

PD 699-006

Issue 007

THE
CASSINI PROGRAM
SCIENCE MANAGEMENT PLAN

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The
Cassini Program
Science Management Plan

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CHANGE LOG

<u>ISSUE</u>	<u>DATE</u>	<u>COMMENTS</u>
001	11/18/91	Baseline
002	06/26/92	Cassini redesign and CRAF cancellation
003	06/20/94	Planned update to include more MO&DA issues; addition of waiver permitting INMS to operate like a PI investigation during the MO&DA Phase
004	05/16/97	Changes in Project Science Office and Mission and Science Operations Office organizations; other changes to make the document more directly applicable to MO&DA
005	06/98	Deletion of Development Phase information; other changes to make document more directly applicable to MO&DA including documentation and review requirements, addition of FI MSO Coordinator role statement, and expansion of IDS role statement consistent with AO.
006	07/99	Adaptation to new Cassini organization, consolidation of PI roles into one office, consolidation of TL roles into one office and addition of support role for Instrument Operations, increased emphasis on Investigation support for Science Planning staff, nomenclature changes.
007	06/03	Update to reflect better understanding of SOP Integration Process, SOP Implementation Process, After Market Process, SOP Update Process and Science and Sequencing Update Process

TABLE OF CONTENTS

1.	INTRODUCTION.....	1-1
1.1	PURPOSE	1-1
1.2	SCOPE	1-1
1.3	REVISION	1-1
2.	BACKGROUND.....	2-1
3.	ORGANIZATION, ROLES, AND RESPONSIBILITIES	3-1
3.1	SCIENTIST PARTICIPATION	3-1
3.1.1	<i>Principal Investigator Teams</i>	3-3
3.1.2	<i>Facility Instrument Teams</i>	3-5
3.1.3	<i>Interdisciplinary Scientists</i>	3-7
3.1.4	<i>Science Team Operations Technical Leader</i>	3-8
3.2	PROGRAM SCIENTIST	3-8
3.3	PROJECT SCIENTIST.....	3-9
3.3.1	<i>Deputy Project Scientist</i>	3-10
3.4	PROJECT SCIENCE GROUP	3-10
3.4.1	<i>Working Groups</i>	3-11
3.5	SCIENCE AND UPLINK OFFICE	3-11
3.5.1	<i>Science and Uplink Manager</i>	3-12
3.6	SCIENCE PLANNING.....	3-13
3.6.1	<i>Science Planning Manager</i>	3-13
3.6.2	<i>Investigation Scientists</i>	3-14
3.6.3	<i>Science Planning Engineers</i>	3-15
3.7	INSTRUMENT OPERATIONS.....	3-16
3.7.1	<i>Instrument Operations Manager</i>	3-16
3.8	UPLINK OPERATIONS	3-18
3.8.1	<i>Uplink Operations Manager</i>	3-18
4.	SCIENCE INVESTIGATION PLANS.....	4-1
4.1	OVERVIEW	4-1
4.2	SUGGESTED PLAN CONTENTS	4-1
4.2.1	<i>Investigation Management Plan</i>	4-1
4.2.2	<i>Investigation Team Operations Plan</i>	4-2
4.2.3	<i>Investigation Team Operations Verification and Validation Plan</i>	4-2
5.	DATA ANALYSIS, REPORTING, AND ARCHIVING REQUIREMENTS.....	5-1
5.1	DATA ANALYSIS	5-1
5.2	REPORTS	5-1
5.2.1	<i>Scientific Reports</i>	5-1
5.2.2	<i>Public Information Releases</i>	5-1
5.3	DATA ARCHIVING	5-2
6.	SCIENCE INVESTIGATIONS RESOURCE MANAGEMENT	6-1
6.1	FUNDING ALLOCATIONS	6-1
6.2	IMPOSED CHANGES	6-1
6.3	DESCOPING	6-1
6.4	RESOURCE REPORTING	6-2
7.	ACRONYMS AND ABBREVIATIONS	7-1

1. INTRODUCTION

1.1 Purpose

This Cassini Program Science Management Plan defines authorities and responsibilities with regard to science aspects of the Cassini Program of:

- (1) The United States National Aeronautics and Space Administration (NASA)
- (2) The Cassini Program at the Jet Propulsion Laboratory (JPL)
- (3) Facility Instrument Team Members and Leaders
- (4) Principal Investigators and Co-Investigators
- (5) Interdisciplinary Scientists

This plan defines only funding provisions for Huygens Probe Principal Investigators, Co-Investigators, and Interdisciplinary Scientists being funded by the United States. It does not define European Space Agency (ESA) requirements on Huygens Probe investigators or on their investigations.

1.2 Scope

This plan applies from NASA's confirmation of investigations through the End of Mission (EOM) for data collection and through an additional three months for data analysis, reporting, and archiving. EOM for the Cassini Mission (nominally 07/01/2008) is four years past Saturn orbit insertion. If the Cassini mission should be extended beyond its nominal End of Mission, then this plan will be revised accordingly.

This plan is subordinate to the Cassini Program Management Plan (PD 699-005). In the event of an inconsistency between the two plans, the Cassini Program Management Plan shall prevail.

1.3 Revision

This plan will be revised as needed to accommodate changes in the Cassini Mission. Revisions require the same approvals as the plan itself. Upon approval, revisions will be disseminated to the Cassini Program Manager, to all Principal Investigators, Facility Instrument Team Leaders, and Interdisciplinary Scientists for the Cassini Mission, and to the Cassini Program management staff.

2. BACKGROUND

The Cassini Program is part of the NASA Solar System Exploration Program directed by the NASA Office of Space Science (OSS). The Cassini Program is a joint NASA/European Space Agency (ESA) mission. NASA provides the Cassini Orbiter; ESA provides the Huygens Probe. NASA has assigned management of the Cassini Program to the Jet Propulsion Laboratory (JPL) of the California Institute of Technology.

The Cassini Mission consists of an orbiter to Saturn and a probe to study Titan, a satellite of Saturn. The mission carries an assortment of instruments to collect data.

Some instruments serve individual investigations while other instruments serve multiple investigations. Instruments for individual investigations are called Principal Investigator (PI) Instruments, provided by their respective PIs. Instruments for multiple investigations are called Facility Instruments (FIs), provided by JPL (Imaging Science Subsystem), Goddard Space Flight Center (Ion and Neutral Mass Spectrometer), and JPL and Agenzia Spaziale Italiana (Radio Science Subsystem, Visible and Infrared Mapping Spectrometer, and Cassini Radar).

By Announcements of Opportunity (AOs), NASA solicited proposals for scientific investigations for the Cassini Mission (AO Nos. OSSA-1-89 and OSSA-1-91). ESA solicited proposals for scientific investigations on the Huygens Probe through a separate AO (SCI(89)2).

NASA announced tentative selections of investigations for the Cassini Mission on 13 November 1990 and for the Cassini Ion and Neutral Mass Spectrometer on 13 February 1992. NASA Headquarters confirmed all investigations tentatively selected for the Cassini Saturn orbiter on 28 October 1992. ESA confirmed selections for the Huygens Probe on 11 September 1990. Any changes in the scope of an investigation or in its investigators require approval by NASA or ESA, as appropriate.

3. ORGANIZATION, ROLES, AND RESPONSIBILITIES

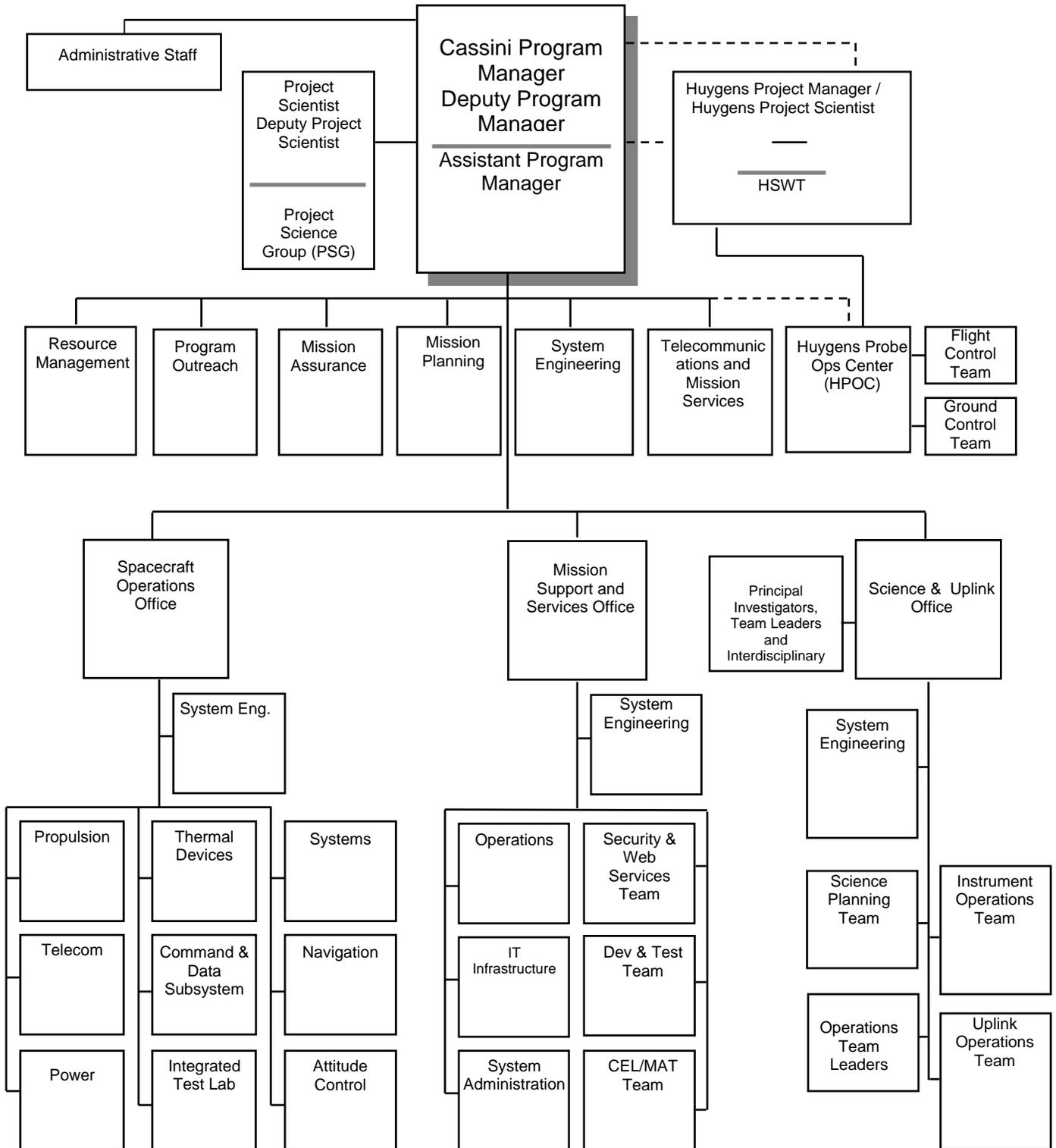
3.1 *Scientist Participation*

Scientists in the Cassini Mission participate in one or another of three modes:

- (1) Participants who jointly proposed to use an instrument supplied by a Principal Investigator (PI) or Co-Investigators who were later added to the team are members of investigations led by the selected PI.
- (2) Participants in the Imaging Science Subsystem (ISS), Visible and Infrared Mapping Spectrometer (VIMS), Cassini Radar (RADAR), Ion and Neutral Mass Spectrometer (INMS), and Radio Science Subsystem (RSS) investigations are members of Facility Instrument Teams formed by NASA on the basis of proposals submitted by individuals. Each team is led by a NASA-selected Facility Instrument Team Leader (TL).
- (3) Interdisciplinary Scientists (IDSs) conduct investigations that use data from two or more instruments provided by others.

All participants are members of the Science and Uplink Office (SAUL). They work closely with SAUL Science Planning for setting of science policy and requirements, for performing long-range science planning, and for analyzing data and publishing results. They also work closely with SAUL Instrument Operations in mission planning, sequencing, data processing, and other day-to-day operations.

CASSINI / HUYGENS PROGRAM



3.1.1 Principal Investigator Teams

Each Principal Investigator Team consists of scientists interested in a specific investigation who were either selected as a team or subsequently became team members as a result of NASA-approved changes. The team leader is the Principal Investigator (PI); other members are Co-Investigators (Co-Is). Each team shall plan and conduct its investigation, work with the data, and publish its results.

3.1.1.1 Principal Investigator Responsibilities

Each PI shall conduct the investigation and ensure that the investigation's detailed definition, planning and operational support of mission operations, and data analysis are successfully accomplished within the Program schedule and the team's available resources. The PI is responsible for developing and supplying the flight instrumentation and software, and associated ground support equipment as well as for the overall conduct of the investigation.

Specific responsibilities of a PI are to:

- (1) Be the investigation's primary point of contact with other elements of the Program regarding investigation requirements, schedules, and funds.
- (2) Participate as a member of the Project Science Group (PSG) (see Section 3.4) and ensure that the investigation is represented on appropriate PSG Working Groups (see Section 3.4.1).
- (3) Represent the team in relevant Program reviews.
- (4) Generate and maintain adequate documentation regarding the investigation, including the documents listed in Section 4.2.
- (5) Ensure that instrument calibration and operation are appropriate to the objectives of the investigation.
- (6) Descope the investigation as needed to stay within allocated resources.
- (7) Designate an Operations Technical Leader as the point of contact with the Cassini Operations System regarding development of the investigation's distributed operations capabilities and corrective actions, if any, which may be required to assure that operational commitments to other elements of the Program are met. (See Section 3.1.4 for a representative list of the duties of an Operations Technical Leader.)
- (8) Participate in mission, spacecraft, and operations design.
- (9) Negotiate with appropriate data processing facilities to provide science data processing support, if applicable.

- (10) Negotiate written agreements with each relevant Interdisciplinary Scientist (IDS) regarding the data or results to be provided to the IDS and the release and publication of data and results.
- (11) Participate in detailed planning and execution of mission operations, including:
 - a) specification and verification of observational designs, including spacecraft system configurations.
 - b) ground data system integration and test (both within the science team and at Program system level).
 - c) operations training and test.
 - d) generation and validation of instrument commands, subsequences, and flight software modifications.
 - e) evaluation of instrument health, safety, and performance.
 - f) processing of housekeeping and science data and generation of selected ancillary data.
 - g) ground and flight instrument calibration.
 - h) operation and maintenance of the instrument engineering model.
- (12) Ensure that data reduction and analysis and reporting of investigation results meet high scientific standards and are consistent with budgetary and other relevant constraints.
- (13) Prepare preliminary reports, quick-release products, detailed scientific summaries, and public information releases, as appropriate (see Section 5.0).
- (14) Deposit data during the course of the mission in a Science Team-maintained database; deposit reduced data, an instrument description, calibration data, associated software, documentation, and other pertinent investigation information in a Program archive in accord with the Program Data Management Plan (PD 699-061) and the Program Archive Plan for Science Data (PD 699-068).
- (15) Negotiate MO&DA contracts with the Science and Uplink Manager.
- (16) Negotiate funding and manage subcontracts for all US Co-Is (US-funded PIs only)
- (17) Notify the Science and Uplink Manager of funding amounts by fiscal year to be given to non-contract US Co-Is located at NASA centers or other government agencies (US-funded PIs only).
- (18) Suggest to the Science and Uplink Manager the funding by fiscal year for each US-funded Co-I (European-funded PIs only).

Except for responsibilities (1), (5), (6),(14), (15), (16), (17) and (18), PIs may delegate their authority to Co-Is and/or their Operations Technical Leader.

3.1.1.2 Co-Investigator Responsibilities

Co-Is shall participate in their investigation in accord with its Investigation Management Plan and shall assist their PI in meeting his or her responsibilities. Co-Is shall not delegate their authority to anyone.

3.1.2 Facility Instrument Teams

The Cassini ISS, VIMS, RSS, RADAR, and INMS Science Teams are Facility Instrument Teams. Each team consists of Team Members and a Team Leader (TL) who is responsible for the overall coordination of team investigations. Design and development of each Facility Instrument were the responsibility of JPL (or Goddard Space Flight Center for INMS).

Specific responsibilities of each Facility Instrument's Team Members are to:

- (1) Plan and conduct Team Member investigations using its Facility Instrument, reduce the data, and publish its results (see Section 5.0).
- (2) Develop calibration requirements pertaining to the investigation and participate in calibrating the instrument.
- (3) Help define instrument test plans and test data handling plans and to review test results.
- (4) Participate in the mission, spacecraft, and operations designs.
- (5) Ensure that data reduction and analysis, reporting, and publication of investigation results are consistent with high scientific standards and within mission and budgetary constraints.
- (6) Participate in detailed planning and execution of mission operations, including:
 - a) specification of observational objectives and measurement requirements.
 - b) processing of science data according to specifications contained within the Program Data Management Plan, PD 699-061.

For the facility instruments other than INMS, SAUL Instrument Operations will assume primary responsibility for the following aspects of planning and executing mission operations (note that INMS Team operations mimic those of a PI Team):

- (1) Representation and verification of timelines of activities, including spacecraft system configurations, in response to the team's specification of observational designs.
- (2) Ground data system integration and test.
- (3) Operations training and test.
- (4) Generation and validation of instrument commands, subsequences, and predicts.

- (5) Evaluation of instrument health, safety, and performance.
- (6) Processing of science data through a stage as defined in the Program Data Management Plan (PD 699-061).

Also, SAUL Instrument Operations will participate in ISS, RADAR, RSS, and VIMS instrument flight calibration planning, data processing, and analysis.

3.1.2.1 Facility Instrument Team Leader Responsibilities

Each TL shall have primary responsibility for coordination of the team's investigations and facilitating of team activities. The TL shall also represent the team in Program activities and be the primary contact between the team and other Program elements.

Specific responsibilities of a TL are to:

- (1) Be the team's primary point of contact with other elements of the Program regarding investigation requirements, schedules, and funds.
- (2) Participate as a member of the Project Science Group (PSG) (see Section 3.4) and ensure that the team is represented on appropriate PSG Working Groups (see Section 3.4.1).
- (3) Represent the team in relevant Program reviews.
- (4) Generate and/or negotiate approval of pertinent instrument documentation related to the team's investigations, including the documents listed in Section 4.2.
- (5) Maintain cognizance of and working interfaces with Program activities that may affect the team.
- (6) Recommend a budget for each TM and assist the Science and Uplink Manager in finalizing contracts with each TM, as required.
- (7) Designate, post-Launch, an Operations Technical Leader as the point of contact with the Cassini Operations System regarding development of the investigations' distributed operations capabilities and corrective actions, if any, which may be required to assure that operational commitments to other elements of the Program are met.
- (8) Negotiate with appropriate data processing facilities to provide science data processing support, if applicable.
- (9) Negotiate written agreements with each relevant Interdisciplinary Scientist (IDS) regarding the data or results to be provided to the IDS and the release and publication of data and results.

- (10) Coordinate the preparation of preliminary reports, quick-release products, detailed scientific summaries, and public information releases as appropriate (see Section 5.0).
- (11) Deposit data during the course of the mission in a Science Team-maintained database and to deposit reduced data, an instrument description, calibration data, associated software, documentation, and other pertinent investigation information in a Program archive, in accord with the Program Archive Plan for Science Data (PD 699-068).
- (12) Coordinate the descope of the investigations as required to stay within allocated resources.

Except for responsibilities (1), (6), (7), (12), and (13), TLs may delegate their authority to TMs and/or their Operations Technical Leader.

3.1.2.2 Facility Instrument Team Member Responsibilities

Team Members (TMs) shall assist their Team Leader (TL) in meeting the team's responsibilities and shall participate in the Team's activities as defined in its Investigation Management Plan. TMs may not delegate their authority to anyone outside the team. The Science and Uplink Manager shall administer an individual contract with each TM as appropriate.

3.1.3 Interdisciplinary Scientists

Each Interdisciplinary Scientist (IDS) shall conduct a clearly defined investigation that uses scientific information returned from two or more instruments provided by others. IDSs will have access to the science database; however, provisions for accessing the information and a data-release and publication policy shall be negotiated in accord with items (2) and (3) below.

Specific responsibilities of an IDS are to:

- (1) Develop a plan to accomplish the investigation goals within a budget negotiated with the Science and Uplink Manager.
- (2) Negotiate with relevant TLs and PIs specific arrangements for obtaining data and information from them and for providing any services to them.
- (3) Negotiate with relevant TLs and PIs specific data-release and publication arrangements that provide a protected period during which the Facility Instrument and Principal Investigator teams may convert information returned from their instruments into a useful form and publish or otherwise make it available.
- (4) Participate as a member of the Project Science Group (PSG) (see Section 3.4) and ensure that the investigation is represented on appropriate PSG Working Groups (see Section 3.4.1).

- (5) Prepare preliminary reports, quick-release products, detailed scientific summaries, and public information releases, as appropriate (see Section 5.0).
- (6) Participate in all phases of the mission (science planning, operations, data analysis, data management, and publications of results).
- (7) Deposit any significant new data products from the investigation in a Program-maintained database for collaborative studies.
- (8) Maintain a broad and critical scientific overview of mission activities during planning and operations.
- (9) Support, as required, the Program by leading (e.g. chairing or co-chairing) an appropriate subgroup of the PSG during all phases of the mission.

3.1.4 Science Team Operations Technical Leader

The Science Team Operations Technical Leader (OTL) reports to the PI/TL and is the technical lead for overseeing the development, operation and maintenance of the Science Team's operations facility. The PI OTL is responsible for assuring that the PI Instrument is operated in accordance with the Cassini Mission Plan (PD 699-100). The relevant texts of the Mission Plan concern the health and safety of the instrument (if delegated by the PI), and the development and maintenance of PI instrument operations capabilities for the science phase of the mission. The FI OTL is responsible for carrying out tasks assigned to the TL (see TL column in Appendix A) as delegated by the TL to the OTL.

3.2 *Program Scientist*

The Cassini Program Scientist represents the scientific interests of the Cassini Program at NASA Headquarters. Within the scope of this position the Program Scientist has the responsibility to:

- (1) Provide the Program with the mission's major scientific objectives and reviewing and arranging approvals of any significant changes in mission scientific content or investigator participation, in consultation with the Cassini Project Scientist and the ESA Huygens Project Scientist.
- (2) Communicate scientific matters between NASA Headquarters and the JPL Cassini Program Office.
- (3) Serve as a vice chair on the Project Science Group (PSG), as a member of the Huygens Science Working Team (HSWT), and as an *ex officio* member of all PSG Working Groups (see Section 3.4.1).

- (4) Bring to the attention of the PSG specific questions from NASA Headquarters and information about other relevant planetary flight programs and science research and analysis activities.
- (5) Verify that the Program Data Management Plan (PD 699-061) is developed and in place before Launch.

3.3 Project Scientist

The Project Scientist is a member of JPL's Cassini Program Office and is the Program's chief scientist. The Project Scientist reports to the Cassini Program Manager and is responsible for maximizing the science return from the mission within Program constraints. In his responsibilities, the Project Scientist is supported in carrying out his role by the Science and Uplink (SAUL) Manager and by the Science Planning (SP) Manager. Specific responsibilities of the Project Scientist are to:

- (1) Set scientific requirements and priorities on behalf of the Program and the PSG.
- (2) Make scientific judgments for the Program.
- (3) Serve as the scientific spokesman for the Program.
- (4) Assure (with the support of the SAUL and SP Managers) effective working relationships between the Investigators and the Program.
- (5) Assure (with the support of the SAUL and SP Managers) that the Investigations are properly supported.
- (6) Assure that the scientists involved in the Program properly carry out their responsibilities.
- (7) Assure that conflicting science requirements are resolved.
- (8) Participate in Program activities (e.g., mission and operations designs and Program decisions), continually seeking ways to maximize (within Program constraints) the science return from the mission.
- (9) Organize, manage, and chair the Cassini Project Science Group (PSG) so that it is effective and efficient. The Project Scientist shall call on the PSG to help resolve conflicting scientific requirements. Whenever the PSG is unable to satisfactorily resolve these conflicts, the Project Scientist shall recommend solutions to the Program Manager.
- (10) Serve as an *ex officio* member of all science investigation teams and PSG Working Groups and as a vice chair of the Huygens Science Working Team (HSWT).
- (11) Assure that all participating scientists are informed in a timely manner of major Program

activities and actions.

- (12) Notify the NASA Program Scientist of any changes in objectives, techniques, or resource allocations for individual investigations as they evolve.

3.3.1 Deputy Project Scientist

The Cassini Deputy Project Scientist reports to the Cassini Project Scientist. The Deputy Project Scientist participates in Program activities, continually seeking ways to maximize the science return from the mission within Program constraints. The Deputy Project Scientist has the responsibility to:

- (1) Act on behalf of the Project Scientist when the latter is absent.
- (2) Represent the Cassini science elements on the DSN Resource Allocation Review Board.
- (3) Serve as the Executive Secretary of the Cassini Project Science Group (PSG) and as a member of the PSG.
- (4) Participate in Program contingency planning (e.g., spacecraft performance and Earth flyby).
- (5) Oversee the liaison between the Project Science Group (and its working groups) and other elements of the Program.
- (6) Administer Project Science Group protocols (e.g., Requests for Action, action items, resolutions, recommendations and endorsements, archiving and distribution of documents).
- (7) Participate in the development of conflict-free Science Operations Plans.
- (8) Assist in the development, negotiation, and monitoring of the interfaces and liaison between science elements and various other Program elements to assure effective working relationships.
- (9) Carry out special assignments under authority delegated by the Project Scientist.

3.4 *Project Science Group*

The Project Science Group (PSG) helps to optimize mission science return and to resolve conflicting science requirements.

Specific responsibilities of the PSG are to:

- (1) Develop detailed science observation objectives for the mission.

- (2) Understand how the science requirements affect the distribution of resources and recommend and conduct appropriate trade-off studies.
- (3) Help develop detailed science plans for the mission, the mission design and the mission operations design to accommodate the science investigations.
- (4) Provide advice to the Program to maximize the effectiveness of science support.
- (5) Help resolve conflicting science requirements.

The PSG is chaired by the Project Scientist. The NASA Cassini Program Scientist and the Huygens Project Scientist are vice chairs of the PSG. Other members include the PIs, TLs, and IDSs. The Deputy Project Scientist is a member and serves as the Executive Secretary of the PSG.

The PSG shall meet at regular intervals, according to the needs of the particular Program phase, to coordinate investigations and review the mission's science aspects. For planning purposes, the PSG shall be assumed to hold three meetings per year. One or two PSG meetings shall be held annually in the United States, usually at the Jet Propulsion Laboratory (JPL) in Pasadena, and one meeting annually in Europe.

3.4.1 Working Groups

The PSG may form Working Groups to gather information and to study and debate science requirements, policies, and science tradeoffs as they affect the scientific success of the mission. Each Working Group shall be chaired by a scientist selected by the PSG chair.

Each Working Group's membership shall consist of those PIs, TLs, IDSs, and others as needed to carry out the work of the group. PIs and TLs may, with the approval of the relevant Working Group chair, designate one or more Co-Is or TMs to work with that Working Group in place of or in addition to the PI or TL.

The Cassini Project Scientist, the Huygens Project Scientist, the Cassini Program Scientist, and the Cassini Deputy Project Scientist are ex officio members of all Working Groups.

3.5 *Science and Uplink Office*

Facility Instrument Team Leaders and Team Members, Principal Investigators and their Co-Investigators, and Interdisciplinary Scientists are associated with the Science and Uplink (SAUL) Office for all of their development and operational responsibilities and for purposes of contract management and other administrative support within the Cassini Program. The SAUL Office is managed by the SAUL Manager. Additionally, SAUL contains three teams known as Science Planning, Instrument Operations, and Uplink Operations.

3.5.1 Science and Uplink Manager

The Science and Uplink Manager reports to the Assistant Program Manager for Development regarding development tasks and to the Program Manager for all other tasks. The Science and Uplink Manager has the responsibility to:

- (1) Manage science planning, instrument operations, and uplink operations, including development of corresponding planning and operational capabilities.
- (2) Negotiate science team contracts and serve as Contract Technical Manager for all science contracts.
- (3) Provide support to the Project Scientist.
- (4) Implement approved science requirements.
- (5) Articulate conflicting requirements levied by other elements of the Program on the science teams and secure their resolution by the Program Manager.
- (6) Ensure that the Program satisfies its science data archiving commitments.
- (7) Negotiate with the Assistant Program Manager for Development (APM-D) regarding the schedule for receiving validated operating capabilities, including flight and ground software, hardware, procedures, and trained personnel.
- (8) Negotiate operational readiness criteria with the APM-D, certify operational readiness of developments upon reviewing their operational validation test (OVT) results submitted by the APM-D, and see to their successful conclusion.
- (9) Monitor Science and Uplink Office progress, status, and problems and reporting them to the Program Manager in a timely manner.
- (10) Assure that science policies and priorities are appropriately reflected in sequence development priorities.
- (11) Plan and schedule activities required to get Cassini Science Investigators “on contract”.
- (12) Coordinate Cassini science contract activities with the JPL Business Operations Directorate (200).
- (13) Support negotiations of science investigator Statements of Work (SOWs) for the next contract phase.
- (14) Review 533Qs and other financial reports and identify resource variances requiring follow-up and/or corrective action.
- (15) Ensure alignment between PIs/TLs and the rest of the Program for contract dependencies and commitments.

3.6 Science Planning

Science Planning is one of three teams within the Science and Uplink (SAUL) Office and has as its primary responsibility the development and execution of a PSG-approved Science Planning Process and the production of a PSG-approved and Program-approved Science Operations Plan (including engineering events) for Saturn Tour. Science Planning includes the Science Planning Manager, the Investigation Scientists and the Science Planning Engineers.

3.6.1 Science Planning Manager

The Science Planning Manager reports to the Science and Uplink Manager. Specific responsibilities of the Science Planning Manager are to:

- (1) Collect from Science Teams and document for Program use the geometric, timing, and other observation characteristics needed for successful definition of science activities in Cruise and Tour.
- (2) Jointly oversee the development of science planning tools and operations design with the ULO Manager.
- (3) Define and apply procedures for science planning.
- (4) Develop science options, including contingency plans.
- (5) Coordinate science planning activities with the work of the Science and Uplink, Spacecraft Operations, and Mission Support and Services Offices and with distributed operations sites in developing science sequences of events.
- (6) Oversee science planning activities on behalf of the Project Science Group.
- (7) Develop and deliver to the SAUL Manager items that meet the requirements negotiated between the SAUL Manager and the Science Planning Manager, and do so on a schedule and within a budget also negotiated between these managers.
- (8) Organize and staff a team of personnel needed to accomplish item (7).
- (9) Serve as the principal point of contact with other elements of the Program with respect to the deliverables referred to in item (7).
- (10) Provide support to the Project Scientist.
- (11) Implement approved science requirements.
- (12) Represent the work of Science Planning in Program meetings, design teams, working

groups, and reviews.

- (13) Develop and manage system resource margins for Science Planning use, with the concurrence of the SAUL Manager.
- (14) Establish and maintain a status reporting system and assess and report technical, schedule, and budgetary performance and estimates-to-complete as negotiated with the SAUL Manager.

3.6.2 Investigation Scientists

Investigation Scientists report to the Science Planning Manager and serve as the primary liaison between the Science Investigation Teams and the Program on a day-to-day basis. They also serve (on a rotating basis) as Science Staff for Science Planning representation on Discipline Working Groups, Mission Planning Team and Sequence Virtual Team, and to assist in science integration and conflict resolution. Specific duties of an Investigation Scientist are to:

- (1) Be the primary interface regarding science matters between the Program and a Principal Investigator Team or Facility Instrument Team. As such, Investigation Scientists are expected to be regular participants in Investigation Team Meetings.
- (2) Represent one (or two) Science Investigation Team(s) in science trade-off discussions as needed, and to be an advocate for that team and for Cassini Science in general.
- (3) Bring to the attention of relevant Principal Investigators or Facility Instrument Team Leaders any issues or problems that may affect the investigation's science return.
- (4) Assist the Program and the Science Investigation Teams in developing a process (and tools as required) for improving the science return of the Cassini Mission.
- (5) Take the lead role, on a rotating basis, for planning and developing of a conflict-free integrated timeline and plan for Program-approved cruise science opportunities, and to shepherd that plan through the remainder of sequence development.
- (6) Assist the Program and Science Investigation Teams in developing an integrated and conflict-free Science Operations Plan (SOP) for the period from six months before Saturn Orbit Insertion to End of Mission, and to assist in revising that SOP as needed.
- (7) Serve (on a rotating basis) as the Science representative to Mission Planning and/or Sequence Teams to assure that overall science objectives are preserved or enhanced by decisions made within those teams.
- (8) Provide unbiased science advice to the Project Scientist, the Science Planning Manager, and the SAUL Manager, especially in matters that require rapid turnaround.
- (9) Be a resource to other elements of the Program regarding Cassini Science and the impact on science return of ground system and mission design alternatives.

- (10) Participate in the activities of and represent the decisions and intents of the Project Science Group (PSG) in discussions and activities within Science Planning.
- (11) Participate in education and public outreach efforts regarding the science objectives and science return of the Cassini Mission and related items.

Affiliation with one or more investigations during the Saturn Tour, as negotiated by the Investigation Scientist with individual Principal Investigators, Facility Investigation Team Leaders, or Interdisciplinary Scientists, is permissible for purposes of science data analysis and publication. Funding (up to a total ≤ 4 hours per week of IS time [out of the total of 20 hours per week allocated to each IS] in any given fiscal year plus travel and minor procurement costs) for this activity is provided by the Science Planning Manager; this does not preclude additional funding by the relevant Principal Investigator, Team Leader, or Interdisciplinary Scientist.

3.6.3 Science Planning Engineers

The Science Planning Engineers report to the Science Planning Manager. The Science System consists of Science Planning, the Science Investigators, and interfaces between Science Planning and other elements of the Program. Science Planning Engineers assure that all aspects of the Science System operate in a manner that optimizes (within Program constraints) the performance of the system. The Science Planning Engineer also assures that the Science System interacts efficiently with external interfaces and in accord with the Distributed Operations concept.

Specific responsibilities of the Science Planning Engineers are to:

- (1) Perform system engineering studies internal to Science (including the Science and Uplink Office, the Project Science Group, and the Investigation Teams) and between Science Planning and other elements of the Program.
- (2) Coordinate and assist in developing the design of the pre-uplink and post-downlink processes within Science.
- (3) Perform or assist in other tasks as assigned by the Science Planning Manager, including:
 - a) Coordination of internal Science interfaces and external interfaces with other elements of the Program.
 - b) Monitoring and coordination of the design and implementation of the Science Planning Process, including internally or externally provided software to assist in the Science Planning Process and appropriate validation of requirement specifications for that software.
 - c) Reviewing and assisting in the coordination of changes to Science documents, the relevant Interface Requirements Documents, and Mission Planning documents.

- d) Recommending improvements to internal Science Planning functions and assisting in integrating Science activities in support of other Program processes.
- e) Providing guidelines for and reviewing Science internal training and V&V plans, and monitoring and assessing the adequacy of internal Science V&V and training.
- f) Monitoring Science processes (e.g., pre-uplink and post-downlink) during operations and making appropriate recommendations to improve those processes.

3.7 Instrument Operations

Instrument Operations is one of three teams within the Science and Uplink (SAUL) Office. Instrument Operations is responsible for Science Operations and Planning Computer (SOPC) integration and validation, for SOPC maintenance coordination, for Facility Instrument flight software, commanding, and health and safety maintenance, and for general coordination of distributed science operations for both Principal Investigations and Facility Investigations.

3.7.1 Instrument Operations Manager

The Instrument Operations Manager reports to the Science and Uplink Manager and has the responsibility to:

- (1) Develop tools (including appropriate models), procedures, and training for:
 - a) Generating Facility Instrument (FI) internal commands.
 - b) Generating Facility Instrument command sequences.
 - c) Calibrating Facility Instruments and analyzing and predicting their performance.
 - d) Generating high-level Facility Instrument science data products.
 - e) Maintaining Facility Instrument flight software.
 - f) Developing, validating and archiving Facility Instrument event science data E-kernels and I-kernels.
 - g) Using Program-provided tools and delivery systems for use at distributed sites, including the Science Operations and Planning Computer (SOPC).
- (2) Participate and concur in interface negotiations with Principal Investigators and Facility Instrument Team Leaders.
- (3) Coordinate Principal Investigator and Team Leader developments and operations.
- (4) Chair the Instrument Operations Working Group (IOWG) and publish its minutes, including the action item list.
- (5) Provide a single point of contact for investigators with respect to troubleshooting mission services.

- (6) Coordinate distributed science and uplink activities and data production and distribution.
- (7) Generate and validate:
 - (a) Facility Instrument commands.
 - (b) Facility-Instrument-driven system commands.
 - (c) Science data products for Facility Instruments, per the Program Data Management Plan (PD 699-061).
 - (d) Facility Instrument telemetry predictions.
- (8) Maintain and operate ISS, and RADAR engineering models and the VIMS breadboard model.
- (9) Establish and maintain a complete set of E-kernels and I-kernels.
- (10) Evaluate and maintain Facility Instrument health, safety, and performance.
- (11) Develop and deliver to the Science and Uplink Manager items that meet the requirements negotiated between the Instrument Operations Manager and the Science and Uplink Manager, and do so on a schedule and for a budget also negotiated by IO and SAUL Managers.
- (12) Organize and staff a team of personnel needed to accomplish item (12), including approving (or rejecting) personnel proposed by Division 3X to staff the team.
- (13) Serve as the principal point of contact with other elements of the Program with respect to the deliverables referred to in (12).
- (14) Represent the work of Instrument Operations in Program meetings, design teams, working groups, and reviews.
- (15) Develop and manage system resource margins for Instrument Operations use, with the concurrence of the Science and Uplink Manager.
- (16) Establish and maintain a status reporting system, and assess and report technical, schedule, and budgetary performance and estimates-to-complete as negotiated with the Science and Uplink Manager.
- (17) Develop the system needed for Facility Instrument engineering operations for Tour.
- (18) Develop and maintain Program Archive Tracking Tool.
- (19) Archive all Program generated SPICE data in the PDS
- (20) Develop and maintain the SPICE Toolkit

- (21) Provide training and user consultation for the SPICE system.

3.8 Uplink Operations

Uplink Operations is one of three teams within the Science and Uplink Office and has as its primary responsibility the development of the Uplink software, development and use of the High Speed Simulator, and development and operation of the Cassini Sequence Team. The Sequence Team prepares and validates the sequences of commands that are radiated to the spacecraft.

3.8.1 Uplink Operations Manager

The Uplink Operations Manager reports to the Science and Uplink Manager and has the responsibility to:

- (1) Define uplink operations requirements.
- (2) Develop and provide tools (including models) for:
 - a) Identifying operational resource constraints.
 - b) Tracking resource usage.
 - c) Designing and checking spacecraft attitude changes
 - d) Generating, integrating, translating, validating, and constraint-checking spacecraft and ground sequences of events.
 - e) High-speed simulation of spacecraft performance.
 - f) Science planning.
- (3) Identify needed Deep Space Mission System uplink and downlink support, including timing, for operations, testing, and training.
- (4) Generate cruise-phase and orbit-specific tour-phase integrated sequences, using inputs from the Science Planning Manager and the Mission Planning Leader.
- (5) Generate and coordinate real-time command schedules for spacecraft systems and instruments.
- (6) Allocate ground and spacecraft resources to various science and engineering sequence users and generate an activity plan for each sequence.
- (7) Integrate all portions of distributed sequences into a cohesive ground and spacecraft sequence of events, commands, and activities.
- (8) Check sequences against flight rules and mission plan constraints.
- (9) Develop and deliver to the Science and Uplink (SAUL) Manager items that meet the requirements negotiated between the Uplink Operations Manager and the SAUL Manager, and do so on a schedule and within a budget also negotiated by the two managers.

- (10) Organize and staff the team as needed to develop the deliverable items negotiated in item (9), including approving (or rejecting) personnel proposed by Division 3X to staff the team.
- (11) Serve as the principal point of contact with other elements of the Program with respect to the deliverables referred to in item (9).
- (12) Represent the work of Uplink Operations in Program meetings, design teams, working groups, and reviews.
- (13) Develop and manage system resource margins for use by Uplink Operations, with the concurrence of the Science and Uplink Manager.
- (14) Establish and maintain a status reporting system, and assess and report technical, schedule, and budgetary performance and estimates-to-complete as negotiated with the Science and Uplink Manager.

4. SCIENCE INVESTIGATION PLANS

4.1 Overview

Each Cassini Orbiter Principal Investigator (PI) and Interdisciplinary Scientist (IDS) is responsible for developing a plan for managing his or her team's respective investigations, associated division of responsibilities among team members, and funding. Each Cassini Orbiter Facility Instrument Team Leader (TL) is responsible for coordinating a plan for developing his or her team's respective investigations, for the associated division of responsibilities among team members, and for funding. Copies of relevant documentation, whether formal or informal, should be sent to the Science and Uplink Manager (see Section 4.2.1 for suggested contents of an Investigation's management plan).

Each Cassini Orbiter Principal Investigator (PI) is additionally responsible for developing plans for how the team is to perform its operations tasks and for how the team will verify and validate those plans, both internally and as a part of Program-level verification and validation. For Facility Investigations, this responsibility is the responsibility of SAUL Instrument Operations.

Investigation Team Operations Plans and Investigation Team Operations Verification and Validation Plans were written by Orbiter PI Teams for Cruise (from Launch to SOI - 2 years). Updates to those plans for the period SOI - 2 years to End of Mission should be sent to the Science and Uplink Office Manager. These updates need not be formal documents, but could be in the form of electronic or paper memoranda. Suggested contents for such plans are given in Sections 4.2.2 and 4.2.3 below. Documentation may be combined when it is appropriate to do so.

4.2 Suggested Plan Contents

4.2.1 Investigation Management Plan

An Investigation's management plan could appropriately include:

- (1) Description of the PI's, TL's, or IDS's role and each Co-I's or TM's role in the development of ground hardware and ground or flight software, planning of observations, participation in mission operations, data analysis and publication, data archiving, and interactions with other elements of the Program.
- (2) Definition of all responsibilities delegated by the PI or TL to Co-I's or TMs or to the Operations Technical Leader.
- (3) A budget, in real-year dollars by government fiscal year, for each US PI, TL, or IDS and for each separately funded US Co-I or TM. The MO&DA budget information should be provided in two "bins" (i.e., with totals for Development and non-Development separately).

- (4) An overall investigation organization chart showing team members and their affiliations and how the work is distributed within subteam elements (e.g. science team, engineering team, operations team, science data processing team, etc.).
- (5) A description of the descope strategy to be employed in the event investigation plans exceed the resources available.
- (6) A description of the major tasks to be implemented for the MO&DA Phase and the associated high-level schedule for the development and operations of these tasks (capabilities) consistent with Program schedules.
- (7) An investigation data management plan that includes plans for archiving and plans for data analysis and data product validation (including plans for using specialized data processing facilities such as the Multimission Image Processing System).

4.2.2 Investigation Team Operations Plan

An Investigation Team's operations plan could appropriately include:

- (1) An overview of basic operational functions, e.g., science planning, commanding and sequencing, health and safety monitoring, data processing, calibrations, data analysis, archival product generation, risk assessment, contingency planning, anomaly response, and data system maintenance.
- (2) Plans for performing these functions, including organization, facility management, processes, procedures, and team internal and external interfaces, staffing profile, and operations readiness assessment.

4.2.3 Investigation Team Operations Verification and Validation Plan

An Investigation Team's operations verification and validation plan could appropriately include:

- (1) An overview of internal verification and validation, including schedule, resources, tools, and techniques and overall roles and responsibilities.
- (2) Plans for performing internal verification and validation activities and for participation in Program-level verification and validation activities, end-to-end tests, ground data system integration tests, team training, and operations verification tests).

5. DATA ANALYSIS, REPORTING, AND ARCHIVING REQUIREMENTS

Cassini Program PIs, TLs, and IDSs shall disseminate scientific information in a timely and orderly way to the scientific community and to the public, as set forth in the following requirements.

5.1 Data Analysis

Each PI, TL, and IDS shall prepare for prompt data analysis. Preparation includes necessary improvement and tests of theoretical models, data analysis planning, software development, arranging computing resources and staff, etc. The Science and Uplink Manager and the investigators shall negotiate funding and other arrangements for these preparations.

Science data products will be made available for electronic access as specified in the Program Policies and Requirements Document (PD 699-004), Section 4.3.2.2.7.

The Program will provide a more timely data capability in near-real time during key events such as Saturn orbit insertion, Huygens Probe descent, and selected satellite flybys to enable investigators to obtain preliminary scientific results. Each PI and TL shares responsibility with other elements of the Program for developing adequate capabilities, as negotiated by the PIs and TLs and other elements of the Program.

5.2 Reports

Each PI, TL, and IDS shall prepare preliminary reports, quick-release products, detailed scientific summaries, and public information releases in accord with the following requirements.

5.2.1 Scientific Reports

Preliminary reports and quick-release products shall be prepared after key events or mission phases. Key events may include Jupiter flyby, Saturn orbit insertion, Huygens Probe descent, and selected satellite flybys, among others.

Detailed summaries of significant scientific findings of key events, as determined by the Project Scientist, shall be issued within three months of the preliminary reports.

5.2.2 Public Information Releases

NASA and ESA personnel and Program representatives shall coordinate releases of information to the public, duly acknowledging the contribution of appropriate parties. NASA and ESA shall honor the science teams' first publication rights. However, NASA and ESA shall otherwise have the right to use Program data at any time to support their official responsibilities.

In keeping with the National Aeronautics and Space Act, NASA releases preliminary scientific results from space flight investigations as close to real time as possible. The Program Data Management Plan (PD 699-061) is consistent with this NASA policy.

Scientists conducting investigations shall scientifically describe the data to be released, which shall be provided to NASA and ESA in advance of public release.

Within a few days following a quick-look analysis of data acquired during key events, a public press conference may be held to present significant scientific results obtained from the near-real-time analysis of the data.

5.3 Data Archiving

TLs and PIs shall ensure that their science data are delivered to be archived in the Planetary Data System (PDS) and are produced in accordance with PDS formats specified in the Program Data Management Plan (PD 699-061) and the Program Archive Plan for Science Data (PD 699-068). TLs and PIs shall validate the quality, format, and completeness of all science data that they deliver to be archived in the PDS. These validations and data deliveries shall be performed according to the schedule shown in Table 5.3-1.

Table 5.3-1. Data Archiving Schedule

Period of Data Collection:	Data Validated and Delivered By:
All data acquired prior to SOI	SOI + 1year
SOI through completion of the Titan flyby which includes Probe delivery	Probe Descent + 15 months
Completion of Titan Flyby which includes Probe delivery until SOI + 2 years	15 months after data receipt by investigation team*
SOI + 2years until EOM -1 year	12 months after data receipt by investigation team*
EOM - 1year until EOM	EOM + 3months

* Deliveries shall be every third month and contain 3 months worth of data. The delivery date is the indicated period after the latest data (including supplementary data) in the delivered set was received by the investigation team.

Guidelines for archiving any additional data products are defined in the Program Archive Plan for Science Data (PD 699-068).

6. SCIENCE INVESTIGATIONS RESOURCE MANAGEMENT

The Cassini Program will use the methods described in this section to allocate and control MO&DA resources for Principal Investigators, Facility Instrument Team Leaders, and Interdisciplinary Scientists. MO&DA resources include both funds and tour observation allowances.

6.1 *Funding Allocations*

Each PI, TL, and IDS receives his or her funding allocation for the remainder of the MO&DA Phase (FY00-08) in a documented communication with the SAUL Manager. These are approved in FY99 for fiscal years 2000 through 2003 and in FY03 for the remaining years. These allocations included the basic development and non-development costs for investigation planning, operations, and data analysis. In addition, these allocations establish the funding cap for each fiscal year in the MO&DA period (exclusive of supplements to that funding, if any, approved by the Program during subsequent negotiations).

These allocations are reviewed during each new round of contract (or non-contract funding) negotiations after each investigation has gained experience with the distributed operations concept and has confirmed instrument functionality and performance levels. Any adjustments are then dependent upon (a) Program assessment of the requestor's rationale and (b) availability of Program funding. Negotiated changes, if any, are reflected in the respective Memoranda of Funding Plans.

Note that, in general, unspent funds are not automatically carried over from one fiscal year to the next, but will be kept by the Program for subsequent redistribution. In special cases where work has not been accomplished and funds not spent for reasons such as unavailability of workforce, agreements may be negotiated with the SAUL manager for exceptions to this policy.

6.2 *Imposed Changes*

Any significant increase in investigation cost due to Program-directed changes in scope, issued in writing and signed by the Program Manager, shall be compensated out of Program reserves. Funding will be negotiated before work commences on the changes. Support of studies and analysis required to support the definition of science-related operational processes and scenarios, as required by the Cassini Design Team or the Saturn Tour Science Planning Process, are not considered changes in scope.

6.3 *Descoping*

Any significant increase in investigation cost over and beyond the initial funding allocation and not resulting from a Program-directed change shall be accommodated by an investigation descope. This includes cost increases due to uncertainties such as those resulting from "bad

luck”, salary and burden rate adjustments at home institutions, changes in PI, Co-I, TL, or TM home affiliations, poor estimates, or other changes of that nature. Descoping to keep resources within allocated limits requires SAUL Manager approval prior to implementation. TLs, PIs, and IDSs are encouraged to document their *a priori* descope strategy (in their respective Investigation Management Plan [see Section 4.2.1]).

6.4 Resource Reporting

Each non-JPL investigation being funded by NASA shall provide to the SAUL Manager a quarterly resource report using NASA Form 533Q, “Quarterly Contractor Financial Management Report” or its electronic equivalent.

7. ACRONYMS AND ABBREVIATIONS

AO	Announcement of Opportunity
CDS	Command and Data Subsystem
Co-I	Co-Investigator (Principal Investigator Team)
EOM	End of Mission
ESA	European Space Agency
FI	Facility Instrument
FY	Fiscal Year
HSWT	Huygens Science Working Team (Titan Probe)
ICO	Instrument Checkout
IDS	Interdisciplinary Scientist
INMS	Ion and Neutral Mass Spectrometer
IO	Instrument Operations Team
IS	Investigation Scientist
ISS	Imaging Science Subsystem
JPL	Jet Propulsion Laboratory
MO&DA	Mission Operations and Data Analysis phase
MOFP	Memorandum of Funding Plans
NASA	National Aeronautics and Space Administration
NSC	National Security Council
OSSA	Office of Space Science and Applications (of NASA)
PD	Project Document
PDS	Planetary Data System
PFE	Program Furnished Equipment
PI	Principal Investigator
PSG	Project Science Group
RADAR	Cassini Radar
RSS	Radio Science Subsystem
RTG	Radioisotope Thermoelectric Generator
SAUL	Science and Uplink Office
SOI	Saturn Orbit Insertion
SOPC	Science Operations and Planning Computer
SP	Science Planning Team
TL	Team Leader (Facility Instrument Team)
TM	Team Member (Facility Instrument Team)
ULO	Uplink Operations Team
VIMS	Visible and Infrared Mapping Spectrometer

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