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NASA Goddard Space Flight Center
ADVANCED COMPOSITION EXPLORER (ACE)
PROJECT DATA MANAGEMENT PLAN (PDMP)

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1.0 Introduction

This document describes the Project Data Management Plan for the Advanced Composition Explorer (ACE) mission.

1.1 Purpose and Scope

This data management plan describes the generation and delivery of ACE data products, institutional responsibilities for data analysis, and the transfer of archival data products to the National Space Science Data Center. Covered in this plan are:

1. Description of the telemetry data and subsequent science products
2. Processing requirements and facilities
3. Policies for access and use of ACE data
4. Data product documentation

Not covered in this plan is the NOAA Real Time Solar Wind subsystem which may be attached to the ACE spacecraft.

1.2 Data Policy Statement

Operations of the ACE Observatory are simple. The instruments basically need to be turned on and left on. The MOC at GSFC will take care of spacecraft commanding such as data recorder usage, attitude maintenance, etc. The ACE Science Center will act as a consolidation center for commands to the instruments, and relay the requests to the MOC. On special occasions the ASC will receive and process real-time data for "feedback critical" instrument commanding, such as high voltage turn-on.

ACE data will include measurements of composition of various source materials and measurements of the environment of those source materials. These measurements are performed with a suite of nine instruments. Good science with these measurements requires cooperative, collaborative data analysis by the nine instrument teams. To facilitate that collaboration the ACE team has planned a data analysis effort which includes a centralized analysis facility (the ACE Science Center), standards for data formats and analysis, schedule goals for validation and distribution of the data, encouragement of guest investigators, and prompt delivery of validated data to public domain distribution sites.

The ACE Science Center will set standards for data formatting and processing. It will receive and process all spacecraft data to level one, deliver that data to each of the ACE Science Analysis Remote Sites (the instrument teams), generate a "browse parameter" file which will be easily accessible via network access, receive level two and three highly-processed data from the Remote Sites, archive all these data sets, and distribute them to the public domain via NASA facilities such as NSSDC and SPDS.

The "browse parameter" file will likely be the most popular and most quickly delivered data product. It will include summary or average parameters from each of the instruments intended for characterization of the interplanetary medium and selection of time periods of particular interest for further research. The validation period (after the initial debugging phase is completed) for these data will be quite short, perhaps as little as one week.

The ACE team has waived "proprietary rights" to the data. All appropriate data products will be properly validated and documented so that they are useful in the public domain, and delivered in accordance with a detailed schedule of goals which will allow detection of inadequate compliance. The validation period will be very short for some products, such as the browse parameters, necessitating caveats in their usage; and substantially longer for other products such as level three processed data, which are typically validated by something approaching a peer review process. Most products will have validation periods intermediate between these extremes.

The ACE team has recommended a guest investigator plan which includes theorist guest investigators, who would start immediately after launch and would not depend on access to detailed data; associate investigators who would work with a specific instrument team or teams at a host institution to help develop instrument capability and validation procedures starting immediately after launch; and experimental/phenomenological investigators who would start about two years after launch, working somewhat more independently on correlative studies with public domain data and some direct help from instrument teams.

In the unlikely event that the ACE Science Team is requested to assist an unassociated user to develop a parallel data analysis effort (for example, to help an unassociated user to generate his own higher level products from the public domain level 0 data), priority will be given to the normal Team validation process in the case of limited time and resources.

The schedule for data delivery will be used to determine whether the validation process is being abused to provide an unacceptable proprietary period. It will need frequent updating since there can be a great number of valid reasons for slow debugging/validation of data processing. (For example, we may not be able to turn on all of the instruments until we actually get near L1, more than 90 days after launch.) A conservative strawman schedule is provided here, based on an appropriately funded level of effort:

Browse parameter data should be validated in less than 30 days after receipt at the ASC, with a goal of 7 days (after the initial debugging phase).

Level 0 processed data should be validated within no more than 12 months.

Level 1 processed data should be validated within 18 months at the beginning of the mission, dropping to within 8 months by the end of the mission.

Many level 2/3 processed data sets should be available within 24 months of launch, with a goal of delivering most level 2/3 data sets within 12 months by end of mission.

1.3 PDMP Development, Maintenance, and Management Responsibility

This document has been developed and will be maintained by the assistant to the Project Scientist:

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1.4 Change Control

This document will be under configuration control by the ACE project office of the Explorers Project, NASA/GSFC Code 410.

1.5 Relevant Documents

This document shall be consistent with the following documents

Document Title	Document Number	Latest Version
ACE Science Requirements Document	GSFC-410-ACE-002	11 Sep 1992
ACE Mission Requirements Document	GSFC-410-ACE-003	Feb 1992
ACE Project Plan	Draft	Sep 1993
Guidelines for Development of a Project Data Management Plan		Dec 1992

2.0 Project Overview

Origins of the ACE mission concept go back to the 1970s and the time of NASA AOs 6 and 7. As the result of a competitive solicitation, a thorough Phase A mission study was carried out between June 1988 and June 1989 under contract NAS5-30340. RFP5-63446/505 was issued in 1990, which led to a Phase B study under contract NAS5-31459 which began in April 1991. This definition study is ongoing, and is expected to be completed by the end of 1993. These studies were led by Caltech and were supported by the ACE Science Team and by the spacecraft development group at the Johns Hopkins University / Applied Physics Laboratory (JHU/APL). Phase C/D is expected to begin by the end of 1993, on schedule for a launch of the ACE spacecraft in August 1997.

2.1 Project Objectives

The prime objective of ACE is to determine and compare the elemental and isotopic composition of several distinct samples of matter, including the solar wind (and thus the corona), the interplanetary medium, the local interstellar medium, and galactic matter. This objective is approached by performing comprehensive and coordinated determinations of the elemental and isotopic composition of energetic nuclei accelerated on the Sun, in interplanetary space, and from galactic sources. These observations will span five decades in energy, from solar wind to galactic cosmic ray energies, and would cover the element range from hydrogen to zirconium ($Z = 1$ to 40). The comparison of these samples of matter would be used to study the origin and subsequent evolution of both solar system and galactic material by isolating the effects of fundamental processes that include nucleosynthesis, charged and neutral-particle separation, bulk plasma acceleration, and the acceleration and transport of suprathermal and high energy particles.

2.2 Science Objectives

The specific scientific objectives of the ACE mission are:

1) The Elemental and Isotopic Composition of Matter

A major objective is the accurate and comprehensive determination of the elemental and isotopic composition of the various samples of "source material" from which nuclei are accelerated. Thus, using ACE measurements we will:

- Generate a set of solar *isotopic* abundances based on *direct* sampling of solar material.

- Determine the coronal *elemental and isotopic* composition with greatly improved accuracy.

- Establish the pattern of isotopic differences between galactic cosmic ray and solar system matter.

- Measure the elemental and isotopic abundances of interstellar and interplanetary "pick-up ions".

- Determine the isotopic composition of the "anomalous cosmic ray component", thought to represent a sample of the local interstellar medium.

2) Origin of the Elements and Subsequent Evolutionary Processing

Isotopic "anomalies" in meteorites indicate that the solar system was not homogeneous when formed, while other data suggest that the solar composition continues to evolve. Similarly, the galaxy is neither uniform in space nor constant in time due to continuous stellar nucleosynthesis. Using measurements from ACE we will:

- Search for additional differences between the isotopic composition of solar and meteoritic material.

- Determine the contributions of solar-wind and solar flare nuclei to lunar and meteoritic material, and to planetary atmospheres and magnetospheres.

- Determine the dominant nucleosynthetic processes that contribute to cosmic ray source material.

- Determine whether cosmic rays are a sample of freshly synthesized material (e.g., from supernovae), or of the contemporary interstellar medium.

- Search for isotopic patterns in solar and galactic material as a test of galactic evolution models.

3) Formation of the Solar Corona and Acceleration of the Solar Wind

Solar energetic particle, solar wind, and spectroscopic observations show that the *elemental* composition of the corona is differentiated from that of the photosphere, although the processes by which this occurs, and by which the solar wind is subsequently accelerated, are poorly understood. The detailed composition and charge-state data provided by ACE will allow us to:

- Isolate the dominant coronal formation processes by comparing a broad range of coronal and photospheric abundances.
- Study plasma conditions at the source of the solar wind and the solar energetic particles by measuring and comparing the charge states of these two populations.
- Study solar wind acceleration processes and any charge or mass-dependent fractionation in various types of solar wind flows.

4) Particle Acceleration and Transport in Nature

Particle acceleration is ubiquitous in nature and is one of the fundamental problems of space plasma astrophysics. The unique data set obtained by ACE measurements will enable us to:

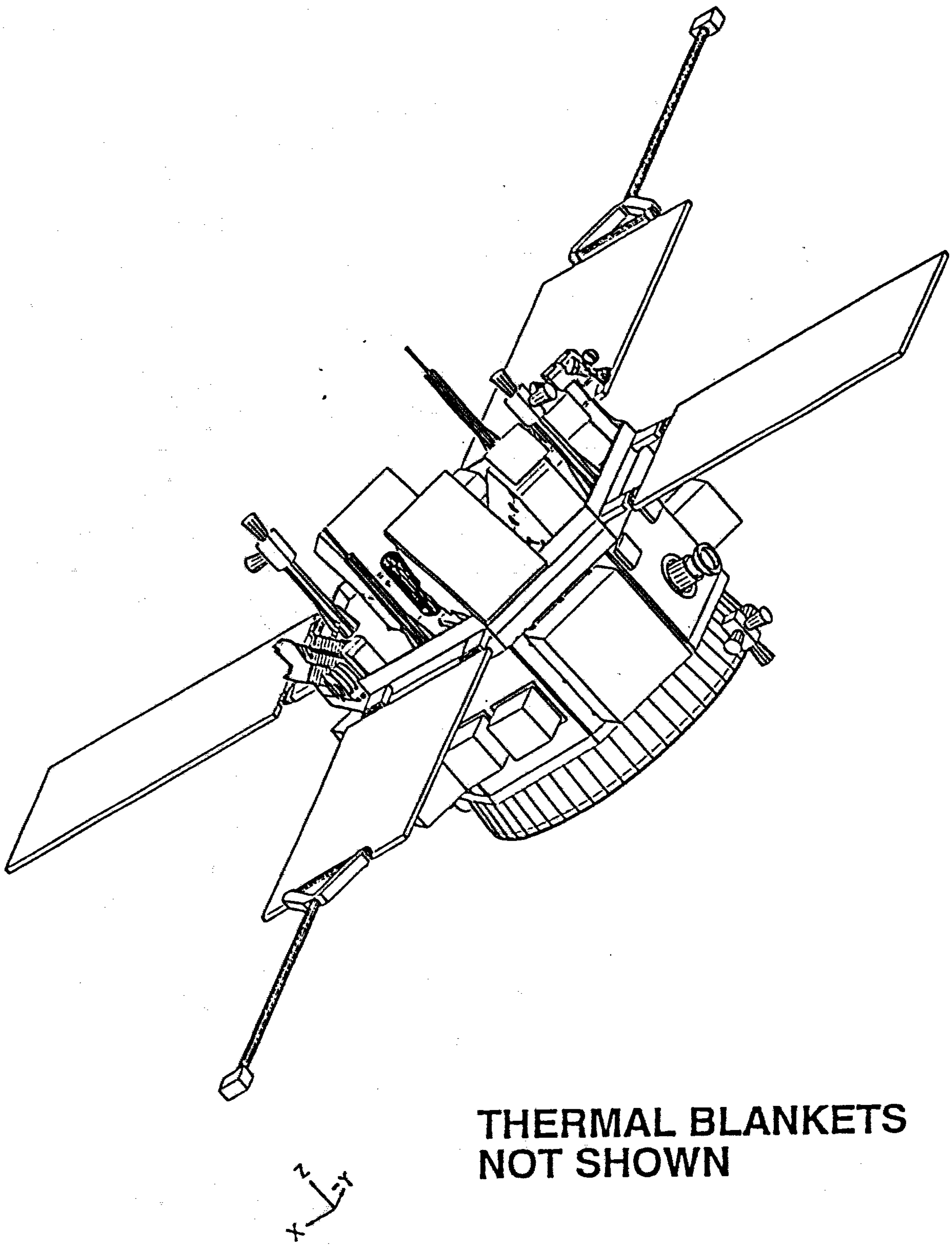
- Make direct measurements of charge and/or mass-dependent fractionation during solar flares and/or interplanetary acceleration.
- Constrain solar flare and interplanetary acceleration models with charge, mass, and spectral data spanning up to five decades in energy.
- Test theoretical models for ^{3}He-rich flares and solar gamma-ray events.
- Measure cosmic ray acceleration and propagation time scales using radioactive clocks.
- Test whether the "anomalous" cosmic rays are a singly-ionized sample of the neutral interstellar gas by directly measuring their charge state.

2.3 Spacecraft Description

The ACE spacecraft is based on designs that evolved from the AMPTE/CCE program. The AMPTE/CCE spacecraft was designed as a Sun-pointing mounting bus for scientific instruments, built by APL/JHU, and successfully launched in August 1984. The ACE spacecraft body consists of a two deck, irregular octagon, 68 inches (1.73 m) across flat-to-flat (Figure 2.3-1). The decks are spaced 30 inches (0.76 m) apart, and the total height of the spacecraft is about 72 inches (1.83 m) (Figure 2.3-2). Most of the instruments are mounted to the top deck, and the four 32" by 56" (0.81 m by 1.42 m) solar panel arrays are also attached to the front deck (Figure 2.3-3). The two magnetometers are mounted on the ends of deployment booms attached to opposite solar panels. The spacecraft subsystem packages and the CRIS and SWIMS instruments are attached to the side panels, as are radiators for thermal control of the spacecraft. The rear deck supports the RF subsystem and antennas, and the inner deck region contains the propulsion system fuel tanks.

The spacecraft is to be built by the Applied Physics Laboratory of the Johns Hopkins University. The Preliminary ACE Spacecraft System Functional Block Diagram is shown in Figure 2.3-4. Due to cost constraints, many of the spacecraft subsystems are single string.

Figure 2.3-1 ACE Spacecraft Orbital Configuration



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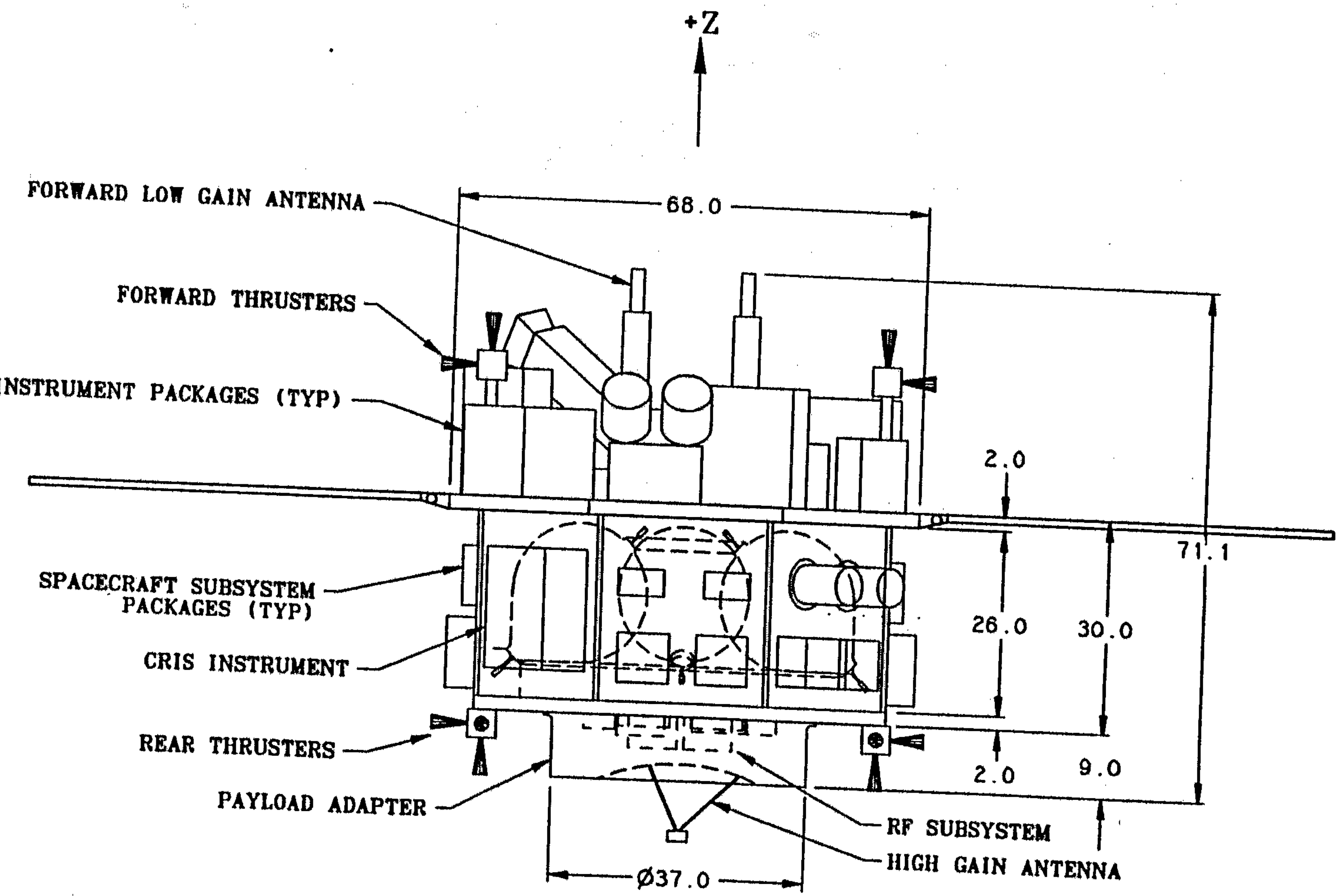
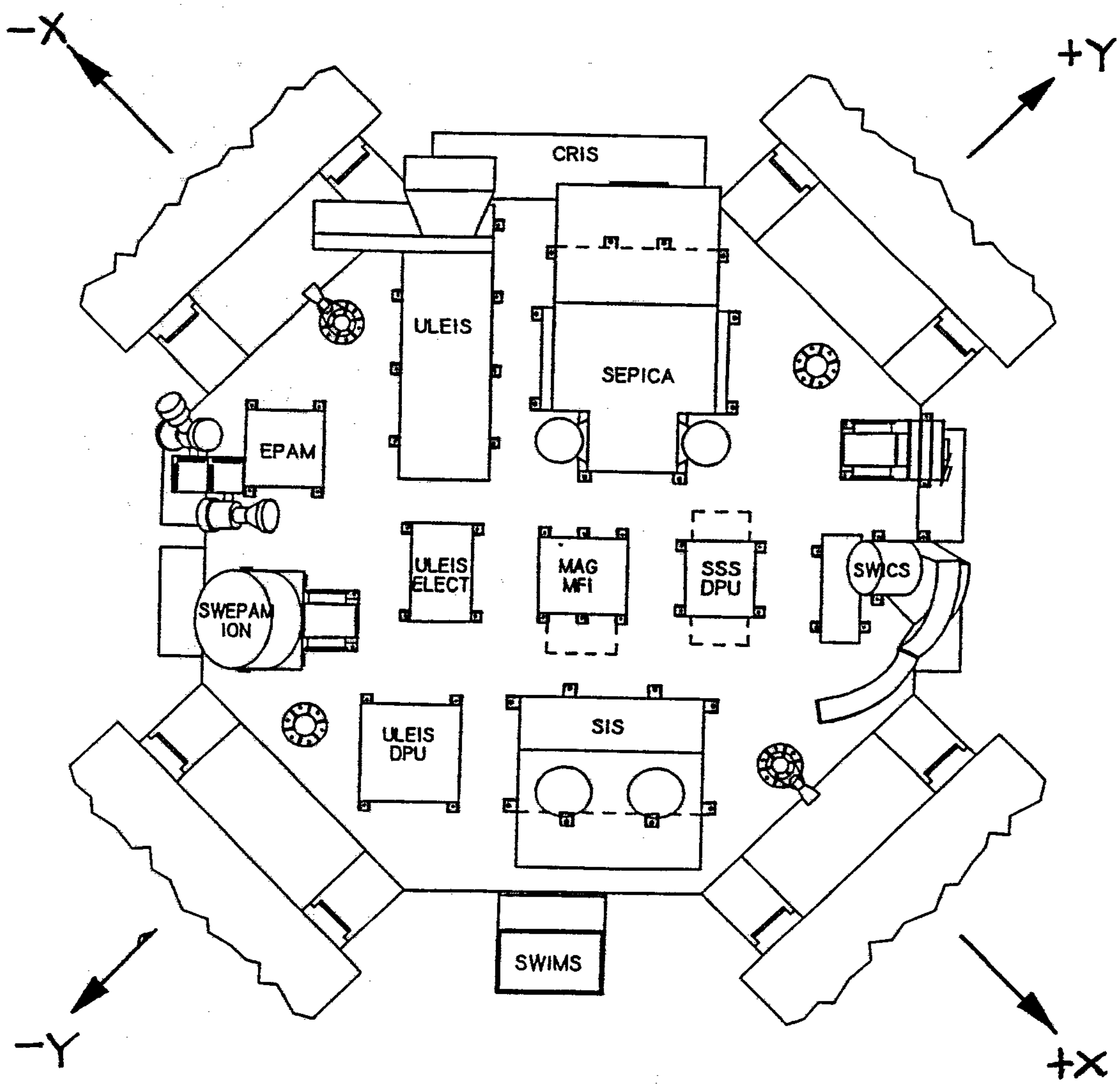


Figure 2.3-2 ACE Observatory Layout, Side View

Figure 2.3-3 ACE Observatory Layout, Top View



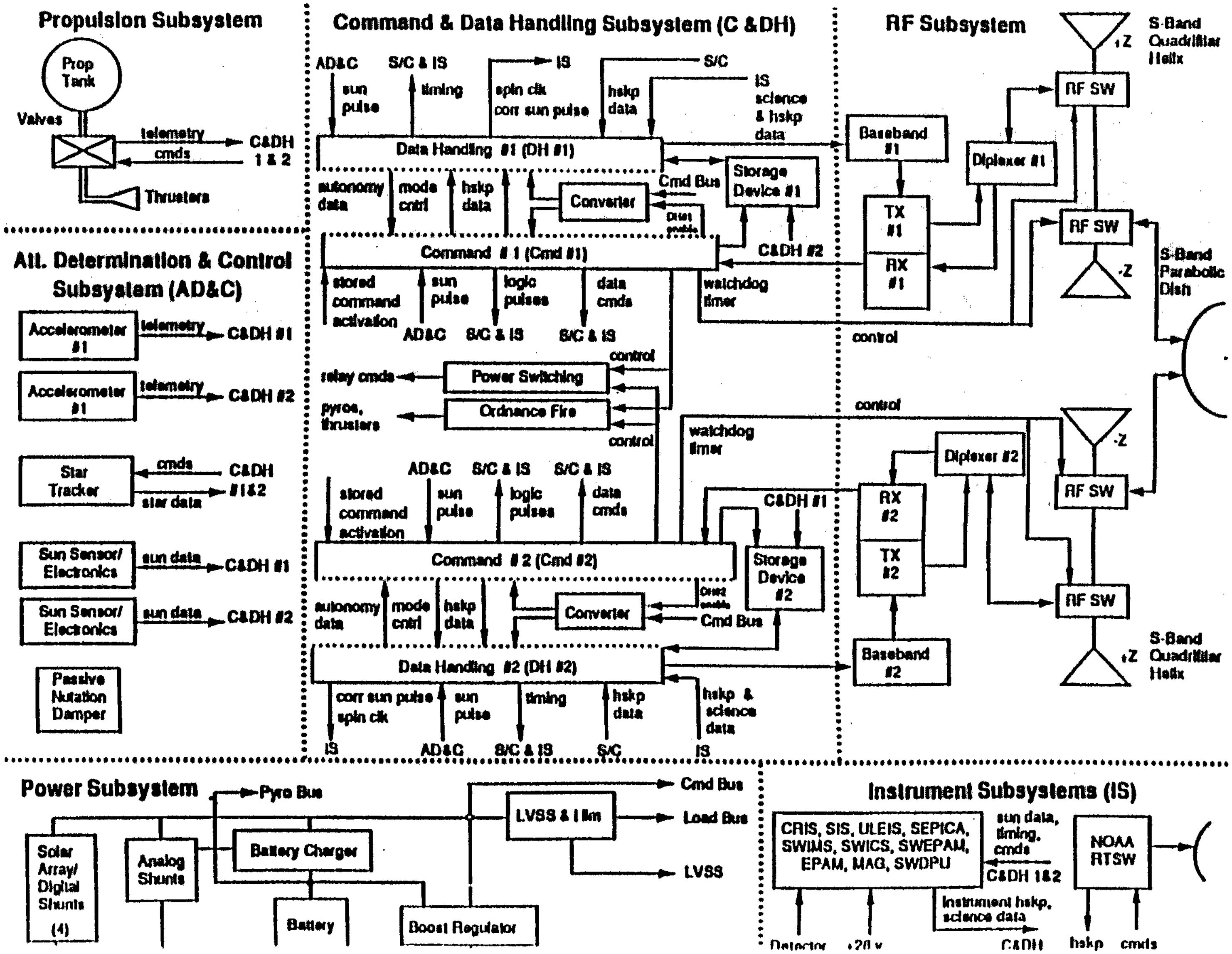


Figure 2.3-4 Preliminary ACE Spacecraft System Functional Block Diagram

2.4 Mission Summary

The orbit chosen for the ACE mission is a modified halo about the Earth-Sun interior libration point, L1. Located at L1, about 1 million miles (1.5 million km) from Earth, the ACE spacecraft will be well outside the Earth's magnetosphere, allowing a comprehensive study of charged particles in the interplanetary medium. The orbit baselined for ACE is a broken ellipse (Lissajous) with a major axis of about 0.2 million miles (0.3 million km) in the direction of the Earth's orbit, and a minor axis of about 0.1 million miles (0.15 million km) perpendicular to the ecliptic plane. The spin axis of the spacecraft is kept close (< 20°) to the Earth-Sun line. Orbit corrections will be required every few months, and spin axis torquing maneuvers will occur every few days.

Table 2.4-1 Mission Summary Parameters

Project Name:	Advanced Composition Explorer (ACE)
Orbit Description:	Modified Lissajous halo orbit about the Earth-Sun interior libration point, L1.
Launch Date:	August 21, 1997
Launch Vehicle:	Delta II 7920
Nominal Mission Duration:	2 Years
Potential Mission Life:	5+ Years
Spacecraft Mass:	1241 lb (563 kg) (without fuel)
Spacecraft Power	4 Solar Arrays: 500 W at End-of-Life
Attitude Control:	Spin Stabilized
Propulsion type/capacity:	hydrazine thrusters/417 lb (189 kg)

Table 2.4-2 Mission data acquisition parameters

On-Board Data Storage Capacity:	1.3 Gbit
Continuous Data Acquisition Rate:	6944 bits/s
On-Board storage saturation:	52 hours
Attitude determination accuracy:	0.5° post facto

3.0 Instrument Overview

Generally, each of the nine instruments on ACE are completely autonomous units which do not interface to or in any way effect other instruments, only the spacecraft. The exception is that there is a single Data Processing Unit which services the three instruments SWICS, SWIMS, and SEPICA. The data from each of the instruments generally falls into three categories. "Event Data" contains directly measured quantities for individual events or incident particles. "Rate Data" summarize the number of incident events satisfying certain criteria in a given time interval. "Housekeeping Data" monitor instrument health and safety including temperatures, pressures, what's stored in on-board memory, etc..

3.1 CRIS

3.1.1 Instrument Description

The Cosmic Ray Isotope Spectrometer (CRIS) is designed to provide statistically significant measurements of all stable and long-lived isotopes of galactic cosmic ray nuclei from He to Zn (Z= 2 to 30) over the general energy range from about 100 to 600 MeV/nucleon. It will also provide limited measurements of hydrogen isotopes at low energies, and the first exploratory studies of the isotopes of ultra-heavy nuclei from Ga (Z = 31) through Zr (Z = 40).

The CRIS detector system consists of a Scintillating Optical Fiber Telescope (SOFT) hodoscope and four identical stacks of large-area silicon solid-state detectors. The SOFT detector utilizes scintillating fibers to provide two distinct functions for CRIS. The fibers are used as: 1) a hodoscope consisting of three xy fiber planes (H1, H2, and H3) which determine the trajectory of cosmic ray nuclei entering the CRIS experiment and; 2) a "trigger counter" (T) which provides two signals, one from the x-trigger fibers and one from the y-trigger fibers, for the CRIS coincidence logic.

Each stack includes eight 4" diameter lithium-drifted (LiD) silicon solid-state detectors (SSD), designated E1 to E8. Detectors E1, E2, and E9 are 3 mm thick, while detectors E3 through E8 are 6 mm thick and consist of pairs of 3 mm devices. All detectors except E9 are pulse-height analyzed. The central active area of each of detectors E2 through E8 is surrounded by an integral guard ring used in anticoincidence to eliminate particles which enter or exit the stack through the side. The final detector in the stack (designated E9) identifies particles which penetrate the entire telescope.

3.1.2 Capabilities and Requirements

Table 3.1.2-1 CRIS summary parameters

Measurements:	Mass, Charge, and Energy of individual galactic cosmic ray nuclei with energies between about 100 and 600 MeV/nucleon and charges between 1 and 30
Detectors:	One Scintillating Optical Fiber Trajectory (SOFT) hodoscope and four identical stacks of solid state detectors
Sensitive area, SOFT:	26 cm x 26 cm
Sensitive area, SSDs:	324 cm^2 total
Geometry Factor, Total:	~ 200 cm^2 sr (energy dependent)
Field of View:	45° half-width
Energy Range:	100 - 600 MeV/nucleon
Mass Resolution:	≤ 0.25 amu
Instrument Weight:	58.2 lb (26.4 kg)
Dimensions:	20.375" x 17.25" x 9"
Average Power:	17.8 Watts
Data Rate:	464 bits/s

3.1.3 Data Acquisition

Rate and housekeeping data account for only a small portion of the CRIS telemetry (~16 bits/s). Most of the telemetry is given over to event data. Each event requires about 224 bits, and during large solar events, the CRIS telemetry allocation is insufficient to transmit data from each triggered event. A priority system ensures that all of the most interesting events are selected for readout. Stopping heavy particles ($Z \geq 3$) are given the highest priority, followed by penetrating heavies, stopping hydrogen and helium, and then penetrating hydrogen and helium. With this scheme, it is possible to read out all of the $Z \geq 3$ events that are suitable for isotope analysis under all interplanetary conditions.

3.2 SIS

3.2.1 Instrument Description

The Solar Isotope Spectrometer (SIS) experiment will provide isotopically resolved measurements of the elements from Li to Zn ($3 \leq Z \leq 30$) over the energy range 10 - 100 MeV/nucleon. This energy range is typically dominated by solar energetic particles, anomalous cosmic rays, and interplanetary particles. In addition, SIS will extend measurements of galactic cosmic ray nuclei to lower energies than is possible with CRIS.

The SIS detector system consists of two identical "telescopes" composed of large-area ion-implanted and lithium-drifted silicon solid-state detectors. Each telescope consists of a hodoscope system made up of a pair of two-dimensional position-sensitive detectors (M1 and M2), followed by an "energy-loss stack" containing eight devices of graduated thicknesses (T1 to T8). The final detector in each stack (T8) identifies particles which penetrate the entire telescope.

The position-sensitive detectors (PSDs) give a precise measurement of the particle trajectories. Each detector (M1 or M2) is a 60 micron thick silicon ion-implanted device with active areas of 32 cm^2. The electrodes on the surfaces of these detectors are sets of closely spaced, parallel strips, 0.975 mm in pitch. There are 64 parallel "X" strips on one side of a detector, and orthogonal to these, 64 "Y" strips on the reverse side. Each of these strips is separately pulse-height analyzed to allow identification of multiple-track events. In addition, these devices measure energy loss.

Detectors T1 through T8 consist of combinations of 4" diameter, 1 mm thick ion-implanted silicon solid-state devices T1 through T5, and T8 are composed of single 1mm thick detectors, while T6 consists of three 1 mm detectors, and T7 consists of six 1 mm detectors. The signals from all detectors except T8 are pulse height analyzed to provide accurate energy determination.

3.2.2 Capabilities and Requirements

Table 3.2.2-1 SIS summary parameters

Measurements:	Mass, Charge, and Energy of individual cosmic ray nuclei with energies between about 10 and 100 MeV/nucleon and charges between 1 and 30
Detectors:	Two identical "telescopes" composed of ion-implanted and lithium-drifted silicon solid-state detectors
Sensitive area	32 cm^2 each telescope, 64 cm^2 total
Geometry Factor, Total:	~ 25 cm^2 sr (energy dependent)
Field of View:	55° half-width (at the lowest energies)
Energy Range:	10 - 100 MeV/nucleon
Mass Resolution:	≤ 0.25 amu
Instrument Weight:	34.8 lb (15.8 kg)
Dimensions:	16.5" x 11.812" x 11.812"
Average Power:	16.8 Watts
Data Rate:	2000 bits/s

3.2.3 Data Acquisition

SIS data will be similar to those described for CRIS in section 3.1.3 including the three general categories of event, rate, and housekeeping data. In SIS, however, the amount of information that is produced by an individual incident nucleus varies considerably from event to event, with the majority of events due to flare nuclei requiring a small fraction of the maximum possible number of bits. Therefore, SIS will use a "variable-length event format" to optimize the use of the assigned bit rate.

The average event length will be about 200 bits, and the assigned telemetry rate of 2 kbits/s will accommodate 10 events per second. During large solar events the rate of $Z \geq 6$ nuclei in SIS will sometimes exceed the 10 events/s that can be transmitted, so SIS will have a priority system for events. The order of priority is assigned by the SIS microprocessor based on the pulse heights and other event characteristics, taking into account the estimated charge, "range", and event quality. Generally, heavier nuclei that penetrate deeper into the stack are assigned highest priority.

3.3 ULEIS

3.3.1 Instrument Description

The Ultra Low Energy Isotope Spectrometer (ULEIS) measures ion fluxes over the charge range from He through Ni from about 20 keV/nucleon to 10 MeV/nucleon. Exploratory measurements of ultra-heavy species (mass range above Ni) will also be performed in a more limited energy range near 0.5 MeV/nucleon.

The ULEIS sensor telescope is a time-of-flight mass spectrometer which identifies ions by measuring the time-of-flight, t, and residual kinetic energy, E, of particles which enter the telescope cone and stop in one of the array of silicon solid-state detectors. The time-of-flight is determined by Start and Stop pulses from microchannel plate (MCP) assemblies which detect secondary electrons which are emitted from the entrance foil and other foils within the telescope when the ion passes through them. To prevent electronic pile-up during intense flux periods, a mechanical shutter ('iris') slides partially closed under on-board control depending on the start MCP singles counting rate. The iris can decrease the geometrical factor by a range of ~ 100:1 thereby making it possible for ULEIS to operate in the most intense events.

3.3.2 Capabilities and Requirements

Table 3.3.2-1 ULEIS summary parameters

Measurements:	Mass and Energy of individual cosmic ray nuclei with energies between about 20 keV/nucleon and 10 MeV/nucleon and charges between 1 and 28
Detectors:	One telescope with three time-of-flight Start/Stop MCPs with position-sensing anodes and an array of silicon solid-state detectors for measurement of residual energy.
Sensitive area	80 cm^2
Geometry Factor, Total:	~ 1 cm^2 sr
Field of View:	24° by 20°
Energy Range:	20 keV/nucleon - 10 MeV/nucleon
Mass Resolution:	≤ 0.30 amu

Instrument Weight:	37.5 lb (17 kg)	
Dimensions:	Telescope Box	30" x 6" x 8" (76.5 x 15 x 20 cm)
	Analog Elect. Box	9" x 6" x 5.5" (23 x 15 x 14 cm)
	Digital Elect. Box	6" x 6" x 6" (15 x 15 x 15 cm)
Average Power:	17.1 Watts	
Data Rate:	1000 bits/s	

3.3.3 Data Acquisition

The ULEIS data rate of 1000 bits/s is allocated among several different data types. Full analyses of individual charged particles will require 128 bits/event, and ULEIS will transmit 6 events per second for a total of 768 bits/s. Two types of rate data are included: sectored singles rates for each detector, 8 sectors, 18 rates, 12 bits/rate (compressed); and sectored counts of 5 particle species in 20 energy ranges, 8 sectors, 12 bits/s (compressed). These rate data are read out every 60 seconds and account for 189 bits/s. Housekeeping, status (read back of volatile tables and command status), and miscellaneous data take up the other 43 bits/s.

3.4 SEPICA

3.4.1 Instrument Description

SEPICA is designed to measure the ionic charge state, Q, the kinetic energy, E, and the nuclear charge, Z, of energetic ions above 0.2 MeV/nucleon. This includes ions accelerated in solar flares, energetic storm particles, co-rotating interaction region events, and anomalous cosmic rays.

The SEPICA instrument combines the determination of the electrostatic deflection of incoming ions in a collimator-analyzer with a dE/dx - E telescope. Energetic particles entering the multi-slit collimator, which focuses the particles on a line in the detector plane, will be electrostatically deflected between a set of electrode plates which are supplied with a high voltage up to 30 kV. The deflection, which is inversely proportional to energy per charge, is determined in a multi-wire thin-window proportional counter. The proportional counter is also used to measure the energy loss, dE/dx, of the particle. The residual energy of the particle is directly determined in a solid-state detector behind the proportional counter. There is also an anti-coincidence CsI scintillator at the back of the solid-state detector to suppress background signals from penetrating high energy particles.

SEPICA will be composed of three pairs of telescopes, with each pair sharing a high-voltage deflection electrode. Two of the pairs will have collimators that are optimized for a large geometrical factor to allow high sensitivity to small SEP events. The third pair will have a fine collimator which will improve the charge state resolution.

3.4.2 Capabilities and Requirements

Table 3.4.2-1 SEPICA summary parameters

Measurements:	Ionic charge state, nuclear charge, and energy of individual energetic particles with energies between about 0.2 and 2.0 MeV/nucleon and charges between 2 and 26	
Detectors:	Three pairs of telescopes with collimators, electrostatic deflection electrodes, proportional counters, and solid-state detectors.	
Geometry Factor:	0.36 cm^2 low resolution total (four sections)	
	0.06 cm^2 high resolution total (two sections)	
Field of View:	six parallel 24° by 50°	
Energy Range:	0.2 - 2.0 MeV/nucleon	
Charge Resolution:	~ 10 % high resolution sections	
Instrument Weight:	43 lb (19.5 kg)	
Dimensions:	Sensor Box	16" x 16" x 12" (40 x 40 x 30 cm)
	Electronics Box	8" x 8" x 6" (20 x 20 x 15 cm)
Average Power:	6.8 Watts	
Data Rate:	604 bits/s	

3.4.3 Data Acquisition

SEPICA event data consist of 46 bits/events and 12 events/s will be read out. The allocation of these bits and the rest of the SEPICA data rate is shown in Table 3.4.3. Matrix rates are defined in the SEPICA DPU according to a preset algorithm, which combines the multi-parameter pulse-heights.

Table 3.4.3-1 SEPICA Bit Rate

PHA DATA

Item	# of bits		bits/s
dE/dX channel	10		
Energy channel	10		
Position channel	10		
Sensor system code	3		
Time code	4		
Sector code	3		
Event ID	3		
Spare	3		
Total PHA	46	x 12 events/s	552 bits/s

RATE DATA

Rate Class	Rates	Sectors	bits/rate	resolution	bits/s
1. Basic Rates					
He	6	8	12	60 s	9.6
Z > 2	6	8	12	60 s	9.6
2. Single Rates					
SSD	6	8	12	60 s	9.6
PC	3	8	12	60 s	4.8
Anticoinc.	2	8	12	60 s	3.2
3. Matrix Rates	64		12	300 s	2.56
Total Rates					39.8

HOUSEKEEPING DATA

Parameter	# of bits	resolution	bits/s
Exp. Status	40000	3600 s	11.1
Gas Pressure	10	60 s	0.2
Temperatures	4 x 8	60 s	0.5
Total HK			11.8

Total SEPICA Bit Rate 604 bits/s

3.5 SWIMS

3.5.1 Instrument Description

The Solar Wind Ion Mass Spectrometer (SWIMS) will provide an accurate determination every few minutes of the abundances of most of the elements and a wide range of isotopes in the solar wind. The abundances of rarer isotopes and ultra-heavy elements (mass > 60 amu) will be determined every few hours. The velocity range of the sensor is mass dependent, extending from about 200 -1500 km/s for He and from 200 - 500 km/s for Fe.

SWIMS consists of a versatile deflection system followed by a time-of-flight telescope. Solar wind ions enter a wide angle three-chamber deflection system which acts as an energy-per-charge passband filter. The energy-per-charge passband can be adjusted by changing the deflection voltage. Ions within the passband enter the mass analyzer section of the sensor by passing through a thin carbon foil. After passing through the carbon foil, the ions emerge as predominantly as neutrals or singly charged ions. Along with the emerging ion, a small number of secondary electrons are ejected from the foil. These electrons are deflected to a microchannel plate assembly and generate the start signal for the time-of-flight analysis. The particles are then deflected in an electrostatic square potential. The stop detector (a large area MCP assembly) detects the deflected ion when it reaches the ground surface and measures its arrival time.

3.5.2 Capabilities and Requirements

Table 3.5.2-1 SWIMS summary parameters

Measurements:	Mass and energy of solar wind ions with velocities between 200 km/s and about 1000 km/s
Detectors:	A three-chamber deflection system and a time-of-flight spectrometer with start and stop MCPs
Field of View:	50° by 60°
Velocity Range:	200 - 1500 km/s
Mass Resolution:	≤ 1 %
Instrument Weight:	22 lb (10 kg)
Dimensions:	17" x 18" x 7" (43 x 45 x 18 cm)

Average Power: 8 Watts
Data Rate: 505 bits/s

3.5.3 Data Acquisition

The SWIMS telemetry will include event PHA data, rate data, and housekeeping data. Five events per second with 64 bits/events will be read out, rates will add another 180 bits/s, and housekeeping and status will take up the other 5 bits second of the SWIMS allocation.

3.6 SWICS

3.6.1 Instrument Description

The Solar Wind Ion Charge Spectrometer (SWICS) will determine the elemental and ionic-charge composition and the temperature and mean speeds of all major solar wind ions from H through Fe at solar wind speeds ranging from a minimum of 145 km/s (protons) to a maximum of 1532 km/s (Fe IX). The instrument steps through an energy per charge range from 0.11 keV/Q to 66.7 keV/Q approximately every 13 minutes. It combines an electrostatic analyzer with post-acceleration, time-of-flight measurement, and energy measurement.

Ions enter the electrostatic deflection analyzer through a large-area multi-slit collimator which serves as a filter, allowing only ions within a given energy-per-charge interval to enter the TOF vs. Energy system. Ions are then post-accelerated by a 30 kV potential drop before passing through a thin foil at the start of the TOF. At the rear of the TOF vs. Energy system, a solid-state detector measures the residual energy of the ion (after acceleration). The TOF start and stop times are measured with MCPs that detect secondary electrons from the ion passing through the thin foil (start) and entering the solid-state detector (stop).

A smaller deflection analyzer region is also included to monitor solar wind protons, as well as helium and heavier ions. These ions will be post-accelerated and will be counted by a single solid-state detector at two threshold levels corresponding to protons and heavies. As the deflection analyzer is stepped through its range, this channel provides energy-per-charge spectra, allowing the bulk speed, temperature, and density of the solar wind to be determined.

3.6.2 Capabilities and Requirements

Table 3.6.2-1 SWICS summary parameters

Measurements:	Ionic charge and energy of solar wind ions with total energies between about 35 and 600 keV	
Detectors:	An electrostatic deflection system and a time-of-flight vs. energy system with start and stop MCPs and a solid-state residual energy detector and a separate solid-state proton/helium monitor.	
Geometry Factor:	Isotropic	.002 cm^2 sr
	Directional	.009 cm^2
Field of View:	4° by 69°	
Energy Range:	35 to 600 keV	
Mass/Charge Resolution:	≤ 3.5 % typical	
Instrument Weight:	12 lb (5.5 kg)	
Dimensions:	15" x 12" x 13" (37 x 30 x 32 cm)	
Average Power:	5 Watts	
Data Rate:	500 bits/s	

3.6.3 Data Acquisition

The SWICS telemetry will include event PHA data, rate data, and housekeeping data. Thirteen events per second with 24 bits/events will be read out, rates will add another 180 bits/s, and housekeeping and status will take up the other 8 bits second of the SWIMS allocation.

3.7 EPAM

3.7.1 Instrument Description

The Electron, Proton, and Alpha-particle Monitor (EPAM) instrument will measure solar and interplanetary particle fluxes with a wide dynamic range and covering nearly all directions. EPAM will use low energy solar particle fluxes as probes of the morphological changes or coronal and large-scale interplanetary magnetic field structures. EPAM will also investigate solar flare processes using non-relativistic and relativistic electrons.

EPAM consists of five apertures in two telescope assemblies. It measures ions with incident energy greater than 50 keV using two Low Energy Magnetic Spectrometers (LEMS) and electrons with incident energies greater than 30 keV with two Low Energy Foil Spectrometers. The apertures are inclined at different angles relative to the spacecraft spin axis and the spinning of the ACE spacecraft is used to obtain nearly complete pitch angle coverage. It also has a Composition Aperture (CA) which will measure the elemental composition of the ions. One of the telescope assemblies contains a LEFS aperture inclined 60° to the spin axis (LEFS 60) and a LEMS aperture inclined 120° (LEMS 120). The other assembly has a LEFS at 150° inclination (LEFS 150) and a LEMS at 30° (LEMS 30) with the addition of the CA inclined 60° from the spin axis.

3.7.2 Capabilities and Requirements

Table 3.7.2-1 EPAM summary parameters

Measurements:	Ion fluxes and elemental composition for particles with kinetic energies above 50 keV, and electron fluxes for kinetic energies above 30 keV	
Detectors:	Two Low Energy Magnetic Spectrometers, two Low Energy Foil Spectrometers, and one Composition Aperture	
Geometry Factor:	LEMS	.48 cm^2 sr each (x2)
	LEFS	.48 cm^2 sr each (x2)
	CA	.24 cm^2 sr
Field of View:	LEMS	51° full width cone
	LEFS	53° full width cone
	CA	45° full width cone
Energy Range:	30 keV - 5 MeV electrons, 50 keV - 5 MeV ions	
Instrument Weight:	15 lb (6.75 kg)	
Dimensions:	7" x 7" x 6" (18 x 18 x 15 cm) box plus external sensors	
Average Power:	7.1 Watts	
Data Rate:	160 bits/s	

3.7.3 Data Acquisition

The EPAM data rate is 168 bits per second including science data and digital housekeeping data. There are also four analog housekeeping lines to be sampled once every 32 seconds.

3.8 SWEPAM

3.8.1 Instrument Description

The Solar Wind Electron, Proton, and Alpha Monitor (SWEPAM) will measure low energy solar wind electron fluxes from 1 to 900 eV and ion fluxes between 0.26 and 35 KeV. SWEPAM will be composed of spare Los Alamos solar wind electron and ion analyzers from the Ulysses mission.

Both sensors make use of curved-plate electrostatic analyzers (ESAs) which are spherical sections cut off in the form of a sector. Biased channel electron multipliers (CEMs) are spaced alone the exit apertures of the ESAs for ion and electron detection. Different CEMs sample different portions of the fan-shaped fields-of view.

The ion sensor consists of a 105° bending angle ESA with an average radius of 100 mm and a plate spacing of 2.84 mm. 16 CEMs contiguously spaced along the exit gap of the ESA give ~ 5° polar angular resolution over the ~85° acceptance fan.

The electron sensor consists of a 120° bending angle ESA with an average radius of 41.9 mm and a plate spacing of 3.5 mm. Seven large-funnel CEMs along the exit gap give ~ 20° polar angular resolution over a 160° fan.

3.8.2 Capabilities and Requirements

Table 3.8.2-1 SWEPAM summary parameters

Measurements:	Ion flux counts between about 260 eV and 35 keV and Electron flux counts between 1 and 900 eV.
Detectors:	Two curved plate electrostatic analyzers (one ion and one electron). Ion sensor: 16 CEMS. Electron sensor: 7 CEMS.

Geometry Factor:	Isotropic	.002 cm^2 sr
	Directional	.009 cm^2
Field of View:	70° polar fan for ion sensor, 160° polar fan for electrons.	
Energy Range:	1 - 900 eV electrons, 260 eV to 35 KeV Ions.	
Energy Resolution:	5% ion sensor, 12% electron sensor.	
Instrument Weight:	5.5 lb (2.5 kg) (E) + 9 lb (4.1 kg) (I)	
Dimensions:	10" x 7" x 7.5" (25 x 18 x 19 cm) (E)	
	14" x 9.5" x 12" (36 x 24 x 30 cm) (I)	
Average Power:	5.5 Watts	
Data Rate:	1000 bits/s	

3.8.3 Data Acquisition

SWEPAM data consists of ion and electron rates collected at each E/Q stop, polar look direction, and azimuthal (spin) direction. Over a single spacecraft spin, the accumulated count matrix is sufficient to fully calculate the electron and ion distribution functions from which the bulk moments can be calculated on the ground. The accumulated counts will be summed over 1 second (5 spins) for increased statistical accuracy and to reduce the telemetry requirement, but lower resolution data from a single spin will also be provided for timing the passage of transient solar wind structures.

3.9 MAG

3.9.1 Instrument Description

The magnetometers (MAG) that will be used on ACE are the two spare MFI instruments built for the WIND mission, with minor modifications. The basic configuration of MAG consists of two, wide-range (±0.004 to ±65536 nT) triaxial fluxgate magnetometers mounted remotely from the spacecraft body. Each of the two identical sensors (M1 and M2) is mounted at the end of a boom that extends beyond the solar panels to a distance of 4 meters from the center of the spacecraft. The advantages of the twin magnetometer approach for weak magnetic field measurements like those associated with the interplanetary magnetic field have been proven over many space missions.

3.9.2 Capabilities and Requirements

Table 3.9.2-1 MAG summary parameters

Measurements:	Magnetic field strength and direction (3-axis)
Detectors:	Two triaxial fluxgate magnetometers
Magnetic Field Range:	.002 - 50000 nTesla (8 ranges)
Resolution:	.025% of full range in each of 8 ranges.
Instrument Weight:	8.4 lb (3.8 kg)
Dimensions:	5" diameter by 12" long (x2)
Average Power:	2.4 Watts
Data Rate:	304 bits/s

3.9.3 Data Acquisition

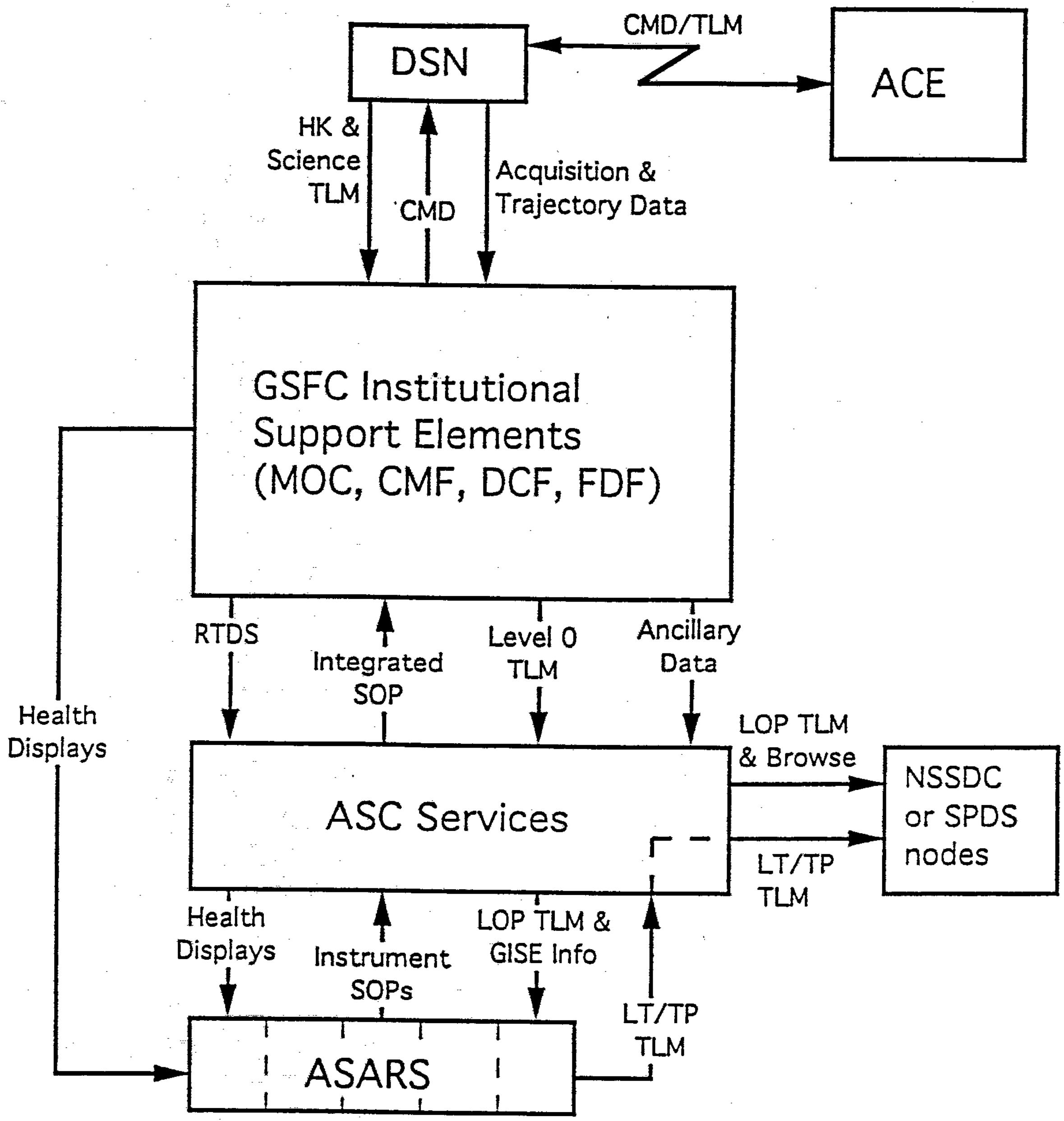
Three types of data are read out from the MAG instrument. Average magnetic field vectors are read out from both the primary and secondary magnetometers. The telemetry has 216 bits/s allocated for average vectors, which corresponds to 6 vectors/s. These vectors can be split between the primary and secondary sensors either 3:3, 5:1, or 6:0. Upon certain trigger conditions a "Snap-Shot Memory" will store field vectors at the full sampling rate of 30 vectors/s, and this will be read out at a rate of 48 bits per second. Also a Fast Fourier Transform of 17 seconds worth of vectors gives spectral matrixes of the components and the total magnitude which will be transmitted at 32 bits per second.

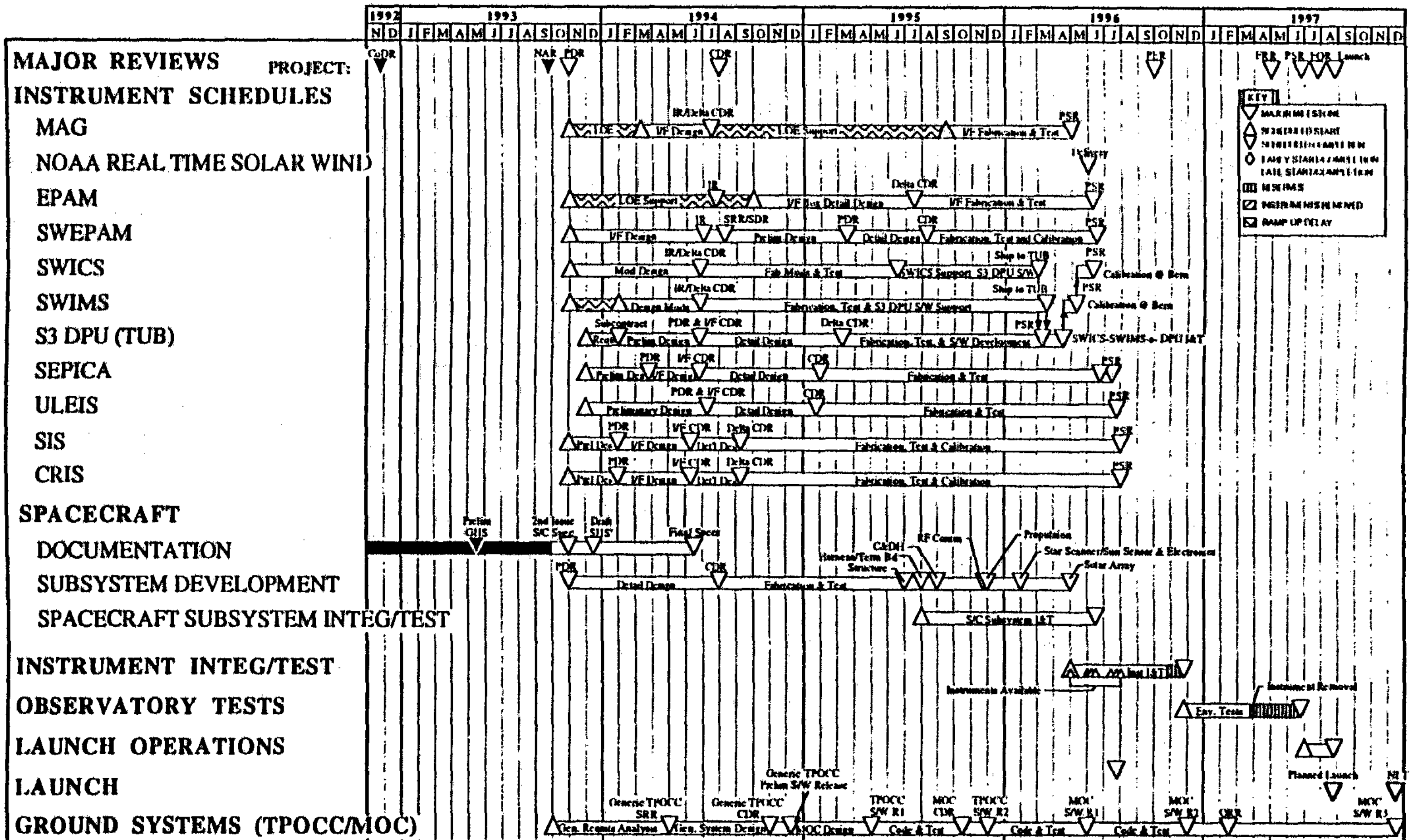
4.0 Project Data Flow

Communication to and from the spacecraft will be via the Deep Space Network (DSN) operated by the Jet Propulsion Laboratory. The telemetry stream will be transmitted to the ACE Mission Operations Center (MOC) located at GSFC via NASCOM. The MOC is one of the GSFC Institutional Support Elements (GISE) which also include the Flight Dynamics Facility (FDF), the Data Capture Facility (DCF), and the Command Management Facility (CMF). This data stream consists of two virtual channels: a real-time data stream (RTDS) and a recorded data stream (RCDS), which is the playback from the onboard recorder, and it includes both housekeeping and science data. The data is then delivered to the ACE Science Center (ASC) which will be located at the California Institute of Technology. It is currently baselined that the RTDS will be transmitted to the ASC via NSI with the TCP/IP protocol. The RCDS will be delivered to the ASC via 4 mm tape sent through the mail. The ASC is responsible for processing the data to level 1 and generating the browse files. It is then the responsibility of the ASC to distribute the data to the science co-investigators at ACE Science Analysis Remote Sites (ASARS). The data is then processed at the ASARS and higher level data is returned to the ASC for local archiving and eventual transferal to the National Space Science Data Center (NSSDC).

Command requests will be forwarded (generally electronically) from the instrument facility to the ASC for coordination and conflict resolution. Integrated command files will then be forwarded to the GISE in a manner TBD. The actual command files are sent to the ACE spacecraft (via DSN) by the GISE. It should be noted that ACE is not an "active" observatory, and that, except for the turn-on period, instrument commands will be rather infrequent.

Figure 4.0-1 Communications Overview





Goddard Space Flight Center
Approval: Dan Margolies

ASSY - Assembly
CDR - Critical Design Review
C/O - Checkout
CoDR - Concept Design Review
CRIS - Cosmic Ray Isotope Spectrometer
DES - Design
DET'L - Detail
ENG - Engineering
EPAM - Electron, Proton & Alpha-Particle Monitor
FAB - Fabrication
FOR - Flight Operations Review
FRR - Flight Readiness Review
GIIS - General Instrument Interface Specification
I&T - Integration and Test
I/F - Interface
IR - Inheritance Review
MAG - Magnetic Field Monitor
NAR - Non-Advocate Review
NLT - Not Later Than
PDR - Preliminary Design Review
PER - Pre-Environmental Review
PREL - Preliminary
PSR - Pre-Shipment Review
SIIS - Specific Instrument Interface Specification
SIS - Solar Isotope Spectrometer
SEPICA - Solar Energetic Particle Ionic Charge Analyzer
SPEC - Specification
S/W - Software
SWEPAM - Solar Wind Electron, Proton & Alpha Monitor
SWICS - Solar Wind Ion Composition Spectrometer
SWIMS - Solar Wind Ion Mass Spectrometer
S3 DPU - SWICS, SWIMS & SEPICA Data Processing Unit
TUB - Technical University @ Braunschweig
ULEIS - Ultra Low Energy Isotope Spectrometer

Orig Approval: 00/00/00
Last Change: 10/8/93

Status As Of: 10/1/93
Rev: 3

Figure 4.0-2 Overall Project Timeline

4.1 Mission Operations

There are several distinct phases of mission operations during the ACE mission lifetime. During the prelaunch phase, preparations must be performed to ensure that all systems are in place and fully tested, operations and documentation procedures are in place and checked out, and operations personnel are trained for satisfactory performance of the mission. This is the responsibilty of the Mission Operations Working Group. A Delta II rocket will launch the ACE observatory and put it in a transfer orbit out to the L1 libration point. After separation from the Delta II, deployment of the solar arrays and initial checkout of the spacecraft will occur. At that time, ground tracking will be used to obtain the spacecraft trajectory and to plan orbit maneuvers to initiate the first mid-course correction.

After the checkout of the spacecraft, the instruments will be turned on for checkout and calibration. This phase is planned to continue until about launch plus 30 days. Travel time to the L1 point will take about 100 days from launch, during which time it is planned that the instruments will be on and taking data. After arrival at the L1 point the ACE spacecraft will be inserted into its halo orbit.

The ACE mission is planned for a minimum of 2 years on station at the L1 point, and has a goal of greater than 5 years. The primary consumable that limits mission lifetime is fuel because the halo orbit requires periodic corrections. There will be enough fuel onboard to last more than 5 years under nominal operations.

4.1.1 Telemetry Services

The JPL DSN is responsible for acquisition and operation of the spacecraft to ground data link and for the generation of spacecraft metric tracking data and its transfer to the Flight Dynamics Facility at GSFC. The DSN will receive command data from the GISE via NASCOM provided data interfaces, and telemetry data will be transferred to the GISE also via NASCOM. The GISE is responsible for Level Zero Processing (LZP) and monitoring of the spacecraft health and safety, and for forwarding the LZP to the ASC at the Caltech.

4.1.1.1 Space to Ground Communications

There are three modes of data communication from the spacecraft. The primary mode is at 88 kbps and includes two virtual channels, one composed of a real time data stream

(RTDS) and another with the playback from the recorded data stream (RCDS) from the onboard recorders. The second mode is a 8 kbps data rate which does not include the RCDS playback, and there is also a slow mode of 418 bps which only contains spacecraft housekeeping and status.

The 26 m DSN is baselined, although the 34 m can also be used.

Space to Ground Communications Parameters

S/C Link	Frequency	S-Band
	Path	DSN
Data Rates [kbps]		
Forward		1 kpbs
Return		88 kpbs
Bit Error Rate		< 1 in 1,000,000
Contact Frequency		1 per day
Avg. Duration		3 hours

4.1.1.2 Telemetry Processing

The GISE at GSFC is responsible for capturing, decoding, and storing downlinked data. It will perform level zero processing on the data and distribute the level zero data products to the ASC. Spacecraft and instrument housekeeping will be monitored in real time at the GISE and also in near-real time on special occassions at the ASC. This monitoring would include comparison of actual values to allowed values and detection of changes. During the turn-on phase of the mission, and at selected other times, the RTDS will be available to the instrumenters for quick-look monitoring of their experiments.

Telemetry Processing Parameters

Annual Volume Input	220 Gbits
Annual Volume Output	220 Gbits
Data Distribution from on-ground to PI	< 5 minutes RTDS (upon request of PI)
	< 10 days RCDS

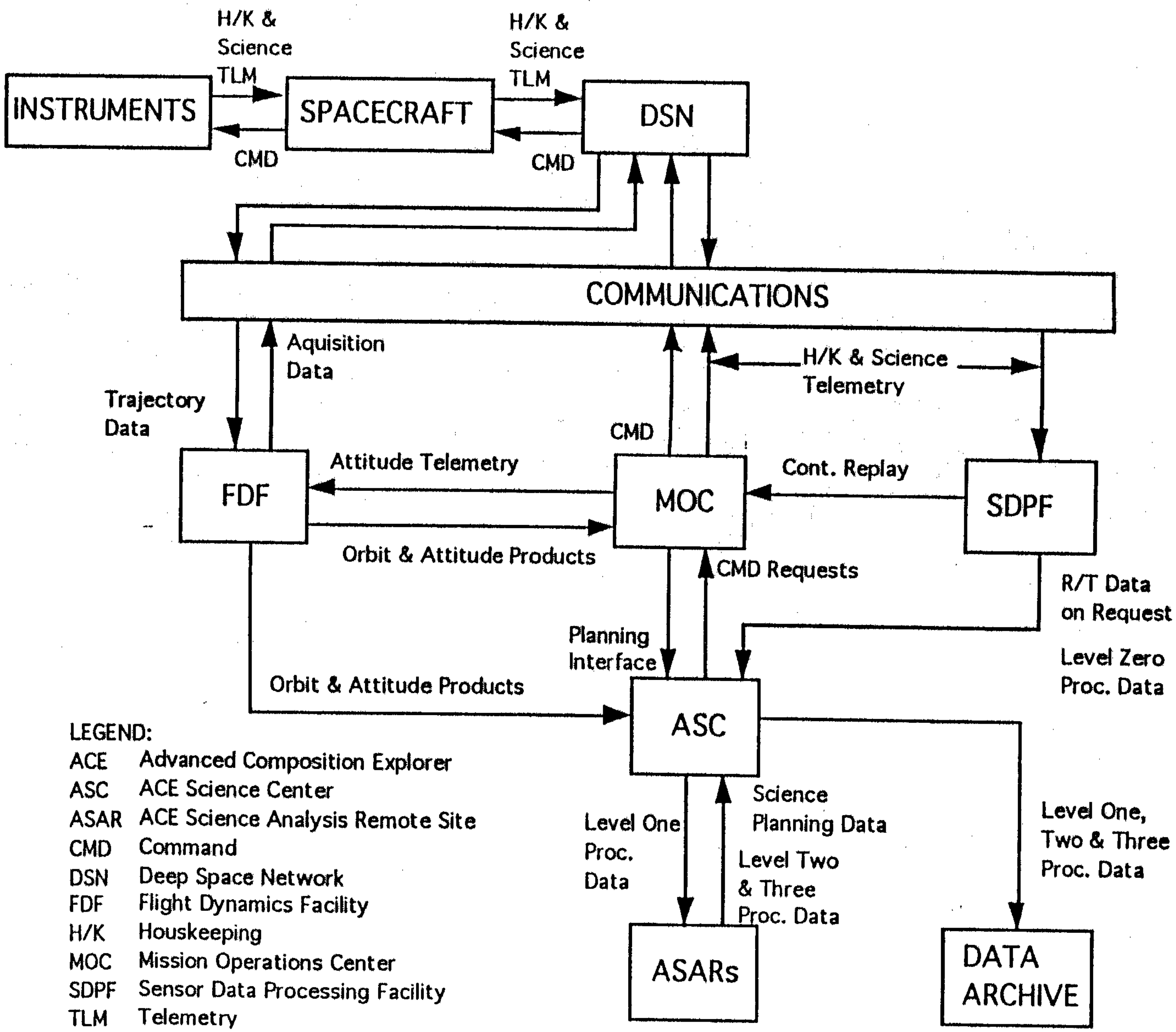
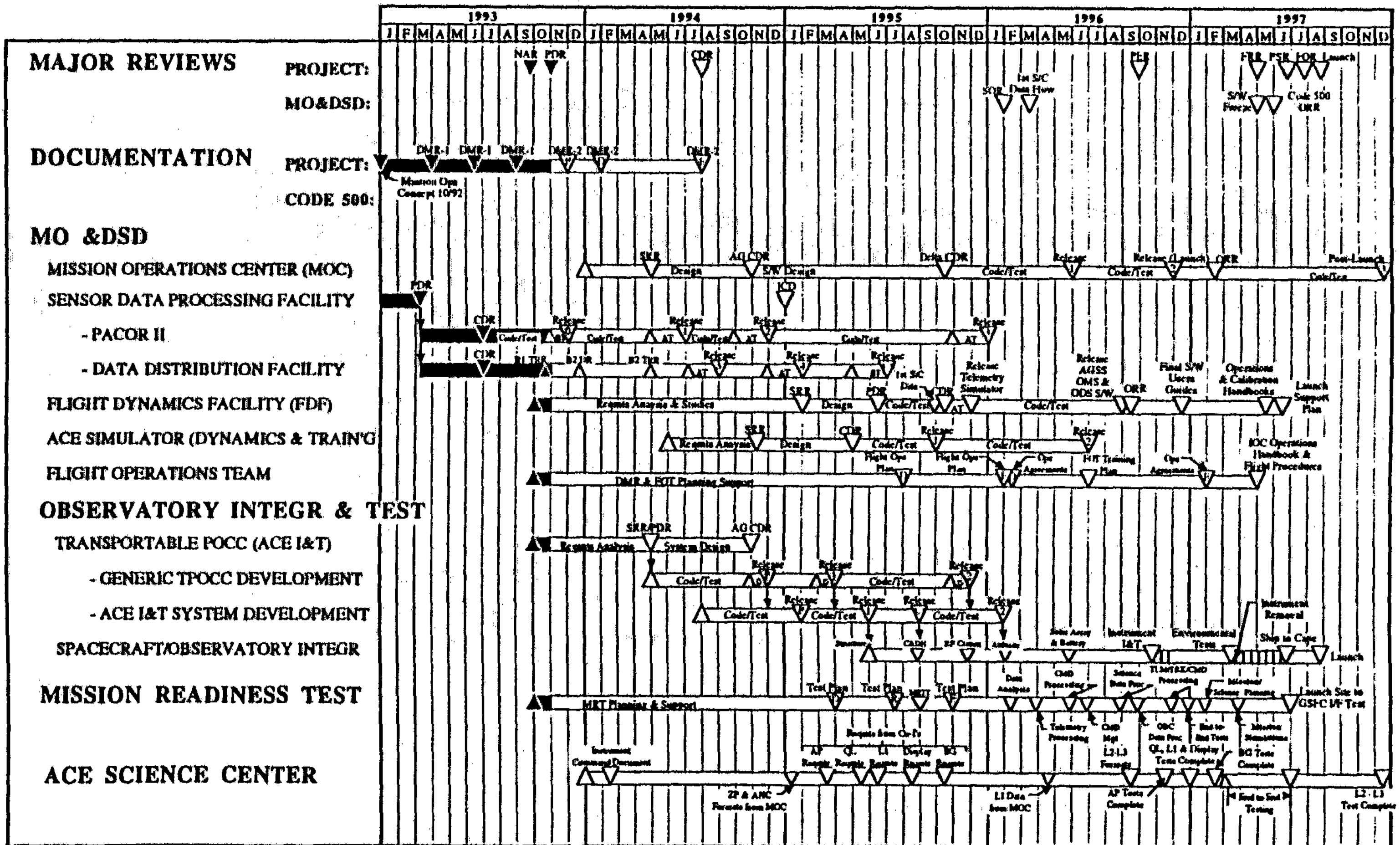


Figure 4.1-1 Detailed Mission Ops Concept



Goddard Space Flight Center
Approval: Frank Snow

AG CDR - ACE Generic TPOCC CDR
AGSS - Attitude Software
AP - Alarm Processing
AT - Acceptance Test
BG - Browse Generator
C&DH - Command & Data Handling
CDR - Critical Design Review
CMD - Command
D - Draft
DR - Design Review
DMR - Detailed Mission Requirements
F - Final
FOR - Flight Operations Review
FRR - Flight Readiness Review
GSFC - Goddard Space Flight Center
I/F - Interface
I&T - Integration & Test
ICD - Interface Control Documents
L1 - Level One Processing
L2 - Level Two Processing
L3 - Level Three Processing
MRT - Mission Readiness Test
NAR - Non-Advocate Review
ODS - Orbit Determination Software
OMS - Orbit Maneuver Software
ORR - Operational Readiness Review
P - Preliminary
PDR - Preliminary Design Review
PER - Pre-Environmental Review
PSR - Pre-Ship Review
QL - Quick-Look
RF Comm - Radio Frequency Communications
SOR - System Operations Review
SRD - System Requirements Document
SRR - System Requirements Review
TLM - Telemetry
TRK - Tracking
TRR - Test Readiness Review

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Rev: 4

Figure 4.1-2 Mission Ops Timeline

4.1.2 Mission Control

The GISE at GSFC is responsible for the safe and successful control of the ACE observatory. The GISE will generate spacecraft and instrument commands for transmission, perform command checking, schedule DSN contacts, monitor spacecraft performance, monitor instrument functions, and schedule ground communications and data transportation. The ASC will direct the science operations through generation of the science timeline, and direct the GISE activities on issues related to science data acquisition.

4.1.3 Mission Planning & Scheduling

The mission planning function will be performed in the GISE at GSFC. The ASC will support the GISE by providing schedules of routine instrument operations, typically instrument calibration sequences. Mission Planning will be performed in three phases: long term science planning, short term planning , and timeline preparation. Long term planning will take the scientist's calibration sequence proposals and establish an observation outline. Short term planning, performed on a weekly basis, three weeks in advance of planned operations, will refine the science observation plan and will allow for specific spacecraft functions required for maintenance of the spacecraft equipment and for NASA institutional systems availability. Timelines will be updated daily, three days in advance of the planned operations, and will define spacecraft and instrument configurations, command times, telemetry transmission times, and data recording and playback operations. Science operations are not expected to drive daily timelines since instrument operations will generally be "turn us on and leave us on". No conflicts are expected.

4.2 Science Operations

The ACE Science Operations will be guided by the ACE Investigator Working Group (IWG) shich includes the Project Scientist, PI, and Co-Is. The IWG is responsible for the development of science operations policies, priorities, and objectives. The IWG will also charter and staff relevant science working groups to support operations, development and execution.

4.2.1 Science Control

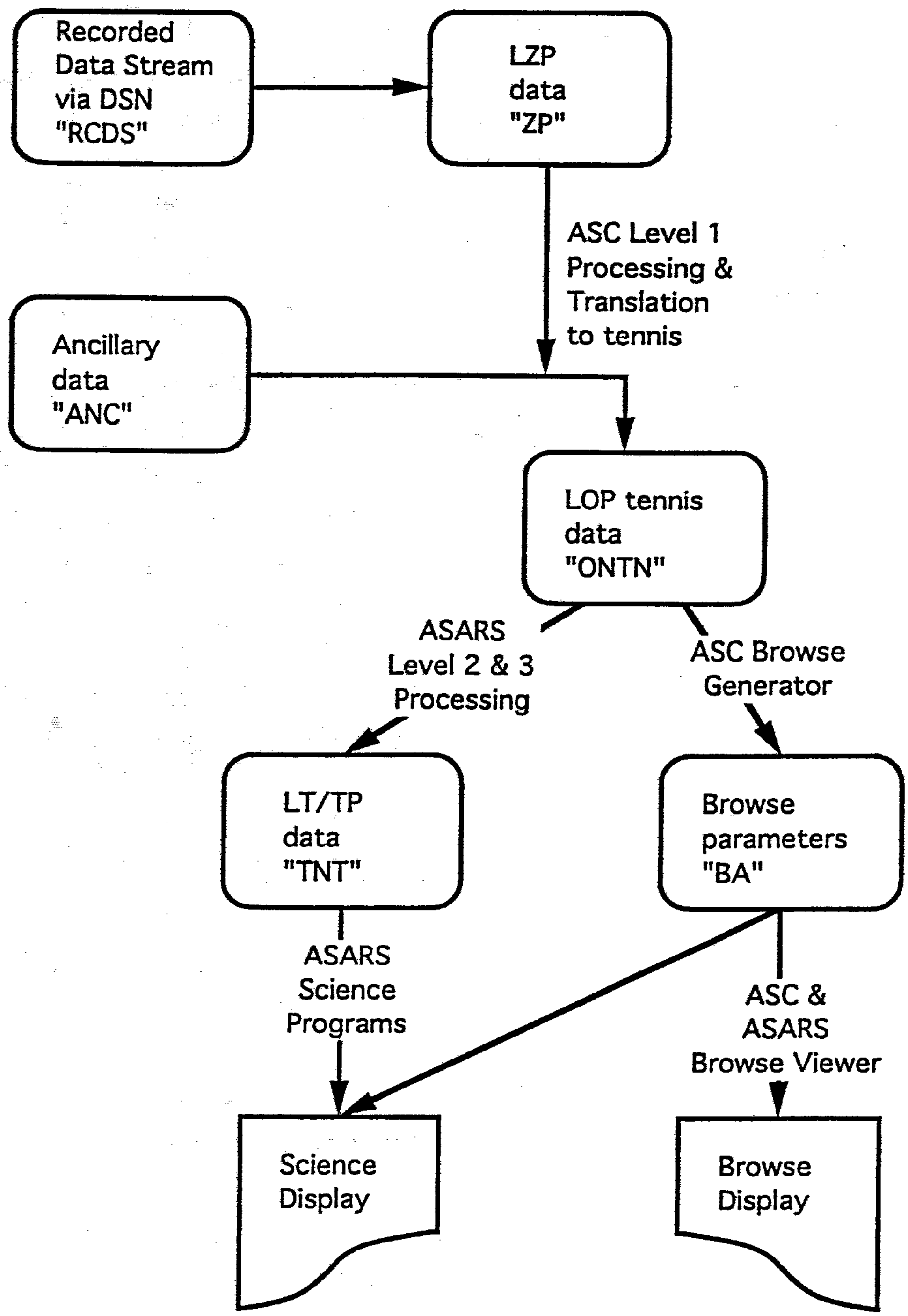
Mission planing of science operations will be performed at the GISE with the support of the ASC. Command requests will be forwarded (generally electronically) from the instrument facility to the ASC for coordination and conflict resolution. The ASC will then transmit Integrated Command Files (ICF) to the GISE. In the event that conflict resolution does become nescessary, the first step will be contact with the instrument team leaders for the appropriate instruments and/or the ACE Payload Scientist. Beyond that, thePI and/or the IWG will be consulted.

The GISE is responsible for monitoring the health and safety of the ACE instruments and spacecraft. Whenever the RTDS is available, the GISE will conduct alarm processing and quick-look processing. At special times, to be arranged in advance, alarm processing, interactive displays, and quick-look processing will be available in real-time at the ASC and/or a facility adjacent to the MOC.

4.2.2 Science Planning and Scheduling

The infrequent science commands required by instruments can typically be scheduled a week or more in advance, and will not normally require real time monitoring or response except at the GISE. Most commands will be low risk and no conflicts are expected so scheduling is easy and will mostly be left to the individual instrument teams.

Figure 4.2-1 Data Analysis Functional Flow



4.3 Continued Accessibility

The ACE team has waived "proprietary rights" to the data. All appropriate data products will be properly validated and documented so that they are useful in the public domain, and delivered in accordance with a detailed schedule of goals which will allow detection of inadequate compliance. The validation period will be very short for some products, such as the browse parameters, necessitating caveats in their usage; and substantially longer for other products such as level three processed data, which are typically validated by something approaching a peer review process. Most products will have validation periods intermediate between these extremes.

The schedule for data delivery will be used to determine whether the validation process is being abused to provide an unacceptable proprietary period. It will need frequent updating since there can be a great number of valid reasons for slow debugging/validation of data processing. (For example, we may not be able to turn on all of the instruments until we actually get near L1, more than 90 days after launch.) A conservative strawman schedule is provided here, based on an appropriately funded level of effort:

Browse parameter data should be validated in less than 30 days after receipt at the ASC, with a goal of 7 days (after the initial debugging phase). The browse parameter data will be available at the ASC via network access.

Level 0 processed data should be validated within no more than 12 months.

Level 1 processed data should be validated within 18 months at the beginning of the mission, dropping to within 8 months by the end of the mission.

Many level 2/3 processed data sets should be available within 24 months of launch, with a goal of delivering most level 2/3 data sets within 12 months by end of mission.

A Guest Investigator (GI) program has been proposed by the ACE science team which would include three kinds of GIs, all funded within a more general Space Physics Data Program:

1) Theoretical GIs would have no restrictions on scientific focus, could start immediately after launch, are expected to not be dependent on level 2/3 processed data, and may or may not be associated with instrument teams.

2) Associate Investigators would work collaboratively with a specific instrument team at the host institution, would help develop instrument capability, have joint authorship of papers, and the instrument team could suggest areas of focus. These investigations could also start immediately after launch.

3) Experimental/Phenomenological Investigations are meant to encourage interdisciplinary/correlative studies. These would require processed (levels 1, & 2/3) data from one or more instruments, may use the ASC or remote site facilities, and may or may not associate with instrument teams. It is expected that some areas of investigation would be off-limits to these GIs (e.g. prime objectives, thesis topics, etc.) and that these positions would start about 2 years after launch.

The ACE team is particularly interested in encouraging investigations in which the GI works closely with one or more of the instrument teams. Although the team will develop a system that can be readily used by outside investigators, it is also true that most of the instruments are sufficiently complex that a considerable investment of time would be required to understand the detailed data. Because of this, the most productive Guest Investigations will be those that combine the experience developed within the instrument teams with the enthusiasm and new ideas of outside investigators.

In the unlikely event that the ACE Science Team is requested to assist an unassociated user to develop a parallel data analysis effort (for example, to help an unassociated user to generate his own higher level products from the public domain level 0 data), priority will be given to the normal Team validation process in the case of limited time and resources.

4.3.1 Data Repositories

4.3.1.1 Project Data Repositories

The GISE will archive raw data for two years and LZP data for 30 days. The ASC will archive all data created by the team including level zero, one, two, and three processed data. Since the transfer of data to the ASARS will be via 4 mm tape, each ASARS will also have a permanent version of their data.

4.3.1.2 Discipline Archives

It is expected that the ASC will be able to set up as a Space Physics Data System node. This will allow the space physics discipline to access all ACE science data, as well as any ancilliary information.

4.3.1.3 NSSDC

The NSSDC is baselined as the final repository for all ACE processed (Level 2/3) data and the browse data set. The format and transfer process are TBD. The volume of data per year will be about 200 Gbyte.

4.3.2 Directories and Catalogs

The ACE Science Center will provide, via network access, browse parameter files which will contain summary data from each instrument and can be used to select events and time periods of particular interest such as flares, shock passages, etc. It will include time averages of magnetic field vectors, averaged count rates from each of CRIS, SIS, ULEIS, SEPICA, SWIMS, SWICS, and EPAM, and proton density, temperature, solar wind speed, and bi-streaming electron indicators from SWEPAM. It will also include housekeeping and status parameters from all instruments and the spacecraft, attitude and spin angle, etc. Time resolution will range roughly from 1 to 5 minutes, and the data volume will be roughly 11 megabytes per week.

One aspect of this data set will be a catalog of data files, so that event times can be easily translated into data file name. The housekeeping and other parameters stored in the browse files will also be useful for trend monitoring.

In the browse parameter file, CRIS, SIS, and SEPICA will provide count rate versus time with five-minute time resolution for about 40 of the most interesting rates. This will also provide nuclear charge versus time with a time resolution of about one second. ULEIS and EPAM will provide count rate versus time for 40 more rates, but with a time resolution of about 1 minute. SWIMS and SWICS provisions to the browse file are TBD. The MAG instrument will provide average magnetic field in an inertial co-ordinate system with approximately 1 minute time resolution. Indicators of fluctuations in the field and the power spectra of those fluctuations will be provided with the same time resolution.

4.3.3 Standards

The data will be in compliance with documented standards which include at least minimal operating system independence, substantial self documentation, and tools for data manipulation. The baseline is that the data will be available in both HDF and the Tennis formats, as appropriate.

4.3.4 Scientific Computing Resources

The ACE project will use the NASA computing resources of the GISE only to a level consistent with the performance of its payload operations and monitoring duties. The primary scientific computing resources used will be the workstations at the ASC and the ASARS. At this time, there is no plan to provide non-project researchers with substantial computer resources, although the ACE Science Center is investigating how much additional resources would be needed to make the ASC a node of the Space Physics Data System, if that system develops in time.

4.3.5 Networking Requirements

The ASC and all ASARS plan to support both TCP/IP and DECnet protocols for network communications. It is expected that both NASA Science Internet (NSI) and NSI/SPAN will be used for network connections.

5.0 Products

It is expected that all data products will be permanently stored at the ASC. The data products will include all levels of unprocessed and processed data (Levels 0, 1, and 2/3) and the browse data set, as well as spacecraft housekeeping and orbit/attitude data. Because inclusion of analysis software and any calibration data and tables is implicit in the Tennis data storage format, these will also be included in the archive. Current NASA policy calls for the use of the NSSDC as a final archive.

5.1 Science Data Product Summary

Although the general content of the processed data sets (level 2/3 processed data) from the instruments is known, the specifics of the data products that will actually be archived is TBD. As per tennis standards, analysis software and internal documentation will be included with the individual data sets archived at Caltech, as well as any test and calibration information that is required. HDF is the baseline for the data products which will be archived at the NSSDC, but the specifics of content and media are TBD.

6.0 Special Considerations

No special considerations for the ACE mission have been identified at this time.

Glossary

Ancillary Data	Non-science data needed to generate Level 1 data sets.
Browse Parameter File	Data set containing summary data from each instrument. It will be used to select events/time periods of particular interest such as flares, shock passages, etc.
Co-Investigator (Co-I)	Scientist who have a well-defined and essential responsibility for an experiment or its data products. Appointed by NASA Headquarters program office.
Guest Investigator	Scientist with access to observations to conduct independent investigations. May not have participated in initial mission planning or instrument design.
Investigator Working Group	The entire ACE science team composed of Co-I and other members of the instrument teams. Under the leadership of the ACE Mission Scientist.
Level 0 Processed Data	Raw spacecraft data which has had any duplication removed, is correctly time ordered, and has data quality and time flags. Performed by MOC.
Level 1 Processed Data	Data which has been decoded, decompressed, reformatted, and converted to engineering units as appropriate. Spin attitude and phase information, position information, and other ancillary data has been folded in. Level one processed data is a superset of level zero and therefore is re-doable.
Level 2/3 Processed Data	Data which has undergone non-reversible processing such as averaging of rates over extended time

interval, and data which has been reduced to a single collection of plots or images as opposed to a list of data items.

Principal Investigator (PI)	Leader of the science team with chief responsibility for planning, development, integration of instruments, and data analysis.
Science Steering Group	A science decision group composed of a selected senior members of the overal mission science team with balanced representation from all ACE instruments and from all institutions responsible for major items of instrument hardware.

Acronyms and other Abbreviations

ACE	Advanced Composition Explorer
ACF	Actual Command File
AD&C	Attitude Determination and Control
AMPTE/CCE	Active Magnetospheric Particle Tracer Explorers/ Charge Composition Explorer
ANC	Ancilliary Data
AO	Announcement of Opportunity
APL/JHU	Applied Physics Laboratory / Johns Hopkins University
ASARS	ACE Science Analysis Remote Sites
ASC	ACE Science Center
BA	Browse ACE Data Set
CA	Composition Aperture
C&DH	Command and Data Handling
CDR	Critical Design Review
CEM	Channel Electron Multiplier
CMD	Command
CMF	Command Management Facility
CRIS	Cosmic Ray Isotope Spectrometer
CsI	Cesium Iodide
DCF	Data Capture Facility
DMR	Detailed Mission Requirements
DPU	Data Processing Unit
DSN	Deep Space Network
EPAM	Electron, Proton, and Alpha Monitor
ESA	Electro-Static Analyzer
FDF	Flight Dynamics Facility
GI	Guest Investigator
GISE	Goddard Institutional Support Elements
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
HDF	Hierarchical Data Format
HK	Housekeeping
ICD	Interface Control Document
IS	Instrument Subsystem

IWG	Investigator Working Group
JPL	Jet Propulsion Laboratory
LANL	Los Alamos National Laboratory
LEFS	Low Energy Foil Spectrometer
LEMS	Low Energy Magnetic Spectrometer
LiD	Lithium Drifted
LOP	Level One Processed
LT/TP	Level Two / Three Processed
LVSS	Low Voltage Sub System
LZP	Level Zero Processed
MAG	Magnetometer
MCP	Multi-Channel Plate
MOC	Mission Operations Center
NAR	Non-Advocate Review
NASA	National Aeronautics and Space Administration
NASCOM	NASA Communicatins Network
NOAA	National Oceanic and Atmospheric Administration
NSI/SPAN	NASA Science Internet / Space Physics Analysis Network
NSSDC	National Space Science Data Center
PDMP	Project Data Management Plan
PDR	Preliminary Design Review
PER	Pre-Environmental Review
PSD	Position Sensitive Detector
PSR	Pre Ship Review
RCDS	Recorded Data Stream
RF	Radio Frequency
RTDS	Real Time Data Stream
RX	Receive
S/C	Spacecraft
SEPICA	Solar Energetic Particle Ionic Charge Analyzer
SIS	Solar Isotope Spectrometer
SOFT	Scintillating Optical Fiber Telescope
SOP	Science Operations Plan
SPDF	Sensor Data Processing Facility
SPDS	Space Physics Data System
SSD	Solid-State Detector

SWEPAM	Solar Wind Electron, Proton, and Alpha Monitor
SWICS	Solar Wind Ionic Charge Spectrometer
SWIMS	Solar Wind Ionic Mass Spectrometer
TBD	To Be Determined
TLM	Telemetry
TOF	Time Of Flight
TX	Transmit
ULEIS	Ultra Low Energy Isotope Spectrometer
UMd	University of Maryland
UNH	University of New Hampshire

References

Guidelines for Development of a Project Data Management Plan (PDMP)		Dec 1992
Phase A Study of an Advanced Composition Explorer		2 Jul 1989
ACE Science Operations and Data Analysis (SODA) plan		15 Jun 1993
ACE Mission Operations Concept Document		1 Oct 1992
ACE Detailed Mission Requirements		2 Aug 1993
ACE Science Requirements Document	GSFC-410-ACE-002	11 Sep 1992

Appendix A: Project Summary Tables

Table A-1 ACE Project Summary Parameters

Mission Summary		Parameter Values
Project Name		Advanced Composition Explorer (ACE)
Orbit Description		Halo orbit about L1 libration point
Launch Date		August 1997
Launch Vehicle:		Delta II 7920
Nominal Mission Duration:		2 Years
Potential Mission Life:		5+ Years
Spacecraft Mass:		563 kg (wo fuel)
Spacecraft Power		4 Solar Arrays: 500 W at End-of-Life
Attitude Control:		Spin Stabilized
Propulsion type/capacity:		hydrazine thrusters/189 kg
Data Acquisition		
On-Board Data Storage Capacity:		1.3 Gbit
Continuous Data Acquisition Rate:		6944 bits/s
On-Board storage saturation:		52 hours
Attitude determination accuracy:		0.5° post facto
Space to Ground Communications		
S/C Link	Frequency	S-Band
	Path	DSN
Data Rates [kbps]		
Forward		1 kpbs
Return		88 kpbs
Bit Error Rate		< 1 in 1,000,000
Contact Frequency		1 per day
Avg. Duration		3 hours
Telemetry Processing		
Annual Volume Input		220 Gbits
Annual Volume Output		220 Gbits

Data Distribution from on-ground to PI	< 1 Day RTDS < 2 Weeks RCDS

Support Facilities

GISE / GSFC	Payload Operations
ASC / Caltech	Science Operations
ASARS / Various locations	Science Support
NSSDC	Archiving Facility

CRIS

Measurements:	Mass, Charge, and Energy of individual galactic cosmic ray nuclei with energies between about 100 and 600 MeV/nucleon and charges between 1 and 30
Detectors:	One Scintillating Optical Fiber Trajectory (SOFT) hodoscope and four identical "telescopes" of solid state detectors
Sensitive area, SOFT:	26 cm X 26 cm
Sensitive area, SSDs:	324 cm^2 total
Geometry Factor, Total:	~ 200 cm^2 sr (energy dependent)
Field of View:	45° half-width
Energy Range:	100 - 600 MeV/nucleon
Mass Resolution:	≤ 0.25 amu
Instrument Weight:	58.2 lb (26.4 kg)
Dimensions:	20.375" x 17.25" x 9"
Average Power:	17.8 Watts
Data Rate:	464 bits/s

Science Resources (ASARS)

California Institute of Technology	Pasadena, CA
Jet Propulsion Laboratory	Pasadena, CA
Goddard Space Flight Center Code 661	Greenbelt, MD
Washington University	St. Louis, MO

SIS

Measurements:	Mass, Charge, and Energy of individual cosmic ray nuclei with energies between about 10 and 100 MeV/nucleon and charges between 1 and 30
Detectors:	Two identical "telescopes" composed of ion-implanted and

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lithium-drifted silicon solid-state detectors

Sensitive area	32 cm^2 each telescope, 64 cm^2 total
Geometry Factor, Total:	~ 25 cm^2 sr (energy dependent)
Field of View:	55° half-width
Energy Range:	10 - 100 MeV/nucleon
Mass Resolution:	≤ 0.25 amu
Instrument Weight:	34.8 lb (15.8 kg)
Dimensions:	16.5" x 11.812" x 11.812"
Average Power:	16.8 Watts
Data Rate:	2000 bits/s

Science Resources (ASARS)

California Institute of Technology	Pasadena, CA
Jet Propulsion Laboratory	Pasadena, CA
Goddard Space Flight Center Code 661	Greenbelt, MD

ULEIS

Measurements:	Mass and Energy of individual cosmic ray nuclei with energies between about 20 keV/nucleon and 10 MeV/nucleon and charges between 1 and 28	
Detectors:	One telescope with three time-of-flight Start/Stop MCPs with position-sensing anodes and an array of silicon solid-state detectors for measurement of residual energy.	
Sensitive area	80 cm^2	
Geometry Factor, Total:	~ 1 cm^2 sr	
Field of View:	24° by 20°	
Energy Range:	20 keV/nucleon - 10 MeV/nucleon	
Mass Resolution:	≤ 0.30 amu	
Instrument Weight:	37.5 lb (17 kg)	
Dimensions:	Telescope Box	30" x 6" x 8" (76.5 x 15 x 20 cm)
	Analog Elect. Box	9" x 6" x 5.5" (23 x 15 x 14 cm)
	Digital Elect. Box	6" x 6" x 6" (15 x 15 x 15 cm)
Average Power:	17.1 Watts	
Data Rate:	1000 bits/s	

Science Resources (ASARS)

Applied Physics Laboratory / JHU	Laurel, MD
University of Maryland	College Park, MD

SEPICA

Measurements:	Ionic charge state, nuclear charge, and energy of individual energetic particles with energies between about 0.2 and 2.0 MeV/nucleon and charges between 2 and 26	
Detectors:	Three pairs of telescopes with collimators, electrostatic deflection electrodes, proportional counters, and solid-state detectors.	
Geometry Factor:	0.36 cm^2 low resolution total (four sections) 0.06 cm^2 high resolution total (two sections)	
Field of View:	six parallel 24° by 50°	
Energy Range:	0.2 - 2.0 MeV/nucleon	
Charge Resolution:	~ 10 % high resolution sections	
Instrument Weight:	43 lb (19.5 kg)	
Dimensions:	Sensor Box	16" x 16" x 12" (40 x 40 x 30 cm)
	Electronics Box	8" x 8" x 6" (20 x 20 x 15 cm)
Average Power:	6.8 Watts	
Data Rate:	604 bits/s	

Science Resources (ASARS)

University of New Hampshire — Durham, NH

Max Planck Institute for Extraterrestrial Physics — Garching, Germany

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SWIMS

Measurements:	Mass and energy of solar wind ions with velocities between 200 km/s and about 1000 km/s
Detectors:	A three-chamber deflection system and a time-of-flight spectrometer with start and stop MCPs
Field of View:	50° by 60°
Velocity Range:	200 - 1500 km/s
Mass Resolution:	≤ 1 %
Instrument Weight:	22 lb (10 kg)
Dimensions:	17" x 18" x 7" (43 x 45 x 18 cm)
Average Power:	8 Watts
Data Rate:	505 bits/s

Science Resources (ASARS)

University of Maryland — College Park, MD

University of Bern	Bern, Switzerland

SWICS

Measurements:	Ionic charge and energy of solar wind ions with total energies between about 35 and 600 keV	
Detectors:	An electrostatic deflection system and a time-of-flight vs. energy system with start and stop MCPs and a solid-state residual energy detector and a separate solid-state proton/helium monitor.	
Geometry Factor:	Isotropic	.002 cm^2 sr
	Directional	.009 cm^2
Field of View:	4° by 69°	
Energy Range:	35 to 600 keV	
Mass/Charge Resolution:	≤ 3.5 % typical	
Instrument Weight:	12 lb (5.5 kg)	
Dimensions:	15" x 12" x 13" (37 x 30 x 32 cm)	
Average Power:	5 Watts	
Data Rate:	500 bits/s	

Science Resources (ASARS)

University of Maryland	College Park, MD
Max Planck Institute for Aeronomy	Garching, Germany
University of Bern	Bern, Switzerland

EPAM

Measurements:	Ion fluxes and elemental composition for particles with kinetic energies above 50 keV, and electron fluxes for kinetic energies above 30 keV	
Detectors:	Two Low Energy Magnetic Spectrometers, two Low Energy Foil Spectrometers, and one Composition Aperture	
Geometry Factor:	LEMS	.48 cm^2 sr each (X2)
	LEFS	.48 cm^2 sr each (X2)
	CA	.24 cm^2 sr
Field of View:	LEMS	51° full width cone
	LEFS	53° full width cone
	CA	45° full width cone
Energy Range:	30 keV - 5 MeV electrons, 50 keV - 5 MeV ions	

Instrument Weight:	15 lb (6.75 kg)
Dimensions:	7" x 7" x 6" (18 x 18 x 15 cm) box plus external sensors
Average Power:	7.1 Watts
Data Rate:	160 bits/s

Science Resources (ASARS)

Applied Physics Laboratory / JHU   Laurel, MD

SWEPAM

Measurements:	Ion flux counts between about 260 eV and 35 keV and Electron flux counts between 1 and 900 eV.
Detectors:	Two curved plate electrostatic analyzers (one ion and one electron). Ion sensor: 16 CEMS. Electron sensor: 7 CEMS.
Geometry Factor:	Isotropic .002 cm^2 sr
	Directional .009 cm^2
Field of View:	70° polar fan for ion sensor, 160° polar fan for electrons.
Energy Range:	1 - 900 eV electrons, 260 eV to 35 KeV Ions.
Energy Resolution:	5% ion sensor, 12% electron sensor.
Instrument Weight:	5.5 lb (2.5 kg) (E) + 9 lb (4.1 kg) (I)
Dimensions:	10" x 7" x 7.5" (25 x 18 x 19 cm) (E)
	14" x 9.5" x 12" (36 x 24 x 30 cm) (I)
Average Power:	5.5 Watts
Data Rate:	1000 bits/s

Science Resources (ASARS)

Los Alamos National Laboratory   Los Alamos, NM

MAG

Measurements:	Magnetic field strength and direction (3-axis)
Detectors:	Two triaxial fluxgate magnetometers
Magnetic Field Range:	.002 - 50000 nTesla (8 ranges)
Resolution:	.025% of full range in each of 8 ranges.
Instrument Weight:	8.4 lb (3.8 kg)
Dimensions:	5" diameter by 12" long (x2)
Average Power:	2.4 Watts
Data Rate:	304 bits/s

Science Resources (ASARS)

Bartol Research Institute, U. of Delaware	Newark, DE
Goddard Space Flight Center, Code 690	Greenbelt, MD