GSFC/ASC ICD/1095

MISSION OPERATIONS AND DATA SYSTEMS DIRECTORATE

Interface Control Document Between the Advanced Composition Explorer Mission Team and the California Institute of Technology Advanced Composition Explorer Science Center

23 February 1996

Goddard Space Flight Center
Greenbelt, Maryland

National Aeronautics and Space Administration

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Advanced Composition Explorer Mission Team
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Science Center

23 February 1996

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Preface

This Interface Control Document (ICD) provides a detailed definition of the data interface between the Goddard Space Flight Center (GSFC) Advanced Composition Explorer (ACE) Ground System (GS) Mission Team (MT) and the California Institute of Technology (CIT) ACE Science Center (ASC) in support of the ACE mission. This document should be used by ACE personnel involved in the development and/or operations of ACE ground software at GSFC or the ASC.

This document is maintained and controlled by the GSFC ACE Ground System Mission Team. Questions and proposed changes concerning this document shall be addressed to:

ACE Ground System Project Manager Code 410/501 and
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Section 1. Introduction

1.1 Purpose

The purpose of this Interface Control Document (ICD) is to define the transmission protocol and specific data format for information transferred between the Goddard Space Flight Center (GSFC) Advanced Composition Explorer (ACE) Ground System (GS) Mission Team (MT) and the California Institute of Technology (CIT) ACE Science Center (ASC). These organizations both support the ACE mission and will be using this document to maintain and control information transferred between software and personnel located at these sites. The information contained in this document is in effect during the ACE mission planning phase through the life of the mission.

1.2 Document Organization

The remainder of this ICD document is organized as follows.

Supporting document references, and maintenance and control guidelines for this ICD are provided in Section 2. An overview of each organization along with a description of the software functions which generate the data products defined in this ICD are found in Section 3. The organization responsibilities within GSFC for each interface component or layer is described in Section 4.

For quick reference, a summary of all data products is available in Section 5.

The application programmer should refer to Section 6 for the data format and content descriptions.

The communications protocol and physical circuit characteristics are provided in Sections 7 through 10. Section 7 discusses the Session Layer, which establishes a logical circuit with the interface facility. Section 8 describes the Network/Transport Layer, which converts messages to packets, routes them to the correct destination, and defines end-to-end protocols. Section 9 describes the Data Link Layer, which defines the media access for transmission of data over the ground system network. Section 10 describes the Physical Layer, which defines the electrical and mechanical characteristics of physical circuits.

Section 2. Applicable Documents

2.1 Standards

To the extent possible, this ICD follows the guidelines of the National Aeronautics and Space Administration (NASA)/GSFC, Space Tracking and Data Network (STDN) No. 102.8, *Handbook for Preparing Interface Control Documents for Non-Project Related Ground Facilities* and in addition, the *Consultative Committee for Space Data Systems Parameter Value Language (CCSDS PVL), 641.0-G-1.*

Guidelines have been adapted to conform to the International Standards Organization (ISO)/Open Systems Interconnection (OSI) network communications reference model.

2.2 Related Documents

ACE Science Requirements Document (GSFC-410-ACE-002)

ACE Mission Requirements Document (GSFC-410-ACE-003)

ACE Mission Requirements Request (MRR)

ACE Detailed Mission Requirements (DMR) GSFC-410-ACE-017

Appendix Y, *Interface Control Document Between the Jet Propulsion Laboratory and the Goddard Space Flight Center for GSFC Missions Using the Deep Space Network for the ACE Mission*

Appendix J, *Advanced Composition Explorer Science Center Implementation for the Advanced Composition Explorer*

Memorandum of Understanding (MOU) Between the Flight Projects Directorate and the Mission Operations and Data Systems Directorate for the ASC (See Appendix A)

Deep Space Network (DSN) System Requirements Detailed Interface Design, 820-13

DSN Telemetry With the Advanced Composition Explorer, Module , TLM 3-27

Parameter Value Language-- A Tutorial, CCSDS641.0-G-1, May 1992

Parameter Value Language Specification, CCSDS 641.0-B-1, May 1992

ACE Spacecraft Command and Data Handling Component Specification, Johns Hopkins University Applied Physics Laboratory 7345-9030, October 16, 1995

MOU Between the NASA Flight Projects Directorate and the National Oceanic and Atmospheric Administration (NOAA) for the Operation of the ACE Satellite.

Level 3 Requirements are maintained in the Requirements Generation System (RGS) at GSFC under control of the ACE Deputy Ground System Project Manager.

Figure 2-1, shown below, illustrates the ACE document hierarchy with respect to this ICD.

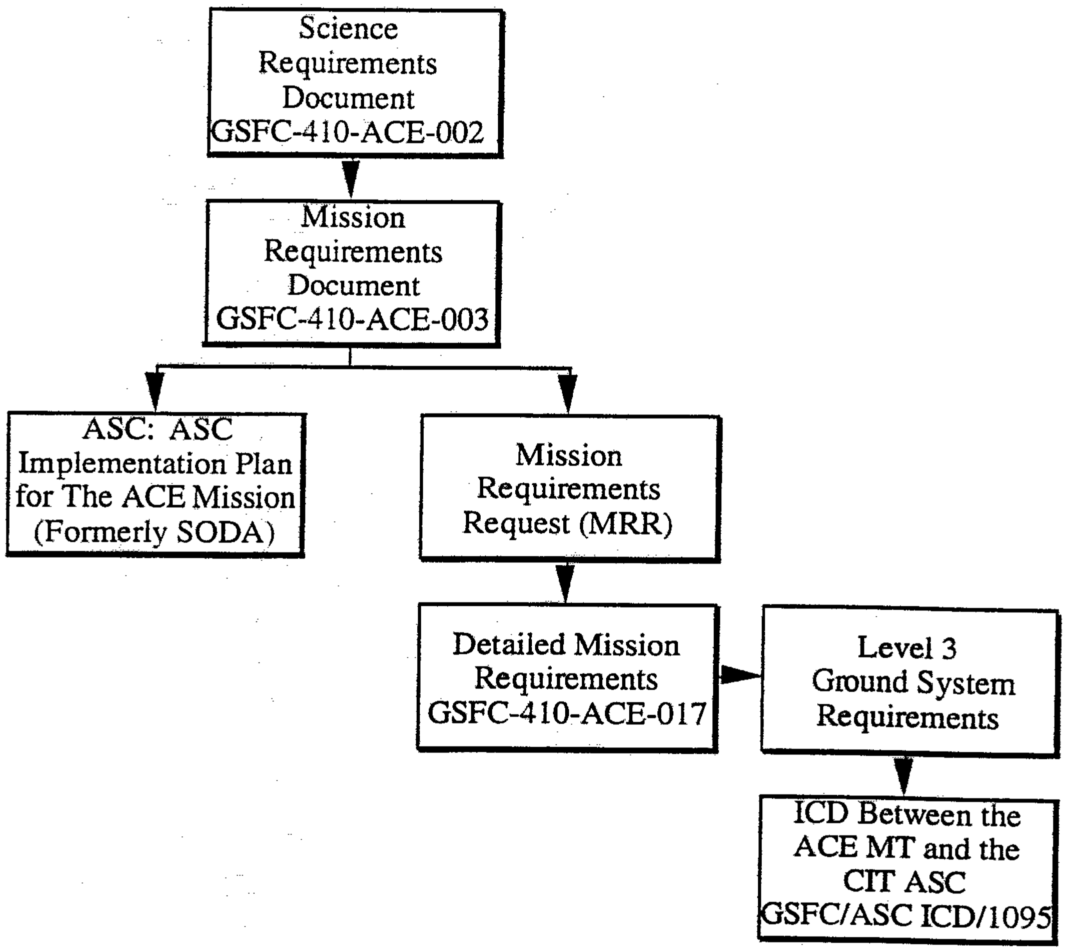


Figure 2-1. ACE Requirements Hierarchy

2.3 Document Control

The contents in this ICD can be traced to the DMR and other source documents as indicated in the ACE Requirements Hierarchy (Figure 2-1). Changes to the source documents will be reflected in this ICD, as necessary. The information in this ICD will take precedence over all other documentation, except the DMR. In the case of information conflict between this ICD and the DMR, the DMR document will take precedence. The appendices of this ICD are for reference and are not under the configuration control of the ACE MT.

Section 3. Functional Descriptions

3.1 General

This section provides an interface overview of the GSFC ACE GS MT and the CIT ASC. A summary of the components within each organization are provided along with a functional description of the software used to generate the data products described in this document.

3.2 Interface Overview

The interface agreement is maintained to allow routine and special request data products to be exchanged between the ACE GS software and the ASC facility. The components of the ACE GS will be described in the next subsection. The ASC will be directing ACE instrument scheduling and acting as the hub for scientific data distribution. The data products received by and transmitted from the ASC will be controlled and maintained on an ASC workstation located within the ASC facility at the CIT.

3.2.1 ACE Ground System

The ACE GS consists of three components: The Integrated Mission Operations Center (IMOC), Flight Dynamics Orbit Determination, and NASA Communications (Nascom).

Within the IMOC four software functions are performed: the Real-Time Command and Control Function (RTCCF), the Mission Planning Function (MPF), the Data Processing Function (DPF), and the Attitude Determination Function (ADF).

The high level data flow across the ACE GS/ASC interface is illustrated in Figure 3-1.

3.2.1.1 Integrated Mission Operations Center

The four software functions in the IMOC are summarized below.

3.2.1.1.1 Real-Time Command and Control Function

The RTCCF executes during real-time contacts to monitor spacecraft health and safety and perform spacecraft commanding. The major real-time command and control functions are command generation and transmission, data capture and history logging, telemetry processing and engineering conversion, data distribution and activity logging, external communications between the control center and the spacecraft and tracking network, and a graphical user interface.

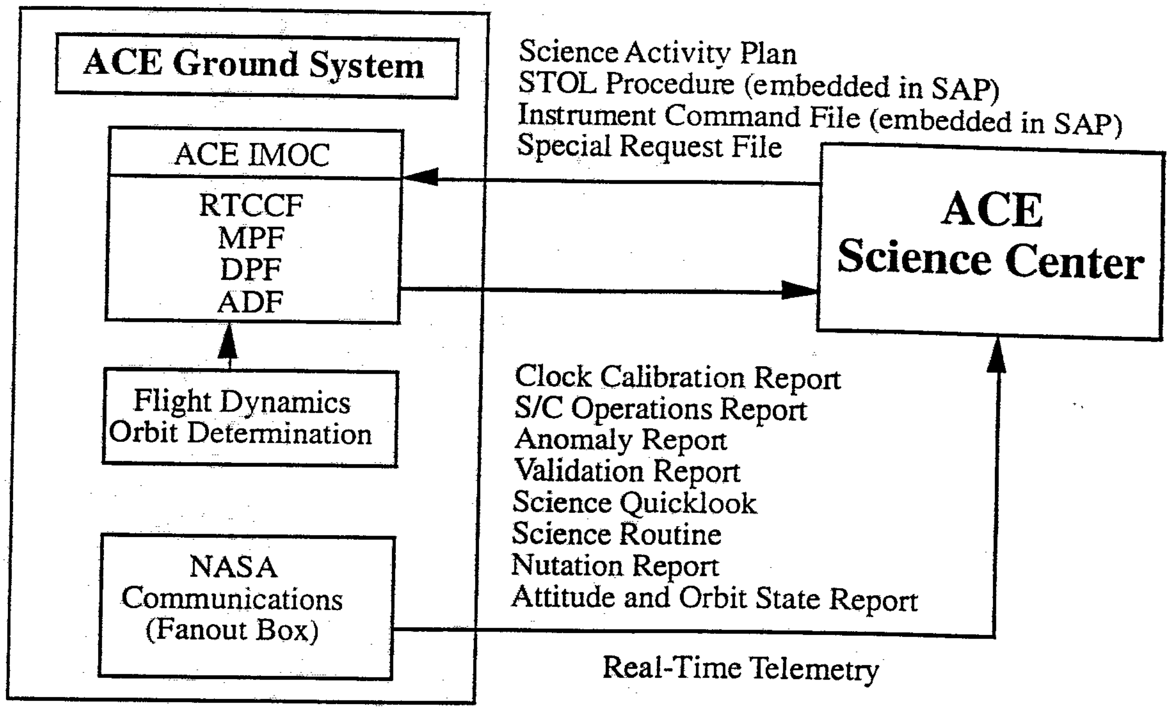


Figure 3-1. ACE Ground System /ASC Mission Interface

3.2.1.1.2 Mission Planning Function

The MPF provides capabilities for spacecraft scheduling, maneuver support, and spacecraft control. This subsystem generally operates in an off-line mode. The primary mission planning functions are prediction, command load generation, and resource scheduling. These functions are controlled from a graphical user interface and rely on a common centralized mission data base.

3.2.1.1.3 Data Processing Function

The DPF provides science data set preparation on both a quicklook and routine processing basis. Telemetry packets are captured, time ordered and merged, and redundant data are deleted. Missing data are reported and a Quality and Accounting Capsule (QAC) is attached. Level Zero (LZ) products are generated based on user defined criteria maintained in a local database within the IMOC. Products are forwarded to users with a detached Standard Format Data Unit (SFDU) describing the product contents.

3.2.1.1.4 Attitude Determination Function

The ADF processes attitude sensor engineering data received from the spacecraft along with spacecraft/planetary environmental data such as ground-computed ephemeris, solar ephemeris, and star ephemeris to determine and monitor the spacecraft attitude. The output of this function will be combined with other attitude maneuver software to assist in the planning of attitude maneuvers. Graphical displays of the attitude and attitude sensors are used to monitor the spacecraft health and safety. The attitude determination subsystem can be executed in real-time and non real-time mode.

3.2.1.2 Flight Dynamics Orbit Determination

The Flight Dynamics Orbit Determination is performed within the Flight Dynamics Facility (FDF) at the GSFC. FDF is responsible for operational orbit determination for satellite mission support and will provide spacecraft orbit ephemeris products to the IMOC based on tracking data obtained from the DSN ground stations. The FDF orbit products are used by the IMOC for attitude determination and spacecraft range. The orbit ephemeris used to process spacecraft telemetry data by the IMOC ADF will be sent to the ASC via the IMOC.

3.2.1.3 NASA Communication

Nascom is responsible for the ground communications for the mission. Nascom will provide connectivity for the following nodes: Applied Physics Laboratory (APL), the DSN Network Operations Control Center (NOCC), the IMOC at GSFC, the GSFC Building 5 Thermal Vacuum Testing Facility, the Cape Canaveral Testing Facilities, NOAA and the ASC.

The data transmission lines employed will be secured by Nascom from commercial carriers. The protocol used on these lines will be Transmission Control Protocol/Internet Protocol (TCP/IP) and User Datagram Protocol/Internet Protocol (UDP/IP). This is a departure from the Nascom block Protocol used in previous missions. A further departure will be the use of Isis.

Isis is a commercial communications software that employs UDP/IP. It provides fault tolerance tools as well as broadcast tools. Using Isis, a single telemetry stream will be delivered from the Jet Propulsion Laboratory (JPL) to GSFC. An Isis fan-out box will be located at the GSFC Nascom facility. This box is responsible for distributing the data to the appropriate users [e.g., ASC, IMOC, NOAA (as specified in the GSFC/NOAA MOU), etc]. Fault tolerance is allowed for in Isis because a redundant system is maintained and ready to broadcast information. If one system goes down, Isis initiates the redundant system to continue the transmission. Nascom is responsible for resolving transmission problems.

3.2.2 ACE Science Center

The ASC, located at the CIT, coordinates all of the activities related to the nine on-board scientific instruments. In this role, the ASC is responsible for integrating the instrument operations planning schedules developed by each of the instrument investigators into a coordinated plan of science operations requirements for upcoming ACE contacts. In addition, the ASC will act as the "hub" through which all ACE science data will travel. During spacecraft contacts the ASC will receive real-time telemetry from the Nascom fanout box. The ASC will employ the same real-time telemetry processing software as the IMOC to decommutate and monitor this telemetry.

Section 4. Interface Configuration and Control

4.1 Organizational Responsibilities

The ACE GS/ASC interface is defined with respect to the seven OSI interactions. Figure 4-1 illustrates these layers and shows the organizational responsibilities for each layer. The ACE GS and the ASC interact directly at the Application, Presentation, and Session Layers (user layers). The Network/Transport, Data Link, and Physical Layers (transport layers) are managed through Nascom.

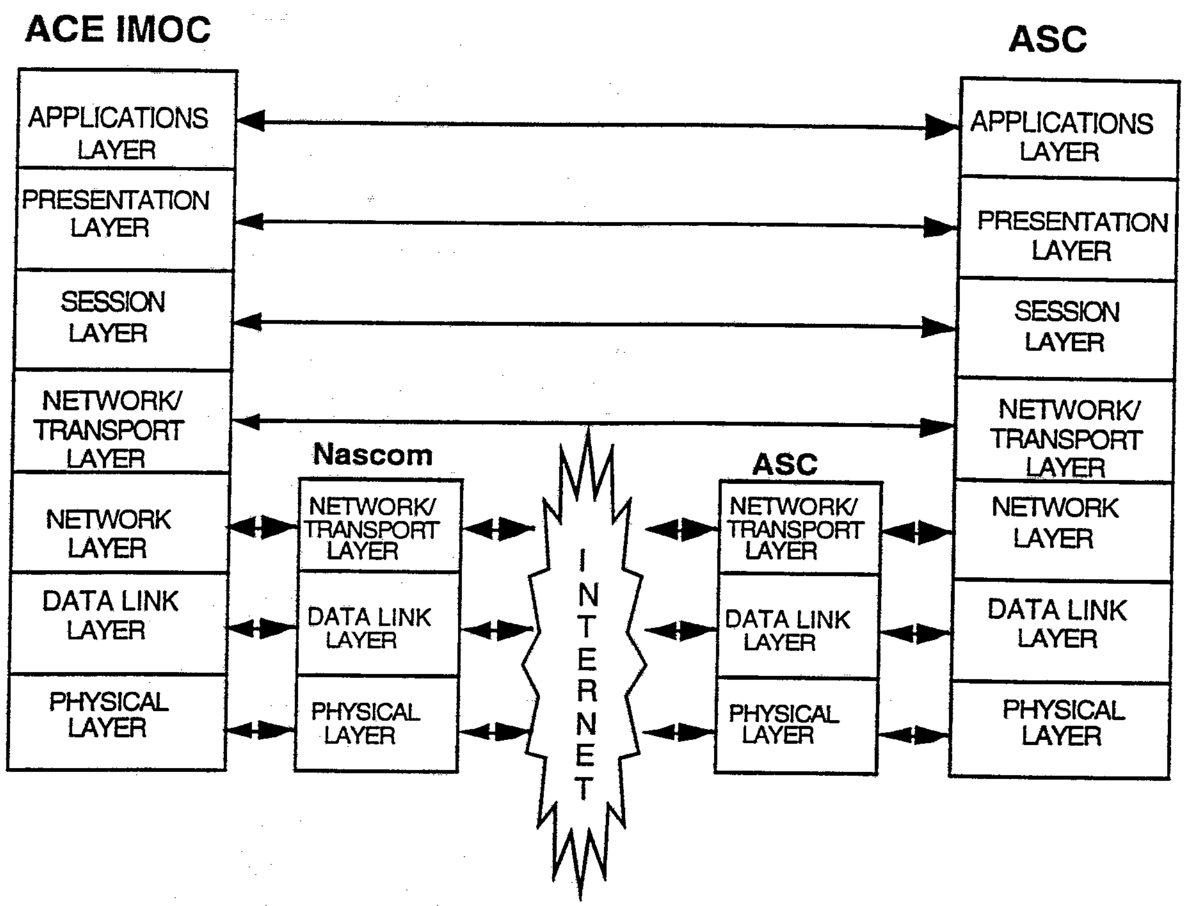


Figure 4-1. ACE Ground System /ASC Operational Data Communications Reference Model

Section 5. Application Layer

5.1 Definition

The Application Layer defines the user data transferred across the interface.

5.2 Product Summaries

The following products will be provided by the ACE GS to the ASC:

a) Clock Calibration Report
b) Spacecraft Operations Report
c) Anomaly Report
d) Validation Report
e) Real-Time Telemetry
f) Science Quicklook
g) Science Routine
h) Nutation Report
i) Attitude and Orbit State Report

The following products will be provided by the ASC to the ACE GS.

a) Science Activity Plan (Instrument Command File and STOL Procedure are embedded in SAP.)
b) Special Request File to the Flight Operations Team (FOT)
    - Quick-look data
    - Archival data

Table 5-1 provides a summary of all products exchanged between the ACE GS and the ASC.

Table 5-1. Product Summary Chart

Product Name	Product Description	File Description	Nominal Product Time Span	Product Type Descriptor
Clock Calibration Report	Daily calibration parameters for converting ACE spacecraft clock ticks to ground observed time	PVL	Daily for each C&DH	CCR
Spacecraft Operations Report	Summary of each S/C contact includes command summary, time and duration, and special events	ASCII	One report for every contact	SOR
Anomaly Report	Anomalous operations as reported by the FOT	ASCII	As required	ANR
Validation Report	Validation of the science activity plan	ASCII	Response to SAP	VAL
Real-Time Telemetry	ACE telemetry data	Data packets via Isis connection	Daily	N/A
Science Quicklook	Contains all or a subset of the data received in a single ground acquisition session	Detached SFDU in PVL and Binary	Upon request	QLP
Science Routine	Contains all data received from acquisition sessions that occurred within a 24 hour period	Detached SFDU in PVL and Binary	Every 24 hours	LZP
Nutation Report	Spin period variation caused by nutation which can occur following S/C maneuvers.	PVL	Nominally after S/C maneuvers until spin period variation is less than 7 msec	NTR
Attitude and Orbit State Report	Attitude and orbit state for a given time based on a real-time pass	PVL	Nominally two reports per day, issued for the beginning and end of a pass. Also issued before and after maneuvers	AOR

Table 5-1. Product Summary Chart (continued)

Product Name	Product Description	File Description	Nominal Product Time Span	Product Type Descriptor
Science Activity Plan	Instrument commands and loads	PVL	As needed	SAP
Instrument Command File	Binary instrument command load	Embedded ASCII data within the SAP	As needed	ICF
STOL Procedure	ASCII STOL Procedure	Embedded ASCII data within the SAP	As needed	PRC
Special Request File	Special data requests from ASC	ASCII	As needed	SRF

Section 6. Presentation Layer

6.1 Definition

The Presentation Layer describes the contents and format of data to be transferred between the ACE GS and the ASC.

6.2 General File Format

The general file format includes the file naming convention and the file format definition.

6.2.1 File Naming Convention

The file naming convention is based on the CCSDS format standard. The general file name used for transfer of data products between the ACE GS and the ASC is as follows:

ACE_Giii**_**ttt**_**yyyy**-**ddd**T**hh**-**mm**-**ss**Z_V**nn**.**uuuu**.**

where:

Giii	= group identification
ttt	= product type
yyyy-dddThh-mm-ss	= Product Generation Date, defined as: year, day of year, hour, minute, second
nn	= version number of product
uuuu	= file suffix

The characters denoted in **bold** must be entered as shown, the remaining fields are variable and are defined in the following subsections. Additions or changes to this naming convention are discussed under *specific format descriptions*, found within the section for each application layer functional area.

6.2.1.1 Group Identification

The group identification provides the instrument/organization generating the product. The allowed values for this field are as follows:

iii =	SEP	(SEPICA)
	SWC	(SWICS)
	SWM	(SWIMS)
	SWI	(SWEPAM ION)
	SWE	(SWEPAM ELECTRON)
	SIS	(SIS)
	S3D	(S3DPU)
	ULI	(ULEIS)
	EPM	(EPAM)
	MAG	(MAG)
	CRI	(CRIS)
	ASC	(Product from ASC to IMOC)
	MOC	(Product from IMOC to ASC)
	001	(Used to denote DPF products)

6.2.1.2 Product Type

The product type field is used to specify the type of product. The allowed values are:

ttt =	CCR	Clock Calibration Report
	SOR	Spacecraft Operations Report
	ANR	Anomaly Report
	VAL	Validation Report
	QLP	Quick Look Product
	LZP	Level Zero Product
	NTR	Nutation Report
	AOR	Attitude and Orbit State Report
	SAP	Science Activity Plan
	ICF	Instrument Command File (embedded in SAP)
	PRC	STOL Procedure (embedded in SAP) See section 6.4.1.7 for rules

6.2.1.3 Product Generation Date

The product generation date is used to specify the earliest time of the data contained in the file. All dates and times for ACE data are in given as a date in coordinated Universal Time Code (UTC). The format of the product generation date is provided in Section 6.2.1. The hour, minutes and seconds are delimited by dashes (-) instead of colons (:) in the file naming convention to ensure compatibility of file names with personal computer operating systems (i.e., DOS, Windows, Mac OS).

yyyy:	Four digit year. (e.g. 1995,2000)
ddd:	Three digit day in the range 001-366
hh:	Two digit hour in the range 00-23
mm:	Two digit minutes in the range 00-59
ss:	Two digit seconds in the range 00-59

6.2.1.4 Version Number

The version number is used to identify a specific version of a file when more than one version of the file exists for a given day and time period.

nn: Two digit version in the range 00-99

6.2.1.5 File Suffix

The file suffix is used to differentiate between data products and the IMOC/DPF header file. The following are the file extensions:

uuuu: DATA (for all data products except DPF)
SFDU (for IMOC/DPF header files)
DAT1 (IMOC/DPF data products)

6.2.1.6 File Extension Examples

Several examples of file names are shown below:

The following is an example of a Science Activity Plan from the ASC;
ACE_GASC_SAP_1995-001T01-02-04Z_V00.DATA

The following is an example of an attitude and orbit state report from the ADF;
ACE_GMOC_AOR_1995-001T01-02-04Z_V00.DATA

The following is an example of a level Zero DATA file from the DPF;
ACE_G001_LZP_1995-091T01-02-04Z_V00.DAT1

The following is an example of a Quick Look SDFU file from DPF;
ACE_G001_QLP_1995-031T01-02-04Z_V00.SFDU

6.2.2 File Format Definition

In general, the file format definition uses the Parameter Value Language (PVL). Some files contain binary data or American Standard Code for Information Interchange (ASCII) text without PVL headers. Additions or changes to the PVL are discussed under *specific format descriptions*, found within the section for each application layer functional area.

6.2.2.1 General PVL Format Description

The file contents follows the PVL standard as defined by the CCSDS PVL Standards guide. Each file consists of a header and an optional data section. Data sections may be repeated within the same file. The general syntax is:

PVL Keyword = Value;

All keyword statements are terminated by a semi-colon. The general layout of the *keywords* are defined below. Additional keywords are defined within the format description for each data product. The general format for a file using PVL is:

```
BEGIN_GROUP = HEADER;
      KEYWORDA = VALUE;
      KEYWORDB = VALUE;
END_GROUP = HEADER;
BEGIN_GROUP = cccccccc;
      KEYWORDA = VALUE;
      KEYWORDC = VALUE;
END_GROUP =    cccccccc;
BEGIN_GROUP = dddddd;
      KEYWORDD = VALUE;
      KEYWORDB = VALUE;
END_GROUP =    dddddd;
```

Within the body of the PVL text a comment field can be inserted as follows:
/* represents a comment within the body of a file*/
A carriage return that is not preceded by a semicolon is interpreted as a continuation of a line.

6.3 Real-Time Command and Control Function File Format

The products generated by the RTCCF follow the general file naming and format conventions. The spacecraft operations and anomaly reports are both ASCII reports without PVL keywords.

6.3.1 Clock Calibration Report

The clock calibration report provides the conversion factors needed to calculate a calibrated spacecraft time (UTC) based on spacecraft clock counter (ticks). The clock calibration function will be contained in an off-line utility and executed in the IMOC/RTCCF on a daily basis. The calibration algorithm will use coincident observations of the spacecraft clock counter and the ground received time at the tracking station. The ground time will be corrected for transmission and equipment delay and then correlated with the spacecraft clock counter to determine the relationship between a spacecraft count and a time as measured by the ground clock. The results of this linear regression analysis will be a daily slope and offset relating the number of elapsed counts since the spacecraft epoch to the number of elapsed seconds as measured by the ground station clock. This slope and offset will correct the spacecraft counter for clock error. The number of elapsed seconds from the spacecraft clock epoch will then yield a calibrated spacecraft time.

The clock calibration report will be updated daily by the RTCCF clock calibration utility. A separate clock calibration report will be generated for each Command and Data Handling Unit (C&DH). The clock calibration report will contain the computed slope and offset relating the current spacecraft clock counter to seconds based on the ground station clock, the current spacecraft epoch, the beginning value (C initial) and end value (C final) that the clock calibration is valid, and the calendar year/day of year that the regression was derived. The format of the clock calibration report is as follows:

```
BEGIN_GROUP=HEADER;
        FILENAME=ACE_GMOC_CCR_1997-300T00-00-00Z_V01.DATA
        CDH=A;
        DATE_CREATED=1997-301T15:27:30Z;
END_GROUP=HEADER;
BEGIN_GROUP=Daily_Clock_Calibration_Record;
/* Daily Linear Regression Equation relating spacecraft      */
/* counts to seconds from spacecraft epoch:                  */
/*   T =  C * SLOPE + OFFSET                                 */
/*   Where T = elapsed seconds from s/c epoch                */
/*           C = observed s/c time count                     */
/*           SLOPE = slope of regression line                */
/*           OFFSET = y intercept of regression line         */
/*   The regression solution is derived from s/c time        */
/*   count observations from DAY_OF_YEAR/PRODUCT_YEAR.       */
/*   This regression equation will be used by the ACE/IMOC */
/*   to process spacecraft telemetry data with a s/c time  */
/*   count between C_INITIAL and C_FINAL corresponding     */
/*   to 00:00:00Z of DAY_OF_YEAR +1 to 23:59:59Z of         */
/*   DAY_OF_YEAR +1.  The spacecraft_EPOCH is the time      */
/*   when the ACE spacecraft clock was turned on.           */
     PRODUCT_YEAR=1997;
     DAY_OF_YEAR=300;
     C_INITIAL=250000;
     C_FINAL=336399;
     SLOPE-1=4.56E-04;
     OFFSET=0.56E-04;
     SPACECRAFT_EPOCH=1996-120T12:15:36.333Z;
END_GROUP=Daily_Clock_Calibration_Record;
```

6.3.2 Spacecraft Operations Report

The FOT will execute a procedure at the end of every real-time DSN contact to consolidate the following information for delivery to the ASC:

a) Command Summary Report
b) Limit Violation File
c) Actual Acquisition of Signal (AOS) and Loss of Signal (LOS) of the DSN real-time contact
d) Predicted AOS and LOS of the next scheduled DSN contact
e) Predicted schedule for the next orbit/attitude maneuver
f) Special spacecraft events that may impact science data capture

The format of this file will consist of ASCII text. The physical layout of the file will be provided after the above reports are further defined.

6.3.3 Anomaly Report

The FOT will generate an anomaly report following real-time passes. This report will be used to document unusual events encountered during spacecraft data processing. The Operations Manager will be responsible for closing out all in-flight anomalies. The anomaly report will be delivered to the ASC as required when a processing anomaly occurs that may impact science operations. The format of this file will be ASCII text; however, the physical layout of the data has not been determined. The general contents of the anomaly report are described below:

1) Anomaly Number (assigned by the FOT)
2) Year, Day of year and UTC
3) Report Status (Open/Closed)
4) Originator of Report
5) Contact Number of Anomaly
6) DSN station in contact
7) Anomaly Title
8) Spacecraft subsystem, instrument, or ground system involved
9) Supporting Documentation
10) Limit violations or other event messages
11) Detailed anomaly description
12) Description of action in response to anomaly
13) Description of known impacts
14) Description of anomaly resolution (if known)
15) Author of Anomaly Report
16) Approval
17) Approval Date

Start here

6.4 Mission Planning Function File Format

The IMOC/MPF provides data analysis capabilities needed for spacecraft scheduling, maneuver support, and spacecraft control. The MPF typically operates in an off-line mode between real-time passes, and provides prediction, command load generation, and resource scheduling. The MPF receives the Science Activity Plan (SAP) from the ASC, processes it, and transmits a validation report back to the ASC.

6.4.1 Specific Format Description

The products generated and received by the IMOC/MPF follow the general PVL standards described in Section 6.2 with the following additional keywords and definitions:

KEYWORD	DESCRIPTION
INSTRUMENT	Instrument name.
WORKSTATION	Workstation name.
ORIGINATOR	Person originating file.
DATE_CREATED	Date file was created.
NUM_CMDS	Number of commands specified.
NUM_BYTES	Number of bytes in data section of file.
COMMAND	Specifies a command mnemonic.
EARLIEST,LATEST	Specifies the earliest and latest times for the data to be uplinked.
UUFILENAME	UUENCODED file name.
FILENAME	Name of source file
COMMENT	Arbitrary comments

The MPF files nominally contain a header group followed by one or more data groups. The keyword layout for the mission planning files is illustrated below. The valid language types for each keyword are enclosed in <brackets>, and are described in subsections 6.4.1.1 through 6.4.1.7. Note that some keywords are optional.

```
BEGIN_GROUP=HEADER;                          (required)
      FILENAME=<File>;                       (required)
      WORKSTATION=<String>;                  (optional)
      ORIGINATOR=<String>;                   (optional)
      DATE_CREATED=<Date>;                   (optional)
      COMMENT=<String>;                      (optional)
END_GROUP=HEADER;                            (required)
```

To define an ACTIVITY, the following syntax is used. Within an ACTIVITY group, at least one object must be defined. Required fields for that object must be specified.

```
BEGIN_GROUP=ACTIVITY;                        (required)
      EARLIEST=<Date>;                       (required)
      LATEST=<Date>;                         (required)
      INSTRUMENT=<Instrument>;               (required)
      BEGIN_OBJECT=BINARY_LOAD;              (required)
        UUFILENAME=<File>;                   (required)
        NUM_BYTES=<Integer>;                 (required)
        ***Embedded UUENCODED FILE is inserted here***
      END_OBJECT=BINARY_LOAD;                (required)

      BEGIN_OBJECT=STOL_PROCEDURE;           (required)
        UUFILENAME=<File>;                   (required)
        NUM_BYTES=<Integer>;                 (required)
        ***Embedded UUENCODED STOL PROCEDURE is inserted here***
      END_OBJECT=STOL_PROCEDURE;

      BEGIN_OBJECT=PDB_COMMAND;
        NUM_CMDS = <Integer>;                (required)
        COMMAND=<Mnemonic>;                  (required)
      END_OBJECT=PDB_COMMAND;                (required)
END_GROUP=ACTIVITY;                          (required)
```

6.4.1.1 Label Type

The label type is an alphanumeric string (upper and lowercase characters and numbers) which may contain underscores, but may not contain blank spaces or a dash (-). Label types are not enclosed in quotes. Examples of valid label types are: Science_Activity_Plan, or SAP_1. Invalid label types are: -SAP_1, or SAP 1.

6.4.1.2 Instrument Type

An instrument type is a specialized label type for denoting one of the ACE science instruments. Instrument types are restricted to the following values:

Label	Instrument
SEP	(SEPICA)
SWC	(SWICS)
SWM	(SWIMS)
SWI	(SWEPAM ION)
SWE	(SWEPAM ELECTRON)
SIS	(SIS)
S3D	(S3DPU)
ULI	(ULEIS)
EPM	(EPAM)
MAG	(MAG)
CRI	(CRIS)

6.4.1.3 String Type

A string type is any ASCII text enclosed between double (" ") quotation marks. A string type is nominally used for adding explanatory text. Embedded double quotation marks are not allowed. If text needs to be quoted within a string, the single quote (' ') is to be used.

6.4.1.4 Date Type

A date type is also a specialized label type used to denote a date and is in the following format:

yyyy-dddThh:mm:ss.MMMZ,
where:

yyyy	4 Digit Year (eg. 1995)	(required)
ddd	3 Digit Day (001- 366)	(required)
hh	2 Digit Hour in the range 00-23	(optional)
mm	2 Digit Minutes in the range 00-59	(optional)
ss	2 Digit Seconds in the range 00-59	(optional)
MMM	3 Digit milliseconds in the range [000-999]	(optional)

Some examples of valid date types are: 1998-026T18:30:00Z, 1998-026T18:30:00.114Z or 1998-026 .

6.4.1.5 Integer Type

An integer type consists of any combination of the following string: [0 1 2 3 4 5 6 7 8 9].

6.4.1.6 Mnemonic Type

A mnemonic type is a special label type used to denote instrument command mnemonics defined in the ACE Project Database (PDB).

6.4.1.7 File Type

A file type is another special case of a label type used to denote the SAP file name. The valid MPF file names are as follows:

ACE_GASC_SAP_yyyy-ddd**T**hh-mm-ss**Z_**Vnn.**DATA,** or

ACE_Giii_ICFxxxxxxxxxxxxx.**DATA**: Embedded Command File

ACE_Giii_PRCxxxxxxxxxxxx.**DATA** Embedded STOL Procedure

Where iii is an <instrument> type, xxxxxxxxxx, is any valid string allowed as a UNIX filename.

6.4.1.8 Group and Object Types

A group or object type is a specialized label for delimiting a section of the ACE SAP. The following are valid group and object type values.

Group Types	Object Types
HEADER	BINARY_LOAD
ACTIVITY	STOL_PROCEDURE
	PDB_COMMAND

6.4.2 Validation Report

The validation report is sent from the IMOC/MPF to the ASC upon receipt of SAP. The validation report is an ASCII text file containing an echo of the input SAP, and a summary of processing status information. The exact contents and physical layout of the validation report are as follows.

MOC SCIENCE ACTIVITY PLAN VALIDATION REPORT

```
SAP VALIDATION REPORT:
ACE_GMOC_VAL_1998-028T16-27-30Z_V00.DATA

INPUT FILE:
ACE_GASC_SAP_1998-028T16-27-30Z_V00.DATA

PROCESS TIME:
     1998-067T15:49:55Z

SCIENCE ACTIVITITY PLAN STATISTICS:
             Total Number of Errors:    1
             Total Number of Warnings:  0
```

```
SCIENCE ACTIVITY PLAN VALIDATED INPUT DATA:

BEGIN_GROUP = HEADER;
   FILENAME = ACE_GASC_SAP_1998-028T16-27-30Z_V00.DATA;
   WORKSTATION=ASC_OPS1;
   ORIGINATOR="Tom Garrard";
   DATE_CREATED=1998-025T15:27:30Z;
   COMMENT="ASC Science Plan";
END_GROUP = HEADER;

BEGIN_GROUP= ACTIVITY;
   INSTRUMENT=SWC;          /* the abbreviation for SWICS */
   EARLIEST = 1998-025T16:27:30Z;
   LATEST = 1998-025T17:27:30Z;
   BEGIN_OBJECT=PDB_COMMAND;
     NUM_CMDS=3;
     COMMAND = HEATER1_ON;
     COMMAND = HEATER2_ON, TEMP=100.0;
     COMMAND = HEATER3_OFF;
     ERROR = Invalid command. Command HEATER3_OFF does not exist in PDB;
   END_OBJECT=PDB_COMMAND;

   BEGIN_OBJECT = STOL_PROCEDURE;
     NUM_BYTES=246;
     UUFILENAME=ACE_GSWC_PRCmyStolProcedure.DATA;
   END_OBJECT = STOL_PROCEDURE;

   BEGIN_OBJECT = BINARY_LOAD;
     NUM_BYTES = 300;
     UUFILENAME = ACE_GSWC_ICFmyinstrumentload.DATA;
   END_OBJECT = BINARY_LOAD;
END_GROUP = ACTIVITY;
```

6.4.3 Science Activity Plan

The SAP is used to transmit Project Database Instrument Commands, STOL procedures, and binary encoded instrument loads from the ASC to IMOC. The format of the SAP follows the PVL standard described in Section 6.4.1. A SAP will nominally begin with a header followed by one or more instrument activity groups. Within each instrument activity group, specific mnemonic commands, STOL procedures and/or an uuencoded binary instrument command loads may be included. Each section of the science plan is now discussed.

6.4.3.1 Activity Group

Within the Science Activity Plan, the activity group specifies the activities to be performed for a given instrument in a time period covered by the keywords, EARLIEST and LATEST. The EARLIEST keyword is used to specify the earliest time at which the activity may begin, and the LATEST keyword specifies the latest time. Execution of the activity is guaranteed to occur at some time between this interval. (The latest time must be >= earliest time.)

Within this group, three objects are allowed, BINARY_LOAD, STOL_PROCEDURE and PDB_COMMANDS. Each is described below.

6.4.3.2 Binary Load Object (Instrument Command File)

Instrument Command Files (ICF) may be included in the BINARY LOAD OBJECT group within the Science Activity Plan (SAP). ICFs are typically binary data (ASCII FORTH commands are also included in this group) destined for a particular instrument. To include ICFs in a SAP, the instrumenter must first encode the binary data, using the UNIX utility UUENCODE, then insert this encoded data into the BINARY_LOAD _OBJECT section of the SAP. In addition, the NUM_BYTES and UUFILENAME fields must be filled out with the number of bytes in the original file, and the corresponding filename, respectively. These fields are used in validating the decoded file to minimally ensure that the data transfer was successful. NOTE: Only one encoded file may be included within a given object definition.

The IMOC will then decode the file, and insert the corresponding data into the USER DATA portion of the data command. Using the INSTRUMENT keyword, the IMOC will place the appropriate User Select Number corresponding to the instrument into the data command.

NOTE: No interpretation of the data is assumed, the IMOC simply reads the ICF as stream data and inserts it into the USER DATA portion of the data command.

6.4.3.3 STOL Procedure Object (STOL Procedures)

STOL Procedures may be transferred to the IMOC much in the same way as ICF's. STOL procedures contain STOL directives or instrument commands that have been defined in the project database.

The STOL procedure is created, encoded as described in Section 6.4.3.2, and inserted into the STOL_PROCEDURE section of the SAP. The NUM_BYTES and UUFILENAME fields must also be filled out with the number of bytes in the uuencoded file, and the corresponding filename, respectively. These fields are used in validating the decoded file to minimally ensure that the data transfer was successful. Only one STOL file is allowed per definition of a STOL object.

The IMOC will extract the STOL procedure from the SAP, and will place it in a directory in the IMOC to be executed by the Flight Operations Team prior to the time specified by the LATEST keyword, and after the time specified by the EARLIEST keyword. There is no automated means of executing a STOL procedure.

6.4.3.4 PDB Command Object (PDB Instrument Commands)

Instrument commands that have been defined in the ACE Mission project database may be included in the PDB_COMMAND section of the SAP. Each command to be executed must be specified using the COMMAND keyword. The total number of commands appearing in this section must be specified using the NUM_CMDS keyword.

The IMOC will extract the commands, build the appropriate command load, and uplink at a time prior to the time specified by the LATEST keyword and after the time specified by the EARLIEST keyword.

6.4.3.5 Science Activity Plan Examples

SAP Example 1:

The following example shows a SAP for a science instrument containing only instrument command mnemonics from the PDB:

```
BEGIN_GROUP=HEADER;
     FILENAME=ACE_GASC_SAP_1998-028T16-27-30Z_V00.DATA;
     WORKSTATION=ASC_OPS1;
     ORIGINATOR="Tom Garrard";
     DATE_CREATED=1998-025T15:27:30Z;
END_GROUP=HEADER;
BEGIN_GROUP=ACTIVITY;
     INSTRUMENT=SWC;
     EARLIEST = 1998-025T16:27:30Z;
     LATEST = 1998-025T17:27:30Z;
     BEGIN_OBJECT=PDB_COMMAND;
       NUM_CMDS =3;
       COMMAND = HEATER1_ON;
       COMMAND = HEATER2_ON, TEMP=100.0;
       COMMAND = HEATER3_OFF;
     END_OBJECT=PDB_COMMAND;
END_GROUP=ACTIVITY;
```

SAP Example 2:

The following example shows a SAP containing a STOL procedure, Instrument Command File, and PDB mnemonics:

```
BEGIN_GROUP=HEADER;
     FILENAME=ACE_GASC_SAP_1998-025T16-27-30Z_V00.DATA;
     WORKSTATION=ASC_OPS1;
     ORIGINATOR="Tom Garrard";
     DATE_CREATED=1998-025T15:27:30Z;
     COMMENT="UUENCODED Instrument Information";
     COMMENT="STOL Procedure";
     COMMENT = "Along with other stuff";
END_GROUP=HEADER;
BEGIN_GROUP=ACTIVITY;
     INSTRUMENT=SWC;
     EARLIEST = 1998-025T16:27:30Z;
     LATEST = 1998-025T17:27:30Z;
     BEGIN_OBJECT=PDB_COMMAND;
          NUM_CMDS = 3;
          COMMAND = HEATER1_ON;
          COMMAND = HEATER2_ON, TEMP=100.0;
          COMMAND = HEATER3_OFF;
     END_OBJECT=PDB_COMMAND;
     BEGIN_OBJECT=BINARY_LOAD;
          UUFILENAME = ACE_GSWC_ICFmySWCload.DATA;
          NUM_BYTES=400;
          ***Embedded UUENCODED FILE is inserted here***
     END_OBJECT=BINARY_LOAD;
END_GROUP=ACTIVITY;
```

```
BEGIN_GROUP=ACTIVITY; /* ULI Activity */
      INSTRUMENT=ULI;
      EARLIEST = 1998-025T18:27:30Z;
      LATEST = 1998-025T19:27:30Z;
      BEGIN_OBJECT=PDB_COMMAND;
            NUM_CMDS = 3;
            COMMAND = HEATER1_ON;
            COMMAND = HEATER2_ON, TEMP=100.0;
            COMMAND = HEATER3_OFF;
      END_OBJECT=PDB_COMMAND;
      BEGIN_OBJECT=BINARY_LOAD;
            UUFILENAME = ACE_GULI_ICFmyULIload.DATA;
            NUM_BYTES=989;
            ***Embedded UUENCODED FILE is inserted here***
      END_OBJECT=BINARY_LOAD;
      BEGIN_OBJECT=STOL_PROCEDURE;
            UUFILENAME = ACE_GULI_PRCmyULIstolProc.DATA;
            NUM_BYTES=156;
            ***Embedded UUENCODED FILE is inserted here***
      END_OBJECT=STOL_PROCEDURE;
END_GROUP=ACTIVITY;
```

6.4.3.6 Science Activity Plan Electronic Mail

Science Activity Plans will be encrypted and signed using the Pretty Good Privacy (PGP) software package. The encrypted and signed Science Activity Plans will be placed as an attachment to the Electronic Mail Message. The maximum length of an electronic mail message is 200 kilobytes.

6.5 Data Processing Function File Format

The DPF will provide Level Zero processing for the ACE IMOC. The DPF will produce two data products for the ASC; the Science Routine Production data set file and the Science Quicklook data set file. All the data received from the acquisition sessions that occurred within a 24 hour period is merged into a Science Routine Production data set file. The Science Routine product will be available to the ASC within 10 days. The Science Quicklook product shall contain all or a subset of the data received in a single ground acquisition session. Data will be available forward-ordered, but are not merged with data received in other acquisition sessions. Quicklook files are available to the ASC within 3 hours after the DPF receives the last packet of the session for prenegotiated data sets, and within 3 hours after DPF receives a contingency request for Quicklook data.

6.5.1 Specific DPF Definitions

There are certain definitions that are critical to understanding the DPF. These definitions are described in the following subsections.

6.5.1.1 Source Identifier

Source Identifier (SRCID)[Pseudo Application Process Identifier (APID)] - DPF uses the SRCID to identify the source supplying the time and sequence count stamped on each packet. ACE source sequencing is dependent on the source Command and Data Handling Unit (C&DH) and downlink mode. This results in four independent sources of data sequencing. An ACE "SRCID" will consist of the 2 bit C&DH ID followed by a 1 bit playback/real-time flag. The four valid ACE SRCIDs are:

3 BIT SRCID	DESCRIPTION
010 = 2	C&DH A Real-time
011 = 3	C&DH A Playback
100 = 4	C&DH B Real-time
101 = 5	C&DH B Playback

6.5.1.2 Format Identifier

Format Identifier (FMID) [Pseudo Virtual Channel Identifier (VCID)] - DPF uses FMID to select data for inclusion in products. The nine valid FMIDs for ACE are listed below. Not all of the valid FMID listed are projected for product inclusion at the writing of this document.

4 BIT FMID	DESCRIPTION
0001 = 1	Science
0010 = 2	Attitude Determination & Correction (ADC)
0011 = 3	C&DH Memory Dump
0100 = 4	C&DH Bin Dump
0101 = 5	Low Rate Housekeeping
0110 = 6	Low Rate ADC
0111 = 7	Low Rate Memory Dump
1000 = 8	Low Rate Bin Dump
1001 = 9	Real Time Solar Wind (RTSW)

6.5.1.3 Byte Ordering

The bits and bytes are ordered from left to right, Most Significant Byte, Most Significant bit, to Least Significant Byte, Least Significant bit as shown in Figure 6-1. Bit numbering goes from 1 to 8, right to left.

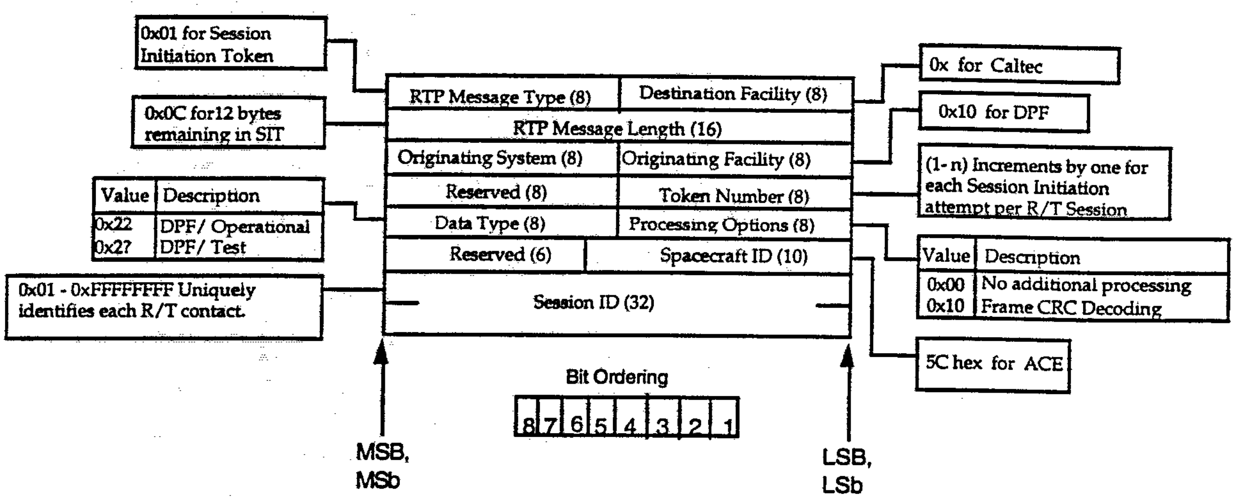


Figure 6-1. Byte Ordering

6.5.2 Science Routine Production Data Product

The DPF will generate Production Data Set Files based on 24 hours of acquired science data generated by the ACE spacecraft. Unless otherwise requested, ASC will receive FMIDs (1-4) from SRCIDs (2-3). Generation of the Science Routine data files will begin after all the data contained within the 24 hour time frame has been received. Data set generation will occur automatically if the data received exceeds the percentage of missing data threshold (90% - configurable). Figure 6-2 presents an ASC Science Routine Data Set File. There will be one detached Standard Format Data Unit (SFDU) header for each file.

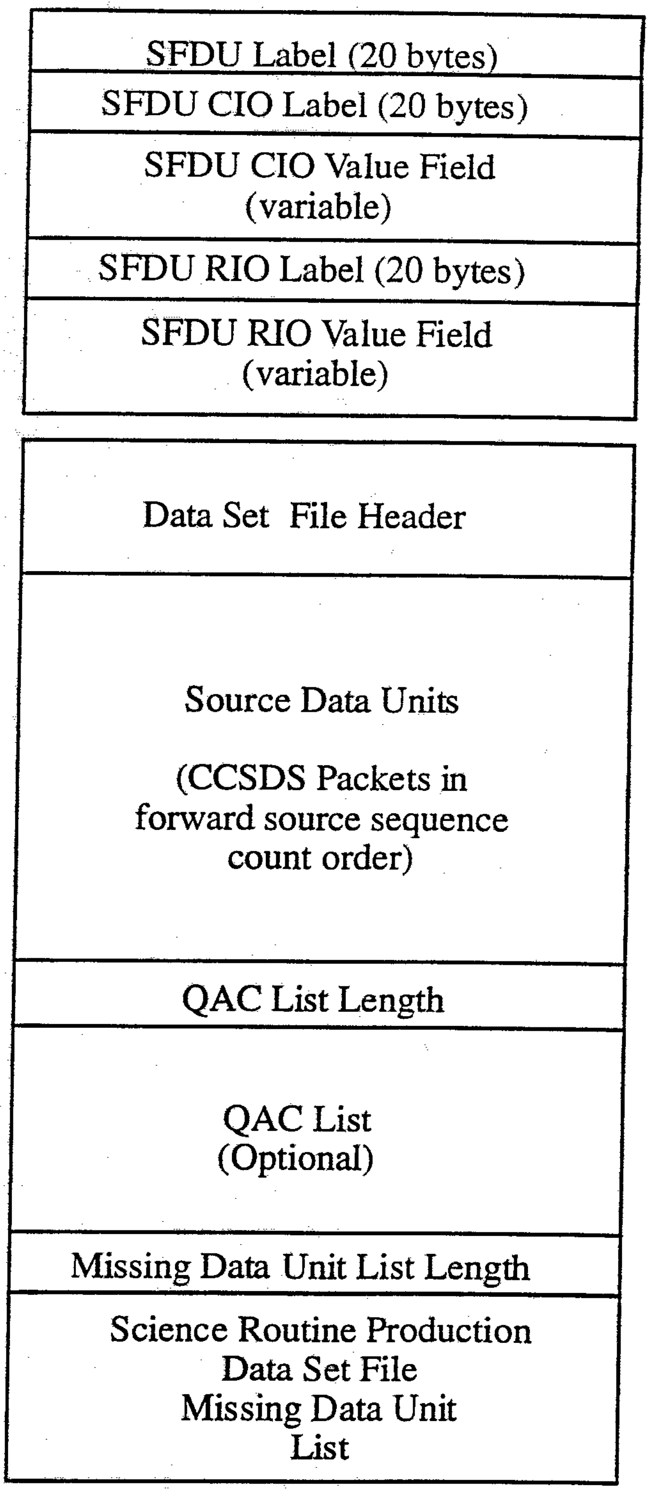


Figure 6-2. ASC Science Routine Production Data Set File

Figure 6-3 shows a sample SFDU header. The SFDU is defined in Section 6.5.2.1. Each production data file created by the DPF will contain a file header, followed by data packets received during a 24 hour period, sorted and merged. The packets are placed into forward time order, with redundant data deleted. (Note: Two packets are considered redundant if they have the same spacecraft time, sequence count, format ID, and source ID). If a real-time and playback packet from the primary C&DH contain the same time stamp, then the two packets source ID and format ID are used to determine which packet to include in the product and which packet to discard. The following hierarchy identifies the preferred packet:

1. (Highest Preference) Playback packet with science, memory dump, or bin dump format ID.
2. Real-time packet with science, memory dump, or bin dump format ID.
3. Playback packet with ADC format ID.
4. (Lowest Preference) Real-time packet with ADC format ID.

The optional Quality Accounting Capsule (QAC) list will be included for the Science Routine product. The QAC is defined in Section 6.5.2.1.3.1. There will also be a Missing Data Unit List (MDUL) at the end of any Routine Production file with data gaps. The MDUL will describe the location and size of any data gaps within the Science Routine Production Data Product. A missing packet is reported for any one second spacecraft time interval not represented in the product. The MDUL is defined is Section 6.5.2.1.3.2.

```
CCSD1Z000001000005 34NSSD1K00006000000384
     PROJECT = "ACE>Advanced Composition Explorer"
     DISCIPLINE = "Space Physics>Interplanetary Studies";
     SOURCE_NAME = "ACE>Advanced Composition Explorer";
     DATA_TYPE = "LZ>Level-Zero";
     DESCRIPTOR = "G001>SRCID01";
     START_DATE = 1995-039T15:24:31Z;
     STOP_DATE = 1995-039T15:24:44Z;
     DATA_VERSION = 1;
     GENERATION_DATE =  1995-052T12:37:37Z;
     FILE_ID = ACE_G001_LZP_1995-039T15-24-31Z_V01;
     CCSD1R00000300000011
     REFERENCETYPE = ($CCSDS2);
     LABEL = NSSD3IE0Z33300000001;
     REFERENCE = (ACE_G001_LZP_1995-039T15-24-31Z_V01.DAT1);
```

Figure 6-3. Sample SFDU Header

6.5.2.1 Science Routine Production Formats

The Production Data Products are formatted as flat files. The following paragraphs describe the formats of the data, and specify fields and their contents within these files.

The following types of data items are transferred across the data interface from the ACE IMOC to the ASC:

a. SFDU. Consists of standard labels that uniquely identify and link a data set file to its description. The SFDU is referred to as the Detached SFDU Header.

b. Data Set Files. Elements of a data product transferred in file format.

ASC will receive one SFDU file and one data set file per transfer.

6.5.2.1.1 Detached SFDU Header

The Detached SFDU Header consists of three Label Value Objects (LVO): an SFDU Exchange Data Unit (EDU) Label, a Contents Identifier Object (CIO), and a Reference Identifier Object (RIO). Figure 6-4 shows the structure of the Detached SFDU Header, and the following paragraphs describe the contents and format of the fields.

SFDU EDU Label (20 Bytes)
SFDU Contents Identifier Object Label (20 Bytes)
SFDU Contents Identifier Object Value Field (variable)
SFDU Reference Identifier Object Label (20 Bytes)
SFDU Reference Identifier Object Value Field (variable)

Figure 6-4. Detached SFDU Header

6.5.2.1.1.1 SFDU EDU LVO

The SFDU EDU LVO label field identifies the Detached SFDU Header as an SFDU with multiple LVOs. The subfields in the EDU Label are shown in Figure 6-5 and described as follows:

a. Control Authority ID. A 4-byte ASCII subfield specifying the control authority. CAID = CCSD for CCSDS.
b. Version ID. A 1-byte ASCII subfield indicating the delimitation option. Version ID = 1.
c. SFDU Class ID. A 1-byte ASCII subfield identifying the label. For Exchange Data Unit, this value = Z.
d. S1. A 1-byte (ASCII) subfield indicating the delimitation ID for Version ID. S1 = 0 for version ID 1.
e. S2. A 1-byte (spare) subfield, always = 0.
f. Data Description ID. A 4-byte (ASCII) subfield, contains a value of 0001 to specify an EDU.
g. Delimitation Parameter. An 8-byte ASCII subfield containing the delimitation parameter: this is the byte length in ASCII (including line feeds) of the remainder of this LVO.

Control Authority ID (4 Bytes)	
Version ID (1 byte)	SFDU Class ID (1 byte)
S1 (1 byte)	S2 (1 byte)
Data Description ID (4 Bytes)	
Delimitation Parameter (8 Bytes)	

Figure 6-5. SFDU EDU Label

6.5.2.1.1.2 SFDU CIO LVO

The Content Identifier Object (CIO) carries parameters provided by the DPF to manage the associated data files. The SFDU CIO label field identifies the SFDU CIO. The subfields in the SFDU CIO label are shown in Figure 6-6 and described as follows:

a. Control Authority ID. A 4-byte ASCII subfield specifying the control authority. CAID = NSSD for NSSDC.
b. Version ID. A 1-byte (ASCII) subfield indicating the delimitation option. Contains a value of 1.
c. SFDU Class ID. A 1-byte (ASCII) subfield identifying the label. For EDU, this value = K for catalog data.
d. S1 = 0 for version ID of 1.
e. S2. A 1-byte (spare) (ASCII) subfield, set to 0.
f. Data Description ID. A 4-byte (ASCII) subfield to specify a CIO assigned by National Space Sciences Data Center (NSSDC) to specify an ACE CIO. DDID = 0060.
g. Delimitation Parameter. An 8-byte (ASCII) subfield containing the delimitation parameter: this is the byte length in ASCII (including line feed) of the remainder of this LVO.

Control Authority ID (4 Bytes)	
Version ID (1 byte)	SFDU Class ID (1 byte)
S1 (1 byte)	S2 (1 byte)
Data Description ID (4 Bytes)	
Delimitation Parameter (8 Bytes)	

Figure 6-6. SFDU CIO Label

The SFDU CIO value field contains the parameters used to describe the data products being transferred between the IMOC and the ASC. The fields are described in PVL, and are delimited by semicolons. A sample SFDU CIO value field is depicted in Figure 6-7.

A general set of parameter names for the CIO has been derived from the *Directory Interchange Format Manual,* Version 3.0, December 1990, NASA GSFC NSSDC. These have been supplemented with the additional parameters needed to fully describe the data files. Some parameters may have multiple values (e.g., both a short name and a long name). In these cases, the values are separated by a >. The following are valid parameters for an ACE CIO. Required parameters are marked as such.

1. PROJECT (optional).
2. DISCIPLINE (required).
3. SOURCE_NAME (required).
4. DATA_TYPE (required).
5. DESCRIPTOR (required).
6. START_DATE/STOP_DATE (required).
7. DATA_VERSION (required)
8. GENERATION_DATE (optional).
9. FILE_ID (optional).
10. BEGIN_GROUP (optional).

```
PROJECT="ACE>Advanced Composition Explorer";
DISCIPLINE="Space Physics>Interplanetary Studies";
SOURCE_NAME="ACE>Advanced Composition Explorer";
DATA_TYPE="LZ>Level-zero";
DESCRIPTOR="G001>SRCID01";
START_DATE=1994-099T00:00:05Z;
STOP_DATE=1994-099T07:33:26Z
DATA_VERSION=1;
GENERATION_DATE= 1994-100T00:19:01Z;
FILE_ID=ACE_G001_LZP_1994-099T16:01:00Z_V01;
BEGIN_GROUP=REFDES;
REF_FILE=ACE_G001_LZP_1994-099T00-00-05Z_V01.DAT1;
START_DATE=1994-099T00:00:05Z;
STOP_DATE=1994-099T02:12:37Z;
REF_FILE=ACE_G001_LZP_1994-099T00-00-05Z_V01.DAT2;
START_DATE=1994-099T02-12-56Z;
STOP_DATE=1994-099T04-10-23Z;
REF_FILE=ACE_G001-LZP_1994-099T00-00-05Z_V01.DAT3;
START_DATE=1994-099T04:10:33Z;
STOP_DATE=1994-099T06:34:58Z;
REF_FILE=ACE_G001_LZP_1994-099T00-00-05Z_V01.DAT4;
START_DATE=1994-099T06:35:04Z;
STOP_DATE=1994-099T07:33:26Z;
END_GROUP=REFDES;
```

Figure 6-7. SFDU CIO Value Field

6.5.2.1.1.2.1 ELEMENT DEFINITIONS

NAME = PROJECT (optional).
The PROJECT parameter identifies the name of the project. Both a short and a long name are provided. This string must be enclosed in double quotes (").

Example 1:

PROJECT = "ACE>Advanced Composition Explorer";

NAME = DISCIPLINE (required).
The DISCIPLINE parameter describes the science discipline and subdiscipline. This string must be enclosed in double quotes (").

Example 2:

DISCIPLINE = "Space Physics>Interplanetary Studies";

NAME = SOURCE_NAME (required)
The SOURCE_NAME parameter identifies the mission or investigation that contains the sensors. This string must be enclosed in double quotes ("). Both a long name and a short name are provided with the short name portion listed first.

Example 3:

SOURCE_NAME = "ACE>Advanced Composition Explorer";

NAME = DATA_TYPE (required).
The DATA_TYPE parameter identifies the data type of the data file associated with the CIO. Both a long name and a short name are given with the short name portion listed first. This string must be enclosed in double quotes ("). The following are valid values:
Data_type = LZ>Level-zero
= QL>QUICKLOOK

Example 4:

DATA_TYPE = "LZ>Level-zero";

NAME = DESCRIPTOR (optional).
The DESCRIPTOR parameter supplies the group identifier and source identifier associated with every file. The short portion of this parameter is the group identifier and the long descriptor provides all of the SRCIDs used in creating the specified file. If a given group specifies more than 1 SRCID, a value of SRCID_MULTI is used.

Example 5:

DESCRIPTOR = "G001>SRCID3";
DESCRIPTOR = "G026>SRCID_MULTI";

NAME = START_DATE (required).
The START_DATE parameter contains the first date and time of the data associated with the SFDU. Dates and times are specified in a form compatible with ISO 8601 and CCSDS Recommendation CCSDS 301.0-B-2 (Time code formats) and CCSDS 641.0-B-1 (PVL specification). All dates and times for ACE data are given as a date in coordinated UTC. This is indicated by the Z following the time field. Times are given to seconds. In the case where the SFDU references multiple data files, the start times in the CIO represent the earliest start times for the data files in the group.

Example 6:

START_DATE = 1994-082T13:05:22Z;

NAME = STOP_DATE (required)
The STOP_DATE parameter contains the last date and time of the data associated with the SFDU. Dates and times are specified in a form compatible with ISO 8601 and CCSDS Recommendation CCSDS 301.0-B-2 (Time code formats) and CCSDS 641.0-B-1 PVL specification. All dates and times for ACE data are given as a date in coordinated UTC. This is indicated by the Z following the time field. Times are given to seconds. In the case where the SFDU references multiple data files, the stop times in the CIO represent the latest times for the data files in the group.

Example 7:

STOP_DATE = 1994-082T23:59:45Z;

NAME = DATA_VERSION (required)
The DATA_VERSION parameter indicates the version of the data file or data file group associated with this SFDU. DATA_VERSION starts at 1 and is incremented for each subsequent generation of the data.

Example 8:

DATA_VERSION = 2;

NAME = GENERATION_DATE (optional).
The GENERATION_DATE parameter contains the date and time for the generation of the data. For data files generated by the DPF, this is the date and time of creation by DPF. Dates and times are specified in a form compatible with ISO 8601. All dates and times for DPF data are given as a date with UTC time. This is indicated by the Z following the time field. Times are given to seconds.

Example 9:

GENERATION_DATE = 1993-163T14:25:27Z;

NAME = FILE_ID (optional)
The FILE_ID parameter identifies the SFDU and the data file or data file group associated with the SFDU. Both the SFDU and the data files in the group should have this parameter incorporated internally (the SFDU as part of the CIO and the data files as part of their embedded metadata). The DPF convention for naming data files and SFDUs is to give data files and SFDU files the same filename with different extensions. FILE_ID serves as a mechanism independent of the physical filename to associate an SFDU with a particular data file.

Example 10:

FILE_ID = ACE_G001_LZP_1994-099T16-01-00Z_V01;

The FILE_ID would identify the following physical files as belonging to the same group:

ACE_G001_LZP_1994-099T16-01-00Z_V01.SFDU
ACE_G001_LZP_1994-099T16-01-00Z_V01.DAT1

6.5.2.1.1.3 SFDU RIO LVO

The SFDU RIO is made up of the SFDU RIO label and the SFDU RIO value field. All the parameters in these fields are inserted in variable byte-size records. The format of the SFDU RIO Label and the contents therein are shown in Figure 6-8 and described as follows:

a. Control Authority ID. A 4-byte (ASCII) subfield specifying the control authority. For example, CCSD (CCSDS Secretariat controlled).
b. Version ID. A 1-byte (ASCII) subfield indicating the delimitation option. Contains a value of 1.
c. SFDU Class ID. A 1-byte (ASCII) subfield identifying the label. For Replacement Service Object, this value = R.
d. S1. A 1-byte (ASCII) subfield = 0.
e. S2. A 1-byte subfield (spare) = 0.
f. Data Description ID. A 4-byte (ASCII) subfield, contains a value of 0003 to specify the referencing LVO.
g. Delimitation Parameter. An 8-byte (ASCII) subfield containing the delimitation parameter: this is the byte length in ASCII (including line feed) of the remainder of this LVO.

Control Authority ID (4 Bytes)	
Version ID (1 byte)	SFDU Class ID (1 byte)
S1 (1 byte)	S2 (1 byte)
Data Description ID (4 Bytes)	
Delimitation Parameter (8 Bytes)	

Figure 6-8. SFDU RIO Label

The SFDU RIO value field contains the parameters used to list the data products being transferred between the DPF and the ASC. The fields are described in PVL, and are delimited by semicolons. Figure 6-9 is an example of the RIO value field for an ACE mission data product. The following parameters are used in all the RIOs as well as the values specific for the example:

a. REFERENCE TYPE. Identifies the type of reference object, defining the reference system. It determines the format of the REFERENCE parameter. DPF uses values of CCSDS0 and CCSDS2. CCSDS0 indicates an environment requiring multiple file names of different file naming conventions referencing the same file. CCSD2 denotes long filename(s) that are provided by the DPF. The second example in Figure 6-8, includes four files, each of which may be referred to by either of two names. The file name of the ***$1*** form follows the 8.3 file naming convention and the ***$2*** file names are the long filename(s) that are provided by the DPF (ACE uses only CCSDS2).

b. LABEL. The LABEL parameter indicates what the label for the data object would have been if the data had been attached to this SFDU. It also identifies where the data set files end and describes where the definition for the data object is registered.

c. REFERENCE. Identifies the files associated with the detached SFDU Header. To denote more than one file, the identifiers are separated by commas. The value of the REFERENCE parameter is always enclosed in parentheses. If the value of the REFERENCETYPE parameter is CCSDS2, only the long filename(s) are provided (see the first example in Figure 6-9). If the value of the REFERENCETYPE parameter is CCSDS0, the multiple file names are provided for each file. In this case, the file naming convention used is supplied by preceding the filename with either ***$1=*** for the 8.3 file naming convention, or ***$2=*** for the long filename convention. The names of each file are separated by commas and enclosed in double quotes (see the second example in Figure 6-9).

```
EXAMPLE 1

REFERENCETYPE=($CCSDS2);
LABEL=NSSD31E0134700000001;
REFERENCE=(ACE_G01_LZP_1994-099T00-00-05Z_V01.DAT1);

EXAMPLE 2

REFERENCE TYPE=CCSDS0;
LABEL=NSSD31E0134700000001;
REFERENCE=("$1=40990101.D01,$2=ACE_G001_LZP_1994-099T00-00-05Z_V01.DAT1",
"$1=40990201.D02,$2=ACE_G001_LZP_1994-099T00-00-05Z_V01.DAT2",
"$1=40990301.D03,$2=ACE_G001_LZP_1994-099T00-00-05Z_V01.DAT3",
"$1=40990401.D04,$2=ACE_G001_LZP_1994-099T00-00-05Z_V01.DAT4");
```

Figure 6-9. Two SFDU RIO Value Field Examples

6.5.2.1.2 Data Set Files

A data set file consists of a Data Set File Header, a unique data set and quality and accounting information for errored source data units. The format of the file is depicted in Figure 6-10. One Detached SFDU Header may reference multiple data set files. In order to avoid ambiguity, all unused bits contain a value of 0. A bit that has been set contains a value of 1.

SFDU EDU Label (20 Bytes)
SFDU CIO Label (20 Bytes)
SFDU CIO Value Field (Variable)
SFDU RIO Label (20 Bytes)
SFDU RIO Value Field (Variable)

Data Set File Header
Source Data Units
QAC List Length
QAC List
Missing Data Unit List Length
Missing Data Unit List

Figure 6-10. Data Set File

6.5.2.1.2.1 Data Set File Headers

Each data set file begins with a Data Set File Header. Figure 6-11 shows the format of the Data Set File Header and the following paragraphs describe the contents of the fields (refer to the figure for the correct ordering of the fields):

a. Reserved. A 6-bit field reserved to maintain byte boundaries.

b. Spacecraft ID (SCID). A 10-bit field containing the source SCID.

c. Spacecraft Clock: First Data Unit With Valid Spacecraft Time. A 32-bit binary field non-CCSDS compatible Time Code is used for ACE.

d. Spare. A field reserved to maintain byte boundaries. For ACE there are three 48-bit fields and one 8-bit field.

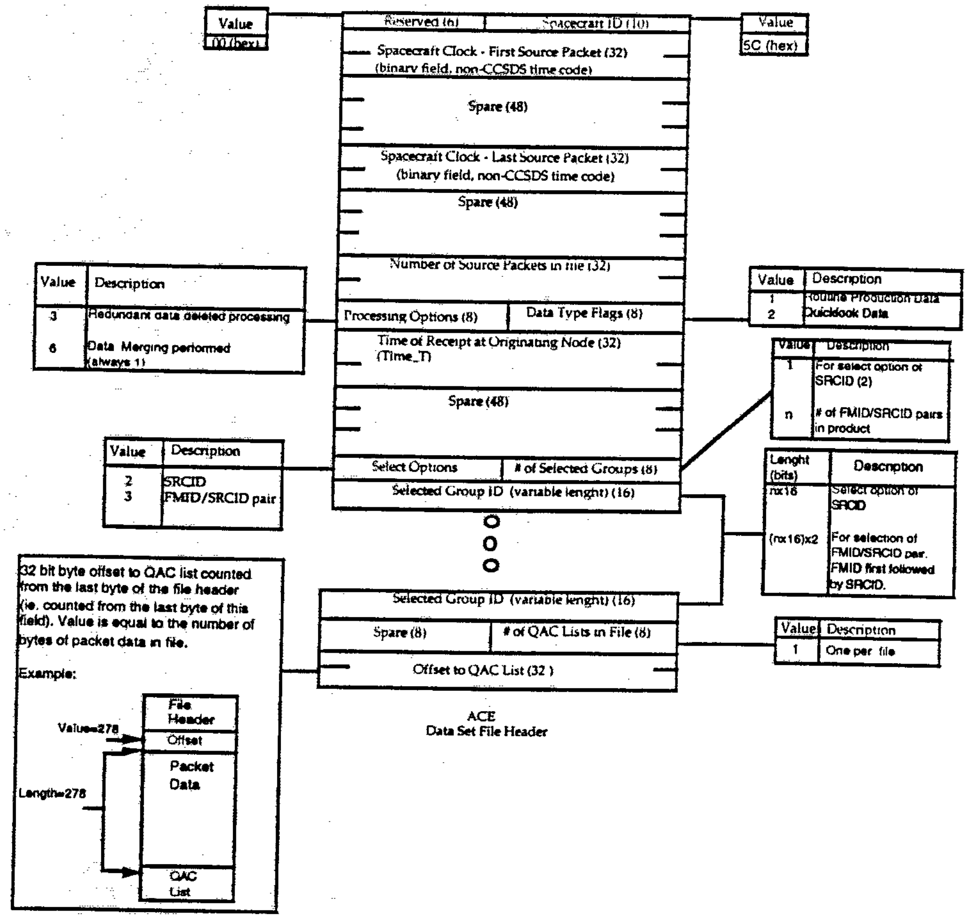
e. Spacecraft Clock: Last Data Unit With Valid Spacecraft Time. A 32-bit binary field non-CCSDS compatible Time Code is used for ACE.

f. Number of Source Packets in File. A 32-bit (integer/4 bytes) field which contains the actual number of source packets units in the data set contained in the file.

g. Processing Option Flag. An 8-bit field, each bit of which is used as a flag indicating whether or not an optional process was performed on the production service data products. The individual bits are defined in Table 6-1. For ACE, only bits 3 and 6 are used.

Table 6-1. Processing Options Flags

BIT	DESCRIPTION
1,2	Reserved
3	Redundant Data Deleted Processing is used for ACE
4	Telemetry Frame CRC Decoding Performed is not used for ACE
5	VCDU Header Control Decoding Performed is not used for ACE
6	Data Merging Performed (always set to 1)
7	RS Decoding Performed is not used for ACE
8	Data Reversal Performed is not used for ACE



Processing Options Description

Bit	Long Description
3 6	Redundant packets (i.e Packets with identical sequence numbers and times) were deleted. the packets chosen for deletion will be of equal or lesser quality as compared to those retained. Data merging is performed
1,2,4,5,7,8	These bits are not applicable to ACE and will be set to 0.

Figure 6-11. ACE Data Set Header

h. Data Type Flag. An 8-bit (integer/1 byte) field, each bit of which is used as a flag indicating the type of data contained in the output stream. For ACE, the type of data will either be Routine Production data or Quicklook data. The individual bits are defined in Table 6-2.

Table 6-2. Data Type Flags

BIT	DESCRIPTION
1	Routine Production Data
2	Quick-look Data

i. Time of Receipt at Originating Node. A 32-bit field (TIME_T), is the format used for ACE. This contains the time to the nearest second, at which the last telemetry acquisition session containing the last downlinked source data unit in the data set was terminated at DPF.

j. Select Options. A 1-byte (integer) field containing a value specifying the select options for grouping source data units within a data set file. The options and the values are given in Table 6-3.

Table 6-3. Data Set Select Options

DATA SET TYPES VALUES	FORMAT IDENTIFIER (FMID)	SOURCE IDENTIFIER (SRCID)
1	Select by	-
2	-	Select by
3	Select by	Select by

k. Number of Selected Groups. A 1-byte integer field containing the number of selected items contained in the data set. For example, for option 1 - the selection by FMID the Number of selected items = Number of selected FMIDs = n.

l. Selected Group ID. A variable length integer field repeated the number of times indicated by the number of selected items, containing the integer values of the selected option. For example, for the selection by FMID only, say FMIDs 1(Science), 2(ADC), and 3(Memory Dump), the next three fields, S_i as defined in Figures 6-12(a), 6-12(b), and 6-12(c), will contain the respective integer values of 1, 2 and 3.
FMID = 16 bits ("01", "02", "03")
Number of Selected Items = Number of FMIDs = 3

Source Identifier - SRCID (16)

Figure 6-12(a). Selection by SRCID Only

Format Identifier - FMID (16)

Figure 6-12(b). Selection by FMID Only

FMID (16)
SRCID (16)

Figure 6-12(c). Selection by FMID/SRCID Pairs

m. Number of QAC Lists in File. A 1-byte (integer) field containing the number of QAC lists in the data set file:

Number of QAC Lists = m (m will always be equal to 1 for ACE)

n. Offset to QAC Lists. A 32-bit (integer) field indicating the position of the QAC list counted from the last bit of the Data Set File Header. This field is repeated the number of times indicated by the number of QAC lists in the data set file, i.e., 'm' times.

6.5.4.2.2 Data Set

a. A data set is an ordered collection of source data units from a specific spacecraft selected by SRCID, FMID or any combination thereof as shown previously in Table 6-3.

b. A data set will contain data units from all selected items sorted and placed in one dataset in sorted order, merged with any redundant data deleted. For example, all science (FMID1) and all ADC (FMID2) could be requested in a combined data set. There are two kinds of data sets as follows:

1. Routine production data set consisting of source data unit received during multiple acquisition sessions. The source data units in a routine production data set can be unambiguously identified, and the data set contains merged real-time and playback data with (optionally) no duplicate source data units and forwarded to the ASC within 24 hours of receipt of the source data units at the DPF.

2. Quicklook data set consisting of source data units received during a single acquisition session, which can be unambiguously identified and forwarded to the ASC within 3 hours of receipt of the source data units at DPF.

6.5.2.1.3 Quality and Accounting Information

There are two different optional elements for the quality and accounting information associated with the source data units in the data set files that are sent to the ASC. The first element is a QAC which will be appended for each source data unit for which an anomaly was detected. The other element is a MDUL for the data set, identified by source data unit sequence number. These quality and accounting items are appended to the end of the data set. The format of these data elements is shown in Figure 6-13.

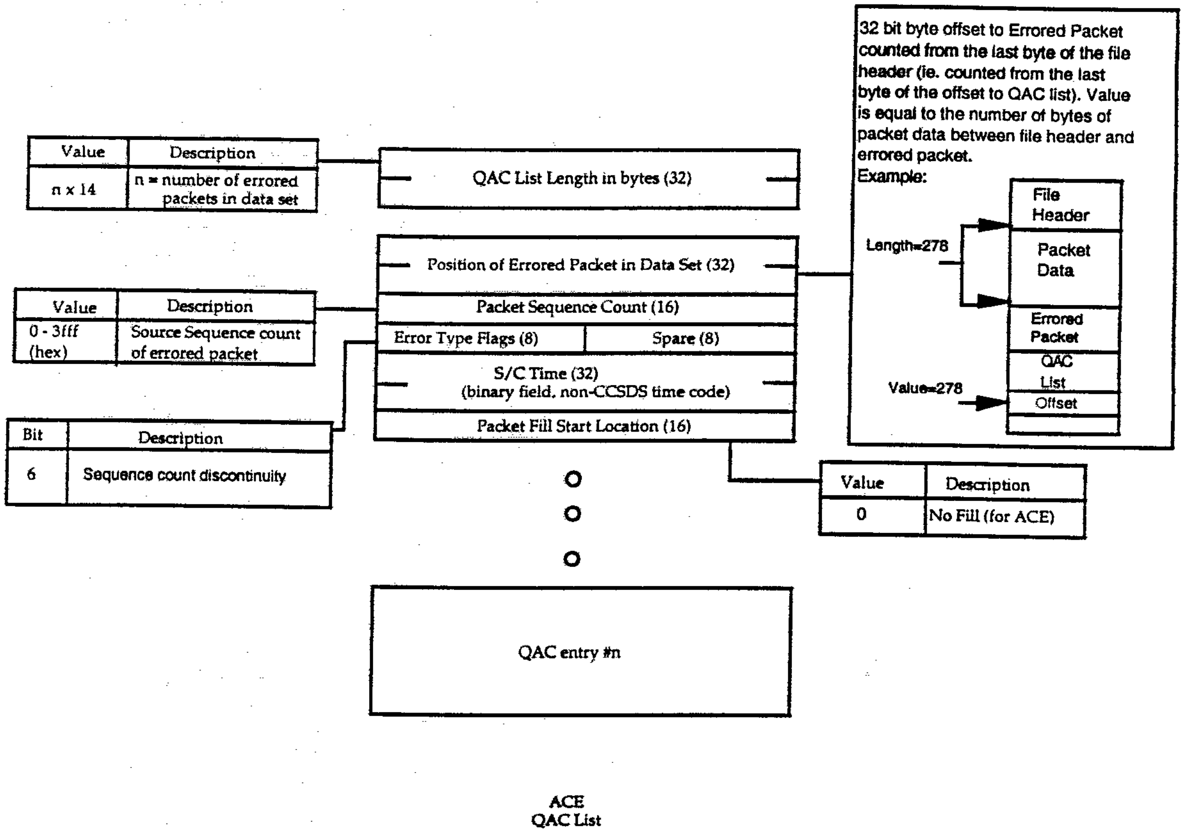


Figure 6-13. Data Unit QAC List

6.5.2.1.3.1 Quality and Accounting Capsules

This quality and accounting element contains anomaly information about the errored-source data unit(s) in the data set. The first field in the QAC is the length of the QAC list. The next set of fields is repeated for every source data units for which anomalies were detected, and contains flags indicating the type of errors. Figure 6-13 depicts the fields and values applicable to ACE.

a. Length of QAC List. A 32-bit field specifying the length, in bytes, of the QAC list for the data set file. The QAC list length is set to -1 if the QAC is not requested.

b. Offset of Data Unit in Data Set. A 32-bit field indicating the position of the errored data unit in the data set counted from the last bit of the Data Set File Header.

c. Data Unit Sequence Count. A 16-bit (integer) field containing a count indicating the sequence number of source data unit.

d. Error Type Flags. An 8-bit field indicates the types of error(s) associated with the data unit, and defined in Table 6-4. Bit 6 is the only error flag used for ACE. The definitions of each flag are as follows:

   1. Not Used.

2. Reed-Solomon (RS) Header Errors. When set to one, this indicates that one or more bits were corrected in the Virtual Channel Data Unit (VCDU) header by the RS decoder. This flag is not used for ACE.

3. Data Unit Length Code Wrong. When set to one, indicates that the specified length of the data unit was found to be inconsistent with the minimum and maximum data unit length of the data unit, or with the amount of data provided for the data unit. This flag is not used for ACE.

4. RS Frame Errors. When set to one, indicates that one or more bits in the frame were corrected by the RS. This flag is not used for ACE.

5. Cycle Redundancy Checks (CRC) Frame Errors. When set to one, indicates the specified frame contained in a detected CRC error. This flag is not used for ACE.

6. Data Unit Sequence Count Error/Discontinuity. When set to one, indicates that a data unit sequence number discontinuity was detected with this packet.

7. Detected Frame Errors During the Generation of This Data Unit. When set to one, indicates that one or more frames used to construct the data unit contain a detected frame level error. This flag is not used for ACE. The possible errors are as follows:

   a.) Bit slip errors.
   b.) Frame CRC errors.
   c.) Invalid frame synchronization pattern.
   d.) Invalid frame version number.
   e.) Invalid spacecraft ID.
   f.) Uncorrectable RS error.

8. Not Used.

Table 6-4. Error Type Flags

BIT	Error Type
1	Not used
2	Reed-Solomon Header Errors N/A to ACE
3	Data Unit Length Code Wrong N/A to ACE
4	Reed-Solomon Frame Errors N/A to ACE
5	CRC Frame Errors N/A to ACE
6	Data Unit Sequence Count Error/Discontinuity. Used for ACE. MDUL reflects specifics.
7	Detected Frame Errors During the generation of this Data Unit N/A for ACE
8	Not used

e. Spare. An 8 bit spare field is used for ACE.

f. S/C Time. A 32-bit field. The time inserted here is taken from the packet secondary header of the ACE telemetry frame. The field is binary and the basic time unit is the second.

g. Packet Fill Start Location. A value of zero (0000 hexadecimal) indicates that there is no fill for ACE.

6.5.2.1.3.2 Missing Data Unit List

This accounting element follows the QAC entries. The first part of the MDUL is the length of the MDUL followed by the list of the missing data units. Figure 6-14 shows the structure of the MDUL for ACE.

a. Length of MDUL. A 32-bit field specifying the length in bytes of the MDUL.

b. Offset to Missing Data Unit. A 32-bit (integer) field indicating the position from the last bit of the data set file header to the start of the data unit immediately preceding the first data unit of the MDUL entry. The offset is set to -1 (0xFFFFFFFF) if the first data unit of the data set is missing.

c. From S/C time. Last 16 bits of the ACE spacecraft time from the first packet of the gap.

d. To S/C time. Last 16 bits of the ACE spacecraft time from the last packet of the gap.

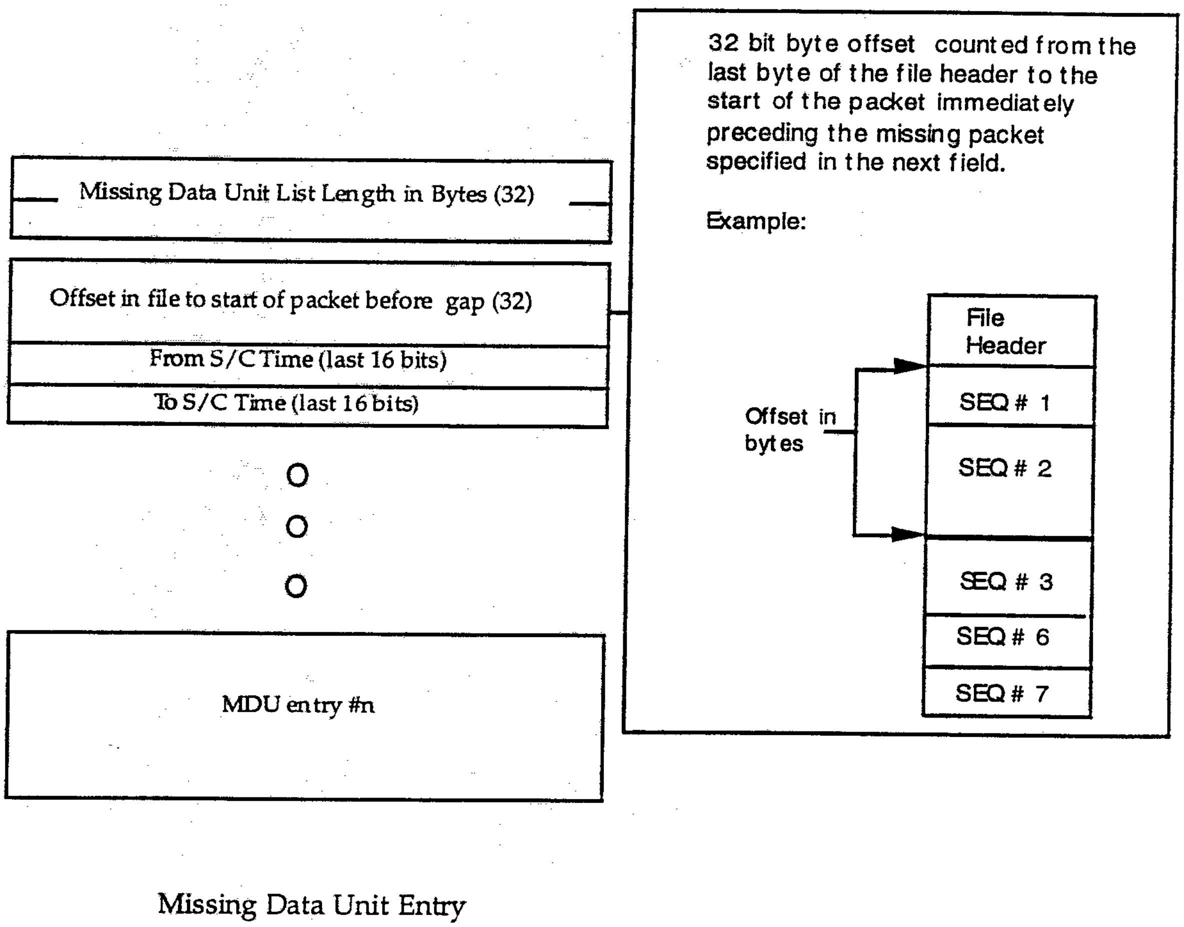


Figure 6-14. ACE MDUL Structure

6.5.2.2 Product Generation Mechanisms

Automatic Generation will be performed when the following criteria are true: The data are captured after the 24 hour spacecraft time window and the missing packet threshold for the product is met (e.g. less than 1 percent of the data is missing).

Manual Generation will be performed when the following criteria are true: The missing packet threshold fails; an analyst concludes the missing data will not be recovered; and an analyst manually starts product generation.

6.5.3 Science Quicklook Data Product

The Quicklook data product will consist of one science data file plus one detached SFDU header, as shown in Figure 6-15 (see Section 6.5.2.1.1). Each Quicklook data file created by the DPF will contain a file header, followed by all data packets received during a single acquisition session. The packets are sorted into forward packet time and source sequence count order with duplicate packets removed. For ACE, the QAC option will not be selected for Quicklook products. [Note: The Quicklook data set header will reflect the value of one as the number of QAC lists in the file. The appropriate 32-bit offset to the start of the QAC list will be set in the data set header and the QAC list length in bytes will be set to -1 ($FFFF_{HEX}$).] There will not be a MDUL for Quicklook products. Each Quicklook data set will be forwarded to the ASC within 3 hours of receipt of the last packet included in the data set. Quicklook products contain all real-time packets for Virtual Channel 1 (VC1) with science, bin dump, memory dump, and Attitude Determination and Control (ADC) Format IDs from the primary C&DH within one acquisition period (2+ hour contact period). Quicklook product requests may be received in two ways: 1) special request with a time boundary, or 2) permanent request. The product generation mechanism starts with a request made to the FOT. Product generation process begins automatically as soon as the capture session terminates. The ASC should make requests via a telephone call to the IMOC FOT at GSFC, followed by an electronic request form transmitted through electronic mail, fax, or by File Transfer Protocol (FTP) (see Section 6.5.4).

6.5.4 Special Request File

The special request file is used by the ASC to request additional IMOC/DPF products. The special request file can be sent to the IMOC via e-mail, fax, or FTP. The information contained in this special request form is described in the following Table 6-5.

Table 6-5. Information for Special Request Form

Item	Description
Acquisition Session	Identify acquisition session by date (DOY)
Format ID	
Source ID	
Scheduling Option	Request applies to single session only
Time Range (S/C Time)	
Partial Duration	Portion of data to select from, if requesting subset of data

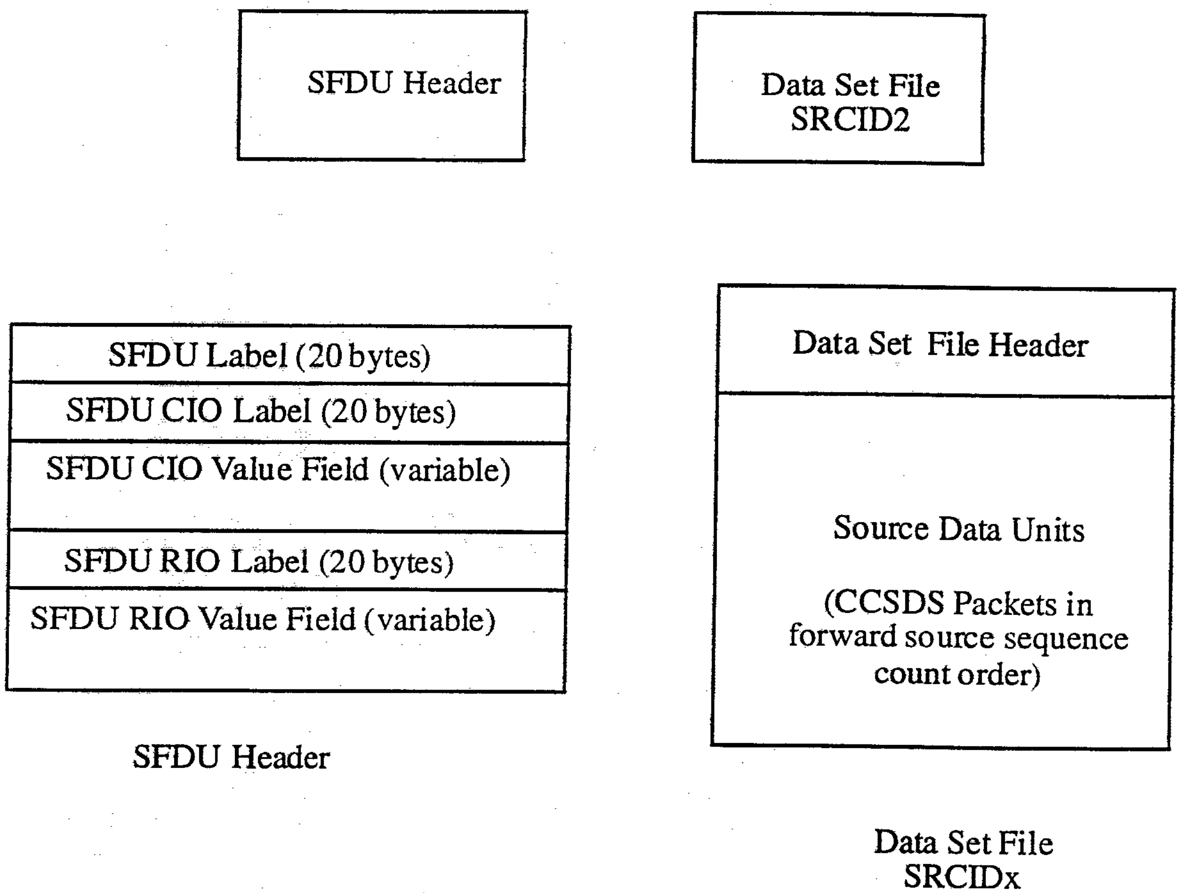


Figure 6-15. ASC Quicklook Data Set File

6.6 Attitude Determination Function File Format

This section defines the format of the attitude and orbit state report and the nutation report generated by the IMOC/Attitude Determination Function (ADF) and transmitted to the ASC.

6.6.1 Specific Format Descriptions

The contents of the attitude products use the PVL standard. The ACE spacecraft attitude is defined relative to the Radial-Tangential-Normal (RTN) coordinate system, and the J2000 Geocentric Inertial Coordinate (GCI) system. The three components of the attitude are:

1. orientation of the spacecraft body Z axis
2. phase angle
3. spin rate

The RTN coordinate system is a right-handed orthogonal coordinate system and is Sun centered. The bases of the triad are defined as follows:

Basis 1, **R,** is the Sun-to-spacecraft unit vector.

Basis 2, **T,** is the unit vector which lies in the Sun's equatorial plane 90 degrees from **R** and points in the same direction as the Sun spins.

Basis 3, **N,** is the unit vector which completes the orthogonal triad.

The RTN coordinate system is described mathematically as:

$\mathbf{R} = (\mathbf{r} - \mathbf{S}) / | (\mathbf{r} - \mathbf{S}) |$,

$\mathbf{T} = (\mathbf{S}_{spin} \times \mathbf{R}) / | (\mathbf{S}_{spin} \times \mathbf{R}) |$,

$\mathbf{N} = \mathbf{R} \times \mathbf{T}$,

where

S is the Sun vector (in GCI),

r is the spacecraft vector (in GCI),

$\mathbf{S}_{spin}$ is the Sun's spin axis (in GCI)

The ACE spacecraft spin-axis attitude, **Z,** is parameterized as the right ascension, α, and declination, δ, angles in the RTN coordinate system. The **Z** vector is computed as:

$$\mathbf{Z} = [\, Z_R \;\; Z_T \;\; Z_N \,]^T$$

where:

$$Z_R = \cos(\delta)\cdot\cos(\alpha)$$
$$Z_T = \cos(\delta)\cdot\sin(\alpha)$$
$$Z_N = \sin(\delta)$$

The attitude phase angle, Λ, is defined to be equal to 0 (zero) when the Sun sensor boresight crosses the **R-N** plane, in the direction of +**R** (i.e., at the Sun pulse time.) Phase angle is measured positively in a right-handed sense about +**Z.**

Spacecraft spin rate, ω, is also defined as being positive in a right-handed sense about +**Z.**

All attitude angles (α, δ, and Λ) are expressed in radians. Spin rate (ω) is expressed in radians/second.

The orbit ephemeris is defined relative to the J2000 GCI, and GSE coordinate systems. The GSE coordinate system is similar to the RTN system except that it is Earth centered. The X-axis points toward the Sun, the Y-axis points antiparallel to the orbital velocity of the Earth, and the Z-axis is normal to the orbital plane of the Earth such that:

$$\mathbf{X} \times \mathbf{Y} = \mathbf{Z}$$

6.6.2 Attitude and Orbit State Report

Fine attitude determination shall be provided to the ASC from separation to End of Mission (EOM). The attitude and orbit state report will include: spin rate, spin axis orientation, phase angle, the time tag of the attitude determination, and the direction cosine matrix from principal to body coordinates. The spacecraft position and velocity at the time of the attitude determination will also be provided in this report. The report will nominally be provided at the beginning and at the end of each ground station contact when no maneuvers are scheduled. During spacecraft maneuvers, the report will also contain attitude and orbit state before and after the maneuver. The "State_Status" parameter will be used to denote the beginning/end of a pass, or a maneuver.

The attitude and orbit state report file will use the PVL format as follows:

<u>Sample Attitude and Orbit State Report Format:</u>

```
BEGIN_GROUP = HEADER;
   FILENAME = ACE_GMOC_AOR_1995-001T01-02-04Z_V00.DATA;
   DATE_CREATED = 1997-300T12:15:35.789Z;
END_GROUP = HEADER;
BEGIN_GROUP = Definitive_Attitude_State;
    Spacecraft Clock = Clock_Value; /* counts */
    UTC_Time=1997-300T12:15:35.789Z;
    PB11 = P_to_B_11;
    PB12 = P_to_B_12;
    PB13 = P_to_B_13;
    PB21 = P_to_B_21;
    PB22 = P_to_B_22;
    PB23 = P_to_B_23;
    PB31 = P_to_B_31;
    PB32 = P_to_B_32;
    PB33 = P_to_B_33;
    State_Status = (BEG_PASS/END_PASS/BEG_MANVR/END_MANVR);
    J2000_X=J2000_X_of_Angular_Momentum_Vector; /* direction cosine */
    J2000_Y=J2000_Y_of_Angular_Momentum_Vector; /* direction cosine */
    J2000_Z=J2000_Z_of_Angular_Momentum_Vector; /* direction cosine */
    J2000_Spin_Rate_Vector= (X_Rate_Value,Y_Rate_Value,Z_Rate_Value);
    /* radians/second */
    RTN_R=RTN_R_of_Angular_Momentum_Vector;  /* direction cosine  */
    RTN_T=RTN_T_of_Angular_Momentum_Vector;  /* direction cosine  */
    RTN_N=RTN_N_of_Angular_Momentum_Vector;  /* direction cosine  */
    RTN_Spin_Rate_Vector = (R_Rate_Value, T_Rate_Value, N_Rate_Value);
    /*radians/second*/
END_GROUP = Definitive_Attitude_State;
BEGIN_GROUP=Definitive_Orbit_State;
    Spacecraft Clock = Clock_Value; /* counts */
    UTC_Time=1997-300T12:15:35.789Z;
    S/C_POS_J2000_X=J2000_X_Position; /* km */
    S/C_POS_J2000_Y=J2000_Y_Position; /* km */
    S/C_POS_J2000_Z=J2000_Z_Position; /* km */
    S/C_VEL_J2000_X=J2000_X_Velocity; /* km/s */
    S/C_VEL_J2000_Y=J2000_Y_Velocity; /* km/s */
    S/C_VEL_J2000_Z=J2000_Z_Velocity; /* km/s */
```

```
    S/C_POS_X=1.44566E6; /*km*/
    S/C_POS_Y=1.48756E6;
    S/C_POS_Z=1.41234E6;
    S/C_VEL_X=1.09E-3; /*km/sec*/
    S/C_VEL_Y=1.09E-3;
    S/C_VEL_Z=1.09E-3;
    S/C_POS_GSE_X=GSE_X_Position; /* km */
    S/C_POS_GSE_Y=GSE_Y_Position; /* km */
    S/C_POS_GSE_Z=GSE_Z_Position; /* km */
    S/C_VEL_GSE_X=GSE_X_Velocity; /* km/s */
    S/C_VEL_GSE_Y=GSE_Y_Velocity; /* km/s */
    S/C_VEL_GSE_Z=GSE_Z_Velocity; /* km/s */
END_GROUP=Definitive_Orbit_State;
```

6.6.3 Attitude Phase Angle Computation

The apparent spin period is the time interval between successive Sun pulses. In the presence of nutation, the apparent spin period will deviate from the true spin period. As a result, the science data will be incorrectly sectored onboard; the science data will need to be normalized to the true attitude phase angle on the ground by ASC. FDF will provide algorithms to perform the data normalization. These algorithms are currently TBD and will be finalized by 15 March 1996. Once finalized, they will be located in Appendix C of this document.

6.7 NASA Communications Data

This section defines the products transmitted via NASA communications.

6.7.1 Specific Format Descriptions

The real-time telemetry data are transmitted via Isis.

6.7.2 Real Time Telemetry Data

Real-time telemetry data will be transmitted in Standard DSN Block (SDB) format as defined in the module TLM 3-27 of the DSN System Requirements Detailed Interface Design document.

Section 7. Session Layer

7.1 Definition

The Session Layer provides services to help manage and control the flow of information between systems. The Session Layer provides system-dependent, process-to-process communications functions, which include:

- Receipt and processing of incoming and outgoing logical link connect, disconnect, and abort requests
- Receipt and processing of incoming and outgoing data
- Detection of network disconnects and failure of the transport layer to deliver data in a timely manner

7.2 Transmission Protocol

The ACE GS MT will be responsible for delivering ACE mission products to the ASC using TCP/IP via FTP. The ASC will also provide products to the ACE GS using Electronic Mail.

Non real-time data flows (i.e. FTP, schedules, Telnet, etc.) between the IMOC at GSFC, on the closed Modnet, and the ASC, on the open Modnet, must explicitly use the Internet Access facility. Non real-time flows orginating at the ASC must use the Internet Access facility and one time passwords (implemented with Secure ID). Electronic Mail Message sent from the ASC to the IMOC do not need to use one time passwords implemented with Secure ID.

7.3 Real Time Data Transfer

All real-time data transport will be accomplished via standard off the shelf Internet Protocol (IP) networks. IP network layer routing protocols provide fault detection and re-routing capabilities in the wide area and local area networks.

Fault tolerance in the end stations, the source and destinations themselves, is obtainable through a Commercial Off The Shelf (COTS) Software Developer Kit (SDK) from Isis distributed systems. This SDK also provides the capability to distribute real-time data to multiple destinations. The real-time IP interface, based on this SDK, is incorporated in the IMOC releases with run time capability.

The focal points of the real-time IP capability are the ground station interfaces and the fanout boxes. The ground station interfaces are the source of all telemetry data, and the destination of all command or forward link data. Real-time telemetry is required by multiple destinations dispersed throughout the IP network. In order to conserve Wide Area Network (WAN) bandwidth, which there is a monetary charge for, distribution points are established throughout the IP network to handle replication (fanout) of the data to any local attached destinations for the real-time data [Local Area Network (LAN) bandwidth is a non-recurring cost].

The SDK handles multicasting of the data to multiple destinations and fault tolerance through the establishment of group processes. If a user requires real-time receipt of a particular data stream from the spacecraft, the user process joins that group, ingests the data a message at a time, and makes it available to any required processes. For instance, a process could join the ACE/VC1 group, receive all frames associated with VC1, and make those frames available to routines that process those frames real-time and log, display or serve the data to other processes in the system. The "server" for the group in this instance is the fanout process, which actually is a group of processes, one of which is responsible for the actual fanout of VC1 with the other processes standing by.

7.3.1 Real-Time Data Flow

Figure 7-1 depicts the real-time data flow. Spacecraft data is captured by the DSN and provided to GSFC, via the Special Function Gateway at JPL, over an IP network. The data is captured at GSFC in the fanout box , served real-time to the IMOC and the fanout box on the open side of the MODNET. The ASC IP front end process joins its real-time groups at the fanout box on the open side. All data connections are proposed via Internet connectivity provided at GSFC by the Center Network Environment (CNE) which is plugged into SURAnet at the University of Maryland. Connectivity for the ASC is via the CIT campus network.

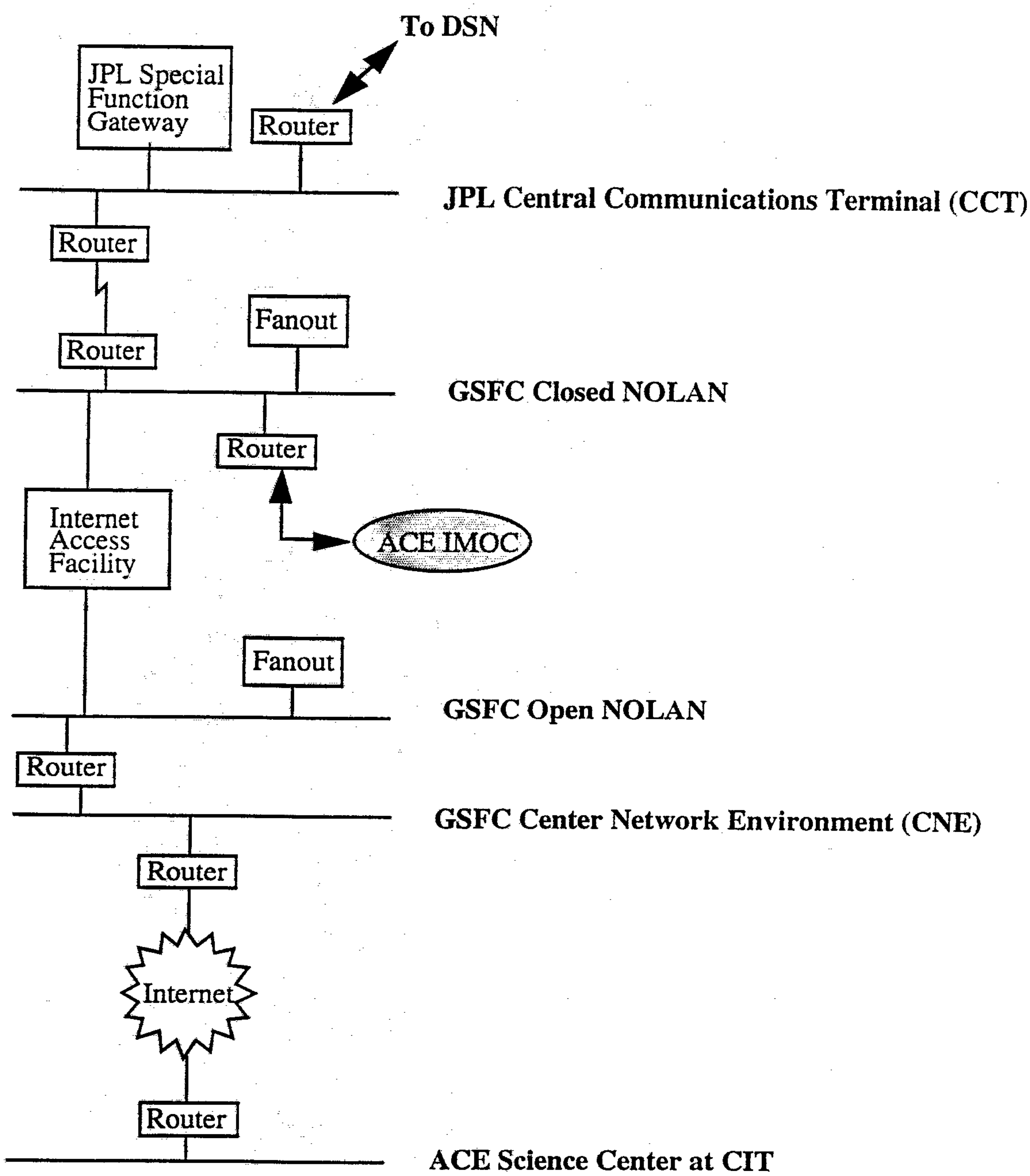


Figure 7-1. Real-Time IP Interfaces

Section 8. Network/Transport Layer

8.1 Definition

The Network Layer provides transparent data transfer between two Transport Layer entities. The Network Layer accepts packets from the Transport Layer at the sources node and forwards them to a destination node.

The Transport Layer provides a system-independent process-to-process communications service in association with the underlying services provided by lower layers. The Transport Layer permits two systems to exchange data reliably and sequentially, regardless of their location within a network.

8.2 Network

The Network Layer is a nominal IP LAN/WAN, built on the infrastructure of the Nascom Operational Local Area Network (NOLAN) network at GSFC, the Internet and local LAN/WAN segments at the ASC. As the Internet segments in particular are non-deterministic, GSFC cannot guarantee delay or throughput performance for any particular instance. However it is expected that the nominal end-to-end performance will be well within project requirements.

Using Simple Network Management Protocols (SNMP) and Network Management Status (NMS), real-time monitoring of the IP WAN and attached LANs is accomplished. Control of the Network components is accomplished via password protected telnet logins, and on site contacts, when necessary.

Network users have standard UNIX tools available to determine the Network status, such as ping and traceroute.

GSFC delivery guarantees cannot extend beyond the closed network environment of the NOLAN networks.

8.3 Transport

The Transport Layer is implemented with standard Internet Protocols, TCP and User Datagram Protocol (UDP). Real-time multicasting and fault tolerance is implemented via the Isis SDK Application Programmer's Interface (API), which relies on TCP and UDP transport protocols.

Section 9. Data Link Layer

9.1 Definition

The Data Link Layer creates the communications path between adjacent nodes and ensures the integrity of the data transferred between them. Functions covered by this layer include:

- Establishing and terminating the link
- Detecting and responding to link transmission errors
- Synchronizing link data transmissions and reporting link status

9.1.1 Data Link Interface

The Data Link Layer interface is a nominal Ethernet Version 2 and IEEE 802.2 LAN specification. Standard Internet routers provide access to wide area circuit facilities which transport data between widely dispersed LAN segments over IP network protocols.

Section 10. Physical Layer

10.1 Definition

The Physical Layer manages the physical transmission of data over a channel, which includes:

- Monitoring change signals
- Handling hardware interrupts
- Informing the data link layer when transmission is complete

This layer will be implemented using Nascom equipment and lines.

10.1.1 Physical Interface

The Physical Layer interface is specified as nominal Ethernet Version 2, a standard workstation LAN interface. Standard Internet routers provide access to wide area circuit facilities which transport data between widely dispersed LAN segments over IP network protocols.

Acronyms

ACE	Advanced Composition Explorer
ADC	Attitude Determination and Control
ADF	Attitude Determination Function
ANR	Anomaly Report
AOR	Attitude and Orbit State Report
AOS	Acquisition of Signal
API	Application Programmers Interface
APID	Application Process Identifier
APL	Applied Physics Laboratory
ASC	ACE Science Center
ASCII	American Standard Code for Information Interchange
CAID	Control Authority Identification
C&DH	Command and Data Handling
CCR	Clock Calibration Report
CCSDS	Consultative Committee for Space Data Systems
CCT	Central Communications Terminal
CIO	Contents Identifier Object
CIT	California Institute of Technology
CHI	Computer Human Interface
CLCW	Command Link Control Word
CNE	Center Network Environment
COTS	Commercial Off the Shelf
CRC	Cyclic Redundancy Checks
CRIS	Cosmic Ray Isotope Spectometer
DDID	Data Description Identification
DMR	Detailed Mission Requirements
DOY	Day of Year
DPF	Data Processing Function
DSN	Deep Space Network
EDU	Exchange Data Unit
EOM	End of Mission
EPAM	Electron Proton and Alpha Monitor
ER	Eastern Range
FDF	Flight Dynamics Facility
FMID	Format Identifier
FOT	Flight Operations Team
FTP	File Transfer Protocol
GCI	Geocentric Inertial
GMT	Greenwich Mean Time
GS	Ground System
GSFC	Goddard Space Flight Center
GSPMP	Ground System Project Management Plan
HEX	Hexadecimal
I&T	Integration and Testing
ICD	Interface Control Document
ICF	Instrument Command File
ID	Identification
IMOC	Integrated Mission Operations Center
IP	Internet Protocol

Acronyms

ISO	International Standards Organization
ITOCC	Integration and Test Operations Control Center
JPL	Jet Propulsion Laboratory
KSC	Kennedy Space Center
LAN	Local Area Network
LOS	Loss of Signal
LVO	Label Value Objects
LZ	Level Zero
LZP	Level Zero Product
MAG	Magnetometer
MAR	Mission Analysis Room
MCC	Mid Course Correction
MDUL	Missing Data Unit List
MMS	Master Mission Schedule
MO&DSD	Mission Operations and Data Systems Directorate
MODNET	MO&DSD Operational/Development Network
MOR	Mission Operations Room
MOT	Mission Operations Team
MOU	Memorandum of Understanding
MPF	Mission Planning Function
MRR	Mission Requirements Request
MT	Mission Team
NASA	National Aeronautics and Space Administration
Nascom	NASA Communications
NOCC	Network Operations Control Center
NMS	Network Management Status
NOAA	National Oceanic and Atmospheric Administration
NOLAN	Nascom Operational Local Area Network
NSSDC	National Space Sciences Data Center
NTR	Nutation Report
ODB	Operations Database
OSI	Open Systems Interconnection
PDB	Project Database
PGP	Pretty Good Privacy
PRC	STOL Procedure
PVL	Parameter Value Language
QAC	Quality and Accounting Capsule
QLP	Quick Look Product
R/F	Radio Frequency
RGS	Requirements Generation System
RIO	Reference Identifier Object
RS	Reed Soloman
RTCCF	Real-Time Command and Control Function
RTN	Radial-Tangential-Normal
RTSW	Real Time Solar Winds
SAP	Science Activity Plan
S/C	Spacecraft
SCID	Spacecraft Identification
SDB	Standard DSN Block
SDK	Software Developer Kit
SEPICA	Solar Energetic Particle Ionic Charge Analyzer

Acronyms

SFDU	Standard Format Data Unit
SIS	Solar Isotope Spectrometer
SNMP	Simple Network Management Protocols
SOR	Spacecraft Operations Report
SOTA	Special Operations Training Area
SRCID	Source Identifier
STDN	Space Tracking and Data Network
SWEPAM	Solar Wind Electron Proton and Alpha Monitor
SWICS	Solar Wind Ion Composition Spectrometer
SWIMS	Solar Wind Ion Mass Spectrometer
TBS	To Be Supplied
TCP/IP	Transmission Control Protocol/Internet Protocol
TTI	Transfer Trajectory Insertion
TPOCC	Transportable Payload Operations Control Center
UDP	User Datagram Protocol
ULEIS	Ultra Low Energy Isotope Spectrometer
UTC	Universal Time Code
VAL	Validation Report
VC	Virtual Channel
VCID	Virtual Channel Identifier
VCTF	Virtual Channel Transfer Frame
VCDU	Virtual Channel Data Unit
WS	Workstation
WAN	Wide Area Network

Appendix A

Memorandum of Understanding (MOU) Between the Flight Projects Directorate and the Mission Operations and Data Systems Directorate for the Advanced Composition Explorer Science Center (ASC)

MEMORANDUM OF UNDERSTANDING (MOU)

BETWEEN THE

FLIGHT PROJECTS DIRECTORATE

AND THE

MISSION OPERATIONS AND DATA SYSTEMS DIRECTORATE

FOR THE

ADVANCED COMPOSITION EXPLORER (ACE) SCIENCE CENTER

10/26/94
Francis E. Snow — Date
ACE Mission Operations Manager
Code 501

10/26/94
Steven E. Coyle — Date
ACE Ground System Project Manager
Code 502

11/14/94
Donald L. Margolies — Date
Associate Project Manager for ACE
Code 410

10/29/94
Dorothy C. Perkins — Date
Acting Chief,
Mission Operations Division
Code 510

11/10/94
Vernon J. Weyers — Date
Director of Flight Projects
Code 400

11/3/94
Dale L. Fahnestock — Date
Director of Mission Operations
and Data Systems
Code 500

INTRODUCTION

The Mission Operations and Data Systems Directorate, Code 500, and the Flight Projects Directorate, Code 400, have agreed to provide an Integrated ACE Mission Operations Center (IMOC) system to the ACE Science Center (ASC) for the purpose of instrument health and safety. In addition, Code 500 will procure for Code 400 for use at the ASC one (1) workstation front end processor and one (1) user interface workstation. These software and hardware deliverables will be referred to as the "ACE Science Center System" throughout the remainder of this MOU. The provision of this ACE Science Center System contributes to a common hardware and software architecture for the entire ACE Ground System.

This MOU documents the roles and responsibilities for the development, integration, test, and delivery of the ACE Science Center System. Enclosure 1 contains a list of ASC hardware deliverables and required Commercial Off The Shelf (COTS) products. Enclosure 2 provides an initial hardware/software delivery schedule. (Note: this schedule will be maintained external to this MOU by the ACE Mission Team Configuration Control Board (ACE MT CCB), Code 500).

The following assumptions were made when deriving schedules and deliverables:

SOFTWARE/HARDWARE SCHEDULES:

1. Schedules of software and hardware will be maintained via the Master Mission Schedule (MMS). The MMS will be tracked by the Ground System Readiness Manager (GSRM), Code 500.

SOFTWARE/HARDWARE DELIVERABLES:

1. The ACE Science Center System will NOT include the Generic Trend and Analysis System (GTAS).

2. Software deliveries to the ASC (executables only) are functionally compatible with deliveries made to the IMOC. Maintenance releases following launch will be the responsibility of the Space Sciences Directorate Code 600. The ACE Project Operations Director (POD) of Code 500 will provide future software releases to Code 600 according to a separate milestone schedule agreement.

3. The ASC will utilize common Project Data Base (PDB) software as employed in the IMOC.

4. The provided hardware/software is designed to support ground data communications using TCP/IP protocols. The interface complies with the Consultative Committee for Space Data Systems (CCSDS) recommendations.

5. The delivered ASC hardware is supplied with a one year warranty from the manufacturer. The ASC is responsible for extending any maintenance coverage.

REQUIRED COTS:

1. The ASC will procure, upgrade and maintain, as necessary, COTS releases to preserve system compatibility. All licensing costs and agreements for COTS will be the responsibility of the ASC.

CODE 400 RESPONSIBILITIES

SOFTWARE/HARDWARE DELIVERABLES AND FUNDING:

1. Code 400 will receive the ACE Science Center System from Code 500 and be responsible for the delivery of the system to the ASC.

2. Code 400 will provide funding for one (1) HP 748/743 including monitor and one (1) HP 715/100 including monitor. This equipment will be procured by Code 500 and delivered directly to the ASC.

3. Code 400 will provide funding for any ASC unique software capabilities required of Code 500 to implement.

SOFTWARE REQUIREMENTS:

1. Code 400 will provide updates to the ACE Detailed Mission Requirements (ACE DMR) via the Requirements Generation System (RGS) identifying capabilities required by both the IMOC and the ASC.

2. Code 400 will work with Code 500 to maintain configuration control of the ACE Science Center System to insure compatibility with the IMOC. The goal for commonality includes the data base, TSTOL, display, telemetry, command, level zero processing and the attitude determination subsystems. In addition, TSTOL procedures, display pages, and expert systems can be shared.

POINTS OF CONTACT:

1. Code 400 will assign a point of contact to interface with the Code 500 IMOC development team for the purpose of insuring adequate technical information exchange.

2. Code 400 will designate a point of contact for system administration at the ASC. The system administrator is responsible for configuring COTS products to comply with system configuration settings, installation of new IMOC releases, updating to the latest data base, upgrading the operating system, trouble shooting problems with the operating system and performing system backups.

NETWORK INTERFACE:

1. Code 400 will assure an electronic interface (INTERNET protocols) between the ASC and the IMOC.

SOFTWARE DISCREPANCIES AND CHANGE REQUESTS:

1. Code 400 will track and attend, when necessary, the Transportable Payload Operation Control Center Configuration Review Board (TPOCC CRB) and the ACE MT CCB meetings.

2. Code 400 will provide to Code 500 software discrepancies initiated by the ASC. Code 400 will document these discrepancies via the Comprehensive Discrepancy System (CDS). A CDS Training/User's Guide will be available to Code 400.

3. Code 400 will provide to Code 500 software Configuration Change Requests (CCRs) initiated by the ASC. CCRs will be managed as described in the "ACE Ground System Configuration Management Plan".

SOFTWARE TESTING:

1. Code 400 will provide a participant in Code 500's testing of the ACE Generic and IMOC systems to verify that they also meet the ASC requirements.

CODE 500 RESPONSIBILITIES

SOFTWARE/HARDWARE DELIVERABLES AND FUNDING:

1. Code 500 will deliver to Code 400 a fully tested ACE Science Center System (executables only) along with fully documented system installation procedures. Code 500 will also provide initial system installation training.

2. Code 500 will procure for Code 400 for use at the ASC one (1) HP 748/743 including monitor and one (1) HP 715/100 including monitor. This equipment will be delivered directly to the ASC.

3. Code 500 will provide a software mechanism that allows the ASC to integrate their own ASC specific software with the ACE Science Center System. The algorithms provided by the ASC will comply with standards addressed in the "Mission Development Group Standards and Procedures", May 1994.

4. Code 500 will provide software patch releases to Code 400 as necessary. Installation of patch releases shall be fully documented.

5. Code 500 will provide to Code 400 IMOC documentation, and a "Data Format Control Document (DFCD) for the Project Database (PDB) Supporting the Advanced Composition Explorer (ACE) Mission Operations Center (MOC)".

SOFTWARE REQUIREMENTS:

1. Code 500 will verify that all of Code 400's ASC software requirements specified in the ACE DMR are provided and delivered as indicated by the MMS. The MMS will be tracked by the GSRM Code 500.

2. Code 500 will conduct regular documented IMOC working group meetings which code 400 will be invited to attend. These meetings will be made available to the ASC via telecon.

POINT OF CONTACT:

1. Code 500 will assign a point of contact to interface with Code 400 and the ASC to insure information exchange and ACE Science Center System delivery.

NETWORK INTERFACE:

1. Code 500 will utilize an electronic interface (INTERNET protocols) assured by Code 400 for installation and diagnostics of the system releases and patches.

SOFTWARE DISCREPANCIES AND CHANGE REQUESTS:

1. Code 500 will respond to and provide corrections for discrepancies in the ACE Science Center System software reported by Code 400. Code 500 will work with Code 400 to insure the resolution of ACE Science Center System discrepancies are addressed in a well documented fashion via the CDS.

2. Code 500 will deliver software for CCRs initiated by Code 400 and approved by the ACE MT CCB.

SOFTWARE TESTING:

1. Code 500 will provide to Code 400 access to the ACE Ground System Integration and Test facility at GSFC Building 1.

ACE SCIENCE CENTER HARDWARE/COTS REQUIREMENTS FOR A SINGLE SYSTEM

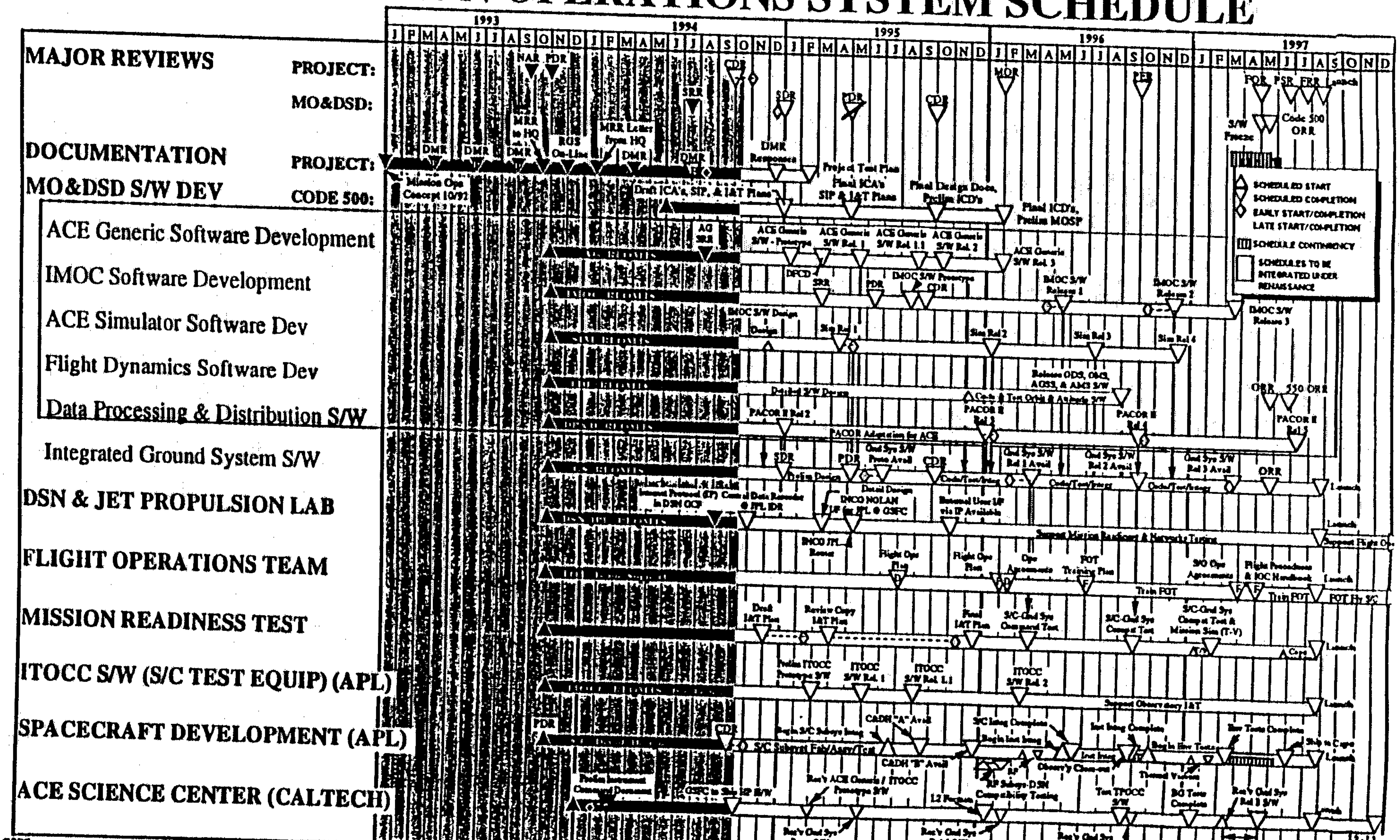
HARDWARE

SUPPLIER	DESCRIPTION	QUANTITY	VERSION	SCHEDULE
Code 500	Workstation FEP - HP 748/743 including monitor	1	N/A	Oct-94
Code 500	Workstation - HP 715/100 including monitor	1	N/A	Oct-94
Code 500	HP OS Version 9.05	1	9.05	Oct-94

COTS PRODUCTS

SUPPLIER	DESCRIPTION	QUANTITY	VERSION	SCHEDULE
ASC	VED (Visual Editor)	1	A.02.12	TBD by ASC
ASC	Builder Xcessory (MOTIF page builder)	1	3.1	TBD by ASC
ASC	CD ROM documentation	1	Month or Bi-Month	TBD by ASC
ASC	ORACLE	1	7.0.16	TBD by ASC
ASC	ANSII C Development Kit	1	A.09.30	TBD by ASC

ACE MISSION OPERATIONS SYSTEM SCHEDULE



GSFC
Approval: Frank Snow

ACE - Advanced Composition Explorer
AG - ACE Generic (MOC/ITOCC Common)
AOSS - Attitude Software
AMS - Attitude Maneuver S/W
ANC - Ancillary S/W
AP - Alarm Processing
BG - Browse Generator
CADH - Command & Data Handling
CCB - Configuration Control Board
CDR - Critical Design Review
Compat - Compatibility

D - Draft
Dev - Develop
DMR - Detailed Mission Requirements
Docs - Documents
DP&D - Data Processing &
DSN - Deep Space Network
F - Final
FDF - Flight Dynamics Facility
FOR - Flight Operations Review
FOT - Flight Operations Team
FRR - Flight Readiness Review

Gnd - Ground
GS - Ground System
HQ - Headquarters
I/F - Interface
ICA's - I/F Control Agreements
I&T - Integration & Test
ICD - Interface Control Documents
ITOCC - I&T Operations Control Console
L1 - Level One Processing
L2 - Level Two Processing
L3 - Level Three Processing

MOC - Mission Operations Center
MOR - Mission Operations Review
MOSP - Mission Ops Support Plan
MRT - Mission Readiness Test
NAR - Non-Advocate Review
ODS - Orbit Determination S/W
OMS - Orbit Maneuver Software
Ops - Operations
ORR - Operational Readiness Review
PDR - Preliminary Design Review
PER - Pre-Environmental Review

Prelim - Preliminary
Proto - Prototype
PSR - Pre-Ship Review
QL - Quick-Look
RGS - Requirements Generation System (DMR)
RF Comm - Radio Frequency Communications
S/W - Software
S/O - Sign-off
SDR - System Design Review
Sim - Simulation
SIP - System Implementation Plan

SRD - System Requirements Document
SRR - System Requirements Review
T-V - Thermal Vacuum Test
ZP - Level Zero Processing
DFCD - Data Format Control Document

Orig Approval: 4/30/93
Last Change: 10/14/94
Status As Of: 10/14/94
Rev: A

Enclosure 2

Appendix B

ACE Transfer Frame Structure

Section B.1 Virtual Channel Transfer Frame

Each ACE Virtual Channel transfer frame (VCTF) is 6944 bits long. The format of the transfer frame is shown in Figure B-1 . Each VCTF is composed of a sync word (32-bits), a VCTF header (48-bits), a packet header (80-bits), a frame header (16-bits), packet data 6736-bits), and a Command Link Control Word (CLCW) (32-bits). Each ACE packet consists of a packet header, a frame header and packet data. For additional information on the structure of ACE telemetry packets and transfer frames see the ACE Spacecraft Command & Data Handling Component Specification.

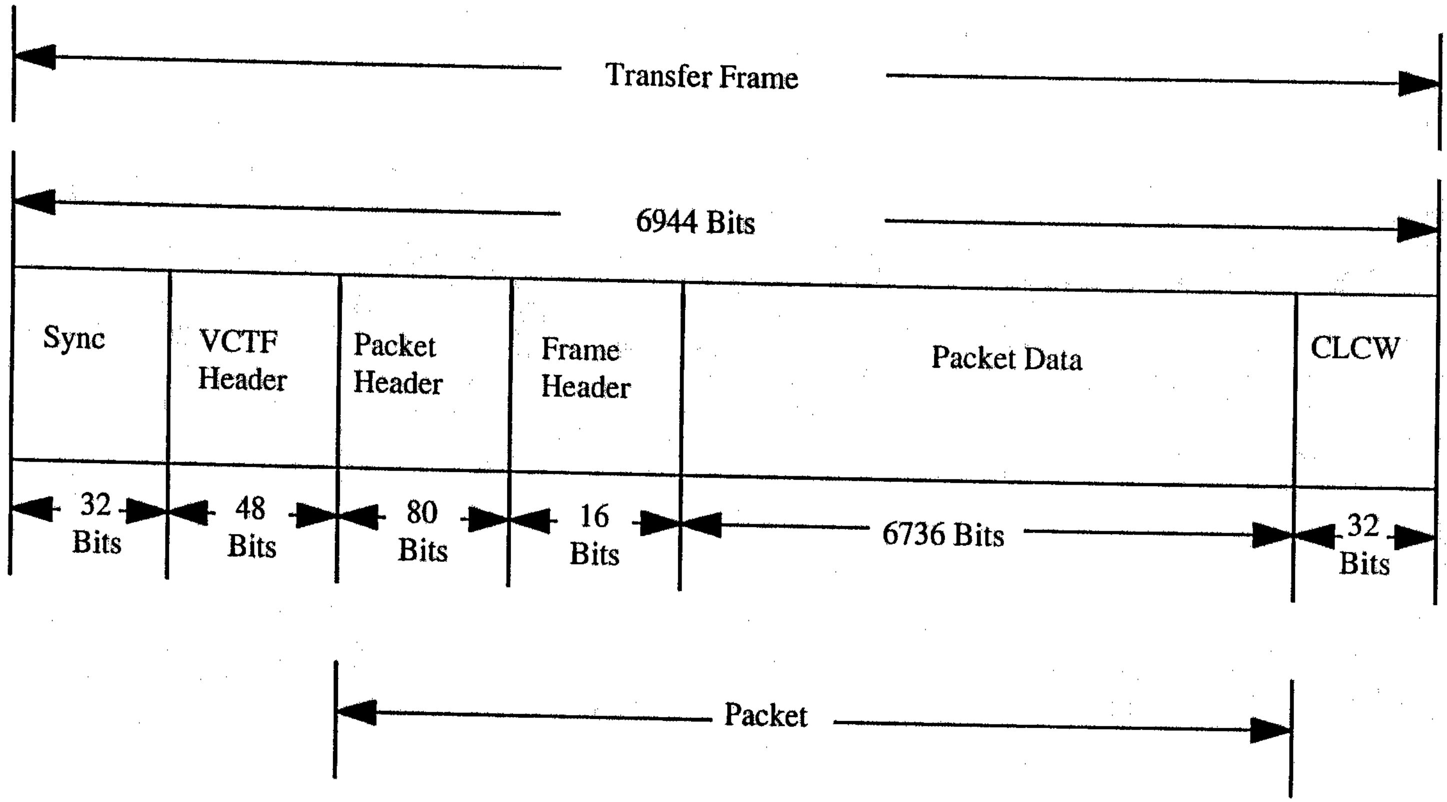


Figure B-1 ACE Transfer Frame Structure

Appendix C

Attitude Processing Algorithms

TBD

Distribution List

Organization	Name of Recipient	Copies
GSFC/410	Snow, Frank	2
GSFC/410	Margolies, Don	1
GSFC/410	Thurber, John	1
GSFC/410	Cross, Bill	1
GSFC/410	Laudadio, John	1
GSFC/410	ACE Library	1
GSFC/510.1	Dent, Carolyn	2
GSFC/511.2	Steck, Jane	1
GSFC/513	Walyus, Keith	1
GSFC/513.1	Barker,Quinton	1
GSFC/513.2	Pages, Raymond	1
GSFC/513.3	Mims, Jacqueline	1
GSFC/514.3	Nickens, Stephanie	1
GSFC/515.2	Welch, John	1
GSFC/543	Spinolo, Chris	1
GSFC/552.1	Sparmo, Joe	1
GSFC/553.1	Woodard, Mark	1
GSFC/553.2	Harrington, Tammy	1
JHU/APL	Chiu, Mary	2
JHU/APL	Rodberg, Elliot	1
JHU/APL	von Mehlem, Ute	1
CIT/ASC	Garrard, Tom	1
CIT/ASC	Hammond, Jeff	1
CIT/ASC	Lin, Al	1
ATSC/519.1	Burris, James	1
ATSC/519.1	Volosin, Jeff	1
CSC/510	Bacon, Beverly	1
CSC/518	Gutman, Irv	1
LORAL/510	Switalski, Len	1
OMITRON/410	Gehr, Vic	1
OMITRON/410	Griffith, Gabrielle	1
OMITRON/410	Olson, Don	1