Cassini Program
Data Management Plan

PD 699-061, Rev. B
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Cassini Program Data Management Plan

Change Record for PD 699-061

Basic	June'95	Initial Release	-
A	7 Apr'98	Updated for new organization and referenced document revisions	All
B	26Apr'99	Updated for new organization and changed "Project" to "Program"	All
		Deleted from use the terms "expert", "non-expert", "readily-useable", and "arduously-useable"	All
		Updated Purpose, Scope; organized Related Documents into "Governing", "Peer" "Subordinate" and "Reference" categories.	1.1,1.2, 1.3
		Removed unnecessary text throughout.	All
		Clarified that RS will deliver L0 products, not L1 and added SPICE data to text.	2.3.1
		Clarified that "maintain" scientific data means life-of-mission storage in this section	2.3.1
		Clarified that "archive" really means "life-of-mission archive".	2.4.1
		Added CODMAC levels to the table.	Table 1
		Clarified level of RSS ATDF and contents of the ODF in the table	Table 1
		Clarified table	Table 2
		Simplified archiving guidelines	2.4.2
		Minor clarifications to include Radio Science peculiarities	3.1
		Clarified "MSO database"	3.1
		Removed "representative data products lists". ReferencedPD 699-068 for the list..	3.3, 2.4.2
		Minor definition updates	4
		Minor glossary updates	5
		Modified figures to show PDS science archive interface is with MSO, not SAUL	Fig 1,2,3
		Deleted table.	Table 4.

Cassini Program Data Management Plan

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1. INTRODUCTION

1.1 Purpose

The purpose of this document is to provide Cassini Program data management roles and responsibilities; to define data processing and product "levels"; to identify data types and show end-to-end flow; and to establish requirements for the archiving and disposition of Cassini Program science and non-science data.

Regarding Cassini's science data, the information contained herein is intended to guide the planning and implementation of NASA-funded data product repositories and the operational interfaces between those capabilities and the Cassini system.

1.2 Scope

This document is the controlling document for all Cassini data. The subordinate documents identifying the non-science and science data products to be archived are: *PD 699-035, Cassini Program Archive Plan for Non-Science Data* and *PD 699-068, Cassini Archive Plan for Science Data.*

This document currently addresses only the science and supplementary data associated with the Cassini Orbiter investigations. A future update will be issued to include the Huygens Probe science data , once necessary Program-level agreements with our ESA partners are finalized.

1.3 Related Documents

1.3.1 Governing Documents. This PDMP is governed by the following documents:

a) OSSA Program Directive - Policy for the Management of OSSA Science Data dated March 5, 1992

b) Memorandum of Understanding between the European Space Agency and the United States National Aeronautics and Space Administration concerning the Joint ESA / NASA Cassini Mission (ESA / NASA MOU)

c) Program Plan, PD 699-001, Rev A, 26 Aug. 1996

d) Cassini / Planetary Data System Interface Requirements Document, PD 699-108, Rev B, 14 April 1998

1.3.2 Peer Documents. This PDMP is peer with the following documents (these documents are on-line in the Cassini Electronic Library at http: / / cel.jpl.nasa.gov):

a) Program Management Plan, PD 699-005, Version 2.0, 12 February 1999.

b) Project Policies and Requirements Document (PPRD), PD 699-004, latest version.

c) Science Management Plan (SMP), PD 699-006, Issue 006, April'99.

d) Cassini Program Security Requirements, PD 699-502, Rev C, 20 Oct'98..

1.3.3 Subordinate Documents. The following documents are subsiduary portions of and governed by this PDMP:

a) Cassini Program Archive Plan for Non-Science Data, PD 699-035, 16 Aug '96.

b) Cassini Program Archive Plan for Science Data, PD 699-068, Prelim, April'99.

1.3.4 Reference Documents. The following documents are referenced in this PDMP:

a) Mission Plan , PD 699-100, latest version.

b) Cassini Operations System Functional Requirements Document, PD 699-500-3-MSO/R, latest version.

c) Cassini Operations System Functional Design Document , PD 699-500-3-GS/D, latest version.

d) JPL/ESA Project Implementation Plan for the Cassini Mission: Saturn Orbiter / Huygens Probe System, PD 699-081, Annex 1, 15 Mar. 95.

The following reference documents are available on-line from the PDS homepage at http://pds.jpl.nasa.gov:

e) Planetary Data System Data Preparation Workbook , Version 3.1, 17 February 1995, JPL D-7669, part 1.

f) Planetary Data System Data System Standards Reference, Version 3.2, 24 July 1995, JPL D-7669, part 2.

g) Planetary Science Data Dictionary Document, Rev. D, 15 March 1996, JPL D-7116.

h) Issues and Recommendations Associated with Distributed Computation and Data Management Systems for the Space Sciences, Committee on Data Management and Computation Space Science Board, Commission on Physical Sciences, Mathematics and Resources, National Research Council, 1986 (CODMAC Report).

1.4 Document Change Control

The PDMP becomes change controlled once it is signed by all parties on the signature page. Change control will be done via revision control. Each revision must be approved by all the parties on the signature page.

2. Program Data Management

2.1 Program Description

The Cassini organization and science objectives are described in the Program Management Plan (PMP).

The Cassini mission is described in the Mission Plan (MP).

The Cassini Flight System, including science instruments, Huygens Probe and spacecraft bus, is described in the Program Policies and Requirements Document (PPRD).

The Cassini operations approach is described in the Cassini Operations System Functional Description Document (COS FRD).

The Cassini end-to-end data flow (Figure 1) includes the payload, spacecraft, Mission Support , Spacecraft Operations, and Science and Uplink "systems" that handle Cassini information, internal interfaces, and external interfaces (PDS, JPL Public Information Office, and the JPL Archive).The end-to- end data flow can be decomposed into uplink and downlink processes (Figure 2). The top half of the figure shows the main functions and interfaces associated with each of the systems for the uplink process. The bottom half shows the functions and interfaces associated with the downlink process.

Note: For purposes of simplifying Figures 1, 2 and 3, the seven (7) Principal Investigator teams and five (5) Facility Instrument teams are assumed to be part of the Science and Uplink (SAUL) Office.

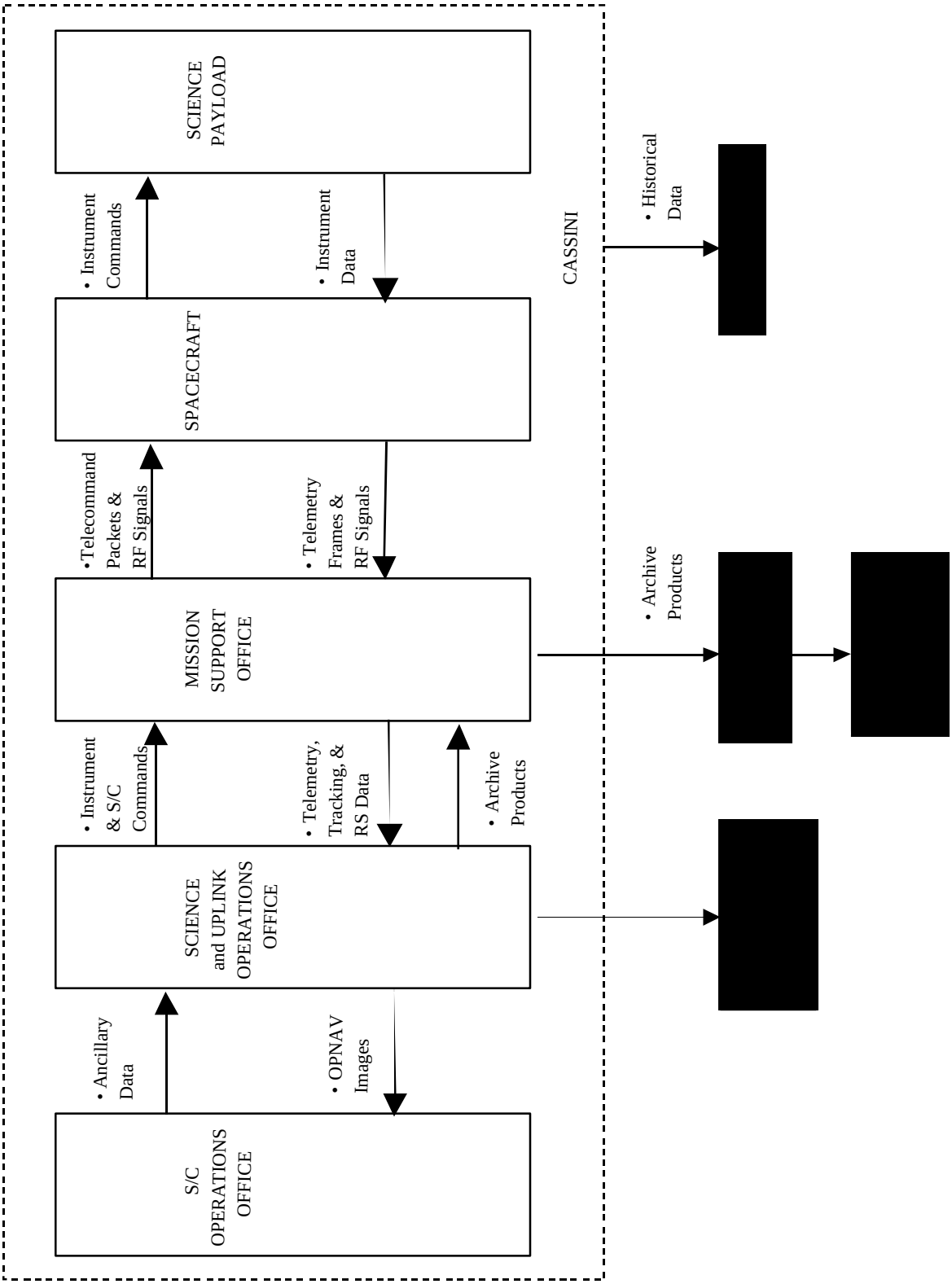

Figure 1: Cassini End-to-End Data Flow Diagram

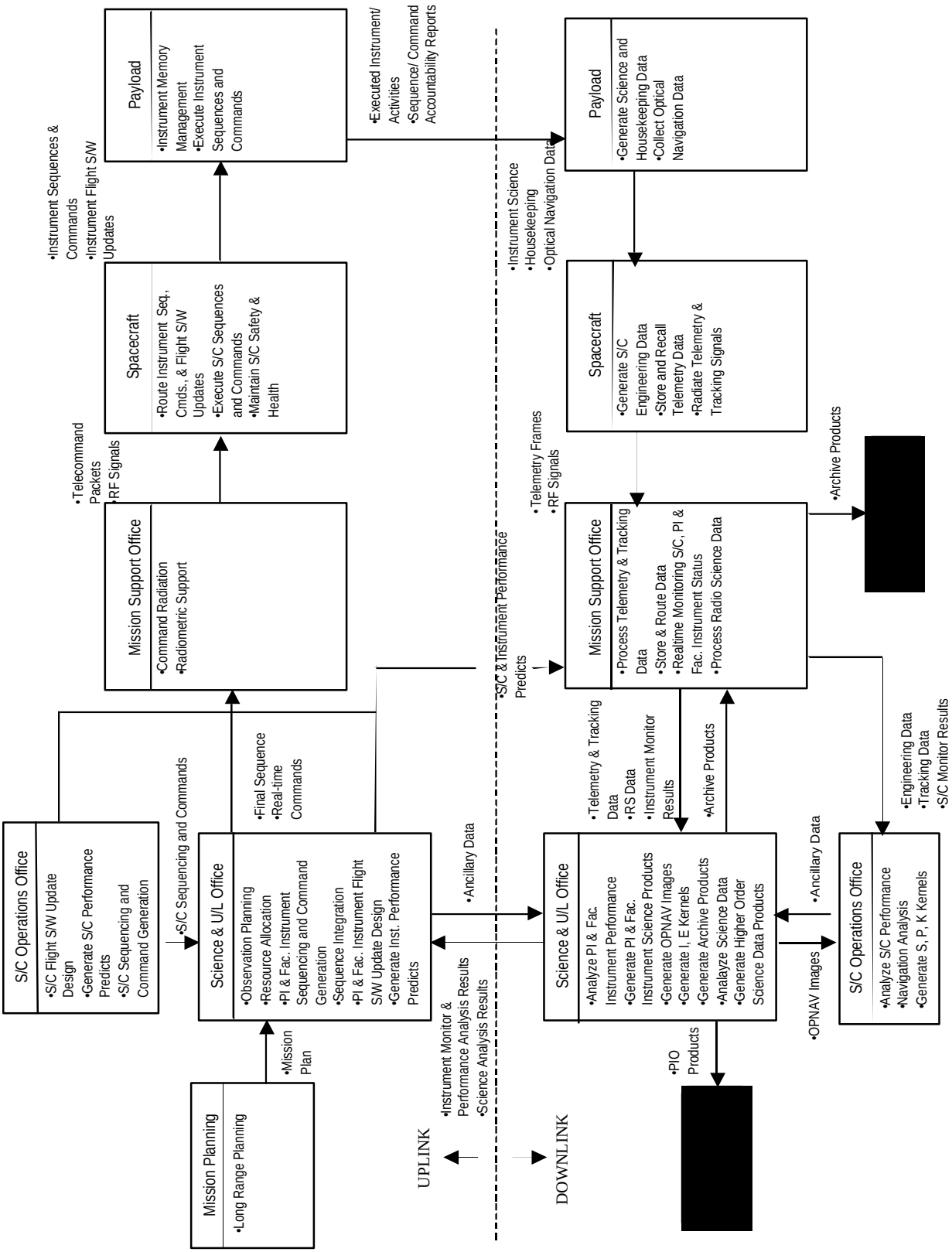

Figure 2: End-to-End Data Flow Design Overview

2.2 Data Management Roles and Responsibilities

2.2.1 Cassini Program

The Cassini Program consists of three separate offices -- Mission Support, Spacecraft Operations, and Science and Uplink Operations. System Engineering across offices is performed by the System Engineering Team.

The Mission Support Office (MSO) includes the Real Time Operations (RTO) and Data and Computing Services (DCS) Teams. DCS is responsible for serving as a conduit between the investigators and the PDS for archiving science data products, and for implementing a data volume production and validation capability to transfer data to the PDS archive. DCS is also responsible for generating and maintaining PD 699-068, *Program Archive Plan for Science Data* (the Program Assessment and Integration Office is responsible for maintaining the sister document , PD 699-035, for non-science data).

The Spacecraft Operations (SCO) Office includes the Attitude Control & Propulsion, Power & Thermal, Navigation, Systems / CDS & Telecommunications, and engineering flight software teams. The Navigation Team is responsible for generating and maintaining the spacecraft and planet (S, P) ephemeris kernels. The Attitude Control & Propulsion Team is responsible for generating and maintaining the C kernel, which provides transformation matrices for getting from spacecraft primary axes to instrument axes.

The Science and Uplink (SAUL) Office includes the Science Planning, Instrument Operations, and Uplink Operations Teams. (Note: For the purposes of negotiating the generation and archival of science data products, the Principal Investigators (PIs) and Facility Instrument Team Leaders (TLs) interface directly with the SAUL Office. In turn, the SAUL Office coordinates science data management issues and activities with MSO, SCO, and other elements of the Program Office). The PIs and TLs are responsible for generating, validating, and delivering to DCS their science data archive products (these products are identified and described in PD 699-068). The Instrument Operations Team is responsible for developing and maintaining the science data instrument and events (I, E) kernels, for generating , validating and maintaining Level 1A science data products for all facility instruments, except RSS, and for developing and maintaining the Navigation Anciliary Information Facility (NAIF) toolkit for reading and processing the SPICE kernels.

2.2.2 Planetary Data System

The PDS shall provide an archive system for the Cassini science data identified in PD699 -068. This system and its support organization shall be designed to stimulate research, facilitate data access, and support correlative analysis of Cassini science data.

The PDS shall assist the Program in archive design and validation of products and coordinate the interfaces with the National Space Science Data Center (NSSDC).

2.2.3 JPL Archives

The JPL Archives and Records Office shall collect the historically valuable records that document Cassini development and flight operations activities, as specified in PD699-035, and provide secure storage for these records. JPL Archives shall make these records available for research and provide a reference service to assist researchers.

2.3 Data Processing and Product Classifications

Table 1 shows the hierarchical breakdown of Cassini data products and the associated NASA Level, which are used throughout this document. CODMAC levels are cross-referenced in the table for readers who think in these terms. For each "level", examples of Cassini products are identified.

Table 2 lists the Cassini supplementary data products. Each product is defined and examples provided. Also, the rationale for life-of-mission storage for each product is given.

Table 3 lists the Cassini data processing levels and examples of Cassini data processing capabilities for each level

Science Data Product	NASA Level	CODMAC	Cassini Examples
Data stream as received at ground station	Raw	Level 1	Digital Original Data Records, Intermediate Data Records
Telemetry frame synchronized, any coding removed, and time-tagged data, invalid and redundant data discarded, data gaps accounted for (space-to-ground communications effects removed or accounted for)	Level 0	Level 2	Instrument, Science, & Engineering Packets, Radio Science Subsystem (RSS) Archival Tracking Data File (ATDF)
(Decompressed) data numbers (DN) divided into meaningful instrument data sets (e.g., instrument frames or cycles)	Level 1A	Level 3	Multimission Image Processing System (MIPS) Unprocessed Data Record (UDR) (DN placed in image frame format), Radio Science Subsystem (RSS) Orbit Data File
Calibrated (for instrument characteristics and geometry) physical units in geometrically labeled or referenced instrument frames/cycles (instrument measurement effects and spacecraft/instrument position and orientation effects removed or accounted for)	Level 1B	Level 4	MIPS Experiment Data Record (EDR) (calibrated DN in image frame format)
Geophysical parameter units (underlying phenomena are measured) or interpretation enhancements such as re-sampling	Higher levels	Level 5	Mosaics, contrast stretching, false color, movies, gravity fields, magnetic fields

Table 1: Cassini Science Data Product Levels

Supplementary Data Type	Cassini Examples	Needed to Support:
Metadata	Data product labels	Access to archived data products
Instrument Calibration Data	RSS Media Calibration Files	Level 1 RSS data processing
Geometric Calibration Data	S/C ephemerides (SPK), Target physical and cartographic constants (PcK), Instrument (IK), and C-matrix (CK) Kernels	Level 1 and higher data processing
Time Conversion Data	Leap Second (LSK) and S/C Clock (SCLK) Kernels	Level 1 and higher data processing
Experiment Description	E Kernels (Science Plan component)	Brief descriptions of distinct components of each investigation providing context for interpreting event/command data
S/C Engineering Data	S/C engineering packets	Investigation of possible S/C effects on archived data products, possible improvement of C Kernels
Instrument Engineering Data	Instrument housekeeping (HK) packets	Investigation of possible instrument effects on archived data products
Engineering Processing Parameters	DN to engineering unit conversion parameters	Investigation of possible S/C or instrument effects on archived data products
Tracking Data	Orbit Data File	Possible improvement of S, P Kernels
GS Monitor Data	Deep Space Network (DSN) monitor blocks	Investigation of possible GS effects on archived data products
Event/Command Data	E Kernels (Sequence component)	Investigation of possible event effects on and interpretation of archived data products
Experiment and Mission Operations Logs	E Kernels (Experimenter's Notebook component)	Investigation of possible S/C and ground system effects on archived science data

Table 2: Cassini Supplementary Data Products

Data Processing Level	Cassini Example	Needed to Support:
Raw	Radio Science open-loop data processing S/W	Generation of Level 0 RS data products
Level 0	Telemetry Input System Software (S/W)	Investigation of possible Level-0 processing effects on archived data products
Level 1	MIPS Telemetry Processing S/W	Level 1B data processing; investigation of possible Level 1A data processing effects on archived data
	Radio and Plasma Wave Spectrometer (RPWS) Medium Frequency Receiver Processing S/W	Level 1 data processing; investigation of possible science Level 1 data processing effects on archived data
Higher levels	RPWS Frequency Spectra Processing S/W	Higher level data processing
Supplementary	Orbit Determination S/W	Possible improvement of S, P, and C Kernels; investigation of possible effects of supplementary data processing on stored data.

Table 3: Cassini Data Processing Levels

2.4 Data Management Policies

Program-level data management policies are documented in the PPRD, SMP, and the Cassini/PDS IRD (see section 1.3 for these references).

3. Operations Data Management

3.1 Data Types and Flow

The primary Cassini data types are science, engineering / housekeeping, and tracking/optical navigation. The flow of these data types are shown in Figure 3 through 5, respectively.

Figure 3 shows the downlink functions and interfaces necessary to collect, analyze, and archive science data . This flow begins with science data collected during science observations. There are two types of science data: data produced on the spacecraft (science bits) and science data produced at the ground station (radio science). For the first type, science bits are stored on board and recalled later to be transmitted to the ground. The science bits are transmitted to a Deep Space Network (DSN) station via a S/C telemetry signal. The telemetry signal is received by the DSN station where the bits representing the science data are reconstructed and sent to JPL. For the second type, radio science data (open-loop, closed-loop, and calibration) are collected at the station and sent to JPL. Closed-loop and calibration data are collected during every track. Open-loop data are collected only during specific radio science experiments. The Mission Support Office stores the telemetry, the raw Radio Science, and reduced science data products in a repository that is accessible by authorized instrument team personnel. The Mission Support Office coordinates the assembly and transfer of science data products to the PDS.

Figure 4 shows the downlink functions and interfaces necessary to collect engineering data from the spacecraft engineering subsystems and housekeeping data from the payload, and deliver the engineering and housekeeping data to the science teams. This flow begins with housekeeping data collected from the payload and engineering data collected from the spacecraft engineering subsystems. These data bits are either transmitted to the ground immediately or stored on board and recalled later to be transmitted to the ground. The engineering and housekeeping data bits are transmitted to a DSN station via a S/C telemetry signal. The telemetry signal is received by the DSN station where the bits representing the engineering and housekeeping data are reconstructed and sent to JPL along with data describing the status of the DSN. At JPL, Program personnel monitor the mission using the engineering, housekeeping, and DSN status data and store these data in a data base. Science teams retrieve housekeeping and engineering data from the data base at JPL and use them to analyze instrument performance.

Figure 5 shows the downlink functions and interfaces necessary to collect optical navigation and tracking data and deliver these data to the Program. This flow begins with imaging data collected during optical navigation observations. These data bits are stored on board and recalled later to be transmitted to the ground. The optical navigation data bits are transmitted to a DSN station via a S/C telemetry signal. The

telemetry signal is received by the DSN station where the bits representing the optical navigation data are reconstructed. The DSN station also generates tracking data (i.e., ranging and Doppler) based on the radio signal transmitted from the spacecraft. The DSN also generates related data that allow the tracking data to be calibrated. The optical navigation data, tracking data, and calibration data are sent to JPL where there are processed into optical navigation images. The Spacecraft Operations Office uses the tracking data and optical navigation data to determine the trajectories of the spacecraft and the target bodies.

3.2 Data Management Requirements

The high-level Cassini Program data management requirements are:

1. The Cassini Program shall store all Level-0 science data (i.e. packets which are part of the telemetry data) in a "near-line" storage system until end-of-program. This storage system shall be part of the Telemetry Data System (TDS) with modern access and retrieval capabilities for the user community.

2. All radiometric data acquired for the Cassini Program shall be archived by the Telecommunications and Mission Operations Directorate (TMOD).

3 .The Cassini Program shall transfer validated Level-0 open-loop radio science data and closed-loop tracking data to the PDS for archiving and use by the scientific community at large.

4. The Cassini Program shall transfer all Level-1B scientific data products (or the capability to generate these products) for the non-RSS investigations, and associated ancillary data to the PDS for archiving and use by the scientific community at large.

5. The time period for validating and transferring Cassini science data to the PDS shall be in accordance with the schedule specified in PD 699-006, Section 5.3.

6. The list and description of each Cassini science product and supplementary product to be transferred to the PDS shall be specifed in PD 699-068.

7. All non-science data necessary to support the Program and to comply with NASA's and JPL's information retention policies shall be part of the Cassini Archive, which is managed and maintained by the PA&I Office. The Cassini Archive shall meet the technical requirements defined in PD 699-035.

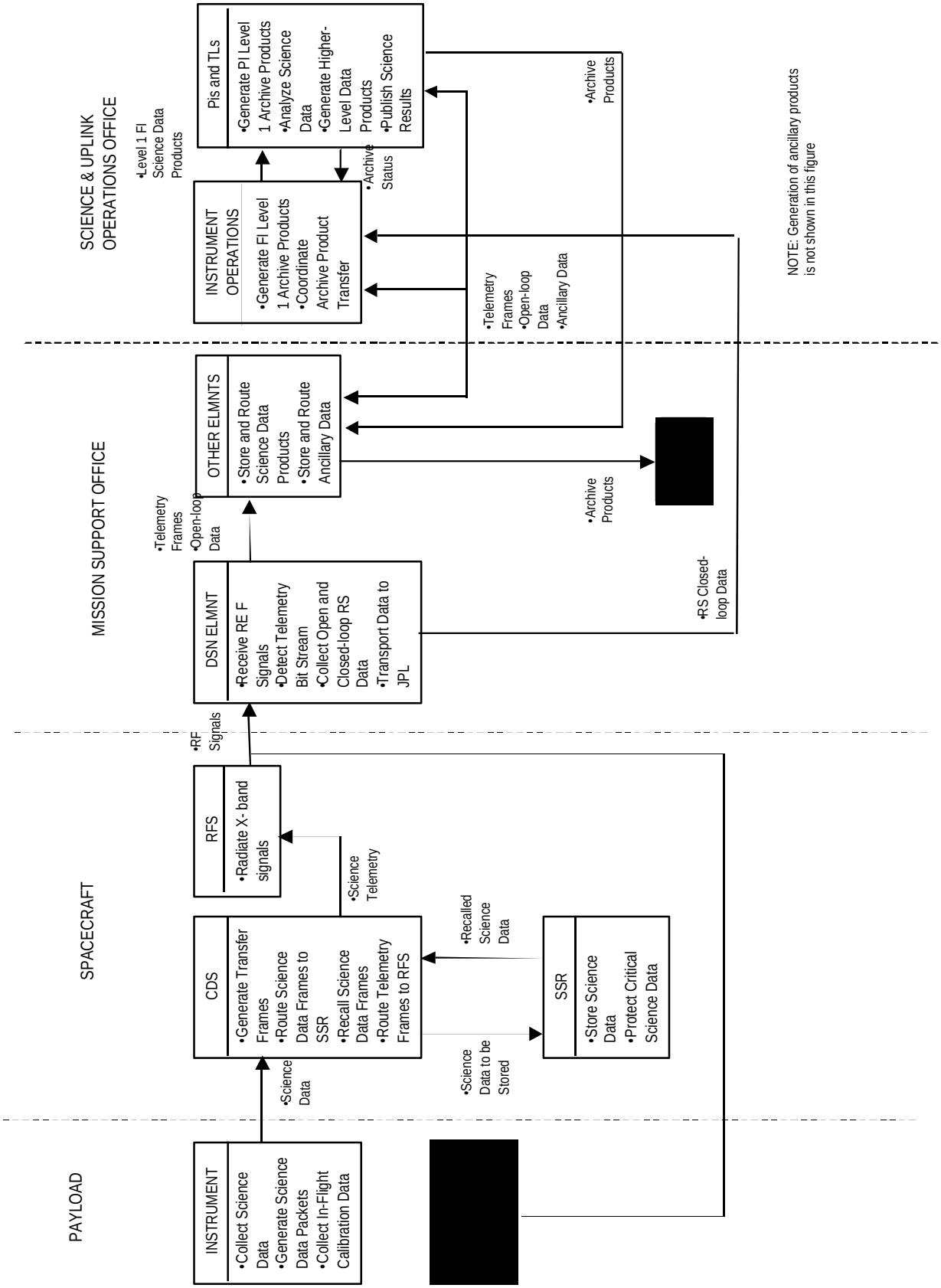

Figure 3: End-to-End Science Data Flow

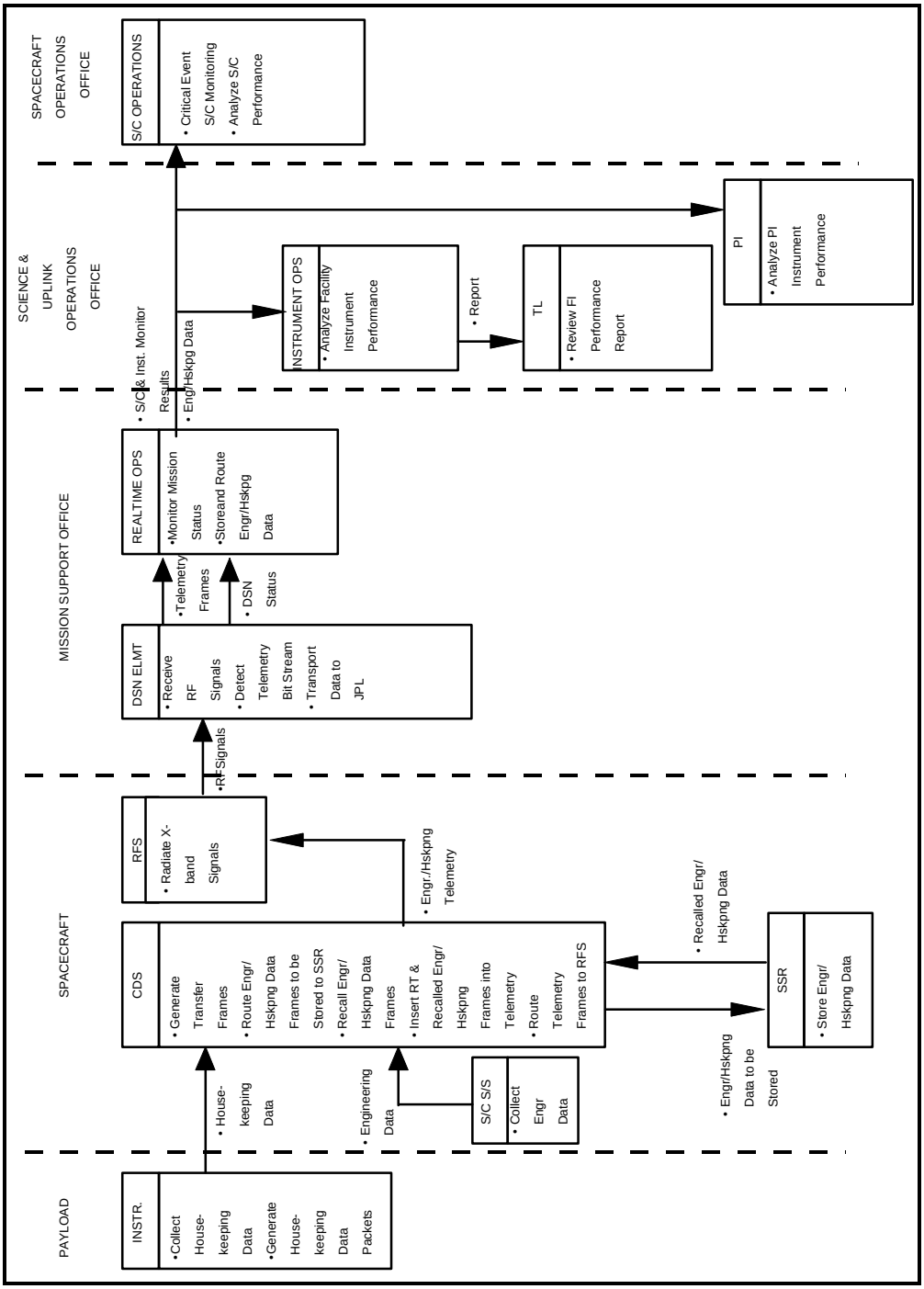

Figure 4: End-to-End Engineering and Housekeeping Data Flow

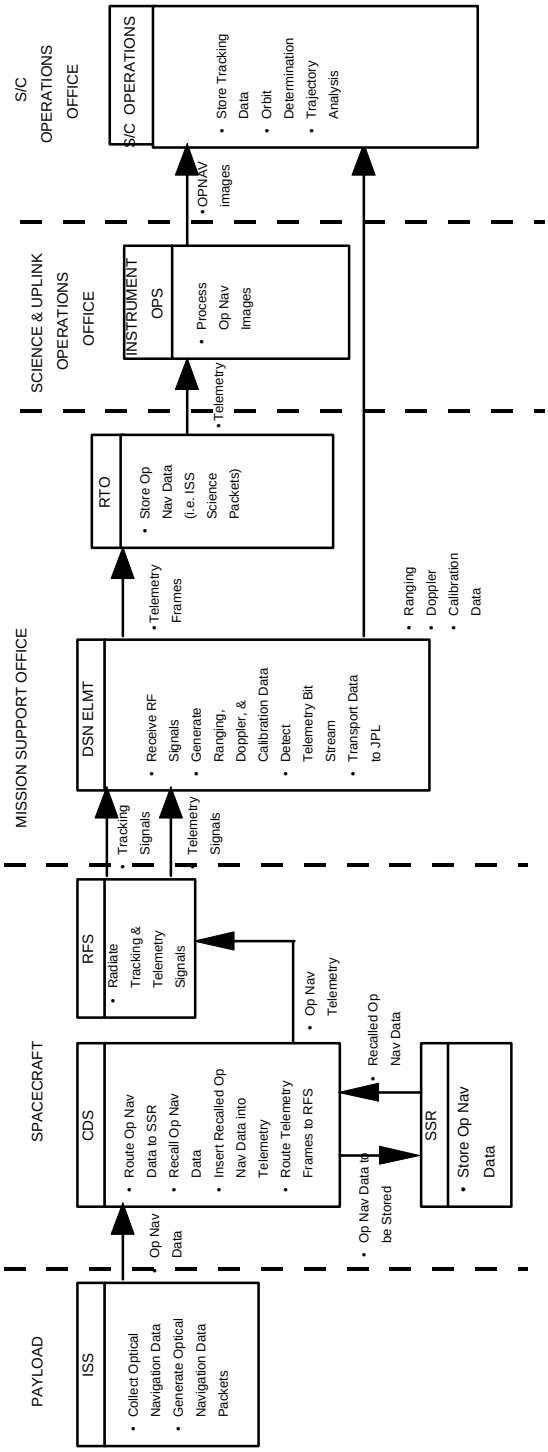

Figure 5: End-to-End Tracking and Optical Navigation Data Flow

4. Definitions

4.1 Data Management

Data Management includes all of the activities associated with the flow of Cassini science, non-science, and supplementary data from generation of the data type through the delivery of resulting data products to the archive facilities.

4.2 Data Archive

Data Archive is the facility for preserving Cassini data for the future. Data Archiving is the act of placing the data and accompanying descriptive information in an archive facility.

4.3 Data Storage

Data Storage is the maintenance of a copy of the data that are available to users until such data have been transferred to an archive, and the maintenance of a copy (may or may not be the same copy) of the data in a way that ensures that it will not be lost or damaged before it is transferred to an archive.

5. Appendix A: Acronyms and Abbreviations

CAPS	Cassini Plasma Spectrometer
CDA	Cosmic Dust Analyzer
CDS	Command and Data Subsystem
CIRS	Composite Infrared Spectrometer
CODMAC	Committee on Data Management and Computation
Co-I	Co-Investigator
COS	Cassini Operations System
DSN	Deep Space Network
EDR	Experiment Data Record
FDD	Functional Design Document
FI	Facility Instrument
HK	Housekeeping
IDR	Intermediate Data Record
IDS	Interdisciplinary Scientist
IK	SPICE instrument geometry data kernal
IRD	Interface Requirements Document
INMS	Ion and Neutral Mass Spectrometer
ISS	Imaging Science Subsystem
LSK	SPICE leapseconds data kernal
MAG	Magnetometer
MIMI	Magnetospheric Imaging Instrument
MIPS	Multimission Image Processing System
MP	Mission Plan
NSSDC	National Space Science Data Center
OTL	Operations Team Leader
PcK	SPICE target size, shape and orientation kernal
PDMP	Program Data Management Plan
PDS	Planetary Data System
PI	Principal Investigator
PPRD	Program Policies & Requirements Document
RPWS	Radio and Plasma Wave Spectrometer
RSS	Radio Science Subsystem
SCLK	SPICE spacecraft clock coefficients data
SFDU	Standard Formatted Data Unit
SMP	Science Management Plan
SPICE	Spacecraft, Planet, Instrument, C-matrix, Events
SPK	SPICE Spacecraft and target (planet, etc.) ephemeris kernal
SSR	Solid State Recorder
TL	Team Leader
TM	Team Member
TMOD	Telecommunications and Mission Operations Directorate
UDR	Unprocessed Data Record

UVIS	Ultraviolet Imaging Spectrograph
VIMS	Visual and Infrared Mapping Spectrometer

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