APAF-PDMP-15-03561-V1.3

July 10, 2003

PROJECT DATA MANAGEMENT PLAN

For The

Mars Express
ASPERA-3 Processing
and Archiving Facility
(APAF)

SwRI® Project No. 15-03561

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REVISION NOTICE

Document Revision History			
Revision	Date	Section	Description of Changes
Initial Rel. (V1.0)	May-05-2000		
Revision 1 (V1.1)	Dec-29-2000	Page i	Added REVISION NOTICE section
		Page iii	Added new acronyms
		1.3	Updated dates & versions for related documents
		2.1	Added explanation of Scanning Unit, Data Processing Unit, & Orbit/Attitude
		2.2	Made clarifications about what will be submitted to PDS with estimated dates
		3.2	Clarifications made to SwRI responsibilities
		3.3	Clarifications made to PDS responsibilities
		4	Reference to Appendix C added
		5	Clarifications made to archival process
		Appendix C	Added table of ASPERA-3 Data Products
Revision 2 (V1.2)	Oct-31-2001	Signature Pg	Updates due to personnel changes
		Page iii	Added new acronyms
		1.3	Updated Applicable Documents
		2.2	Included MEX Orbit/Attitude telemetry data
		4.1	Included all documents containing packet info
		4.2	Described level of received data packets
		4.3.1	Corrected typos of 1e6 amu/q to 106 amu/q
		4.3.2	Clarifications made to IDFS description
		5	Updated archiving process as it is known now
		Appendix C	Added CODMAC Processing Levels
		Appendix D	Added MESDA Processing Levels
		Appendix E	"Old" Appendix C is now Appendix E; Updated ASPERA-3 Data Products Table
Revision 3 (V1.3)	Jul-10-2003	Page iii	Updated and added acronyms
		1.3	Updated Applicable Documents
		2.1	Updated launch date information
		2.2	Updated data flow and Figures 2-1 & 2-2
		3.1	Added ESTEC role and responsibilities
		3.2	SwRI role includes delivery to PSA
		3.3	PDS role includes coordination with PSA
		4	Included CODMAC & PSA processing levels
		4.1	Updated ASPERA-3 TM document reference
		4.3.2	Minor clarifications of ASPERA-3 Data Format
		4.4	Added EAICD to Data Set Documentation
		4.5	Added exportIDFS PDS option development
		5	Updates made to archival process
		Appendix E	Updated ASPERA-3 Data Products Table
		General	Replaced references to MESDA with PSA

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ACRONYMS

APAF	ASPERA-3 Processing and Archiving Facility
ASPERA-3	Analyzer of Space Plasma and Energetic Atoms (3rd Version)
Co-I	Co-Investigator
CODMAC	Committee On Data Management And Computation (of NRC – National Research Council)
DDID	Data Delivery Interface Document
DDS	Data Disposition System
DPU	Data Processing Unit (of the ASPERA-3 instrument package)
DSID	Data System Interface Document
EAICD	Experimenter to Planetary Science Archive Interface Control Document
ELS	Electron Spectrometer (of the ASPERA-3 instrument package)
ENA	Energetic Neutral Atom
E/PO	Education and Public Outreach
ESA	European Space Agency
ESOC	European Science Operations Center
ESTEC	European Space Research and Technology Center
GSE	Ground Support Equipment
ICD	Interface Control Document
IDFS	Instrument Data File Set or Instrument Description File Set
IMA	Ion Mass Analyzer (of the ASPERA-3 instrument package)
IRF	Swedish Institute of Space Physics
JPL	Jet Propulsion Laboratory (NASA Center managed by California Institute of Technology)
MESDA	Mars Express Science Data Archive (no longer used)
MU	Main Unit – refers to ASPERA-3 Main Unit DPU (IMA has separate DPU)
NAIF	Navigation Ancillary Information Facility
NASA	National Aeronautics and Space Administration
NPD	Neutral Particle Detector (of the ASPERA-3 instrument package)
NPI	Neutral Particle Imager (of the ASPERA-3 instrument package)
OA	Orbit/Attitude (information from the Mars Express spacecraft)
OPD	Operations Procedures Document
PDMP	Project Data Management Plan
PDS	NASA Planetary Data System
PI	Principal Investigator
PM	Project Manager
PPI	Planetary Plasma Interactions
PR	Peer Review
PSA	ESA Planetary Science Archive
SDP	Software Development Plan
SGICD	Space / Ground Interface Control Document
SIS	Software Interface Specification
SPICE	Spacecraft, Planet, Instrument, C-matrix, Events files and software
SPM	Software Project Manager
SU	Scanning Unit (of the ASPERA-3 instrument package)
SwRI®	Southwest Research Institute®
TM	Telemetry
US	United States

1. INTRODUCTION

1.1 Purpose and Scope

The APAF Data Management Plan presents a high-level plan for the generation, validation, and delivery of the ASPERA-3 data products to the ASPERA-3 team, Mars Express Co-I's, the ESA Planetary Science Archive, and the NASA Planetary Data System. This document covers only the data products generated, validated, and distributed through the ASPERA-3 Processing and Archiving Facility (APAF), and does not discuss data products generated and/or distributed external to the APAF.

1.2 Contents of Document

Section 1 introduces the document by discussing the purpose, scope, applicable documents, and any associated constraints. An overview of the Mars Express Mission and an overview of the ASPERA-3 Ground Data System are discussed in Section 2. Roles, responsibilities, and operational interfaces affecting the data system are given in Section 3. The ASPERA-3 data products, and the generation, associated software, and validation of the data products are discussed in Section 4. Finally, Section 5 discusses the processing and archiving functions of the APAF.

1.3 Applicable Documents and Constraints

The APAF Software Development Plan (APAF-SDP-15-02853-V1.3, June 7, 2001) describes the processes and procedures to follow for designing, implementing, and testing the APAF software system.

The APAF Data System Interface Document (APAF-DSID-15-03561-V1.2, to be released July, 2003) identifies the necessary external interfaces for developing and operating the APAF. The contents and level of detail in this document depend on external documentation provided by ESOC. This is considered to be a constraint since there is no control over when the documents are released and the descriptions contained therein.

The Mars Express Archive Generation, Validation and Transfer Plan (ESA-MEX-TN-4009, May 10, 2003) provides a plan for generation, validation, and transfer of raw data, reduced data, documentation and software/algorithms from the European Mars Express mission to the Mars Express Science Data Archive of ESA.

The PDS Standard Reference (JPL Document D-7669, Part 2, V3.5, October 15, 2002) contains specific PDS data preparation standards for preparing archive quality data sets.

The ASPERA-3 Experimenter to Planetary Science Archive Interface Control Document (MEX-ASPERA-PSA-ICD-15-03561, version 1.0 to be released by end of 2003) describes the

generation, validation, and transfer of ASPERA-3 data products to PSA/PDS. The EAICD is equivalent to the PDS Software Interface Specification (SIS).

The APAF Operations Procedures (APAF-OPD-15-03561, to be released before orbit encounter) describes the details of operating the APAF system in a production mode during the orbital phase of the Mars Express Mission.

2. OVERVIEW OF MISSION

2.1 Mars Express Mission Overview

Mars Express, an ESA mission, was launched from Russia on a Soyuz Fregat launcher on June 2, 2003. Arrival at Mars is planned for the following December.

The mission comprises an orbiter spacecraft, plus a deployable lander, their instruments, and a network of ground and data processing stations. Seven scientific instruments on-board the orbiting spacecraft will perform a series of remote sensing experiments designed to shed new light on the Martian atmosphere, the planet's structure and geology. The lander will perform exobiology and geochemistry research.

ASPERA-3, one of the seven scientific instruments on-board the orbiting spacecraft, is provided to the Mars Express program by the Swedish Institute of Space Physics (IRF). The general scientific objectives of ASPERA-3 are to study the solar wind and atmosphere interaction, and to characterize the plasma and neutral gas environment in the near-Mars space through energetic neutral atom (ENA) imaging and in-situ plasma measurements.

The ASPERA-3 investigation is comprised of four science instruments: the Neutral Particle Imager (NPI), the Neutral Particle Detector (NPD), an Electron Spectrometer (ELS), and an Ion Mass Analyzer (IMA). In addition to the science instruments, the ASPERA-3 experiment has a Scanning Unit (SU) and a Data Processing Unit (DPU) that will return data necessary for scientific analysis. The spacecraft Orbit/Attitude (OA) data is also relevant for science data analysis. The SwRI involvement in the ASPERA-3 investigation is a Discovery Program Mission of Opportunity project.

2.2 ASPERA-3 Ground Data System

IRF receives data files of ASPERA-3 telemetry from the ESOC Data Disposition System (DDS). SwRI then acquires the ASPERA-3 telemetry data files from IRF (see Figure 2-1). SwRI acquires the spacecraft OA telemetry from NAIF and/or ESTEC in the form of SPICE kernels. The ASPERA-3 Processing and Archiving Facility (APAF) is used to process all of the ASPERA-3 and spacecraft OA telemetry into the IDFS form. The APAF sorts the ASPERA-3 and spacecraft OA telemetry into several different logical virtual instruments for each of seven physical instruments (ELS, IMA, NPI, NPD, DPU, Scan Unit, and Spacecraft Orbit/Attitude). During the process, ASPERA-3 and spacecraft OA telemetry are stored at SwRI for later reprocessing if required by additional definitions imposed by the science staff. SwRI will submit only the ASPERA-3 processed telemetry (not the raw telemetry) to PDS and PSA for long-term archive. Since the spacecraft ancillary data is processed into SPICE kernels for community use and is submitted to PSA and PDS for long-term archive, only ASPERA-3 science data need to be submitted by SwRI for long-term archive to PDS and PSA.

Definitions, documentation, and design reviews for the virtual instrument data files will be performed prior to Mars encounter, as the APAF is being constructed. Once the APAF converts telemetry into virtual instrument data files, the IDFS data files will be transmitted from SwRI to IRF and the ASPERA-3 Co-I Institutions, both in the US and Europe (see Figure 2-2). IDFS data files are formatted for science data analysis and can be used immediately for scientific studies. SwRI will produce and make available the virtual instrument data files within 24 hours after receiving telemetry from IRF.

Data files are anticipated to contain all data from one day of operations. Data from virtual instruments created by the APAF will be made available to a set of predefined web displays. Initially, only the most current data from ASPERA-3 will be available for public view over the Internet, as newer data files will always replace older data files. Internet viewing is meant to monitor instrument performance before validation of the data by the ASPERA-3 science staff. Thus, predefined web displays will be designed to emphasize instrument performance assessment as well as public quick look access as a part of E/PO.

Predefined web displays for science analysis will also be constructed and viewable over the Internet. These displays will be password protected and accessible only to the ASPERA-3 team for collaborative analysis and validation. Upon completion of a six-month science validation period, the data products will begin to be delivered to PDS and PSA, and the web displays will be made available to the public. There are no plans to archive the web displays at this time. The validated data products will continue to be delivered to PDS and PSA throughout the mission on a monthly basis six months after receipt of the data. The first monthly data submission to PDS and PSA is estimated to be in July 2004.

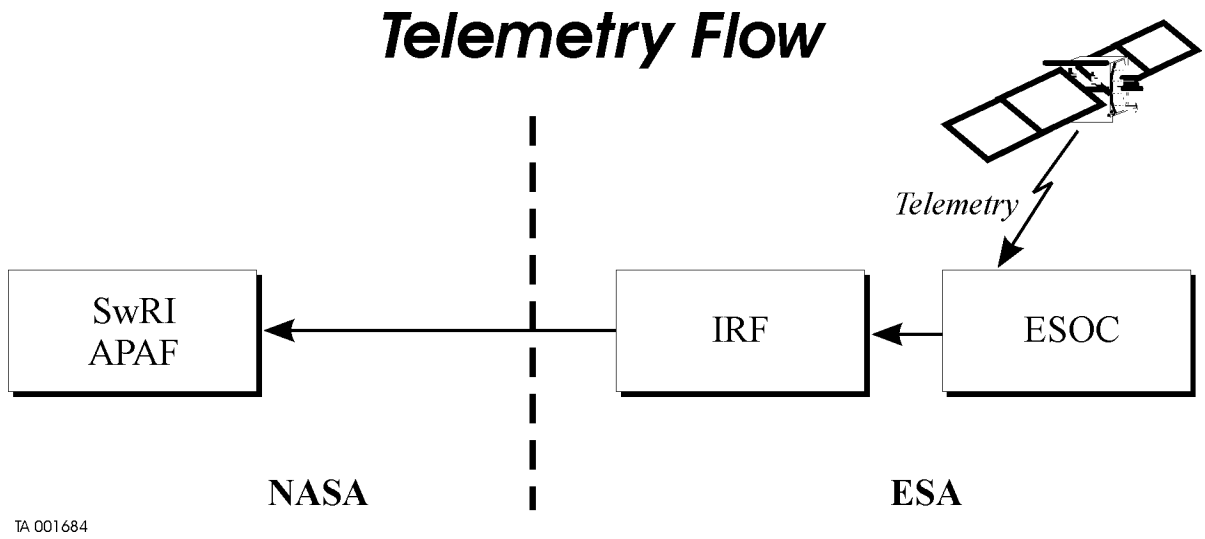

Figure 2-1

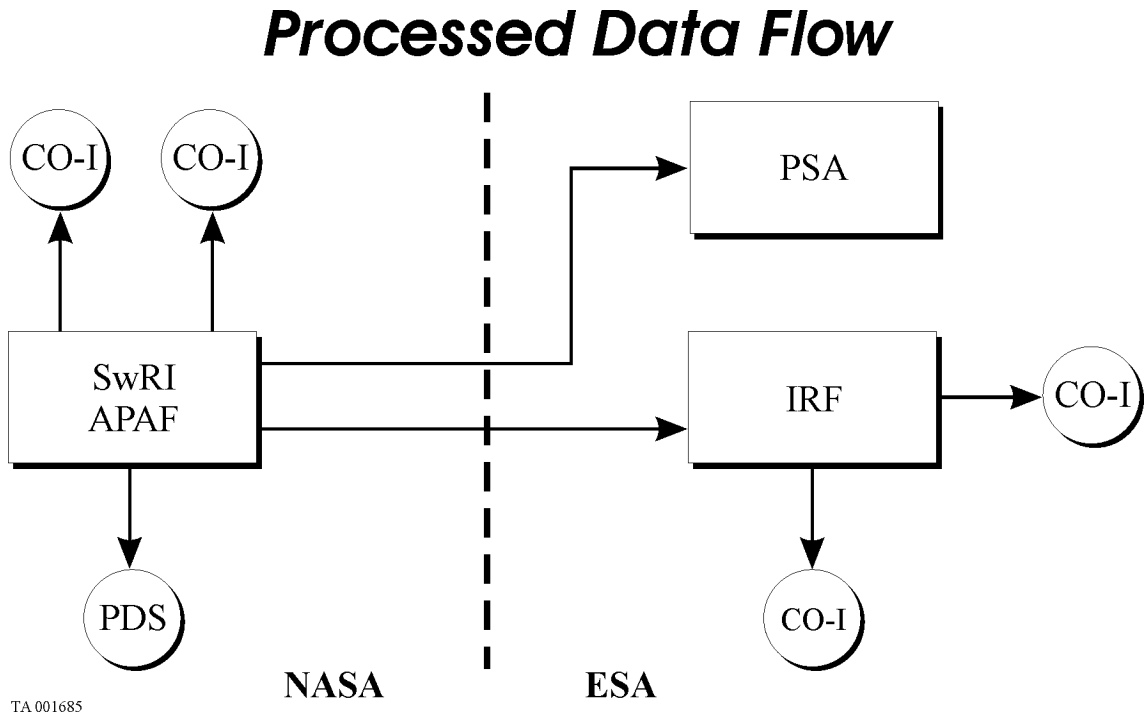

Figure 2-2

3. ROLES AND RESPONSIBILITIES

3.1 Mars Express Mission (ESA, ESOC, ESTEC, IRF, NASA)

ESA is responsible for the overall Mars Express mission, which includes providing the instrument teams with information regarding mission policies and procedures for data ingestion, data handling, data validation, and data distribution.

ESOC is responsible for the Mars Express Data Disposition System (DDS), which allows for quick access to the most recent data available over communication lines on a call-up basis. The data includes science and engineering data, as well as related catalogs. The telemetry data will be provided as time-stamped packets and individually stored on logical files according to the application identifier and data type.

The Planetary Mission Division (SCI-SB) of the Research and Scientific Support Department (RSSD) of ESA, located at ESTEC, the Netherlands, is responsible for the *official* Mars Express Science Data Archive. The PSA team is to advise instrument teams regarding appropriate data formats, validate delivered data from instrument teams for PDS compliance, ensure usability of archived data by other scientists, distribute data to instrument teams and PDS discipline nodes as well as to the general public, and ensure long-term preservation of the archived data. Any data sets distributed to PDS discipline nodes must be identical copies of the PSA data sets.

IRF is the ASPERA-3 leading PI institution. IRF is responsible for ensuring the proper information is disseminated for the development and operation of the APAF, which includes interfacing between ESA, ESOC, and SwRI where appropriate.

NASA provides oversight and funding to SwRI to accomplish the generation and validation of the ASPERA-3 archives. NASA will help ensure that the ASPERA-3 archives have been generated and validated during the operational phases of the mission.

3.2 Southwest Research Institute

Southwest Research Institute is responsible for developing the data reduction system and software to be used during instrument integration, test, calibration, and mission operations for the full ASPERA-3 experiment. This task includes interfacing with all ASPERA-3 sensor teams and appropriate ESA, ESOC, and IRF personnel to determine and affect data packetization and storage strategies. This system (APAF) will be available on a schedule to satisfy the mission needs per agreement with IRF, and to satisfy data availability requirements for delivery to PDS and PSA.

Southwest Research Institute is responsible for the production and delivery to PDS and PSA of documented archives that use PDS standards. Prior to PDS/PSA delivery, SwRI is responsible for collecting engineering and ancillary information necessary to validate and calibrate the scientific data. SwRI must work with PDS and PSA on planning, generating, and validating archives of ASPERA-3 instrument data. During the peer review cycle with PDS and PSA of archive products, the peer review panel may make change requests. It is SwRI's responsibility to resolve the change requests. However, the ASPERA-3 PI has the final say on what data are included in the archive. Currently, SwRI personnel are working with PDS and PSA personnel to ensure proper understanding of the policies and procedures for delivery of the PDS-compliant data products.

SwRI will document the specific generation, validation, and transfer to PDS/PSA of the ASPERA-3 data products. This documentation will specify the contents of the archives, estimates of the amount of delivered data, and a delivery schedule.

3.3 Planetary Data System

The PDS is the primary organization within NASA responsible for archiving planetary data, and thus the designated point of contact on archive-related issues. Relevant PDS personnel are responsible for participation in archive planning efforts to ensure that archives are planned, generated, and reviewed using PDS standards. For ASPERA-3 data products, the relevant PDS personnel are within the Planetary Plasma Interactions (PPI) Node. PDS standards require that all archive products undergo a peer review (PR) cycle, much in the way a journal article is reviewed. The PDS-PPI and PSA personnel have indicated that the peer review cycle shall be a coordinated effort between PSA, ASPERA-3 team, and PDS-PPI. During this review, the panel may make change requests called liens. As stated earlier, it is the responsibility of the ASPERA-3 team to work with PDS and PSA to resolve PR liens. Once the data have been released by the ASPERA-3 team and delivered, the PDS is responsible for distributing ASPERA-3 archives to the broad science community.

4. DATA PRODUCTS

The science-related data products to be produced during the ASPERA-3 investigation are described in this section, including standard data products, engineering and other ancillary products, and documentation that are to accompany data sets as they are delivered to the PDS and PSA. Appendix B gives the NASA definitions of processing levels for science data sets, Appendix C has the CODMAC processing level definitions, and Appendix D contains the PSA definitions for processing levels. The table of ASPERA-3 data products with estimated data volumes is given in Appendix E.

4.1 Packetized Data Records

These data records consist of packetized telemetry received from the spacecraft along with ancillary information needed to determine packet contents. ESOC's Data Delivery Interface Document (DDID), ESA's Space / Ground Interface Control Document (SGICD), and IRF's Main Unit Software User's Guide are used to determine the definitions, formats, and contents of the data packets.

4.2 Experiment Data Records

Experiment data records are equivalent to the NASA Level 0 products (see Appendix B) and consist of time-stamped sequences of raw science and engineering data obtained by a given instrument. These data records will be made available by ESOC and are the inputs to the ASPERA-3 data reduction system (APAF). It is understood, at this time, that these data are equivalent to the CODMAC Level 2 data (see Appendix C) and the PSA Level 1a data (see Appendix D), and that these data are in packet format, time ordered, with duplicates removed, separated by instrument, and organized by days.

4.3 Standard Data Products

The ASPERA-3 standard data products will be generated from the raw science and ancillary data provided by ESOC. These data products will be generated, distributed, and archived by the ASPERA-3 Processing and Archiving Facility (APAF) at SwRI. The ASPERA-3 standard products are described below and will be delivered to the PDS and PSA.

4.3.1 ASPERA-3 Data Products

In order to accomplish the baseline scientific objectives of the ASPERA-3 investigation (as outlined in section 2.1), the complete data set of the integrated ASPERA-3 investigation to all ASPERA-3 Co-I's, the NASA Planetary Data System (PDS), and the ESA Planetary Science Archive (PSA) will be provided by the APAF. Some of the specific measurements delivered as higher-level data products will be:

1. Integral ENA fluxes in the energy range of 0.1 to 60 keV.
2. Mass/Energy resolved neutral hydrogen and oxygen atom spectra in the energy range of 0.1 to 100 keV.
3. Ion energy/mass/angle resolved spectra in the energy range of 0.001 to 40 keV, 1-106 atomic mass units per unit charge (amu/q), with 4π steradian coverage.
4. Electron spectra in the energy range of 0.001 to 20 keV, with 4π steradian coverage.
5. Ions and electrons in the energy range of 0.001 to 40 keV, 1-106 amu/q.

4.3.2 ASPERA-3 Data Format

ASPERA-3 data are archived at SwRI in the Instrument Data File Set (IDFS) format. The IDFS format is described at http://www.idfs.org. The IDFS is a collection of files written in a prescribed format that contain data, timing information, and meta-data. The impetus behind the IDFS is the need to maintain certain meta-data parameters with the data in order to correctly interpret the data. The two key tasks supported by the IDFS are the conversion of telemetry values to physical units and the registration of each data sample to a given point in time. When dealing with data taken by various instruments, time tagging is very important because data are commonly acquired from many different sensors at the same time. When comparing data from different sensors taken at the same time, slight time shifts can cause different scientific interpretations. The IDFS format provides for automatic adjustments of time differences in an effort to eliminate interpretation errors.

There are three kinds of information that go into an IDFS for a given instrument: the telemetry of the sampled data, ancillary or engineering telemetry, and a large quantity of information not necessarily from the spacecraft. The latter class of data can contain all sorts of calibration and timing factors. Given the fact that many spacecraft now have instruments that operate in nondeterministic ways due to data adaptive mode changing, the IDFS can be exceedingly detailed. Once data is stored in an IDFS, a library of access routines allows one to extract any needed parameter.

There are three required files within an IDFS: data file (DF), header file (HF) and the virtual instrument description file (VIDF). A virtual instrument is a data stream of one measured parameter or a group of closely related parameters, and it may optionally contain calibration data. The data file is a series of fixed-length data records where each consists of timing information, spin information, references to header records, and the sensor and calibration data in their most basic forms, such as telemetry values. The header file holds data that, for the most part, are slowly varying in time and need not be repeated every data record. The VIDF contains text parameter descriptions, calibration tables, and meta-data relevant in describing the instrument.

IDFS file interaction is described in Figure 4-1 for ASPERA-3 processing and use. The VIDF file is created using inputs from engineers and scientists that describe instrument performance. The spacecraft ASPERA-3 telemetry and Mars Express Orbit/Attitude telemetry are processed by the APAF into header and data files described for each virtual instrument. As an optional file, SwRI creates a Plotting Instrument Description File (PIDF) that is defined using

inputs from scientists and engineers to describe the display capabilities of the data. The header file, data file, VIDF, and (optionally) PIDF are the archived file set for science and engineering analysis, E/PO display, and public archive. The Southwest Data Display and Analysis System (SDDAS) can be used to access IDFS data and provides the analysis tools available for scientists and engineers. If the scientists and/or engineers define an update or change to the virtual instrument definition, these changes will be incorporated within the system definitions.

One goal (and a very important one) of IDFS is to preserve the raw high-resolution data in an organized way that requires no reprocessing. This approach automatically does the archiving of the total telemetry base in an organized, reversible fashion. Reprocessing has been an extreme cost in past data reduction and analysis approaches. Definition and development of each virtual instrument data source are carried out with the same design, execution, testing, and verification processes as with the flight hardware. This will ensure the integrity of the software so that it can be used for instrument testing and verification.

The data in IDFS format are archived at SwRI and accessed by the ASPERA-3 team for science data analysis. A software tool that can be executed both interactively and in batch mode is under development to "export" IDFS data to a more PDS-compliant form. This tool will be added to the existing exportIDFS application as a PDS option. When the PDS option is chosen, the software tool will generate the appropriate PDS label file(s) and PDS-compliant data file(s) in the new spreadsheet/field object format. This software tool (exportIDFS PDS option) can be used to export the raw edited data (PSA level 1a, CODMAC level 2), the calibrated data (PSA level 1b, CODMAC level 3), and derived data (PSA levels 2/3, CODMAC level 5) to CSV format for archival.

4.4 Data Set Documentation

Documentation of data acquisition and processing histories is crucial to successful long-term use of project data. The IDFS data format provides the documentation necessary for understanding the instrumentation and sensors. An Experimenter to Science Data Archive Interface Control Document (EAICD) is under development to provide the details of the data products to be archived, how they are generated, the validation process, and the transfer procedures. Along with the standard data products converted to PDS-compliant form from the IDFS format, appropriate documentation as prescribed by the PDS and PSA will be provided.

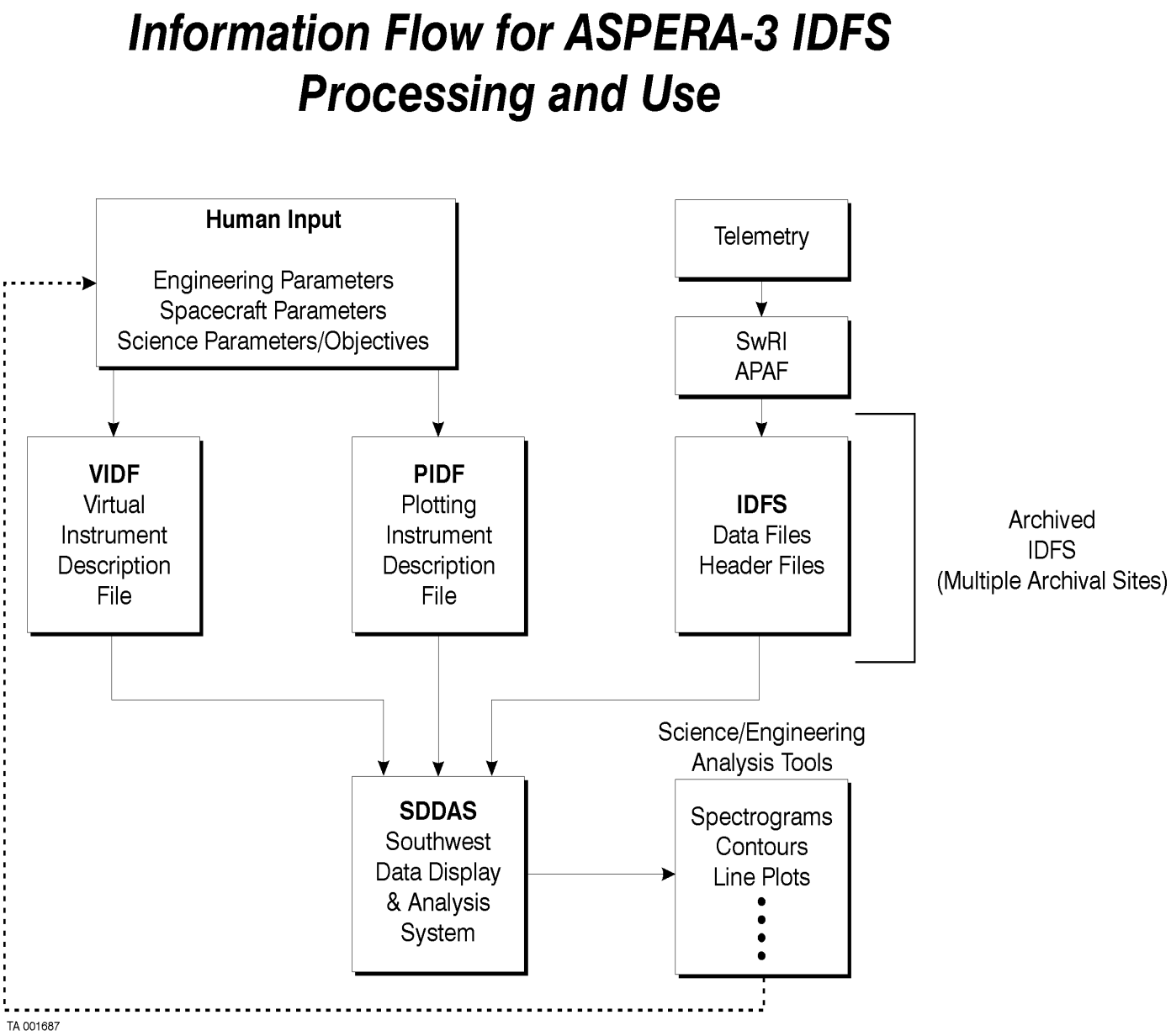
Information Flow for ASPERA-3 IDFS Processing and Use
Human Input
Engineering Parameters
Spacecraft Parameters
Science Parameters/Objectives
Telemetry
SwRI
APAF
VIDF
Virtual
Instrument
Description
File
PIDF
Plotting
Instrument
Description
File
IDFS
Data Files
Header Files
Archived
IDFS
(Multiple Archival Sites)
Science/Engineering
Analysis Tools
SDDAS
Southwest
Data Display
& Analysis
System
Spectrograms
Contours
Line Plots
TA 001687

Figure 4-1

4.5 Software Development and Validation

The ASPERA-3 IDFS processing software development flow is shown in Figure 4-2. Web-based tools are used to gather ASPERA-3 instrument information and IDFS processing requirements. Instrument specifications, Mars Express spacecraft specifications, and science objectives are input into the system from various ASPERA-3 team members throughout the globe. Based on this information, the IDFS requirements are extracted by SwRI. The website is also a natural gathering place for all ASPERA-3 instrument documentation. The ASPERA-3 team has reviewed the requirements, and a requirements document was generated by SwRI and delivered to IRF. SwRI is designing, reviewing, and validating the IDFS processing software against the requirements.

Once the design has been validated, SwRI begins the software implementation and test plan development. The software code is reviewed by SwRI to minimize coding and logic errors. Upon completion of the implementation, code reviews, and test plan development, the software undergoes verification testing. Simulation and/or stimulated data sets in the defined telemetry format are used as input for the verification tests. These tests are to follow the test plan and the results are documented. SwRI works with other members of the ASPERA-3 team to generate and crosscheck test data sets such that the test results both highlight expected science data and check for processing inconsistencies. When all IDFS processing verification tests pass, the software is ready for use.

The exportIDFS application accesses IDFS data and will generate PDS label files and PDS-compliant data files if the PDS option is chosen. SwRI, IRF, PSA, and PDS will all work together to define specific input choices for producing the desired data products for submission to the PSA and PDS archives. The predefined configuration files will be used in a production fashion to generate the PDS label and data files. The data products and associated documentation will undergo the PDS peer review process with both PSA and PDS. Upon successful review and validation, the exportIDFS software with the predefined configuration files will be ready for production of ASPERA-3 PDS-compliant data products.

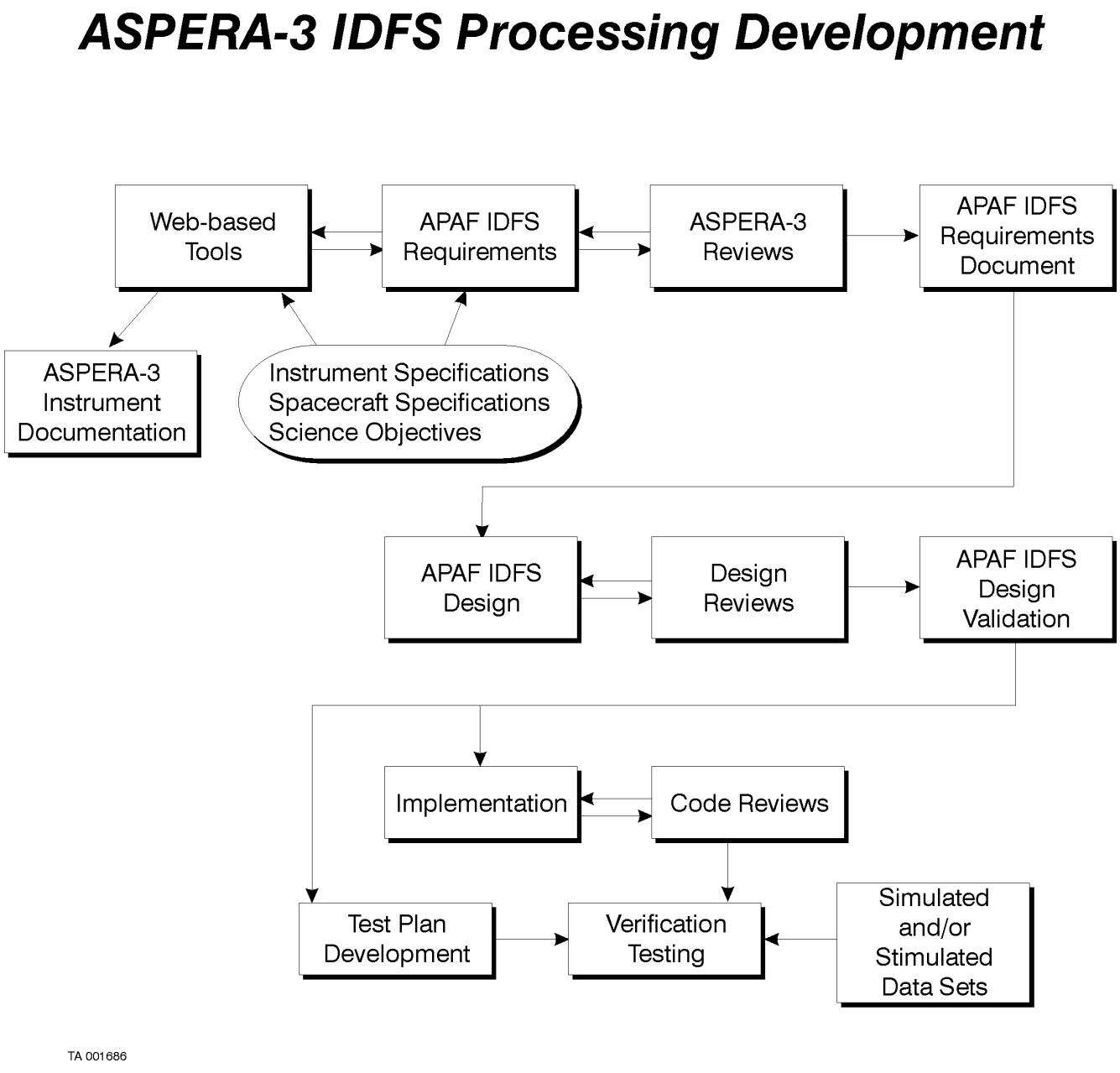
ASPERA-3 IDFS Processing Development
Web-based Tools
APAF IDFS Requirements
ASPERA-3 Reviews
APAF IDFS Requirements Document
ASPERA-3 Instrument Documentation
Instrument Specifications
Spacecraft Specifications
Science Objectives
APAF IDFS Design
Design Reviews
APAF IDFS Design Validation
Implementation
Code Reviews
Test Plan Development
Verification Testing
Simulated and/or Stimulated Data Sets
TA 001686

Figure 4-2

5. DATA ARCHIVING

Data will be stored in at least two locations after they have been processed. This will be at IRF (the ASPERA-3 PI Institution) and SwRI (the US PI Institution). Data may also be stored at other ASPERA-3 Co-Investigator sites at the discretion of the PI. Six months after the data is taken, it will be submitted to the ESA Planetary Science Archive (PSA) and the NASA Planetary Data System (PDS) for long-term archive and public use. The six-month time delay is the proprietary period granted to the PI as requested by the ASPERA-3 science staff to allow for verification and validation of the data before it is released to the general scientific community.

Discussions and meetings with both the PDS Planetary Plasma Interactions Node and PSA are ongoing regarding ASPERA-3 data submission for long-term archive. PSA, PDS PPI Node, and SwRI will continue to plan for the submission of ASPERA-3 data to PSA and PDS throughout the mission.

The Planetary Data System currently requires that the final archive product be placed on a stable media. PDS uses both CD and DVD technologies for final archive. Data are commonly delivered to the PDS on other media or electronically, depending on the volume, and then transferred to the stable media. SwRI is currently planning to submit ASPERA-3 data products to PSA and PDS electronically. PDS will produce the archive volumes when the appropriate amount of data is collected and place the archive volumes on the physical media.

PDS has indicated that the IDFS format planned for ASPERA-3 data is acceptable for archiving as long as the required documentation accompanies the data files. However, SwRI is in the process of developing a software tool to access the IDFS files and generate more PDS-compliant data files along with the associated PDS label files. SwRI, with the help and advice of PSA and PDS-PPI, is in the process of developing the software tool (exportIDFS PDS option) and required PDS documentation, and all will continue working together to make sure that the exportIDFS software tool remains PDS compatible. The main issue here is uniformity of structure. PDS standard documentation cannot be used to describe files whose internal structure changes within a single file. SwRI has evaluated the PDS required documents and finds that most of its documentation will be transferable to satisfy the PDS documentation requirement. There are some PDS required documents that are PDS specific and will be generated when appropriate throughout the Mars Express mission. These documents include templates (data set, instrument, reference, and personnel) that are used to load meta-data into the PDS catalog. SwRI will generate the required PDS templates following the outline provided by PDS.

The SwRI software staff is currently working with PSA and PDS staffs to define and document the ASPERA-3 datasets to be submitted to PSA and PDS for archival. This is an ongoing process where the level 1b (PSA level definition, see Appendix D) ASPERA-3 datasets will be determined and documented during the cruise phase of the mission. The initial datasets will focus on the science data and refer to the engineering, housekeeping, and orbit/attitude data as ancillary where appropriate. The higher-level ASPERA-3 science data sets to be delivered to PSA and PDS for long-term archival will be developed well into the Mars Express mission.

Currently, plans to initially test data submission to PSA and PDS will be accomplished sometime during the cruise phase of the Mars Express mission (June 2003 through January 2004). This test will include a peer review of pre-launch data and any cruise data that may be available. The peer review allows the science community outside the Mars Express project to provide feedback to the instrument team as to the appropriateness and completeness of the archive data sets, documentation, and organization. After the pre-launch and cruise data have completed the PSA/PDS review cycle, and the archive structure and documentation are finalized, the submission of ASPERA-3 science data to PSA and PDS should become routine.

PDS prefers block data submissions where the block size is similar to the archive media volume. The frequency of data delivery to the PDS and PSA will be once a month where each ASPERA-3 data submission will contain a month's worth of data that were acquired no less than six (6) months prior to submission.

Updates to the virtual instrument descriptions or the ASPERA-3 data files, and any additional data products defined by the science staff during the operational phase will be made available to the public via delivery to PSA and PDS. These data products are any defined, derived, and created data products by the science staff during their analysis of ASPERA-3 data. The higher-order data products to be submitted to PDS for long-term archive will be determined by the ASPERA-3 science team. The PDS-PPI staff has requested that at a minimum, these data products should contain distribution functions and moments, be de-coupled from software, and include published references. However, final higher-level data products to be delivered to PDS and PSA for long-term archival will be at the discretion and approval of the ASPERA-3 PI at IRF and the ASPERA-3 US PI at SwRI.

APPENDIX A: Glossary of Selected Terms

Archive	One or more data sets along with the documentation and ancillary information needed to understand and use the data. An archive is a logical construct independent of the medium on which it is stored.
Archive Volume	A volume is a unit of media on which data products are stored, e.g., one CD-ROM. An *archive volume* is a volume containing all or part of an archive.
Archive Volume Set	When an archive spans multiple volumes, they are called an *archive volume set*.
Data Product	A labeled grouping of data resulting from a scientific observation. A product label identifies, describes, and defines the structure of the data. Examples of data products include planetary images, spectrum tables, or time series tables.
Experiment Data Records	NASA Level 0 data for a given instrument; raw data.
Reduced Data Records	Science data that have been processed from raw data to NASA Level 1 or higher. See APPENDIX B for definitions of processing levels.
Standard Data Product	A data product that has been defined during the proposal and selection process and that is contractually promised by the PI as part of the investigation. Standard data products are generated in a predefined way, using well-documented procedures, and processed in a production fashion.
Virtual instrument	Data stream of a measured parameter or a group of closely related parameters.

APPENDIX B: NASA Definitions of Processing Levels

Packet Data	Telemetry data stream as received at the ground station, with science and engineering data embedded.
Level 0	Instrument science data (e.g., raw voltages, counts) at full resolution, time ordered, with duplicates and transmission errors removed.
Level 1A	Level 0 data that have been located in space and may have been transformed (e.g., calibrated, rearranged) in a reversible manner and packaged with needed ancillary and auxiliary data (e.g., radiances with the calibration equations applied).
Level 1B	Irreversibly transformed (e.g., resampled, remapped, calibrated) values of the instrument measurements (e.g., radiances, magnetic field strength).
Level 1C	Level 1A or 1B data that have been resampled and mapped onto uniform space-time grids. The data are calibrated (i.e., radiometrically corrected) and may have additional corrections applied (e.g., terrain correction).
Level 2	Geophysical parameters, generally derived from Level 1 data, and located in space and time commensurate with instrument location, pointing, and sampling.
Level 3	Geophysical parameters mapped onto uniform space-time grids.

APPENDIX C: CODMAC Definitions of Processing Levels*

Level	Type	Data Processing Level Description
1	Raw Data	Telemetry data with data embedded.
2	Edited Data	Corrected for telemetry errors and split or decommutated into a data set for a give instrument. Sometimes called Experimental Data Record. Data are also tagged with time and location of acquisition. Corresponds to NASA Level 0 data.
3	Calibrated Data	Edited data that are still in units produced by instrument, but that have been corrected so that values are expressed in or are proportional to some physical unit such as radiance. No resampling, so edited data can be reconstructed. NASA Level 1A.
4	Resampled Data	Data that have been resampled in the time or space domains in such a way that the original edited data cannot be reconstructed. Could be calibrated, also. NASA Level 1B.
5	Derived Data	Derived results, as maps, reports, graphics, etc. NASA Levels 2 through 5.
6	Ancillary Data	Nonscience data needed to generate calibrated or resampled data sets. Consists of instrument gains, offsets, pointing information for scan platforms, etc.
7	Correlative Data	Other science data needed to interpret space-based data sets. May include ground-based data observations such as soil type or ocean buoy measurements of wind drift.
8	User Description	Description of why the data were required, any peculiarities associated with the data sets, and enough documentation to allow secondary user to extract information from the data.

* As described in the PDS Standard Reference, JPL Document D-7669, Part 2, Version 3.5, Chapter 6, p. 6-6.

APPENDIX D: PSA Definitions of Processing Levels*

Level 0	The raw telemetry data as received at the ground receiving station or ground test GSE, organized by contacts or ground tests.
Level 0a	The telemetry data as produced by the data handling system on the spacecraft and passed to the telemetry subsystem. Level 0a contains transfer frame packets organized by contacts or ground tests.
Level 1	Level 0a data that have been cleaned and merged, time ordered, and in packet format. Cleaned and merged means that duplicate data have been deleted, missing packets are padded out, and the data are organized by days. The actual format of these data is the same as Level 0. This is the level that should be passed to the instrument GSE's for their processing.
Level 1a	The Level 1 data that have been separated by instrument.
Level 1b	Level 1a data that have been sorted by instrument data types and instrument modes. Data are in scientifically useful form, e.g., as images or individual spectra. These data are still uncalibrated.
Level 1c	Level 1a data that have been sorted by instrument data types and instrument modes. Data are in scientifically useful form, e.g., as images or individual spectra. The data are in calibrated form and have been calibrated onboard the spacecraft. The calibration is irreversible and the Level 1b data cannot be reproduced on the ground.
Level 2	Level 1b with calibration and corrections applied to yield data in scientific units.
Level 3	Higher-level data products developed for specific scientific investigations.

* As described in the Mars Express Archive Generation, Validation and Transfer Plan, ESA-MEX-TN-4009, Rev. 1.1, p. 32.

APPENDIX E: ASPERA-3 Data Products*

Instrument Acronym	Data Type / Level†	Long-term Archival	Description	Approx. Total Data Set Size (Mbytes)‡
NPINORM	Edited / 2 Calibrated / 3 Derived / 5	Yes Yes TBD	32 Azimuthal sectors (anodes) from normal mode science data	32 anodes x 32 samples x 2 bytes/sample = 2048 bytes/accum 42,048
NPISTEP	Edited / 2 Calibrated / 3 Derived / 5	Yes Yes TBD	32 Azimuthal sectors (anodes) from deflection stepping mode science data	32 anodes x 32 samples x 2 bytes/sample = 2048 bytes/accum 42,048
NPD1BIN	Edited / 2 Calibrated / 3 Derived / 5	Yes Yes TBD	3 Directions, 16 Mass Steps, 16 Energy Steps in Bin Matrix Data mode for NPD1	768 samples/accum x 2 bytes/sample = 1,536 bytes/accum 15,768
NPD2BIN	Edited / 2 Calibrated / 3 Derived / 5	Yes Yes TBD	3 Directions, 16 Mass Steps, 16 Energy Steps in Bin Matrix Data mode for NPD2	768 samples/accum x 2 bytes/sample = 1,536 bytes/accum 15,768
NPD1RAW	Edited / 2 Calibrated / 3 Derived / 5	Yes Yes TBD	3 Directions, 16 Mass Steps, 16 Energy Steps in Raw data mode for NPD1	768 samples/accum x 2 bytes/sample = 1,536 bytes/accum 15,768
NPD2RAW	Edited / 2 Calibrated / 3 Derived / 5	Yes Yes TBD	3 Directions, 16 Mass Steps, 16 Energy Steps in Raw data mode for NPD2	768 samples/accum x 2 bytes/sample = 1,536 bytes/accum 15,768
NPD1TOF	Edited / 2 Calibrated / 3 Derived / 5	Yes Yes TBD	3 Directions, 16 Mass Steps, 16 Energy Steps in TOF mode for NPD1	768 samples/accum x 2 bytes/sample = 1,536 bytes/accum 15,768
NPD2TOF	Edited / 2 Calibrated / 3 Derived / 5	Yes Yes TBD	3 Directions, 16 Mass Steps, 16 Energy Steps in TOF mode for NPD2	768 samples/accum x 2 bytes/sample = 1,536 bytes/accum 15,768
NPD1PHD	Edited / 2 Calibrated / 3 Derived / 5	Yes Yes TBD	3 Directions, 16 Mass Steps, 16 Energy Steps in TOF mode for NPD1	768 samples/accum x 2 bytes/sample = 1,536 bytes/accum 15,768
NPD2PHD	Edited / 2 Calibrated / 3 Derived / 5	Yes Yes TBD	3 Directions, 16 Mass Steps, 16 Energy Steps in TOF mode for NPD2	768 samples/accum x 2 bytes/sample = 1,536 bytes/accum 15,768
IMA_Hp	Edited / 2 Calibrated / 3 Derived / 5	Yes Yes TBD	16 Anodes with 96 max energy steps for Mass H+	16 x 96 steps/accum x 2 bytes/sample = 3,072 bytes/accum 21,024
IMA_Op	Edited / 2 Calibrated / 3 Derived / 5	Yes Yes TBD	16 Anodes with 96 max energy steps for Mass O+	16 x 96 steps/accum x 2 bytes/sample = 3,072 bytes/accum 21,024

Instrument Acronym	Data Type / Level†	Long-term Archival	Description	Approx. Total Data Set Size (Mbytes)‡
IMA_HEp	Edited / 2 Calibrated / 3 Derived / 5	Yes Yes TBD	16 Anodes with 96 max energy steps for Mass He+	16 x 96 steps/accum x 2 bytes/sample = 3,072 bytes/accum 21,024
IMA_GTOp	Edited / 2 Calibrated / 3 Derived / 5	Yes Yes TBD	16 Anodes with 96 max energy steps for Mass > O+	16 x 96 steps/accum x 2 bytes/sample = 3,072 bytes/accum 21,024
IMA_HEpp	Edited / 2 Calibrated / 3 Derived / 5	Yes Yes TBD	16 Anodes with 96 max energy steps for Mass He++	16 x 96 steps/accum x 2 bytes/sample = 3,072 bytes/accum 21,024
IMA_Opp	Edited / 2 Calibrated / 3 Derived / 5	Yes Yes TBD	16 Anodes with 96 max energy steps for Mass O++	16 x 96 steps/accum x 2 bytes/sample = 3,072 bytes/accum 21,024
IMA_MASS	Edited / 2 Calibrated / 3 Derived / 5	Yes Yes TBD	16 Anodes for all 32 Mass Levels with 96 max energy steps	16 x 32 samples/accum x 2 bytes/sample = 32,768 bytes/accum 24,028
ELSSCIL	Edited / 2 Calibrated / 3 Derived / 5	Yes Yes TBD	16 Anodes, 128 steps for science Low energy levels	16 Anodes x 128 Steps x 0.25 samples/accum x 2 bytes/sample = 1,024 bytes/accum 10,512
ELSSCIH	Edited / 2 Calibrated / 3 Derived / 5	Yes Yes TBD	16 Anodes, 128 steps for science High energy levels	16 Anodes x 128 Steps x 0.25 samples/accum x 2 bytes/sample = 1,024 bytes/accum 10,512
ELSSWPL	Edited / 2 Calibrated / 3 Derived / 5	Yes Yes TBD	16 Anodes, 128 steps for sweep Low energy levels	16 Anodes x 128 Steps x 0.25 samples/accum x 2 bytes/sample = 1,024 bytes/accum 10,512
ELSSWPH	Edited / 2 Calibrated / 3 Derived / 5	Yes Yes TBD	16 Anodes, 128 steps for sweep High energy levels	16 Anodes x 128 Steps x 0.25 samples/accum x 2 bytes/sample = 1,024 bytes/accum 10,512
MUSOLAR	Edited / 2 Calibrated / 3 Derived / 5	Yes Yes TBD	TBD Solar Sensor Values	TBD bytes/accum TBD
SCANPOS ?	Edited / 2 Calibrated / 3 Derived / 5	TBD TBD TBD	TBD Values for Science Position/Orientation	TBD bytes/accum TBD

* Data Products will be in PDS Spreadsheet/Field Object format.

† Data Types and Levels are taken from the CODMAC definitions (see Appendix C). CODMAC Level 2 = PSA Level 1b; CODMAC Level 3 = PSA Level 1c; CODMAC Level 5 = PSA Levels 2, 3

‡ Totals assume maximum bit rate and are based on 2 Earth Years unless specified otherwise.