvers. It is recommended that the playback data mode also be RS-coded with an overall downlink BER requirement of 5E-5. To achieve a data rate lower than the currently available Half-Plbk-Sync mode PB12 (4800 bps) it will be required to develop a mode which utilizes the Hardware Sync playback capability (PB15). This is the preferred mode unless the Hardware Sync Playback capability proves unworkable during the development phase, in which case PB12 will be required in its place. If on the other hand, development of the H/W sync capability is successful, then it will not be necessary to include PB12 due to its relatively short useful lifetime and the desire to conserve ground development resources for higher priority items. No real-time data are required with this playback.

5.4.3.3 High-rate PWS Record and Playback

There should also exist the capability to record and playback high-rate PWS data to provide valuable science data and a means of calibration for the low-rate PWS. By developing a playback mode (PB14) which utilizes the Hardware Sync capability, and a compatible record mode (GS4b), it is acceptable to return only one out of every 5 lines of PWS to achieve a downlink rate (1400 bps) which is significantly lower than PB05 (7200 bps). In the UNC GS4a format, the full GS&E frame is recorded along with the high-rate PWS; in the new format it will only be required to return low-rate PWS data. Multiple transmission of this data is a further enhancement and is addressed in 5.4.3.9. So that a longer lifetime is achievable for this data mode, the acceptable BER for the high and low-rate data is 5E-3 (RS-code is not required). No real-time data are required with this mode.

PB05 is not to be included in VIM-5 unless the Hardware Sync mode (PB14) proves unworkable during development or until all other higher priority enhancements have been included (see 5.4.1).

5.4.3.4 Inhibited LECP Stepping During GS4b

It is requested that the LECP stepping be inhibited during the recording of high-rate PWS (GS4b) to eliminate LECP interference in the PWS high-rate data.

5.4.3.5 Combined MAG/PLS/LECP Autocal

It is requested that a MAG/PLS/LECP autocal capability be included so that, while operating in the MC format, all three calibrations can be initiated by one command and performed simultaneously. Autocal capability is desired for both GS&E and cruise data modes.

5.4.3.6 GS&E-Rate UVS Plus Cruise Science (UV5a)

A data mode which combines the GS&E-rate UVS data that is currently returned in the GS06 mode, with a low-rate GS&E frame (CR5a) at a low, cruise-like data rate is desired. Its function will be to provide continuous GS&E-rate UVS data over a 34m station without interrupting the collection of the cruise science data. This mode will serve as the basic cruise mode for the period of time that it is recoverable over a 34m station using X-Band low power. Following exhaustion of the low power telecom performance of this mode, it may be used to obtain periodic GS&E-rate UVS using X-Band high power or 70m station coverage. CR05 is to be used only if CR5a is not available.

5.4.3.7 Cruise Science

A cruise science mode (CR5a) similar in format to the current CR05 mode, but without PPS, will be the primary format used during the VIM-5 period. For six of the seven VIM instruments it is desired that modifications to instrument processing schemes be incorporated into the new cruise format. The specific motivations for these changes vary from instrument to instrument but fall broadly into two categories: those that require changes to fix long-standing problems with CR05 processing, and those that require enhancements to accommodate the new environments to be encountered in the outer solar system.

RS-coding of CR5a science data is a basic requirement regardless of the number of processing modifications included. Achieving a data rate of 160 b/s (rather than 186-2/3 b/s) is, however, dependent upon removing 160 bits from the science fields in the minor frame to enable use of RS-coding. As the modifications are currently designed, the two instruments which will provide these 160 bits are the LECP (32) and the PRA (128). Since PRA is third on the list of instrument modifications, the higher bit rate will have to be used if only the first two are incorporated.

5.4.3.8 Instrument Processing Modification Descriptions

Brief descriptions of the requested CR5a processing modifications follow. Detailed descriptions are provided in Appendix A.

5.4.3.8.1 LECP Modification

In the LECP modification, it is proposed that current CR05 be replaced with a scheme which emulates CR07 processing but maintains the CR05 step rate of 192 seconds. Current CR05 processing has the problem that motor steps occur during accumulation periods for 52 of the 76 logics read out (the use of the word logic refers to the various instrument configurations, not step position). This "mixed sector" sampling severely hinders the determination of directional measurements of particle fluxes, or anisotropy, a major goal of the LECP. The proposed scheme will read out the LECP accumulators in bursts so that data collection can be synchronized with motor stepping in such a way that no mixing occurs in any of the logics. The scheme represents a simplification in format and timing and provides a significant enhancement to the scientific information returned by the LECP instrument. In addition, 32 of the 160 bits/minor frame needed to reduce the RS-coded CR5a data rate to 160 bps are made available by this modification.

5.4.3.8.2 PLS Modification

A simple modification to the CR05 PLS processing has been requested in which D-cup (lateral detector) measurements are added to the M-mode (the high resolution positive ion mode). In the current scheme, measurements from all four detectors are sampled during the M-mode, but only those from the A, B and C- cup (main detectors) are returned. During interplanetary cruise periods, the lateral measurements have not been required. After crossing the heliospheric shock, however, it is anticipated that the sub-sonic plasma flow will be best characterized with information from all four sensors, because of the different look direction of the D-cup as compared to the A, B, and C-cups. To accommodate the added D-cup measurements without increasing the current PLS minor frame bit allocation, the number of channels returned per cup can be reduced from 99 to 74 for a total of 297 returned per M-mode. The current capability of modifying specific channel sampling schemes by changing the M-start words is still desired and will afford flexibility for adapting to changing environments. In addition, it is desirable to occasionally get a full M-mode scan, e.g., every 96 minutes, without having to change the M-start words. This could be accomplished by doing a lower 74/upper 74 scan in two consecutive M-modes and then immediately returning to the nominal M-start word algorithm.

5.4.3.8.3 PRA Modification

It is desired to modify the PRA CR05 processing in such a way that instrument sensitivity and sampling sensitivity in the lower frequencies is increased at the expense of less useful higher frequency channels (solar radio emissions are not detectable in the high channels). The most general scheme samples 8 frequencies in a 48-second period using the FIXLO mode at the encounter instrument scan rate of 6 seconds per scan. The set of 8 frequencies is altered in each of the next seven 48-sec frames, so that a total of 64 frequencies are sampled in a period of 384 sec. During the scan, 200 8-bit samples are taken, 100 at each polarization. The PRA data consists of two 16-bit words, each a sum of the 100 samples of one polarization, for each 6-second scan, with 56 bits per minor frame budgeted to return the PRA data. This makes available 200 bits per minor frame to accomplish the lower downlink rate for CR5a with 72 bits to spare.

5.4.3.8.4 PWS Modification

It is proposed that the spare 72 bits per minor frame made available from the PRA modification be used to increase the total PWS bit allocation to 88 bits per minor frame. With this increased downlink capability it is possible to sample at the encounter rate of 4 seconds per 16 channel scan, then accumulate 10 bit sums over four of these scans in each channel. In addition, every twelfth 16 second cycle could be thrown out to eliminate contamination by the LECP stepping interference thereby bringing the total bit rate to 88 bits per minor frame. The net gain in science return would be an increase in instrument duty cycle by a factor of 19.2. Further, the temporal resolution of the measurements is increased to a full spectrum every 16 seconds vs. 76.8 seconds in the current scheme.

5.4.3.8.5 MAG Modification

It is desired to modify the CR05 processing of the MAG instrument to replace the current Delta Modulation scheme with a linear 6 bit differencing scheme. The proposed scheme is similar to that used in the GS03 mode, except that bit efficiency is weighted for the Outboard Low Field Magnetometer (LFM). The new scheme has the advantage that better fidelity is maintained in the low field environments, and it will provide more reliable results, particularly when power spectral studies are carried out on the data. The basic scheme would bring down a Primary LFM difference each 0.48 seconds plus full 3 axis reference vectors (12 bits per axis) for the Primary and Secondary LFM at rates of 12 and 24 seconds, respectively. The new scheme does not exceed the current MAG minor frame bit allocation.

5.4.3.8.6 UVS Modification

The requested UVS modification makes use of the unused PPS bits in the UVS/PPS subcom to decrease the UVS CR05 scan rate from 9.6 minutes to 4.0 minutes. At the current scan rate of 9.6 minutes it is difficult to deconvolve information regarding when and how long the source is within the UVS FOV. Decreasing the scan rate to 4.0 minutes will significantly increase efficiency and usefulness of the low-rate data. To accomplish this scheme, it is also necessary to delete 8 channels (out of 128 in a full scan) and truncate the word length returned for each channel to 8 bits. The UVS/PPS/status-word subcom structure need not be modified to accommodate this proposal.

5.4.3.9 Multiple Transmission of the low-rate PWS in PB14

It is desired to have multiple transmissions of the low-rate PWS which is returned with the high-rate PWS in PB14 so that some form of error correction could be carried out on the low-rate data by the users.

5.5 CR5a Processing Changes

The new CR5a data mode, though based on the old CR05, incorporates several changes to the processing of the science data. The purpose of these modifications is to correct problems encountered with the old CR05 and to enhance the performance of the cruise data mode in general. A summary of the new processing requirements is given below. Detailed specifications are contained in Appendix A.

LECP Instrument cycle time is changed to 192 seconds, synchronizing with the motor step cycle, in order to avoid the problem of mixed sector data collection.

PLS D cup data is added in the M mode. The number of M mode channels to be read out with every cycle is consequently reduced to 74 channels every PLS scan from the current 99. A full spectrum PLS scan is returned once every 48 minutes by automatically adjusting the M start words in the FDS.

PRA Scan rate is increased to 1 scan every 6 seconds from 1 scan every 60 seconds. PRA operation is constrained to the FIXLO and LEVEL modes. Frequency selection in the FIXLO mode is controlled by a new algorithm which iteratively scans through 64 frequencies, one frequency per scan or every 6 seconds, in the range of 1.2 to 1210.8 kHz.

PWS Processing is changed to output the average of four consecutive 4-second scans once every 16 seconds. One out of every 12 scans is corrupted by LECP motor stepping and is deleted.

MAG The current scheme of delta modulation is replaced by a 6-bit differencing scheme. Differences are between consecutive averages from each axis of the primary Low Field Magnetometer. Each axis is sampled at a rate of one sample every 0.06 seconds. Eight consecutive samples are averaged for a rate of one average every 0.48 seconds. A primary "Full Vector Word" is telemetered every 12 seconds for each axis and a secondary "Full Vector Word" is telemetered every 24 seconds for each axis.

UVS Scan time is reduced to 4 minutes per UVS scan. Individual channel data is output as 8-bit words (truncate 2 MSBs of the nominal 10-bit UVS word). Eight of the 128 total UVS channels are deleted to meet bit rate constraints.

5.6 New Data Formats

Contained here and in Appendix B are the details on the content and arrangement for all new data formats to be developed for use in the VIM-5 FDS program. The information should be considered tentative pending final assembly of the VIM-5 program. Format IDs for new VIM data formats will be defined in the ECRs which deliver the new formats to the project.

5.6.1 CR5a Data Format

The CR5a data format contains the instrument processing changes discussed in Subsection 5.5. Minor frame length is 1312 bits, generated over a period of 9.6 seconds. Figure B-1 (see Appendix B) compares CR5a with the "old" CR05 format, showing the order and allocation of data in each minor frame. Note that CR5a does not contain a header. The CR5a format will always be embedded in a transport frame (either CR5T or UV5a), so as long as the transport frame uses a 64-bit header, a separate header for CR5a is redundant.

5.6.2 CR5T Data Format

The CR5T data format is the Reed-Solomon coded transport frame used to return CR5a. Figure B-2 illustrates the construction of the CR5T data format. Minor frame length is 7680 bits, generated over a period of 48 seconds. FDS count increments by one MOD 60 count per minor frame; line count is always 001. A 64-bit header precedes five embedded CR5a minor frames. The header and all five CR5a minor frames are Reed-Solomon coded. Since the embedded CR5a minor frames do not contain headers, their FDS counts must be constructed from the CR5T header. Timing of the embedded CR5a minor frames with respect to the CR5T FDS count will be detailed in the ECR delivering the CR5T format to the project.

5.6.3 EH24 Data Format

EH24 is the format of recorded high-rate engineering when played back in PB15 with DSS H/W sync enabled. Figure B-3 illustrates the construction of the EH24 format. Minor frame length is 6720 bits generated over a period of 2.4 seconds. The 64-bit EH24 header is followed by six embedded EH12 minor frames. Format IDs for the embedded EH12 minor frames follow the convention of the real-time EH12 data format. The embedded EH12 minor frames are interspersed with fill to prevent false lock on the EH12 headers. A large fill field follows the engineering data to bring the minor frame length up to the required 6720 bits. The entire Header/Data/Fill field of the EH24 minor frame is Reed-Solomon coded on playback by the PB15 processing. Note that bit errors induced by the DTR write/read process cannot be detected or corrected by the Reed-Solomon code. The EH24 header is a transport frame header and does not follow the convention of engineering minor frame headers. Engineering commutator format must be extracted from the embedded EH12 headers. Note that spacecraft time is available in the EH24 header and in the headers of each of the embedded EH12 minor frames.

5.6.4 EHRH Data Format

EHRH is the format of recorded high rate engineering when recorded in half PB sync and played back (in half PB sync) using PB12. Figure B-4 illustrates the construction of the EHRH data format. Minor frame length is 8640 bits generated over a period of 2.4 seconds. The 48-bit EHRH header is followed by a EH24 header and six EH12 minor frames interspersed with fill. Note that, while the EHRH parent frame contains an embedded EH24 header, it does not contain a complete embedded EH24 minor frame: there is no Reed-Solomon code block as in EH24. Format IDs for the embedded EH12 minor frames follow the convention of the real-time EH12 data format. A large fill field follows the engineering data to bring the minor frame length up to the required 8640 bits. (For purposes of EHRH processing, the 48-bit DSS Sync pattern at the end of the minor frame can be regarded as fill.) The EHRH header (like the embedded EH24 header) is a transport frame header and does not follow the convention of engineering minor frame headers. Engineering commutator format must be extracted from the embedded EH12 headers. Spacecraft time is available in the embedded EH24 header and in the headers of each of the embedded EH12 minor frames.

5.6.5 GS4b Data Format

The GS4b data format is the format of high-rate PWS when played back using PB14 with H/W sync enabled. Figure B-5 illustrates the construction of the GS4b data format. Minor frame length is 6720 bits recorded over a period of 0.06 seconds, but played back over a period of 4.8 seconds. Only every fifth line of GS4b is returned on playback. So, while the minor frame duration is one FDS line, FDS count increments by 5 lines per playback minor frame. Starting line count for GS4b playback is not controlled. The 64-bit

GS4b header is followed by a 256-bit GS&E field and one line of high rate PWS.

Construction of the 256-bit GS&E data field in the GS4b data format is illustrated in Figure B-6. This design assumes the only data of interest in the GS&E field is the low-rate PWS. The 56-bit LECP field will be discarded on the ground. Note that the GS4b GS&E data field consists of two repetitions of the first 128 bits of one truncated GS&E field (as defined in Subsection 5.6.7 for the GS08 data format). Since ten GS4b minor frames are recorded in the time it takes to generate one truncated GS&E minor frame, this 256-bit GS&E field is repeated in ten consecutive GS4b minor frames. Sample time of the embedded GS&E data will be detailed in the ECR delivering the GS4b format to the project. Since two of every ten recorded GS4b minor frames are actually played back, these 128 bits from one truncated GS&E minor frame are repeated four times in a GS4b playback. This redundant data set provides the PWS users a means to identify and correct bit errors in the low-rate PWS data contained in the GS&E data field.

The ISS status subcom is not in the GS4b format; presence of high-rate PWS data must be inferred from the GS4b format ID.

5.6.6 GS4c Data Format

The GS4c data format is the format of high-rate PWS when played back using PB05. Design of the GS4c data format is constrained by the characteristics of the embedded GS4b minor frame. Figure B-7 illustrates the construction of the GS4c data format. Minor frame length is 6912 bits recorded over a period of 0.06 seconds, but played back over a period of 0.96 seconds. The 48-bit GS4c header is followed by an embedded GS4b minor frame and fill. (For purposes of GS4c processing, the 48-bit DSS Sync pattern at the end of the minor frame can be regarded as fill.) All recorded lines of GS4c are played back in PB05, so the 128 bits of data derived frm a truncated GS&E minor frame (as described in section 5.6.5) are recorded and recovered a total of 20 times for each truncated GS&E minor frame.

The ISS status subcom is not in the GS4c format; presence of high-rate data must be inferred from the GS4c format ID.

5.6.7 GS08 Data Format

GS08 is the VIM format for real-time GS&E. In addition, GS08 is the format for recorded GS&E played back in PB15 with H/W sync enabled. Construction of the GS08 data format is illustrated in Figure B-8. First, a 1408-bit "truncated" GS&E data field, derived as shown from GS07 by removing the header and the data fields for instruments not required in VIM, is generated over a 0.6 second period. The ISS status/engineering data fields, formerly in the 48-bit Status/PLS/PWS Subcom, contain fill in the truncated GS&E minor frame. High field magnetometer data, though not required in VIM, is retained in the truncated GS&E minor frame. An 8-bit fill field is added between the PRA and UVS data fields for the convenience of FDS processing. Location of instrument data fields are compared for GS07 and truncated GS&E in Table 5.6.7-1.

Table 5.6.7-1 GS07 and "Truncated" GS&E Data Fields

DATA FIELD	LOCATION IN GS07 MINOR FRAME	LOCATION IN TRUNCATED GS&E MINOR FRAME
HEADER	BITS 1 - 64	DELETED
(ISS)/STATUS/ PLS/PWS SUBCOM	65 - 112	1 - 48 (ISS DELETED)
ENGINEERING	113 - 136	49 - 72
LECP	137 - 496	73 - 432
MAG	497 - 946	433 - 882
2 BITS FILL	947 - 948	883 - 884
CRS	949 - 1104	885 - 1040
PRA	1105 - 1264	1041 - 1200
IRIS	1265 - 1936	DELETED
PPS	1937 - 1960	DELETED
8 BITS FILL	NOT APPLICABLE	1201 - 1208
UVS	1961 - 2160	1209 - 1408

GS08 data format minor frame length is 6720 bits, generated over a period of 2.4 seconds. A 64-bit GS08 header is followed by four of the truncated GS&E data fields and a Reed-Solomon code block. Note that the header is Reed-Solomon coded along with the four truncated GS&E minor frames.

Since they do not contain headers, FDS counts for the embedded truncated GS&E minor frames must be reconstructed on the ground from the FDS count in the GS08 header. Timing of the embedded truncated GS&E minor frames with respect to the GS08 FDS count will be detailed in the ECR delivering the GS08 format to the project.

When returned as a playback format (in the PB15 data mode), Reed-Solomon code is not applied to the minor frame in GS08 until after the data are read off the tape recorder. Also, the playback GS08 appears as a parent frame on the downlink, not as a format embedded in a playback minor frame. This process results in two characteristics of playback GS08 which must be understood by the users:

- Reed-Solomon code does not correct bit errors induced in the DTR read/write operation

- The ground processing cannot distinguish, based on Format ID or format architecture, between real-time and playback GS08

5.6.8 GS09 Data Format

GS09 is the format of recorded GS&E when recorded in half PB sync and played back (in half PB sync) using PB12. Construction of the GS09 data format is illustrated in Figure B-9. Minor frame length is 8640 bits generated over a period of 2.4 seconds. A 48-bit GS09 header is followed by a 64-bit embedded GS08 header and four of the "truncated" GS&E minor frames described in Subsection 5.6.7. Note that, while the GS09 parent frame contains an embedded GS08 header, it does not contain a complete embedded GS08 minor frame: there is no Reed-Solomon code block as GS08. Fill is added to bring the minor frame length up to the required 8640 bits. (For purposes of GS09 processing, the 48-bit DSS Sync pattern at the end of the minor frame can be regarded as fill). Reconstruction of the FDS counts for the truncated GS&E minor frames from the FDS count in the GS08 header will be the same as for GS08, and will be detailed in the ECR delivering the GS09 format to the project.

5.6.9 UV5a Data Format

The UV5a data format combines the cruise data of CR5a with UVS data of GS08. Construction of the UV5a data format is illustrated in Figure B-10. Minor frame length is 5760 bits generated over a period of 9.6 seconds. A 64 bit UV5a header is followed by a CR5a minor frame, fill, and a UVS field which is equivalent to the UVS data fields from sixteen consecutive truncated GS&E minor frames. The relationship between UVS sample time and UV5a header FDS count will be detailed in the ECR which delivers the UV5a format to the project. The entire minor frame, including header, is Reed-Solomon coded. Note the following characteristics of the UV5a data format:

- Time for one UVS scan is 3.84 seconds, same as for GS08

- S/C attitude (returned in the engineering data) is sampled at the CR5a rate of 10 b/s, or 12 s/sample for each axis in the CE commutator format
- UVS fields in the embedded CR5a minor frame contain fill

5.7 VIM-5 Data Modes

Data modes for the VIM-5 program are summarized in Table 5.7-1 and in Appendix C. Individual data modes are briefly discussed in the subsections below.

5.7.1 CR5T Data Mode

The CR5T data mode delivers the CR5T data format to the MDS High Rate (HR) channel. No data are recorded or played back. The UVS readout inhibit option of CR05, controlled by the SC34AF command (FDS mnemonic UVSROF) is carried over into CR5T. Also, the PLS integration control using the second field (third digit) of the SC06BB command (0=long, 1=short) is carried over from CR05 to CR5T.

5.7.2 EL40 Data Mode

With the exception of the deletion of the safing commands for PPS and ISS discussed in Subsection 5.3.4, the EL40 data mode is unchanged in the VIM-5 program.

5.7.3 EH12 Data Mode

Recorded data in the EH12 data mode are changed from previous FDS programs. Format of the recorded data depends on whether DSS Normal or Half PB Sync is selected. With Normal PB Sync selected, format of the recorded data is as illustrated in Figure C-1. When played back in PB15, these data are processed to produce the EH24 data format.

With Half PB Sync selected, the EH12 data mode records the EHRH data format, as illustrated in Figure C-2. In addition, the EH12 data mode shall record a large "1010101..." pattern in the fill field to facilitate development of an automatic CCS routine for establishing DSS sync with Half PB Sync is selected.

The PPS and ISS safing commands are deleted from the EH12 data mode, as discussed in Subsection 5.3.4.

5.7.4 GS4b Data Mode

The GS4b data mode delivers GS08 to the MDS HR channel and GS4c to the DTR. The recorded data can either be played back in PB05 to be returned intact, or in PB14, which edits the recorded data to produce the GS4b data format, as described in Subsection 5.7.8.

In addition, LECP motor stepping is inhibited in the GS4b data mode in order to eliminate LECP interference in the recorded high-rate PWS. Note that this makes GS4b unsuitable for return of real-time GS&E, unless it is acceptable to collect LECP data from a single sector.

Table 5.7-1: VIM-5 Data Mode Summary

	CMD	MDS HR		DTR				
DATA MODE	CODE (DEC)	RATE (kb/s)	FMT	MODE	RATE (kb/s)	REC FMT	SYNC	COMMENTS
CR5T	53	0.16	CR5T	NONE	NONE	NONE	N/A	
EL40	32	0.04	EL40	NONE	NONE	NONE	N/A	
EH12	16	1.2	EH12	REC	3.6 7.2	EHRH EH24	HALF/ NORM	PB12 PB PB15 PB
GS4b	03	2.8	GS08	REC	115.2	GS4c GS4b	NORM/ NORM	PB05 PB PB14 PB
GS08	07	2.8	GS08	REC	3.6 7.2	GS09 GS08	HALF/ NORM	PB12 PB PB15 PB
PB05	11	7.2	GS4c*	PB	7.2	N/A	NORM	PB GS4c
PB12	49	4.8	PB12	PB	3.6	N/A	HALF	PB GS9H, EHRH
PB14	TBD	1.4	GS4b*	PB	7.2	N/A	H/W	PB GS4b
2PB15	TBD	2.8	GS08* EH24*	PB	7.2	N/A	H/W	PB GS08, EH24
UV5a	TBD	0.6	UV5a	NONE	NONE	NONE	N/A	

*: Playback data, not real time

ALSO:

- o PLS/MAG/LECP AUTOCAL
- o MC, CE ENGINEERING FORMATS,
  plus CCS, FDS, AACS Memory Readout
- o FDS COPY

5.7.5 GS08 Data Mode

The GS08 data mode delivers the GS08 data format to the MDS HR channel. Format of the recorded data depends on whether DSS Normal or Half PB Sync is selected. With Normal PB Sync selected, format of the recorded data is as illustrated in Figure C-3. When played back in PB15, these data are processed to produce the GS08 data format.

With Half PB Sync selected, the GS08 data mode records the GS09 data format, as illustrated in Figure C-4. In addition, the GS08 data mode shall record a large "1010101..." pattern in the fill field to facilitate development of an automatic CCS routine for establishing DSS sync when Half PB Sync is selected.

5.7.6 PB05 Data Mode

The PB05 data mode shall be unmodified from previous FDS programs. Its sole function in the VIM-5 program is to play back the recorded GS4c data format at 7.2 kb/s. This provides a backup capability for playback of high-rate PWS if the PB14 data mode can't be used.

5.7.7 PB12 Data Mode

The PB12 data mode shall be modified in the VIM-5 program to delete the embedded CR05 data format. Note that this removes the real-time data from the minor frame. PB12 is used in the VIM-5 program to play back the recorded EHRH and GS09 data formats at a playback rate of 3.6 kb/s, or downlink rate of 4.8 kb/s after Reed-Solomon code is applied. This provides a backup capability for record and playback of high-rate engineering or GS&E if the PB15 data mode can't be used.

5.7.8 PB14 Data Mode

The PB14 data mode uses DSS H/W sync to allow formatted playback of recorded high-rate PWS data. This allows editing of the recorded data to reduce the bit rate to the ground. Figure C-5 illustrates this process. Four of every five minor frames of recorded GS4c are deleted. In the remaining minor frame, the GS4c header, fill field, and H/W sync pattern are deleted, leaving a GS4b minor frame. This process reduces the 7.2 kb/s playback rate to a 1.4 kb/s downlink rate. Note that there are no real-time data in PB14.

5.7.9 PB15 Data Mode

The PB15 data mode uses DSS H/W sync to allow formatted playback of recorded high-rate engineering or GS&E. This allows the recorded data to be both edited to reduce the bit rate to the ground, and Reed-Solomon coded. Figure C-6 illustrates this process for recorded high-rate engineering; Figure C-7 illustrates this process for recorded GS&E. For each high-rate engineering (GS&E) minor frame, the H/W sync pattern, EHRH (GS09) header, and final 10,560 bits of fill are deleted. The remaining data are Reed-Solomon coded, producing the EH24 (GS08) format. This process reduces the 7.2 kb/s playback rate to a 2.8 kb/s downlink rate with no loss of data. Note that there are no real-time data in PB15.

5.7.10 UV5a Data Mode

The UV5a data mode delivers the UV5a data format to the MDS HR channel. No data are recorded or played back. The UVS is commanded as in any GS&E data mode, with a UVS command word (SC34AE, FDS mnemonic UVSMVC) issued every 60 ms. However, the UVS command word appears in telemetry as in the CR5T data mode; every 20th minor frame (3.2 min) in the CR5a Command Subcom. The UVS readout inhibit option of CR5T, controlled by the SC34AF command (FDS mnemonic UVSROF) shall not be included in UV5a. PLS integration time is controlled by the second field (third digit) of the SC06BB command (0=along, 1=short) as in CR05 or CR5T.

5.8 PLS/MAG/LECP Autocal

In addition to PLS and MAG autocals, the VIM-5 program will also contain an LECP autocal. Each of the three autocals is further divided into two versions, Cruise and GS&E. Commands issued by the algorithm are the same for either version, but start time can vary (in the case of the PLS autocal) and duration is different: Cruise autocals take four times as long as GS&E autocals. The type of autocal executed depends on the data mode in effect at the time. Autocal type for the VIM-5 data modes is given in Table 5.8-1. Note that no autocals are executed in engineering data modes, and that autocal type is irrelevant in playback data modes, since no real-time data are returned. The autocal algorithms do not select data mode or engineering commutator format; this must be done by command from the CCS. Details for the individual autocals are given in the following subsections.

Table 5.8-1 Autocal Types for VIM-5 Data Modes

CRUISE	GS&E	NOT EXECUTED
CR5T	GS4b	EL40
PB12*	CG08	EH12
UV5a	GS08	EH12
	PB05*	
	PB14*	
	PB15*	

* Autocals are executed but no TLM returned.

5.8.1 MAG Autocal

The MAG Autocal algorithm is unchanged from the UNC-5 and UBC-5 programs.

5.8.2 PLS Autocal

The PLS Autocal start times, command sets, and durations for both Cruise and GS&E versions are unchanged from the UNC-5 program. However, in the Cruise version, M Start Word 1, configured by the SC32AL command (FDS mnemonic PLSMC1) will be overridden to force the PLS M Mode scan to start readout at M-channel 1; and M Start Word 2, configured by the SC32AM command (FDS mnemonic PLSMC2) will be overridden to force the PLS M Mode scan to start readout at

M-channel 55. This assures that all 128 M channels are calibrated in a cruise PLS Autocal.

5.8.3 LECP Autocal

The GS&E and Cruise versions of the LECP Autocal algorithm are specified in Table 5.8.3-1. Note that the LECP autocal also temporarily selects FDS -12 V to be monitored. Start time for either version is the FDS frame start after the SC06BY command enabling the autocal is issued.

Table 5.8.3-1 LECP (and FDS Voltage) Autocal Algorithm

COMMAND	GS&E TIMING (GS08, GS4b)				CRUISE TIMING (CR5T, UV5a)			
	DELTA		ACCUM		DELTA		ACCUM	
	(FR)	(MIN)	(FR)	(MIN)	(FR)	(MIN)	(FR)	(MIN)
SC25AH 6036	--	--	--	--	--	--	--	--
SC06BQ 1	21	16.8	21	16.8	84	67.2	84	67.2
SC06BQ 2	38	30.4	59	47.2	152	121.6	236	188.8
SC25AH 6032	1	0.8	60	48.0	4	3.2	240	192.0
SC25AH 5200	2	1.6	62	49.6	8	6.4	248	198.4

The LECP autocal will be enabled by setting the third Least Significant Bit (LSB) of FDS word AUTOCF to 1. As with the other autocal algorithms, this bit will internally reset to 0 at the end of the LECP autocal. The SC06BY command, which configures AUTOCF, shall be modified to permit additional parameter values for LECP Autocal control, as shown in Table 5.8.3-2.

Table 5.8.3-2 SC06BY Parameter Values

AUTOCALS ENABLED

SC06BY	BEFORE VIM-5			VIM-5		
PARAMETER	LECP	PLS	MAG	LECP	PLS	MAG
1	N/A	NO	YES	NO	NO	YES
2	N/A	YES	NO	NO	YES	NO
3	N/A	YES	YES	NO	YES	YES
4	---------------			YES	NO	NO
5	---------------			YES	NO	YES
6	---------------			YES	YES	NO
7	---------------			YES	YES	YES

5.9.3 GDS Systems Modifications

The DSN, and FPSO are required to provide Telemetry processing support for the new formats, data rates, minor data frames, channelized Engineering Data, and extracted Science Data. The above telemetry formats contain no imaging data. GS4b does however, include Plasma Wave Data, as does GS4c. The MIPS shall be required to support these Telemetry formats. There will be no NERT Science support for the modified Telemetry formats prior to integration of SFOC-provided GDS capabilities. Current data processing capabilities will be maintained.

In the Data Records System, EDRPROC for both science and engineering data will require modifications for the new VIM-5 data formats. In addition, Voyager-specific capabilities including CTAB/CPLOT, channelizer and memory compare will require change. Voyager will not accept delivery of new multimission software once the Neptune Encounter baseline is established. The project will plan to incorporate the current multimission DRS baseline in conjunction with VIM MOSS 9.0. It shall be required that the deltas between the Voyager encounter version of the DRS and the evolving multimission DRS be fully documented to ensure a timely transition to the multimission baseline.

Command System modifications are expected to be limited to changes to the Voyager Real Time Command Translator (JTRAN) as required to support the new downlink capabilities. Deliveries of the MCCC Command Subsystem will be required in support of the JTRAN deliveries.

The MCCC Simulation Subsystem is required to support development and testing of Command and Telemetry capabilities.

The Mission Sequence System software is to be modified (if necessary) to support the modular block method of sequencing. It is expected that modifications will be limited to SEQTRAN macros redefinition/modification, SEQGEN (block dictionary) and probably COMSIM. The MSS is required to provide both core and enhancement capabilities in a single delivery followed by an anomaly correction delivery. MOSS 9.1 is to be utilized to correct MSS VIM-5 anomalies. Modifications to improve sustainability while desired, are not required. Resources permitting, modifications other than for core or enhancement capabilities will be considered for the MOSS 9.2 delivery.

The Spacecraft Analysis System software will be modified as required to accommodate Scan Platform operational usage. Like the MSS, SAS will be restricted to core and enhancement capabilities implementation until the MOSS 9.2 delivery.

5.9.4 GDS Implementation Schedule

The schedule for the implementation of the VIM-5 capabilities is as follows:

MOSS 9.0 - Online March 1, 1990 provides:

TLM: CR5a, CR5T, PB12, GS4b, GS08, EH24.
CMD: all VIM-5 capability
SIM: all core VIM Telemetry and all Command capability; must be available to support development testing of both Telemetry and Command Systems. Simulation of VIM-5 core capabilities is required 1 October 1989. Simulation of VIM-5 enhancements is required 1 January 1990.

DRS: VIM-5 core capabilities.

MSS: VIM-5 core and enhancement capabilities.

SAS: VIM-5 core and enhancement capabilities.

MOSS 9.1 - Online June 1, 1990 provides:

TLM: FR corrections to Core capabilities, and GS4c EHRH, GS09, and UV5a.

SIM: FR corrections to Core capabilities, and support for development of the enhancement Telemetry capabilities.

CMD: FR corrections for all VIM-5 capabilities.

DRS: VIM-5 enhancement capabilities.

MSS: FR corrections for all VIM-5 capabilities.

SAS: FR corrections for all VIM-5 capabilities.

MOSS 9.2 - Online October 1, 1990 provides:

TLM: FR corrections for all VIM-5 capabilities.

DRS: FR corrections for all VIM-5 capabilities.

MSS: possible sustainability upgrades.

SAS: possible sustainability upgrades.

MOSS 9.3 - GDS Delivery April 1, 1991 provides:

SFOC: all SFOC subsystems VIM-5 capabilities.

MOSS 9.5 - Online 1 October 1991 provides:

SFOC: SFOC subsystems anomaly corrections, all SFOC subsystems operations (MCCC retirement).

6.0 VOYAGER INTERSTELLAR MISSION VIM-7 PROGRAM FUNCTIONAL REQUIREMENTS

6.1 Applicability

Whereas Sections 1-4 of this document are general in nature, usually applicable to the overall VIM Data System consisting of both the VIM-5 and VIM-7 FDS programs and supporting GDS requirements, Section 6 is specific to the VIM-7 program requirements.

6.2 Objectives

The objectives of Section 6, along with Appendices D-F, are to provide sufficient details on the functional requirements that must be satisfied by the VIM-7 science and engineering data modes and related capabilities so that it will be possible to design, code, and test the necessary data system in time to meet the schedule milestones of Subsection 4.6 with a pre-negotiated and reliable product.

Regarding the organization of Section 6, it should be noted that the basic engineering and science requirements are set forth in Subsections 6.3 and 6.4, whereas the derived specific requirements may be found in Subsections 6.5-6.8, as well as in Appendices D-F. Subsection 6.9 specifies ground data system requirements unique to the VIM-7 program and SFOC time era.

From the standpoint of the overall developmental priorities on the VIM-7 FDS program, the order of importance (from highest to lowest) shall be to satisfy engineering requirements (spacecraft health and safety including CMROT), CR07 science data mode, EL-40 data mode, VIM-7 program to fit into one-half FDS memory, CR7a processing changes, PLS/MAG/LECP Autocal, FDS memory copy, and MC engineering table.

6.3 Engineering Requirements

6.3.1 Engineering Commutator Formats

Engineering commutator formats in VIM-7 shall be as listed in Table 6.3.1-1.

Table 6.3.1-1 VIM-7 Engineering Commutator Formats

COMMUTATOR FORMAT	GDS MNEMONIC
Cruise Engineering, AACS Telemetry Readout	CE
Cruise Engineering, AACS Memory Readout	CA
CCS Memory Readout	CC
FDS Memory Readout	FD

Engineering commutator format command codes, as specified by the third field (fourth and fifth digits) of the SC06BB command, for commutator formats not in VIM-7, shall default to a compatible commutator format in VIM-7 as specified in Table 6.3.1-2.

Table 6.3.1-2 Engineering Commutator Format Defaults in VIM-7

SC06BB FIELD	COMMUTATOR FORMAT	VIM-7 DEFAULT
00	FDS Memory Readout	FDS Memory Readout
02	CCS Memory Readout	CCS Memory Readout
04	Launch	Cruise
07	Cruise	Cruise
09	Encounter	Cruise
10	Maneuver	Cruise
14	Modified Cruise	Cruise

The Cruise Engineering Commutator format shall be updated to incorporate any required measurements of the Modified Cruise format. Unnecessary channels (those from instruments not operating during the VIM-7 timeframe) may be deleted.

If memory space is available, a possible VIM-7 enhancement is the inclusion of the Modified Cruise Engineering Commutator Format instead of the revision of the Cruise Engineering format. If so then the Engineering commutator formats in VIM-7 shall be as listed in Table 6.3.1-3

Table 6.3.1-3 Enhanced VIM-7 Engineering Commutator Formats (Modified Cruise Included)

COMMUTATOR FORMAT	GDS MNEMONIC
Cruise Engineering, AACS Telemetry Readout	CE
Cruise Engineering, AACS Memory Readout	CA
Modified Cruise, AACS Telemetry Readout	SM
Modified Cruise, AACS Memory Readout	SA
CCS Memory Readout	CC
FDS Memory Readout	FD

Engineering commutator format command codes, as specified by the third field (fourth and fifth digits) of the SC06BB command, for commutator formats not in VIM-7, shall default to a compatible commutator format in the Enhanced VIM-7 as specified in Table 6.3.1-2.

Table 6.3.1-2 Engineering Commutator Format Defaults in the Enhanced VIM-7 (Modified Cruise included)

SC06BB FIELD	COMMUTATOR FORMAT	VIM-7 DEFAULT
00	FDS Memory Readout	FDS Memory Readout
02	CCS Memory Readout	CCS Memory Readout
04	Launch	Modified Cruise
07	Cruise	Cruise
09	Encounter	Cruise
10	Maneuver	Modified Cruise
14	Modified Cruise	Modified Cruise

6.3.2 Engineering Data Formats

Engineering data formats in the VIM-7 program shall be EL10 (10 b/s engineering embedded in CR7a), and EL40 (40 b/s engineering stand-alone).

6.3.3 Engineering Data Modes

The engineering commutator shall be embedded in the CR7a data format at a rate of 10 b/s. In addition, there shall be the EL40 (real-time engineering at 40 b/s) stand alone engineering data mode.

6.3.4 Science Instrument Command Constraints

The science instrument housekeeping and safing commands that are currently used in the EL and EH data modes shall be retained in the VIM-7 program. The safing commands are listed in Table 6.3.4-1. Note however, that PPS and ISS safing commands used prior to VIM are deleted.

Table 6.3.4-1 Science Instrument Safing Commands (both S/C) in EL40

Instrument	FDS Command (Hex)	Instrument Configuration	
LECP	A802	Motor Frequency	60 HZ
		D1 Fast Channel	Not Subcom
		Motor Scan	Full
		Emergency Motor Power	OFF
		Motor DR Power	Normal
		Motor Step Rate	Normal
		Motor Scan	Normal
		Motor Position	Sector 4
PLS	0000	Power State	On
		Instrument Gain	7
		Amp Gain	1

6.3.5 Program Address Constraints

Addresses of certain "SC" commands are constrained so that their use on the spacecraft does not depend on which FDS program is prime. These SC commands and their required addresses are listed in Table 6.3.5-1. Program address constraints previously imposed on PPS commands no longer apply.

Table 6.3.5-1 Constrained Program Addresses

Mnemonic	Addr	Command	Function
MODE	0BE5	SC06BB	Data Mode Select
CPYFLG	0F81	SC06BC	Copy Flag*
SVCFLG	0BE2	SC06BP	FDS Prime Memory Select
CRSHVF	0F80	SC21AG	CRS HV ON
LECPSC	0BEA	SC25AH	LECP CMD WD
SCIDNO	0BEF	SC06QF	Spacecraft ID

* Only if FDS Memory Copy is included in VIM-7

6.3.6 Program Memory Constraints

The VIM-7 FDS program shall be designed to fit within a single FDS memory half. The purpose of this is to restore memory redundancy on S/C 31. This requires that all failed addresses in either memory half of either spacecraft must be avoided. In addition, all corresponding locations must be avoided, i.e. if memory location 1BE0 is failed then in addition to avoiding this memory address, location 0BE0 must also be avoided. One exception is that addresses F00-FFF may be used since these are special registers which are required for program operation.

6.3.7 CMROT Compatibility

The VIM-7 FDS program shall be compatible with the minimum CMROT routine. This is to allow software loads to S/C 31 FDS memory.

6.3.8 FDS Memory Copy

Should memory space be available, an enhancement to the VIM-7 FDS program is the inclusion of the FDS Memory Copy routine. Needed for performing FDS memory diagnostics (GALPAT and BITPAT tests), FDS Memory Copy can reduce the uplink time required during FDS memory loads. FDS programs only need to be loaded (via RTC) to one memory half and may then be copied by FDS Memory Copy to all other available memory halves. FDS memory copy shall be modified to include the capability of copying between FDS memory halves. This will require the definition of new SC commands to control the destination of the copy procedure.

6.4 Science Requirements

The VIM-7 program will contain only one cruise science data mode, similar to the current CR07, but without PPS and UVS. The data rate will be 46-2/3 bps, uncoded.

6.4.1 Instrument Processing Modifications

Instrument processing modifications are requested for four of the six VIM-7 instruments. Brief descriptions of the modifications follow. Detailed descriptions are provided in Appendix D.

(a) MAG Modifications

The MAG processing modifications to CR07 are to use a linear 6-bit differencing scheme with 2.4 second resolution, summing 40 samples with double precision. Using a 12-bit truncated sum, return 12-bit primary references and 12-bit secondary references every 144 seconds, and 6-bit primary differences every 24 seconds.

(b) PLS Modifications

Add M-mode D-cup data. Return up to 68 channels, and at least 64, per M-scan. Override M start words every 192 minutes to return a full M scan.

(c) PWS Modifications

Return peaks and sums with 96-second resolution. Collect one scan every four seconds. Over a 96-second (24 scan) interval (1) delete the 4-second scans polluted by LECP stepping; (2) sum the remaining samples for each channel, returning 12 LSBs and accepting the risk of overflow; and (3) return the 8-bit peak sample for each channel.

(d) PRA Modifications

Return one FIXLO scan every 6 seconds. Sum 396 RH and 396 LH samples every 24 seconds. Return the 12 MSBs of the sum, accepting the risk of overflow. Step through a 16-frequency table, one step every 24 second (one cycle every 384 seconds).

6.4.2 Status Word Modifications

To reduce the size of the VIM-7 program and maximize bits in the data stream available for science data, instrument status words can be modified to fit into one status subcommutator. Changes can be made as follows:

(a) Move PRA status word from the instrument data field to the status subcom.

(b) Add a PRA POR 4-bit counter.

(c) Move 7 PLS status words from the instrument data field to the status subcom.

(d) Return all 4 PLS mode command words in telemetry. Delete 4 MSBs from the PLS mode command words, as these bits are ignored by the instrument.

(e) The CRS status word sampling may be reduced to once every 384 seconds if necessary.

(f) Delete all non-VIM-7 instrument status words.

(g) Reduce sample rate of MAG command word, MAG status, PWS status and PLS M-start word.

6.5 CR7a Processing Changes

The new CR7a data mode is based on the old CR07 data mode with the inclusion of several changes to the processing of the science data and the science instrument status words. The purpose of these changes is to enhance the performance of the cruise data mode and concentrate resources (both processing time and space in the minor frame) on the instruments that are going to be active during the VIM-7 phase of the Voyager mission. A summary of the new processing requirements is given below. Detailed specifications are contained in Appendix D.

LECP Instrument cycle time is 384 seconds, synchronous with the motor step cycle, timed to avoid the problem of mixed sector data collection. The location of the LECP data in the output stream may be reorganized to match the CR5a format, in order to simplify changes in LECP related ground software.

PLS D cup data is added in the M mode. 68 M mode channels are read out every PLS scan, with 2 basic PLS scans making up a complete PLS cycle. A PLS scan lasts 384 seconds, a complete PLS cycle 768 seconds. A full spectrum PLS scan is returned once every 192 minutes by automatically adjusting the M start words in the FDS.

PRA Scan rate of the PRA is set to 1 scan every 6 seconds. PRA operation is constrained to the Fixlo and Level modes. In the Fixlo mode, 396 right hand samples and 396 left hand samples (the data from four consecutive 6 second PRA scans) are summed producing two 16 bit sums every 24 seconds. Only the 12 MSBs of the sum are returned in the telemetry stream. The risk of overflow is accepted. Frequency selection is controlled by stepping through a 16 position table one step every 24 seconds (384 second cycle).

PWS Peaks and sums with a resolution of 96 seconds are returned. PWS scans occur at a rate of one scan every 4 seconds. Over a 96 second period, all 4 second scans corrupted by LECP motor step are deleted, the remaining samples are summed in each channel and the 12 LSBs of each sum are returned. As with PRA the risk of overflow is accepted. Also during the 96 second period the 8 bit peak sample for each channel is returned.

MAG A linear differencing scheme with 2.4 second resolution is used. Every 2.4 seconds, 40 consecutive MAG samples are summed using double precision. These sums are right shifted 6 bits to produce a 12 bit truncated sum. Every 2.4 seconds a 6 bit primary difference (the difference between two consecutive 12 bit truncated sums) is returned. A 12 bit primary "Full Vector Word" and a 12 bit secondary "Full Vector Word" are returned every 144 seconds for each axis.

In order to fit within the limitations of space in the CR7a minor frame, the above changes assume certain modifications in the science instrument status word handling. In the current CR07 program, status words occur in three places: the instrument data field, status group 1, and status group 2. In the CR7a program all required status and command words (except LECP status) shall be combined into a single subcommutator. This subcom will be the same size as the original status group 1 subcom, thus freeing up more of the CR7a minor frame for science data.

6.6 New Data Format

Contained here and in Appendix E are the details on the content and arrangement for the new VIM-7 data format to be developed for use in the VIM-7 FDS program. The information should be considered tentative pending final assembly of the VIM-7 program. The format ID for new VIM-7 data format will be defined in the ECRs which deliver the new formats to the project.

6.6.1 CR7a Data Format

The CR7a data format contains the instrument processing changes discussed in Subsection 6.5. Minor frame length is 2240 bits, generated over a period of 48 seconds. Figure E-1 (see Appendix E) compares CR7a with the "old" CR07 format, showing the order and allocation of data in each minor frame. FDS count increments by one MOD 60 count per minor frame. Note that in order to free-up space in the CR7a minor frame, the 10-bit count has been deleted from the CR7a header. Since CR7a minor frames occur on 48 second centers, line count does not change between minor frames.

6.7 VIM-7 Data Modes

Data modes for the VIM-7 program are summarized in Table 6.7-1 and in Appendix F. Individual data modes are briefly discussed in the subsections below.

6.7.1 CR7a Data Mode

The CR7a data mode delivers the CR7a data format to the MDS High Rate (HR) channel. No data are recorded or played back. The PLS integration control using the second field (third digit) of the SC06BB command (0—long, 1—short) is carried over from CR05 and CR5a to CR7a.

6.7.2 EL40 Data Mode

With the exception of the deletion of the safing commands for PPS and ISS discussed in Subsection 6.3.4, the EL40 data mode is unchanged in the VIM-7 program.

Table 6.7-1: VIM-7 Data Mode Summary

	CMD	MDS HR		DTR			
DATA MODE	CODE (DEC)	RATE (b/s)	FMT	MODE	RATE (kb/s)	REC FMT	SYNC
CR7a	55	46.6	CR7a	NONE	NONE	NONE	N/A
EL40	32	40	EL40	NONE	NONE	NONE	N/A

6.8 PLS/MAG/LECP Autocal

If sufficient space is available in FDS memory, implement the cruise PLS/MAG/LECP Autocal capability used in the VIM-5 FDS program, except use 16-frame count centers for the PLS calibration. LECP calibrations will require the availability of Modified Cruise engineering format or the ability to sample the LECP Cal mux on the 100 deck in Cruise Engineering format during the calibrations.

6.9 Ground Data System Requirements

6.9.1 General Overview

VIM-7 modifications will be integrated into the existing DSN and Voyager data processing elements which comprise the GDS. FPSO-provided data processing elements will be based in the SFOC. VIM-7 requirements are not generally levied against MCCC subsystems; however, limited capability is required by the MCCC Command Subsystem and Simulation Subsystem to support VIM-7 load preparation and possible transmission.

In general, the GDSEO shall make modifications to the GDS as required to support the VIM era spacecraft configuration as described in other sections of this document. Requirements for modification of the GDS to incorporate VIM-7 capabilities will be provided in the same manner as has been the custom for the last several years, i.e. SCP and SRD level requirements information will be generated and transferred to the implementing organization following Voyager Change Board approval. Somewhat of an exception to this process will be the statement of requirements for SFOC based subsystems. The GDSEO will undertake an activity designed to develop SRD level requirements, purged of references to existing hardware/software designs, for use by SFOC implementors. Distribution of functions and data flow among the GDS subsystems will require redefinition as the distribution of functions among SFOC subsystems is better understood. The GDSEO requires the availability of SFOC System Engineering personnel to support development of functional requirements, functional designs, and SRD detailed requirements.

Descriptions of the VIM-7 FDS formats and data modes are provided in Appendix D, E, and F of this document, and should be reviewed by the technical organizations as this information will be the basis for generating SCPs and updated SRDs.

It is anticipated that SFOC adaptation and/or modifications will be required in six of the ten systems which make up the GDS. The six systems effected are Telemetry, Command, Simulation, Data Records, Mission Sequence, and Spacecraft Analysis. SCPs to document updates to the GDS shall be generated for each subsystem where requirements dictate modifications.

6.9.2 New Data Modes and Telemetry Formats

The VIM-7 FDS provides one new spacecraft data mode and one new Telemetry format. A detailed description of the format and data mode is provided in Table 6.7-1, the VIM-7 Data Mode Summary, and in Appendixes E and F. The VIM-7 shall be restricted to two downlink telemetry formats: Cruise 7A (CR7a), and Low Rate Engineering (EL40) at 46.7 bits coded and 40 bits uncoded respectively.

6.9.3 GDS Systems Modifications

The DSN, and FPSO are required to provide Telemetry processing support for the new format, data rate, minor data frames, channelized Engineering Data, and extracted Science Data. The MIPS shall be required to provide continued processing support for PWS data. Full NERT Science support will be provided for all formats based upon SFOC provided GDS capabilities.

In the Data Records System, it is anticipated that VIM-7 modifications will be of the same nature as those done for VIM-5 except that fewer new formats will need to be developed. Again, EDRPROC for both science and engineering data will require modifications for the new VIM-7 data formats. In addition, Voyager-specific capabilities including CTAB/CPLOT, channelizer and possibly memory compare will require change.

The Project expects to adapt SFOC based Command System capabilities. It is expected that the Voyager JTRAN capability will be retired, and replaced by a multimission Command Data Base Generator (CDBG). However, the Project will modify JTRAN to support load preparation and possible load transmission, thus a delivery of the MCCC Command Subsystem will be required for VIM-7 in conjunction with the MOSS 9.0 build. It is expected that the MCCC Command Subsystem modification for VIM-7 will be minor.

The Simulation Subsystem is required to support development and testing of Command and Telemetry capabilities. It is expected that the MCCC Simulation Subsystem will be retired and replaced by a SFOC-based capability. Except as required to support the Command System, VIM-7 requirements are not levied against the MCCC Simulation Subsystem.

VIM-7 capability will be developed in the current Mission Sequence System and delivered with MOSS 9.1. This early delivery of VIM-7 capability is designed to capture VIM-7 FDS design details and to minimize the probable loss of this detailed information with the passage of time. Portions of the Mission Sequence System software will be integrated into and/or replaced by the SFOC multimission capabilities as SFOC uplink functions are developed. MSS functions shall reflect reduced data rates, longer sequence periods, and utilization of onboard sequence blocks. Sustaining improvements will be considered after VIM-7 requirements have been satisfied.

The Spacecraft Analysis System software will be modified as required to support VIM-7. SAS VIM-7 capabilities are to be delivered in MOSS 9.1. Resources permitting, modifications for reducing sustaining costs will be considered after all VIM-7 requirements have been satisfied.

6.9.4 GDS Implementation Schedule

The schedule for the implementation of the VIM-7 capabilities is as follows:

MOSS 9.0 - Online March 1, 1990 provides:

CMD: all VIM-7 capability.

MOSS 9.1 - Online June 1, 1990 provides:

MSS: all VIM-7 capabilities.

SAS: all VIM-7 capabilities.

MOSS 9.2 Online October 1, 1990 provides:

MSS: VIM-7 anomaly corrections and possible sustainability upgrades.

SAS: VIM-7 anomaly corrections and possible sustainability upgrades.

MOSS 9.3 - Online April 1, 1991 provides:

DRS: VIM-7 new format CR7a.

SIM: VIM-7 capabilities

MOSS 9.4 - GDS Delivery July 1, 1991 provides:

SFOC: all SFOC subsystems VIM-7 capabilities.

MOSS 9.5 - Online 1 October 1991 provides:

SFOC: SFOC subsystems anomaly corrections, all SFOC subsystems operational (MCCC retirement).

Appendices
A - C

Appendix A
Detailed CR5a Processing Changes

All times and formats included within this document should be taken as tentative. Sample times and the location of the data within the output field may change as the problems associated with the implementation become clearer. The final sample times and location of the data within the output field will be documented in the final ECRs. GDS and user processing software should not be developed in response to this document but should wait until approval of the ECRs delivering the processing changes to the project

The new CR5a data mode, though based on the old CR05, incorporates several changes to the processing of the science data. The purpose of these modifications is to correct problems encountered with the old CR05 and to enhance the performance of the cruise data mode in general. A summary of the new processing is as follows:

LECP Instrument cycle time is changed to 192 seconds, matching the motor step cycle, in order to avoid the problem of mixed sector data collection.

PLS D cup data is added in the M mode. The number of M mode channels to be read out with every cycle is consequently reduced to 74 channels every PLS scan from the current 99. A full spectrum PLS scan is returned once every 96 minutes by automatically adjusting the M start words in the FDS.

PRA Scan rate is increased to 1 scan every 6 seconds from 1 scan every 60 seconds. PRA operation is constrained to the Fixlo and Level modes. Frequency selection in the Fixlo mode is controlled by a 64 position FDS table which iteratively scans through sixty four frequencies, one frequency per scan or every 6 seconds.

PWS Processing is changed to output the sum of four consecutive 4 second scans once every 16 seconds. One out of every 12 sums is corrupted by LECP motor stepping and is thus deleted.

MAG The current scheme of delta modulation is replaced by a 6-bit differencing scheme. Differences are between consecutive averages from each axis of the primary Low Field Magnetometer. Each axis is sampled at a rate of one sample every 0.06 seconds. Eight consecutive samples are averaged for a rate of one average every 0.48 seconds. A primary "Full Vector Word" is telemetered every 12 seconds for each axis and a secondary "Full Vector Word" is telemeterd every 24 seconds for each axis.

UVS Scan time is reduced to 4 minutes per UVS scan. Individual channel data is output as 8-bit words (truncate 2 MSBs of the nominal 10-bit UVS word). 8 of the 128 total UVS channels are deleted to meet bit rate constraints

A.1 LECP Processing Modifications

Issue LECP motor step once every 192 seconds (20 CR5a minor frames) at P18L1921 X 3200 (t_o + 115.245 sec where t_o is the time of SCT60 MOD 4 = 0). This places the motor step at the start of the LECP data cycle which is also 192 seconds long. Motor step is assumed to last 0.5 seconds, Rate/Status commanding can not begin until after this time (see below).

LECP data is comprised of two types: PHA and Rate/Status. PHA events are sampled every 6 seconds (40 bits each sample) and samples are buffered until entered into the telemetry stream. Rate/Status data are sampled following the issuance of each Rate/Status command by a burst of four Rate/Status word gates (10 bits each word gate). The first of the four word gates is issued 0.0625 seconds (1 line and 1 p period) after the corresponding Rate/Status command. The three subsequent word gates are separated by 0.0025 seconds (1 p period).

Rate/Status commands determine which Rate/Status group is to be read out next and are issued in 4 sets during the LECP cycle. The first set is sent as a reset to zero all counters so no corresponding data is sampled by the FDS. The remaining three sets are evenly spread out among the rest of the 192 second cycle. All Rate/Status commands in a set are sent at 240 msec intervals until the set is finished.

Table A.1-1 presents the LECP Rate/Status groups and outlines which rate channels are in the different rate groups. Note that the LECP status words (S1-S6) are output with rate groups 16 and 17.

Table A.1-2 presents the new CR5a LECP Rate/Status Commanding. The column "Rate Group" designates which Rate/Status group is specified by a particular Rate/Status command. The Rate/Status groups correspond to the Rate/Status groups outlined in table A.1-1. The starting time of the Rate/Status command sets are separated by 62.4 seconds (1040 FDS lines). This time is chosen to maximize the time between command sets while maintaining a delta which is a multiple of 4 FDS lines (an FDS processing requirement).

Table A.1-3 presents the new CR5a LECP sampling scheme. The numbers following the R/S (rate/status) in the data type column correspond to the Set and Sample Group number found in table A.1-2. For example R/S 4, 1 is the data obtained following Rate/Status command set 4, sample group 1.

Table A.1-4 presents LECP status word timing. Special note should be taken of R/S 4, 15 and 4, 16. As shown in Table A.1-2, Sample group 15 corresponds to rate group 16 and Sample group 16 corresponds to rate group 17. As shown in Table A.1-1, rate group 16 contains Status words S_5 and S_6, and rate group 17 contains Status words S_1 - S_4. This translates to Status words S_5 occurring in minor frame 19 bits 125-128 (4 MSBs) and minor frame 20 bits 1-6 (6 LSBs), S6 occurring in minor frame 20 bits 7-16 and Status words S_1 - S_4 occurring in minor frame 20 bits 17-56.

TABLE A.1-1
LECP Rate Status Groups

Rate Group	Rate Channels in Rate Group			
1	Pα1	Pα2	Pα3	Eβ4
2	Eβ1	Eβ2	Eβ3	Eγ6
3	39	33	32	31
4	Eγ7	Eγ8	Eγ9	Eβ5
5	1	44	3	10
6	Pα4	Pα8	42	16
7	11	23	27	4
8	13/46*	17/47*	28	38
9	35	Pα5	Pα6	Pα7
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	Aα1	Aα2	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 are multiplexed together.
Each measurement appears in alternate occurrences of the rate group.
Contents of Rate 42 is determined by bits 8, 9, and 10 of Status Word 5:

8	9	10	Rate
0	0	0	AL
0	0	1	AR
0	1	0	E0
0	1	1	E1
1	0	0	E2
1	0	1	E3
1	1	0	E4
1	1	1	E5

TABLE A.1-2
CR5a LECP RATE/STATUS COMMANDING

Samp. Group	FDS Location	Rate Group	Command Time, t_o + (sec) * Set 1	Set 2	Set 3	Set 4
1	LECPT1 + 0	1	115.785	178.185	@48.585	@110.985
2	LECPT1 + 1	2	116.025	178.425	@48.825	@111.225
3	LECPT1 + 2	3	116.265	178.665	@49.065	@111.465
4	LECPT1 + 3	4	116.505	178.905	@49.305	@111.705
5	LECPT1 + 4	5	116.745	179.145	@49.545	@111.945
6	LECPT1 + 5	6	116.985	179.385	@49.785	@112.185
7	LECPT1 + 6	8	117.225	179.625	@50.025	@112.425
8	LECPT1 + 7	9	117.465	179.865	@50.265	@112.665
9	LECPT1 + 8	7	117.705	-------	-------	@112.905
10	LECPT1 + 9	10	117.945	-------	-------	@113.145
11	LECPT1 + 10	11	118.185	-------	-------	@113.385
12	LECPT1 + 11	12	118.425	-------	-------	@113.625
13	LECPT1 + 12	13	118.665	-------	-------	@113.865
14	LECPT1 + 13	15	118.905	-------	-------	@114.105
15	LECPT1 + 14	16	119.145	-------	------	@114.345
16	LECPT1 + 15	17	119.385	-------	------	@114.585
17	LECPT1 + 16	15	119.625	-------	------	--------

Notes for Table A.1-2:

* t_o is the time of SCT60 MOD 4 = 0. <u>Motor Step occurs at t_o + 115.245 sec (P18L1921 X 3200)</u>

@ Command will be issued in the **next** SCT60 MOD 4 = 0 cycle. Time is with respect to <u>following</u> SCT60 MOD 4 = 0

TABLE A.1-3
CR5a LECP SAMPLING SCHEME
192 SECOND (20 MINOR FRAME) CYCLE

MF START * t_o + (SEC)	MF **	BITS	DATA TYPE	SAMPLE TIME * t_o + (SEC)
0.0	1	1- 8	PHA (8 LSB)	#122.3475
		9- 48	PHA	#128.3475
		49- 88	PHA	#134.3475
		89-128	PHA	#140.3475
9.6	2	1- 40	PHA	#146.3475
		41- 80	PHA	#152.3475
		81-120	PHA	#158.3475
		121-128	PHA (8 MSB)	#164.3475
19.2	3	1- 32	PHA (32 LSB)	#164.3475
		33- 72	PHA	#170.3475
		73-112	PHA	#176.3475
		113-128	R/S 2, 1 (16 MSB)	#178.2475
28.8	4	1- 24	R/S 2, 1 (24 LSB)	#178.2475
		25- 64	R/S 2, 2	#178.4875
		65-104	R/S 2, 3	#178.7275
		105-128	R/S 2, 4 (24 MSB)	#178.9675
38.4	5	1- 16	R/S 2, 4 (16 LSB)	#178.9675
		17- 56	R/S 2, 5	#179.2075
		57- 96	R/S 2, 6	#179.4475
		97-128	R/S 2, 7 (32 MSB)	#179.6875
48.0	6	1- 8	R/S 2, 7 (8 LSB)	#179.6875
		9- 48	R/S 2, 8	#179.9275
		49- 88	PHA	#182.3475
		89-128	PHA	#188.3475
57.6	7	1- 40	PHA	2.3475
		41- 80	PHA	8.3475
		81-120	PHA	14.3475
		121-128	PHA (8 MSB)	20.3475
67.2	8	1- 32	PHA (32 LSB)	20.3475
		33- 72	PHA	26.3475
		73-112	PHA	32.3475
		113-128	PHA (16 MSB)	38.3475
76.8	9	1- 24	PHA (24 LSB)	38.3475
		25- 64	PHA	44.3475
		65-104	R/S 3, 1	48.6475
		105-128	R/S 3, 2 (24 MSB)	48.8875
86.4	10	1- 16	R/S 3, 2 (16 LSB)	48.8875
		17- 56	R/S 3, 3	49.1275
		57- 96	R/S 3, 4	49.3675
		97-128	R/S 3, 5 (32 MSB)	49.6075

TABLE A.1-3 (CONT'D)
CR5a LECP SAMPLING SCHEME
192 SECOND (20 MINOR FRAME) CYCLE

MF START * t_o + (SEC)	MF **	BITS	DATA TYPE	SAMPLE TIME * t_o + (SEC)
96.0	11	1- 8	R/S 3, 5 (8 LSB)	49.6075
		9- 48	R/S 3, 6	49.8475
		49- 88	R/S 3, 7	50.0875
		89-128	R/S 3, 8	50.3275
105.6	12	1- 40	PHA	50.3475
		41- 80	PHA	56.3475
		81-120	PHA	62.3475
		121-128	PHA (8 MSB)	68.3475
115.2	13	1- 32	PHA (32 LSB)	68.3475
		33- 72	PHA	74.3475
		73-112	PHA	80.3475
		113-128	PHA (16 MSB)	86.3475
124.8	14	1- 24	PHA (24 LSB)	86.3475
		25- 64	PHA	92.3475
		65-104	PHA	98.3475
		105-128	PHA (24 MSB)	104.3475
134.4	15	1- 16	PHA (16 LSB)	104.3475
		17- 56	PHA	110.3475
		57- 96	R/S 4, 1	111.0475
		97-128	R/S 4, 2 (32 MSB)	111.2875
144.0	16	1- 8	R/S 4, 2 (8 LSB)	111.2875
		9- 48	R/S 4, 3	111.5275
		49- 88	R/S 4, 4	111.7675
		89-128	R/S 4, 5	112.0075
153.6	17	1- 40	R/S 4, 6	112.2475
		41- 80	R/S 4, 7	112.4875
		81-120	R/S 4, 8	112.7275
		121-128	R/S 4, 9 (8 MSB)	112.9675
163.2	18	1- 32	R/S 4, 9 (32 LSB)	112.9675
		33- 72	R/S 4,10	113.2075
		73-112	R/S 4,11	113.4475
		113-128	R/S 4,12 (16 MSB)	113.6875
172.8	19	1- 24	R/S 4,12 (24 LSB)	113.6875
		25- 64	R/S 4,13	113.9275
		65-104	R/S 4,14	114.1675
		105-128	R/S 4,15 (24 MSB)	114.4075
182.4	20	1- 16	R/S 4,15 (16 LSB)	114.4075
		17- 56	R/S 4,16	114.6475
		57- 96	PHA	116.3475
		97-128	PHA (32 MSB)	122.3475

Notes for Table A.1-3:

- * t_o is the time of SCT60 MOD 4 = 0. Motor step occurs at t_o + 115.245 sec (P18L1921 X 3200)
- ** 9.6 second minor frame (of 20) with respect to SCT60 MOD 4 = 0
- \# Sampled in preceding SCT60 MOD 4 cycle. Time is with respect to preceding SCT60 MOD 4 = 0

TABLE A.1-4
LECP STATUS WORD TIMING

STATUS WORD	MINOR FRAME *	LECP BITS
S 1	20	17- 26
S 2	20	27- 36
S 3	20	37- 46
S 4	20	47- 56
S 5	19/20	124-128/ 1- 6
S 6	20	7- 16

Notes for Table A.1-4:

* minor frame (of 20) with respect to SCT60 MOD 4 = 0

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A.2 PLS Processing Modifications

Include M-mode D cup data in the PLS telemetry stream. Previously only A - C cup data were returned.

In order to maintain PLS allocation at its current level of 160 bits per CR05 minor frame, the number of M-mode channels returned with every PLS scan is reduced from 99 channels to 74. PLS data words and status words are 8 bits long, therefore, 20 PLS words may be returned every CR5a minor frame.

The specific 74 M-mode channels to be returned with every PLS scan is controlled, as before, by two M start words. Since the 384 second PLS data cycle is comprised of two 192 second PLS scans, there is an M start word for each scan. The value of an M start word is derived by multiplying the number of channels to be skipped by 4 (since there are four cups A-D sampled for each channel). These M start words may be modified by commands to the FDS. The command SC32AL specifies PLS M-mode Start Word 1 and SC32AM specifies PLS M-mode Start Word 2. Normal operation of the PLS has both M start words the same with both PLS scans in a data cycle returning the same 74 channels. Both M start words are inserted into the telemetry stream as an indicator of the current configuration of PLS M-mode output.

The capability to obtain a full M-mode scan once every 96 minutes is also included. This is accomplished through an internal FDS algorithm which automatically adjusts the two M start words to alternately return the lower 74 of 128 M channels (1 - 74) and then the upper 74 of 128 M channels (55 - 128) in two consecutive M-modes. This is accomplished by setting M start words 1 and 2 to 0_{10} and 216_{10} respectively. The M start words which are inserted into the telemetry stream, as mentioned above, will be updated accordingly. Following the full M-mode scan the PLS will be immediately returned to the nominal M start word algorithm described above.

Interference of the PLS data by LECP motor stepping is assumed to last approximately 10 seconds. Therefore, all PLS samples collected in the minor frame (9.6 seconds) immediately following an LECP motor step are considered corrupted. Since the PLS data cycle (384 seconds) is exactly twice as long as the LECP motor step cycle (192 seconds), two minor frames of PLS data are corrupted by the two LECP motor steps occurring during this time. Furthermore, the same two minor frames in the PLS data cycle are lost every time. LECP motor step occurs 115.245 and 307.245 seconds into the PLS data cycle. This will affect M channels 120-128 both times. Note that even though these corrupted channels may be skipped by judicious use of the M start words in normal PLS operation, they exclude the possibility of returning a full uncorrupted scan every 96 minutes. PLS E1 mode commences at P3L2145 X 6400 and P3L5345 X 6400 (t_o + 128.6475 sec and t_o + 320.6475 sec), 13.4 seconds after the LECP motor step.

Operation during a PLS autocal will be essentially the same as the current scheme in CR05. The differences are to include the M-mode D cup data, as is the case with normal data gathering explained above, and the explicit override of both M start words when in the M-mode. Currently when performing a PLS autocal in CR05, only M start word 1 is modified in order to return the lower 99 channels of the M mode during the first scan in the PLS cycle. This assumes that M start word 2 is set to return the upper 99 channels during the second scan in the PLS cycle (as it normally is in CR05). In CR5a both M start words will be explicitly modified. During an autocal, the PLS will alternate between returning the lower 74 channels (M start word 1 = 00_{10}) and the upper 74 channels (M start word 2 = 216_{10}) when in the M-mode. This means that regardless of how the M start words are configured for normal data gathering in the M mode, a full PLS scan will be returned when performing an autocal. Note that there is some interaction between this capability and the algorithm controlling the full scan every 96 minutes. This must be taken into consideration.

Table A.2-1 presents the new PLS sampling scheme which incorporates M-mode D cup data.

Table A.2-2 presents the PLS data which will be lost due to LECP motor step.

TABLE A.2-1A
PLS CR5a OUTPUT SCHEME
SHORT INTEGRATION

SCT60 MOD 4	MINOR FRAME	SAMPLES COLLECTED	SAMPLES IN TELEMETRY
0	1	M Stat, M(A1) to M(D39)	Int Time WD,
			E1 Stat, E1(D1) to E1(D16)
			L Stat, L(A1)
	2	M(A40) to M(D79)	L(B1) to L(A6)
	3	M(A80) to M(D119)	L(B6) to L(A11)
	4	M(A120) to M(D128)	L(B11) to L(A16)
	5		L(B16) to L(D16),
			E2 Stat, E2(D1) to E2(D16)
1	6		M Start WD1, M Start WD2,
			M Stat, M(A1+d) to M(A5+d)
	7	E1 Stat, E1(D1) to E1(D16)	M(B5+d) to M(A10+d)
	8		M(B10+d) to M(A15+d)
	9		M(B15+d) to M(A20+d)
	10		M(B20+d) to M(A25+d)
2	11		M(B25+d) to M(A30+d)
	12	L Stat, L(A1) to L(D16)	M(B30+d) to M(A35+d)
	13		M(B35+d) to M(A40+d)
	14		M(B40+d) to M(A45+d)
	15		M(B45+d) to M(A50+d)
3	16		M(B50+d) to M(A55+d)
	17	E2 Stat, E2(D1) to E2(D16)	M(B55+d) to M(A60+d)
	18		M(B60+d) to M(A65+d)
	19		M(B65+d) to M(A70+d)
	20		M(B70+d) to M(D74+d),
			8 bits fill
0	1	M Stat, M(A1) to M(D39)	Int Time WD,
			E1 Stat, E1(D1) to E1(D16)
			L Stat, L(A1)
	2	M(A40) to M(D79)	L(B1) to L(A6)
	3	M(A80) to M(D119)	L(B6) to L(A11)
	4	M(A120) to M(D128)	L(B11) to L(A16)
	5		L(B16) to L(D16),
			E2 Stat, E2(D1) to E2(D16)
1	6		M Start WD1, M Start WD2,
			M Stat, M(A1+d) to M(A5+d)
	7	E1 Stat, E1(D1) to E1(D16)	M(B5+d) to M(A10+d)
	8		M(B10+d) to M(A15+d)
	9		M(B15+d) to M(A20+d)
	10		M(B20+d) to M(A25+d)
2	11		M(B25+d) to M(A30+d)
	12	L Stat, L(A1) to L(D16)	M(B30+d) to M(A35+d)
	13		M(B35+d) to M(A40+d)
	14		M(B40+d) to M(A45+d)
	15		M(B45+d) to M(A50+d)
3	16		M(B50+d) to M(A55+d)
	17	E2 Stat, E2(D1) to E2(D16)	M(B55+d) to M(A60+d)
	18		M(B60+d) to M(A65+d)
	19		M(B65+d) to M(A70+d)
	20		M(B70+d) to M(D74+d),
			8 bits fill

NOTE: d = Number of M mode A, B, C, and D cup sample groups skipped before start of readout divided by 4

TABLE A.2-1B
PLS CR5a OUTPUT SCHEME - LONG INTEGRATION

SCT60 MOD 4	MINOR FRAME	SAMPLES COLLECTED	SAMPLES IN TELEMETRY
0	1	M Stat, M(A1) to M(D9)	Int Time WD,
			E1 Stat, E1(D1) to E1(D16)
			L Stat, L(A1)
	2	M(A10) to M(D19)	L(B1) to L(A6)
	3	M(A20) to M(D29)	L(B6) to L(A11)
	4	M(A30) to M(D39)	L(B11) to L(A16)
	5	M(A40) to M(D49)	L(B16) to L(D16),
			E2 Stat, E2(D1) to E2(D16)
1	6	M(A50) to M(D59)	M Start WD1, M Start WD2,
			M Stat, M(A1+d) to M(A5+d)
	7	M(A60) to M(D69)	M(B5+d) to M(A10+d)
	8	M(A70) to M(D79)	M(B10+d) to M(A15+d)
	9	M(A80) to M(D89)	M(B15+d) to M(A20+d)
	10	M(A90) to M(D99)	M(B20+d) to M(A25+d)
2	11	M(A100) to M(D109)	M(B25+d) to M(A30+d)
	12	M(A110) to M(D119)	M(B30+d) to M(A35+d)
	13	M(A120) to M(D128)	M(B35+d) to M(A40+d)
	14	E1 Stat, E1(D1) to E1(D5)	M(B40+d) to M(A45+d)
	15	E1(D6) to E1(D15)	M(B45+d) to M(A50+d)
3	16	E1(D16)	M(B50+d) to M(A55+d)
		L Stat, L(A1) to L(D3)	
	17	L(A4) to L(D13)	M(B55+d) to M(A60+d)
	18	L(A14) to L(D16),	M(B60+d) to M(A65+d)
		E2 Stat, E2(D1)	
	19	E2(D2) to E2(D11)	M(B65+d) to M(A70+d)
	20	E2(D12) to E2(D16)	M(B70+d) to M(D74+d),
			8 bits fill
0	1	M Stat, M(A1) to M(D9)	Int Time WD,
			E1 Stat, E1(D1) to E1(D16)
			L Stat, L(A1)
	2	M(A10) to M(D19)	L(B1) to L(A6)
	3	M(A20) to M(D29)	L(B6) to L(A11)
	4	M(A30) to M(D39)	L(B11) to L(A16)
	5	M(A40) to M(D49)	L(B16) to L(D16),
			E2 Stat, E2(D1) to E2(D16)
1	6	M(A50) to M(D59)	M Start WD1, M Start WD2,
			M Stat, M(A1+d) to M(A5+d)
	7	M(A60) to M(D69)	M(B5+d) to M(A10+d)
	8	M(A70) to M(D79)	M(B10+d) to M(A15+d)
	9	M(A80) to M(D89)	M(B15+d) to M(A20+d)
	10	M(A90) to M(D99)	M(B20+d) to M(A25+d)
2	11	M(A100) to M(D109)	M(B25+d) to M(A30+d)
	12	M(A110) to M(D119)	M(B30+d) to M(A35+d)
	13	M(A120) to M(D128)	M(B35+d) to M(A40+d)
	14	E1 Stat, E1(D1) to E1(D5)	M(B40+d) to M(A45+d)
	15	E1(D6) to E1(D15)	M(B45+d) to M(A50+d)
3	16	E1(D16)	M(B50+d) to M(A55+d)
		L Stat, L(A1) to L(D3)	
	17	L(A4) to L(D13)	M(B55+d) to M(A60+d)
	18	L(A14) to L(D16),	M(B60+d) to M(A65+d)
		E2 Stat, E2(D1)	
	19	E2(D2) to E2(D11)	M(B65+d) to M(A70+d)
	20	E2(D12) to E2(D16)	M(B70+d) to M(D74+d),
			8 bits fill

NOTE: d = Number of M mode A, B, C, and D cup sample groups skipped before start of readout divided by 4

TABLE A.2-2
PLS DATA LOST DUE TO LECP MOTOR STEP
192-SECOND (20 MINOR FRAME) CYCLE

* LECP motor step occurs once every 192 seconds. Interference of PLS data by LECP motor step assumed to last 10 seconds

* PLS data cycle is 384 seconds long. This is made up of two scans 192 seconds each.

* Thus the cycle of interaction between LECP motor stepping and PLS data taking repeats every 384 seconds and involves 2 motor steps.

* SCT60 MOD 4 and MINOR FRAME count refer to those shown on table A.2-1A and table A.2-1B

SHORT INTEGRATION

No interference

LONG INTEGRATION

MOTOR STEP	SCT60 MOD 4	MINOR FRAME	SAMPLES COLLECTED
1	2	13	M (A120) to M(D128) PLS scan 1 of 2
2	2	13	M (A120) to M(D128) PLS scan 2 of 2

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A.3 PRA Processing Modifications

PRA scan rate is increased from 1 scan every 60 seconds to 1 scan every 6 seconds.

PRA operation in CR5a is restricted to the Fixlo and Level modes. The Fixlo mode is for normal operations and data gathering and the Level mode, formerly a calibration mode, is now used only as an indicator of correct operation of the instrument.

In the Fixlo mode, a scan consists of two hundred samples obtained at a specified frequency. These two hundred samples are output over a period of 6 seconds. Which frequency a scan is sampled at depends upon which Fixlo mode command is sent to the instrument.

The issuance of Fixlo mode commands is controlled by a 64 position table in the FDS. A complete cycle through the table requires 384 seconds and encompasses 64 PRA scans. The contents of the table have been initially set to implement the "sliding comb" described below. However, the type and order of Fixlo commands to be issued from the table may be updated to any desired 64 scan scheme by an ST command which is yet to be defined.

Fixlo mode commands specify select frequencies in the range of 1.2 to 72499.2 kHz. However, in CR5a, operation in the Fixlo mode has been initially constrained to cover the range of 1.2 to 1210.8 kHz. This represents 64 discrete frequencies separated by 19.2 kHz each. The PRA monitors this frequency band in a "sliding comb" fashion. In a 48 second period, the PRA samples 8 frequencies evenly distributed throughout the frequency band, 153.6 kHz between frequencies, 1 scan per frequency, 6 seconds per scan. In the next 48 seconds a set of an additional 8 frequencies, offset from the original set by 19.2 kHz, is sampled. This continues until all 64 frequencies have been sampled. At 6 seconds per frequency this is equivalent to a 384 second PRA data cycle. As mentioned above, this scheme can replaced at a later date by any alternate 64 scan scheme.

Since the PRA experiences interference from LECP motor stepping in the lower frequencies, the data sampling is adjusted such that higher frequency channels are sampled at the time of LECP motor step. LECP motor step occurs twice within the 384 second PRA data cycle, once during scan #20 (the 1210.8 kHz scan in the "sliding comb" scheme) and once during scan #52 (the 1134.0 kHz scan in the "sliding comb" scheme).

Note that the 64 position table mentioned above is also used in GS&E Fixlo processing (meaning the same Fixlo frequency commands will be sent in both modes). The pupose of this change is to simplify PRA processing, save FDS memory, and to give the VIM GS&E PRA processing the same flexibility as CR5a. Note that in addition to the Fixlo and Level modes, the Pollo mode will also be included in GS&E processing. Pollo can also be selected in the CR5a processing but will not return useful data. It is the responsibility of the requestor to assure that Pollo is not requested in CR5a processing.

Of the two hundred 8 bit samples output for a particular scan or frequency, one hundred are Left Hand Circular Polarization (LHCP), the other one hundred are Right Hand Circular Polarization (RHCP). In the Fixlo mode, samples alternate polarization, changing polarization with every new sample (i.e. LHCP, RHCP, LHCP, RHCP...). Which polarization is actually output first is yet to be determined.

The first two samples of a 200 sample scan (one LHCP sample and one RHCP sample) are not considered high quality data, and as a result are not used. The remaining 99 LHCP samples are summed in one accumulator, the remaining 99 RHCP samples are summed in a separate accumulator. This results in two 16 bit sums (one LHCP and one RHCP) output with every scan.

16 sums are produced every 48 seconds, eight LHCP and eight RHCP. In addition eight 16 bit PRA status words are also sampled in this time. However, only the final 16-bit status word sampled during the 48 second period is returned in the output telemetry. This is equivalent to 272 PRA bits every 48 seconds. This is telemetered in a PRA field of 56 bits. This requires the insertion of 8 fill bits every 48 seconds. In CR5a these 8 fill bits are replaced by the 8 LSBs of the PRA POR counter.

56 bits per CR5a minor frame is a considerable reduction of the current PRA allocation in CR05 of 256 bits per minor frame. The 200 bits freed up by the modification of PRA processing are used to increase the PWS field and to allow Reed-Solomon encoding of the telemetry stream at 160 bits per second.

As mentioned above, the Level mode is used as an indicator of the correct operation of the instrument. However, instead of the two sums output with each scan representing the LHCP and RHCP sums, they merely represent the sums of the odd and even samples within a scan.

Attenuation control in the Level mode is the same as the current GS&E scheme. In the Level mode, the Configuration command sent is the PRANCC (PRA Nominal Configuration Command) with the 6 LSBs (of the 12-bit PRA command) set to 000111_2, and with 0010_{16} added (cumulatively) before each of the 8 outputs per major frame. This will result in cycling the PRA twice through the attenuation levels 90, 75, 60, and 45 db (6 seconds each level) every 48 seconds.

The PRA is commanded by a combination of mode and configuration commands. Mode commands determine which of the 6 basic modes the PRA will operate in. In the Fixlo mode they specify the particular frequency of operation. The 6 basic modes are: Pollo, Fixlo, Level, Harad, Polhi, and Vlobr. In CR5a the PRA is constrained to operate in the Fixlo and Level modes. In GS&E the Pollo mode is also used.

The PRA mode is controlled by a single FDS location which is updated by the appropriate Level or Pollo command or by zero to specify the Fixlo mode. If the commanded value is zero, the 64 position Fixlo command table is entered and mode commands are issued from there. Otherwise the non zero value of the Level (or Pollo in GS&E) command is used as is. Note that the validity of the commanded value is not checked within the FDS. Updates of this location will be through an SC command yet to be defined. PRA mode changes take effect at line 1 X 800 and may be changed once every 48 seconds.

Configuration commands set the configuration of the PRA. Under the heading of "configuration" are: power levels, gain control, noise calibration, phase calibration, preamp choice and ADC control. Configuration commands are sent if they differ from the last configuration command sent. In CR5a configuration may be changed once every scan (6 seconds).

PRA mode and configuration commands are sent to the instrument over the same physical line. PRA differentiates between these mode and configuration commands by the order in which the commands are sent. The PRA considers the first command received after a sample status command, to be a mode command. The second command, if sent, is considered to be a configuration command. Note that configuration commands are only sent if the configuration has been changed or a POR has occurred. These commands take effect with the next sample status command.

In the event of a PRA POR the FDS will invoke an algorithm to reset the PRA to its pre-POR status. It is necessary to allow the PRA sufficient time to react to a POR condition before reconfiguration commands can be issued by the FDS. Therefore, the FDS will wait 60 seconds (10 PRA scans) after the detection of a POR before recommanding the appropriate configuration command to reset the PRA.

A PRA POR is detected by the FDS through changes in the PRA status word. A POR is indicated if bits 9 and 14-16 of the PRA status word are all ones (bit 16 is the LSB). PRA status is tested for a PRA POR condition every PRA scan. Recall that even though PRA status is telemetered only once every 48 seconds, PRA status is sampled by the FDS every 6 seconds (once every PRA scan). As mentioned above the 8 LSBs of the POR counter are returned once every 48 seconds in place of the 8 spare bits in the PRA telemetry field. The 2 LSBs of the POR counter are not overlaid over bits 10 and 12 of the PRA status word as is currently done. POR count is returned as a separate 8-bit word in CR5a and is no longer returned in GS&E data modes (GS08, GS4b).

Figure A.3-1 presents the CR5a PRA Level commands.

Table A.3-1 outlines the CR5a PRA Fixlo frequencies with corresponding Fixlo mode commands.

Table A.3-2 presents the PRA output scheme.

FIGURE A.3-1
CR5a PRA LEVEL COMMANDS

		12 BIT PRA COMMAND												PRA DESTINATION CODE			
PRANCC		X	X	X	X	X	X	X	X	X	X	X	X	0	0	1	1
COMMAND SENT	1	X	X	X	X	X	X	0	0	1	0	0	0				
	2										0	0	1				
	3										0	1	0				
	4										0	1	1				
	5										1	0	0				
	6										1	0	1				
	7										1	1	0				
	8	X	X	X	X	X	X	0	0	1	1	1	1	0	0	1	1

TABLE A.3-1
CR5a PRA FIXLO FREQUENCY CONTROL
(ASSUMING "SLIDING COMB")

START * t_o + (sec)	SCAN # (OF 64)	SCAN FREQ. (kHz)	PRACT HEX VALS	FIXLO FREQ COMMAND	
0.0025	1	346.8	8333	SC22AG 051	
6.0025	2	193.2	82B3	SC22AG 043	
12.0025	3	39.6	8233	SC22AG 035	
18.0025	4	1095.6	85A3	SC22AG 090	
24.0025	5	942.0	8523	SC22AG 082	
30.0025	6	788.4	84A3	SC22AG 074	
36.0025	7	634.8	8423	SC22AG 066	
42.0025	8	481.2	83A3	SC22AG 058	
48.0025	9	327.6	8323	SC22AG 050	
54.0025	10	174.0	82A3	SC22AG 042	
60.0025	11	20.4	8223	SC22AG 034	
66.0025	12	1076.4	8593	SC22AG 089	
72.0025	13	922.8	8513	SC22AG 081	
78.0025	14	769.2	8493	SC22AG 073	
84.0025	15	615.6	8413	SC22AG 065	
90.0025	16	462.0	8393	SC22AG 057	
96.0025	17	308.4	8313	SC22AG 049	
102.0025	18	154.8	8293	SC22AG 041	
108.0025	19	1.2	8213	SC22AG 033	
114.0025	20	1210.8	8603	SC22AG 096	← LECP MOTOR STEP
120.0025	21	1057.2	8583	SC22AG 088	
126.0025	22	903.6	8503	SC22AG 080	
132.0025	23	750.0	8483	SC22AG 072	
138.0025	24	596.4	8403	SC22AG 064	
144.0025	25	442.8	8383	SC22AG 056	
150.0025	26	289.2	8303	SC22AG 048	
156.0025	27	135.6	8283	SC22AG 040	
162.0025	28	1191.6	85F3	SC22AG 095	
168.0025	29	1038.0	8573	SC22AG 087	
174.0025	30	884.4	84F3	SC22AG 079	
180.0025	31	730.8	8473	SC22AG 071	
186.0025	32	577.2	83F3	SC22AG 063	

TABLE A.3-1 (CONT'D)
CR5a PRA FIXLO FREQUENCY CONTROL
(ASSUMING "SLIDING COMB")

START * t_o + (sec)	SCAN # (OF 64)	SCAN FREQ. (kHz)	PRACT HEX VALS	FIXLO FREQ COMMAND	
192.0025	33	423.6	8373	SC22AG 055	
198.0025	34	270.0	82F3	SC22AG 047	
204.0025	35	116.4	8273	SC22AG 039	
210.0025	36	1172.4	85E3	SC22AG 094	
216.0025	37	1018.8	8563	SC22AG 086	
222.0025	38	865.2	84E3	SC22AG 078	
228.0025	39	711.6	8463	SC22AG 070	
234.0025	40	558.0	83E3	SC22AG 062	
240.0025	41	404.4	8363	SC22AG 054	
246.0025	42	250.8	82E3	SC22AG 046	
252.0025	43	97.2	8263	SC22AG 038	
258.0025	44	1153.2	85D3	SC22AG 093	
264.0025	45	999.6	8553	SC22AG 085	
270.0025	46	846.0	84D3	SC22AG 077	
276.0025	47	692.4	8453	SC22AG 069	
282.0025	48	538.8	83D3	SC22AG 061	
288.0025	49	385.2	8353	SC22AG 053	
294.0025	50	231.6	82D3	SC22AG 045	
300.0025	51	78.0	8253	SC22AG 037	
306.0025	52	1134.0	85C3	SC22AG 092	← LECP MOTOR STEP
312.0025	53	980.4	8543	SC22AG 084	
318.0025	54	826.8	84C3	SC22AG 076	
324.0025	55	673.2	8443	SC22AG 068	
330.0025	56	519.6	83C3	SC22AG 060	
336.0025	57	366.0	8343	SC22AG 052	
342.0025	58	212.4	82C3	SC22AG 044	
348.0025	59	58.8	8243	SC22AG 036	
354.0025	60	1114.8	85B3	SC22AG 091	
360.0025	61	961.2	8533	SC22AG 083	
366.0025	62	807.6	84B3	SC22AG 075	
372.0025	63	654.0	8433	SC22AG 067	
378.0025	64	500.4	83B3	SC22AG 059	

Notes for Table A.3-1:

* Start time is begin time of 6 second PRA scan. t_o is the time of:

SCT60 MOD 8 = 0 when FDS 2 ** 16 counter is even
SCT60 MOD 8 = 4 when FDS 2 ** 16 counter is odd

TABLE A.3-2
PRA CR5a OUTPUT SCHEME

MF START * t_o + (SEC)	MF **	BITS	SUM TYPE	SAMPLE PERIOD t_o + (SEC)***
0.0	1	1-16	SCAN # 64 LHCP SUM	#378.0275 -
		17-32	SCAN # 64 RHCP SUM	#383.9975
		33-48	16 BITS PRA STATUS	#378.025
		49-56	8 LSBs PRA POR CTR	
9.6	2	1-16	SCAN # 1 LHCP SUM	0.0275 -
		17-32	SCAN # 1 RHCP SUM	5.9975
		33-48	SCAN # 2 LHCP SUM	6.0275 -
		49-56	SCAN # 2 RHCP SUM BITS 1-8	11.9975
19.2	3	1- 8	SCAN # 2 RHCP SUM BITS 9-16	
		9-24	SCAN # 3 LHCP SUM	12.0275 -
		25-40	SCAN # 3 RHCP SUM	17.9975
		41-56	SCAN # 4 LHCP SUM	18.0275 -
28.8	4	1-16	SCAN # 4 RHCP SUM	23.9975
		17-32	SCAN # 5 LHCP SUM	24.0275 -
		33-48	SCAN # 5 RHCP SUM	29.9975
		49-56	SCAN # 6 LHCP SUM BITS 1-8	30.0275 -
38.4	5	1- 8	SCAN # 6 LHCP SUM BITS 9-16	35.9975
		9-24	SCAN # 6 RHCP SUM	
		25-40	SCAN # 7 LHCP SUM	36.0275 -
		41-56	SCAN # 7 RHCP SUM	41.9975
48.0	6	1-16	SCAN # 8 LHCP SUM	42.0275 -
		17-32	SCAN # 8 RHCP SUM	47.9975
		33-48	16 BITS PRA STATUS	42.025
		49-56	8 LSBs PRA POR CTR	
57.6	7	1-16	SCAN # 9 LHCP SUM	48.0275 -
		17-32	SCAN # 9 RHCP SUM	53.9975
		33-48	SCAN # 10 LHCP SUM	54.0275 -
		49-56	SCAN # 10 RHCP SUM BITS 1-8	59.9975
67.2	8	1- 8	SCAN # 10 RHCP SUM BITS 9-16	
		9-24	SCAN # 11 LHCP SUM	60.0275 -
		25-40	SCAN # 11 RHCP SUM	65.9975
		41-56	SCAN # 12 LHCP SUM	66.0275 -

TABLE A.3-2 (CONT'D)
PRA CR5a OUTPUT SCHEME

MF START * t_o + (SEC)	MF **	BITS	SUM TYPE	SAMPLE PERIOD t_o + (SEC)***
76.8	9	1-16	SCAN # 12 RHCP SUM	71.9975
		17-32	SCAN # 13 LHCP SUM	72.0275 -
		33-48	SCAN # 13 RHCP SUM	77.9975
		49-56	SCAN # 14 LHCP SUM BITS 1-8	78.0275 -
86.4	10	1- 8	SCAN # 14 LHCP SUM BITS 9-16	83.9975
		9-24	SCAN # 14 RHCP SUM	
		25-40	SCAN # 15 LHCP SUM	84.0275 -
		41-56	SCAN # 15 RHCP SUM	89.9975
96.0	11	1-16	SCAN # 16 LHCP SUM	90.0275 -
		17-32	SCAN # 16 RHCP SUM	95.9975
		33-48	16 BITS PRA STATUS	90.025
		49-56	8 LSBs PRA POR CTR	
105.6	12	1-16	SCAN # 17 LHCP SUM	96.0275 -
		17-32	SCAN # 17 RHCP SUM	101.9975
		33-48	SCAN # 18 LHCP SUM	102.0275 -
		49-56	SCAN # 18 RHCP SUM BITS 1-8	107.9975
115.2	13	1- 8	SCAN # 18 RHCP SUM BITS 9-16	
		9-24	SCAN # 19 LHCP SUM	108.0275 -
		25-40	SCAN # 19 RHCP SUM	113.9975
		41-56	SCAN # 20 LHCP SUM	114.0275 -
124.8	14	1-16	SCAN # 20 RHCP SUM	119.9975
		17-32	SCAN # 21 LHCP SUM	120.0275 -
		33-48	SCAN # 21 RHCP SUM	125.9975
		49-56	SCAN # 22 LHCP SUM BITS 1-8	126.0275 -
134.4	15	1- 8	SCAN # 22 LHCP SUM BITS 9-16	131.9975
		9-24	SCAN # 22 RHCP SUM	
		25-40	SCAN # 23 LHCP SUM	132.0275 -
		41-56	SCAN # 23 RHCP SUM	137.9975
144.0	16	1-16	SCAN # 24 LHCP SUM	138.0275 -
		17-32	SCAN # 24 RHCP SUM	143.9975
		33-48	16 BITS PRA STATUS	138.025
		49-56	8 LSBs PRA POR CTR	

TABLE A.3-2 (CONT'D)
PRA CR5a OUTPUT SCHEME

MF START * t_o + (SEC)	MF **	BITS	SUM TYPE	SAMPLE PERIOD t_o + (SEC)***
153.6	17	1-16	SCAN # 25 LHCP SUM	144.0275 -
		17-32	SCAN # 25 RHCP SUM	149.9975
		33-48	SCAN # 26 LHCP SUM	150.0275 -
		49-56	SCAN # 26 RHCP SUM BITS 1-8	155.9975
163.2	18	1- 8	SCAN # 26 RHCP SUM BITS 9-16	
		9-24	SCAN # 27 LHCP SUM	156.0275 -
		25-40	SCAN # 27 RHCP SUM	161.9975
		41-56	SCAN # 28 LHCP SUM	162.0275 -
172.8	19	1-16	SCAN # 28 RHCP SUM	167.9975
		17-32	SCAN # 29 LHCP SUM	168.0275 -
		33-48	SCAN # 29 RHCP SUM	173.9975
		49-56	SCAN # 30 LHCP SUM BITS 1-8	174.0275 -
182.4	20	1- 8	SCAN # 30 LHCP SUM BITS 9-16	
		9-24	SCAN # 30 RHCP SUM	179.9975
		25-40	SCAN # 31 LHCP SUM	180.0275 -
		41-56	SCAN # 31 RHCP SUM	185.9975
192.0	21	1-16	SCAN # 32 LHCP SUM	186.0275 -
		17-32	SCAN # 32 RHCP SUM	191.9975
		33-48	16 BITS PRA STATUS	186.025
		49-56	8 LSBs PRA POR CTR	
201.6	22	1-16	SCAN # 33 LHCP SUM	192.0275 -
		17-32	SCAN # 33 RHCP SUM	197.9975
		33-48	SCAN # 34 LHCP SUM	198.0275 -
		49-56	SCAN # 34 RHCP SUM BITS 1-8	203.9975
211.2	23	1- 8	SCAN # 34 RHCP SUM BITS 9-16	
		9-24	SCAN # 35 LHCP SUM	204.0275 -
		25-40	SCAN # 35 RHCP SUM	209.9975
		41-56	SCAN # 36 LHCP SUM	210.0275 -
220.8	24	1-16	SCAN # 36 RHCP SUM	215.9975
		17-32	SCAN # 37 LHCP SUM	216.0275 -
		33-48	SCAN # 37 RHCP SUM	221.9975
		49-56	SCAN # 38 LHCP SUM BITS 1-8	222.0275 -

TABLE A.3-2 (CONT'D)
PRA CR5a OUTPUT SCHEME

MF START * t_o + (SEC)	MF **	BITS	SUM TYPE	SAMPLE PERIOD t_o + (SEC)***
230.4	25	1- 8	SCAN # 38 LHCP SUM BITS 9-16	227.9975
		9-24	SCAN # 38 RHCP SUM	
		25-40	SCAN # 39 LHCP SUM	228.0275 -
		41-56	SCAN # 39 RHCP SUM	233.9975
240.0	26	1-16	SCAN # 40 LHCP SUM	234.0275 -
		17-32	SCAN # 40 RHCP SUM	239.9975
		33-48	16 BITS PRA STATUS	234.025
		49-56	8 LSBs PRA POR CTR	
249.6	27	1-16	SCAN # 41 LHCP SUM	240.0275 -
		17-32	SCAN # 41 RHCP SUM	245.9975
		33-48	SCAN # 42 LHCP SUM	246.0275 -
		49-56	SCAN # 42 RHCP SUM BITS 1-8	251.9975
259.2	28	1- 8	SCAN # 42 RHCP SUM BITS 9-16	
		9-24	SCAN # 43 LHCP SUM	252.0275 -
		25-40	SCAN # 43 RHCP SUM	257.9975
		41-56	SCAN # 44 LHCP SUM	258.0275 -
268.8	29	1-16	SCAN # 44 RHCP SUM	263.9975
		17-32	SCAN # 45 LHCP SUM	264.0275 -
		33-48	SCAN # 45 RHCP SUM	269.9975
		49-56	SCAN # 46 LHCP SUM BITS 1-8	270.0275 -
278.4	30	1- 8	SCAN # 46 LHCP SUM BITS 9-16	275.9975
		9-24	SCAN # 46 RHCP SUM	
		25-40	SCAN # 47 LHCP SUM	276.0275 -
		41-56	SCAN # 47 RHCP SUM	281.9975
288.0	31	1-16	SCAN # 48 LHCP SUM	282.0275 -
		17-32	SCAN # 48 RHCP SUM	287.9975
		33-48	16 BITS PRA STATUS	282.025
		49-56	8 LSBs PRA POR CTR	
297.6	32	1-16	SCAN # 49 LHCP SUM	288.0275 -
		17-32	SCAN # 49 RHCP SUM	293.9975
		33-48	SCAN # 50 LHCP SUM	294.0275 -
		49-56	SCAN # 50 RHCP SUM BITS 1-8	299.9975

TABLE A.3-2 (CONT'D)
PRA CR5a OUTPUT SCHEME

MF START * t_o + (SEC)	MF **	BITS	SUM TYPE	SAMPLE PERIOD t_o + (SEC)***
307.2	33	1- 8	SCAN # 50 RHCP SUM BITS 9-16	
		9-24	SCAN # 51 LHCP SUM	300.0275 -
		25-40	SCAN # 51 RHCP SUM	305.9975
		41-56	SCAN # 52 LHCP SUM	306.0275 -
316.8	34	1-16	SCAN # 52 RHCP SUM	311.9975
		17-32	SCAN # 53 LHCP SUM	312.0275 -
		33-48	SCAN # 53 RHCP SUM	317.9975
		49-56	SCAN # 54 LHCP SUM BITS 1-8	318.0275 -
326.4	35	1- 8	SCAN # 54 LHCP SUM BITS 9-16	323.9975
		9-24	SCAN # 54 RHCP SUM	
		25-40	SCAN # 55 LHCP SUM	324.0275 -
		41-56	SCAN # 55 RHCP SUM	329.9975
336.0	36	1-16	SCAN # 56 LHCP SUM	330.0275 -
		17-32	SCAN # 56 RHCP SUM	335.9975
		33-48	16 BITS PRA STATUS	330.025
		49-56	8 LSBs PRA POR CTR	
345.6	37	1-16	SCAN # 57 LHCP SUM	336.0275 -
		17-32	SCAN # 57 RHCP SUM	341.9975
		33-48	SCAN # 58 LHCP SUM	342.0275 -
		49-56	SCAN # 58 RHCP SUM BITS 1-8	347.9975
355.2	38	1- 8	SCAN # 58 RHCP SUM BITS 9-16	
		9-24	SCAN # 59 LHCP SUM	348.0275 -
		25-40	SCAN # 59 RHCP SUM	353.9975
		41-56	SCAN # 60 LHCP SUM	354.0275 -
364.8	39	1-16	SCAN # 60 RHCP SUM	359.9975
		17-32	SCAN # 61 LHCP SUM	360.0275 -
		33-48	SCAN # 61 RHCP SUM	365.9975
		49-56	SCAN # 62 LHCP SUM BITS 1-8	366.0275 -
374.4	40	1- 8	SCAN # 62 LHCP SUM BITS 9-16	#366.0275 -
		9-24	SCAN # 62 RHCP SUM	#371.9975
		25-40	SCAN # 63 LHCP SUM	#372.0275 -
		41-56	SCAN # 63 RHCP SUM	#377.9975

Notes for Table A.3-2:

* t_o is the time of:

SCT60 MOD 8 = 0 frame start when FDS 2 ** 16 counter is even

SCT60 MOD 8 = 4 frame start when FDS 2 ** 16 counter is odd

** Minor frame (of 40) with respect to:

SCT60 MOD 8 = 0 frame start when FDS 2 ** 16 counter is even

SCT60 MOD 8 = 4 frame start when FDS 2 ** 16 counter is odd

*** Sample period represents time required to obtain a full 200 word PRA scan. PRA data is sampled at p-periods 11 and 23 every FDS line, all 200 samples are obtained in 100 FDS line counts. The 200 words are separated according to polarity (LHCP or RHCP) and are summed. Two sums are output for every scan. PRA status is sampled at P10L1 X 100. Only every eighth sample is returned.

Sampled in preceding SCT60 MOD 8 cycle.

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A.4 PWS Processing Modifications

PWS scan rate is increased to one scan every 4 seconds. Each scan is comprised of 16 8-bit words. These 16 words correspond to 16 frequency channels in the range of 10 Hz to 56.2 kHz. Data from corresponding channels are summed over 4 consecutive scans yielding a set of 16 10-bit sums. These 16 10-bit sums (160 bits total) are produced once every 16 seconds.

Every 192 seconds the LECP motor step corrupts the current PWS scan, which in turn corrupts the current set of sums. In order to avoid LECP motor step interference, one set out of every 12 is deleted. The deleted set is chosen such that the LECP motor step occurs early in the first of the four scans which make up that set. This allows for 12.8 seconds of dead time following the LECP motor step. With only 11 out of every 12 sets telemetered to the ground, this is the equivalent of 1760 PWS bits every 192 seconds.

In order to accommodate the increased bit requirements, PWS allocation in the CR5a minor frame is increased to 88 bits from the current allocation of 16 bits in CR05. The 72 extra bits are obtained as a result of modifications made to PRA processing (see PRA processing modifications section).

PWS experiences interference from the PLS L mode. When the PLS is in the short integration mode interference is from t_o + 109.5 seconds to t_o + 113.34 seconds. This affects all PWS samples from filter 12 of the 4th scan of PWS set 7 to filter 2 of the 1st scan of PWS set 8. When the PLS is in the long integration mode interference is from t_o + 149.82 seconds to t_o + 165.12 seconds. This affects all PWS samples from filter 12 of the 2nd scan of PWS set 10 to filter 2 of the 2nd scan of set 11. Though it would be desirable to contain all L mode interference to within one PWS set, no modification of PWS processing as presented above is planned due to the complexity of the required changes.

Table A.4-1 presents the center frequencies of the 16 channels which make up a PWS scan

Figure A.4-1 summarizes the new PWS processing scheme and outlines the interference to PWS data from the LECP motor step

Table A.4-2 outlines the PWS output scheme for CR5a

TABLE A.4-1
PWS CENTER FREQUENCIES

	Filter Number	Center Frequency (Hz)
Low Frequency Analog Output A	1	10.0
	2	17.8
	3	31.1
	4	56.2
	5	100.0
	6	178.0
	7	311.0
	8	562.0
	Filter Number	Center Frequency (kHz)
High Frequency Analog Output B	9	1.0
	10	1.78
	11	3.11
	12	5.62
	13	10.00
	14	17.8
	15	31.1
	16	56.2

TABLE A.4-2
PWS CR5a OUTPUT SCHEME

MF START * t_o + (SEC)	MF **	BITS	DATA	SAMPLE TIME *** t_o + (SEC)
0.0	1	1- 6	#SET 11, FILTER 16(6 LSBs)	#163.925
		7-16	#SET 11, FILTER 8	#163.9325
		17-26	#SET 12, FILTER 9	#176.425
		27-36	#SET 12, FILTER 1	#176.4325
		37-46	#SET 12, FILTER 10	#176.925
		47-56	#SET 12, FILTER 2	#176.9325
		57-66	#SET 12, FILTER 11	#177.425
		67-76	#SET 12, FILTER 3	#177.4325
		77-86	#SET 12, FILTER 12	#177.925
		87-88	#SET 12, FILTER 4 (2 MSBs)	#177.9325
9.6	2	1- 8	#SET 12, FILTER 4 (8 LSBs)	#177.9325
		9-18	#SET 12, FILTER 13	#178.425
		19-28	#SET 12, FILTER 5	#178.4325
		29-38	#SET 12, FILTER 14	#178.925
		39-48	#SET 12, FILTER 6	#178.9325
		49-58	#SET 12, FILTER 15	#179.425
		59-68	#SET 12, FILTER 7	#179.4325
		69-78	#SET 12, FILTER 16	#179.925
		79-88	#SET 12, FILTER 8	#179.9325
19.2	3	1-10	SET 1, FILTER 9	0.425
		11-20	SET 1, FILTER 1	0.4325
		21-30	SET 1, FILTER 10	0.925
		31-40	SET 1, FILTER 2	0.9325
		41-50	SET 1, FILTER 11	1.425
		51-60	SET 1, FILTER 3	1.4325
		61-70	SET 1, FILTER 12	1.925
		71-80	SET 1, FILTER 4	1.9325
		81-88	SET 1, FILTER 13(8 MSBs)	2.425
28.8	4	1- 2	SET 1, FILTER 13(2 LSBs)	2.425
		3-12	SET 1, FILTER 5	2.4325
		13-22	SET 1, FILTER 14	2.925
		23-32	SET 1, FILTER 6	2.9325
		33-42	SET 1, FILTER 15	3.425
		43-52	SET 1, FILTER 7	3.4325
		53-62	SET 1, FILTER 16	3.925
		63-72	SET 1, FILTER 8	3.9325
		73-82	SET 2, FILTER 9	16.425
		83-88	SET 2, FILTER 1 (6 MSBs)	16.4325

TABLE A.4-2 (CONT'D)
PWS CR5a OUTPUT SCHEME

MF START * t_o + (SEC)	MF **	BITS	DATA	SAMPLE TIME *** t_o + (SEC)
38.4	5	1- 4	SET 2, FILTER 1 (4 LSBs)	16.4325
		5-14	SET 2, FILTER 10	16.925
		15-24	SET 2, FILTER 2	16.9325
		25-34	SET 2, FILTER 11	17.425
		35-44	SET 2, FILTER 3	17.4325
		45-54	SET 2, FILTER 12	17.925
		55-64	SET 2, FILTER 4	17.9325
		65-74	SET 2, FILTER 13	18.425
		75-84	SET 2, FILTER 5	18.4325
		85-88	SET 2, FILTER 14 (4 MSBs)	18.925
48.0	6	1- 6	SET 2, FILTER 14 (6 LSBs)	18.925
		7-16	SET 2, FILTER 6	18.9325
		17-26	SET 2, FILTER 15	19.425
		27-36	SET 2, FILTER 7	19.4325
		37-46	SET 2, FILTER 16	19.925
		47-56	SET 2, FILTER 8	19.9325
		57-66	SET 3, FILTER 9	32.425
		67-76	SET 3, FILTER 1	32.4325
		77-86	SET 3, FILTER 10	32.925
		87-88	SET 3, FILTER 2 (2 MSBs)	32.9325
57.6	7	1- 8	SET 3, FILTER 2 (8 LSBs)	32.9325
		9-18	SET 3, FILTER 11	33.425
		19-28	SET 3, FILTER 3	33.4325
		29-38	SET 3, FILTER 12	33.925
		39-48	SET 3, FILTER 4	33.9325
		49-58	SET 3, FILTER 13	34.425
		59-68	SET 3, FILTER 5	34.4325
		69-78	SET 3, FILTER 14	34.925
		79-88	SET 3, FILTER 6	34.9325
67.2	8	1-10	SET 3, FILTER 15	35.425
		11-20	SET 3, FILTER 7	35.4325
		21-30	SET 3, FILTER 16	35.925
		31-40	SET 3, FILTER 8	35.9325
		41-50	SET 4, FILTER 9	48.425
		51-60	SET 4, FILTER 1	48.4325
		61-70	SET 4, FILTER 10	48.925
		71-80	SET 4, FILTER 2	48.9325
		81-88	SET 4, FILTER 11 (8 MSBs)	49.425

TABLE A.4-2 (CONT'D)
PWS CR5a OUTPUT SCHEME

MF START * t_o + (SEC)	MF **	BITS	DATA		SAMPLE TIME *** t_o + (SEC)
76.8	9	1- 2	SET 4, FILTER 11	(2 LSBs)	49.425
		3-12	SET 4, FILTER 3		49.4325
		13-22	SET 4, FILTER 12		49.925
		23-32	SET 4, FILTER 4		49.9325
		33-42	SET 4, FILTER 13		50.425
		43-52	SET 4, FILTER 5		50.4325
		53-62	SET 4, FILTER 14		50.925
		63-72	SET 4, FILTER 6		50.9325
		73-82	SET 4, FILTER 15		51.425
		83-88	SET 4, FILTER 7	(6 MSBs)	51.4325
86.4	10	1- 4	SET 4, FILTER 7	(4 LSBs)	51.4325
		5-14	SET 4, FILTER 16		51.925
		15-24	SET 4, FILTER 8		51.9325
		25-34	SET 5, FILTER 9		64.425
		35-44	SET 5, FILTER 1		64.4325
		45-54	SET 5, FILTER 10		64.925
		55-64	SET 5, FILTER 2		64.9325
		65-74	SET 5, FILTER 11		65.425
		75-84	SET 5, FILTER 3		65.4325
		85-88	SET 5, FILTER 12	(4 MSBs)	65.925
96.0	11	1- 6	SET 5, FILTER 12	(6 LSBs)	65.925
		7-16	SET 5, FILTER 4		65.9325
		17-26	SET 5, FILTER 13		66.425
		27-36	SET 5, FILTER 5		66.4325
		37-46	SET 5, FILTER 14		66.925
		47-56	SET 5, FILTER 6		66.9325
		57-66	SET 5, FILTER 15		67.425
		67-76	SET 5, FILTER 7		67.4325
		77-86	SET 5, FILTER 16		67.925
		87-88	SET 5, FILTER 8	(2 MSBs)	67.9325
105.6	12	1- 8	SET 5, FILTER 8	(8 MSBs)	67.9325
		9-18	SET 6, FILTER 9		80.425
		19-28	SET 6, FILTER 1		80.4325
		29-38	SET 6, FILTER 10		80.925
		39-48	SET 6, FILTER 2		80.9325
		49-58	SET 6, FILTER 11		81.425
		59-68	SET 6, FILTER 3		81.4325
		69-78	SET 6, FILTER 12		81.925
		79-88	SET 6, FILTER 4		81.9325

TABLE A.4-2 (CONT'D)
PWS CR5a OUTPUT SCHEME

MF START * t_o + (SEC)	MF **	BITS	DATA		SAMPLE TIME *** t_o + (SEC)
115.2	13	1-10	SET 6, FILTER 13		82.425
		11-20	SET 6, FILTER 5		82.4325
		21-30	SET 6, FILTER 14		82.925
		31-40	SET 6, FILTER 6		82.9325
		41-50	SET 6, FILTER 15		83.425
		51-60	SET 6, FILTER 7		83.4325
		61-70	SET 6, FILTER 16		83.925
		71-80	SET 6, FILTER 8		83.9325
		81-88	SET 7, FILTER 9	(8 MSBs)	96.425
124.8	14	1- 2	SET 7, FILTER 9	(2 LSBs)	96.425
		3-12	SET 7, FILTER 1		96.4325
		13-22	SET 7, FILTER 10		96.925
		23-32	SET 7, FILTER 2		96.9325
		33-42	SET 7, FILTER 11		97.425
		43-52	SET 7, FILTER 3		97.4325
		53-62	SET 7, FILTER 12		97.925
		63-72	SET 7, FILTER 4		97.9325
		73-82	SET 7, FILTER 13		98.425
		83-88	SET 7, FILTER 5	(6 MSBs)	98.4325
134.4	15	1- 4	SET 7, FILTER 5	(4 LSBs)	98.4325
		5-14	SET 7, FILTER 14		98.925
		15-24	SET 7, FILTER 6		98.9325
		25-34	SET 7, FILTER 15		99.425
		35-44	SET 7, FILTER 7		99.4325
		45-54	SET 7, FILTER 16		99.925
		55-64	SET 7, FILTER 8		99.9325
		65-74	SET 9, FILTER 9		128.425
		75-84	SET 9, FILTER 1		128.4325
		85-88	SET 9, FILTER 10	(4 MSBs)	128.925
144.0	16	1- 6	SET 9, FILTER 10	(6 LSBs)	128.925
		7-16	SET 9, FILTER 2		128.9325
		17-26	SET 9, FILTER 11		129.425
		27-36	SET 9, FILTER 3		129.4325
		37-46	SET 9, FILTER 12		129.925
		47-56	SET 9, FILTER 4		129.9325
		57-66	SET 9, FILTER 13		130.425
		67-76	SET 9, FILTER 5		130.4325
		77-86	SET 9, FILTER 14		130.925
		87-88	SET 9, FILTER 6	(2 MSBs)	130.9325

TABLE A.4-2 (CONT'D)
PWS CR5a OUTPUT SCHEME

MF START * t_o + (SEC)	MF **	BITS	DATA	SAMPLE TIME *** t_o + (SEC)
153.6	17	1- 8	SET 9, FILTER 6 (8 LSBs)	130.9325
		9-18	SET 9, FILTER 15	131.425
		19-28	SET 9, FILTER 7	131.4325
		29-38	SET 9, FILTER 16	131.925
		39-48	SET 9, FILTER 8	131.9325
		49-58	SET 10, FILTER 9	144.425
		59-68	SET 10, FILTER 1	144.4325
		69-78	SET 10, FILTER 10	144.925
		79-88	SET 10, FILTER 2	144.9325
163.2	18	1-10	SET 10, FILTER 11	145.425
		11-20	SET 10, FILTER 3	145.4325
		21-30	SET 10, FILTER 12	145.925
		31-40	SET 10, FILTER 4	145.9325
		41-50	SET 10, FILTER 13	146.425
		51-60	SET 10, FILTER 5	146.4325
		61-70	SET 10, FILTER 14	146.925
		71-80	SET 10, FILTER 6	146.9325
		81-88	SET 10, FILTER 15 (8 MSBs)	147.425
172.8	19	1- 2	SET 10, FILTER 15 (2 LSBs)	147.425
		3-12	SET 10, FILTER 7	147.4325
		13-22	SET 10, FILTER 16	147.925
		23-32	SET 10, FILTER 8	147.9325
		33-42	SET 11, FILTER 9	160.425
		43-52	SET 11, FILTER 1	160.4325
		53-62	SET 11, FILTER 10	160.925
		63-72	SET 11, FILTER 2	160.9325
		73-82	SET 11, FILTER 11	161.425
		83-88	SET 11, FILTER 3 (6 MSBs)	161.4325
182.4	20	1- 4	SET 11, FILTER 3 (4 LSBs)	161.4325
		5-14	SET 11, FILTER 12	161.925
		15-24	SET 11, FILTER 4	161.9325
		25-34	SET 11, FILTER 13	162.425
		35-44	SET 11, FILTER 5	162.4325
		45-54	SET 11, FILTER 14	162.925
		55-64	SET 11, FILTER 6	162.9325
		65-74	SET 11, FILTER 15	163.425
		75-84	SET 11, FILTER 7	163.4325
		85-88	SET 11, FILTER 16(4 MSBs)	163.925

Notes for Table A.4-2:

- * t_o is the time of SCT60 MOD 4 = 0 frame start
- ** minor frame (of 20) with respect to SCT60 MOD 4 = 0
- *** Sample time shown is for the first of four consecutive samples to be summed. Subsequent three samples, of a four sample sum, follow on 4 second deltas.
- \# Sampled in preceding SCT60 MOD 4 cycle

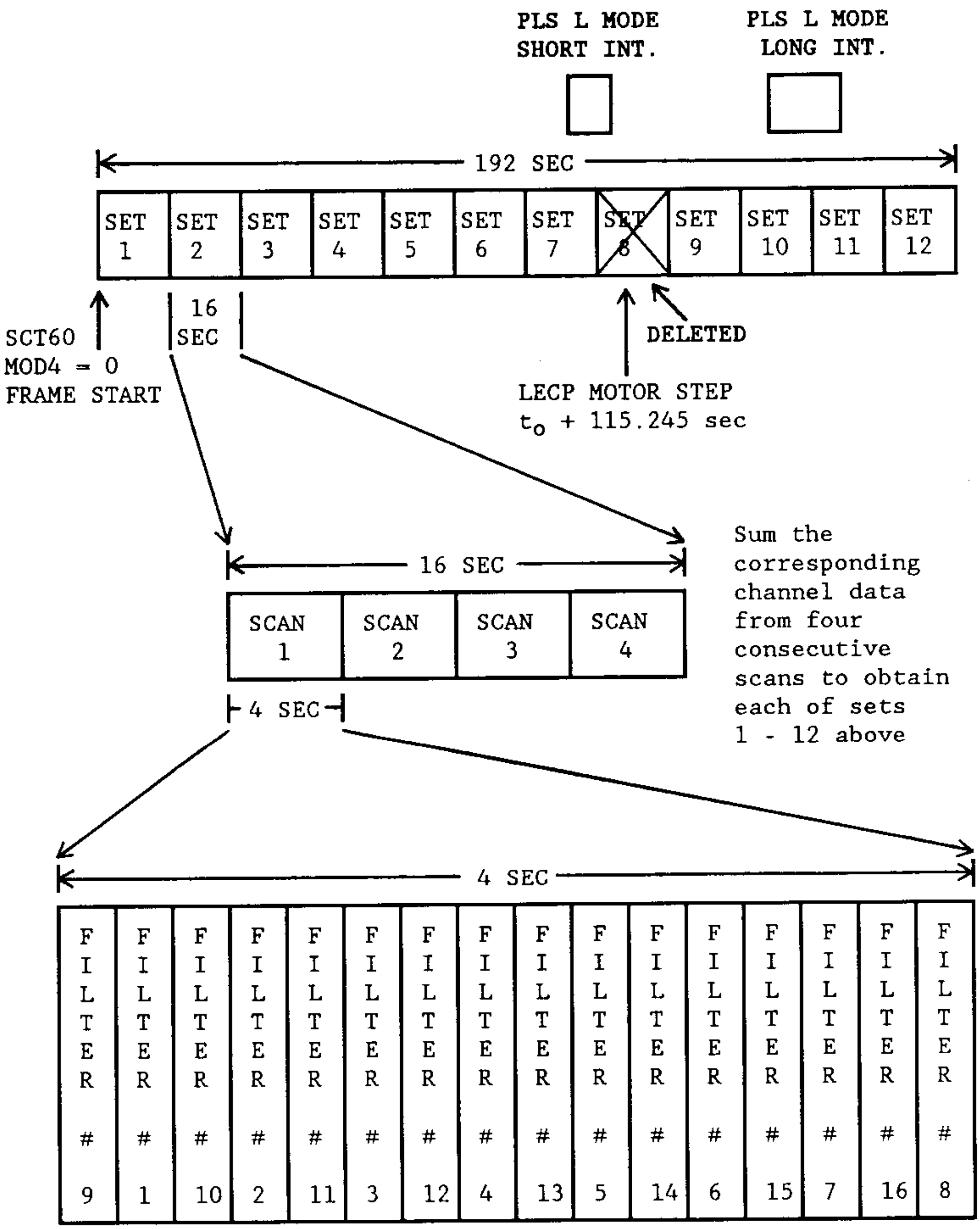
FIGURE A.4-1

PWS CR5a PROCESSING SCHEME
192 SECOND (20 MINOR FRAME) CYCLE

* One complete PWS scan every 4 seconds

* Sum corresponding channels from 4 consecutive scans yielding a set of 16 10-bit sums every 16 seconds

* Delete one out of every 12th set to allow a 16 second "dead time" after every LECP motor step



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A.5 MAG Processing Modifications

Replace the current delta modulation scheme currently used for CR05 MAG telemetry with a 6-bit differencing scheme similar to that used in standard GS&E.

Once every 0.06 seconds (1 FDS line) the FDS samples the X, Y, and Z axis data from both the Outboard (primary) and Inboard (secondary) Low Field Magnetometers (LFMs) yielding 6 MAG sample vectors. This is equivalent to 72 MAG bits (6 sample vectors at 12 bits each) every 0.06 seconds.

For each axis, 8 consecutive sample vectors are averaged for a rate of 0.48 seconds/average. This results in three Outboard (primary) vector averages and three Inboard (secondary) vector averages (12 bits apiece) every 0.48 seconds.

Each Outboard (primary) vector average is differenced from the preceding vector average. The 6 LSBs of the difference form the "Temporal Difference Field" or simply the difference. A difference is calculated for each of the primary axes resulting in three Primary Differences (PD) every 0.48 seconds. This is equivalent to 18 bits every 0.48 seconds. All primary differences are entered into the telemetry stream.

In addition, every 25th Outboard (primary) average is also telemetered as a 12 bit "Full Vector Word" (reference). With one reference per primary axis, this results in 3 primary Full Vector Words or 36 bits every 12 seconds.

Every 50th Inboard (secondary) average is telemetered as a 12 bit "Full Vector Word" (reference). With one reference per secondary axis, this results in 3 secondary Full Vector Words or 36 bits every 24 seconds.

The primary Full Vector Words should be redundant (in that they repeat information that can be derived from the differences), however, they are included to correct for possible saturation (overflow) of the 6-bit differences or other possible telemetry errors. The secondary Full Vector Words are included to provide some visibility of secondary LFM data. Secondary Full Vector Word sample times are concurrent with every second primary Full Vector Word sample time.

Since the primary and secondary Full Vector Words are returned on centers (12 and 24 seconds) that are not integral multiples of 9.6 seconds, the number of data bits for data sampled within a minor frame is not the same for each CR5a minor frame. To distribute the data more evenly and stay within the MAG budget in each minor frame, the data collected over a CR5a minor frame period (9.6 seconds or 160 FDS line counts) is no longer necessarily contained within a single CR5a minor frame. This results in a 5 minor frame (48 second) MAG data output cycle.

Table A.5-1 demonstrates the generation of MAG data.

Table A.5-2 presents the MAG output scheme.

TABLE A.5-1
MAG DATA GENERATED IN EACH MINOR FRAME

	CR5a MF									
	1 OF 5		2 OF 5		3 OF 5		4 OF 5		5 OF 5	
SAMPLE TIME (LINESX160)	DATA TYPE	NUM BITS	DATA TYPE	NUM BITS	DATA TYPE	NUM BITS	DATA TYPE	NUM BITS	DATA TYPE	NUM BITS
1 - 8	PD PR SR	18 36 36	PD	18	PD	18	PD	18	PD	18
9 - 16	PD	18	PD	18	PD	18	PD	18	PD	18
17 - 24	PD	18	PD	18	PD	18	PD	18	PD	18
25 - 32	PD	18	PD	18	PD	18	PD	18	PD	18
33 - 40	PD	18	PD	18	PD	18	PD	18	PD	18
41 - 48	PD	18	PD PR	18 36	PD	18	PD	18	PD	18
49 - 56	PD	18	PD	18	PD	18	PD	18	PD	18
57 - 64	PD	18	PD	18	PD	18	PD	18	PD	18
65 - 72	PD	18	PD	18	PD	18	PD	18	PD	18
73 - 80	PD	18	PD	18	PD	18	PD	18	PD	18
81 - 88	PD	18	PD	18	PD PR SR	18 36 36	PD	18	PD	18
89 - 96	PD	18	PD	18	PD	18	PD	18	PD	18
97 - 104	PD	18	PD	18	PD	18	PD	18	PD	18
105 - 112	PD	18	PD	18	PD	18	PD	18	PD	18
113 - 120	PD	18	PD	18	PD	18	PD	18	PD	18
121 - 128	PD	18	PD	18	PD	18	PD PR	18 36	PD	18
129 - 136	PD	18	PD	18	PD	18	PD	18	PD	18
137 - 144	PD	18	PD	18	PD	18	PD	18	PD	18
145 - 152	PD	18	PD	18	PD	18	PD	18	PD	18
153 - 160	PD	18	PD	18	PD	18	PD	18	PD	18
TOTAL		432		396		432		396		360

Notes for Table A.5-1: PD: Primary Difference, PR: Primary Reference, SR: Secondary Reference

TABLE A.5-2
MAG CR5a OUTPUT SCHEME

MF START * t_o + (SEC)	MF **	MAG BITS	DATA TYPE	SAMPLE TIME *** (MF) LINE NUMBER
0.0	1	1- 6	PRI X DIF	(1 of 5) 001-008
		7- 18	PRI X REF (12 BITS)	
		19- 24	PRI Y DIF	
		25- 36	PRI Y REF (12 BITS)	
		37- 42	PRI Z DIF	
		43- 54	PRI Z REF (12 BITS)	
		55- 66	SEC X REF (12 BITS)	
		67- 78	Y	
		79- 90	Z	
		91- 96	PRI X DIF	(1 of 5) 009-016
		97-102	Y	
		103-108	Z	
		109-114	PRI X DIF	(1 of 5) 017-024
		115-120	Y	
		121-126	Z	
		127-132	PRI X DIF	(1 of 5) 025-032
		133-138	Y	
		139-144	Z	
		145-150	PRI X DIF	(1 of 5) 033-040
		151-156	Y	
		157-162	Z	
		163-168	PRI X DIF	(1 of 5) 041-048
		169-174	Y	
		175-180	Z	
		181-186	PRI X DIF	(1 of 5) 049-056
		187-192	Y	
		193-198	Z	
		199-204	PRI X DIF	(1 of 5) 057-064
		205-210	Y	
		211-216	Z	
		217-222	PRI X DIF	(1 of 5) 065-072
		223-228	Y	
		229-234	Z	
		235-240	PRI X DIF	(1 of 5) 073-080
		241-246	Y	
		247-252	Z	
		253-258	PRI X DIF	(1 of 5) 081-088
		259-264	Y	
		265-270	Z	
		271-276	PRI X DIF	(1 of 5) 089-096
		277-282	Y	
		283-288	Z	
		289-294	PRI X DIF	(1 of 5) 097-104
		295-300	Y	
		301-306	Z	

TABLE A.5-2 (CONT'D)
MAG CR5a OUTPUT SCHEME

MF START * t_o + (SEC)	MF **	MAG BITS	DATA TYPE	SAMPLE TIME *** (MF) LINE NUMBER
0.0	1	307-312	PRI X DIF	(1 of 5) 105-112
		313-318	Y	
		319-324	Z	
		325-330	PRI X DIF	(1 of 5) 113-120
		331-336	Y	
		337-342	Z	
		343-348	PRI X DIF	(1 of 5) 121-128
		349-354	Y	
		355-360	Z	
		361-366	PRI X DIF	(1 of 5) 129-136
		367-372	Y	
		373-378	Z	
		379-384	PRI X DIF	(1 of 5) 137-144
		385-390	Y	
		391-396	Z	
		397-402	PRI X DIF	(1 of 5) 145-152
		403-408	Y	
9.6	2	1- 6	Z	
		7- 12	PRI X DIF	(1 of 5) 153-160
		13- 18	Y	
		19- 24	Z	
		25- 30	PRI X DIF	(2 of 5) 001-008
		31- 36	Y	
		37- 42	Z	
		43- 48	PRI X DIF	(2 of 5) 009-016
		49- 54	Y	
		55- 60	Z	
		61- 66	PRI X DIF	(2 of 5) 017-024
		67- 72	Y	
		73- 78	Z	
		79- 84	PRI X DIF	(2 of 5) 025-032
		85- 90	Y	
		91- 96	Z	
		97-102	PRI X DIF	(2 of 5) 033-040
		103-108	Y	
		109-114	Z	
		115-120	PRI X DIF	(2 of 5) 041-048
		121-132	PRI X REF (12 BITS)	
		133-138	PRI Y DIF	
		139-150	PRI Y REF (12 BITS)	
		151-156	PRI Z DIF	
		157-168	PRI Z REF (12 BITS)	
		169-174	PRI X DIF	(2 of 5) 049-056
		175-180	Y	
		181-186	Z	

TABLE A.5-2 (CONT'D)
MAG CR5a OUTPUT SCHEME

MF START * t_o + (SEC)	MF **	MAG BITS	DATA TYPE	SAMPLE TIME *** (MF) LINE NUMBER
9.6	2	187-192	PRI X DIF	(2 of 5) 057-064
		193-198	Y	
		199-204	Z	
		205-210	PRI X DIF	(2 of 5) 065-072
		211-216	Y	
		217-222	Z	
		223-228	PRI X DIF	(2 of 5) 073-080
		229-234	Y	
		235-240	Z	
		241-246	PRI X DIF	(2 of 5) 081-088
		247-252	Y	
		253-258	Z	
		259-264	PRI X DIF	(2 of 5) 089-096
		265-270	Y	
		271-276	Z	
		277-282	PRI X DIF	(2 of 5) 097-104
		283-288	Y	
		289-294	Z	
		295-300	PRI X DIF	(2 of 5) 105-112
		301-306	Y	
		307-312	Z	
		313-318	PRI X DIF	(2 of 5) 113-120
		319-324	Y	
		325-330	Z	
		331-336	PRI X DIF	(2 of 5) 121-128
		337-342	Y	
		343-348	Z	
		349-354	PRI X DIF	(2 of 5) 129-136
		355-360	Y	
		361-366	Z	
		367-372	PRI X DIF	(2 of 5) 137-144
		373-378	Y	
		379-384	Z	
		385-390	PRI X DIF	(2 of 5) 145-152
		391-396	Y	
		397-402	Z	
		403-408	PRI X DIF	(2 of 5) 153-160
19.2	3	1- 6	Y	
		7- 12	Z	
		13- 18	PRI X DIF	(3 of 5) 001-008
		19- 24	Y	
		25- 30	Z	
		31- 36	PRI X DIF	(3 of 5) 009-016
		37- 42	Y	
		43- 48	Z	

TABLE A.5-2 (CONT'D)
MAG CR5a OUTPUT SCHEME

MF START * t_o + (SEC)	MF **	MAG BITS	DATA TYPE	SAMPLE TIME *** (MF) LINE NUMBER
19.2	3	49- 54	PRI X DIF	(3 of 5) 017-024
		55- 60	Y	
		61- 66	Z	
		67- 72	PRI X DIF	(3 of 5) 025-032
		73- 78	Y	
		79- 84	Z	
		85- 90	PRI X DIF	(3 of 5) 033-040
		91- 96	Y	
		97-102	Z	
		103-108	PRI X DIF	(3 of 5) 041-048
		109-114	Y	
		115-120	Z	
		121-126	PRI X DIF	(3 of 5) 049-056
		127-132	Y	
		133-138	Z	
		139-144	PRI X DIF	(3 of 5) 057-064
		145-150	Y	
		151-156	Z	
		157-162	PRI X DIF	(3 of 5) 065-072
		163-168	Y	
		169-174	Z	
		175-180	PRI X DIF	(3 of 5) 073-080
		181-186	Y	
		187-192	Z	
		193-198	PRI X DIF	(3 of 5) 081-088
		199-210	PRI X REF (12 BITS)	
		210-216	PRI Y DIF	
		217-228	PRI Y REF (12 BITS)	
		229-234	PRI Z DIF	
		235-246	PRI Z REF (12 BITS)	
		247-258	SEC X REF (12 BITS)	
		259-270	Y	
		271-282	Z	
		283-288	PRI X DIF	(3 of 5) 089-096
		289-294	Y	
		295-300	Z	
		301-306	PRI X DIF	(3 of 5) 097-104
		307-312	Y	
		313-318	Z	
		319-324	PRI X DIF	(3 of 5) 105-112
		325-330	Y	
		331-336	Z	
		337-342	PRI X DIF	(3 of 5) 113-120
		343-348	Y	
		349-354	Z	

TABLE A.5-2 (CONT'D)
MAG CR5a OUTPUT SCHEME

MF START * t_o + (SEC)	MF **	MAG BITS	DATA TYPE	SAMPLE TIME *** (MF) LINE NUMBER
19.2	3	355-360	PRI X DIF	(3 of 5) 121-128
		361-366	Y	
		367-372	Z	
		373-378	PRI X DIF	(3 of 5) 129-136
		379-384	Y	
		385-390	Z	
		391-396	PRI X DIF	(3 of 5) 137-144
		397-402	Y	
		403-408	Z	
28.8	4	1- 6	PRI X DIF	(3 of 5) 145-152
		7- 12	Y	
		13- 18	Z	
		19- 24	PRI X DIF	(3 of 5) 153-160
		25- 30	Y	
		31- 36	Z	
		37- 42	PRI X DIF	(4 of 5) 001-008
		43- 48	Y	
		49- 54	Z	
		55- 60	PRI X DIF	(4 of 5) 009-016
		61- 66	Y	
		67- 72	Z	
		73- 78	PRI X DIF	(4 of 5) 017-024
		79- 84	Y	
		85- 90	Z	
		91- 96	PRI X DIF	(4 of 5) 025-032
		97-102	Y	
		103-108	Z	
		109-114	PRI X DIF	(4 of 5) 033-040
		115-120	Y	
		121-126	Z	
		127-132	PRI X DIF	(4 of 5) 041-048
		133-138	Y	
		139-144	Z	
		145-150	PRI X DIF	(4 of 5) 049-056
		151-156	Y	
		157-162	Z	
		163-168	PRI X DIF	(4 of 5) 057-064
		169-174	Y	
		175-180	Z	
		181-186	PRI X DIF	(4 of 5) 065-072
		187-192	Y	
		193-198	Z	
		199-204	PRI X DIF	(4 of 5) 073-080
		205-210	Y	
		211-216	Z	

TABLE A.5-2 (CONT'D)
MAG CR5a OUTPUT SCHEME

MF START * t_o + (SEC)	MF **	MAG BITS	DATA TYPE	SAMPLE TIME *** (MF) LINE NUMBER
28.8	4	217-222	PRI X DIF	(4 of 5) 081-088
		223-228	Y	
		229-234	Z	
		235-240	PRI X DIF	(4 of 5) 089-096
		241-246	Y	
		247-252	Z	
		253-258	PRI X DIF	(4 of 5) 097-104
		259-264	Y	
		265-270	Z	
		271-276	PRI X DIF	(4 of 5) 105-112
		277-282	Y	
		283-288	Z	
		289-294	PRI X DIF	(4 of 5) 113-120
		295-300	Y	
		301-306	Z	
		307-312	PRI X DIF	(4 of 5) 121-128
		313-324	PRI X REF (12 BITS)	
		325-330	PRI Y DIF	
		331-342	PRI Y REF (12 BITS)	
		343-348	PRI Z DIF	
		349-360	PRI Z REF (12 BITS)	
		361-366	PRI X DIF	(4 of 5) 129-136
		367-372	Y	
		373-378	Z	
		379-384	PRI X DIF	(4 of 5) 137-144
		385-390	Y	
		391-396	Z	
		397-402	PRI X DIF	(4 of 5) 145-152
		403-408	Y	
38.4	5	1- 6	Z	
		7- 12	PRI X DIF	(4 of 5) 153-160
		13- 18	Y	
		19- 24	Z	
		25- 30	PRI X DIF	(5 of 5) 001-008
		31- 36	Y	
		37- 42	Z	
		43- 48	PRI X DIF	(5 of 5) 009-016
		49- 54	Y	
		55- 60	Z	
		61- 66	PRI X DIF	(5 of 5) 017-024
		67- 72	Y	
		73- 78	Z	
		79- 84	PRI X DIF	(5 of 5) 025-032
		85- 90	Y	
		91- 96	Z	

TABLE A.5-2 (CONT'D)
MAG CR5a OUTPUT SCHEME

MF START * t_o + (SEC)	MF **	MAG BITS	DATA TYPE	SAMPLE TIME *** (MF) LINE NUMBER
38.4	5	97-102	PRI X DIF	(5 of 5) 033-040
		103-108	Y	
		109-114	Z	
		115-120	PRI X DIF	(5 of 5) 041-048
		121-126	Y	
		127-132	Z	
		133-138	PRI X DIF	(5 of 5) 049-056
		139-144	Y	
		145-150	Z	
		151-156	PRI X DIF	(5 of 5) 057-064
		157-162	Y	
		163-168	Z	
		169-174	PRI X DIF	(5 of 5) 065-072
		175-180	Y	
		181-186	Z	
		187-192	PRI X DIF	(5 of 5) 073-080
		193-198	Y	
		199-204	Z	
		205-210	PRI X DIF	(5 of 5) 081-088
		211-216	Y	
		217-222	Z	
		223-228	PRI X DIF	(5 of 5) 089-096
		229-234	Y	
		235-240	Z	
		241-246	PRI X DIF	(5 of 5) 097-104
		247-252	Y	
		253-258	Z	
		259-264	PRI X DIF	(5 of 5) 105-112
		265-270	Y	
		271-276	Z	
		277-282	PRI X DIF	(5 of 5) 113-120
		283-288	Y	
		289-294	Z	
		295-300	PRI X DIF	(5 of 5) 121-128
		301-306	Y	
		307-312	Z	
		313-318	PRI X DIF	(5 of 5) 129-136
		319-324	Y	
		325-330	Z	
		331-336	PRI X DIF	(5 of 5) 137-144
		337-342	Y	
		343-348	Z	
		349-354	PRI X DIF	(5 of 5) 145-152
		355-360	Y	
		361-366	Z	

TABLE A.5-2 (CONT'D)
MAG CR5a OUTPUT SCHEME

MF START * t_o + (SEC)	MF **	MAG BITS	DATA TYPE	SAMPLE TIME *** (MF) LINE NUMBER
38.4	5	367-372	PRI X DIF	(5 of 5) 153-160
		373-378	Y	
		379-384	Z	
		385-408	**FILL BITS**	

Notes for Table A.5-2:

* t_o is the time of SCT60 frame start

** minor frame (of 5) with respect to SCT60 frame start

*** Sample time represents minor frame (of 5) with respect to SCT60 frame start and range of line counts in which data is sampled for a particular difference or reference

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A.6 UVS Processing Modifications

Increase UVS scan rate to 1 scan every 4 minutes (25 CR5a minor frames). Three modifications to UVS data processing by the FDS are required in order to meet the higher scan rate requirements.

First, the effective UVS allocation in the CR5a minor frame is increased from 384 bits every 15 minor frames (as is the current scheme in CR05) to 576 bits by utilizing all bits previously used by PPS in the UVS/PPS/status subcom. There is no requirement for PPS processing in CR5a.

The UVS/PPS/status subcommutator is a 48 bit, 15 position subcommutator transmitted as part of the CR05 minor frame. In CR05, UVS data is transmitted in 8 of the 15 subcommutator positions:

SUBCOM MF 2,3,4,5,7,8,9,10 X 15

for a total of 384 bits every 15 minor frames. PPS data is transmitted in 4 of the 15 subcommutator positions:

SUBCOM MF 12,13,14,15 X 15

for a total of 192 bits every 15 minor frames. The remaining 3 subcommutator positions (1,6,11 X 15) are used to telemeter status information (the same status words are telemetered each time).

By giving the PPS slots over to UVS, UVS data is transmitted in 12 out of the 15 subcommutator positions:

SUBCOM MF 2,3,4,5,7,8,9,10,12,13,14,15 X 15

or 576 bits every 15 CR5a minor frames. This furthermore means that the subcommutator can be reduced to five positions:

SUBCOM MF	CONTENTS
1 X 5	Status
2,3,4,5 X 5	UVS data

Second, the number of channels telemetered per UVS scan is reduced from 128 to 120. This is accomplished by deleting channels 3, 4 and 123 - 128. These channels are considered to be of lower priority than the remaining 120. Channel deletion is controlled by an internal FDS algorithm.

Third, the number of bits used to represent each channel is reduced from the current 10 bits to 8, by truncating the 2 MSB's. UVS data words begin as 16 bit words which are log compressed within the FDS hardware into 10 bit words containing a 4-bit exponent followed by a 6-bit mantissa. Within the FDS the 2 MSB's are truncated resulting in the 8 bit UVS word which is telemetered to the ground. Note that truncation of the 2 MSB's of the 10-bit log compressed sample reduces the exponent field from 4 bits to 2 bits. This reduces the maximum count that can be represented by a UVS word from 65,024 DN to 508 DN. This means that should the UVS experience counts higher than 508 DN in any channel, overflow will result.

One final note, changes in the UVSROF (UVS Readout Flag) will take effect at the start of the UVS data cycle (once every 4 minutes at P5L1 X 4000) and will reflect the last commanded value received in that period.

Figure A.6-1 presents the current CR05 UVS/PPS/status subcommutator and the updated CR5a UVS/status subcommutator.

Table A.6-1 presents the UVS output scheme for CR5a.

FIGURE A.6-1A
UVS/PPS/STATUS SUBCOM
CR05 VERSION

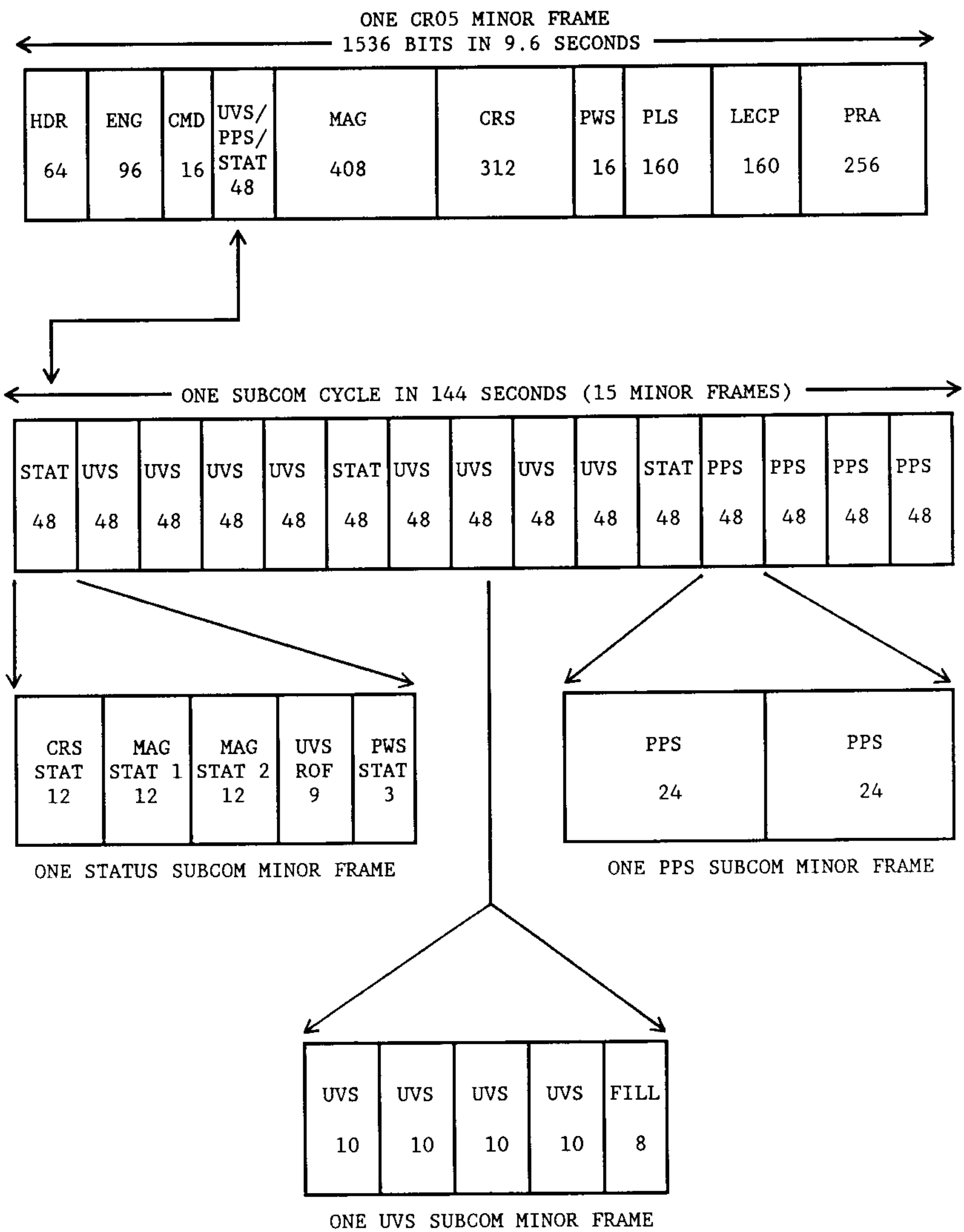

FIGURE A.6-1B
UVS/STATUS SUBCOM
CR5A VERSION

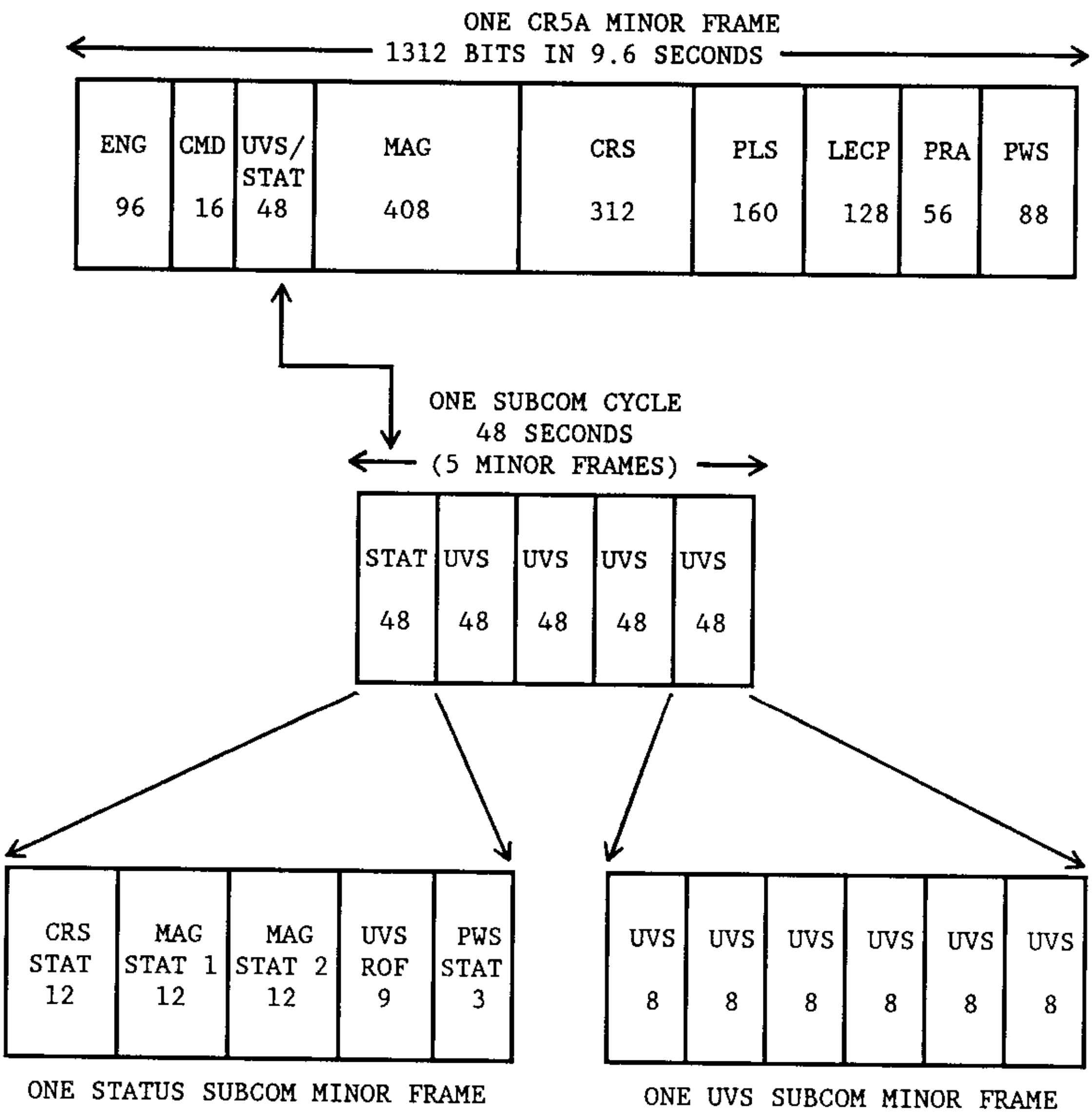

TABLE A.6-1
CR5a UVS OUTPUT SCHEME

MF START * t_o + (SEC)	MF **	UVS BITS	CHANNEL #/ STATUS TYPE	SAMPLE TIME * t_o + (SEC)
0.0	1	0-12	CRS STATUS	0.0150
		13-24	MAG STAT 1	0.0450
		25-36	MAG STAT 2	0.0475
		37-45	UVSROF	0.5000
		46-48	PWS STATUS	0.4925
9.6	2	0- 8	1	0.0125
		9-16	2	0.0125
		17-24	5	0.1325
		25-32	6	0.1325
		33-40	7	0.1925
		41-48	8	0.1925
19.2	3	0- 8	9	0.2525
		9-16	10	0.2525
		17-24	11	0.3125
		25-32	12	0.3125
		33-40	13	0.3725
		41-48	14	0.3725
28.8	4	0- 8	15	0.4325
		9-16	16	0.4325
		17-24	17	0.4925
		25-32	18	0.4925
		33-40	19	0.5525
		41-48	20	0.5525
38.4	5	0- 8	21	0.6125
		9-16	22	0.6125
		17-24	23	0.6725
		25-32	24	0.6725
		33-40	25	0.7325
		41-48	26	0.7325
48.0	6	0-12	CRS STATUS	48.0150
		13-24	MAG STAT 1	48.0450
		25-36	MAG STAT 2	48.0475
		37-45	UVSROF	48.5000
		46-48	PWS STATUS	48.4925

TABLE A.6-1 (CONT'D)
CR5a UVS OUTPUT SCHEME

MF START * t_o + (SEC)	MF **	UVS BITS	CHANNEL #/ STATUS TYPE	SAMPLE TIME * t_o + (SEC)
57.6	7	0- 8	27	0.7925
		9-16	28	0.7925
		17-24	29	0.8525
		25-32	30	0.8525
		33-40	31	0.9125
		41-48	32	0.9125
67.2	8	0- 8	33	0.9725
		9-16	34	0.9725
		17-24	35	1.0325
		25-32	36	1.0325
		33-40	37	1.0925
		41-48	38	1.0925
76.8	9	0- 8	39	1.1525
		9-16	40	1.1525
		17-24	41	1.2125
		25-32	42	1.2125
		33-40	43	1.2725
		41-48	44	1.2725
86.4	10	0- 8	45	1.3325
		9-16	46	1.3325
		17-24	47	1.3925
		25-32	48	1.3925
		33-40	49	1.4525
		41-48	50	1.4525
96.0	11	0-12	CRS STATUS	96.0150
		13-24	MAG STAT 1	96.0450
		25-36	MAG STAT 2	96.0475
		37-45	UVSROF	96.5000
		46-48	PWS STATUS	96.4925
105.6	12	0- 8	51	1.5125
		9-16	52	1.5125
		17-24	53	1.5725
		25-32	54	1.5725
		33-40	55	1.6325
		41-48	56	1.6325

TABLE A.6-1 (CONT'D)
CR5a UVS OUTPUT SCHEME

MF START * t_o + (SEC)	MF **	UVS BITS	CHANNEL #/ STATUS TYPE	SAMPLE TIME * t_o + (SEC)
115.2	13	0- 8	57	1.6925
		9-16	58	1.6925
		17-24	59	1.7525
		25-32	60	1.7525
		33-40	61	1.8125
		41-48	62	1.8125
124.8	14	0- 8	63	1.8725
		9-16	64	1.8725
		17-24	65	1.9325
		25-32	66	1.9325
		33-40	67	1.9925
		41-48	68	1.9925
134.4	15	0- 8	69	2.0525
		9-16	70	2.0525
		17-24	71	2.1125
		25-32	72	2.1125
		33-40	73	2.1725
		41-48	74	2.1725
144.0	16	0-12	CRS STATUS	144.0150
		13-24	MAG STAT 1	144.0450
		25-36	MAG STAT 2	144.0475
		37-45	UVSROF	144.5000
		46-48	PWS STATUS	144.4925
153.6	17	0- 8	75	2.2325
		9-16	76	2.2325
		17-24	77	2.2925
		25-32	78	2.2925
		33-40	79	2.3525
		41-48	80	2.3525
163.2	18	0- 8	81	2.4125
		9-16	82	2.4125
		17-24	83	2.4725
		25-32	84	2.4725
		33-40	85	2.5325
		41-48	86	2.5325

TABLE A.6-1 (CONT'D)
CR5a UVS OUTPUT SCHEME

MF START * t_o + (SEC)	MF **	UVS BITS	CHANNEL #/ STATUS TYPE	SAMPLE TIME * t_o + (SEC)
172.8	19	0- 8	87	2.5925
		9-16	88	2.5925
		17-24	89	2.6525
		25-32	90	2.6525
		33-40	91	2.7125
		41-48	92	2.7125
182.4	20	0- 8	93	2.7725
		9-16	94	2.7725
		17-24	95	2.8325
		25-32	96	2.8325
		33-40	97	2.8925
		41-48	98	2.8925
192.0	21	0-12	CRS STATUS	192.0150
		13-24	MAG STAT 1	192.0450
		25-36	MAG STAT 2	192.0475
		37-45	UVSROF	192.5000
		46-48	PWS STATUS	192.4925
201.6	22	0- 8	99	2.9525
		9-16	100	2.9525
		17-24	101	3.0125
		25-32	102	3.0125
		33-40	103	3.0725
		41-48	104	3.0725
211.2	23	0- 8	105	3.1325
		9-16	106	3.1325
		17-24	107	3.1925
		25-32	108	3.1925
		33-40	109	3.2525
		41-48	110	3.2525
220.8	24	0- 8	111	3.3125
		9-16	112	3.3125
		17-24	113	3.3725
		25-32	114	3.3725
		33-40	115	3.4325
		41-48	116	3.4325

TABLE A.6-1 (CONT'D)
CR5a UVS OUTPUT SCHEME

MF START * t_o + (SEC)	MF **	UVS BITS	CHANNEL #/ STATUS TYPE	SAMPLE TIME * t_o + (SEC)
230.4	25	0- 8	117	3.4925
		9-16	118	3.4925
		17-24	119	3.5525
		25-32	120	3.5525
		33-40	121	3.6125
		41-48	122	3.6125

Notes for Table A.6-1:

* t_o is the time of SCT60 MOD 5 = 0 frame start

** minor frame (of 25) with respect to SCT60 MOD 5 = 0

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Appendix B

Vim-5 Data Format Specifics

Content

The purpose of this appendix is to provide detailed format specifications for the several different VIM-5 data formats identified in Subsection 5.6. Figures B-1 through B-10 diagram bit/time allocations for CR5a, CR5T, EH24, EHRH, GS4b, GS&E in high-rate PWS minor frames, GS4c, GS08, GS09, and UV5a.

FIGURE B-1:
CR5a DATA FORMAT -- CRUISE SCIENCE UTILIZING ALL INSTRUMENT PROCESSING CHANGES

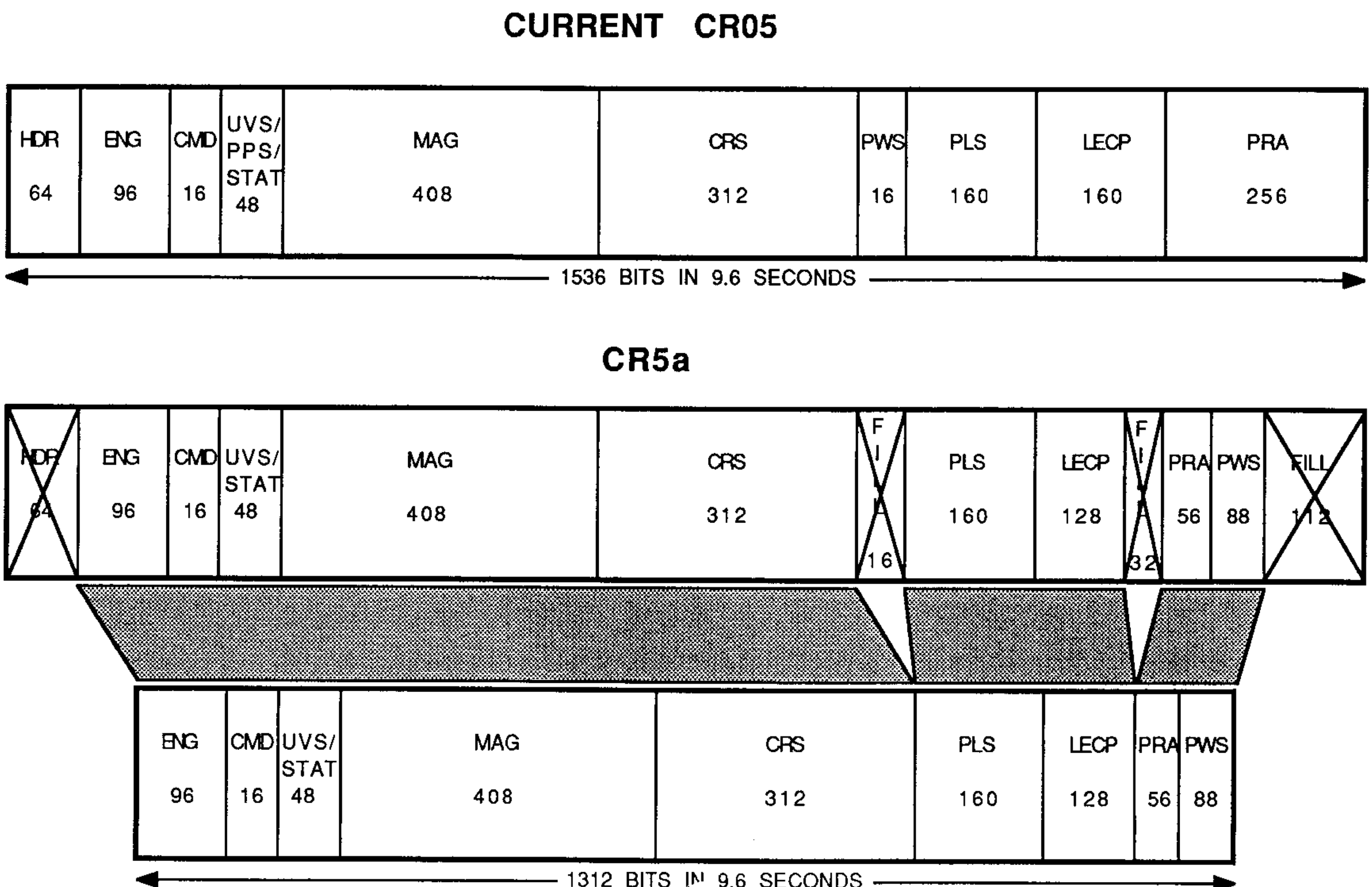

FIGURE B-2:
CR5T DATA FORMAT -- CR5a RS CODED AT 160 b/s

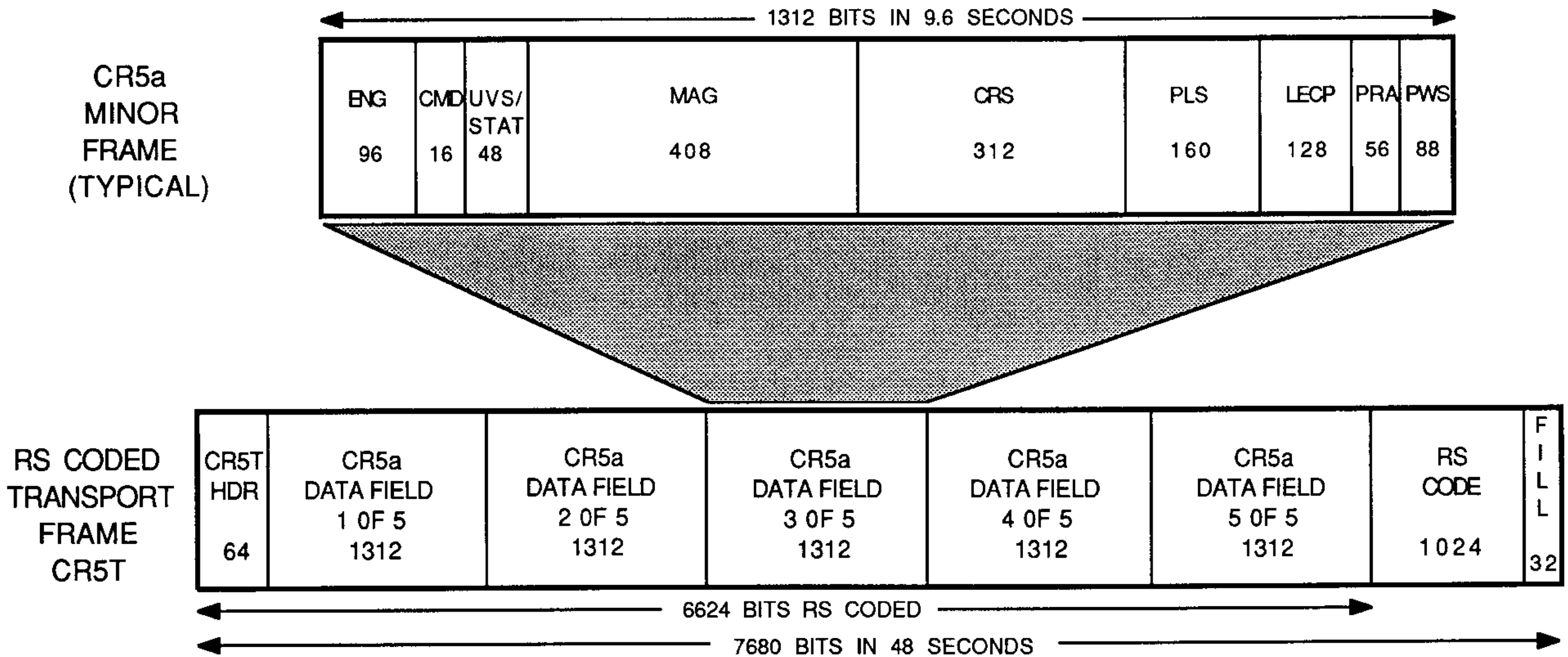

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FIGURE B-3:
EH24 DATA FORMAT -- RECORDED HIGH-RATE ENGINEERING PLAYED BACK RS CODED AT 2800 b/s (USING PB15)

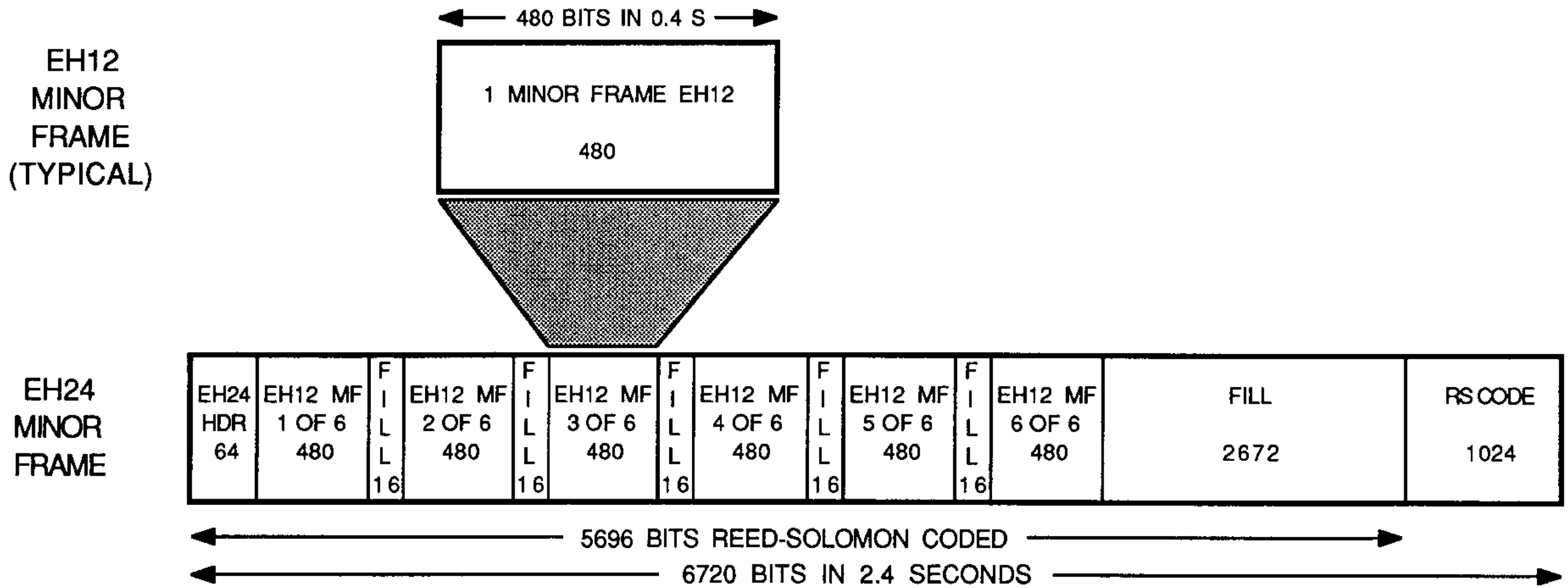

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FIGURE B-4:
EHRH DATA FORMAT -- RECORDED HIGH-RATE ENGINEERING PLAYED BACK AT 3600 b/s (USING PB12)

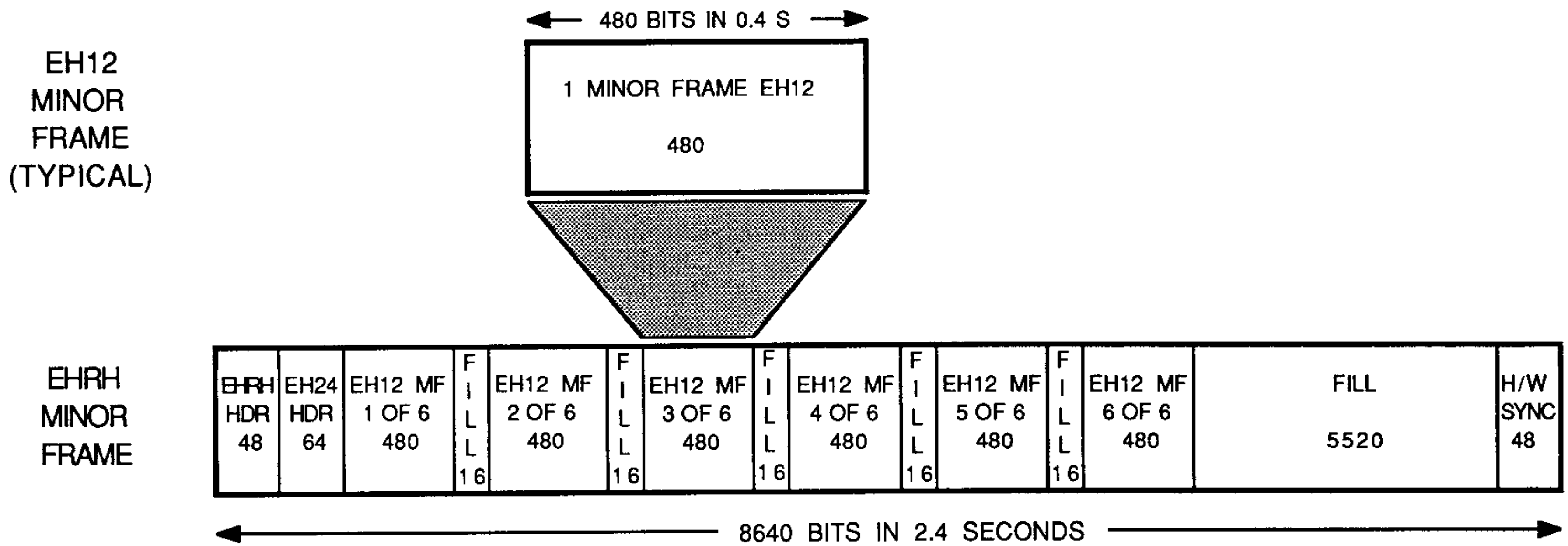

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FIGURE B-5:
GS4b DATA FORMAT -- EVERY FIFTH LINE OF HIGH-RATE PWS PLAYED BACK AT 1400 b/s (USING PB14)

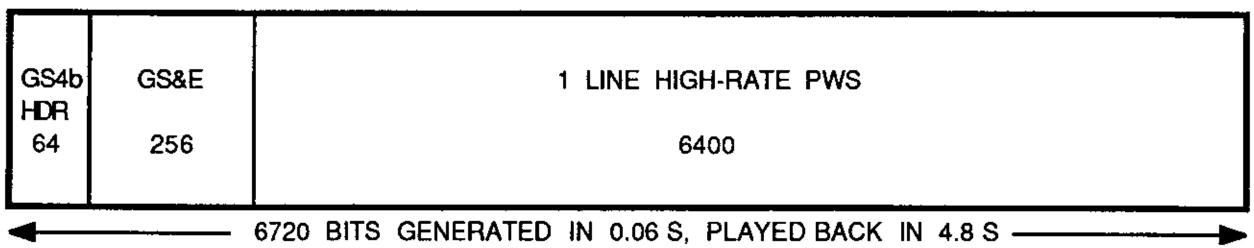

FIGURE B-6:
GS&E CONTENT IN HIGH-RATE PWS MINOR FRAMES

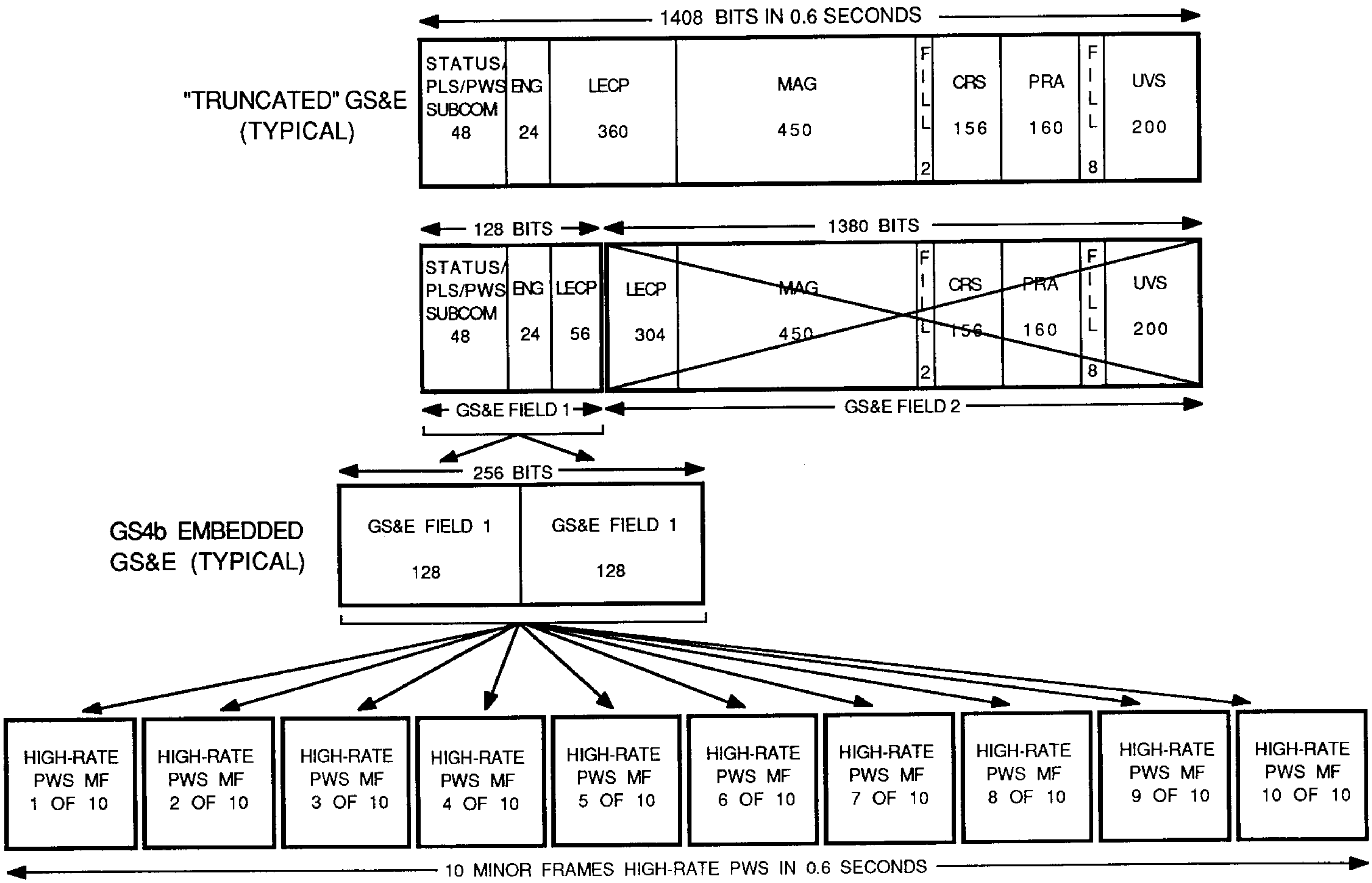

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FIGURE B-7:
GS4c DATA FORMAT -- ALL LINES OF HIGH-RATE PWS PLAYED BACK AT 7200 b/s (USING PB05)

GS4c HDR	GS4b HDR	GS&E	1 LINE HIGH-RATE PWS	FILL	H/W SYNC
48	64	256	6400	96	48

← 6912 BITS GENERATED IN 0.06 S, PLAYED BACK IN 0.96 S →

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FIGURE B-8:
GS08 DATA FORMAT -- TRUNCATED, RS CODED GS&E (2800 b/s)

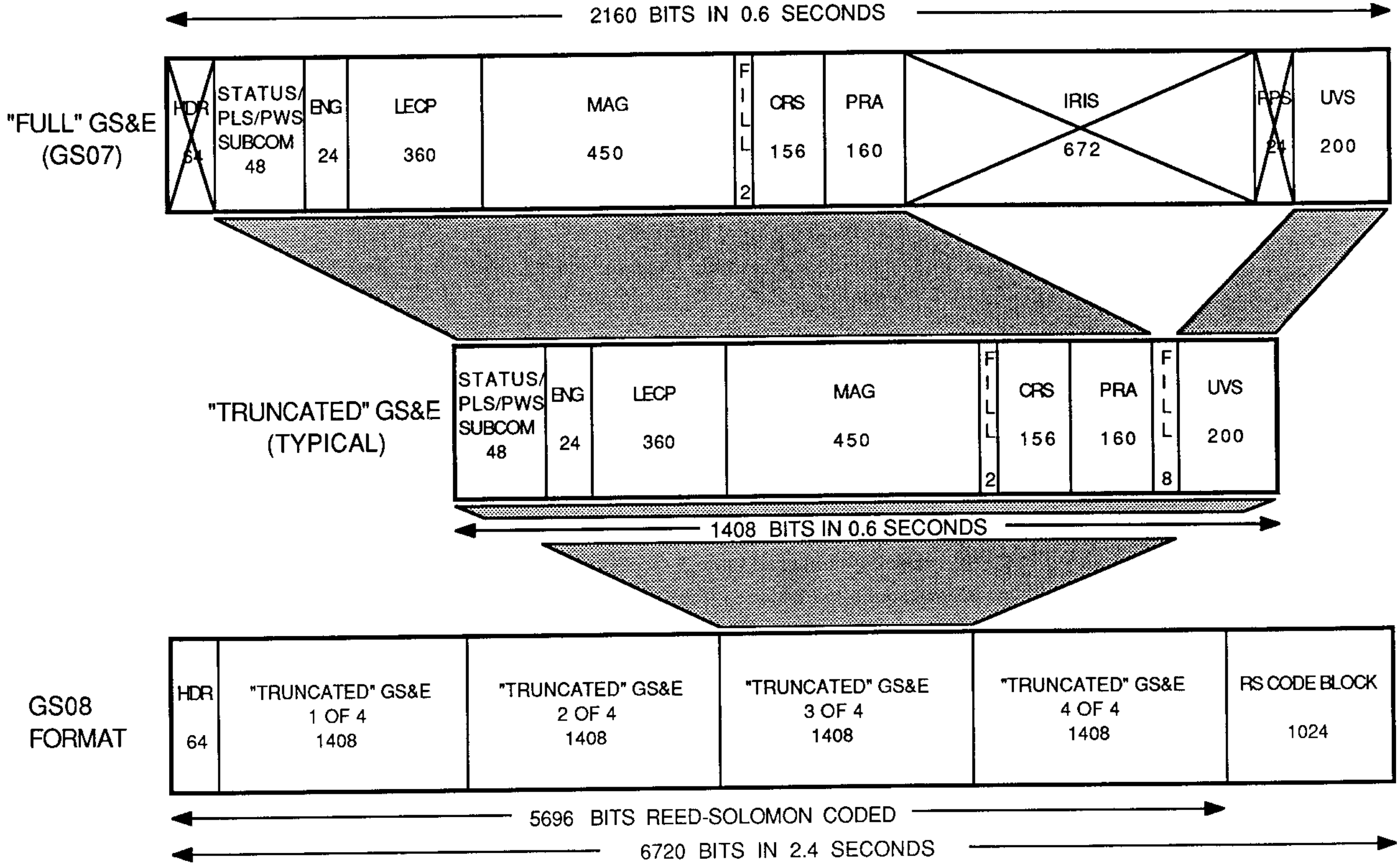

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FIGURE B-9:
GS09 FORMAT -- RECORDED GS&E PLAYED BACK AT 3600 b/s (USING PB12)

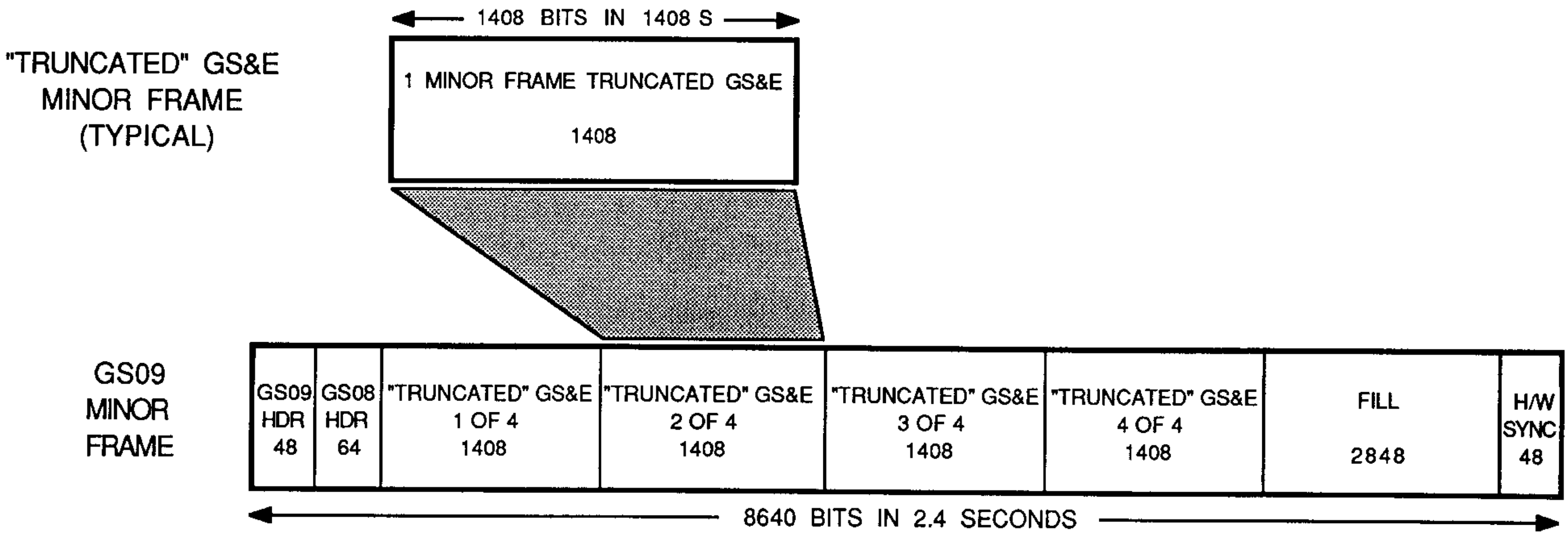

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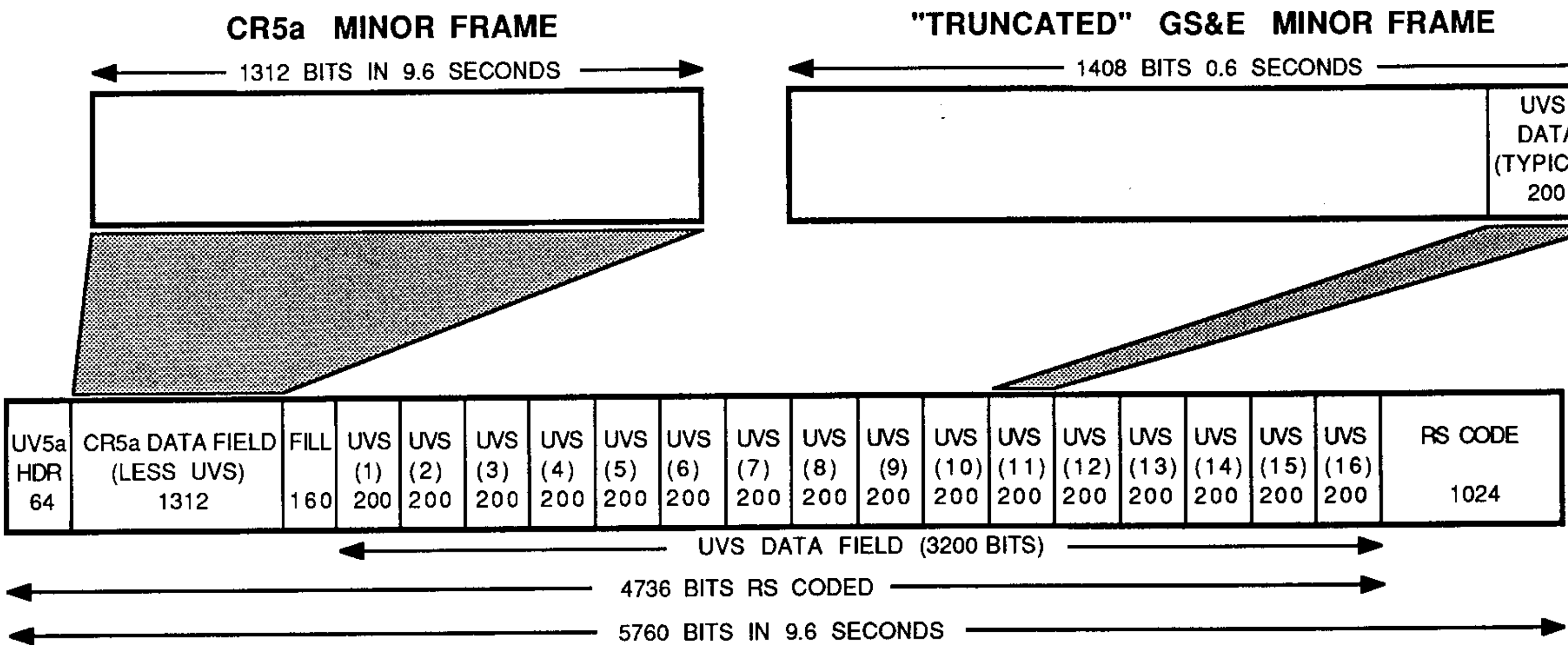
FIGURE B-10:
UV5a DATA FORMAT -- CR5a AND GS&E-RATE UVS, ALL RS CODED AT 600 b/s



Appendix C

VIM-5 Data Mode Specifics

Content

The purpose of this appendix is to provide detailed data mode specifications for the several different VIM-5 data modes identified in Subsection 5.7. Figures C-1 through C-7 diagram bit/time structures for EH12 (both normal and half-playback sync selected), recorded GS&E in GS08 data mode (both normal and half-playback sync selected), PB14, and PB15 (both to produce EH24 and GS08 formats).

FIGURE C-1:
RECORDED ENGINEERING IN EH12 DATA MODE, NORMAL PB SYNC SELECTED

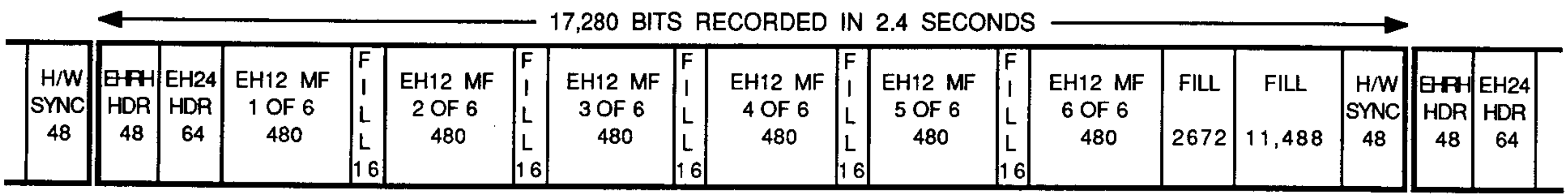


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FIGURE C-2:
RECORDED ENGINEERING IN EH12 DATA MODE, HALF PB SYNC SELECTED

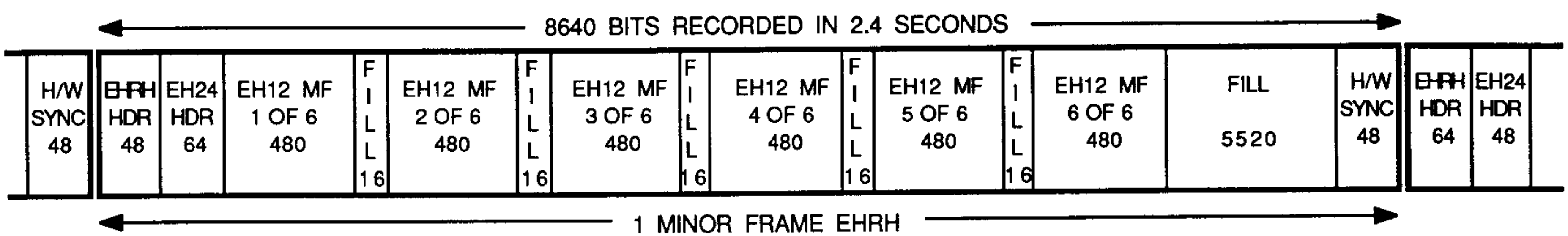

FIGURE C-3:
RECORDED GS&E IN GS08 DATA MODE, NORMAL PB SYNC SELECTED

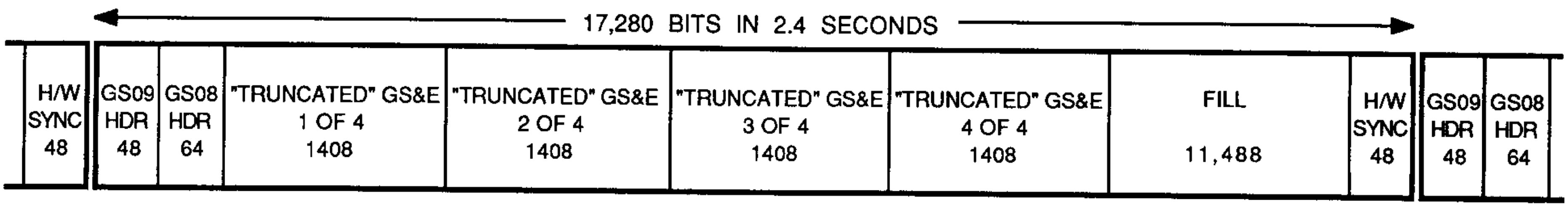

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FIGURE C-4:
RECORDED GS&E IN GS08 DATA MODE, HALF PB SYNC SELECTED

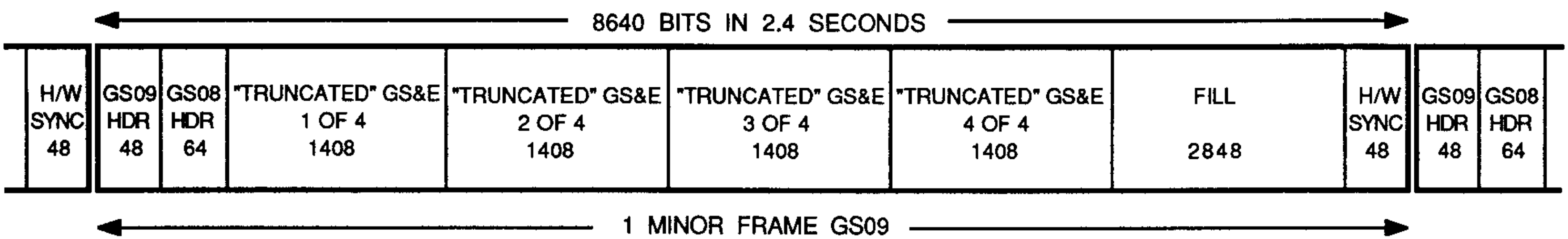

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FIGURE C-5:
PB14 PLAYBACK PROCESSING TO PRODUCE GS4b FORMAT AT 1.4 kb/s DOWNLINK

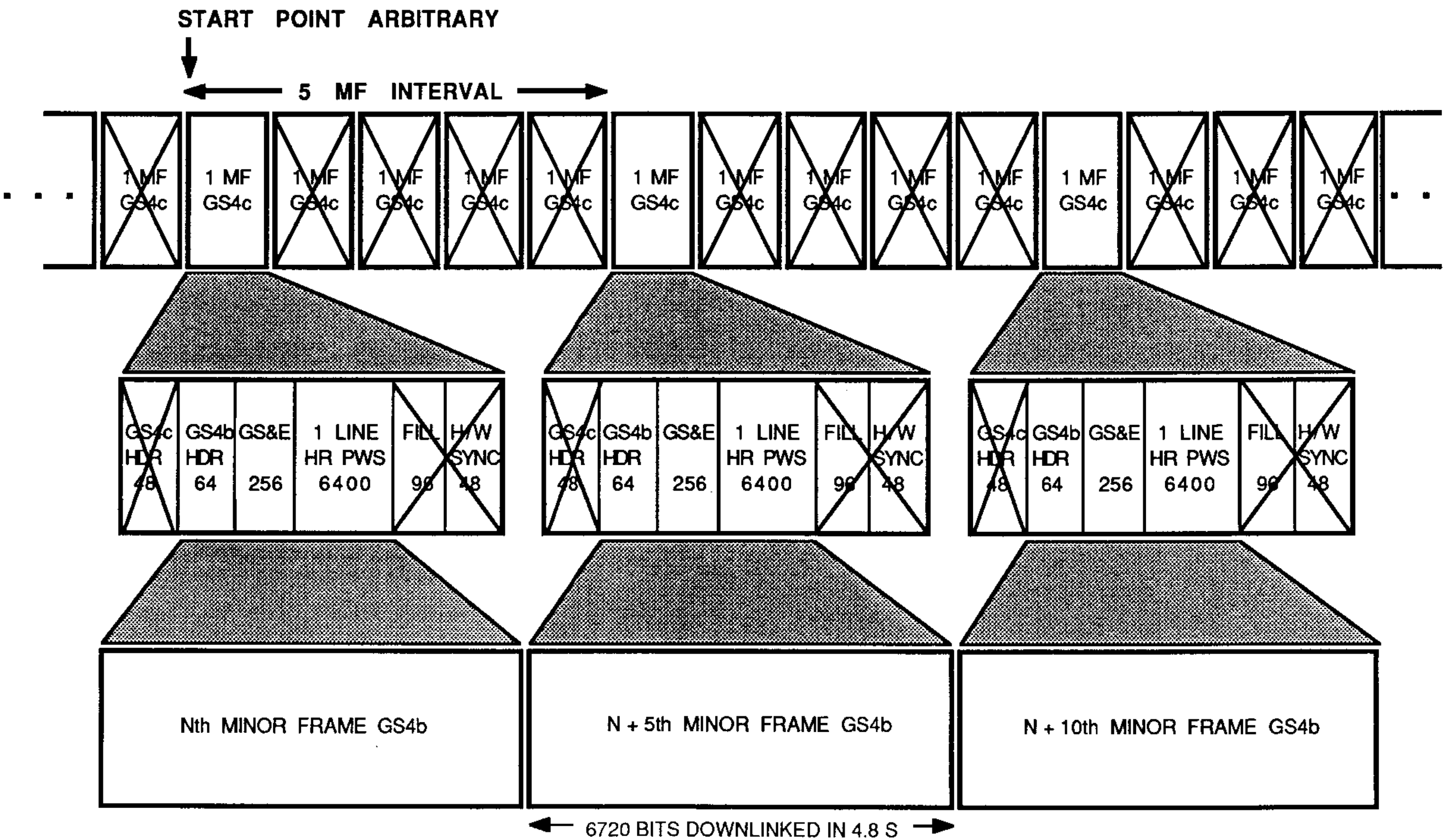

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FIGURE C-6:
PB15 PROCESSING TO PRODUCE EH24 FORMAT
AT 2.8 kb/s DOWNLINK

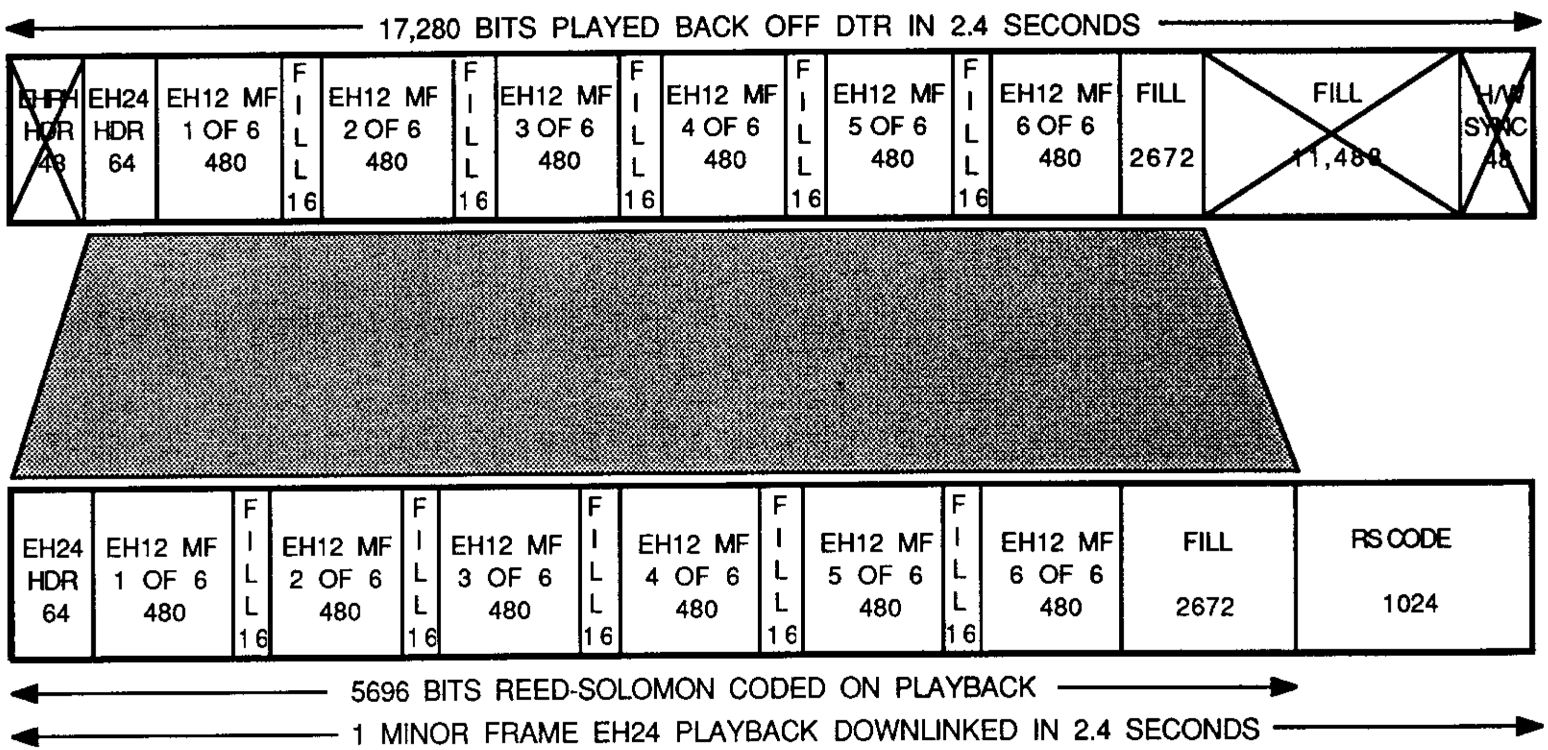

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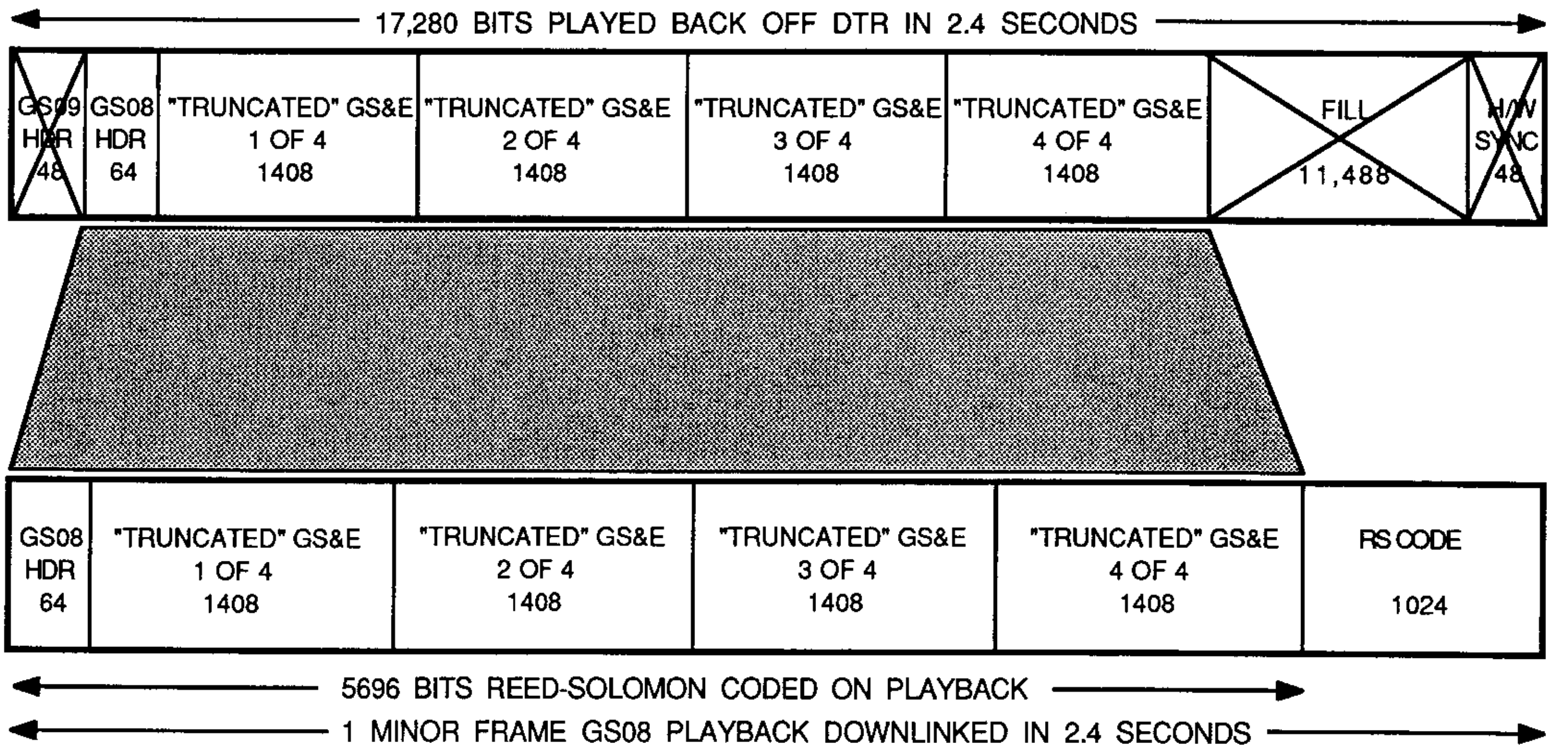
FIGURE C-7:
PB15 PROCESSING TO PRODUCE GS08 FORMAT AT 2.8 kb/s DOWNLINK



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