Earth System Science Pathfinder Program Office

Program Plan

Earth System Science Pathfinder Program Office
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1.0 PROGRAM OVERVIEW

1.1 Introduction

The Earth System Science Pathfinder (ESSP) Program is a strategic investment by the Science Mission Directorate (SMD) Earth Science Division (ESD) that includes a series of relatively low-to-moderate cost, small-to-medium sized, competitively selected, Principal Investigator-led missions that are built, tested, and launched in a short time interval that accommodate new and emergent scientific priorities. ESSP Projects are operational and developmental, high-risk, high-return orbital and sub-orbital Earth Science missions and advanced remote sensing instruments for missions of opportunity; they often involve partnerships with other U.S. agencies and/or with international science and space organizations. These support a variety of scientific objectives related to Earth Science, including the atmosphere, oceans, land surface, polar ice regions, and solid Earth. ESSP Projects encompass the entire life cycle from definition, through design, development, integration and test, launch or deployment, operations, science data analysis and distribution. The ESSP Program Office, located at Langley Research Center, is the management structure established by ESD that is responsible for the management, direction, and implementation of the ESSP program elements. .

ESSP Projects are encouraged to take advantage of opportunities arising from domestic and international cooperative efforts or technical innovation, consistent with recommendations issued by the National Research Council in their 2007 report, *Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond* (Decadal Survey).

The projects within the ESSP Program are: (1) legacy and future competitively-selected orbital projects; (2) non-competitive, directed projects that are designed to meet unique needs, such as the replacement of a mission that did not fulfill its intended mission requirements; and (3) the Earth Venture (EV) series of uncoupled, relatively low-to-moderate cost, small to medium-sized, competitively selected, orbital and sub-orbital projects that are built, tested and launched short time intervals.

The Principal Investigator (PI) for each competitively selected project is responsible for the overall success of the Project and is accountable to NASA for the success of the mission. Project teams may include academia, industry, government, Federally Funded Research and Development Centers (FFRDC), and international partners, as desired by the PI.

1.2 Goals and Objectives

ESSP Program goals and objectives trace to Agency needs, goals, and objectives via SMD and Earth Science Division (ESD) strategic planning. The *2006 NASA Strategic Plan* (NPD 1001.0) specifies six Strategic Goals for the Agency. SMD is responsible for defining, planning, and overseeing NASA's space and Earth Science programs to enable the Agency's strategic Sub-Goal 3A: "Study Earth from space to advance scientific understanding and meet societal needs."

The *2010 Science Plan: For NASA's Science Mission Directorate* (Science Plan) details how SMD will turn NASA's science vision into scientific discovery. The Science Plan identifies six Focus Areas for NASA Earth Science: **atmospheric composition, weather, carbon cycle and**

ecosystems, water and energy cycle, climate variability and change, and **Earth surface and interior**. Within these six areas, the Science plan articulates seven Earth Science activity outcomes as the benchmarks against which sponsors in the Agency and stakeholders in the science community measure NASA Earth Science progress:

1. Progress in understanding and improving predictive capability for changes in the ozone layer, climate forcing, and air quality associated with changes in atmospheric composition.

2. Progress in enabling improved predictive capability for weather and extreme weather events.

3. Progress in quantifying global land cover change and terrestrial and marine productivity, and in improving carbon cycle and ecosystem models.

4. Progress in quantifying the key reservoirs and fluxes in the global water cycle and in improving models of water cycle change and fresh water availability.

5. Progress in understanding the role of oceans, atmosphere, and ice in the climate system and in improving predictive capability for its future evolution.

6. Progress in characterizing and understanding Earth surface changes and variability of the Earth's gravitational and magnetic fields.

7. Progress in expanding and accelerating the realization of societal benefits from Earth system science.

The ESSP Program goal is to stimulate new scientific understanding of the global Earth system through the development and operation of remote-sensing missions and the conduct of investigations utilizing data from these missions to address unique, specific, highly focused requirements in Earth science research. The ESSP objectives to achieve this goal are to:

- Provide periodic opportunities for competitively selected, PI-led Projects addressing NASA's high priority Earth system science outcomes that are built, tested, and launched or deployed in a short time interval

- Contain Project and mission costs through commitment to, and control of, design, development, and operational costs within the risk and technical standards established by the Agency

ESSP Projects pursue science investigations in one or more of the six Earth Science Focus Areas and promote the outcomes listed above. By looking at properties of the Earth system in innovative ways, the Earth Science community can understand variability, forcing, and response mechanisms from new perspectives. ESSP provides flexible opportunities to stimulate new scientific understanding by encouraging increased participation by small projects and creativity in all aspects of project development; the implementation of these leads to new strategies for acquiring and distributing datasets. ESSP Projects also demonstrate measurement techniques for application on future Earth Science operational missions.

ESSP Program Office internal goals and objectives articulate an approach undertaken by the ESSP Program Office to enable constituent projects to meet their science objectives, while managing performance to cost, risk, schedule, and technical standards established by the Agency.

GOAL #1: Support ESD efforts to achieve NASA Earth Science goals by assisting in the development of competitive solicitations to the Earth Science community for innovative orbital and sub-orbital projects, and by leading directed projects as assigned.

- Objective 1a: Support open solicitations for innovative Earth Science projects.
- Objective 1b: Initiate an ongoing communications and outreach effort to inform, educate, and encourage a broad-based pool of quality proposals.
- Objective 1c: Collect lessons learned from recent solicitations and engage stakeholders to ensure future solicitations reflect improvements and leverage efficiencies and synergies where identified.
- Objective 1d: Collect lessons learned from solicited and directed ESSP missions and share this knowledge to improve flight operations and promote best practices across the Earth Science Division.

GOAL #2: Create a management environment for Projects conducive to successful delivery of Earth system science within agreed-to cost, schedule, and technical parameters at a level of risk acceptable to NASA.

- Objective 2a: Regularly and actively engage ESSP Projects through formal and informal channels and across working levels to stay informed of Project activities and cost, schedule, and technical status in order to more effectively advocate for Projects with stakeholders.
- Objective 2b: Perform regular assessment of risk across ESSP Projects in order to inform and advise ESD on the deployment of division-level resources to promote efficient, effective risk-based decision making within the Program and Projects.
- Objective 2c: Prepare and provide educational / guidance materials for newly selected PIs, and conduct activities to educate PIs / Project Managers on NASA policies governing cost, schedule, risk and technical standards.
- Objective 2d: Regularly engage ESD through formal and informal channels and across working levels to more effectively anticipate ESD requirements on behalf of Projects.

GOAL #3: Promote an atmosphere of productive engagement and open communication within the Program, across NASA organizations, and externally to the public.

- Objective 3a: Conduct deliberate, scheduled program "Pause and Learn" sessions to share knowledge and experiences, to share customer feedback, to build consensus, and to establish a common vision among Program Office personnel.

- Objective 3b: Conduct regular interactions with other ESD organizations to leverage programmatic efficiencies within the Division.

- Objective 3c: Regularly engage critical support services across NASA to better anticipate and mitigate risks to Projects and promote effective use of Agency resources.

- Objective 3d: Execute an Education and Public Outreach (E/PO) strategy coordinated with ESD and the ESSP projects to further NASA and ESD's objectives.

1.3 Program Architecture

The ESSP Program is classified as uncoupled and is composed of a series of competitively selected, PI-led, cost-capped, orbital, and sub-orbital projects, and of directed projects assigned to the Program by SMD. These projects are independent of one another in terms of science objectives, mission requirements, or technical interdependencies yet integrated to the Program through a common funding and management structure. Each project operates independently in achieving its unique set of mission science objectives, which directly contribute to the Program objectives. In addition, the projects often identify beneficial synergies provided by coincident measurements from other NASA Projects (ESSP or non-ESSP) that enhance the overall science return.

Most ESSP Projects have been selected from proposals submitted in response to Announcements of Opportunity (AO) and NASA Research Announcements (NRA) released in 1996, 1998, 2001, and 2009 and are listed in Appendices G through Q. Taken together, the Program Office and respective projects constitute the major components of the program architecture.

Table 1-1 identifies the projects and their current status for the ESSP Program.

Table 1-1: ESSP Project Portfolio

Project	Date	Phase	Status
Orbital Missions	Launch		
GRACE	Mar-02	Phase E	Extended Operations
CALIPSO	Apr-06	Phase E	Extended Operations
CloudSat	Apr-06	Phase E	Extended Operations
Aquarius	Jun-11	Phase D	Implementation
OCO-2	Feb-13	Phase C	Implementation
Earth Venture 1	Initial Deployment		
AirMOSS	Jun-12	Phase B	Formulation
ATTREX	Sept-11	Phase B	Formulation
CARVE	Jun-11	Phase B	Formulation
DISCOVER-AQ	Jun-11	Phase B	Formulation
HS3	Aug-12	Phase B	Formulation
Future Solicitations			
Earth Venture 2			Solicitation Formulation
Earth Venture Instrument			Solicitation Formulation

In addition to the above projects, the ESSP Program Office implements special studies and special projects to support the Program Activities. These studies can include areas such as mission feasibility and instrument accommodations. A special project led by the Program Office that is crosscutting across all Earth Venture Instrument projects is known as the Common Instrument Interface project. This project defines Instrument to Spacecraft interfaces and develops simulators for which proposers of instruments to the Earth Venture Instrument AO can utilize in order to facilitate the accommodation of the instrument on missions of opportunities and is intended to control the costs of instrument to spacecraft interface design and implementation.

1.3.1 Program Interfaces with Organizations Within and Outside NASA

ESSP Projects will enter into formal agreements with organizations within and outside NASA as needed to support the objectives and requirements of the individual Projects. Examples of other organizations with which Projects may engage include: NASA Launch Services Program, Space Communications and Navigation (SCaN), the Rapid Spacecraft Development Office (RSDO), the Airborne Science Program, and Sub-orbital Projects. The ESSP Program Office may facilitate the interaction between the Project and the responsible NASA organization to ensure timely implementation of the agreements.

Projects that require external agreements with respect to other US Agencies, industry, and academia will also make direct contact to reach agreement for support. Projects involved with international non-NASA partner will work with SMD and the NASA Office of International and Interagency Relations to generate the appropriate agreement and approvals. These external agreements are referenced in the individual Project Plans.

The ESSP Program Office supports the ESD as the ESD develops the framework for the solicitation, and works with the Science Office for Mission Assessments (SOMA) and other ESD organizations in the development of the solicitation used to fulfill SMD science objectives. ESSP is an observer in the evaluation and selection process and assumes management responsibility for the selected projects.

1.4 Stakeholder Definition and Advocacy

ESD and the Earth Science community are the immediate stakeholders for the ESSP Program. ESD provides the ESSP Program with its operating budget, programmatic guidelines, and identification of scientific goals and objectives. The Earth Science community is the principal user of data resulting from ESSP Projects and provides the intellectual guidance and rationale for the measurements and science investigations. These data are also utilized by commercial users; federal, state, local, and international public sector users; the educational community; public media; and technology users.

Programmatic advocacy comes from the ESD Director, the Associate Administrator for Science Mission Directorate (SMD AA), and the NASA Administrator in their budgetary submittals to Congress and by the Congress via its authorization and appropriation of the funding necessary to implement the Program. Program Office advocacy with SMD is achieved through monthly reporting and interaction among the Program Manager (PM), Program Executives (PE), and the ESD Associate Director for Flight Programs. The ESSP Program Office also engages with other NASA organizations, including the Earth Science Technology Office (ESTO), as well as the Applied Sciences and Research elements of ESD to promote mission success.

Stakeholder advocacy is achieved through interactions with the Earth Science community and with the general public interested in Earth science. These interactions involve the NASA HQ ESD, NASA Advisory Committee (NAC) Earth Science Subcommittee (ESS), Project Scientists, PIs, Advisory Committees and non-scientific user groups.

The ESSP Program engages the Earth Science community through formal and informal interactions. Formal interactions include the release of solicitations for proposals to work with NASA and participation in solicitation pre-proposal conferences, PI forums, project science meetings, or advisory committee meetings. Informal interactions include periodic lessons-learned workshops to solicit feedback on program processes.

The Program Office recognizes that the general public is a key stakeholder. Helping the public understand Earth Science and the activities of ESSP is important to the Program and to NASA. The Program Office engages the public by supporting invitations to speak at community educational forums, Earth Science events, or at nearby schools. The ESSP Program also seeks out forums in the professional communities such as those conducted by the Institute of Electrical and Electronics Engineers (IEEE), the American Institute of Aeronautics and Astronautics (AIAA), and the American Geophysical Union (AGU).

1.5 Program Authority, Management Approach and Governance Structure

ESSP is an uncoupled, multiple-project program with program management authority delegated by the SMD AA through ESD to the ESSP Program Manager located at Langley Research Center (LaRC). The Agency Program Management Council (PMC) is the governing PMC for the ESSP Program, while the Science Mission Directorate PMC governs the scientific and strategic management of the individual ESSP Projects.

The ESSP Program follows program governance and implementation guidelines for space investigations in a manner consistent with *NASA Space Flight Program and Project Management Requirements* (NPR 7120.5) and with the *Science Mission Directorate Management Handbook* (SMD Handbook). In specific instances dealing with sub-orbital investigations, ESSP follows *NASA Research and Technology Program and Project Management Requirements* (NPR 7120.8). For all projects, ESSP includes best practices and implementing Center requirements as sources of guidance.

1.5.1 Management Approach

The ESSP program management structure consists of three principal levels of authority:

1) Scientific and strategic management within SMD
2) ESSP program management at LaRC (program implementation)
3) Management of individual ESSP investigations by their respective project teams

The SMD AA is the Selecting Official and the Decision Authority (DA) for ESSP Projects, unless precluded from doing so because of conflicts of interest. The SMD AA has designated the ESD Director as the senior Agency official who serves as the SMD focal point for ESSP scientific and strategic management.

Program management responsibility for implementation has been assigned to the ESSP Program Manager, located at LaRC; the LaRC Center Director is responsible for providing the Center resources required to execute the Program. Programmatic authority is delegated from the SMD AA to the ESD Director to the Associate Director for Flight Programs to the ESSP PM. The Program Office oversees projects' implementation to ensure technical, cost, and schedule commitments are met, and advocates for projects with ESD and SMD.

Management authority for each ESSP investigation is assigned to the respective PI. Each PI is responsible for the overall success and safety of his/her investigation and is accountable to the SMD AA for the scientific success and to the ESSP PM for the programmatic success. In cases where there is no PI, the Project Manager (PM) will assume the PI responsibilities. An ESSP PI may delegate project management responsibilities to a Project Manager who may also report to the ESSP PM. A PI's NASA Center and/or home institution provides facilities, staff, and technical expertise.

To achieve an unambiguous line of direction and reporting within these levels, all formal direction from SMD to the ESSP Program flows from the ESD Associate Director for Flight Programs to the Program Manager. Similarly, to ensure an unambiguous line of direction and reporting with ESSP Projects, all formal direction from the Program to the Project flows from the Program Manager to the PI.

In order to ensure effective day-to-day dialogue between ESD and the Program Office, and to execute responsibilities held by ESD, the ESD Director selects ESD staff members to represent SMD and ESD to the Program. ESD staff who ensure this timely exchange include PEs, Program Scientists (PS), and Program Analysts (PA). Together the Program Office and the HQ staff form a team that is charged with managing/coordinating the entire suite of activities necessary to carry out ESSP Projects to their final successful phase. The team follows established processes for communicating progress, issues, and problems regularly to the ESD management.

Figure 1-1 illustrates the ESSP program management structure, including the relationships among key participants.

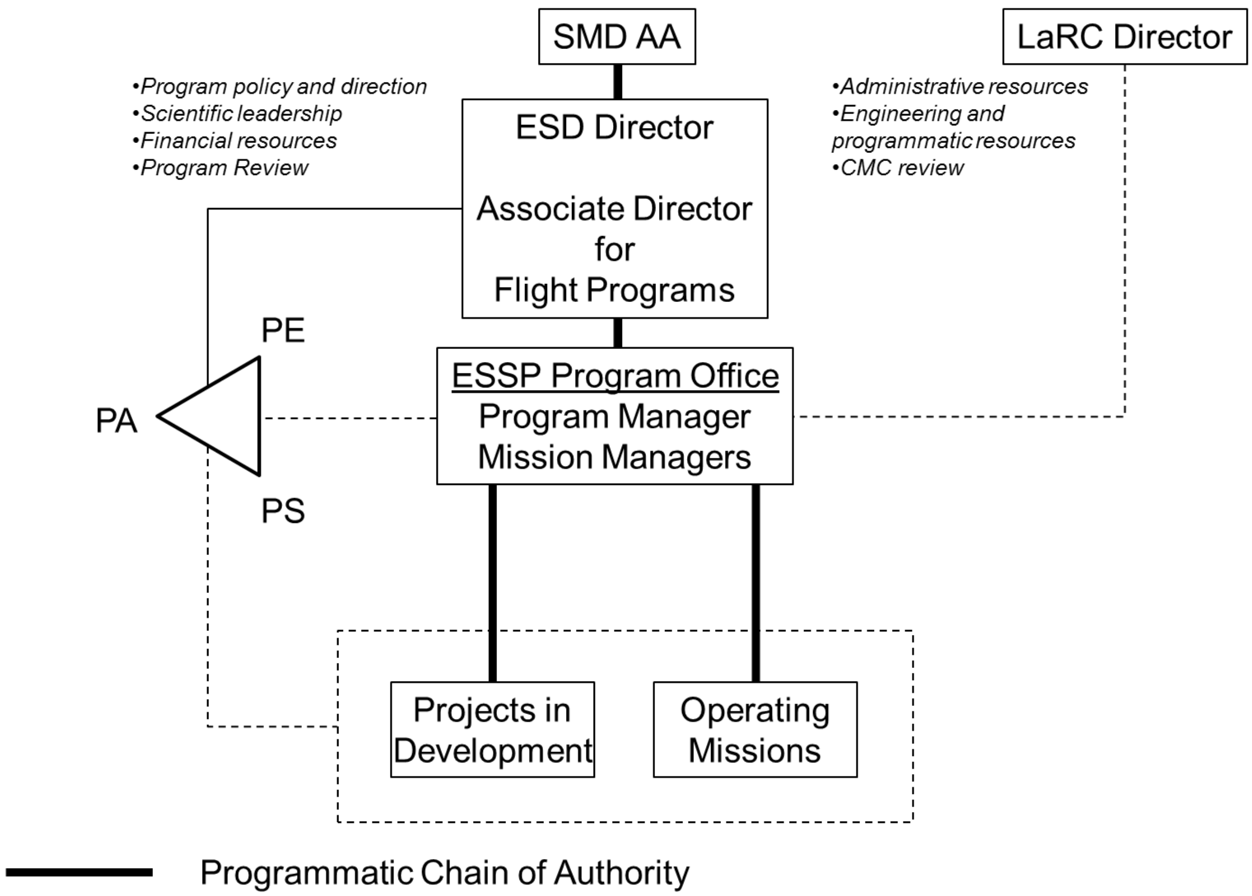


Figure 1-1: ESSP Programmatic Authority

The following is a high-level description of roles and responsibilities of key individuals in the ESSP management and accountability chain.

- Science Mission Directorate Associate Administrator—is responsible for managing the programs within the SMD; serves as the KDP DA for ESSP Projects; is responsible for all program requirements, including budgets, schedules, and the high-level programmatic requirements levied on projects within the SMD.

- ESD Director—is delegated all Earth Science programmatic authority and responsibility from the SMD AA.

- ESD Associate Director for Flight Programs—defines, integrates, and assesses program/project activities and provides policy direction and guidance to the program/projects.

- ESSP Program Manager—is responsible for all facets of the ESSP Program. Section 1.5.2.1 provides specific PM roles and responsibilities.

- ESD Program Executives—represent ESD to the ESSP Program Office and Projects on all technical, management, and cost issues for an assigned Project.

- ESD Program Scientists—represent ESD to the ESSP Program Office and Projects on all science issues for an assigned Project.

- ESD Program Analysts—represent ESD to the ESSP Program Office and Projects on all financial resource issues for an assigned Project.

- ESSP Mission Managers—are responsible for ensuring Program Office support for Projects, leading the regular assessment of Projects' performance, identifying issues for which the Projects need assistance, and for maintaining effective working relations with the Projects.

- Center Directors—are responsible for establishing, developing, and maintaining the institutional capabilities (processes and procedures, human capital, facilities, and infrastructure) required for the execution of the ESSP Program and Projects. This includes the system of checks and balances to ensure the technical integrity of programs and projects assigned to the Center. Center Directors are also responsible for certifying readiness of the mission for launch and mission operations.

- ESSP Project Principal Investigator—is responsible for the scientific integrity of the investigation and is the lead for the ESSP Project team. The PI reports directly to the ESSP PM on all project-level matters.

- ESSP Project Manager—is responsible for the formulation and implementation of the Project per the governing agreement with the PM, if delegated from the ESSP Project PI.

1.5.2 ESSP Program Office Roles and Responsibilities

The ESSP Program Office implements the Program on behalf of SMD. Figure 1-2 presents the current ESSP Program Office organization chart.

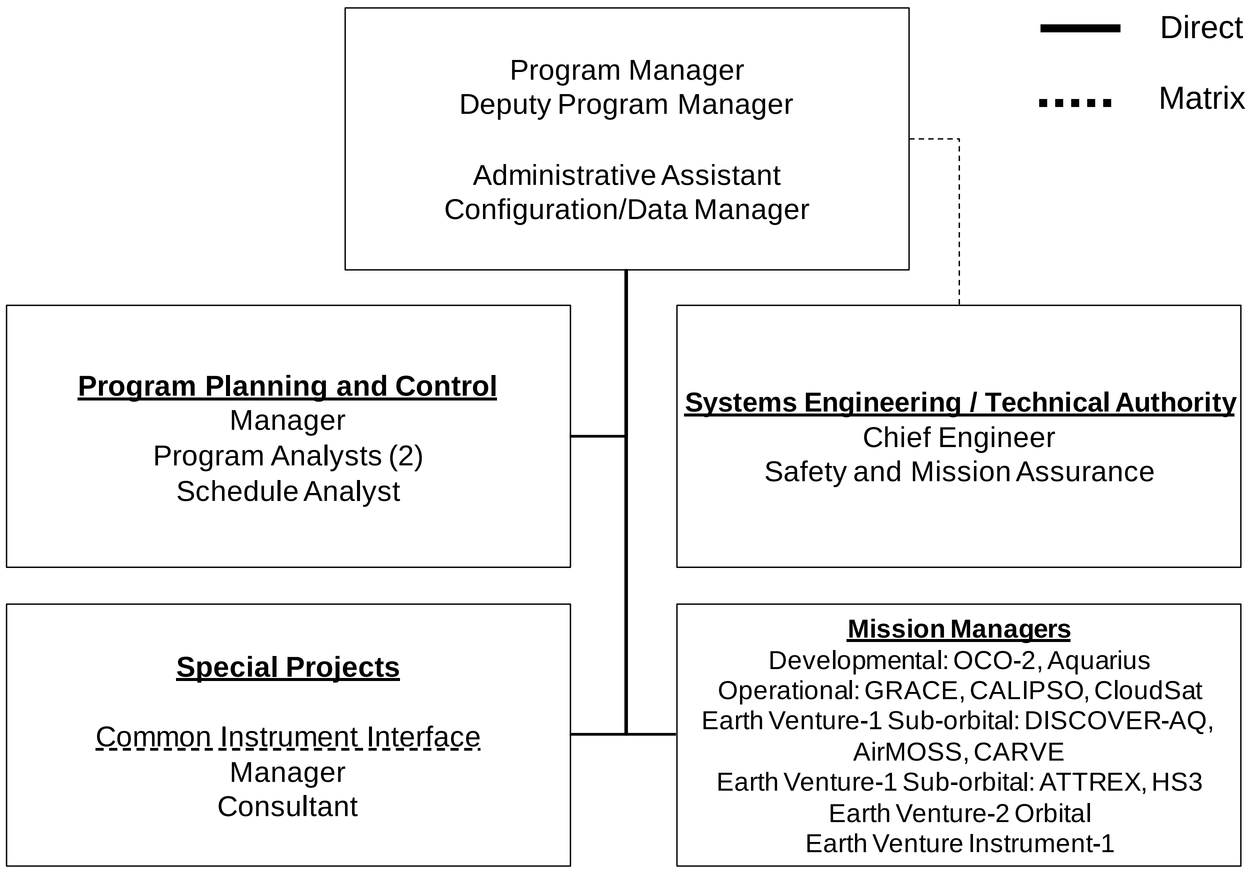


Figure 1-2: ESSP Program Office Organization

1.5.2.1 ESSP Program Manager

The ESSP PM is responsible for planning and implementing the ESSP Program consistent with top-level policies, strategies, requirements, and funding established by NASA HQ. The PM's Roles and Responsibilities are discussed in detail in the SMD Handbook. For the ESSP Program, these include but are not limited to:

- Implementing the ESSP Program for the SMD-selected investigations
- Ensuring open communications with ESSP Program customers and communicating program customer needs to SMD
- Developing and managing program-level metrics to assess the performance and health of the Program
- Maintaining the ESSP Program Plan in accordance with NPR 7120.5

- Independently evaluating and assessing program and project technical, schedule, and cost performance, and mitigating risk as appropriate
- Providing program technical experts as required to support the Projects
- Managing the ESSP Program implementation budget. Developing detailed program Operating Plans and Cost Phasing Plans for the implementation budget. Monitoring distribution of funds to implementing organizations
- Assessing the Program for Project liens and threats which could impact the ESSP Futures Budget
- Assigning a Program Office Mission Manager (MM) to each mission
- Conducting disposition of mission flight and ground hardware
- Assessing Program and Project readiness and recommending whether they should proceed past KDPs
- Supporting SMD in the initiation and preparation of ESSP solicitations
- Planning, coordinating, and implementing an E/PO program
- Communicating Project status to the ESD Associate Director for Flight Programs
- Recommending options to solve Program and Project challenges to the ESD Associate Director for Flight Programs

1.5.2.2 ESSP Program Planning and Control Manager

The ESSP Program Planning and Control Manager performs financial and programmatic management functions on behalf of the PM, ensuring the PM maintains an awareness of Project financial status and performance vs. plan, and that the financial needs of the Projects are being adequately addressed.

The Program Planning and Control Manager's responsibilities include, but are not limited to:

- Establishing and performing resources management oversight of Project contracts and task orders
- Independently evaluating Project schedule, management, and cost data and issues for the PM
- Identifying Project liens and threats that could result in cost cap breaches
- Coordinating Project funding requirements

- Coordinating with the PA to ensure consistent budget direction between SMD and the Program Office

- Ensuring that appropriate Program resources are provided to the Projects in a timely manner

- Leading the Program Office planning and implementation of Planning, Programming, Budgeting, and Execution (PPBE) activities. Preparing information requests for all Projects and the Program Office and a schedule for submittal to the PM

- Providing monthly assessments of project performance by documenting commitments, obligations, and costs and explaining variances that exceed ± 10%

- Providing monthly assessments of each Project's projected cost at the end of the FY vs. New Obligation Authority (NOA) anticipated at the end of the FY as well as total cost for all Projects vs. Total NOA to be provided to all Projects and the Program Office

- Alerting the PM at any time a Project's cumulative commitments, obligations, or costs are expected to exceed 95% of the NOA available

- Maintaining the program milestones/events calendar with at least monthly updates to reflect all significant Project and Program Office events

- Leading the Program Office regular reporting activities, including transmitting after report finalization and review, negotiating format, receiving and distributing project-level input, and assigning section drafting and submission schedules

1.5.2.3 ESSP Program Chief Engineer

The ESSP Program Chief Engineer (CE) is assigned systems technical authority for communicating technical excellence and exercising technical authority for the ESSP Program. The ESSP Program CE, in partnership with the ESSP PM, ensures an atmosphere of "checks and balances" within the ESSP Program and Projects. For Projects assigned to NASA Centers and the Jet Propulsion Laboratory (JPL), the Technical Authority for these Projects is delegated from the NASA Office of Chief Engineer directly to the engineering management at that Center. For any Projects assigned to non-NASA centers, the ESSP Program CE has NASA technical authority. The ESSP Program CE responsibilities include:

- Identifying and utilizing technical expertise from across NASA, industry, and academia to ensure investigation success and technical excellence through risk-based technical insight into the ESSP Projects

- Monitoring project execution and issue resolution

- Serving as a review team member

- For ESSP Projects assigned to NASA Centers and JPL, working to seek resolution of identified issues. If resolution of the issues cannot be done at lower levels, then the CE communicates to the next level of Center or Agency technical authority

- For ESSP Projects assigned to non-NASA centers, retaining technical authority while working closely with the project-level engineering organization to delegate an appropriate level of insight responsibility to the non-NASA center's engineering authority. The CE resolves any identified issues at the lowest level of authority. Major unresolved issues shall be elevated to the next level of Center or Agency technical authority

1.5.2.4 ESSP Mission Managers

ESSP Program Office MMs function as the PM's day-to-day point of contact and advocate for all assigned Projects. They perform technical and programmatic management functions on behalf of the PM, ensuring the PM maintains an awareness of the Project status and that the programmatic needs of the assigned Projects are being adequately addressed. The MMs' responsibilities include:

- Serving as the NASA point of contact (POC) for Projects within the Program

- Interfacing directly with the PIs and Project Managers to develop inputs for program planning, integration, and project issue resolution

- Establishing and performing technical management oversight of project contracts and task orders

- Independently evaluating project metrics, schedule, cost data, management, and issues for the PM

- Independently assessing Projects to identify risks and mitigations

- Identifying Project liens and threats that could result in cost cap breaches

- Providing a monthly project assessment to the PM

- Coordinating with the PE to ensure the clear understanding of programmatic direction between SMD and the Program Office

- Serving as the Program Office representative among NASA, other U.S. governments agencies, and foreign participants on behalf of assigned investigations

- Serving as the Program Office advocate to NASA management, the Public, and other government entities for assigned Projects

- Leading the development of decision packages or products that are fully coordinated within the ESSP Program and with the related PIs and Project Managers

1.5.2.5 ESSP Program Safety and Mission Assurance Lead

The ESSP Program Safety and Mission Assurance (SMA) Lead (*i.e.* Chief Safety and Mission Assurance Officer) is assigned systems SMA authority for communicating SMA excellence and exercising SMA authority for the ESSP Program. The ESSP Program SMA Lead, in partnership with the ESSP PM, ensures an atmosphere of "checks and balances" with the ESSP Program and Projects. For Projects assigned to NASA Centers and JPL, the SMA authority is delegated from the NASA SMA Office directly to the SMA group at that Center. For Projects assigned to non-NASA centers, the ESSP Program SMA Lead has NASA SMA authority. The ESSP Program SMA Lead responsibilities include:

- Ensuring mission success and safety through risk-based technical insight into the ESSP Projects
- Monitoring project execution and SMA issue resolution
- Serving as a review team member
- For ESSP Projects assigned to NASA Centers and JPL, working to seek resolution of identified issues. If the issue is not resolved at lower levels, the SMA Lead communicates it to the next level of the Center or Agency SMA authority
- For ESSP Projects assigned to non-NASA centers, the ESSP Program SMA Lead retains SMA authority while working closely with the Project SMA organization to delegate an appropriate level of insight responsibility to the non-NASA center's SMA authority. The SMA Lead resolves any identified issues at the lowest level of authority

1.5.3 Principal Investigator and Project Manager Roles and Responsibilities

Overall responsibility for scientific integrity and investigation success of each ESSP Project is vested with the PI. This individual is the lead scientist and organizes the team or consortium that develops the mission concept and implements the mission under the prescribed guidelines and constraints. The PI chooses the management approach best suited to the mission design, skills/expertise of the team members, and resources.

The SMD AA holds the PI accountable for proper execution of all aspects of the project, particularly as outlined in the original solicitation, accepted Concept Study Report, Project Plan, and Program-Level Requirements Appendix (PLRA). The PI must notify the ESSP PM if the successful achievement of the threshold scientific objectives is not possible within the prescribed programmatic constraints.

Project Managers are appointed by the implementing organizations with PI concurrence. Each ESSP Project Manager is responsible to the PI for the successful development and implementation of the Project.

The ESSP Program Office interfaces directly with the PI or the Project Manager as delegated at the implementing organization, particularly in the areas of resource allocation and utilization, oversight, reporting, and resolution of project-level issues.

Each PI, with support from the Project Manager, has the following specific responsibilities:

- Serving as the primary scientific spokesperson for the mission and for the scientific investigations
- Assuring delivery of science data to the Distributed Active Archive Center (DAAC) and dissemination of scientific results through professional publications and E/PO
- Informing the ESD Program Scientist of status, changes, or results in the investigation science
- Representing the Project to NASA, other government agencies, industry, and institutions as required on matters pertaining to the investigation. The PI supports NASA in performing ESSP Program advocacy
- Requesting NASA concurrence on key personnel changes
- Planning, developing, and executing an investigation to achieve its scientific requirements in accordance with the PLRA and Project Plan
- Documenting the status of Level 1 Requirements, particularly mission science requirements, at End of Mission
- Developing project-level implementation plans, schedules, and budgets in accordance with program requirements, project objectives and constraints, and with other applicable NASA policies
- Communicating urgent or significant design, test, or operational anomalies to the PM
- Supporting independent assessments and confirmation reviews
- Managing the Project budget. The PI identifies and reports liens and threats and develops PPBE submittals and traces
- Implementing the Project’s SMA processes
- Developing and implementing a risk management process through the project life cycle. The PI assesses and reports project-level risks to the ESSP Program
- Developing and maintaining the Project Plan in accordance with NPR 7120.5 or 7120.8

- Developing and implementing the Project's E/PO activity, in coordination with the ESSP Program E/PO

1.5.4 <u>Science Mission Directorate Detailed Roles and Responsibilities</u>

The Science Mission Directorate within NASA HQ is responsible for the scientific and strategic direction of the ESSP Program within the Earth Science theme. The SMD AA holds the final authority and responsibility for the ESSP Program.

1.5.4.1 Program Executive(s) for ESSP Projects

The PEs support the SMD AA in defining, integrating, and assessing the activities of ESSP Projects. Their roles and responsibilities are discussed in detail in the SMD Handbook. For the ESSP Program, these include but are not limited to:

- Maintaining cognizance of the Projects' programmatic health via regular interaction during formulation and implementation (Phases A, B, C, D, and E), via exposure to reports from the Project, monthly status and major milestone reviews, access to assessments coordinated by the Program Office, and ad hoc interactions deemed necessary to assess Project performance

- Facilitating the negotiation of content for agreements with other US agencies and foreign and domestic organizations

- In collaboration with the PS, Program Office MM, and PI, finalizing development of the Project's PLRA and preparing it for formal negotiation and final agreement

- Participating in annual budget submission reviews with the Program Office

- Assessing Project technical, schedule, and cost performance and recommending course corrections to Directorate management

- Coordinating SMD concurrence on chair, membership, and the Terms of Reference (ToR) for Standing Review Board (SRB) independent reviews

- Coordinating with the MM to ensure the clear understanding of programmatic direction between SMD and the Program Office

- Preparing launch approval documentation (National Environmental Policy Act (NEPA) materials, contingency plans, approval letters, etc.)

- Resolving Project issues through the ESSP Program Office

- Coordinating program and Project issues with other involved SMD division and with HQ Functional offices

1.5.4.2 Program Scientist(s) for ESSP Projects

The PS(s) reside in the ESD of SMD. Their roles and responsibilities are discussed in general in SMD Handbook. For the ESSP Program, these include but are not limited to:

- Managing the selection process, including definition, timing, preparation, and issuance of solicitations; pre-proposal conferences; scientific and technical reviews of submitted proposals; and preparation for selection of ESSP investigations
- Developing the scientific strategy, goals, and objectives for the ESSP Program solicitations
- Serving as the primary ESSP science spokesman and the primary interface with customers, stakeholders, and external elements for scientific objectives and accomplishments
- Assessing Project status against Level 1 science requirements and mission success criteria
- Monitoring and regularly reporting science-related issues to NASA
- Regularly updating NASA and the broad community on mission science results
- Working with the PI to document completion of science objectives
- Chartering program science working groups as required
- Maintaining traceability of completed program science objectives
- Assembling and releasing solicitations and supporting documentation—assisted by the PE and SOMA
- Managing the down-select process, when required, including Concept Study Kickoff, scientific and technical reviews, and preparation for down-select of ESSP investigations
- Collaborating with the Program Executive, ESSP Program Office, and the PI on the generation of the PLRAs, particularly the Level 1 Requirements
- Monitoring the impact of proposed mission changes on the Level 1 Requirements
- Maintaining regular contact with the PI

The tables in Appendix R clarify the functional assignments where ESD and Program Office personnel have similar responsibilities.

1.5.5 <u>ESSP Project Formulation, Approval, Baseline Review and Termination Processes</u>

The ESSP Project Formulation, Approval, and Termination Process comply with the requirements of NPR 7120.5 (or 7120.8 as appropriate), *NASA Systems Engineering Processes and Requirements* (NPR 7123.1), and the *Policy for NASA Acquisition* (NPD 1000.5).

While the ESSP Program Office may determine that the typical NPR 7120.5 project review and approval process requires tailoring to appropriately address the sub-orbital projects, these projects still require reviews and approval decisions.

1.5.5.1 Formulation Process

The purpose of project formulation is to complete the concept, technology development, and preliminary design. Formulation consists of two sub-phases, referred to as Phases A and B. ESSP Projects are primarily awarded through the AO/NRA process. When a project is selected, the project enters into Phase A if it is a one-step process. The two-step selection process makes final awards at the end of step-two, after which the awarded project enters into Phase B.

The SMD initiates a directed mission's official entry into formulation by releasing a project Formulation Authorization Document (FAD) and proceeding in accordance with NPR 7120.5. The Program Office supports the development of the FAD. Once the SMD AA signs the project FAD, the directed project formally enters formulation.

1.5.5.2 Approval Process

The project's implementation phase starts only after successfully passing KDP C. When the project indicates readiness to enter into implementation, the ESSP Program Office requests an independent assessment of the project's readiness. The approval to proceed into implementation marks the point at which NASA makes an external commitment to the cost, schedule, and performance of the mission. These commitments are clearly defined in the PLRA.

KDP's D, E, and F follow the same process as the previous life cycle gates.

1.5.5.3 Baseline Review and Termination Processes

The Program Office conducts periodic assessments of project performance. If an assessment is made that the project cannot meet the commitments at any point during Phase B through E, then the outcome of the assessment will be a recommendation to ESD for rebaselining, termination review, or continuation of the project.

If pursuit of a Termination Review is deemed appropriate, the ESSP Program Office and the project proceed in accordance with NPR 7120.5 and *Notification of Intent to Decommission or Terminate Operating Space Systems and Terminate Missions* (NPD 8010.3) in the case of operating missions. In any event, the outcome shall be documented in a Decision Memorandum and reviewed with the AA prior to final implementation.

1.6 Implementation Approach

The ESSP Program comprises independent orbital and sub-orbital projects, uncoupled from one another in design, hardware, operations, and science objectives. Consistent with the Acquisition Strategy (Section 3.4 of this Plan), investigations are primarily selected through a competitive solicitation process by SMD with support from SOMA. The Program's acquisition strategy emphasizes the regular and frequent release of open and competitive solicitations. The ESSP Program seeks to contain project-level costs through the control of design, development, and operational costs. The ESSP Program Office does not conduct major acquisition activities (such as engineering design studies, hardware and software development, and mission and data operations support) or studies supporting make-or-buy decisions, since these activities are all performed only at the project level.

NASA SMD has the authority to release an ESSP solicitation and commission evaluation of the proposals. The SMD AA is the selecting official and must approve a project's transition to each subsequent life cycle phase. Teaming and partnering arrangements are encouraged. The solicitation selection of a PI-led team provides the full authority necessary to contract with all members of the team without further competition. Partner involvement and specific levels of partner contributions are documented in agreements listed in the respective Project Plans.

SOMA supports the selection of ESSP investigations through a fully-open and competitive process. Investigation teams are led by a single PI, with participation open to all categories of organizations, both foreign (on a no exchange of funds basis) and domestic, including educational institutions, industry, nonprofit organizations, NASA centers, FFRDCs, and other government agencies. For PI-led projects, the PI forms a team from any combination of these institutions.

At the Phase D to E transition point, orbital projects often undergo a transition from a development focus to a flight operations focus, and a change in management oversight. The projects should revise their Project Plan at this point to reflect any new management structure, the new budget, revised reporting, and focus on new procedures and requirements.

PIs must employ management processes, procedures, and methods that comply with NASA policies and procedures. Projects must document their management approach in their respective Project Plans. The Program Office convenes "Pause and Learn" sessions to share Lessons Learned and best practices, and to incorporate these into the project-level management, design, testing, and operational processes.

ESSP Projects follow the implementation policies and practices cited in the Internal Task Agreement (ITA), grant, task, or contract Statement of Work (SOW); these are based on Center or Agency procedures, or both. The ESSP Program Office negotiates the procedures to be cited in the ITA, grant, or contract SOW and implemented with project management.

ESSP Projects are independently proposed and competitively selected PI-led investigations addressing Earth Science themes under a common program funding/management structure. The program requirements in this section are flowed into the acquisition process via solicitations used to select investigations. After project selection, project-specific programmatic requirements (referred to as Level 1 Requirements) are set forth in a PLRA document and approved by the ESSP PM, the implementing Center director and the SMD AA. The PLRAs for the current projects are in Appendices G through P of this Program Plan.

2.0 PROGRAM BASELINE

2.1 Requirements Baseline

The Program Commitment Agreement (PCA) for the ESSP Program defines the commitment that the SMD AA makes to the NASA Associate Administrator for the execution of the Program. The ESSP Program Hi-Level Requirements are:

1) The ESSP Program shall select and complete missions commensurate with the confirmed and approved mission cost cap.

2) ESSP Projects shall use a cost-effective, domestic, flight proven Expendable Launch Vehicle (ELV), unless specifically directed otherwise by NASA. Each ESSP AO or NRA describes the launch vehicle details or appropriate access to space. SMD provides access to space and launch vehicle funding and suborbital platforms. These funds are part of the total cost cap for each mission (except EV-I). Foreign launch vehicles may be utilized only if contributed by the foreign organization (on a no-exchange-of-funds basis) and the launch vehicle meets NASA quality and reliability standards.

3) For each orbital project, the primary planned launch date shall be within the time period specified by the associated AO.

4) For each suborbital investigation, flight operations shall be determined by science objectives and be completed within the timeframe specified in the solicitation.

Key Performance Parameters (KPPs) and outcomes that represent measures of success for the ESSP Program are:

1) Approval for Projects to proceed to Implementation at KDP C.

2) Achievement of the threshold science performance criteria as established in the PLRA for each operating mission.

3) Delivery of mission science data, meeting latency and performance objectives for each approved science data system during primary mission phase.

The assessment of the Program performance is conducted at Program Implementation Reviews and during project reviews.

2.1.1 Project Requirements Baseline

ESSP Projects are independently proposed and competitively selected PI-led investigations addressing Earth Science themes under a common program funding/management structure. The program requirements in this section are flowed into the acquisition process via solicitations used to select investigations. After proposal selection, project-specific programmatic requirements (referred to as Level 1 Requirements) are set forth in a PLRA document and approved by the ESSP PM, the implementing Center director and the SMD AA. The PLRAs for the current projects are in Appendices G through P of this Program Plan. Table 2-1 identifies sources of requirements for ESSP Projects typically included in the solicitation used to select the investigation.

Table 2-1: ESSP Requirements Sources

Type Requirement	Where Created	Where Documented	Applicable to	Compliance Verified By	Conduit to Performer				
					Solicitation	Contract SOW	NPD NPR	PCA	Program Plan
Programmatic (Level 1)	HQ	Program Plan	Individual Project	HQ/ Program	-	-	-	-	√
Program High-Level	HQ	Program Plan	Program	HQ	-	-	-	√	√
Management Process	HQ	HQ NPD/ NPG	Program	HQ	-	-	√	-	-
Management Process	HQ	HQ NPD/ NPR	All Projects	Center	√	√	√	-	-
Center Management Process	Center	Center	All Projects	Center	√	√	-	-	-
All requirements trace back to the NASA Strategic Plan									

The following sections specify programmatic requirements levied on all ESSP Projects.

2.1.1.1 Project Science Requirements

ESSP Projects shall achieve their science requirements while meeting their project-specific cost cap, as specified in their PLRA. The PLRA documents the baseline and the threshold science requirements based on the selected proposal and according to the following definitions:

- Baseline Science Requirements - That mission which, if fully implemented, accomplishes the entire set of scientific objectives identified at the initiation of the mission.

- Threshold Science Requirements - The minimum scientific requirements below which the investigation is not considered justifiable for the proposed cost. Threshold science requirements are also referred to as minimum science requirements or science floor.

The PI may recommend descoping the project-level science requirements from the baseline to the threshold science requirements in incremental fashion as delineated in the approved proposal or Concept Study Report. These descopes are a means for mitigating cost and schedule risks associated with cost-caps and are documented in an update to the PLRA. Projects without significant descope options during formulation and implementation may be considered to be higher risk. The ESSP PM, implementing Center Director, and SMD AA shall approve any descope before that option is exercised.

2.1.1.2 Project Cost Requirements

All ESSP Projects are cost-capped at a level defined in the applicable solicitation. The cost cap is established through the proposal and formulation process and formally documented at KDP C.

The cost cap shall apply to the full life cycle cost (LCC) for all elements needed by the investigation. The solicitation will identify whether launch vehicle costs will be included in the cost-cap.

The cost cap shall include all Project-held reserves. Each Project is required to show a budget reserve posture at the end of phase B commensurate with the risk associated with implementation. Typically, the overall budget reserve posture is no less than 25% of cost-to-go through the end of Phase D, excluding the cost of the launch vehicle. An appropriate cost reserve for Phase E shall also be included.

Current approved NASA accounting practices shall be used in developing the total cost.

2.1.1.3 Project Verification and Validation

Individual Projects shall verify performance of ESSP orbital, sub-orbital, and ground elements through a combination of analysis, inspection, demonstration, similarity, and test, with particular emphasis on incremental, integrated, and concurrent testing. For orbital missions, the launch vehicle supplier shall be responsible for physical integration of the spacecraft with the launch vehicle and for verification of system integrity. For sub-orbital missions, the aircraft provider shall be responsible for the physical integration of the payload and for verification of system integrity. The Project shall be responsible for the end-to-end flight/ground system performance verification, preferably by test, rather than by analysis.

2.1.1.4 Project Implementation Requirements

Each Project shall develop a unique Project Plan, based on NPR 7120.5 or 7120.8 as appropriate, that defines the implementation approach. Implementation requirements specific to ESSP Projects are found below.

As applicable, Earned Value Management (EVM) shall be implemented for the Phase C and D development activities of all ESSP Projects, as required by NPR 7120.5 and *Earned Value Management* (NPD 9501.3). Due to their low total life cycle cost, EVM is not required for ESSP sub-orbital Projects.

Each ESSP Project shall have an effective SMA program as required by *NASA Policy for Safety and Mission Success* (NPD 8700.1) and document it in its Project SMA Plan. Section 3.2 addresses project-level SMA requirements. Projects that reside at institutions that currently have a NASA-approved SMA program may utilize their own institutional practices.

Each ESSP Project shall prepare a science data management plan for approval by the PI and the assigned PS. The PI is responsible for collecting the scientific, engineering, and ancillary information necessary to validate and calibrate the scientific data, analyzing the data to meet the proposal science objectives, delivering the data and data products to an appropriate data repository, publishing scientific findings, arranging the public release of data and data products, and communicating the results to the public. Each PI shall manage all data produced in accordance with ESD Data and Information Policy, available at http://science.nasa.gov/earth-science/earth-science-data/data-information-policy/.

Each ESSP Project shall prepare a final report within three months of the end of the prime mission, documenting the status of the Level I requirements, identifying how science and technical requirements have been met by the execution of the mission.

Any new technology transfer, exchange, or partnership agreements for ESSP Projects shall comply with all laws and regulations regarding export control and the transfer of sensitive proprietary technologies, including the requirements of *NASA Export Control Program* (NPR 2190.1) and the provisions of 22 CFR International Traffic In Arms Regulations (ITAR).

2.1.2 ESSP Requirements Traceability

The project selection process ensures alignment of ESSP Program and Project requirements to those handed down from the Agency and SMD. Successful accomplishment of ESSP Project Level 1 Requirements yields science data that address NASA Strategic Plan Sub-Goal 3A. Table 2-2 traces ESSP Projects, and by extension their associated requirements, to the Science Plan science focus areas relevant to Earth Science. All ESSP Projects support Sub-Goal 3A.7—to achieve "progress in expanding and accelerating the realization of societal benefits from Earth system science."

Table 2-2: Programmatic Requirement Traceability

NASA Strategic Goal	3A.1	3A.2	3A.3	3A.4	3A.5	3A.6
Focus Area→ / Project ↓	Atmospheric Composition	Weather	Carbon Cycle and Ecosystems	Water and Energy Cycle	Climate Variability and Change	Earth Surface and Interior
GRACE						X
CloudSat	X			X		
CALIPSO	X			X		
Aquarius				X	X	
OCO-2	X		X		X	
AirMOSS			X			
ATTREX	X			X	X	
CARVE	X		X		X	
DISCOVER-AQ	X					
HS3		X				

2.2 Work Breakdown Structure Baseline

The ESSP Program is uncoupled and therefore does not implement a program-level Work Breakdown Structure (WBS) baseline. ESSP Projects each develop and implement a customized WBS structure that best fits their organizational approach and mission design concept.

2.3 Schedule Baseline

The ESSP Program Office develops and maintains a master schedule (see Appendix D) that provides a snapshot of the current ESSP Program and Projects' top-level milestones. This schedule is updated when the Program Plan is updated. ESD evaluates program schedule performance.

Each ESSP Project develops and maintains its own integrated master schedule, including all critical milestones, major events, and Agency and project-level reviews throughout the life cycle. These schedules identify any interdependencies for the critical milestones and the critical paths and are tied to the resources required to complete each task and meet critical milestones.

2.4 Resource Baseline

The ESSP Program comprises independent, uncoupled science missions that are primarily the result of a competitive selection process. Program resource and workforce levels adjust in accordance with the solicitation plan, which is based upon program budget constraints and the investigation selection rate. Table E-1 contains the ESSP Program budget included in the most recent President's Budget request. Table E-2 provides the Program Office workforce plan to support fulfillment of programmatic responsibilities. The total budget is updated annually as part of the NASA PPBE process. ESD Resources Management provides ESD's guidance for developing the multi-year ESSP budget request. Each ESSP Project is responsible for the development of its own PPBE budget request. The ESSP Program Office conducts PPBE budget reviews with each Project Manager to ensure that the budget request is aligned with the remaining scope and the ESD guidance.

LaRC provides facility, administrative, and technical infrastructure to support the ESSP Program Office. Individual Projects are provided with facility, administrative, and technical infrastructure by the NASA Center or institution that serves as their host. Infrastructure requirements for acquisition, real property/facilities, aircraft, personal property, and information technology (IT) are fulfilled from existing capabilities.

2.5 Joint Cost and Schedule Confidence Level

Because ESSP is an uncoupled program, program-level Joint Cost and Schedule Confidence Level (JCL) analysis and budgeting is not performed. When required, ESSP Projects perform a JCL analysis, which is used in formulating Agency internal and external financial commitments.

3.0 PROGRAM CONTROL PLANS

3.1 Technical, Schedule, and Cost Control Plan

The ESSP Program achieves its high-level requirements through the successful implementation of its projects. Each new ESSP Project is validated for compliance with ESSP Program requirements through three processes: the selection/acquisition process; the Project requirement development process; and the Project plan review and approval process.

Once an ESSP Project is selected for formulation, the ESSP Program Office provides frequent formal and informal communication with the projects to ensure continued compliance with ESSP Program requirements; timely identification of issues or areas of technical, schedule, or cost risk; and the application of appropriate mitigation or recovery activities.

Drafted initially by the PI as part of the proposal, the PLRA documents ESSP program-level requirements specific to each Project (science requirements, launch timeframe, success criteria, and cost cap). After selection, a PE develops the PLRA in coordination with the MM, PS, and PI. The PLRA is signed no later than KDP-C.

The PI/Implementing Organization develops a unique Project Plan for each ESSP Project that tailors institutional processes and defines the implementation approach. The PM approves each ESSP Project Plan and concurs on the project-level stand-alone control plans.

3.1.1 Program Office Roles in Technical, Schedule, and Cost Performance Monitoring and Control

The MM is the primary POC for program insight into the technical, schedule, and cost status of each ESSP Project. Through regular formal and informal communication with the Project Manager/Principal Investigator, the MM maintains cognizance of the project performance against the project Integrated Master Schedule (IMS), cost cap, and performance requirements, as well as any emerging risks. The Program Office regularly reviews the status and projected ability of each project to meet its approved PLRA. The project plan documents the reporting and management processes. The MM utilizes the project's existing institutional processes and reviews (e.g., project's monthly and quarterly management status reviews), available EVM data for projects in Phase C/D development, and weekly teleconferences for project status updates to maintain cognizance of the project's performance while minimizing the impact on the project by not increasing the programmatic requirements.

The MM is supported by the ESSP Program Planning & Control Group in analyzing and evaluating the projects' performance. For additional insight and support, the MM collaborates with the ESD PE and PS, the ESSP CE, and SMA Lead. The ESSP MM may obtain expertise from NASA, academia, or industry to gain additional risk-based insight or oversight of a particular area for a Project. The Program Office risk-based assessment of ESSP Projects may occur throughout the Project life cycle.

3.1.2 Technical, Schedule, and Cost Performance Monitoring and Control Processes

The ESSP schedule includes program-level milestones for the projects. Monthly schedule status reviews are held to monitor the ESSP Master Schedule and track schedule performance. The control of project schedule milestones (KDPs, launch, etc.) is the responsibility of the ESSP Program and ESD. While the Program Office recommends changes to project Level 1 schedule milestones, the SMD AA approves the changes.

The project is evaluated for performance against the project IMS monthly and at scheduled life cycle reviews or special reviews as requested by the Program or SMD. The evaluation includes a detailed assessment of project schedules for overall implementation strategy and credibility, project budgets through prime mission operations and data analysis, and the approach for contractor/subcontractor management and coordination. ESSP makes recommendations to projects regarding the use of schedule margin as well as corrective actions, based on the Program Office analysis and assessments.

ESSP Project budgets are initially estimated in the acquisition process as part of the original mission proposal and subsequent Concept Study Report. The total cost to NASA for all phases of an ESSP investigation, including the definition, development, launch service, mission operations (including communications costs) and data analysis, and reserves is included. Independent cost estimates and/or independent review boards may be used to verify estimates provided by the implementing organization at the discretion of the ESSP Program Manager.

Each project is required to show a budget reserve posture at the end of phase B, commensurate with the risk associated with the implementation of the mission, but typically no less than 25% of cost-to-go for costs through the end of Phase D (excluding the cost of the launch vehicle). An appropriate cost reserve for Phase E must be included. The PI and associated Project Manager have full discretion in applying the cost reserve in a given Fiscal Year within the approved project budget. Additional cost reserves may be held at ESD and not at the ESSP Program level. The ESSP Program Office recommends the disposition of any Program Unallocated Future Expenses (UFE) to ESD. Program Office analysis and assessments support recommendations to ESD and Projects regarding the use of reserves, as well as corrective actions. Cost control shall incorporate monthly tracking metrics such as reserve status, liens and encumbrances, reserve percentage of cost-to-go, obligations and commitments—plan versus actual, and labor—plan versus actual.

In accordance with NPR 7120.5, ESSP is not required to and will not implement EVM at the Program level. The ESSP Projects shall implement EVM for phase C/D scope, as required per NPR 7120.5, with the exception of the Earth Venture-1 investigations.

Table 3-1 lists the weekly, monthly, and quarterly reporting activities.

Table 3-1: ESSP Program Office Reporting

Report/Activity	Content	Customer	Frequency	Format
Program Office Standup Review	Program/Projects Status. Recent Events. Near-term activities. Technical, schedule, cost, and risk assessment review	PM	Monthly	Presentation, face-to-face meeting and telecon
CMC Status Review	Program/Projects Status	LaRC Center Director and CMC	Monthly	Face-to-face meeting with presentation
Program Weekly Report	Program/Projects Status (technical, schedule, cost and risk)	ESD	Weekly	Written report
Project Tag-Up	Project issues and status (technical, schedule, cost and risk)	ESSP MM, PE	Weekly	Teleconference
Program Staff Meeting	Program/Project status and issues, progress since prior week, activities to be performed during the current week and future weeks	Internal to ESSP Program Office	Weekly	Meeting with agenda, notes
Project Status Report	Technical, cost, schedule and risk (greater detail for quarterly reviews)	ESSP Program Office, SMD, Center	Monthly and Quarterly	Written report & presentation
Project Weekly Report	Accomplishments for Week	ESSP Program Office, PE	Weekly	Written report

3.1.3 Technical Excellence and Technical Authority Implementation

3.1.3.1 Technical Excellence

ESSP Technical Excellence integrates the Program, Project, Engineering, and SMA personnel into a team that emphasizes cooperation and shared ownership regarding mission success. The Program Office facilitates technical excellence for a wide range of issues, which vary in complexity. For less complex issues, the Program CE may leverage subject matter experts (SME) at LaRC or other Centers and arrange for the SMEs to be available to the Program and Projects. For more complex issues, the Program CE may participate directly in Tiger Teams or may identify expertise for inclusion in the Tiger Team.

ESSP Projects typically have a Chief Engineer who serves as the Technical Authority for the project. The ESSP Program Office CE leverages Project CE capabilities to maintain a cognizance of the technical excellence activities within a project and exercise technical authority as appropriate. In the case where a Center or JPL has established an office that coordinates multiple project activities, the ESSP program CE would also maintain cognizance and exercise technical authority through that organization's CE in addition to the project CE. The ESSP Program Office CE collaborates and coordinates with the respective CEs to ensure Program Office perspectives are communicated across the ESSP Projects and supports the elevation of technical authority issues from a program perspective.

3.1.3.2 Technical Authority

A clear separation of programmatic and technical authority is maintained for the ESSP Program; each designated TA is organizationally and financially independent from ESSP programmatic path of authority. The engineering and SMA technical authorities for the ESSP Program are matrixed from and report directly to the LaRC Engineering (Figure 3-1) and SMA Directorates (Figure 3-2). The ESSP Program leverages and interfaces with the existing Health and Medical Authority (HMA) established at the Center that hosts each Project.

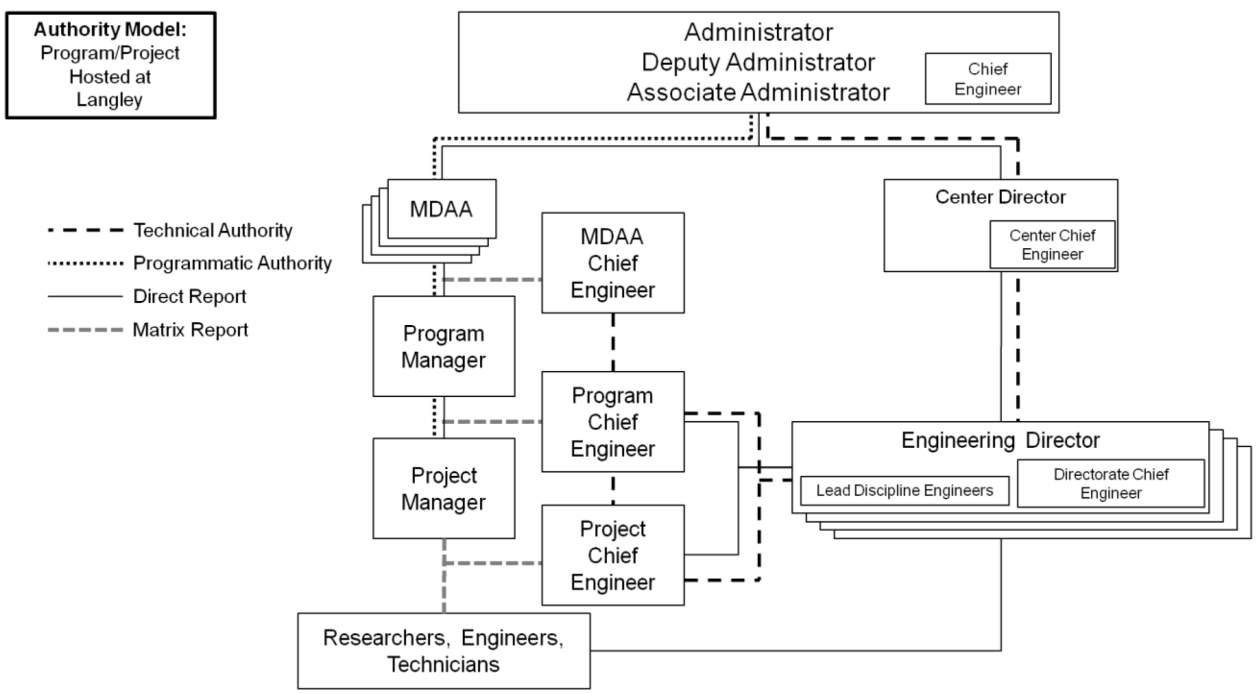


Figure 3-1: Flow of Engineering Technical Authority

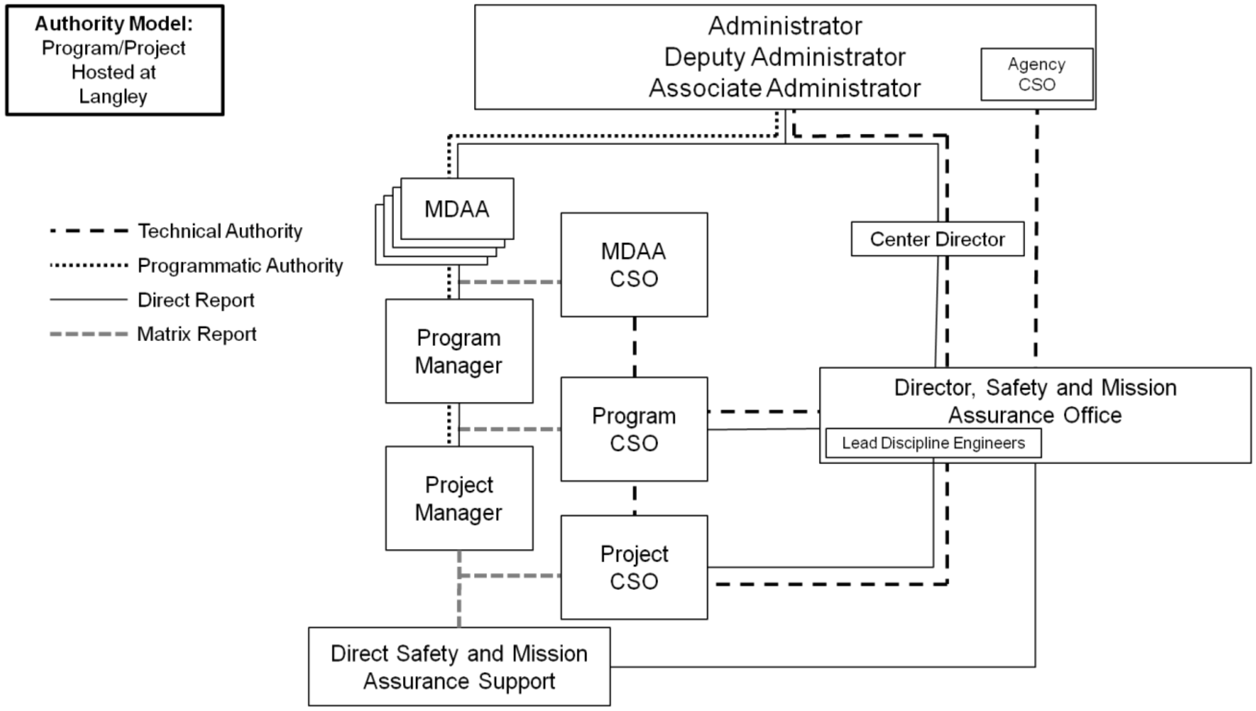


Figure 3-2: Flow of SMA Technical Authority

3.1.3.3 Tailors, Waivers, Deviations, and Dissenting Opinions

ESSP program-level and orbital project tailoring, waivers, deviations, and dissenting opinions adhere to the processes, forms, and authorities explicitly prescribed in *NASA Engineering and Program/Project Management Policy* (NPD 7120.4), NPR 7120.5, NPR 7123.1, and applicable Center policies and procedures. ESSP sub-orbital project tailoring, waivers, deviations, and dissenting opinions adhere to the processes, forms, and authorities explicitly prescribed in NPD 7120.4, NPR 7120.8, NPR 7123.1, and applicable Center policies and procedures. Projects develop necessary waivers in coordination with the Program Office. The Program Office ensures waivers are compliant with task agreements and programmatic guidelines, and coordinates with SMD to forward waiver request through responsible authorities. Waivers against Center practices do not require Directorate approval. Waivers against NPDs and NPRs are advanced by the ESD and the Directorate.

3.1.4 Performance Measures

The ESSP Program Office assesses its program performance in two ways: continuously against the Objectives set out in section 1.2 of this Plan and periodically through the conduct of Program Implementation Reviews (PIR).

The ESSP Program assesses the relevant project performance at key points in the project execution. The basis of assessment is documented in the Program Level Requirements Agreement (PLRA). The requirements are objective, quantifiable, and measurable, and traceable to the Program's five Key Performance Parameters (from section 2.1) and restated here:

1) Confirmation for each Project approved for implementation;

2) Successful orbital launch or sub-orbital deployment and transition to operation of each Project in implementation;

3) Achievement of at least minimum success criteria for each operating mission;

4) Delivery of mission science data meeting latency and performance objectives for each approved science data system; and

5) Completion of mission life for each operating mission.

The project's PLRA documents the science requirements, mission and spacecraft performance, launch requirements, ground system requirements, mission requirements, and cost and cost management. If at any time during implementation of an ESSP project, the estimated cost-to-complete exceeds the firm mission cost cap, the project is subject to a termination review. For specific project performance measures, refer to the project PLRA in the appendices.

3.2 ESSP Safety and Mission Assurance Plan

It is NASA's safety policy to protect the public, astronauts and pilots, NASA workforce, and high-value equipment and property from potential harm as a result of NASA activities and operations by providing safe programs, technologies, operations, and facilities; and to protect the environment. The ESSP Program is committed to supporting this policy by requiring all constituent Projects to adhere to NASA safety requirements during all phases of the life cycle.

The Program Office ensures that ESSP Projects implement thorough and robust SMA activities commensurate with the payload classification and/or risk classification. The goal of these SMA activities is to help ensure investigation success by applying safety, reliability, software assurance and quality NASA policies and procedures. This section of the Program Plan lists the governing documents from which project-level SMA Requirements are derived and the ESSP Program Office's role in implementing these requirements. Since all SMA activities are implemented at the project level, a program-level plan is not required.

The Program Office assesses the Projects' efforts to ensure that the Mission Assurance program being implemented is valid, complete, and effective. The focus of the Program's assessment will be the degree to which investigation success is enhanced by processes such as redundancy, management, configuration management, reliability analysis, fault protections, etc. The ESSP Program Office will ensure project-level compliance with SMA requirements by reviewing SMA plans that are stipulated in the solicitations, and by participating at project reviews. Participation at milestone reviews includes compliance checking on SMA deliverables and activities commensurate with the milestone being reviewed. Additionally, the ESSP Program Office supports the SMD in determining appropriate SMA requirements for inclusion in solicitations. The ESSP Program Office also supports scheduled NASA HQ Institutional Programmatic Support (IPS) reviews and ESSP Project audits (normally every three years at a Center level).

The SMA requirements are based on a project SMA life cycle process perspective. Specific SMA disciplines are applied to each of these life cycle phases through application of the Agency SMA requirements. These applicable Agency documents, shown in Table 3-2, allow for tailoring processes and requirements based on the payload classifications and risk considerations.

Table 3-2: Critical SMA Disciplines

Discipline	Document No.	Document Title
Safety	NPR 8715.3	*NASA General Safety Program Requirements*
Quality Assurance	NPD 8730.5	*NASA Quality Assurance Program Policy*
	NPR 8735.2	*Management of Government Quality Assurance Functions for NASA Contracts*
Compliance Verification, Audit, SMA Reviews, and SMA Process Maps	NPR 8705.6	*Safety and Mission Assurance Audits, Reviews, and Assessments*
Reliability and Maintainability	NPD 8720.1	*NASA Reliability and Maintainability (R&M) Program Policy*
Software Safety and Assurance	NASA-STD-8719.13	*NASA Software Safety Standard*
	NASA-STD-8739.8	*NASA Software Assurance Standard*

To ensure compliance with all Occupational Safety and Health Administration (OSHA) and NASA SMA requirements, ESSP Projects are required to plan and implement a comprehensive Mission Assurance program for all flight and ground hardware, software, Ground Support Equipment (GSE), and mission operations early in formulation. This responsibility extends to all partners, prime contractors, subcontractors, and suppliers. Due to the uncoupled nature of the ESSP Program, the ESSP Program Office will not develop and manage a Closed Loop Problem Reporting and Resolution System as described in NPR 7120.5. Projects will utilize Problem Reporting, Analysis, and Corrective Action (PRACA) systems as prescribed by the implementing Center's requirements. For projects not completed at a NASA Center, equivalent practices will be allowed and documented in the project plan. The Program Office reviews PRACA systems for anomalies and non-conformances that have potential for causing similar issues on other ESSP Projects and communicate these appropriately.

For ESSP Projects that involve aircraft, an independent Airworthiness Safety Review shall be conducted for all aspects of the flight project, including mission operations, as specified by the aircraft host Center processes. Range Safety Review processes or Airworthiness Safety Reviews from organizations outside of NASA may be utilized if the sponsoring NASA Center approves such reviews. Requirements for an aviation safety program for each respective flight activity are set forth in *Aircraft Operations Management* (NPR 7900.3).

NASA Procedural Requirements for Limiting Orbital Debris (NPR 8715.6) requires routine conjunction assessments for all NASA orbital assets with maneuvering capability. The project management staff for each operational orbital payload will establish tasks and appropriate lines of communication with the Conjunction Assessment Risk Analysis (CARA) Program, located at Goddard Spaceflight Center (GSFC), for meeting this policy requirement and to communicate any indicated risks. Final plans, including demonstrations, should be implemented at least three months prior to launch. A foreign partner providing operational services must sign a standard CARA Non-Disclosure Agreement (NDA).

3.3 Risk Management Plan

Agency Risk Management Procedural Requirements (NPR 8000.4) requires the ESSP Program Office and each of the ESSP Projects to implement Continuous Risk Management (CRM) in order to perform Risk-Informed Decision Making (RIDM) consistent with the applicable provisions of NPRs 7120.5 or 7120.8. Each ESSP orbital Project is required to develop a stand-alone Risk Management Plan. Sub-orbital Projects are not required to have a stand-alone Risk Management plan, but will capture their risk management approach in their Project plans. Project Managers are expected to elevate to the Program Office those risks that have the potential to impact Program milestones or that require additional technical or programmatic resources beyond those available at their level.

The risk management plan for each ESSP Project will conform to NASA risk management requirements for all phases of the project life cycle. Projects may use their choice of risk management tools, provided these are consistent with the risk scoring, reporting, and format in NPR 8000.4. Each ESSP Project will identify risk areas conformant to the challenges encountered while executing requirements management, design and development, integration, and test activities under the constraints allocated by Project Level 1 Requirements as documented in Appendices G through P.

ESSP Projects are independent and will capture and manage their own risks. The primary risk management tools available are allocated schedule and financial reserves, technical performance modifications, and/or de-scoping of investigation requirements. Oversight and reporting is established to detect unmanageable risks that might threaten program or project-level baseline milestones, failures to meet KPPs or Level 1 Requirements, and dangerous trends that might threaten project success.

As part of the ESSP Program's risk management effort, the Program Office identifies and tracks Program Office risks, assesses significant project-level identified risks, concurrently with Projects, identifies risks that need to be elevated to the program level, and searches for cross-cutting programmatic risk areas that impact multiple ESSP Projects. The results of these activities form the basis for an overall implementation of RIDM at all levels of the organization. CRM at the program level includes RIDM recommendations to NASA HQ.

A Risk Management Board (RMB) addresses and mitigates risks tracked at the Program level. The RMB is chaired by the ESSP PM, is composed of the ESSP CE, ESSP Program Planning and Control Manager, the ESSP MMs, SMA, Program Office Risk Manager, technical experts and consultants, a facilitator/recorder, and is open to relevant organizations with an interest in the announced topics. Board membership is adjusted as dictated by program requirements. Appropriate project-level personnel may also attend as needed. The RMB members will review, validate, and potentially adjust the risk assessments established by the risk originator. The risk originator will initially be listed as the "Risk Owner," but the RMB may transfer the risk to another ESSP Program or Project team member for mitigation. If the RMB accepts the risk, it is placed into the Program's risk database and reviewed at least monthly. The risk database is posted on the NX server.

The *ESSP Program Risk Management Plan* (ESSP-0008) details the Program's risk management approach.

3.4 Acquisition Plan

The ESSP acquisition strategy closely aligns with Program goals and objectives and enables the effective and efficient advancement of Agency, SMD and ESD needs, goals, and objectives. The ESSP Program acquisition strategy emphasizes the release of open and competitive solicitations during regular and frequent time intervals. The solicitation processes utilize peer review of the science content of the proposed investigations, as well as thorough independent review of their technical, management, and cost elements.

Solicitation development, proposal evaluation, and PI/investigation selection are the responsibility of SMD and are carried out to meet the requirements of the FAR and the NFS. The ESSP Program Office assists ESD and SOMA in defining the scope and strategy for the draft solicitation to ensure incorporation of Program requirements and Lessons Learned from current and previous projects. SOMA supports SMD solicitations and conducts Technical, Management, and Cost (TMC) evaluations of proposals generated as a result of these solicitations.

The ESSP Program Office does not participate in the evaluation of proposals, but observes the entire evaluation process in order to gain a greater understanding of any unique Project risks that should be monitored if the proposal is selected for implementation. Direct interaction between the ESSP Program Office and the proposed Project begins after selection. In all cases, clear and strict firewalls are established and implemented to mitigate any potential conflict of interest (whether real or perceived) that could affect the selection process.

ESSP agreements initiated at the program level are listed in Appendix F.

3.5 Technology Development Plan

The ESSP Program and its constituent Projects are designed to use mature technology—Technology Readiness Level (TRL) 6 or higher. A Technology Development Plan is not required at the program level, because no hardware or software is developed. ESSP Projects are strongly encouraged to utilize mature and low-risk technologies. These technologies are typically matured through other technology development programs (e.g. ESTO's Instrument Incubator Program (IIP)), substantially reducing program- and project-level risk.

The ESSP Program interacts with the Office of the Chief Technologist (OCT) and ESTO to maintain awareness of technology investments and innovation across the Agency, as well as other government agencies, academia and the commercial aerospace community. Concurrently, ESSP identifies future needs and acceptable levels of risk with OCT and ESTO to increase their knowledge of ESSP activities and strategic direction in preparation for solicitation release.

Interactions with these organizations assist the Program Office in keeping abreast of existing and emerging technologies, informing communications with prospective PIs and industry.

3.6 Systems Engineering Management Plan

The ESSP Program does not perform program-level system design and product realization processes, but does oversee the Projects' performance of these functions. As a result no Systems Engineering Management Plan (SEMP) is developed at the program level. The Program Office ensures project implementation of a SEMP that is commensurate with the payload classification and/or risk classification of the project.

3.7 Software Management Plan

There are no requirements for individual ESSP Projects to use common software, computer systems, methodologies, or tools. Additionally, the ESSP Program Office has no plans to develop custom software for purposes of managing its Projects. Therefore, there is no need for a program-level Software Management Plan (SMP).

The ESSP Program Office, however, is ultimately responsible for the success and quality of the total ESSP Program, which involves facilitating the successful implementation of constituent Projects—including software components and the related Software Engineering (SWE) activities employed—that meet all of their Level 1 Science Requirements within cost and resource constraints.

All ESSP Projects that are led by NASA organizations are subject to *NASA Software Engineering Requirements* (NPR 7150.2). This NPR is "self-tailoring." Based on the **Software Classification** and **Safety Criticality** of a project's *software containing systems*, a spreadsheet in the NPR determines the subset of the SWE requirements to be applied. Projects led by JPL organizations currently use JPL SWE procedures and standards that are essentially equivalent to those in NPR 7150.2.

In cases where ESSP Projects are implemented by academic, commercial, or other non-NASA organizations, aspects of Software Management (documents required, specific processes or standards to be used) will be defined by the contract SOW, which would reference applicable Agency and/or Center procedures. The ESSP Program Office would recommend the appropriate Agency and/or Center procedures to the Projects, and work with the project to define the applicable management practices, to be documented in the project plan and SOW.

When applicable, an ESSP Project develops an SMP, which details its plans for managing and developing its software products; the ESSP Program Office concurs with the contents of the SMP and any revisions prior to baselining.

3.8 Review Plan

The ESSP Program and its Projects participate in periodic reviews throughout their life cycles to assess performance and decide on continuation. Program-Level Approach

At the program level, a Standing Review Board (SRB) conducts an independent Program Implementation Review approximately every two years to validate conformance to the terms of the program requirements. The Terms of Reference (ToR) established for the review include gate products, success criteria, special assessments to be performed, and reporting of results. Because the ESSP Program is uncoupled and in its implementation phase, other typical life cycle reviews (Preliminary Design Review (PDR), Critical Design Review (CDR), etc.) are not applicable.

3.8.1 Program Approach to Project-Level Reviews

The ESSP Program Office works with the individual Projects to develop a review plan based on NPD 7120.4 and NPRs 7120.5, 7120.8 and 7123.1. For NASA-led Projects, the Program Office will coordinate its recommendations for the review chair and team members with the implementing Center and the ESD. For non-NASA led Projects (PI or Project Manager not hosted by a NASA Center), the Program Office will coordinate its recommendations for the review chair and team members with the implementing organization and LaRC, the ESSP Program host Center. In both cases, the convening authorities will approve the chair and review team members.

A ToR establishes reporting requirements for each project-level review. As a minimum for each review, the Review Chair submits an Executive Summary providing an assessment of the degree to which the success criteria was met and any outstanding critical deficiencies. For KDPs, the PM recommends to the SMD AA whether the project should enter the next phase of its life cycle.

At a minimum, orbital missions in Phase E must plan for the following formal reviews: Post-Launch Assessment Review (PLAR), bi-annual Senior Reviews, End of Prime Mission Review (EPMR), and Decommissioning Review (DR).

Section 1.5.5.3 describes the Termination Review process, including criteria.

3.9 Mission Operations Plan

ESSP operations occur only at the project level, and each ESSP mission operates independently. Technical management processes are directed towards the successful operation of each independent project. No program-level Mission Operations Plan is required.

ESSP Missions operating within the Morning or Afternoon Constellations must ensure that the spacecraft can move safely out of the Constellation when desired or required. Performing this operation requires that the mission be part of the Constellation Contingency Procedures and the Constellation Operations Coordination Plan.

3.10 Environmental Management Plan

There is no program-level Environmental Management Plan needed, since the NEPA checklist indicates that the Program Office performs no activities with potential environmental impact.

ESSP Projects will prepare stand-alone Environmental Management Plans to comply with *Implementing the National Environmental Policy Act and Executive Order 12114* (NPR 8580.1) if activities indicate potential environmental impact. The Program Office assesses project-level activities associated with NPR 8580.1 and inserts any critical milestones associated with complying with NEPA regulations into the program schedule.

3.11 Logistics Plan

Development and operations occurs only at the project level, and each ESSP Project operates independently. No program-level Logistics Plan is required.

Integrated logistics management supporting development and operations activities occurs and is planned at the project level. The Program Office assesses scope and content of project-developed logistics plans, metrics, and reports for adequacy and conformance with policy directives. At a minimum, logistics planning will be assessed at formal milestone reviews.

Each ESSP Project will summarize its logistics plan in its Project Plan. If a stand-alone plan is required because of the detail and volume of material in the plan, it will comply with *Program and Project Logistics Policy* (NPD 7500.1).

3.12 Science Data Management Plan

The ESSP Program primarily oversees independent PI-led Projects. Each ESSP Project is responsible for all science-related aspects throughout the complete life cycle. Thus, there is no program-level Science Data Management Plan (SDMP).

Each ESSP Project will prepare an SDMP containing its plans related to management of all classes of science data. The initial version of the SDMP is written and baselined concurrently with other project-level document and control plans. The details of this plan should include description of tasks, staffing, schedules, software testing, software development (algorithms) required prior to beginning operations as well as data products development after beginning operations. Typically the SDMP is a stand-alone control plan, which is summarized in the Project Plan, and will addresses the approach for creating and releasing STI publications.

3.12.1 Policies

The SDMP shows how a project plans to implement NASA policies regarding scientific openness, data-sharing, and timely dissemination of results, while preventing inappropriate release of Sensitive But Unclassified (SBU), proprietary, or export-controlled data.

The ESSP Program and its Projects comply with the NASA Earth Science Data and Information Policies, and Mission Data System Requirements. These can be accessed via http://science.nasa.gov/earth-science/earth-science-data.

The Data and Information Policy website also provides a common set of definitions and nomenclature to assist in complying with the Data & Information Policy. ESSP Projects are required to make use of the approved data system standards that apply to their science data systems and products.

3.12.2 Science Data Processing Software Development

All project-level software developed for or by NASA—including software for science data processing, reduction, inversion, visualization, *etc.*—must comply with the SWE Requirements deemed applicable for that specific software effort. For NASA-led projects, NPR 7150.2 applies to Science Data Processing Software development regardless of whether it is governed by NPR 7120.5, NPR 7120.8, or another project management procedure. Section 3.7 of this Program Plan details how the Program Office will assess its Projects' software development performance.

3.12.3 Science Data vs. Information

The SDMP addresses processes and plans for two distinct classes of science data: "Science Data" and "Information." The distinction is important, because the two classes are governed by different agency documents and are archived separately by distinct organizations. (However, note that the term "data" is often used collectively to refer to both classes. In fact, this is how it is defined in the context of the Data & Information Policy.)

Science Data include raw and processed data sets that represent collections of measurements made by science instruments. These may be raw data counts, or values that have undergone calibration, geographical registration, or conversion to engineering units. Also included are higher level Science Data Products (SDPs) derived from the measurement data. This class includes the software, its documentation, and the ancillary, engineering, and other data required to recreate the various products, locate and subset data, read the files, and visualize and understand their contents. Science Data includes artifacts that would be submitted to a NASA DAAC.

Information is referred to by the Agency as "Scientific and Technical Information" (STI), which has a precise meaning:

> *"the results (the analyses of data and facts and resulting conclusions) of basic and applied scientific, technical, and related engineering research and development."*

STI includes the scientific results that are published in peer-reviewed journals or released to public media and is governed by *Management of NASA Scientific and Technical Information* (NPD 2200.1) and by *Requirements for Documentation, Approval, and Dissemination of NASA Scientific and Technical Information* (NPR 2200.2). All STI is archived in the NASA Aeronautics and Space Database (N&ASD). The subset of STI that is not restricted or limited in any way is released to the general public via the NASA Technical Reports Server.

3.13 Information and Configuration Management Plan

3.13.1 Configuration Management

The *ESSP Program Configuration and Data Management Plan* (ESSPPO-0002) defines the requirements and processes for identification/definition, preparation, control, and disposition (storage, access, and records) of the non-scientific ESSP Program data. Change control for the ESSP Program and Project documentation is consistent with NASA change control policies and procedures, in order to enable visibility into all interactions and interdependencies within the Program.

ESSP Projects will manage all non-scientific data, including IT assets, in a cost-effective manner that ensures an appropriate level of integrity, confidentiality, and availability of information. They will follow Agency and Center policies, procedures, and requirements to protect NASA information and IT systems in a manner that is commensurate with the sensitivity, value, and criticality of the information.

3.13.2 Electronic Library

An electronic document library provides the ESSP Program Office an interactive way to collaborate, view, and archive information in a secure manner. The ESSP Program Office Configuration/Data Manager updates and maintains an electronic document library and membership.

The ESSP Program Office utilizes a document library that operates behind the LaRC firewall (known as NX) for internal and business related documentation. SBU documents uploaded to NX must indicate their sensitivity via metadata and document markings in accordance with ESSPPO-0002:

- Include the sensitivity explicitly in the Title field and/or the Summary field
- Select *Sensitive But Unclassified* or *ITAR/EAR* in the Access Constraint field

3.13.3 Lessons Learned

The ESSP Program Office takes a "Pause and Learn" approach, gathering lessons learned after major events such as reviews or solicitations or at a minimum frequency of every six months. The Configuration/Data Manager captures the ESSP Program Office's lessons learned using requirements established by documentation in accordance with NPD 7120.4 and as described in *Lessons Learned Process* (NPR 7120.6).

The ESSP Program Office conducts forums, workshops, and project reviews to share lessons learned. MMs disseminate the lessons learned to each Project through day-to-day meetings and reviews as well as special lessons learned discussions at the start of each development phase.

3.13.4 Knowledge Capture

The ESSP Configuration/Data Manager Program Office captures lessons learned from the Program Office as well as those forwarded by the ESSP Projects and adds them to the electronic library.

3.14 Security Plan

The ESSP Program Office implements plans to address security, technology protection, and emergency response requirements.

3.14.1 Security Requirements

The ESSP Program is committed to a safe and secure work environment, to ensuring that property is protected from vandalism, illegal intrusion, theft, and fire, that personnel are protected from injury, and that appropriate investigations are carried out, and findings are coordinated with designated management and law enforcement organizations. The ESSP Program Office adheres to *NASA Security Program Procedural Requirements* (NPR 1600.1) and *NASA Security Policy* (NPD 1600.2) and works with the LaRC Chief of Security (CCS) to verify adequacy of security implementation.

While the ESSP Program office does not store classified national security information (CNSI), it does handle SBU materials. As part of its information security implementation, the Program Office also follows *Information Security Program Management Procedures and Guidelines* (LPR 1620.1) in designating, identifying, marking, controlling, storing, accessing, disclosing, protecting, transmitting, and destroying SBU information when no longer needed. Industrial security pertains to contracts, grants, cooperative agreements, and other binding transactions in which performance shall require access to CNSI by the contractor, supplier, grantee, or its employees. The ESSP Program Office has no industrial security interfaces.

3.14.2 Information Technology Security Requirements

The ESSP Program adheres to *Security of Information Technology* (NPR 2810.1) and complies with the IT practices of *NASA Information Security Policy* (NPD 2810.1).

3.14.3 Emergency Response Requirements

The ESSP Program Office has no NASA Mission-Essential Infrastructure (MEI). Therefore, Emergency Response is limited to program documentation/information and personnel. All mission-essential program documentation/information is maintained electronically on NX, a central server which is backed up periodically and retained in accordance with *NASA Records Retention Schedules* (NPR 1441.1). Weather or facility related emergencies are announced by LaRC. For other types of emergencies, the ESSP Program Office follows the emergency policies and directives of LaRC. After normal duty hours, emergency instructions are provided through the news media. All emergency response processes and procedures are implemented in accordance with NASA emergency policies and requirements, including *NASA Continuity of Operations Planning (COOP) Procedural Requirements* (NPR 1040.1), *NASA Langley Research Center Emergency Plan* (LPR 1046.1), and *Continuity of Operations (COOP) Plan* (LPR 1040.3).

3.15 Export Control Plan

This Program Plan does not include a program-level Export Control Plan, since all export control activity occurs at the project level.

Each ESSP Project implements an export control process, compliant with the requirements of NPR 2190.1. Requirement compliance is flowed to the Projects through the solicitation process. Through this process, proposers are required to disclose and discuss any international participation, either through involvement of non-U.S. nationals and/or involvement of non-U.S. entities. The Program Office regularly monitors and reviews this activity at the project level to ensure its compliance with the NPR 2190.1.

3.16 Education and Public Outreach Plan

Contributing to the enhancement of the quality of science, mathematics, and technical education and the public understanding of earth science are explicit goals of SMD and the ESSP Program. The ESSP Program is committed to informing the public and providing educational opportunities that support local, state, regional, and national educational objectives and reform efforts. The primary ESSP Program E/PO emphasis is at the project level. However, the ESSP Program also implements program-level education and public outreach aimed at raising public awareness and fostering collaboration between the Program and the Projects to increase the impact of project-level E/PO programs. The ESSP Program and Projects follow the *Policy and Requirements for the Education and Public Outreach Programs of SMD Missions* (SPD-18) [Appendix U] in the development of all E/PO activities.

ESSP Projects provide copies of periodic reports related to their E/PO activities and the SMD-approved E/PO Control Plan to the ESSP Program Office to support programmatic requirements. The ESSP will coordinate its E/PO activities with ESD and SMD E/PO activities.

3.17 End of Mission Plan

The End of Mission Plan (EOMP) is not required at the program-level, because the Program itself does not operate orbital missions. All U.S internal orbital missions require a stand-alone plan, while EOMP requirements for missions with international partners are establish via a Memorandum of Understanding. Stand-alone EOMP's are described in NPR 8715.6 and is outlined in detail in *NASA Standard Process for Limiting Orbital Debris* (NASA-STD-8719.14). This NASA-STD has no automatic exclusions for any program or project due to limited funding, responsibility, or involvement of NASA in the program or project. If the mission is in the Morning or Afternoon Constellation, the EOMP must be coordinated with the Morning or Afternoon Constellation Mission Operations Working Group.

4.0 WAIVERS AND DEVIATIONS LOG

The Program Plan contains a waiver log, located in Table 4-1, which is consistent with the requirements of NPR 7120.5.

To date, the Program Office has not initiated any waivers or deviations. Projects will document waiver that they initiated in their own Project Plans. The ESSP Program Office reviews these waivers and approves them on a case-by-case basis.

Table 4-1: Waivers and Deviations Log

Waiver/ Deviation Number	Project	Date submitted	Submitted By	Waiver/ Deviation Description; NPR 7120.5 Requirement Waived	Action Taken	Date of Action

5.0 CHANGES LOG

The PM monitors NASA policies, directives, and requirements for changes affecting the ESSP Program. Updates required for key top-level program or project documentation are identified immediately, and generally included in annual updates. Table 5-1 documents Program Plan changes.

The PM annually evaluates the need for modifications of this Program Plan due to Project changes and other activities within the ESSP Program, or as driven by the above NASA documentation changes. The Program updates the PCA and applicable sections of this Program Plan whenever budget changes greater than 20 percent in a given year, or ten percent within a five-year horizon, occur.

Table 5-1: Changes Log

This change created document:	Submitted by:	Document Version No.	Effective Date	Description

Appendix A Acronyms and Abbreviations

AA	Associate Administrator
AAOES	Associate Administrator for the Office of Earth Science (GRACE)
ACAM	Airborne Compact Atmospheric Mapper (DISCOVER-AQ)
ACI	Administratively Controlled Information
AGU	American Geophysical Union
AIAA	American Institute of Aeronautics and Astronautics
AirMOSS	Airborne Microwave Observatory of Subcanopy and Subsurface
ALERT	Acute Launch Emergency Reliability Tip
ANSI	American National Standards Institute
AO	Announcement of Opportunity
APG	Annual Performance Goal
APL	Applied Physics Laboratory (GRACE)
ARC	Ames Research Center
ASIC	Application-specific integrated circuit
ASM	Acquisition Strategy Meeting
ASP	Acquisition Strategy Planning
ATBD	Algorithm Theoretical Basis Document (OCO-2)
ATTREX	Airborne Tropical Tropopause Experiment
AVAPS	Airborne Vertical Atmosphere Profiling System (HS3)
AWAS	Advanced Whole Air Sampler (ATTREX)
B-200	Designation for NASA King Air aircraft used for DISCOVER-AQ
BARCA	Balanço Atmosférico Regional de Carbono na Amazôni (CARVE)
BrO	Bromine oxide
BrO_3^-	Bromate ion
BRS	Baseline Requirement Set
Cal/Val	Calibration/Validation
CALIPSO	Cloud Aerosol LIDAR and Infrared Pathfinder Satellite Observations
CARA	Conjunction Assessment Risk Analysis
CARVE	Carbon in Arctic Reservoirs Vulnerability Experiment
CBE	Current Best Estimate
CCB	Configuration Control Board
CCN	Contract Change Notice
CCS	Center Chief of Security
CD	Center Director
CDM	Configuration/Data Manager
CDR	Critical Design Review
CE	Chief Engineer
CEQ	Council on Environmental Quality
CFO	Chief Financial Officer
CH_2O	Formaldehyde
CH_4	Methane
CI	Configuration Item
CIL	Critical Items List

CLIVAR	Climate Variability (Aquarius)
CM	Configuration Management
CMC	Center Management Council
CN	Condensation Nuclei
CNES	Centre National d'Études Spatiales (CALIPSO)
CNSI	Classified National Security Information
CO	Carbon monoxide; Contracting Officer
CO_2	Carbon Dioxide
COM	Center of Mass (GRACE)
CONAE	Comisión Nacional de Actividades Espaciales (Aquarius)
COOP	Continuity of Operations
COTR	Contracting Officer's Technical Representative
COTS	Commercial-Off-The-Shelf
CPL	Cloud Physics LIDAR (ATTREX, HS3)
CPU	Central Processing Unit
CRM	Continuous Risk Management
CS	Civil Service
CSA	Canadian Space Agency; Configuration Status Accounting
CSO	Chief Safety Officer
CSR	Center for Space Research; Concept Study Report
CSU	Colorado State University (CloudSat)
CY	Calendar Year
DA	Decision Authority
DAA	Deputy Associate Administrator
DAAC	Distributed Active Archive Center
DC-8	NASA high altitude atmospheric research aircraft
Dev	Developmental
DFRC	Dryden Flight Research Center
DHC	Designation of De Havilland aircraft (CARVE)
Dir	Directorate
DISCOVER-AQ	Air Quality Experiment
DLH	Diode Laser Hygrometer (ATTREX)
DLR	Deutsche Forschungsanstalt für Luft und Raumfahrt—German Space Agency (GRACE)
DMT	Droplet Measurement Technologies (DISCOVER-AQ)
DOAS	Differential Optical Absorption Spectrometer (ATTREX)
DoE ARM	Department of Energy Atmospheric Radiation Measurement (CloudSat)
DPAF	Dual Payload Attach Fitting (CALIPSO/CloudSat)
DPMC	Directorate Program Management Council
DR	Decommissioning Review
DSCVR	Deep Space Climate Observatory
DSWG	Data Systems Working Group
DTM	Dual Thruster Module (Aquarius)
E/PO	Education and Public Outreach
EAC	Estimate at Completion

EAR	Export Administration Regulation
EAV	Experimental Aerospace Vehicles
ECHI	Early Career Hiring Initiative
ECHO	EOS Clearinghouse
EDOS	EOS Data and Operations System
EEE	Electrical, Electronic, Electromechanical
EESS	Earth Exploration Satellite Service (Aquarius)
EIA	Electronics Industries Alliance
ELV	Expendable Launch Vehicle
EMD	Environmental Management Division
EMI	Electromagnetic Interference
EOM	End of Mission
EOMP	End of Mission Plan
EOS	Earth Observing System
EPMR	End of Prime Mission Review
ER-2	NASA derivative of U-2 high-altitude aircraft
ESD	Earth Science Division; Electrostatic Discharge
ESE	Earth Science Enterprise
ESM	Earth Systematic Missions
ESSP	Earth System Science Pathfinder
ESSPPO	Earth System Science Pathfinder Program Office
ESTO	Earth Science Technology Office
ETA	Engineering Technical Authority
EV	Earth Venture
EVM	Earned Value Management
EVMS	Earned Value Management System
FAD	Formulation Authorization Document
FAR	Federal Acquisition Regulation
FFRDC	Federally Funded Research and Development Center
FMEA	Failure Modes and Effects Analysis
FPGA	Field-Programmable Gate Array
FRR	Flight Readiness Review
FTA	Fault Tree Analysis
FTS	Fourier Transform Spectrometer (CARVE)
FWHM	Full Width at Half Maximum (CloudSat)
FY	Fiscal Year
G, Y, R	Green, Yellow, Red
GCM	General Circulation Model (CloudSat)
GDS	Ground Data System
GFZ	GeoForschungZentrum (GRACE)
GH	Global Hawk (RQ-4 drone)
GIDEP	Government-Industry Data Exchange Program
GOES	Geostationary Operational Environmental Satellite
GOOS	Global Ocean Observing System (Aquarius)
GPMC	Governing Program Management Council

GOTS	Government-off-the-shelf
GPS	Global Positioning System
GRACE	Gravity Recovery and Climate Experiment
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
GSOC	German Space Operations Center (GRACE)
H_2O	Water
HAIRS	High Accuracy Inter-satellite Ranging System (GRACE)
HAMSR	High Altitude MMIC sounding radiometer (HS3)
HDF	Hierarchical Data Format
HIRAD	Hurricane Imaging Radiometer (HS3)
HIWRAP	High-Altitude Imaging Wind and Rain Airborne Radar (HS3)
HMA	Health and Medical Authority
HNO_3	Nitric acid
HQ	Headquarters
HS3	Hurricane and Severe Storm Sentinel
HSRL	High Spectral Resolution LIDAR (DISCOVER-AQ)
HW	Hardware
IBPD	Integrated Budget and Procurement Document
ICA	Independent Cost Analysis
ICE	Independent Cost Estimate
ICR	Investigation Concept Review
ID	Identification
IEEE	Institute of Electrical and Electronics Engineers
IFOV	Instantaneous Field of View (CloudSat)
IIP	Instrument Incubator Program
IIR	Imaging Infrared Radiometer (CALIPSO)
ILS	Integrated Logistic Support
IMOU	International Memorandum of Understanding (GRACE)
IMS	Integrated Master Schedule
INVAP	Argentine manufacturer of SAC-D spacecraft (Aquarius)
IO	Iodine monoxide
IOC	In-Orbit Checkout
IPAO	Independent Program Assessment Office
IPEP	IV&V Project Execution Plan
IPS	Institutional Programmatic Support
IPU	Instruments Processing Unit (GRACE)
IR	Infrared
IRT	Independent Review Team
ISAA	International Space Act Agreement
ISGA	In situ Gas Analyzer (CARVE)
ISO	International Standards Organization
I&T	Integration and Test
IT	Information Technology
ITA	Internal Task Agreement

ITAR	International Traffic in Arms Regulations
IV&V	Independent Verification and Validation
JCL	Joint Cost and Schedule Confidence Level
JPL	Jet Propulsion Laboratory
JSG	Joint Steering Group (Aquarius)
KDP	Key Decision Point
KPP	Key Performance Parameters
KSC	Kennedy Space Center
LAN	Local Area Network
LaRC	Langley Research Center
LCC	Life Cycle Cost
LI-COR	Manufacturer of gas analyzer (DISCOVER-AQ)
LIDAR	LIght Detection And Ranging
LLI	Limited Life Item
LLC	Lessons Learned Committee
LLIS	Lessons Learned Information System
LOA	Letter of Agreement
LPD	LaRC Policy Directive
LPR	LaRC Procedural Requirements; Lawful Permanent Resident
LRR	Launch Readiness Review
LW	Long Wave
MCR	Mission Concept Review
MDAA	Mission Directorate Associate Administrator
MDR	Mission Definition Review
MDRA	Mission Definition and Requirements Agreement
MEI	Mission-Essential Infrastructure
Mgmt	Management
Mgrs	Managers
MM	Mission Manager
MMIC	Monolithic Microwave Integrated Circuit (HS3)
MMS	Meteorological Measurement System (ATTREX)
MOA	Memorandum of Agreement
MODIS	Moderate Resolution Imaging Spectroradiometer (CALIPSO)
MOO	Mission of Opportunity
MOS	Mission Operations System
MOTS	Modified-off-the-shelf
MOU	Memoranda of Understanding
MRB	Material Review Board
MSFC	Marshal Space Flight Center
MTP	Microwave Temperature Profiler (ATTREX)
N_2O	Nitrous oxide
N&ASD	NASA Aeronautics and Space Database
N/A	Not Applicable; Not Available
NACI	National Agency Check and Inquiries
NAR	Non-advocate Review

NARA	National Archives and Records Administration
NASA	National Aeronautics and Space Administration
NDA	Non-disclosure Agreement
NEN	Near Earth Network
NEPA	National Environmental Policy Act
NFS	NASA FAR supplement
NID	NASA Interim Directive
NO_2	Nitrogen dioxide
NOA	New Obligation Authority
NOAA	National Oceanic and Atmospheric Administration
NO_x	Nitrogen oxides
NPD	NASA Policy Directive
NPR	NASA Procedural Requirements
NRA	NASA Research Announcement
NRC	National Research Council
NSS	NASA Safety Standard
NV	Non-volatile (DISCOVER-AQ)
NWP	Numerical Weather Prediction (CloudSat)
NX	LaRC Document Management System
O_2	Molecular Oxygen
O_3	Ozone
OCE	Office of Chief Engineer
OClO	Chlorine dioxide
OCO	Orbiting Carbon Observatory
OCT	Office of Chief Technologist
ODIN	Outsourcing Desktop Initiative for NASA
OEPM	Office of Education Program Management
OES	Office of Earth Science
OMB	Office of Management and Budget
ONERA	Office Nationale d'Études et de Recherces Aérospatiales (GRACE)
Ops	Operations
ORR	Operations Readiness Review
Op	Operational
OSC	Orbital Science Corporation
OSHA	Occupational Safety and Health Administration
OSMA	Office of Safety and Mission Assurance
P-3B	Designation of NASA Orion aircraft used for DISCOVER-AQ
PA	Program Analyst
PA&R	Programmatic Audit and Review
PAL	Programmable Array Logic
PALS	Passive Active L-band System (CARVE)
PAO	Public Affairs Officer
PART	Program Assessment Rating Tool
PB	President's Budget
PBMA	Process Based Mission Assurance

PCA	Program Commitment Agreement
PCRS	Picarro Cavity Ring-Down Spectrometer (ATTREX)
PDR	Preliminary Design Review
PE	Program Executive
PFP	Programmable Flash Pack (CARVE)
PI	Principal Investigator
PIR	Program Implementation Review
PLAR	Post-Launch Assessment Review
PLRA	Program-Level Requirements Appendix
PM	Program Manager
PMC	Program Management Council
POC	Point of contact
PODAAC	Physical Oceanography DAAC
POP	Program Operating Plan
PPBE	Planning, Programming, Budgeting and Execution
PRA	Probabilistic Risk Assessment
PRACA	Problem Reporting, Analysis, and Corrective Action
Proteus	High altitude long-endurance aircraft built by Scaled Composites (CALIPSO)
PS	Program Scientist
PSLA	Project Service Level Agreement
PSM	Procurement Strategy Meeting
PSR	Program Status Review
Q	Yearly quarter
R&A	Research and Analysis
R&M	Reliability and Maintainability
Reps	Representatives
Req.	Requirements
Rev	Revision
RIDM	Risk Informed Decision Making
RIS	Risk Identification Sheet
RLV	Reusable Launch Vehicle
RM	Risk Management; Risk Manager
RMB	Risk Management Board
RMD	Risk Management Database
RMP	Risk Management Plan; Risk Mitigation Phase
RMS	Requirements Management System
ROSES	Research Opportunities in Space and Earth Sciences
RR	Radiance Research (DISCOVER-AQ)
RSC	United States Air Force Research, Development, Test & Evaluation Support Complex (CloudSat)
RSDO	Rapid Spacecraft Development Office
RSM	Range Safety Manual
SA	Solar Array
SAC-D	Satellite de Aplicaciones Cientificas (Aquarius)

SALMON	Stand-Alone Mission of Opportunity Notice
SAP	Software Assurance Plan
SBU	Sensitive But Unclassified
SCaN	Space Communications and Navigation
SCDS	Space Communications and Data Systems
SCSW	Safety Critical Software
SDMP	Science Data Management Plan
SDP	Science Data Product
SDS	Science Data System
SEMP	Systems Engineering Master Plan
SETA	Security Education and Training, and Awareness
SF_6	Sulfur hexafluoride
S-HIS	Scanning High-resolution Interferometer Sounder (HS3)
SIR	System Integration Review
SMA	Safety and Mission Assurance
SMAO	Safety and Mission Assurance Office
SMAP	Soil Moisture Active and Passive (AirMOSS)
SMD	Science Mission Directorate
SME	Subject Matter Expert
SFMR	Stepped Frequency Microwave Radiometer
SMP	Software Management Plan
SMSR	Safety and Mission Success Review
SN	Space Network
SO_2	Sulfur dioxide
SoC	System-on-a-chip
SOMA	Science Office for Mission Assessments
SOW	Statement of Work
SP	Special Publication
SPD	SMD Policy Document
SPIAD	Science Pending International Agreements Database
SR	Senior Review; Status Review
SRA	Schedule Risk Assessment
Sys.	Systems
SRB	Standing Review Board
SRR	System Requirements Review
SS/L	Space Systems Loral (GRACE)
SSFR	Solar Spectral Flux Radiometer (ATTREX)
SSMAP	Systems Safety and Mission Assurance Program
SSS	Sea Surface Salinity
SSTP	System Safety Technical Plan
STA	Safety and Mission Assurance Technical Authority
STD	Standard
STI	Scientific and Technical Information
SuperSTAR	High-precision accelerometer manufactured by ONERA/CNS (GRACE)
SW	Software

SWE	Software Engineering
S/P	Spacecraft / Platform
TA	Technical Authority
TBD	To Be Determined
TBR	To Be Resolved; To Be Reviewed; To Be Revised
TCCON	Total Column Carbon Observing Network (OCO-2)
TCSP	Tropical Cloud Systems and Processes
TDRSS	Tracking and Data Relay Satellite System
Tech.	Technical
TMC	Technical, Management, and Cost
ToR	Terms of Reference
TPM	Technical Performance Measure
TRL	Technology Readiness Level
TSGC	Texas Space Grant Consortium (GRACE)
TTCP	Technology Transfer Control Plan
TWiLiTE	Tropospheric Wind LIDAR Technology Experiment (HS3)
UAS	Uninhabited Aerial System
UAV	Uninhabited Aerial Vehicles
UAVSAR	UAV Synthetic Aperture Radar (AirMOSS)
UCATS	UAS Chromatograph for Atmospheric Trace Species (ATTREX)
UFE	Unallocated Future Expenses
UHF	Ultrahigh Frequency
ULH	UAS Laser Hygrometer (ATTREX)
USSTRATCOM	US Strategic Command
UTCSR	University of Texas Center for Space Research (GRACE)
URL	Uniform Resource Locator
V&V	Verification and Validation
VAFB	Vandenberg Air Force Base
VCL	Vegetation Canopy LIDAR
VHDL	VHSIC Hardware Description Language
VHSIC	Very-High-Speed Integrated Circuit
WB-57	NASA aircraft used for high altitude missions
WBS	Work Breakdown Structure
WFC	Wide Field Camera (CALIPSO)
WOCE	World Ocean Circulation Experiment (GRACE)
WYE	Work Year Equivalent
X_{CO2}	Column Average Carbon Dioxide Dry Air Mole Fraction (OCO-2)

Appendix B References

NASA POLICY DIRECTIVES

NM 7120-81, *NASA Interim Directive (NID) for NASA Procedural Requirements (NPR) 7120.5D*

NPD 1000.0, *NASA Governance and Strategic Management Handbook*

NPD 1001.0, *2006 NASA Strategic Plan*

NPD 1000.5, *Policy for NASA Acquisition*

NPD 1600.2, *NASA Security Policy*

NPD 2200.1, *Management of NASA Scientific and Technical Information*

NPD 2810.1, *NASA Information Security Policy*

NPD 7120.4, *NASA Engineering and Program/Project Management Policy*

NPD 7500.1, *Program and Project Logistics Policy*

NPD 8010.3, *Notification of Intent to Decommission or Terminate Operating Space Systems and Terminate Missions*

NPD 8700.1, *NASA Policy for Safety and Mission Success*

NPD 8720.1, *NASA Reliability and Maintainability (R&M) Program Policy*

NPD 8730.2, *NASA Parts Policy*

NPD 8730.5, *NASA Quality Assurance Program Policy*

NPD 9501.3, *Earned Value Management*

NASA PROCEDURAL REQUIREMENTS

NPR 1040.1, *NASA Continuity of Operations Planning (COOP) Procedural Requirements*

NPR 1441.1, *NASA Records Retention Schedules*

NPR 1600.1, *NASA Security Program Procedural Requirements*

NPR 2190.1, *NASA Export Control Plan.*

NPR 2200.2, *Requirements for Documentation, Approval, and Dissemination of NASA Scientific and Technical Information*

NPR 2810.1, *Security of Information Technology*

NPR 6000.1, *Requirements for Packaging, Handling, and Transportation for Aeronautical and Space Systems, Equipment, and Associated Components*

NPR 7120.5, *NASA Space Flight Program and Project Management Requirements* (see also NM 7120-81)

NPR 7120.6, *Lessons Learned Process*

NPR 7120.8, *NASA Research and Technology Program and Project Management Requirements*

NPR 7123.1, *NASA Systems Engineering Processes and Requirements*

NPR 7150.2, *NASA Software Engineering Requirements*

NPR 7900.3, *Aircraft Operations Management*

NPR 8000.4, *Agency Risk Management Procedural Requirements*

NPR 8580.1, *Implementing the National Environmental Policy Act and Executive Order 12114*

NPR 8705.6, *Safety and Mission Assurance Audits, Reviews, and Assessments*

NPR 8715.3, *NASA General Safety Program Requirements*

NPR 8715.6, *NASA Procedural Requirements for Limiting Orbital Debris*

NPR 8735.2, *Management of Government Quality Assurance Functions for NASA Contracts*

NASA STANDARDS

NASA-STD-8719.13, *NASA Software Safety Standard*

NASA-STD-8719.14, *NASA Standard Process for Limiting Orbital Debris*

NASA-STD-8739.8, *NASA Software Assurance Standard*

NON NASA STANDARDS

ANSI/EIA 748-A, *ANSI Standard for Earned Value Management Systems*

NASA LANGLEY RESEARCH CENTER POLICY DIRECTIVES AND PROCEDURAL REQUIREMENTS

LPR 1040.3, *Continuity of Operations (COOP) Plan*

LPR 1046.1, *NASA Langley Research Center Emergency Plan*

LPR 1620.1, *Information Security Program Management Procedures and Guidelines*

ESSP PROGRAM OFFICE DOCUMENTS

ESSPPO-0001, *ESSP Program Plan*

ESSPPO-0002, *ESSP Program Office Configuration Management Plan*

ESSPPO-0004, *ESSP Program Office Configuration Audit Plan*

ESSPPO-0006, *ESSP Program Office Significant Incident Reporting Procedure for ESSP Operations*

ESSPPO-0007, *Organizational Conflict of Interest Avoidance Plan*

ESSPPO-0008, *ESSP Risk Management Plan*

RELATED REFERENCES

Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond (Decadal Survey), *2007.*

2006 Earth Science Reference Handbook (NP-2006-5-768-GSFC).

Federal Acquisition Regulation (FAR)

International Traffic In Arms Regulations (22 CFR 120-130)

NASA Earth Science Data and Information Policy

NASA FAR Supplement (NFS)

NASA Systems Engineering Handbook (NASA/SP-2007-6105, Rev1)

Policy and Requirements for the Education and Public Outreach Programs of SMD Missions, (SPD-18), January 28, 2010.

Science Mission Directorate Management Handbook (SMD Management Handbook), 2008.

Science Plan for NASA's Science Mission Directorate 2007-2016 (Science Plan)

WEB SITE REFERENCES

ESSP Program Office. http://science.nasa.gov/about-us/smd-programs/earth-system-science-pathfinder/

NASA Federal Acquisition Regulations (FAR) Supplement (NFS). http://www.hq.nasa.gov/office/procurement/regs/nfstoc.htm

NASA Online Directives System (NODIS). http://nodis3.gsfc.nasa.gov/

NASA Science Earth Data & Information Policy. http://science.nasa.gov/earth-science/earth-science-data/data-information-policy/

NASA Solicitation and Proposal Integrated Review and Evaluation System (NSPIRES). http://nspires.nasaprs.com/external/

ScienceWorks. https://scienceworks.hq.nasa.gov/

Appendix C Glossary

Acceptable Risk. A risk that is well understood and agreed to by the program/project, organization partners, stakeholders, governing authority, mission directorate, and other customer(s) such that no further specific mitigating action is required to achieve the defined success criteria within the approved level of resources. Acceptable risk occurs when it is decided that no further expenditures are warranted for mitigating the risk and that no further action will be taken to reduce the risk's exposure.

Access. Access is the ability to do something with a computer resource. This usually refers to a technical ability (e.g., read, create, modify, or delete a file, execute a program, or use an external connection.)

Acquisition Strategy Meeting (ASM). A forum where senior Agency Management reviews major acquisitions in programs, projects, or activities before authorizing budget expenditures. The ASM is held at the Mission Directorate/Mission Support Office level, implementing the decisions that flow out of the Acquisition Strategy Planning (ASP) meeting and recommending implementation plans for approval.

Acquisition Strategy Planning Meeting. A forum that provides an early view of potential major acquisitions so that senior leaders can consider issues such as the appropriate application of new agency and Administration initiatives, current portfolio risk and implications to the future portfolio, high-level make-or-buy strategy and the placement of development or operations work in-house versus out-of-house. It also provides the strategic framework for addressing challenges associated with fully utilizing NASA Centers' capabilities, including workforce and infrastructure and shaping the Agency over time.

Acquisition. The acquiring by contract with appropriated funds of supplies or services (including construction) by and for the use of the Federal Government through purchase or lease, whether the supplies or services are already in existence or must be created, developed, demonstrated, and evaluated. Acquisition begins at the point when Agency needs are established and includes the description of requirements to satisfy Agency needs, solicitation and selection of sources, award of contracts, contract financing, contract performance, contract administration, and those technical and management functions directly related to the process of fulfilling Agency needs by contract.

Active Records. Records that are referred to on a frequent basis, i.e., daily or weekly. Records that are maintained in office files for immediate access, use, and reference. Also considered current records, which are necessary for conducting the business of an office.

Administratively Controlled Information (ACI). Certain official information and material which is not national security information (and therefore cannot be classified), nonetheless, should be protected against disclosure. Such information and material, which may be exempt from disclosure by statute or is determined by a designated NASA official to be especially sensitive, shall be afforded physical protection sufficient to safeguard it from unauthorized disclosure (previously designated "For Official Use Only")

Agency Program Management Council. The senior management group, chaired by the Associate Administrator or designee, responsible for reviewing program formulation performance, recommending approval of proposed programs, and overseeing implementation of designated programs and projects according to agency commitments, priorities and policies.

Aggregate Risk. The cumulative risk associated with a given performance measure, accounting for all significant risk contributors. For example, the total probability of loss of mission is an aggregate risk quantified as the probability of the union of all scenarios leading to loss of mission.

Approval (for Implementation). The acknowledgment by the DA that the program/project has met stakeholder expectations and formulation requirements, and is ready to proceed to implementation. By approving a program/project, the DA commits the budget resources necessary to continue into implementation. Approval (for Implementation) must be documented.

Approval. Authorization by a required management official to proceed with a proposed course of action. Approvals must be documented.

Approved Manufacturer. A manufacturer that has passed an audit intended to verify that a company has the manufacturing capability and implemented quality management system with controlled processes that will ensure that products meet the requirements of applicable specifications.

Aquarius. ESSP Project designed to measure Sea Surface Salinity.

Ascending Node. The point in the orbit where a satellite crosses the Earth's equatorial plane in passing from the southern hemisphere to the northern hemisphere.

Assessment. Review or audit process, using predetermined methods, that evaluates hardware, software, procedures, technical and programmatic documents and the adequacy of their implementation. The evaluation of a program, project, or institutional initiative with respect to its accomplishments and performance in meeting requirements.

Assurance. Providing a measure of increased confidence that applicable requirements, processes, and standards are being fulfilled. Grounds for confidence that the other four security goals (integrity, availability, confidentiality, and accountability) have been adequately met by a specific implementation. "Adequately met" includes (1) functionality that performs correctly, (2) sufficient protection against unintentional errors (by users or software), and (3) sufficient resistance to intentional penetration or bypass.

A-Train or Afternoon Constellation. A group of Earth-orbiting satellites with synergistic science objectives in similar sun-synchronous orbits and with the satellites distributed along the orbit in close proximity, such that they over-fly the same geographic region within seconds to minutes of each other. Their ascending node equator crossings are near 13:30 hours Mean local time. These satellites maintain their relative positions and control boxes by actively, but independently, maneuvering. Individual satellites remain in the "orbital train" so long as they maintain their assigned position in the train and are acquiring the required science measurements.

Audit. (1) an examination of records or financial accounts to check their accuracy, or (2) a systematic check or assessment, especially of the efficiency or effectiveness of an operation.

Background Investigation. The means or procedures used to determine the suitability of an individual to have privileged or limited privilege access and to hold a "Public trust." Conducted by the Center chief of Security.

Baseline (Document Context). An agreed to set of requirements, designs, or documents that will have changes controlled through a formal approval and monitoring process. Implies the expectation of a finished product, though updates may be needed as circumstances warrant. All approvals required by Center policies and procedures have been obtained.

Baseline (general context). An agreed-to set of requirements, cost, schedule, designs, documents, etc. that will have changes controlled through a formal approval and monitoring process.

Baseline Schedule. The original approved plan plus or minus approved scope changes.

Baseline Science Requirements. The investigation performance requirements necessary to achieve the entire set of science objectives identified at the initiation of the mission. (Also see Threshold Science Requirements.)

Case File. A folder or other file unit containing materials relating to a specific action, transaction, event, person, place, project, or other subject. A case file may cover one or many subjects that relate to the case; for example, a contract file contains records on a specific contract, such as the application, correspondence, reports, and processing documents. Other types of case files include official personnel folders, surveys, and studies.

Center Management Council (CMC). The council at a Center that performs oversight of programs and projects by evaluating all program and project work executed at that Center.

CloudSat. An ESSP Project that observes vertical distribution of cloud systems and their ice and water contents.

Commercial-Off-The-Shelf (COTS) Software. Operating systems, libraries, applications and other software purchased from a commercial vendor. Not customized for a particular project. Access to source code and documentation are often limited.

Commitment Baseline. Establishes and documents an integrated set of project requirements, cost, schedule, technical content, and an agreed-to JCL that forms the basis for NASA's commitment with the external entities of OMB and Congress. Only one official baseline exists for a NASA program or project and it is the commitment Baseline.

Complex Item. A product that has quality characteristics not wholly visible in the end item, for which contract conformance cannot be determined through inspection, measurement, and/or test of the end item, and for which conformance can only be established progressively through the item's life by precise measurements, tests, and controls applied. Examples of complex items include assemblies, machinery, equipment, subsystems, systems, and platforms.

Compliance Verification. Compliance verification includes: 1) verifying that appropriate technical and process requirements are in place (requirements flow-down verification), 2) verifying that documented SMA requirements are in place and capable, and 3) observing work activities and products to verify process implementation and compliance with process and technical requirements (e.g., on-site in-process audits and reviews for verification of work discipline.)

Computer Security. The protection afforded to an automated information system in order to attain the applicable objectives of preserving the integrity, availability, and confidentiality of information system resources (including hardware, software, firmware, information/data, and telecommunications.

Concurrence. A documented agreement by a management official that a proposed course of action is acceptable.

Configuration Control Board (CCB). Is constituted to control and authorize baselines, changes, deviations and waivers to configuration controlled documents and other specific program-level activities.

Configuration Management. A management discipline applied over the product's life cycle to provide visibility into and to control changes to performance, functional, and physical characteristics.

Conjunction Assessment. An analysis done to predict the closest point of approach of two space objects based on their orbital parameters.

Continuous Risk Management (CRM). A systematic and iterative process that efficiently identifies, analyzes, plans, tracks, controls, communicates, and documents risks associated with implementation of designs, plans, and processes.

Contract Data Requirements List. A listing of the technical information and reports required for a contract including submittal and approval criteria and instruction.

Contract. A mutually binding legal relationship obligating the seller to furnish the supplies or services (including construction) and the buyer to pay for them. It includes all types of commitments that obligate the Government to an expenditure of appropriated funds and that, except as otherwise authorized, are in writing. In addition to bilateral instruments, contracts include (but are not limited to) awards and notices of awards; job orders or task letters issued under basic ordering agreements; letter contracts; orders, such as purchase orders, under which the contract becomes effective by written acceptance or performance; and bilateral contract modifications. Contracts do not include grants and cooperative agreements.

Convening Authority. The management official(s) responsible for convening a program/project review, establishing the terms of Reference, including review objectives and success criteria, appointing the SRB chair, concurring on SRB membership, and receiving documented results of the review.

Council on Environmental Quality. The President's Council on Environmental Quality (CEQ) was established by the enactment of NEPA. The CEQ was charged with developing regulations to be followed by all Federal agencies in developing and implementing their own specific NEPA implementation policies and procedures.

Countermeasures. Actions, devices, procedures, techniques, or other measurers that reduce the vulnerability of an information system. Synonymous with security controls and safeguards.

Critical Path. A sequential path of tasks in a network schedule that represents the longest overall duration from "time now" through project completion. Any slippage of the tasks in the critical path will increase the project duration.

Critical Single Failure Point. A single item or element, essential to the safe functioning of a system or subsystem, whose failure in a life or mission-essential application would cause serious delays or be hazardous to personnel.

Decision Authority (DA). The individual responsible for evaluating independent assessments and program and project Governing Body recommendations, assessing program and project deliverables, and making the decision at a KDP that authorizes a program or project to transition to the next life cycle phase.

Decommissioning Review. Confirms the decision to terminate or decommission the system and assess the readiness of the system for the safe decommissioning and disposal of system assets.

Derived Requirement. Arise from constraints, consideration of issues implied but not explicitly stated in the high-level direction provided by NASA HQ and Center institutional requirements, factors introduced by the selected architecture, and the design. These requirements are finalized through requirements analysis as part of the overall systems engineering process and become part of the program/project requirements baseline. They are established by and are the responsibility of the Programmatic Authority.

Designated Governing Authority. The management entity above the program, project, or activity level with technical oversight responsibility.

Deviation. . A documented authorization intentionally releasing a program or project from meeting a requirement before the requirement is put under configuration control at the level the requirement will be implemented. .

Dissenting Opinion. A Dissenting Opinion is a disagreement with a decision or action that is based on a sound rationale (not on unyielding opposition) that an individual judges is of sufficient importance that it warrants a specific review and discussion by higher level management and the individual specifically requests

Dominant Root Cause. Along a chain of events leading to a mishap, the first causal action or failure to act that could have been controlled systematically either by policy/practice/procedure or individual adherence to policy/practice/procedure.

Earned Value Management (EVM). A tool for measuring and assessing project performance through the integration of technical scope with schedule and cost objectives during the execution of the project. EVM provides quantification of technical progress, enabling management to gain insight into project status and project completion costs and schedules. Two essential characteristics of successful EVM are EVM system data integrity and carefully targeted monthly EVM data analyses (i.e., risky WBS elements).

Earned Value. The sum of the budgeted cost for tasks and products that have actually been produced (completed or in progress) at a given time in the schedule.

End-of-Mission. The time of completion of all mission activities, experimental operations, and stand-by-status, that immediately precedes passivation and disposal of the spacecraft or launch vehicle stage.

Engineering Requirements. Requirements defined to achieve programmatic requirements and relating to the application of engineering principles, applied science, or industrial techniques.

Environmental Evaluation. An environmental evaluation is the analysis of the environmental effects of proposed actions, including alternative proposals. The analyses are carried out from the very earliest of planning studies for the action in question and are the materials from which the more formal environmental assessments, environmental impact statements, and public record of decisions are made.

Environmental Impact. The direct, indirect, or cumulative beneficial or adverse effect of an action on the environment.

Environmental Management Division—HQ. The Headquarters Environmental Management Division (HQ/EMD) assists the Assistant Administrator for Institutional and corporate Management in implementing assigned environmental management duties and responsibilities for NEPA functions. HQ/EMD is available for consultation and non-legal advice to other NASA entities for implementing assigned environmental responsibilities under NEPA.

Environmental Management. The activity of ensuring that program and project actions and decisions that potentially impact or damage the environment are assessed/evaluated during the formulation/planning phase and reevaluated throughout implementation. This activity must be performed according to all NASA policy and Federal, state and local environmental laws and regulations.

Estimate at Completion (EAC). The sum of actual direct costs, plus indirect costs allocable to the project/contract to date, plus the estimate of costs (direct and indirect) for authorized work remaining and reserves.

Evaluation. The continual, independent (i.e., outside the advocacy chain of the program/project) evaluation of the performance of a program or project and incorporation of the evaluation findings to ensure adequacy of planning and execution according to plan.

Expedition. A series of crewed or uncrewed aircraft flights, generally focused on a specific geographic area, designed to gather scientific measurements of Earth characteristics over a period of time.

Experiment. Generally refers to the instrument making the scientific measurements of Earth characteristics; can also refer to overall proposed scientific investigation approach.

Export Administration Regulations (EAR). US export control regulations administered by the US Department of commerce that require limited availability for technical Date pertaining to commodities, technology and software listed on the commerce Control List. NASA STI reports subject to restriction under this regulation often are referred to as EAR documents.

Factor of Safety. Ratio of the design condition to the maximum operating conditions specified during design.

Fail-Safe. Ability to sustain a failure and retain the capability to safely terminate or control the operation.

Failure Mode. Particular way in which a failure can occur, independent of the reason for failure.

Failure Modes and Effects Analysis (FMEA). A bottoms-up systematic, inductive, methodical analysis performed to identify and document all identifiable failure modes at a prescribed level and to specify the resultant effect of the modes of failure. It is usually performed to identify critical single failure points in hardware. In relation to formal hazard analysis, FMEA is a subsidiary analysis.

Failure Review Board (FRB). A group consisting of representatives from appropriate organizations with the level of responsibility and authority to assure that causes are identified and corrective actions are implemented. The board reviews failure trends, facilitates and manages the failure analysis and participates in developing and implementing the resulting corrective actions. The board's authority is designed to require investigations, analyses, and corrective actions by other organizations. The board should be headed by the reliability manager.

Failure Tolerance. Built-in capability of a system to perform as intended in the presence of specified hardware or software failures.

Failure. Inability of a system, subsystem, component, or part to perform its required function within specified limits.

Fault Tree Analysis (FTA). An analysis that begins with the definition or identification of an undesired event (failure). The fault tree is a symbolic logic diagram showing the cause-effect relationship between a top undesired event (failure) and one or more contributing causes. It is a type of logic tree that is developed by deductive logic from a top undesired event to all sub-events that must occur to cause it.

Fault Tree. A schematic representation resembling an inverted tree that depicts possible sequential events (failures) that may proceed from discrete credible failures to a single undesired final event (failure). A fault tree is created retrogressively from the final event by deductive logic.

Final (Document Context). Implies the expectation of a finished product. All approvals required by Center policies and procedures have been obtained.

Final Acceptance. The act of an authorized representative of the government by which the government, for itself or as an agent of another, assumes ownership of existing identified supplies tendered or approves specific services rendered as partial or complete performance of the contract.

Finding. A conclusion, positive or negative, based on facts established during the investigation by the investigating authority (i.e., cause, contributing factor, and observation.

Firewall. A system designed to prevent unauthorized access to or from a private network. Firewalls can be implemented in both hardware and software, or a combination of both. Firewalls are frequently used to prevent unauthorized internet users from accessing private networks connected to the Internet, especially intranets. All messages entering or leaving the intranet pass through the firewall, which examines each message and blocks those that do not meet the specified security criteria.

Flight Hardware. Any hardware that is flown on or is a part of an aircraft, experimental flight vehicle, satellite, lighter than air vehicles, unoccupied aerial vehicle, or space transportation system.

Flight. A single crewed or uncrewed activity from takeoff to landing.

Foreign National. (For the purpose of general security protection, considerations of national security and access accountability.) Any person who is not a citizen of the US. Includes lawful permanent resident (i.e., holders of green cards) or persons admitted with refugee status to the US.

Formulation Phase. The first part of the NASA management life cycle where system requirements are baselined, feasible concepts are determined, a system baseline is baselined for the selected concept (s), and preparation is made for progressing to the implementation phase.

Functional Redundancy. A situation where a dissimilar device provides safety backup rather than relying on multiple identical devices.

Gantt Chart. Bar chart depicting start and finish dates of activities and products in the WBS.

General Correspondence. A file consisting of correspondence by organizations as a result of their routine operations. Records consist of arrangement of correspondence, memoranda, and messages on a number of different subjects as distinguished from a case file that contains correspondence about specific transactions or projects.

GIDEP ALERT. GIDEP document for reporting a problem with parts, components, materials, specifications, software, facilities, manufacturing processes, or test equipment that can cause a functional failure.

GIDEP. This acronym stands for "Government-Industry Data Exchange Program". GIDEP is a cooperative information-sharing program between the US and Canadian governments and industry participants. The goal of GIDEP is to ensure that only reliable and conforming parts are in use on all Government programs and operations. GIDEP members share technical information essential to the research, design, development, production, and operational phases of the life cycle of systems, facilities, and equipment.

Government Mandatory Inspection Points. Inspection points required by Federal regulations to ensure 100 percent compliance with safety/mission-critical attributes when noncompliance can result in loss of life or loss of mission.

Ground Support Equipment. Ground-based equipment used to store, transport, handle, test check out, service and control aircraft, launch vehicles, spacecraft, or payloads.

Hazard Analysis. Identification and evaluation of existing and potential hazards and the recommended mitigation for the hazard sources found.

High Risk Item. An item which involves technological manufacturing or other state-of-the-art advances or considerations, and program/project management designates as requiring special attention. It is critical from the standpoint of achieving program objectives, reliability, maintainability safety, quality assurance, or other such factors.

Hydros. An ESSP investigation that did not complete formulation, whose mission was to conduct global observations of daily surface freeze/thaw state and soil moisture conditions.

Implementation Phase. The part of the NASA management life cycle where the detailed design of system products is completed and the products to be deployed are fabricated, assembled, integrated, and tested and the products are deployed to their customers or users for their assigned use or mission.

Independent Assessment. The general term referring to an evaluation of a program or project conducted by experts outside the advocacy chain. Specifically, a review or evaluation that results in an assessment of the program's or project's readiness (technical, schedule, cost, risk) to proceed to the next phase in the life cycle that is reported to a program or project governing body and DA..

Independent Cost Analysis (ICA). An independent analysis of program/project resources (including budget) and financial management associated with the program/project content over the program's budget horizon, conducted by an impartial body independent from the management or advocacy chain of the program/project. ICA includes, but is not limited to, the assessment of cost estimates, budgets, and schedules in relation to a program/project and a program's constituent projects' technical content, performance and risk. ICAs may include Independent Cost Estimates (ICE) assessment of resource management, distribution, and planning, and verification of cost-estimating methodologies. (ICAs are not life cycle cost estimates but are assessments of the budget and management practices to accomplish the work scope through the budget horizon; as such, ICAs can be performed for programs/projects when a life cycle ICE is not warranted.)

Independent Cost Estimate (ICE). An independent program/project cost estimate prepared by an office or other entity that is not under the supervision, direction, advocacy, or control of the program/project (or its chain of command) that is responsible for carrying out the development or acquisition of the program/project. An ICE is bounded by the program/project scope (total life cycle through all phases), schedule, technical content, risk, ground rules, and assumptions and is conducted with objectivity and the preservation of integrity of the cost estimate. ICEs are generally developed using parametric approaches that are tailored to reflect the design, development state, difficulty, and expertise of team members.

Information System. The term "information system" means a discrete set of information resources organized for the collection, processing, maintenance, use, sharing, dissemination, or disposition of information. Information systems are also referred to as IT systems.

Information Technology (IT). Any equipment, or interconnected system(s) of subsystem(s) of equipment, that is used in the automatic acquisition, storage, analysis, evaluation, manipulation, management, movement, control, display, switching, interchange, transmission, or reception of data or information by the Agency

Insight. Surveillance mode requiring the monitoring of customer-identified metrics and contracted milestones. Insight is a continuum that can range from low intensity, such as reviewing quarterly reports, to high intensity, such as performing surveys and reviews.

Integrated Baseline. The project's technical performance and content, technology application, schedule milestones and budget. The integrated baseline includes the WBS, WBS dictionary, integrated master schedule, preliminary life cycle cost estimate, and workforce estimate, consistent with the program requirements on the project.

Integrated Master Schedule (IMS). An integrated set of schedule data that reflects the total project scope of work as discrete and measureable tasks/milestones that are time phased through the use of task durations, interdependencies, and date constraints and is traceable to the WBS.

The highest level schedule is the Master Schedule supported by Intermediate Level Schedules and by lowest level detail schedules.

International Partners. Foreign Nationals or US citizen representative of foreign governments, who are involved in a particular international program or project under an International Space Act Agreement (ISAA).

International Traffic in Arms Regulations (ITAR). US Export Control Regulations that require limited availability for technical data that pertain to commodities, technology, and software listed on the US Munitions List. NASA STI reports subject to restriction under this regulation are often referred to as ITAR documents.

Investigation. Generally refers to a proposed scientific endeavor involving measurements of Earth characteristics over a period of time and geographic location; can also refer to determination of root cause of unexpected event.

Joint Cost and Schedule Confidence Level (JCL). (1) The probability that cost will be equal to or less than the targeted cost and schedule will be equal to or less than the targeted schedule date. (2) A process and product that helps inform management of the likelihood of a project's programmatic success. (3) A process that combines a project's cost, schedule, and risk into a complete picture. JCL is not a specific methodology (e.g., resource loaded schedule) or a product from a specific tool (e.g., @RISK).

Key Decision Point (KDP). The event at a point in time in the program or project life cycle, usually at the end of a program or project life cycle phase, when the program or project DA makes the decision (or not) to authorize the program or project to transition to its next life cycle phase. Program KDPs are designated with roman numerals, e.g., KDP II, and project KDPs are designated with letters, e.g., KDP B.

Key Performance Parameters (KPP). Quantitative metrics selected by the Project Manager in order to measure the effectiveness of the project in achieving their goals and related mission success criteria.

Knowledge Management. Getting the right information to the right people at the right time without delay while helping people create knowledge and share and act upon information in ways that will measurably improve the performance of NASA and its partners.

Lawful Permanent Resident (LPR). (Replaces the term "Permanent Resident Alien") A non US citizen legally permitted to reside and work within the US and issued the Resident Alien Identification (green card). Afforded all the rights and privileges of a US citizen with the exception of voting, holding public office, employment in the Federal sector (except for specific needs or under temporary appointments), and access to classified national security information.

Legacy. These are usually software products (architecture, code, requirements) written specifically for one project and then, without prior planning during its initial development, found to be useful on other projects.

Lesson Learned. The significant knowledge or understanding gained through past or current programs and projects that is documented and collected to benefit current and future programs and projects.

Liens. Requirements or tasks not satisfied that have to be resolved within a certain assigned time to allow passage through a control gate to proceed.

Life cycle Cost (LCC). The LCC of a project or system can be defined as the total cost of ownership over the project's or system's life cycle from Formulation through Implementation. The total of direct, indirect, recurring, nonrecurring, and other related expenses incurred, or estimated to be incurred, in the design, development, verification, production, deployment, operation, maintenance, support and disposal of a project.

Logistics. The management, engineering activities, and analysis associated with design requirements definition, material procurement and distribution, maintenance, supply replacement, transportation, and disposal that are identified by space flight and ground systems supportability objectives.

Management Baseline. The integrated set of requirements, cost, schedule, technical content, and associated JCL that forms the foundation for program/project execution and reporting done as part of NASA's performance assessment and governance process.

Management Process Requirements. Requirements that focus on how NASA does business that are independent of the particular program or project. There are four types: engineering, program/project management, safety and mission assurance, and Mission Support Office functional requirements.

Margin of Safety. Deviation of the actual (operating) factor of safety from the specified factor of safety. Can be expressed as a magnitude or percentage relative to the specified factor of safety.

Margin. The allowances carried in budget, projected schedules, and technical performance parameters (e.g. weight, power, or memory) to account for uncertainties and risks. Margin allocations are baselined in the formulation process based on assessments of risk, and are typically consumed as the program/project proceeds through the life cycle.

Metric. A measurement taken over a period of time that communicates vital information about the status or performance of a system, process, or activity. A metric should drive appropriate action.

Milestone. An event of particular significance. Finitely defined events that constitute the start or completion of a task or occurrence of an objective criterion for accomplishment. Milestones should be discretely identifiable, the passage of time alone is not sufficient to constitute a milestone. However, milestones should be associated with schedule data to document when the milestone is to occur.

Mission Assurance. Providing increased confidence that applicable requirements, processes, and standards for the mission are being fulfilled.

Mission Critical. Item or function that must retain its operational capability to assure no mission failure (i.e., for mission success).

Mission Directorate Program Management Council. The senior management group, chaired by a MDAA or designee, responsible for reviewing project formulation performance, recommending approval, and overseeing implementation of Category 2 and 3 projects according to agency commitments, priorities and policies.

Mission Failure. A mishap of whatever intrinsic severity that prevents the achievement of the mission's minimum success criteria or minimum mission objectives as described in the mission operations report or equivalent document.

Mission Manager. Member of the Program Office staff responsible for ensuring Program Office support for each ESSP constituent Project. Specifically, this includes establishing and maintaining effective working relations with the Projects, leading the analysis of Project performance and leading the analysis of mission implementation processes.

Mission Operations. All activities executed by the spacecraft; includes design mission, prime mission, secondary mission, extended mission, and disposal.

Mission. A major activity required to accomplish an Agency goal or to effectively pursue a scientific, technological, or engineering opportunity directly related to an Agency goal. Mission needs are independent of any particular system or technological solution. Can also refer to period in project life cycle after beginning flight operations.

NASA Policy Directive (NPD). HQ level document establishing NASA policy.

NASA Procedural Requirement (NPR). HQ level document that defines process requirements.

Network Administrator. A person who manages a local area network (LAN) within an organization. Responsibilities include network security, installing new applications, distributing software upgrades, monitoring daily activity, enforcing licensing agreements, developing a storage management program and providing for routine backups.

New Obligation Authority (NOA). Approval to obligate resources to the level specified.

Noncompliance. A failure to comply with Federal, State, local, Agency and/or Center requirements. A noncompliance could lead to the loss of life or injury to NADSA personnel or the public, loss of or damage to high-value equipment, or reduction of the likelihood of mission success.

Nonconformance. The state or situation of not fulfilling a requirement.

Nonrecord Material. Material such as extra copies of documents and correspondence that are kept only for convenience or reference, stocks of publications and professional documents, personal records, reference items and library or museum material intended solely for reference or exhibition.

Observation. A factor, event, or circumstance identified during the investigation that did not contribute to the mishap or close call, but, if left uncorrected, has the potential to cause a mishap or increase the severity of a mishap; or a factor, event, or circumstance that is positive and should be noted.

Office of Record. An office designated as the official custodian of records for a specified program, activity, or transaction of an organization. Under functional or decentralized filing plans, the Office of Record is usually the office which created the record or initiated the action on an incoming record, unless otherwise designated. Under centralized filing, the central file(s) are designated or become the Office of Record.

Operability. As applied to a system, subsystem, component, or device is the capability of performing its specified function (s) including the capability of performing its related support function (s).

Orbital Debris. Any object placed in space by humans that remains in orbit and no longer serves any useful function. Objects range from spacecraft to spent launch vehicle stages to components and also include materials, trash, refuse, fragments, and other objects which are overtly or inadvertently cast off or generated.

Other Interested Parties (Stakeholders). A subset of "stakeholders'" other interested parties are groups or individuals who are not customers of a planned technical effort but may be affected by the resulting product, the manner in which the product is realized or used, or have a responsibility for providing life cycle support services.

Outcome. Outcomes are multiyear performance measures of NASA's progress toward achieving longer-term strategic objectives and strategic goals. Performance on an outcome is determined by weighing the performance of associated annual performance goals against management's timeline for achieving the outcome.

Oversight/Insight. The transition in NASA from a strict compliance-oriented style of management to one which empowers line managers, supervisors, and employees to develop better solutions and processes. To monitor actively the implementation of assigned actions, policy and procedures. HQ officials with an oversight role have the responsibility to establish and track performance parameters to ensure assignees are properly implementing their actions, policies, and procedures.

Passivation. The process of removing all forms of stored energy from spacecraft, launch vehicle stages, and propulsion units. Passivation includes, but is not limited to, the depletion of all residual propellants, pressurants, electrical storage devices, and forms of kinetic energy to a level where the remaining internal stored energy is insufficient to cause breakup/disassembly. Some sealed batteries and heat pipes need not be depressurized if their potential for explosion is extremely low.

Peer-Review. Independent evaluation by internal or external subject matter experts who do not have a vested interest in the work product under review. Peer reviews can be planned focused reviews, conducted on selected work products by the producer's peers to identify defects and issues prior to that work product moving into a milestone review or approval cycle.

Performance Budget. A budget that clearly links performance goals with costs for achieving a target level of performance. In general, a performance budget links strategic goals with related long term and annual performance goals (outcomes) with the costs of specific activities to influence these outcomes about which budget decisions are made.

Performance Goal. A target level of performance at a specified time or period expressed as a tangible, measurable outcome, against which actual achievement can be compared, including a goal expressed as a quantitative standard value or rate. A performance goal comprises a performance measure with targets and time frames. The distinction between "long term" and "annual" refers to the relative timeframes for achievement of the goals.

Permanent Records. In US government usage, records appraised by NARA as having enduring value because they document the organization and functions of the agency that created or received them, and/or, because they contain significant information on persons, things, problems, programs, projects and conditions with which the agency dealt. These records are valuable or unique in that they document the history of the Agency and generally record prime missions, functions, responsibilities and significant experiences or accomplishments of the agency.

Post mission Disposal. The orbit/location where a spacecraft/launch vehicle is left after passivation at EOM.

Precursor. An occurrence of one or more events that have significant failure or risk implications.

Preliminary (Document Context). Implies that the product has received initial review in accordance with Center best practices. The content is considered correct, though some TBDs may remain. All approvals required by Center policies and procedures have been obtained. Major changes are expected.

Principal Investigator (PI). A person who conceives an investigation and is responsible for carrying it out and reporting its results. In some cases, PIs from industry and academia act as project managers for smaller development efforts with NASA personnel providing oversight.

Probabilistic Risk Assessment (PRA). A systematic, logical, and comprehensive tool to assess risk (likelihood of unwanted consequences) for the purpose of 1) characterizing and improving system performance and mission success; 2) increasing safety in design, operation and upgrade, and 3) saving money in design, manufacturing or assembly, and operation.

Process. A set of activities used to convert inputs into desired outputs to generate expected outcomes and satisfy a purpose.

Procurement Strategy Meeting (PSM). A forum where management reviews and approves the approach for the Agency's major and other selected procurements. Chaired by the Assistant Administrator of Procurement (or designee), the PSM addresses and documents information, activities, and decisions from the ASP and ASM strategic procurement meetings to insure the alignment of individual procurement action with NASA's portfolio and mission. Detailed PSM requirements and processes, prescribed by the FAR and NFS and formulated by the Office of Procurement, ensure the alignment of portfolio, mission acquisition and subsequent procurement decisions.

Program (Project) Team. All participants in program (project) formulation and implementation. This includes all direct reports and others that support meeting program (project) responsibilities.

Program Commitment Agreement. The contract between the Associate Administrator and the responsible MDAA that authorizes transition from formulation to implementation of a program.

Program Management Council (PMC). One of the hierarchy of forums composed of senior management that assesses program or project planning and implementation, and provides oversight and direction as appropriate. These are established at the Agency or Mission directorate levels.

Program Plan. The document that establishes the Programs' baseline for implementation, signed by the MDAA and Center Director(s).

Program. A strategic investment by a Mission Directorate or Mission Support Office that has a defined architecture and/or technical approach, requirements, funding level, and a management structure that initiates and directs one or more projects. A program defines a strategic direction that the Agency has identified as critical.

Program/Project Management Requirements. Requirements that focus on how NASA and Centers perform program and project management activities.

Program-Level Requirements Appendix (PLRA). The document that establishes the baseline for project implementation, including the Level 1 requirements as well as the agreements among the Program Executive, Program Scientist, cognizant SMD Division Director, managing Center Director, implementing Center Director, and Program Manager. This document is an appendix to the Program Plan under whose management authority it reports at the NASA Center.

Programmatic Authority. Programmatic Authority includes of the Mission Directorates and their respective program and project managers. Individuals in these organizations are the official voices for their respective areas. Programmatic Authority sets, oversees, and ensures conformance to applicable programmatic requirements.

Programmatic Requirement. Requirements set by the mission directorate, program, project, and PI, if applicable. These include strategic scientific and exploration requirements, system performance requirements, and schedule, cost, and similar nontechnical constraints.

Project Plan. A detailed plan which, when formally approved, sets forth the agreement between a program manager and project managers, and defines the guidelines and constraints under which the project will be executed.

Project. A specific investment identified in a *Program Plan* having defined requirements, a life cycle cost, a beginning, and an end. A project yields new or revised products that directly address NASA's strategic needs. Can also refer to time in project life cycle after proposal selection and before beginning flight operations.

Quality Assurance. An independent assessment needed to have confidence that the system actually produced and delivered is in accordance with its functional, performance and design requirements.

Recommendation. An action developed by the investigating authority to correct the cause or a deficiency identified during the investigation.

Redundancy. Use of more than one independent means to accomplish a given function.

Reliability Analysis. An evaluation of reliability of a system or portion thereof. Such analysis usually employs mathematical modeling, directly applicable results of tests on system hardware, estimated reliability figures, and non-statistical engineering estimates to ensure that all known potential sources of unreliability have been evaluated.

Reliability. The measure of the degree to which a system ensures mission success by functioning properly over its intended life. It has a low and acceptable probability of failure, achieved through simplicity, proper design, and proper application of reliable parts and materials. In addition to long life, a reliable system is robust and fault tolerant.

Reserves. Resources (funding, schedule, performance, manpower, and services) held back by a manager, which can be allocated for expansion, unforeseen events, or other adjustments when they occur.

Resource Loading. The process of recording resource requirements for a schedule task/activity or a group of tasks/activities.

Risk Analysis. An evaluation of all identified risks to estimate the likelihood of occurrence, consequence of impact, timeframe of expected occurrence or when mitigation actions

Risk Assessment. An evaluation of a risk item that determines (1) what can go wrong, (2) how likely is it to occur, (3) what the consequences are, and (4) what are the uncertainties associated with the likelihood and consequences.

Risk Classification. 1) The process of grouping risks into high, moderate, and low categories based on the likelihood and consequence adjective ratings. High, moderate, and low risks are represented by colors red, yellow, and green, respectively. 2) The process of grouping risks based on shared characteristics or relationships among risks. Classification helps to identify duplicate risks and supports simplifying the list of risks. Affinity grouping is a form of risk classification.

Risk Control. An activity that utilizes the status and tracking information to make a decision about a risk mitigation effort. A risk may be accepted, watched, researched, mitigated, or closed. A mitigation action may be re-planned or a contingency plan may be invoked. Decisions on the appropriate resources needed are also determined during this risk control activity.

Risk Exposure. The product of Likelihood (Probability) and Consequence (Impact) components of a risk used to prioritize risk to a program. (Risk Exposure=Probability x Impact)

Risk Identification. A continuous effort to capture, acknowledge and document risks as they are identified.

Risk Management. Risk management includes risk-informed decision making and continuous risk management in an integrated framework. This is done in order to foster proactive risk management, to better inform decision making through better use of risk information, and then to more effectively manage implementation risks by focusing the CRM process on the baseline performance requirements emerging from the RIDM process. (See NPR 8000.4).

Risk Mitigation Plan. A formal plan developed to eliminate or reduce a risk's exposure by either reducing its likelihood of occurrence and/or its impact. A Risk management Database (RMD) will be used to enter the risk mitigation plan. The plan should also identify a fallback plan to identify specific action to be taken if the Risk Mitigation Plan is not effective.

Risk Mitigation. The elimination or reduction of an identified risk by reducing the consequences, by reducing the likelihood, or by shifting the timeframe.

Risk Owner. An individual assigned by the program through the RMB to implement action/mitigation plans and activities needed to close or accept a specific risk with the authority and resources to action on a preapproved plan. The individual designated as the lead for overseeing the implementation of the agreed disposition of that risk.

Risk Review Board. Formally established groups of people assigned specifically to review risk information. Their output is twofold: (1) to improve the management of risk in the area being reviewed and (2) to serve as an input to decision-making bodies in need of risk information.

Risk Tracking. An activity to capture, compile, and report risk attributes and metrics that determine whether or not risks are being mitigated effectively and whether risk mitigation plans are being implemented correctly.

Risk. The combination of the probability that a program or project will experience an undesired event and the consequences, impact, or severity of the undesired event, was it to occur. The undesired event may come from technical or programmatic sources (e.g., a cost overrun, schedule slippage, safety mishap, health problem, malicious activities, environmental impact, failure to achieve a needed scientific or technological objective, or success criterion). Both the probability and consequences may have associated uncertainties.

Risk-Based Acquisition Management. The integration of risk management into the NASA Acquisition Process

Risk-Informed Decision Analysis Process. A five-step process focusing first on objectives and next on developing decision alternatives with those objectives clearly in mind and/or using decision alternatives that have been developed under other systems engineering processes. The later steps of the process interrelate heavily with the Technical risk Management Process.

Risk-Informed Decision Making (RIDM). A risk-informed decision making process uses a diverse set of performance measures (some of which are risk-based risk metrics)) along with other considerations without a deliberative process to inform decision making.

Root Cause Analysis. A structured evaluation method that identifies the root causes for an undesired outcome and the actions adequate to prevent recurrence. Root cause analysis should continue until organizational factors have been identified or until data are exhausted.

Safety and Mission Assurance Requirements. Requirements defined by the SMA organization related to safety and mission assurance.

Safety Critical. Term describing any condition, event, operation, process, equipment, or system that could cause or lead to severe injury, major damage, or mission failure if performed or built improperly, or allowed to remain uncorrected.

Safety. Freedom from those conditions that can cause death, injury, occupational illness, damage to or loss of equipment or property, or damage to the environment.

Schedule Logic Network. A schedule format in which tasks/activities and milestones are represented along with their relevant interdependencies, constraints, and durations. It expresses the logic as to how the work scope will be accomplished. Logic network schedules are the basis for critical path analysis, which is a method for identification and assessment of schedule priorities and impacts.

Schedule Risk Assessment (SRA). The process of performing a probabilistic risk assessment on a project schedule. This type of schedule assessment is based on using Monte Carlo simulations that incorporate minimum, maximum, and most likely estimates for task durations.

Scientific and Technical Information (STI). NASA STI is defined as the results (facts, analyses, and conclusions) of the Agency's basic and applied scientific, technical, and related engineering research and development. STI also includes management, industrial and economic information relevant to this research. Examples include, but are not limited to, technical papers and reports, journal articles, meeting, workshop and conference papers and presentations, conference proceedings, preliminary or non-published STI, including any of these examples that will be posted to a public website.

Scientific and Technical Information-Formal. Scientific and technical information intended for publication in the NASA STI Report Series (e.g., Technical Memorandum, conference Publication) or as a professional journal article or presentation for which the NASA STI Program maintains responsibility for dissemination and preservation.

Scientific and Technical Information-Informal. Scientific and technical information not intended for initial publication in the NASA STI Report Series or as a professional journal article or presentation for which the NASA STI Program maintains responsibility for dissemination and preservation.

Security. Protection of people, property, and information assets owned by NASA, which covers physical assets, personnel, IT, communications, and operations.

Sensitive But Unclassified (SBU). Information, data, or systems that require protection due to the risk and magnitude of the harm or loss that could result from unauthorized disclosure, alteration, loss or destruction but has not been designated as classified for national security purposes.

Single Failure Point. An independent element of a system (hardware, software, or human) the failure of which would result in loss of objectives, hardware, or crew.

Solicitation. The vehicle by which information is solicited from contractors to let a contract for products or services.

Stakeholder Expectations. A statement of needs, desires, capabilities and wants, that are not expressed as requirements (not expressed as a "shall" statement) is to be referred to as an "expectation". Once the set of expectations from applicable "stakeholders" is collected, analyzed, and converted into a "shall" statement, the expectation becomes a requirement. Expectations can be stated in either qualitative (nonmeasureable) or quantitative (measurable) items. Requirements are always stated in quantitative terms. Expectations can be stated in terms of functions, behaviors, or constraints with respect to the product being engineered or the process used to engineer the product.

Stakeholder. An individual or organization that is materially affected by the outcome of a decision or deliverable but is outside the organization doing the work or making the decision. A group or individual who is affected by or is in some way accountable for the outcome of an undertaking. The term "relevant stakeholder" is a subset of the term "stakeholder" and describes the people identified to contribute to a specific task. There are two main classes of stakeholders (see "Customers" and "Other Interested Parties"

Standing Review Board (SRB). The entity responsible for conducting independent reviews (life cycle and special) of the program/project. The reviews are conducted in accordance with approved ToR and the life cycle requirements per NPR 7120.5 and NPR 7123.1. The SRB is advisory and is chartered to objectively assess the material presented by the program/project at a specific review.

Statement of Work (SOW). A document that contains a narrative description of the work scope requirements for a project or contract.

Subject Matter Expert (SME). An individual who possesses in-depth expert knowledge of a program, process, technology, or information sufficient to establish classification caveats or determining the need or appropriateness of an existing national security classification.

Success Criteria. That portion of the top-level requirements that define what must be achieved to successfully satisfy NASA Strategic Plan objectives addressed by the program/project. Specific accomplishments that must be successfully demonstrated to meet the objectives of a technical review so that a technical effort can progress further in the life cycle. Standards against which the program/project will be deemed a success. Success criteria are documented in the corresponding technical review plan. Success criteria may be both qualitative and quantitative, and may cover mission cost, schedule and performance results, as well as actual mission outcomes.

System Administrator. A person who manages a multi-user computer system. Responsibilities are similar to that of a network administrator. A system administrator would perform systems programmer activities with regard to operating system and other network control programs.

System. The combination of elements that function together to produce the capability required to meet a need. The elements include all hardware, software, equipment, facilities, personnel, processes, and procedures needed for this purpose.

Systems Engineering. A disciplined approach for the definition, implementation, integration, and operation of a system (product or service).The emphasis is on achieving stakeholder functional, physical and operational performance requirements in the intended use environments over its planned life within cost and schedule constraints. Systems engineering includes the engineering processes and technical management processes that consider the interface relationships across all elements of the system, other systems, or as a part of a larger system.

Tailoring. The process used to adjust or seek relief from a prescribed requirement to accommodate the needs of a specific task or activity (e.g., program or project). The tailoring process results in the generation of deviations and waivers depending on the timing of the request.

Technical Authority (TA). Technical Authorities are part of NASA's system of checks and balances and provide independent oversight of programs and projects in support of safety and mission success through the selection of individuals at selected levels of authority. These individuals are the Technical authorities. Technical authority delegations are formal and traceable to the Administrator. Individuals with Technical authority are funded independently of a program or project.

Technical Performance Measures. The set of critical or key performance parameters that are monitored by comparing the current actual achievement of the parameters with that anticipated at the current time and on future dates. Used to confirm progress and identify deficiencies that might jeopardize meeting a system requirement. Assessed parameter values that fall outside an expected range around anticipated values indicate a need for evaluation and corrective action. Technical performance measures are typically selected from the defined set of measures of performance.

Technology Readiness Level (TRL). Provides a scale against which to measure the maturity of a technology. TRLs range from 1 (Basic Technology Research) to 9 (Systems Test, Launch, and Operations). Typically, a TRL of 6 (i.e. technology demonstrated in a relevant environment) is required for a technology to be integrated into a Systems Engineering process.

Termination Review. A review initiated by the DA for the purpose of securing a recommendation as to whether to continue or terminate a program or project. Failing to stay within the parameters or levels specified in controlling documents will result in consideration of a termination review.

Terms of Reference (ToR). A document specifying the nature, scope, schedule, and ground rules for an independent review or independent assessment.

Threshold (or Minimum) Science Requirements. The minimum performance requirements necessary to achieve the minimum science acceptable for the investment. In some solicitations used for competed missions, threshold science requirements may be called the “science floor” for the mission. This is the KPP threshold.

Traceability. A discernible association among two or more logical entities such as requirements, system elements, verifications, or tasks.

Validate Risk. The process of examining an identified potential risk to verify that it is a threat to the project and has been written in such a way as to allow further analysis and that mitigation actions are within the scope of the program, project, or task in question.

Validated Requirements. A set of requirements that are well formed (clear and unambiguous), complete (agree with customer and stakeholder needs and expectations), consistent (conflict free), and individually verifiable and traceable to a higher level requirement or goal.

Validation. Proof that the product accomplishes the intended purpose based on stakeholder expectations. May be determined by a combination of test, analysis, demonstration, and inspection. (1) An evaluation technique to support or corroborate safety requirements to ensure necessary functions are complete and traceable; or (2) the process of evaluating software at the end of the software development process to ensure compliance with software requirements.

Variance. In program control terminology, a difference between actual performance and planned cost or schedule status.

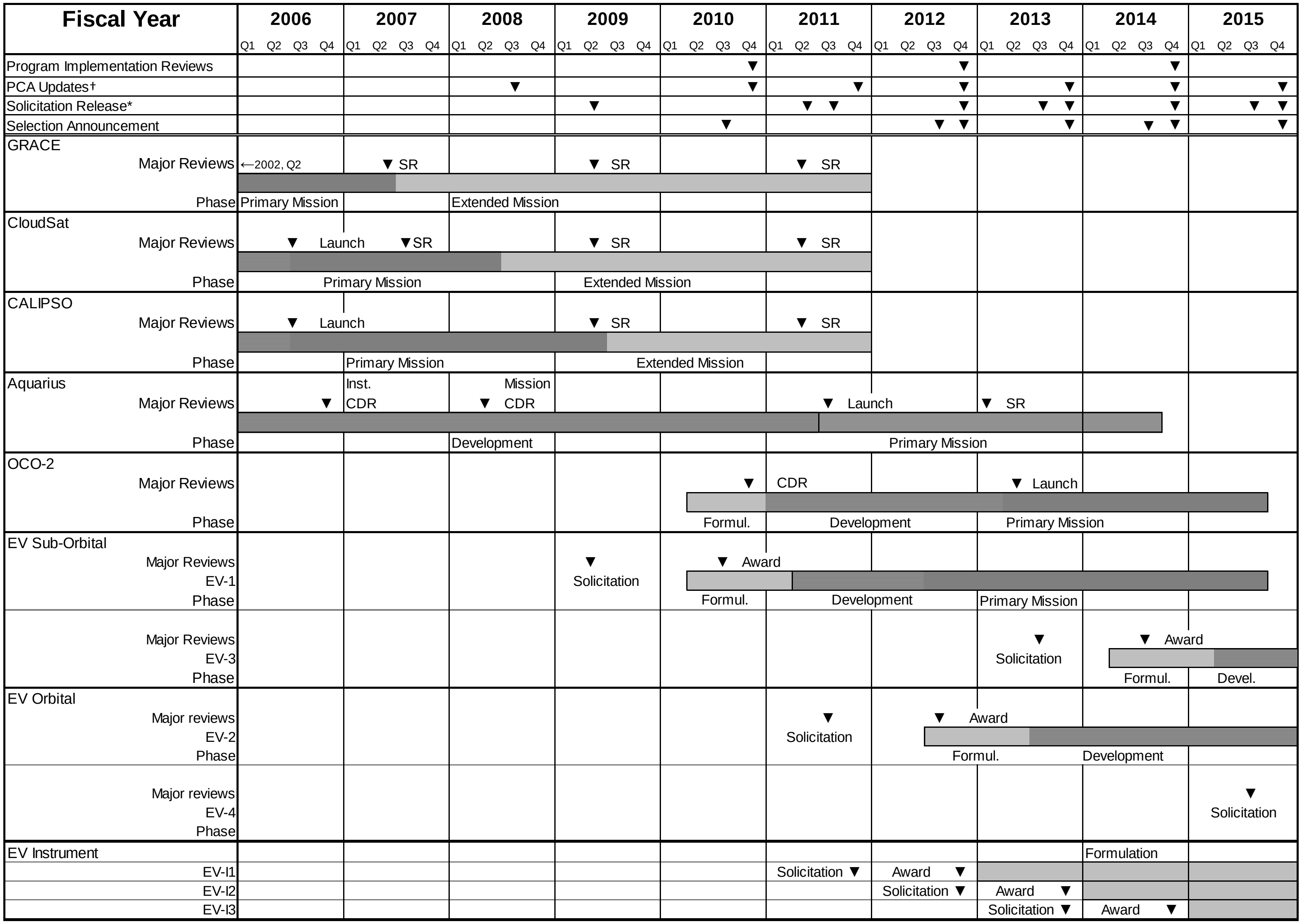
Verification. Proof of compliance with design solution specifications and descriptive documents. May be determined by a combination of test, analysis, demonstration, and inspection. (1) The process of determining whether the products of a given phase of the software development cycle fulfill the requirements established during the previous phase; or (2) formal proof of program correctness; or (3) the act of reviewing, inspecting, testing, checking, auditing, or otherwise establishing and documenting whether items, processes, services, or documents conform to specified requirements.

Waiver. A documented authorization intentionally releasing a program or project from meeting a requirement. (Some Centers use waivers during the life cycle implementation phase, and deviations for the period prior to implementation.

Work Agreement. The Center form (or equivalent), prepared for each program/project cost account and used to document agreements and commitments for the work to be performed, including scope of work, receivables/deliverables, schedule, budget, and assumptions.

Work Breakdown Structure (WBS). A product-oriented hierarchical division of the hardware, software, services, and other tasks that organizes, displays, and defines the products to be developed and or produced and relates the elements of the work to be accomplished to each other and the end product(s). The WBS should reflect the way in which program/project costs, schedule, technical and risk data are to be accumulated, summarized, and reported. The WBS should be accompanied by a text document referred to as a WBS Dictionary that describes the work content of each element of the WBS in detail.

Appendix D ESSP Schedule Baseline



† PCAs are reviewed annually and updated only if significant program changes occur.

* Subject to funding Availability

Appendix E ESSP FY2011 Budget and Workforce Plans

Table E-1: ESSP Budget As Included In the FY 2011 President's Budget Request

$M	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Aquarius	18.3	17.0	5.4	5.2	2.4	4.6
OCO-2	25.0	171.0	91.0	51.0	13.0	4.0
Venture Class Missions	12.9	79.5	75.1	106.9	140.5	185.3
CALIPSO	6.4	6.6	6.6	6.8	7.0	7.2
GRACE	4.8	5.2	4.9	5.0	5.1	5.3
CloudSat	6.7	7.1	7.0	7.2	7.4	7.6
ESSP Program Office	2.6	3.8	4.3	4.4	5.2	5.2
ESSP Program Total $M	76.7	290.2	194.3	186.5	180.6	219.2

Table E-2: ESSP Program PPBE 2011 Workforce Plan

	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
ESSP Program Office FTE	6	10	12	12	12	12

Appendix F ESSP Program-Level Agreements

Type of Agreement	Organizations	Agreement Subject	Approval Date
ITA	ESSP Program Office & DISCOVER-AQ PI	Defines the work to be performed during the EV-1 Project in order to define and establish requirements for all life cycle phases.	7/21/2010
ITA	ESSP Program Office & ATTREX PI	Defines the work to be performed during the EV-1 Project in order to define and establish requirements for all life cycle phases.	7/21/2010
ITA	ESSP Program Office & HS3 PI	Defines the work to be performed during the EV-1 Project in order to define and establish requirements for all life cycle phases.	7/21/2010
Task Plan	ESD & JPL	JPL to perform CARVE requirements development, implementation, and initial flight campaign.	8/26/2010
Task Plan	ESD & JPL	JPL to perform AirMOSS project management activities, requirements development, and design.	8/26/2010
Task Plan	ESD & JPL	JPL to perform CARVE Fourier Transformation Spectrometer procurements, science flight campaigns, and science data analysis	9/15/2010
Task Plan	ESD & JPL	JPL to perform AirMOSS assembly, test, operations, and science analysis.	9/15/2010
NSA	GSFC Robotics System Protection Office & CONAE	GSFC RSPO to perform Conjunction Assessment Risk Analysis using USSTRATCOM data on behalf of CONAE for Aquarius/SAC-D Mission	10/26/2010

Appendix G Gravity Recovery and Climate Experiment (GRACE)

G.1 GRACE DESCRIPTION

GRACE was selected from ESSP AO-1 and comprises twin satellites launched in March 2002. The GRACE satellites are making detailed measurements of Earth's gravity field that are leading to discoveries about gravity and Earth's natural systems. GRACE contributes to:

- Geodesy (defining an improved reference frame for defining position coordinates, better calculation of orbits for geodetic satellites, a more accurate equipotential surface to which land elevations can be referenced)
- Oceanography (enabling a better understanding of ocean currents and mass and heat transport)
- Climate (through ocean interactions, and mass changes in the atmosphere)
- The solid Earth (mass and gravity changes due to subduction zones, post-glacial rebound)
- Glaciology (tracking the changing mass of ice sheets)
- Hydrology (tracking changes in the storage of water on and beneath Earth's surface)
- Other components of the Earth system.

GRACE has completed its primary five-year mission and is currently in an extended mission phase. GRACE underwent Senior Reviews in 2007 and 2009, and is currently extended through FY 2011. GRACE is a joint partnership between the NASA in the United States and Deutsche Forschungsanstalt für Luft und Raumfahrt (DLR) in Germany. The PI is from the University of Texas Center for Space Research (UTCSR). JPL is responsible for project management.

G.2 GRACE LEVEL 1 REQUIREMENTS

Level 1 Requirements for the Gravity Recovery and Climate Experiment (GRACE) Mission

1. SCOPE

This appendix to the Earth Science Enterprise (ESE) Program plans identifies the mission, science and programmatic (funding and schedule) requirements imposed on the University of Texas Center for Space Research (UTCSR) and the Jet Propulsion Laboratory (JPL), having prime responsibility for the development and operations of the Gravity Recovery and Climate Experiment (GRACE) of the Earth System Science Pathfinder Program.

This document serves as the guideline for mission assessments conducted by NASA Headquarters during the Implementation Subprocess and is an aid in the determination of science mission success during mission operations. The Mission Definition and Requirements Agreement (MDRA) under contract NAS5-97213 is the authoritative document for the evaluation of mission success.

Program authority is delegated from the Associate Administrator for the Office of Earth Science (AA/OES) through the Goddard Space Flight Center (GSFC) Center Director to the Earth Probes Program Manager within the Flight Projects Directorate at GSFC.

The Principal Investigator (PI) at UTCSR is responsible for the overall success of the GRACE Mission and is accountable to the AA/OES for the scientific success and to the GSFC Center Director for the programmatic success. The GSFC Program Management Council (PMC) is the governing PMC for the GRACE Mission. The GSFC Center Director is responsible for certifying GRACE flight readiness to the Associate Administrator for Earth Science. The PI at UTCSR is responsible for the JPL effort in the design, development, test, and launch phases of the GRACE Mission, as well as coordinating the efforts of the Co-PI and the co-investigators. On-orbit operations conducted by DLR/GSOC will be responsive to the PI. The PI will use the set of approved co-investigators reflected in the proposal for the scientific investigation and data verification tasks. Any changes to this science team will be coordinated with the ESSP Project Office.

Changes to information or requirements contained in this document require approval by the Office of Earth Science, NASA Headquarters.

2. SCIENCE DEFINITION

2.1 Baseline Science Objectives

The primary goal of the GRACE Mission is to obtain accurate global and high resolution models for both the static and the time variable components of the Earth's gravity field. This goal will be achieved by making accurate measurements of the inter-satellite range and range rate between two co-planar, low altitude and polar orbiting satellites, using a micro-wave tracking system. In addition, each satellite will carry geodetic quality Global Positioning System (GPS) receivers, a laser retro-reflector for satellite laser ranging and high accuracy accelerometers to enable accurate estimation of gravity field models.

The gravity field estimates obtained from data gathered by the GRACE Mission will provide, with unprecedented accuracy, integral constraints on the global mass distribution and its temporal variations. In the oceanographic community, the knowledge of the static geoid, in conjunction with satellite altimeter data, will allow significant advances in the studies of ocean heat flux, long term sea level change, upper oceanic heat content, and the absolute surface geostrophic ocean currents. Further, the estimates of time variations in the gravity field obtained from GRACE, in conjunction with other in-situ data and geophysical models, will help the science community unravel complex processes in oceanography (e.g. deep ocean current change and sea level rise), hydrology (e.g. large scale evapo-transpiration and soil moisture changes), glaciology (e.g. polar and Greenland ice sheet changes), and the solid Earth sciences.

2.2 Science Instrument Summary Description

The GRACE Mission is unique with respect to science instruments. The differential influence of the gravity field is manifested as a difference in the orbital motion of the COM of each GRACE satellite. The distance change, and hence the gravity field variations, must be inferred from the phase change measurements made between the respective antenna phase centers on the two satellites using the K-Band Ranging Instrument. In essence, the two satellites themselves become the instrument.

The High Accuracy Inter-satellite Ranging System (HAIRS) provides measurements of the distance change. In addition, the SuperSTAR Accelerometers are used to measure the non-gravitational accelerations acting on the satellites. The Star Camera Assembly is used to measure satellite orientation. The GPS Turbo-Rogue Receiver and the Instruments Processing Unit (IPU) are used for digital signal processing, as well as measuring the distance change relative to the GPS satellite constellation. The Laser Retro-Reflector Assembly provides measurements of the GRACE satellite orbits relative to terrestrial tracking networks. In addition, the GPS Receiver is also used for secondary atmospheric occultation experiments.

3. PROJECT DEFINITION

3.1 Project Organization & Management

The GRACE Principal Investigator (PI), Prof. Byron Tapley of the University of Texas, Austin Center for Space Research (UTCSR), has established teaming arrangements with a Co-Principal Investigator, Prof. Christoph Reigber of the GeoForschungZentrum (GFZ), Germany; the Deutsche Forschungsanstalt fur Luft und Raumfahrt (DLR), Germany; the Jet Propulsion Laboratory (JPL), Space Systems Loral (SS/L), the Astrium, GmbH, the Applied Physics Laboratory (APL) at Johns Hopkins University, Office National d'Études et de Recherches Aérospatiales (ONERA) and the Langley Research Center (LaRC) to implement the GRACE Mission.

3.2 Project Acquisition Strategy

The PI will have overall responsibility for the total mission, including the instrument, spacecraft, ground system, mission planning and operations, data processing and analysis, and data distribution. Prof. Tapley will be supported by experienced management and engineering teams, which have established close and efficient working relationships. The DLR and GFZ will work under an International Memorandum of Understanding (IMOU) between NASA and DLR in a no-exchange of funds agreement. The DLR/GSOC will provide mission operations. DLR will provide the launch vehicle and launch services. GFZ will provide the German Science Data Systems and the Co-PI who will lead the German science implementation effort and coordinate all elements of the German contributions. JPL provides project management and systems engineering through the launch and early orbit checkout phases. (Astrium GmbH) provides the spacecraft buses and environmental testing under contract to JPL. Space Systems Loral (SS/L) provides the Ka-band ranging system, attitude control algorithms and operations planning support under contract to JPL. ONERA provides the SuperSTAR accelerometer under contract to JPL.

4. PROGRAMMATIC REQUIREMENTS

4.1 Science Requirements

4.1.1 Primary Objectives

The primary goal of the GRACE mission is to provide, with unprecedented accuracy, estimates of the global high-resolution models of the Earth's gravity field for a period of up to 5 years. A temporal sequence of approximately monthly estimates of the gravity field provides the mean (or static) gravity field, as well as a time history of its temporal variability. An additional science objective of the GRACE mission is to provide several hundred globally distributed profiles each day of the excess delay, or bending angle of the GPS measurements due to the ionosphere and the atmosphere, using GPS limb sounding.

During mission operations, the GRACE science data shall be made available to the scientific community in an EOS compatible format, shortly after calibration and validation. The Level-1 data products include line of sight range change between the satellites measured using the K-band ranging instrument, the non-gravitational accelerations measured using the accelerometer, the GPS navigation data, as well as related ancillary data. The Level-2 data products include the coefficients of the geopotential fields, the satellite position and velocity, as well as excess delay and refractivity estimates from GPS limb sounding.

4.1.2 Typical Science Applications

The estimates of the Earth gravity field from GRACE, in conjunction with other space-based measurements, in-situ data and geophysical models, will be used to discriminate time varying changes in the mass of the Earth's dynamical system due to different geophysical processes. Examples include the discrimination of effects due to sea level rise, continental water storage, ice sheet changes and other geophysical phenomena. Additionally, atmospheric model studies will benefit by the recovery of refractivity (and the derived quantities of temperature and water vapor) from the use of GPS limb sounding. Furthermore, limited GPS sounding of the ionosphere beginning at altitudes in the region of 100 km will be available for studying fine ionospheric structure.

As an example, Table 1 summarizes the areas in Earth System Science which will benefit from the geopotential field models estimated using GRACE measurements and other in-situ data and geophysical models. For each scientific application, the principal spatial, and where appropriate, the temporal scales of associated geoid variability are given for which GRACE is expected to have an impact. The accuracy of these determinations will depend on the methods of solution of complex geophysical inverse problems, taking into account not only the GRACE measurement errors but also the errors in the ancillary geophysical model and in-situ data (e.g. atmospheric or ocean tide models).

Table 1 Science Applications Summary

APPLICATION	RESOLUTION	TIME SCALE	COMMENTS
STATIC GRAVITY FIELD			
Oceanic Heat Flux	> 1000 km		
Ocean Currents	> 1000 km		
Solid Earth Sciences	> 300 km		
TIME VARIABLE GRAVITY FIELD			
Oceanic Heat Flux	> 1000 km	Seasonal	30 day estimate
Ocean Bottom Pressure	> 500 km	Seasonal	30 day estimate
Deep Ocean Currents	> 500 km	Seasonal	30 day estimate
Sea Level Rise	> 700 km	Secular	5 year estimate
Evapo-Transpiration	> 300 km	Seasonal	30 day estimate
Greenland/ Antarctic Ice		Secular Seasonal	5 year estimate yearly estimate

4.1.3 Baseline Science Mission Requirements

In the Baseline Science Mission definition, the Earth's geopotential field is characterized by the coefficients of a spherical harmonic expansion. These coefficients will be estimated to degree and order 160 or more for the long term mean part, and to degree and order 100 or less for the time variable part. The temporal variability will be characterized by mean values of the coefficients over 30 days or less. In addition, approximately 200 GPS atmospheric profile soundings per day shall be acquired, subject to data system limitations.

The science data, in conjunction with ancillary data, will be used to obtain estimates of spherical harmonic coefficients of the Earth's gravitational potential. A typical 30 day span of data, collected in a 475 km altitude polar orbit, shall have a global root mean square (rms) geoid height error due to the measurement system errors as specified in Table 2.

Table 2 Geoid Height Error over 30 days

Harmonic Degree	Geoid Height Error Per Degree (mm)	Geoid Height Error Cumulative (from n=3) (mm)
N = 2	< 0.10	--
$3 \le n \le 10$	< 0.01	< 0.02
$10 \le n \le 70$	< 0.15	< 0.40
$70 \le n \le 100$	< 1.50	< 3.50
$100 \le n \le 150$	< 65.0	< 200

4.1.4 Minimum Science Mission Requirements

As a minimum objective for a successful mission, the GRACE measurements shall provide for at least an order of magnitude improvement in the mean global geoid. This improvement in the marine geoid will enhance dramatically the recovery of the general ocean circulation and ocean heat flux from satellite altimetry. Such improvement is a current requirement of both Earth Observation System (EOS) and World Ocean Circulation Experiment (WOCE).

For the Minimum Science Mission, the mean geopotential model will be characterized by a spherical harmonic model to at least degree and order 100. The cumulative contribution to global geoid height error from harmonic coefficients to degree and order 70 shall not exceed 1 cm rms. No atmospheric and ionospheric occultation data products will be available.

4.1.5 Science Measurement Objectives

The data required to realize the science goals are defined in Table 3, which establishes the primary measurement objectives for GRACE.

Table 3 Science Measurement Objectives

Science	Measurement	Instrument	Spacecraft
Earth Gravity Field	Inter-Satellite Range Change	K-Band Ranging m-wave link	2
	Non-Grav. Accelerations	Accelerometer	2
	GPS Tracking Data	GPS Receiver	2
Atmospheric Occultation	GPS-to-GRACE phase change	GPS Receiver	1

4.2 Mission and Spacecraft Performance Requirements

The two GRACE spacecraft shall be designed for a five-year lifetime. The two GRACE satellites shall be in co-planar orbits at approximately 300-500 km altitude, at an inclination of 89 degrees, separated along track by approximately 100-500 km.

The data rates will be up to 20 Mb/day for the gravity field, and 20-40 Mb/day for the occultation experiment. Orbit maneuvers will be required every 30-60 days in order to maintain the separation between the satellites, in addition to the occasional calibration and altitude make-up maneuvers.

4.3 Launch Requirements

The GRACE Mission is planned to launch in November 2001 from the Plesetsk Cosmodrome in Russia. There is no science window for the GRACE Mission.

The GRACE spacecraft will be launched into a near 500 km circular orbit at an inclination of 89 degrees.

4.4 Ground Systems Requirements

The GRACE Mission Operations System shall be capable of acquiring and processing an average of at least 50 Mbytes of science and housekeeping data per day for each satellite.

4.5 Mission Data Requirements

4.5.1 Science Data Management

The Science Data System (SDS) activities include data processing, verification, distribution, and archiving of science data. The SDS is a distributed entity, with some functions occurring at each of JPL, GFZ and UTCSR. Unification of data and product archives is planned, as well as comparison and validation activities. The PI is responsible for coordinating the development and management of the SDS.

4.5.2 Analysis Software

Science analysis software shall be developed by the GRACE Science Data System Team. The Level-0 data system will be at DLR/GSOC, the Level-1 data system will be at NASA/JPL, and the Level-2 data system will be at UTCSR. A back-up Level-1 and Level-2 data system will be established in files at GFZ.

4.5.3 Data Management Plan

A Mission Operations and Data Management Plan shall be developed to address the flow of science data, from acquisition, through processing, data product generation and validation to archiving and preservation.

4.6 Programmatic Milestones

The following programmatic milestones are planned for the GRACE mission:

Mission Confirmation Review - November, 1998
Mission Readiness Review – Third Quarter, 2001
Launch Readiness Review – Fourth Quarter, 2001
Launch - Fourth Quarter, 2001
Initial Receipt of Data – Second Quarter, 2002
Release of Calibrated Data to Broad User Community – Fourth Quarter, 2002

5. NASA MISSION COST REQUIREMENTS

5.1 Cost Cap

The GRACE Mission shall be undertaken on a "design to cost" basis. The GRACE mission shall be accomplished with a cost to NASA of no more than $93,223,503.

5.2 Cost Management and Scope Reduction

The GRACE Mission has undergone extensive studies during Phase B and developed comprehensive risk mitigation strategies for key technical and programmatic risk items. In addition, the PI and PM have built an acceptable cost reserve pool to be used, when needed, to preserve the Baseline Science Mission. Use of this cost reserve is at the discretion of the PI, without further NASA approval. Should it become necessary to descope the Baseline Science Mission, the PI and his mission team will consult with the ESSP Project Office and NASA Headquarters before implementation. The Risk Management Plan and Descope Plan are fully described in the GRACE Cooperative Project Plan.

6. MULTI-MISSION NASA FACILITIES

The GRACE Mission will utilize the PODAAC at JPL or another acceptable archive for science data archiving, as well as several NASA ground stations for launch, early orbit and contingency operations support.

7. EXTERNAL AGREEMENTS

The DLR and GFZ are working on the GRACE Mission under the auspices of an International Memorandum of Understanding between NASA and the DLR. Both the DLR and GFZ confirmed that all necessary funds and resources have been committed for the GRACE Mission.

8. PUBLIC OUTREACH AND EDUCATION

The GRACE Mission has developed and shall execute an Education and Public Outreach Plan. The outreach efforts are coordinated by the Texas Space Grant Consortium (TSGC).

9. SPECIAL INDEPENDENT EVALUATION

The GRACE Mission has successfully completed the Mission Design Review and Mission Confirmation Review. Both of these reviews were staffed with reviewers independent of the GRACE Mission. The GRACE Systems Review Plan includes several independent reviews throughout the Implementation Subprocess.

10. TAILORING

The GRACE Cooperative Project Plan (GRACE Project 327-100) details all tailoring of NPG 7120.5.

11. REQUIRED APPROVALS

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Byron Tapley
GRACE Principal Investigator
University of Texas Center for Space Research

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Richard J. Fitzgerald
GRACE Mission Manager
Goddard Space Flight Center

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Nicholas Chrissotimos
Project Manager
Earth System Science Pathfinder
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Nicholas Chrissotimos
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John Campbell
Director
Flight Programs and Projects Directorate
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Center Director
Goddard Space Flight Center

____

Dr. Ghassem Asrar
Associate Administrator for Earth Science
NASA Headquarters

G.3 GRACE 2009 SENIOR REVIEW

National Aeronautics and
Space Administration
Headquarters
Washington, DC 20546-0001

SEP - 1 2009

Reply to Attn of: SMD/Earth Science Division

TO: University of Texas/GRACE Principal Investigator
Jet Propulsion Laboratory/GRACE Project Manager

FROM: Director for Earth Science

SUBJECT: Results from the 2009 Senior Review of Earth Science Operating Missions

This letter provides programmatic direction for the Gravity Recovery and Climate Experiment (GRACE) mission for Fiscal Years (FY) 2010-2013, based on the findings of the 2009 Earth Science Division (ESD) Senior Review. To complete the Senior Review process, you must develop a plan responsive to the directions of this letter, and forward it to ESD/Cheryl Yuhas by COB on September 30, 2009, for review, possible modification and final acceptance.

The ESD Senior Review consisted of a series of comprehensive reviews of the missions' science quality, operational utility, and continued engineering performance of both spacecraft and instrument. A full description of the evaluation process, the factors used by the review panels, and their findings for all missions, may be found in the Senior Review Final Report, located at URL http://nasascience.nasa.gov/earth-science/mission_list.

The review panels' findings for the GRACE mission are:

Science Value	Outstanding
Operational and Applied Utility	Very High
Technical & Cost Risk	Medium

(As noted in the 2009 Senior Review Call Letter, Education and Public Outreach (E/PO) is being considered separately from the Senior Review.)

The Science Panel recognized that the GRACE science mission has demonstrated significant technological and new scientific achievements. GRACE provides a unique measure of Earth's temporal gravity field, which includes climate-change signals. No other current satellite provides this type of measurement. The scientific achievement is truly cross-disciplinary, covering a broad range of NASA's Earth Science priority areas, including climate change, terrestrial water storage including groundwater variability, cryospheric changes, ocean circulation and sea level, and geodynamics. Although the National Interests Panel rated GRACE as "Very High Utility," primarily due to its critical contribution to the National Vertical Datum effort, the Science Panel believes additional applications science would be both possible and valuable, and supports the proposed new low-latency data product to satisfy hydrologic community requirements. The Technical and Cost Panel rated the mission extension as "Medium Risk," based on the loss of redundancy in several components, but also on the programmatic dependency on the international partner to operate the satellite.

I have used the panel's assessment in formulating the mission programmatic directions for the FY 2010-2013 period. These new guidelines, together with the scope of activities defined in this letter, constitute the new project level one requirements for the extended mission.

Your response to this direction should be in the form of a letter; the letter should include your project's response to the technical guidance below, a discussion of the Science Panel's assessment of your proposal's weaknesses, your project's plans to address those weaknesses, and the budget breakdown using the attached template.

General direction to all projects for E/PO and for efficiency metric reporting will come separately; your responses to these separate directions must be consistent with your response to the guidance in this letter. Dr. Ming-Ying Wei will be issuing the E/PO call simultaneously with this letter; efficiency metric reporting will be handled via e-mail from Cheryl Yuhas and Jennifer Kearns.

All missions are requested to provide an updated End of Mission Plan to ESD by March 30, 2010. End of Mission Plans must be compliant with NASA policies NPR 8715.6a and NPD 8010.3B, and are expected to follow the standards specified in NASA-STD 8719.14.

Specific guidance for the GRACE mission is as follows:
The GRACE Project is directed to implement mission extension for FY2010-2013 in accordance with its optimal proposal, that is, derive regional mascon solutions and conduct mutual validation of regional and global solutions with external investigators. The GRACE Science Team is encouraged to explore additional applications science, and to foster its international partnership.

Funding Direction
Funding guidelines for the GRACE mission are below. These numbers are in real year dollars and represent the new Headquarters guidance for the sum of the traditional mission operations and core data analysis lines.

FY 2010	FY 2011	FY 2012	FY 2013
$5,135,000	$5,239,000	$4,855,000	$4,973,000

Your plan to meet these guidelines, including addressing any specific comments or redirection raised in this letter, should include a cost breakdown in the formats supplied in the attached budget template. While these guidelines are at the top mission level, it is my expectation that the distribution by Center/Workforce Breakdown Structure will be roughly equivalent to the allocations presented in the proposal.

It is our intention that the guidelines provided are the funds that will be made available to you in FY 2010 and FY 2011, but we note that changes in available resources and the requirements placed on us require revisiting budget allocations annually, or more frequently as circumstances warrant. If for some reason we believe that the resources to be available will differ from those indicated above, we will let you know as soon as we can. Guidelines for FY 2012 and FY 2013 should be considered preliminary, to be revisited during the 2011 ESD Senior Review.

I congratulate you and your team on the positive review results, and look forward to your response on September 30, 2009. Any questions may be directed to Ms Cheryl Yuhas, 202-358-0758, Cheryl.L.Yuhas@nasa.gov.

Michael Freilich

cc:

NASA HQ/J.Kaye

- J. Labrecque
- S. Volz
- C. Yuhas
- M. Wei

LaRC/E. Grigsby

JPL/D. Evans

- J. Graf
- M .Watkins
- M .Fujishin
- D. Vane

Appendix H Cloud Aerosol LIDAR and Infrared Pathfinder Satellite Observations (CALIPSO)

H.1 CALIPSO DESCRIPTION

The CALIPSO mission is the culmination of a decade-long and continuing collaboration between NASA and the French Space Agency Centre National d'Études Spatiales (CNES). Since launch on April 28, 2006, CALIPSO has been providing nearly continuous measurements of the vertical structure and optical properties of clouds and aerosols in the Earth's atmosphere. These measurements provide new information and unique insights that will improve our understanding of the distribution and properties of clouds and aerosols, and markedly improve the performance of a variety of models ranging from regional chemical transport and weather forecast models to global circulation models used for climate prediction. The CALIPSO instrument suite consists of a two-wavelength polarization–sensitive LIDAR, a three-channel infrared imaging radiometer, and a single channel wide-field-of-view camera. CALIPSO maintains formation with other spacecraft in the A-Train satellite constellation and provides complementary, near-simultaneous, observations with the other active and passive instruments in the A-Train. CALIPSO has completed its nominal 3-year mission and is currently in its extended mission phase through FY 2011. The PI is from LaRC, and LaRC is responsible for project management.

H.2 CALIPSO LEVEL 1 REQUIREMENTS

LEVEL I REQUIREMENTS

for the

CALIPSO MISSION

June 18, 2002

Revision A
March 12, 2005

Document Revision Record

Revision	Date	Description of Change	Approved By
A	2005/03/12	Title Page: Added Revision A and generation date Section 1.1:Changed references to Earth Science Enterprise to the Science Mission Directorate. Section 2.1: Changed the total cost of the mission from $151M to $199M. This includes two separate replans, one for the increase in the Spring of 2004, from $151M to $186.6M, and the second in the Spring of 2005, to $199M. The first increase also included adjustments required to convert to full cost accounting. Section 2.2: Changed the "Launch Readiness Date from 04/04 to Summer 2005. Section 2.2: Changed the Distribution of Cal/Val Data from 12/05 to Spring 2007. Section 3.1, Table 1: Deleted the two data products for Surface LW fluxes and Atmospheric LW fluxes. These products required the delivery of CERES data products to CALIPSO. Earth science R&A budget reductions eliminated the incoming CERES analyses, and the CALIPSO project could not accommodate the increase. Section 3.3: Changed the launch ready date from April 2004 to Summer 2005. Section 3.6: Added mission success criteria. Section 5: Changed Ghassem Asrar to Alphonso Diaz as the responsible AA, and replaced references to the Earth Science directorate to the Science Mission Directorate	
	2005/05/25	Section 2.2: Added a distribution of calibrated level 1b and level 2a data products by Launch + 180 days to the requirements.	

LEVEL I REQUIREMENTS
FOR THE
CALIPSO MISSION

1. OVERVIEW

1.1 SCOPE

This document identifies the mission, science and programmatic requirements imposed on CALIPSO mission. This document establishes Headquarters' requirements for the implementing center. It serves as the basis for mission assessments conducted by NASA Headquarters during the Implementation Subprocess and provides the baseline for the determination of science mission success during mission operations.

Changes to the requirements specified in this document must be made through the following methods:

- Changes to scientific/technical/cost content require Science Mission Directorate (SMD) Directorate Program Management Council (DPMC) approval.
- Changes to cost requirements may be handled as a part of the POP process.
- Changes to the baseline launch readiness date require SMD DPMC approval and a letter of direction from the Associate Administrator for the Science Mission Directorate (AA/SMD).

Program authority is delegated from the Associate Administrator for Science Mission Directorate (AA/SMD) through the Goddard Space Flight Center (GSFC) Center Director to the Earth Explorers Program Manager for the successful implementation of the mission.

1.2 PROJECT DEFINITION

CALIPSO is a satellite mission designed to provide global measurements of aerosols and clouds required for better understanding of their role in the climate system and to improve our ability to predict long-term climate change and seasonal-to-interannual climate variability.

1.3 SCIENCE OBJECTIVES

The primary science goal of CALIPSO is to acquire a global set of aerosol and cloud observations over a period of three years which, by themselves and in combination with coincident observations from the Aqua and CloudSat platforms, will allow significant advances in our understanding of the role of aerosols and clouds in the climate system. The mission has defined four primary science objectives and one secondary science objective.

- Provide a global suite of measurements from which the first observationally based estimates of direct aerosol forcing, and its certainty, can be made.
- Enable the first global observationally-based assessment of indirect aerosol radiative forcing.
- Improve the accuracy of satellite estimates of longwave radiative fluxes at the surface of the Earth and longwave heating rates within the atmosphere by a factor of 2.
- Provide a new ability to assess cloud feedback in the climate system, including thin cirrus, polar clouds, and multi-layered cloud systems, all of which are poorly determined by passive radiometers alone.

A secondary objective is to provide a set of simultaneous coincident data with which to validate and improve data retrievals from NASA's Earth Observing System (EOS) Aqua mission.

2 PROGRAM REQUIREMENTS

2.1 BUDGET REQUIREMENTS

The total cost for the CALIPSO mission is $199M, and includes NASA mission development, science, operations, and launch costs.

2.2 SCHEDULE REQUIREMENTS

Milestone	Completion Date
Launch Readiness Date	Summer 2005
Distribution of calibrated level 1b and 2a data products (lidar profiles, IIR and WFC radiances, meteorological profiles, lidar aerosol/cloud browse images and backscatter profiles, aerosol layer and cloud height/thickness)	Launch + 180 days
Distribution of Cal/Val Data	Spring 2007

2.3 EXTERNAL AGREEMENT REQUIREMENTS

In accordance with Article III of the NASA/CNES MOU, and in summary, CNES is responsible for providing science team participation, IIR algorithm development, the PROTEUS platform, satellite engineering, Imaging Infrared Radiometer, payload-to-platform integration and test, the command and control data uplink for the satellite, the satellite operations and control center, and support satellite-to-launch vehicle integration and test.

2.4 MULTI-MISSION FACILITIES REQUIREMENTS

The CALIPSO mission will use the LaRC Distributed Active Archive Center (DAAC) for data processing, archive and distribution. Funding for data processing and archive activities is included in the CALIPSO budget.

2.5 CONSTRAINTS

N/A

3. PERFORMANCE REQUIREMENTS

3.1 MISSION REQUIREMENTS

The science objectives will be achieved by flying the lidar, the Imaging Infrared Radiometer (IIR), and a wide field camera (WFC) in formation with Aqua for a three-year mission life. Science requirements can still be met if the IIR and/or WFC are operated discontinuously during the third year of the on-orbit mission to meet power constraints, if required.

The CALIPSO orbit requirements of 705 km altitude with a 1:30 pm equator crossing time are derived from the science requirement for coincident measurements with Aqua and the Aqua orbit. Constellation flying with Aqua will be implemented to ensure science objectives are met, and to ensure safe operations with Aqua and other missions in the proposed Aqua train.

The science data products and associated measurement uncertainties required to realize the mission objectives are defined in Table 1.

Table 1. Science Products and Uncertainties

Data Product	Measurement Capabilities and Uncertainties
Aerosols	
Height, thickness	For layers with $\tau > 0.005$
τ, σ (z)	40%**
Clouds	
Height	For layers with $\tau > 0.01$
Thickness	For layers with $\tau < 5$
τ, σ (z)	Within a factor of 2 for $\tau < 5$
Ice/water phase	Layer by layer
Ice cloud emissivity, ε	$\pm$0.03
Ice particle size	$\pm$50% for $\varepsilon > 0.2$
τ - optical depth σ (z) – profile of extinction cross-section **assumes 30% uncertainty in backscatter-to-extinction ratio	

3.2 INSTRUMENT INFORMATION

The CALIPSO instrument suite and measurements required to achieve the science baseline objectives are described below:

- The lidar acquires vertical profiles of elastic backscatter at 532 and 1064 nm from a near nadir viewing geometry during day and night segments of the orbit. Two orthogonal polarization components (parallel and perpendicular to polarization plane of the transmitted beam) are measured at 532 nm. The lidar profiles provide information on the vertical distributions of aerosols and clouds, cloud particle phase (via the ratio of signals in the two orthogonal polarization channels at 532 nm), and classification of aerosol size (via wavelength dependence of backscatter).
- The IIR provides medium spatial resolution, nadir-viewing images at 8.65 μm, 10.6 μm, and 12.05 μm. The IIR operates continuously, night and day, providing information on cirrus cloud particle size and infrared emissivity, and allows nighttime verification of the co-registration of CALIPSO observations with those of Aqua.
- The WFC is a digital camera that collects high spatial resolution imagery in the 620-nm to 670-nm wavelength range during the daylight segments of orbit. The WFC spectral band is matched to MODIS channel 1. WFC data will be used for ascertaining cloud homogeneity to provide overall meteorological context, and to aid IIR retrievals. Also, the WFC images will be used for highly accurate daytime co-registration of CALIPSO observations with those of Aqua.

3.3 LAUNCH REQUIREMENTS

CALIPSO shall be launch-ready in Summer 2005 in a dual launch configuration with the CloudSat satellite. The launch vehicle will be the Boeing Delta II 7420-10C launch vehicle with a Dual Payload Attach Fitting (DPAF) with CALIPSO in the upper berth. CALIPSO and CloudSat shall be launched from Vandenberg Air Force Base (VAFB) in California.

3.4 MISSION OPERATIONS REQUIREMENTS

The CALIPSO satellite and ground systems shall be designed for a three-year on-orbit lifetime.

3.5 SCIENCE DATA SYSTEM REQUIREMENTS

CALIPSO shall use the LaRC DAAC to perform science Standard Products data processing, distribution, and archive.

3.6 MISSION SUCCESS CRITERIA

Success for CALIPSO is defined as a significant improvement over our current knowledge of the global characteristics of multi-layer cloud structure and the vertical distribution of aerosols. CALIPSO observations will produce:

1) The first high resolution (60 m) global profiles of clouds and aerosols with a backscatter sensitivity of at least 1 x 10^{-3}/km/sr at 532 nm.
2) The first global high resolution (60 m) profiles of cloud ice/water phase.
3) A comprehensive data set including seasonal cloud and aerosol properties to be acquired over periods including 3 months each during summer and winter (Jun-Aug and Dec-Feb), and 2 additional months (April, October) in the spring and the fall.

As CALIPSO will be flying as part of the A-train, all measurements are expected to be coincident with other A-train satellite observations for the data to be available for processing and modeling efforts outside of the CALIPSO project.

4. PUBLIC OUTREACH AND EDUCATION REQUIREMENTS

The CALIPSO project shall develop and execute an Education and Public Outreach Plan. Activities will focus on communicating the CALIPSO mission and scientific results through informal and formal venues. These activities will include creation of CALIPSO content materials, development of education programs that amplify the efforts of CALIPSO and stimulate broad awareness and understanding, and the identification of new applications required to incorporate the rewards of CALIPSO into the fabric of our everyday life.

5. APPROVAL

Original signed by G. Asrar for A. Diaz

A. V. Diaz
Associate Administrator for
Science Mission Directorate

H.3 CALIPSO 2009 SENIOR REVIEW

National Aeronautics and
Space Administration
Headquarters
Washington, DC 20546-0001

SEP - 1 2009

Reply to Attn of: SMD/Earth Science Division

TO: Langley Research Center/CALIPSO Principal Investigator
Langley Research Center/CALIPSO Project Scientist

FROM: Director for Earth Science

SUBJECT: Results from the 2009 Senior Review of Earth Science Operating Missions

This letter provides programmatic direction for the CALIPSO mission for Fiscal Years (FY) 2010-2013, based on the findings of the 2009 Earth Science Division (ESD) Senior Review. To complete the Senior Review process, you must develop a plan responsive to the directions of this letter, and forward it to ESD/Cheryl Yuhas by COB on September 30, 2009, for review, possible modification and final acceptance.

The ESD Senior Review consisted of a series of comprehensive reviews of the missions' science quality, operational utility, and continued engineering performance of both spacecraft and instrument. A full description of the evaluation process, the factors used by the review panels, and their findings for all missions, may be found in the Senior Review Final Report, located at URL http://nasascience.nasa.gov/earth-science/mission_list.

The review panels' findings for the CALIPSO mission are:

Science Value	Very Good
Operational and Applied Utility	Some
Technical & Cost Risk	Low

(As noted in the 2009 Senior Review Call Letter, Education and Public Outreach (E/PO) is being considered separately from the Senior Review.)

The Science Panel recognized that the CALIPSO lidar sensor provides unique vertical information on clouds and aerosols, crucial to radiation feedback, cloud parameterization, polar stratospheric clouds and aerosols, and the marine boundary layer. CALIPSO shows excellent synergy with existing A-Train platforms and is heavily involved in generation of value-added fusion products. The mission data are additionally crucial as a bridge to future satellite lidar missions, and will be essential in exploring climate impacts of ENSO and PNA cycles. Having only recently completed its prime operations phase, the CALIPSO product maturity is still improving, as seen in the release of the Version 3 profile product including product errors. Fairly extensive preliminary validation efforts have been accomplished through aircraft underflights, but detailed analysis of errors in the Level 2 products must still be investigated.

CALIPSO products are beginning to be implemented in retrospective mode by operational forecast agencies to evaluate their model forecast skills, but the long latency limits near-real-time applications, reflected in the "Some Utility" rating by the National Interests Panel. The "Low Risk" rating by the Technical and Cost Panel is based on the available subsystem redundancy, healthy margin in its propellant reserve, and even though one of the 2 lasers has failed, the performance so far of the second laser compared to the first indicates that the mission will remain healthy during the proposed mission extension.

I have used the panel's assessment in formulating the mission programmatic directions for the FY 2010-2013 period. These new guidelines, together with the scope of activities defined in this letter, constitute the new project level one requirements for the extended mission.

Your response to this direction should be in the form of a letter; the letter should include your project's response to the technical guidance below, a discussion of the Science Panel's assessment of your proposal's weaknesses, your project's plans to address those weaknesses, and the budget breakdown using the attached template.

General direction to all projects for E/PO and for efficiency metric reporting will come separately; your responses to these separate directions must be consistent with your response to the guidance in this letter. Dr. Ming-Ying Wei will be issuing the E/PO call simultaneously with this letter; efficiency metric reporting will be handled via e-mail from Cheryl Yuhas and Jennifer Kearns.

All missions are requested to provide an updated End of Mission Plan to ESD by March 30, 2010. End of Mission Plans must be compliant with NASA policies NPR 8715.6a and NPD 8010.3B, and are expected to follow the standards specified in NASA-STD 8719.14.

Specific guidance for the CALIPSO mission is as follows:
The CALIPSO Project is directed to implement its extended mission in accordance with the optimal proposal. This includes the subsetting tool to improve data retrieval for the community. The project is requested to consider including the capability to search among multiple orbits allowing data merges to be implemented for a requested time interval. The project team is encouraged to continue its recent progress in exploring low-latency products and operational uses.

Funding Direction
Funding guidelines for the CALIPSO mission are below. These numbers are in real year dollars and represent the new Headquarters guidance for the sum of the traditional mission operations and core data analysis lines.

FY 2010	FY 2011	FY 2012	FY 2013
$6,580,000	$6,654,000	$6,698,000	$6,888,000

Your plan to meet these guidelines, including addressing any specific comments or redirection raised in this letter, should include a cost breakdown in the formats supplied in the attached budget template. While these guidelines are at the top mission level, it is my expectation that the distribution by Center/Workforce Breakdown Structure will be roughly equivalent to the allocations presented in the proposal.

It is our intention that the guidelines provided are the funds that will be made available to you in FY 2010 and FY 2011, but we note that changes in available resources and the requirements placed on us require revisiting budget allocations annually, or more frequently as circumstances warrant. If for some reason we believe that the resources to be available will differ from those indicated above, we will let you know as soon as we can. Guidelines for FY 2012 and FY 2013 should be considered preliminary, to be revisited during the 2011 ESD Senior Review.

I congratulate you and your team on the positive review results, and look forward to your response on September 30, 2009. Any questions may be directed to Ms Cheryl Yuhas, 202-358-0758, Cheryl.L.Yuhas@nasa.gov.

Michael Freilich

cc:

NASA HQ/J.Kaye

- D. Considine
- S. Volz
- C. Yuhas
- M. Wei

LaRC/L. Vann

- E. Grigsby
- D. MacDonnell

Appendix I CloudSat

I.1 CLOUDSAT DESCRIPTION

CloudSat provides the vertical distribution of cloud systems and their ice and water contents. CloudSat is acquiring the information needed by Numerical Weather Prediction (NWP) models and General Circulation Models (GCMs) to validate and improve their predictions of clouds. In addition, CloudSat provides the quantitative measurements of optical depth, layer thickness, base height, and ice and liquid water contents of clouds, facilitating accurate determination of the radiative properties of clouds and their roles in the radiative heating of the atmosphere. The knowledge of this heating is critical to improving understanding of cloud-climate feedback phenomena. CloudSat was launched in April 2006 and is flying in the A-Train constellation. CloudSat underwent Senior Reviews in 2007 and 2009, which extended the mission through FY 2011. In addition to NASA, contributing partners to CloudSat include the Canadian Space Agency (CSA), which provides radar components, and the U. S. Air Force Research, Development, Test and Evaluation Support Complex (RSC) at Kirtland Air Force Base, which provides the ground station network and conducts ground control of the satellite. The PI is from JPL, and JPL is responsible for project management.

I.2 CLOUDSAT LEVEL 1 REQUIREMENTS

LEVEL I REQUIREMENTS

for the

CloudSat MISSION

August 14, 2002

Revision A
March 12, 2005

Document Revision Record

Revision	Date	Description of Change	Approved By
A	2005/03/12	Title Page: Added Revision A and generation date Section 1.1:Changed references to Earth Science Enterprise to the Science Mission Directorate. Section 1.2: added CALIPSO in formation and other satellites in constellation Section 2.1: Changed the total cost of the mission from $140.2M to $173M. This includes two separate replans, one for the increase in the Spring of 2004, from $140.2M to $168.1M, and the second in the Spring of 2005, to $173M. Section 2.2: Changed the Launch Readiness Date from 04/04 to Summer 2005. Section 2.2: Changed the first release of validated data from 04/05 to Spring 2006. Section 2.3: Changed reference to a CSA-NASA MOU to a US-Canada agreement Section 3.3: Changed the launch ready date from April 2004 to Summer 2005. Section 3.6: Added mission success criteria. Section 5: Changed Ghassem Asrar to Alphonso Diaz as the responsible AA, and replaced references to the Earth Science directorate to the Science Mission Directorate	A. V. Diaz May 2005

LEVEL I REQUIREMENTS FOR THE CloudSat MISSION

1. OVERVIEW

1.1 SCOPE

This document identifies the mission, science and programmatic requirements imposed on CloudSat mission. This document establishes Headquarters' requirements for the implementing center. It serves as the basis for mission assessments conducted by NASA Headquarters during the Implementation Subprocess, and it provides a basis for determining science mission success during mission operations.

Changes to the requirements specified in this document must be made through the following methods:

- Changes to scientific/technical/cost content require Science Mission Directorate (SMD) Directorate Program Management Council (DPMC) approval.
- Changes to cost requirements may be handled as a part of the POP process.
- Changes to the baseline launch readiness date require SMD DPMC approval and a letter of direction from the Associate Administrator for the Science Mission Directorate (AA/SMD).

Program authority is delegated from the Associate Administrator for Science Mission Directorate (AA/SMD) through the Goddard Space Flight Center (GSFC) Center Director to the Earth Probes Program Manager for the successful implementation of the mission.

1.2 PROJECT DEFINITION

CloudSat is a space-mission experiment intended to measure the vertical structure of clouds with a radar from an earth-orbiting spacecraft. This radar is a millimeter-wave radar (94 GHz) capable of detecting a range of clouds from very thin cirrus to thick, precipitating thunderstorms. CloudSat will fly in a near-earth sun-synchronous orbit, in formation with CALIPSO and in a constellation other cloud-measuring satellites (viz. Aqua, Aura).

1.3 SCIENCE OBJECTIVES

The primary science goal of CloudSat is to advance our understanding of the feedback between clouds and climate. Research investigations that utilize CloudSat data will be carried out through NASA NRA funded proposals and through contributions by other USA and non-USA organizations. The following are the science objectives that support the goal:

1. Quantitatively evaluate the representation of clouds and cloud processes in global atmospheric circulation models
2. Quantitatively evaluate the relationship between the vertical profiles of cloud liquid water and ice content and the radiative heating of the atmosphere and surface by the various cloud systems. This involves the following types of studies:
   - Evaluating the connection between cloud liquid water and ice contents and radiative properties
   - Comparing the heating rates derived with CloudSat data to those derived from the classes of models used to address Objective 1
   - Evaluating current approaches in estimating surface radiation fluxes
3. Evaluate cloud properties retrieved from other satellite systems, in particular those of Aqua

The Level 2 CloudSat Science Requirements document shall contain detailed measurements and measurement accuracy requirements.

2. PROGRAM REQUIREMENTS

2.1 BUDGET REQUIREMENTS

The total cost for the CloudSat mission is $173M, and includes NASA mission development, science, operations, and launch costs.

2.2 SCHEDULE REQUIREMENTS

Milestone	Completion Date
Launch Readiness Date	Summer 2005
First release of validated Data	On or before Spring 2006

2.3 EXTERNAL AGREEMENT REQUIREMENTS

The Canadian Space Agency (CSA) is providing radar components to the CloudSat mission in accordance with government-to-government agreement between the United States and Canada. The USAF is providing ground network and mission operations services under a MOA between NASA GSFC and the USAF. Under a Cooperative Agreement with the PI, the DoE ARM Program is providing ground and airborne measurements to support the algorithm development and measurement validation activities.

2.4 MULTI-MISSION FACILITIES REQUIREMENTS

The CloudSat mission will not use any NASA multi-mission facilities.

2.5 CONSTRAINTS

N/A

3. PERFORMANCE REQUIREMENTS

3.1 MISSION REQUIREMENTS

The science objectives are to provide from space the first global survey of cloud profiles and cloud physical properties, with seasonal and geographical variations, needed to evaluate the way clouds are parameterized in global models, thereby contributing to predictions of weather, climate and the cloud-climate feedback problem.

The spacecraft will be placed into a circular, sun-synchronous earth orbit for 22 months of continuous cloud observations, giving coverage over all latitudes (to within 8.2° of the poles) for 22 months. In addition, CloudSat will be flown on-orbit as part of the Aqua constellation.

The science data products required to realize the mission objectives are defined in Table 1.

Table 1. CloudSat Data Products

Standard Data Product	Measurement Accuracy
Cloud classification & geometrical profile (Radar-only)	Detect all single-layer ice clouds with optical depth ≥1.0 and all single-layer water clouds with optical depth ≥ 3.0; Vertical resolution ≤ 550 m from the surface to 25m above the mean geoid.
Ice Water Content (Radar-only)	Ice content of non-precipitating clouds to +100%, -50% error, in ≤ 550m vertical layers;
Liquid water content (Radar-only)	Liquid content of clouds to ≤ 50% error in ≤ 550m layers.
Radiative fluxes & heating rates	Estimates of in-cloud heating for each observed 550m cloud layer to within 1K day-1, km-1; Radiative forcing of clouds on longwave, downward, instantaneous radiative fluxes to ≤10Wm-2 (1-sigma).

These measurement accuracies are those achievable by CloudSat as a standalone mission. CloudSat will fly in formation with and use data from Aqua and

CALIPSO, which is expected to improve the measurement accuracy of CloudSat's data products.

3.2 INSTRUMENT REQUIREMENTS

3.2.1 Cloud Profiling Radar (CPR) Performance

The vertical (range) resolution of the radar measurements will be 500 ± 50 meters, The radar shall detect reflected signals with a sensitivity of ≤ -26 dBZ at end-of-life. The radar shall be calibrated to ±2.0 dBZ pre-launch. The instantaneous radar footprint (IFOV) on the ground (FWHM) shall be ≤ 2km along-track and ≤ 2 km cross-track. Radar sensitivity performance shall be based on a "science footprint" that is ≤ 5 km along-track and ≤ 2 km crosstrack (FWHM).

3.3 LAUNCH REQUIREMENTS

CloudSat shall be launch-ready in Summer 2005 in a dual launch configuration with the CALIPSO satellite. The launch vehicle will be the Boeing Delta II 7420-10C launch vehicle with a Dual Payload Attach Fitting (DPAF) with CloudSat in the lower berth. CALIPSO and CloudSat shall be launched from Vandenberg Air Force Base (VAFB) in California.

3.4 MISSION OPERATIONS REQUIREMENTS

The CloudSat satellite and ground systems shall be designed for a two-year on-orbit lifetime.

3.5 SCIENCE DATA SYSTEM REQUIREMENTS

CloudSat shall provide science data processing, including levels 1-N data processing, distribution, and data storage during the operational phase of the mission.

CloudSat will store Level 0-2 data products, along with the supporting ancillary data, and will transfer the CloudSat data set to the LaRC DAAC using the EOS-DIS HDF format at the conclusion of the mission.

3.6 MISSION SUCCESS CRITERIA

The first set of global cloud measurements will be complete after one 16-day repeat of the groundtrack orbit. Each subsequent 16-day repeat cycle adds statistical information for cloud system types and seasonal changes. There are an estimated 40 such cycles in the 22 months of operations. Success for CloudSat is defined as the acquisition and processing of cloud radar measurements that will be used to greatly improve understanding of cloud physical properties and global characteristics of multi-layered cloud structures. To do this, CloudSat observations will produce on a global scale a significant improvement over current observational capability in these areas:

1. The first vertically resolved measurements and estimates of ice mass in clouds, with 500 m resolution an accuracy of 50% or better.
2. The first vertically resolved measurements and estimates of the liquid water content of clouds, with 500 m resolution and an accuracy of 30%.
3. The first estimates of the fraction of clouds producing precipitation, including all precipitation types (light or heavy, solid or liquid phase) as well as the clouds in which they occur.
4. The first resolved characteristics of vertical cloud structure.
5. The first observationally based estimates of vertical radiative heating by clouds, with 500 m vertical resolution, and to 1K/day.

4. PUBLIC OUTREACH AND EDUCATION REQUIREMENTS

The CloudSat project shall develop and execute an Education and Public Outreach Plan. Activities will focus on communicating the CloudSat mission and scientific results through informal and formal venues. These activities will include creation of CloudSat content materials, development of education programs that amplify the efforts of CloudSat and stimulate broad awareness and understanding, and the identification of new applications required to incorporate the rewards of CloudSat into the fabric of our everyday life.

5. APPROVAL

- signed -

Alphonso Diaz
Associate Administrator for
Science Mission Directorate

I.3 CLOUDSAT 2009 SENIOR REVIEW

National Aeronautics and
Space Administration
Headquarters
Washington, DC 20546-0001

SEP - 1 2009

Reply to Attn of: SMD/Earth Science Division

TO: Colorado State University/CloudSat Principal Investigator
Jet Propulsion Laboratory/CloudSat Project Manager

FROM: Director for Earth Science

SUBJECT: Results from the 2009 Senior Review of Earth Science Operating Missions

This letter provides programmatic direction for the CloudSat mission for Fiscal Years (FY) 2010-2013, based on the findings of the 2009 Earth Science Division (ESD) Senior Review. To complete the Senior Review process, you must develop a plan responsive to the directions of this letter, and forward it to ESD/Cheryl Yuhas by COB on September 30, 2009, for review, possible modification and final acceptance.

The ESD Senior Review consisted of a series of comprehensive reviews of the missions' science quality, operational utility, and continued engineering performance of both spacecraft and instrument. A full description of the evaluation process, the factors used by the review panels, and their findings for all missions, may be found in the Senior Review Final Report, located at URL http://nasascience.nasa.gov/earth-science/mission_list.

The review panels' findings for the CloudSat mission are:

Science Value	Very Good
Operational and Applied Utility	High
Technical & Cost Risk	Low

(As noted in the 2009 Senior Review Call Letter, Education and Public Outreach (E/PO) is being considered separately from the Senior Review.)

The Science Panel recognized that CloudSat is satisfying its mission goals, following a logical validation program, producing data that are already being used in scientific discovery, and demonstrating its potential for future scientific productivity and operational use. Good science is already coming from the Cloudsat products; wider recognition of the value of these products will increase their use by the scientific and operational communities. The panel applauds the Principal Investigator's strategy to foster operational use by placing funded post-doctoral associates to work in the operational centers on integrating CloudSat information into their operational models. The potential to combine CloudSat measurements with measurement from other instruments in the A-Train, and its global coverage, make the CloudSat products unique. The instrument performance and data gathering statistics are all above required levels. The

"High Utility" rating by the National Interests panel is based on the use by the few agencies familiar with its products for operational forecasts, as well model improvement. The "Low Risk" rating from the Technical and Cost panel is based on the nominal performance of the spacecraft and instrument, and the redundancy of the critical component in the Cloud Profiling Radar.

I have used the panel's assessment in formulating the mission programmatic directions for the FY 2010-2013 period. These new guidelines, together with the scope of activities defined in this letter, constitute the new project level one requirements for the extended mission.

Your response to this direction should be in the form of a letter; the letter should include your project's response to the technical guidance below, a discussion of the Science Panel's assessment of your proposal's weaknesses, your project's plans to address those weaknesses, and the budget breakdown using the attached template.

General direction to all projects for E/PO and for efficiency metric reporting will come separately; your responses to these separate directions must be consistent with your response to the guidance in this letter. Dr. Ming-Ying Wei will be issuing the E/PO call simultaneously with this letter; efficiency metric reporting will be handled via e-mail from Cheryl Yuhas and Jennifer Kearns.

All missions are requested to provide an updated End of Mission Plan to ESD by March 30, 2010. End of Mission Plans must be compliant with NASA policies NPR 8715.6a and NPD 8010.3B, and are expected to follow the standards specified in NASA-STD 8719.14.

Specific guidance for the CloudSat mission is as follows:
The CloudSat Project is directed to implement its optimal proposal for mission extension, completing the precipitation products and developing the combined CloudSat/CALIPSO product, as proposed.

Funding Direction
Funding guidelines for the CloudSat mission are below. These numbers are in real year dollars and represent the new Headquarters guidance for the sum of the traditional mission operations and core data analysis lines.

FY 2010	FY 2011	FY 2012	FY 2013
$7,071,000	$7,143,000	$6,999,000	$7,177,000

Your plan to meet these guidelines, including addressing any specific comments or redirection raised in this letter, should include a cost breakdown in the formats supplied in the attached budget template. While these guidelines are at the top mission level, it is my expectation that the distribution by Center/Workforce Breakdown Structure will be roughly equivalent to the allocations presented in the proposal.

It is our intention that the guidelines provided are the funds that will be made available to you in FY 2010 and FY 2011, but we note that changes in available resources and the requirements placed on us require revisiting budget allocations annually, or more frequently as circumstances warrant. If for some reason we believe that the resources to be available will differ from those indicated above, we will let you know as soon as we can. Guidelines for FY 2012 and FY 2013 should be considered preliminary, to be revisited during the 2011 ESD Senior Review.

I congratulate you and your team on the positive review results, and look forward to your response on September 30, 2009. Any questions may be directed to Ms Cheryl Yuhas, 202-358-0758, Cheryl.L.Yuhas@nasa.gov.

Michael Freilich

cc:

NASA HQ/J.Kaye

- D. Considine
- S. Volz
- C. Yuhas
- M. Wei

JPL/D. Evans

- J. Graf
- M. Fujishin

LaRC/E. Grigsby

Appendix J Aquarius

J.1 AQUARIUS DESCRIPTION

Aquarius will make pioneering space-based measurements of Sea Surface Salinity (SSS) with the precision, resolution, and coverage needed to characterize salinity variations and investigate the linkage between ocean circulation, the Earth's water cycle, and climate variability. Salinity is required to determine seawater density, which in turn governs ocean circulation. SSS variations are governed by freshwater fluxes due to precipitation, evaporation, runoff, and the freezing and melting of ice. The Argentine Comisión Nacional de Actividades Espaciales (CONAE) is a partner on the project and is providing the SAC-D spacecraft bus, secondary science instruments, as well as the Mission Operations & Ground System. Aquarius was approved to proceed to Phase C in October 2005 and is planning to launch in 2011. The PI is from Earth and Space Research. JPL is responsible for project management during implementation, and GSFC takes over project management in the operations phase.

J.2 AQUARIUS LEVEL 1 REQUIREMENTS

Aquarius Project

A NASA Earth System Science Pathfinder (ESSP) Mission

Level 1 Requirements and Mission Success Criteria

Version: 2.0

Date: 10 November 2009

Change Log

Revision	Date	Sections Changed	Author
2.0	11/10/09	2.2 – Clarified text; 3.1 – Clarification; 3.2 – Added information on the Operations Phase organization. 4.1.1 – Changed "ice-free oceans" to "open ocean"; 5.1 – Updated to currently approved funding level; 5.2.1.1 – Added to capture mission duration descope direction; 5.3 – Updated to currently approved launch readiness date; Figure 1 – Clarification; Figure 2 added. Approval/concurrence signatures updated.	E. Ianson

Table of Contents

1. Scope

This document describes the Level 1 science, mission, schedule, and cost requirements governing the Earth System Science Pathfinder (ESSP) Aquarius mission. Level 1 Requirements serve as the basis for mission assessments conducted by NASA during the development period and provide the baseline for determining science mission success during the operational phase.

The Aquarius Principal Investigator (PI) is responsible for the overall success of the Aquarius Project, and is accountable to the Associate Administrator of the Science Mission Directorate (SMD). The Aquarius PI delegates the project implementation authority to the Director of the Jet Propulsion Laboratory (JPL), and the JPL Director has delegated this authority to the JPL Earth Science and Technology Directorate (ESTD) and the Aquarius Project Manager. The PI delegates operational phase responsibilities to the Director, Goddard Space Flight Center (GSFC). The Governing Program Management Committee is the NASA SMD Program Management Council.

The Aquarius mission is implemented jointly with the Argentina Comisión Nacional de Actividades Espaciales (CONAE). The CONAE mission is called SAC-D. This joint undertaking is referred to as the Aquarius/SAC-D Mission. Throughout this document, reference to Aquarius will specifically apply to the NASA ESSP Aquarius mission. Reference to Aquarius/SAC-D applies to the integrated NASA-CONAE mission. The implementation of Aquarius/SAC-D is governed by a Memorandum of Understanding (MOU) (see Section 5.4.1).

The Aquarius Level 1 requirements must remain consistent with the MOU. Any changes to the Level 1 requirements specified in this document must be approved by NASA SMD.

2. Science Definition

2.1. Science Objectives

The ESSP Aquarius Project will implement an Exploratory Measurement Mission designed to make pioneering space-based measurements of Sea Surface Salinity (SSS) with the precision, resolution, and coverage needed to characterize salinity variations and investigate the linkage between ocean circulation, the Earth's water cycle, and climate variability. Salinity is required to determine seawater density, which in turn governs ocean circulation. SSS variations are governed by freshwater fluxes due to precipitation, evaporation, runoff and the freezing and melting of ice. The Aquarius SSS measurements will be used to address two key areas of NASA's Earth Science research strategy described ESSP-3 Announcement of Opportunity (AO-01-OES-01):

Earth System Variability and Trends: How are global precipitation, evaporation, and the cycling of water changing?

Earth System Responses and Feedback Processes: How can climate variations induce changes in the global ocean circulation?

In meeting these objectives, Aquarius will also validate a space-based measurement approach and analysis concept that could be used for future systematic SSS monitoring missions.

2.2. Implementation Approach

Space-based SSS measurements are required to provide systematic global mapping because the existing compilation of *in situ* ship and buoy observations is inadequate to meet the science objectives. The *in situ* spatial and temporal sampling is sparse, irregular and largely confined to shipping lanes and the summer season. About 25% of the world oceans have never been sampled, including vast regions of the southern hemisphere. More than 73% of the world oceans have fewer than 10 observations per one-degree square, insufficient to resolve the annual water cycle, interannual variability, or the spatial fronts, eddies and current systems that affect oceanographic circulation processes.

Aquarius will retrieve SSS by microwave remote sensing of surface brightness temperature at L-band, which is governed by the surface salinity, temperature and roughness (due to wind and waves). An integrated L-band microwave radiometer/scatterometer will be developed and deployed as the salinity measuring instrument, consisting of three beams in a pushbroom configuration. The radiometers will measure the L-band microwave surface brightness temperature and the radar scatterometer measurements will be used to derive the brightness temperature correction due to surface roughness. Ancillary measurements of surface temperature, surface wind and other geophysical corrections needed to convert brightness temperature to salinity will be obtained from other satellite observing systems and operational models. Aquarius will provide global sampling on an orderly, comprehensive, spatial and temporal pattern from a low earth orbiting satellite over the open ocean (defined in these requirements as the ocean regions where the microwave emissions are not significantly contaminated by land and ice surfaces which have much higher brightness temperature than the ocean). The observatory will be in a sun-synchronous orbit with the sensors oriented away from the sun to minimize contamination by the L-band solar radiation. Independent calibration and validation will be applied to verify SSS retrieval accuracy. SSS measurements will be provided in practical salinity units (psu) according the international standard Practical Salinity Scale (1978), which is based on seawater electrical conductivity, and is a very near approximation of salt concentration in g/kg.

The open ocean SSS range is ~32-37 psu, and the scale of seasonal-to-inter-annual variations can be as much as 1-2 psu in key regions. Modeling studies show that mapping the mean annual SSS to 0.2 psu accuracy over multiple seasonal cycles on spatial scales of 150 km x 150 km will, at a minimum, enable us to substantially reduce the large uncertainties in the mean global net air-sea freshwater flux, which constitutes ~80% of the global water cycle, and to quantify the associated links to oceanic mean circulation. The Baseline Science Mission enables study of the relevant oceanic processes on intraseasonal to interannual time scales by resolving the SSS with 0.2 psu accuracy on monthly time scales for at least three years. The Minimum Science Mission enables the study of these processes over an annual cycle by resolving the SSS with 0.2 psu accuracy on seasonal time scales for at least one year.

3. Project Definition

3.1. Project Organization and Management

The Aquarius/SAC-D Project includes US institutional partners that are funded by NASA and the international CONAE partnership that is without exchange of funds:

- NASA JPL responsibilities include the Aquarius mission implementation phase project management, Aquarius Project System Engineering; Aquarius Safety and Mission Assurance; Aquarius Instrument, including the scatterometer, antenna, command, data, and power subsystems; Aquarius Instrument integration and test; and data archive.
- NASA GSFC responsibilities include managing the Aquarius PI contract; Aquarius operations phase Project Management; Aquarius instrument radiometer subsystem; science algorithms, calibration and validation; and development and operations of the Aquarius ground data system including NASA-CONAE ground system interfaces.
- NASA Kennedy Space Center (KSC) is responsible for the launch services.
- CONAE responsibilities include development, integration, test and mission operations of the Aquarius/SAC-D observatory; SAC-D service platform; CONAE and third party instruments.

The Aquarius and SAC-D organizations for the implementation phase are shown in *Figure 1*. Key NASA and CONAE management and engineering interfaces for the Aquarius/SAC-D joint implementation are identified. The operational phase organizational changes are reflected in Figure 2. A Joint Steering Group, consisting of senior project and agency officials from both parties, provides overall guidance to the Project and decides any matters that affect the mission launch schedule, Level 1 mission requirements, and other implementation issues not resolved by the respective Project Managers.

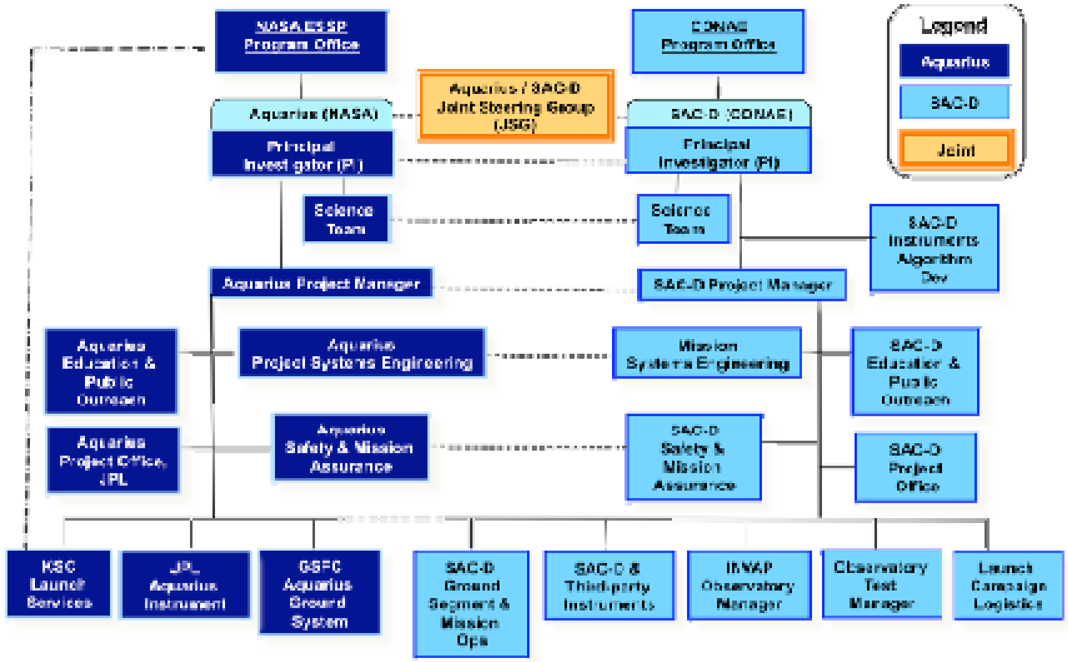

Figure 1: Block diagram showing the Aquarius and SAC-D organizations and their technical/programmatic interfaces during mission implementation phase.

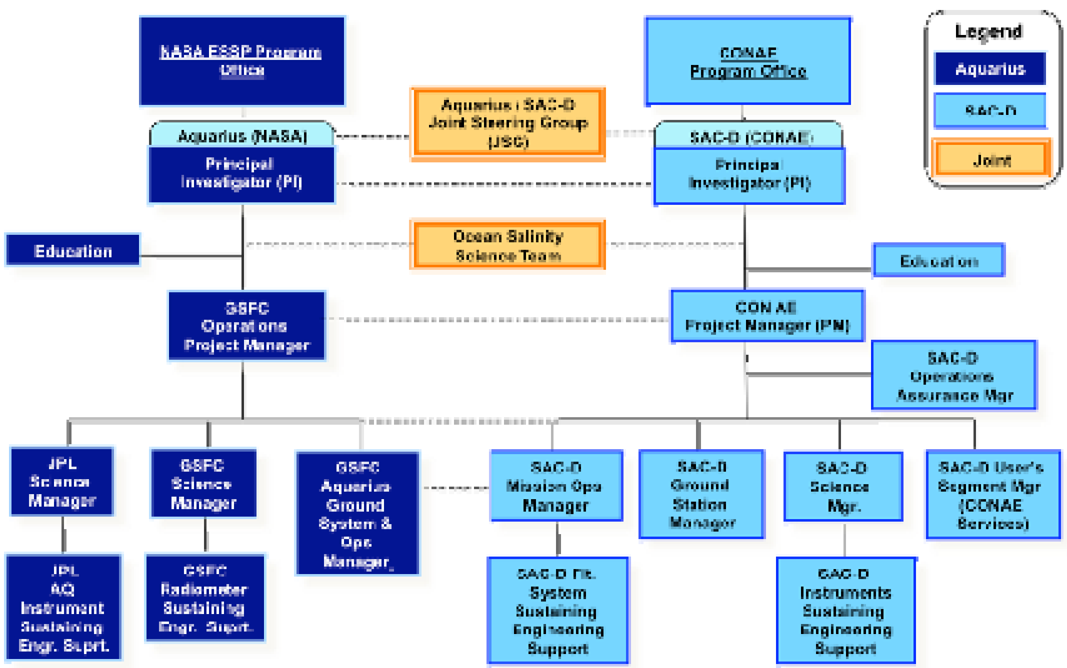

Figure 2: Block diagram showing the Aquarius and SAC-D organizations and their technical/programmatic interfaces during mission operation phase.

3.2. Project Acquisition Strategy

The Aquarius/SAC-D project will be conducted using an observatory made up of the NASA provided Aquarius instrument, SAC-D science instruments, and the SAC-D spacecraft bus (service platform) contributed by CONAE. CONAE's SAC-D requirements are technically and scientifically compatible with Aquarius. The Aquarius/SAC-D mission operations will be conducted using an integrated mission operations system consisting of the CONAE observatory operations control center in Argentina, the GSFC Aquarius science planning and data processing center, and the JPL Physical Oceanography Distributed Active Archive Center (PO.DAAC) for data archive and distribution.

4. Performance Requirements

4.1. Science Requirements

4.1.1. Requirement: The Aquarius Mission shall collect the space-based measurements to retrieve SSS with global root-mean-square (rms) random errors and systematic biases no larger than 0.2 psu on 150 km by 150 km scales over the open ocean;

4.1.2. Requirement: The Baseline Science Mission shall:

- Be at least 3 years in duration.
- Collect data sufficient to produce monthly mean estimates of SSS according to Requirement 4.1.1.

4.1.3. Requirement: The Minimum Science Mission shall:

- Be at least 1 year in duration.
- Collect data sufficient to produce seasonal (3-month) mean estimates of SSS according to Requirement 4.1.1.

4.2. Instrument Requirements

4.2.1. Requirement: The Aquarius instrument radiometers shall operate in the L-band frequency within the Earth Exploration Satellite Service (EESS) passive allocation 1400-1427 MHz.

4.2.2. Requirement: The Aquarius instrument scatterometer shall operate in the L-band frequency EESS active allocation at 1.26 GHz.

4.3. Observatory and Mission Operations Requirements

4.3.1. Requirement: The Aquarius/SAC-D observatory shall fly in a sun synchronous polar Earth orbit that provides coverage to meet the science requirements in Section 4.1.

4.3.2. Requirement: The Aquarius mission shall complete the In-Orbit Checkout (IOC) period within 90 days after launch, and then begin operations according to the science requirements in Section 4.1.

4.4. Launch Requirements

4.4.1. Requirement: NASA shall provide for the launch of the Aquarius/SAC-D observatory from the Vandenberg Air Force Base in California on a dedicated Delta 7320-10 launch vehicle.

4.4.2. Requirement: The launch vehicle and launch services will be procured by NASA through the NASA Kennedy Space Center (KSC).

4.5. Science Measurement Validation Requirements

4.5.1. Requirement: The Aquarius validation program shall assemble and analyze conventional surface *in-situ* measurements from regional and global arrays for instrument calibration and data validation.

4.5.2. Requirement: The *in situ* SSS measurements provided freely by the international Climate Variability (CLIVAR), Global Ocean Observing System (GOOS) Programs or other sources shall be obtained and used. These measurements are available in the public domain and require no external agreements between NASA and other institutions.

4.5.3. Requirement: The Aquarius validation program shall demonstrate that retrievals of SSS meet the science requirements in Section 4.1.

4.6. Data Product Requirements

The Aquarius Data Products are defined in Table 1.

Table 1. Aquarius Data Products

Data Product	Description
Level 1a	Reconstructed Unprocessed Instrument Data
Level 1b	Calibrated Sensor Units
Level 2	Derived Geolocated SSS
Level 3	Time-space averaged SSS on a standard Earth Projection.

4.6.1. Requirement: No later than twelve (12) months after the end of the IOC period, the Aquarius Project shall deliver the first release of data products (containing at least six (6) months of data) in Table 1 to a NASA Distributed Active Archive Center (DAAC).

4.6.2. **Requirement:** After the first release of validated Aquarius data, the Aquarius data products shall be delivered to the DAAC as soon as the validated data are available, but no later than six months after measurements are taken in orbit.

4.6.3. **Requirement:** The final data products produced by the Aquarius Project shall be delivered to the DAAC within six (6) months after the end of the prime mission.

5. Program Requirements

5.1. Budget Requirements

5.1.1. **Requirement:** The total NASA cost for the Aquarius mission shall include the formulation, implementation, launch, operations, calibration, validation, and science data analysis costs to generate the products in Table 1.

5.1.2. **Requirement:** The total direct NASA cost for the Aquarius mission shall not exceed $270.3M.

5.1.3. **Requirement:** The Aquarius mission science investigations shall be augmented by an Ocean Salinity Science Team, funded through a NASA Research Announcement, no later than one year before launch. Funding for the Ocean Salinity Science Team shall not be included in the total NASA mission cost.

5.2. Cost Management and Scope Reduction

5.2.1. **Requirement:** Provided that due consideration has been given to the use of budgetary and schedule reserves, the Aquarius Project shall pursue scope reduction to control cost and mitigate risk. Any potential scope reductions that reduce the science capability from the Baseline Science Mission (section 4.1.1) shall be implemented only with the concurrence of NASA Headquarters and the ESSP Program Office.

5.3. Schedule Requirements

5.3.1. **Requirement:** The Aquarius Project shall target a Launch Readiness Date of December 2010

5.4. External Agreement Definition

5.4.1. **Requirement:** The Aquarius mission shall be conducted in conjunction with the Argentina space agency, CONAE, which will provide specific mission elements and services identified in an MOU between NASA and CONAE (signed 2 March 2004).

5.5. Multi-Mission Facilities Requirements

5.5.1. **Requirement:** NASA shall make available the NASA Near Earth Network for coverage of Aquarius/SAC-D launch, critical flight activities in-flight anomaly resolution, and back-up to the CONAE ground station.

5.6. Safety Requirements

5.6.1. Requirement: The Aquarius project shall implement a safety and mission assurance plan.

6. Education and Public Engagement Requirements

Requirement: The Aquarius Project shall develop and execute an Education and Public Engagement Plan that utilizes unique scientific and/or engineering aspects of the mission to inspire and motivate the Nation's students and teachers as well as to engage and educate the public. The activities shall aim to stimulate broad awareness and understanding of the role of ocean salinity in the Earth's climate and the links between ocean circulation and the water cycle. The plan shall be optimized for educational and cost effectiveness and build upon the resources and capabilities that NASA has accrued in education and public engagement.

7. Mission Success Criteria

7.1. The Aquarius Mission will be considered fully successful if it:

- Meets the baseline science requirements (see Section 4.1)
- Meets the data product requirements (see Section 4.6)

7.2. The Aquarius Mission will be considered minimally successful if it:

- Meets the minimum science requirements (see Section 4.1)
- Meets the data product requirements (see Section 4.6)

8. Approvals

______________________________ ______________

Edward Weiler — Date
Associate Administrator, Science Mission Directorate
NASA Headquarters

______________________________ ______________

Charles Elachi — Date
Director, Jet Propulsion Laboratory

______________________________ ______________

Arthur Obenschain — Date
Director (Acting), Goddard Space Flight Center

______________________________ ______________

Edward Grigsby — Date
Program Manager
Earth System Science Pathfinder Program

9. Concurrences

____ ____________

Gary Lagerloef Date
Principal Investigator, Aquarius Mission
Earth and Space Research

____ ____________

Amit Sen Date
Project Manager, Aquarius Mission
Jet Propulsion Laboratory

____ ____________

Diane Evans Date
Director, Earth Science and Technology Directorate
Jet Propulsion Laboratory

____ ____________

Nicholas White Date
Director, Science and Exploration Directorate
Goddard Space Flight Center

____ ____________

James Wells Date
Mission Manager
Earth System Science Pathfinder Program

____ ____________

Eric Lindstrom Date
Program Scientist
Science Mission Directorate, NASA Headquarters

Eric Ianson
Program Executive
Science Mission Directorate, NASA Headquarters

Date

Ken Ledbetter
Chief Engineer
Science Mission Directorate, NASA Headquarters

Date

Michael Freilich
Director, Earth Science Division
Science Mission Directorate, NASA Headquarters

Date

Mike Luther
Deputy Associate Administrator for Programs
Science Mission Directorate, NASA Headquarters

Date

Chuck Gay
Deputy Associate Administrator
Science Mission Directorate, NASA Headquarters

Date

J.3 AQUARIUS COMMITMENT BASELINE

The following section details the Aquarius Project commitments as proposed to Congress in the 2011 President's Budget Request.

Project Commitments

Project commitments include major mission architecture elements and the organization responsible for providing that element. The primary responsibility for ESSP is to enable successfully delivery of the JPL Aquarius instrument to CONAE.

Table J-1 summarizes Aquarius Project commitments.

Table J-1: Aquarius Project Commitments

Project Element	Provider	Description	FY 2010 PB Request	FY 2011 PB Request
Aquarius Instrument (integrated radiometer/ scatterometer)	JPL	L-band microwave radiometer at 1.413 GHz; scatterometer at 1.26 GHz; SSS measurements with root-mean-sq. random errors and systematic biases ≤ 0.2 psu on 150 km sq. scales over ice-free oceans.	Same	Same
Spacecraft	CONAE	SAC-D	Same	Same
Launch Vehicle	Boeing	Delta II	Same	Same
Data Management	GSFC	N/A	Same	Same
Operations	CONAE	Command and telemetry	Same	Same

Schedule Commitments

The Aquarius mission entered a Risk Mitigation Phase (RMP) in July 2002. Following the RMP, the Project was authorized to proceed to a formulation phase in December 2003. The Aquarius Project was authorized by the NASA SMD to proceed to development on October 12, 2005. In November 2007, the NASA Science Directorate Program Management Council (DPMC) approved a rebaseline of Aquarius, including a launch delay to May 2010. In December 2009, the NASA Science DPMC approved another rebaseline of Aquarius, including a launch delay manifesting the Aquarius/SAC-D mission for a January 2011 launch. The Aquarius schedule commitments are summarized in Table J-2 and Table J-3 for the second rebaseline. Table J-4 summarizes development cost through the second rebaseline.

Table J-2: Aquarius Schedule Commitments

Milestone Name	Confirmation Baseline	FY 2010 PB Request	FY 2011 PB Request
Development			
Project Confirmation Review	September 2005	September 2005	September 2005
Project CDR	August 2007	July 2008	July 2008
Aquarius Instrument Pre-ship Review [FY 2008 APG]	May 2008	May 2009	May 2009
Launch	March 2009	May 2010	January 2011

Table J-3: Aquarius Development Cost and Schedule Summary

Project	Base Year	Base Year Development Cost Estimate ($M)	Current Year	Current Year Development Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Date	Current Year Milestone Date	Milestone Change (months)
Aquarius	2007	192.6	2010	222.6	16	Launch Readiness	07/2009	01/2011	18

Table J-4: Aquarius Development Cost Details

Element	Base Year Development Cost Estimate ($M)	Current Year Development Cost Estimate ($M)	Delta
Total:	192.6	222.6	30.0
Payloads	55.4	96.1	40.7
Launch Vehicle/Services	78.9	79.4	0.5
Ground Systems	5.5	5.5	0.0
Science/Technology	10.9	11.8	0.9
Other Direct Project Cost	41.9	29.8	-12.1

Project Management

The Jet Propulsion Laboratory is responsible for project management. The Science DPMC is responsible for program oversight. The ESD Director is the responsible official. Table J-5 summarizes responsibilities for Aquarius Project elements.

Table J-5: Aquarius Project Element Responsibilities

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Launch Vehicle	KSC	KSC	None
Ground System	JPL	GSFC	None
Aquarius Instrument	JPL	JPL	None
Spacecraft	CONAE	None	CONAE
Radiometer	JPL	GSFC	None
Data management	GSFC	GSFC/JPL	None
Mission operations	CONAE	None	CONAE

Appendix K Orbiting Carbon Observatory-2 (OCO-2)

K.1 OCO-2 DESCRIPTION

The original Orbiting Carbon Observatory was launched on February 24, 2009, but was lost after the launch vehicle payload fairing failed to separate. Like its predecessor, OCO-2 was designed to return the space-based measurements needed to provide global estimates of atmosphere carbon dioxide (CO_2) with the sensitivity, accuracy, and sampling density needed to quantify regional scale carbon sources and sinks and characterize their behavior over the annual cycle. For its two-year prime mission, OCO-2 is to fly in a Sun-synchronous orbit that provides near global coverage of the sunlit portion of the Earth with a 16-day repeat cycle. Its single instrument incorporates three high-resolution grating spectrometers that are designed to measure the near-infrared absorption of reflected sunlight in CO_2 and molecular oxygen (O_2) absorption bands. OCO-2 will validate a space-based measurement approach and analysis concept that can be used for future systematic CO_2 monitoring projects. OCO-2 was approved to proceed into Phase C in September 2010. The Project Manager leads the JPL Project team and is responsible to NASA for scientific integrity and the management.

K.2 OCO-2 LEVEL 1 REQUIREMENTS

Appendix K - Earth System Science Pathfinder Program Plan

Program-Level Requirements for the Orbiting Carbon Observatory – 2 Project

Version: 1.0
Date: September 24, 2010

Change Log

Revision	Date	Sections Changed	Author
1.0	9/24/2010	Initial Release	E. Ianson

Table of Contents

1.0 SCOPE

This appendix to the Earth System Science Pathfinder (ESSP) Program Plan identifies the mission, science and programmatic (funding and schedule) requirements imposed on the Jet Propulsion Laboratory (JPL) for the development and operation of the Orbiting Carbon Observatory – 2 (OCO-2) Project of the ESSP Program. Requirements begin in Section 4. Sections 1, 2 & 3 are intended to set the context for the requirements that follow.

This document serves as the basis for mission assessments conducted by NASA Headquarters during the development period and provides the baseline for the determination of the science mission success following the completion of the operational phase.

Program authority is delegated from the Associate Administrator for the Science Mission Directorate (AA/SMD) through the Earth Science Division within SMD to the ESSP Program Manager at Langley Research Center. Project management will be conducted at JPL. See Section 3.1.

JPL is responsible for scientific success, design, development, test, mission operations, and data verification tasks and shall coordinate the work of all contractors and science team members.

The NASA Earth Science Division will select the investigators that will compose the OCO-2 Science Team through a competitive process.

Changes to information and requirements contained in this document require approval by the Science Mission Directorate (SMD), NASA Headquarters by the officials that approved the original.

OCO-2 is based on the original OCO mission, which was developed under the NASA Earth System Science Pathfinder (ESSP) Program Office and launched from Vandenberg Air Force Base on February 24, 2009. Before spacecraft separation, a launch vehicle anomaly occurred that prevented the spacecraft from reaching injection orbit. The spacecraft was destroyed during re-entry and was unrecoverable.

2.0 SCIENCE DEFINITION

2.1 BASELINE SCIENCE OBJECTIVES

The ESSP OCO-2 Project will implement an exploratory science mission designed to collect the space-based measurements needed to quantify variations in the column averaged atmospheric carbon dioxide (CO_2) dry air mole fraction, X_{CO2}, with the precision, resolution, and coverage needed to improve our understanding of surface CO_2 sources and sinks (fluxes) on regional scales

(≥1000 km) and the processes controlling their variability over the seasonal cycle. This mission will also validate a space-based measurement approach and analysis concept that could be used for future systematic CO_2 monitoring missions.

2.2 Science Instrument Summary Description

The OCO-2 instrument incorporates three near-infrared spectrometers designed to measure reflected sunlight in CO_2 and molecular oxygen (O_2) absorption bands. Soundings, consisting of coincident CO_2 and O_2 spectra, are analyzed with a remote sensing retrieval algorithm to yield spatially-resolved estimates of X_{CO2}. The spectrometer optical design, spectral range, and resolving power were selected to optimize measurement precision and minimize bias. Spectra collected at wavelengths near 1.61 microns are most sensitive to variations in the CO_2 concentration near the surface. Coincident measurements from the O_2 A-band and the CO_2 band near 2.06 microns minimize X_{CO2} errors associated with pointing uncertainties and scattering by thin clouds and aerosols. The small (≤ 3 km^2) sounding footprint is expected to yield > 100 cloud-free soundings on regional scales over > 80% of range of latitudes on the sunlit hemisphere at monthly intervals.

The precision and bias of space-based X_{CO2} retrievals can only be validated at locations where X_{CO2} is well characterized by other methods. OCO-2 results will be validated through comparisons with X_{CO2} retrievals from selected ground-based spectrometers in the Total Column Carbon Observing Network (TCCON). Retrievals from TCCON stations designated as OCO-2 "primary ground validation sites" have been validated against in situ CO_2 profiles collected during aircraft overflights of the station, using measurement techniques traceable to World Meteorological Organization standards for atmospheric CO_2 measurements. OCO-2 can acquire > 100 soundings in the vicinity of a TCCON station in a single cloud-free overflight. At least once each season, space-based X_{CO2} retrievals from cloud-free overflights of ≥ 3 of the primary ground validation sites will be compared with TCCON retrievals to validate the OCO-2 measurement precision and to identify global-scale systematic biases in its space-based X_{CO2} product.

3.0 PROJECT DEFINITION

3.1 Project Organization & Management

The OCO-2 Project Manager shall report to NASA according to Figure 1.

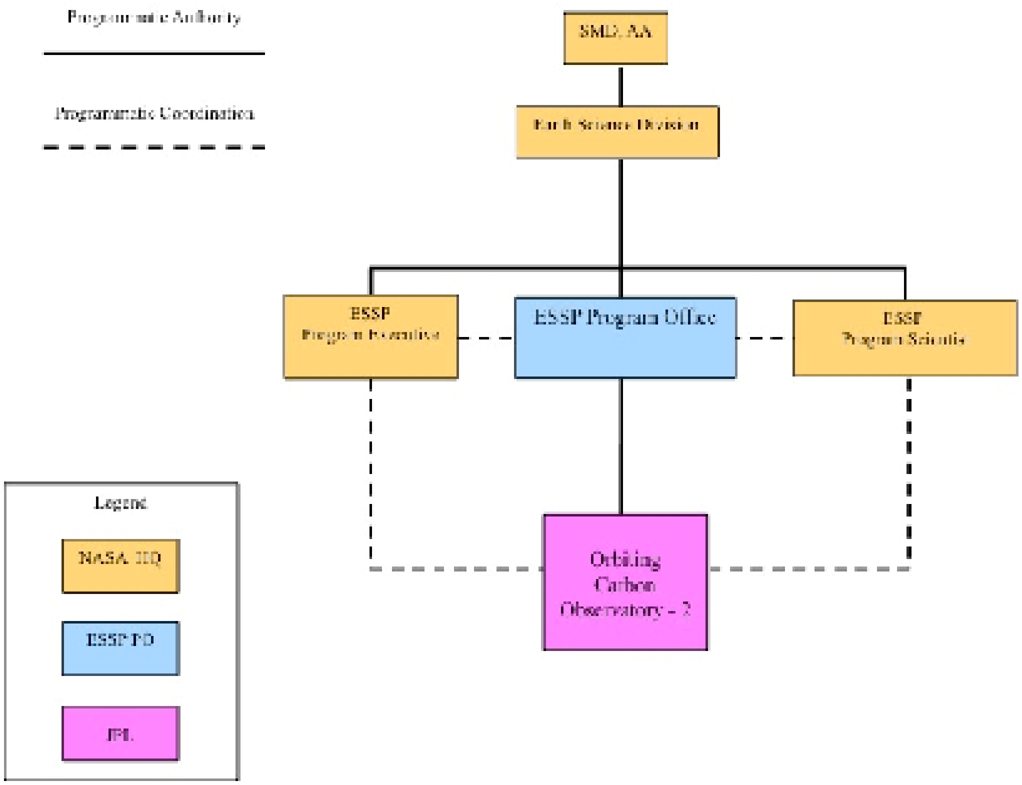

Figure 1. OCO-2 Lines of Authority and Coordination

The OCO-2 Project Manager has overall management responsibility for the success of the project. The OCO-2 Project Scientist has overall management responsibility for the science elements of the project. Specific assigned roles and responsibilities are:

- JPL is responsible for providing: the Project Scientist; project management; system engineering and mission design; safety and mission assurance; the instrument; spacecraft; mission operations and the associated mission operations ground data system; science data processing and delivery of calibrated/validated science data products to an archive for public distribution.

- NASA is responsible for providing a launch vehicle and launch services for OCO-2 and access to the SN (Space Network) for S-band uplink and downlink and Near Earth Network (NEN) for S-band uplink and downlink and X-band downlink compatible with the OCO-2 mission. A NASA-SMD-Earth Science Division-assigned Distributed Active Archive Center (DAAC) is responsible for public distribution of OCO-2 data and long-term science data archiving.

3.2 Project Acquisition Strategy

JPL will implement an in-house development of the instrument, utilizing commercial vendors for parts and assemblies. However, the instrument cryocoolers will be obtained from the GOES-R (Geostationary Operational Environmental Satellite, R-Series) Program through an inter-agency transfer between NASA and NOAA (National Oceanic and Atmospheric Administration). Orbital Science Corporation (OSC) is contracted to provide the spacecraft development, integration, test, launch operations, and mission operations support. NASA's Launch Services Program at Kennedy Space Center will provide the launch vehicle. Sole source justifications will be implemented based on the past experience on OCO.

4.0 PROGRAMMATIC REQUIREMENTS

The science objectives in Section 2.1 can be achieved by either the baseline or threshold science mission requirements listed herein, but the baseline mission provides substantially more value to NASA and the Earth Science Community.

4.1 Science Requirements

4.1.1 Baseline Science Requirements

a) Retrieve estimates of the column-averaged CO_2 dry air mole fraction (X_{CO2}) on regional scales (≥1000 km) from space-based measurements of the absorption of reflected sunlight by atmospheric CO_2 and O_2, collected in cloud-free scenes over ≥ 80% of range of latitudes on the sunlit hemisphere at monthly intervals for 2 years.

b) Compare space-based and ground-based X_{CO2} retrievals from soundings collected during overflights of ≥ 3 primary ground validation sites at least once each season to identify and correct global-scale systematic biases in the space-based X_{CO2} product and to demonstrate a precision of ≤ 0.3% for collections of ≥100 cloud-free soundings.

c) Record, validate, publish, and deliver science data records and calibrated geophysical data products to a NASA SMD-Earth Science Division-assigned DAAC for use by the scientific community.

d) Validate a space-based measurement approach and analysis concept that could be used for future systematic CO_2 monitoring missions.

4.1.2 Threshold Science Requirements

a) Retrieve estimates of the column-averaged CO_2 dry air mole fraction (X_{CO2}) on regional scales (≥1000 km) from space-based measurements of the absorption of reflected sunlight by atmospheric CO_2 and O_2, collected in cloud-free scenes over ≥ 80% of range of latitudes on the sunlit hemisphere at monthly intervals for ≥ 1 year.

b) Compare space-based and ground-based X_{CO2} retrievals from soundings collected during overflights of ≥ 3 primary ground validation sites at least once each season to identify and correct global-scale systematic biases in the space-based X_{CO2} product and demonstrate a precision of ≤ 0.5% for collections of ≥100 cloud-free soundings.

c) Record, validate, publish, and deliver science data records and calibrated geophysical data products to a NASA SMD-Earth Science Division-assigned DAAC for use by the scientific community.

d) Validate a space-based measurement approach and analysis concept that could be used for future systematic CO_2 monitoring missions.

4.1.3 Science Instrument Requirements

a) The space-based instrument shall be capable of acquiring coincident measurements of reflected sunlight in the CO2 bands centered at wavelengths near 1.61 and 2.06 μm and in the O2 A-band centered near 0.765 μm.

b) The spectral range and resolving power of the space-based instrument shall be selected to resolve individual absorption lines from the underlying continuum throughout each CO_2 and O_2 band to retrieve estimates of X_{CO2} that meet the Science Requirements (Section 4.1).

c) The OCO-2 instrument shall be capable of acquiring CO_2 and O_2 soundings with a footprint size ≤ 3 km^2 at nadir to facilitate the acquisition of cloud-free scenes in at least 10% of the soundings collected over the sunlit hemisphere on monthly time scales.

4.2 Mission and Spacecraft Performance

a) The OCO-2 project shall be Category 2 per NPR 7120.5D, and the payload class shall be C per NPR 8705.4.

b) The OCO-2 mission shall complete the In-Orbit Checkout (IOC) period within 90 days after launch, and then begin operations consistent with the science requirements in Section 4.1.1.

c) The Observatory shall fly in a sun-synchronous low Earth orbit that provides access to ≥90% of the range of latitudes on the sunlit hemisphere at least once a month.

d) After IOC, the Observatory's orbit nodal crossing time shall be between 11AM and 2PM, and vary by less than 15 minutes during the science mission as defined in Section 4.2(e).

e) The OCO-2 mission lifetime is 2 years baseline (1 year threshold) following completion of IOC.

4.3 Launch Requirements

a) The Observatory shall be launched on an expendable launch vehicle of Risk Category 2 or 3, per NPD 8610.7C with a payload isolation damping system, if needed.

b) The OCO-2 project shall target a Launch Readiness Date in February 2013.

4.4 Ground System Requirements

The OCO-2 project shall develop a ground system to meet the performance requirements in section 4.1 and the reprocessing and data latency requirements in section 4.5.

4.5 Mission Data Requirements

4.5.1 Science Data Management

a) The OCO-2 Project shall produce the standard science data products listed in Table 1.

b) All standard data products listed in Table 1 shall be delivered, in accordance with the NASA Earth Science Data and Information Policy specified in the 2006 Earth Science Reference Handbook (NP-2006-5-768-GSFC), to a NASA SMD Earth Science Division-assigned DAAC. Public release of this data shall conform to the NASA Earth Science Data and Information Policy, U.S. Law, and the NASA/CalTech prime contract (NAS7-03001).

c) Science algorithms used to generate the standard data products listed in Table 1 shall be documented in Algorithm Theoretical Basis Documents (ATBDs).

4.5.1.1 Science Data Requirements

a) OCO-2's Level 1 and Level 2 science data product formats shall conform to the Hierarchical Data Format (HDF5) standard.

b) The metadata for the OCO-2 standard data products listed in Table 1 shall conform to the Earth Observing System (EOS) Clearinghouse (ECHO) Science Metadata Model.

c) The OCO-2 Project shall coordinate the release of product versions with the NASA SMD-Earth Science Division-assigned DAAC.

d) The OCO-2 Project shall deliver reprocessed data products which meet the science requirements in Section 4.1 within 6 months after completion of the science mission as specified in Paragraph 4.2.e.

e) X_{CO2} products mapped on a uniform spatial grid shall be produced by the OCO-2 Project.

Table 1. OCO-2 Data Products

Data Product	Description	Initial Availability to NASA DAAC	Median Latency in Product Availability to NASA DAAC after Initial Delivery	NASA DAAC Location
Level 0	Raw collected telemetry	Within 24 hours of receipt from EDOS*	Within 24 hours of receipt from EDOS*	GSFC
Level 1	Calibrated Geolocated Spectral Radiances	3 months after IOC**	3 weeks**	GSFC
Level 2	X_{CO2}	3 months after Level 1 data products are available	6 weeks**	GSFC

* EDOS: (Earth Observing System) Data and Operations System
**Delivery latency after ground receipt

4.5.2 Applied Science Data Requirements

Beginning in Phase C, the OCO-2 Project shall participate in an OCO-2 data product application workshop annually. The workshop will share information on OCO-2 science data applications and define potential applications that can be supported with existing OCO-2 data requirements. Results of the workshop will be provided to the OCO-2 science team and at other OCO-2 workshops and meetings.

4.6 Mission Success Criteria

a) Launch into a sun-synchronous orbit that provides near global access at monthly intervals.
b) Collect global space-based measurements of atmospheric carbon dioxide (CO_2) with the precision, resolution, and coverage needed to improve understanding of CO_2 sources and sinks and quantify their variability over an annual cycle (as specified in section 4.1.2).
c) Record, validate, publish, and deliver science data records and calibrated geophysical data products to a NASA SMD-Earth Science Division-assigned DAAC for use by the scientific community.
d) Validate a space-based measurement approach and analysis concept for future systematic CO_2 monitoring missions.

5.0 NASA MISSION COST REQUIREMENT

5.1 Cost

The OCO-2 life cycle cost (LCC) shall not exceed $325.8M. The LCC includes the cost for the formulation, implementation, launch, operations, calibration, validation, science data analysis costs to generate the products in Table 1, and $10M (a not-to-exceed figure) for the two cryocoolers obtained from the NOAA GOES-R Program.

5.2 Cost Management and Scope Reduction

Provided that Program Level Requirements are preserved, and that due consideration has been given to the use of budgeted contingency and planned schedule contingency, the OCO-2 project shall pursue scope reduction and risk management as a means to control cost. The Project Plan shall include potential scope reductions and the time frame in which they could be implemented. If other methods of cost containment are not practical, the reductions identified in the Project Plan may be exercised.

Scope reductions from baseline science requirements (Section 4.1.1) to threshold science requirements (Section 4.1.2) or potential scope reductions affecting these Program Requirements shall be agreed to by the officials represented on the approval page of document.

6.0 MULTI-MISSION NASA FACILITIES

a) The NASA Near Earth Network (NEN) shall be made available by NASA for S-band uplink and downlink and X-band downlink compatible with the OCO-2 Mission.

b) The SN, also known as the NASA Tracking and Data Relay Satellite System (TDRSS) shall be made available by NASA for rapid communications between the spacecraft and ground during the IOC, orbit correction maneuvers, and emergencies.

7.0 EXTERNAL AGREEMENTS

a) The OCO-2 mission shall include no flight hardware or flight software contributions from organizations outside of NASA, precluding the need for external agreements for flight hardware or software contributions.

b) The OCO-2 Project shall reimburse NOAA (National Oceanic and Atmospheric Administration) for the two GOES-R (Geostationary Operational Environmental Satellite, Series R) Program cryocoolers per the countersigned inter-agency transfer MOA (Memorandum Of Agreement).

c) The scope of the contributions from the international or interagency partners on the OCO-2 Science Team, validation activities, or data sharing shall be described in formal agreements between NASA and these organizations.

8.0 PUBLIC OUTREACH AND EDUCATION

The OCO-2 project shall develop and execute an Education and Public Outreach Plan.

9.0 SPECIAL INDEPENDENT EVALUATION

No special independent evaluation is required for the OCO-2 Project.

10.0 WAIVERS

The OCO-2 Project was granted Agency approval to complete a tailored formulation phase that reduced that number of KDP gates, gate product versions, and technical reviews during this period.

11.0 REQUIRED APPROVALS AND CONCURRENCES

APPROVALS

9-24-10

Edward Weiler
Associate Administrator, Science Mission Directorate
NASA Headquarters

Date

9-2-2010

Charles Elachi
Director, Jet Propulsion Laboratory

Date

26 Aug 2010

Greg Stover
Program Manager (Acting), Earth System Science Pathfinder Program
NASA Langley Research Center

Date

CONCURRENCES

Ralph Basilio — Date: 8/24/2010
Project Manager, OCO-2 Mission
Jet Propulsion Laboratory

Michael Gunson — for MRG — Date: 24 AUG 2010
Project Scientist, OCO-2 Mission
Jet Propulsion Laboratory

Diane Evans — Date: 31 Aug '10
Director, Earth Science and Technology Directorate
Jet Propulsion Laboratory

Jim Wells — Date: 26 Aug 2010
Mission Manager, Earth System Science Pathfinder Program Office
NASA Langley Research Center

Ken Jucks — Date: 7 Sep. 2010
Program Scientist
Science Mission Directorate, NASA Headquarters

Eric Ianson
Program Executive
Science Mission Directorate, NASA Headquarters

Date: 8/25/10

Stephen Volz
Associate Director for Flight Programs, Earth Science Division
Science Mission Directorate, NASA Headquarters

Date: 9/8/2010

Michael Freilich
Director, Earth Science Division
Science Mission Directorate, NASA Headquarters

Date: 15 Sept 2010

Kenneth W. Ledbetter
Science Directorate Chief Engineer
Office of the Chief Engineer, NASA Headquarters

Date: 9/12/10

Mike Luther
Deputy Associate Administrator for Programs
Science Mission Directorate, NASA Headquarters

Date: 9/20/10

Chuck Gay
Deputy Associate Administrator
Science Mission Directorate, NASA Headquarters

Date: 9/23/10

K.3 OCO-2 COMMITMENT BASELINE

NASA SMD Program Management Council
Project KDP Decision Agreement

Summary: The Science Mission Directorate Program Management Council met on September 24, 2010 and evaluated the Orbiting Carbon Observatory – 2 (OCO-2) project's Key Decision Point C of the life cycle as defined in NASA Procedural Requirement 7120.5: Space Flight Program and Project Management Requirements. The DPMC determined that the project is ready to proceed to Phase C.

Decision: Based on this review and the project readiness documents, the Decision Authority for the OCO-2 project grants approval for the project's Phase C with the content, schedule, and cost profile specified in the attached summary and reflected in Table 1, below. The OCO-2 project has significantly leveraged the experience from OCO and has been funded appropriately (both total LCC and phasing) to put the project an excellent position to succeed. This decision includes the actions specified below.

Table 1: KDP-C Cost and Schedule Baseline Commitments

	Management (Internal to Project)[1]	**Agency Baseline Commitment** (Reported External to NASA)[2]
Cost – LCC (Phases A through F) Commitment	$325.9M	$349.9M
Cost – Development (Phases C & D) Commitment	$227.0M	$249.0M
Schedule (LRD)	February 2013	February 2013
Years/Months of Operations	24 months	24 months
Joint Confidence Level (Cost and Schedule)	>50%	>70%

Notes:
- The JCL was performed for Phases C & D, excluding project managed Unallocated Future Expenses (UFE), JPL fees, launch services, and low-level fixed cost activities at GSFC (Exploration and Space Communications, EOS Data and Operations System, Flight Dynamics Facility, and NASA Integrated Services Network)
- The Development Commitment includes all activities for Phases C & D
- Months of operation is after the In-Orbit Checkout (IOC) Period

[1]Includes the UFE and schedule margin to be managed by the project, project labor, and project CoF.
[2]Includes all project UFE and schedule margin, including UFE and margin to be managed above the project. Also includes legacy indirect costs.

Concurrence

Project/Mission Manager	Date 9/24/2010	Program Executive	Date 9/24/10
Program Manager	Date 24 Sept 2010	Center Director	Date 9.24.10
SMD Division/Theme Director	Date 9/24/10	Chief Financial Officer designee	Date 9/24/10
Chief Engineer designee	Date 9/24/10		

Approval

MD Associate Administrator — Date 9-24-10

During formulation, the Project Manager agrees that the ensuing phase can be completed within the Management commitment. During implementation, the Project Manager agrees that the project lifecycle can be completed within the

Management commitment; the Program Manager and Mission Directorate agree that the Project can be completed within the External (External to NASA) Commitment as listed in the right column in the table above.

Appendix L Airborne Microwave Observatory of Subcanopy and Subsurface (AirMOSS)

L.1 AIRMOSS DESCRIPTION

North American ecosystems are critical components of the global carbon cycle, exchanging large amounts of carbon dioxide and other gases with the atmosphere. Root-zone soil measurements can be used to better understand these carbon fluxes and their associated uncertainties on a continental scale. The goal of the Airborne Microwave Observatory of Subcanopy and Subsurface (AirMOSS) investigation is to provide high-resolution observations of root-zone soil moisture over regions representative of the major North American climatic habitats (biomes), quantify the impact of variations in soil moisture on the estimation of regional carbon fluxes, and extrapolate the reduced-uncertainty estimates of regional carbon fluxes to the continental scale of North America.

AirMOSS will use an airborne ultra-high frequency synthetic aperture radar to penetrate through substantial vegetation canopies and soil to depths down to approximately 1.2 meters. For AirMOSS, NASA's Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR) will be flown on a Gulfstream-III aircraft. Extensive ground, tower, and aircraft in-situ measurements will validate root-zone soil measurements and carbon flux model estimates. The surveys will provide measurements at 100 meter spatial resolution and at sub-weekly, seasonal, and annual time scales.

AirMOSS responds directly to challenges set down by the NASA Carbon Cycle Science and the North American Carbon Program. Additionally, AirMOSS data provide a direct means for validating root-zone soil measurement algorithms from the Soil Moisture Active & Passive (SMAP) mission and assessing the impact of fine-scale heterogeneities in its coarse-resolution products.

The UAVSAR instrument operating for the first time at UHF band will provide measurements of root zone soil moisture, net ecosystem exchange, CO_2, CH_4, H_2O, soil moisture, temperature and water potential profile. The tower sites will use Fluxnet sensors and provide soil moisture, temperature, vegetation characteristics and water and carbon flux. The in-situ aircraft instrument will be the Piccaro spectrometer, which will measure CO_2, CH_4, and H_2O. Tower and aircraft instruments have been used in numerous missions over several years.

The PI is from the University of Michigan, Ann Arbor, and JPL is responsible for project management.

Cost: $25.9M over five years (2010-2015)

Appendix M Airborne Tropical Tropopause Experiment (ATTREX)

M.1 ATTREX DESCRIPTION

Stratospheric water vapor has large impacts on the Earth's climate and energy budget. Future changes in stratospheric humidity and ozone concentration in response to changing climate are significant climate feedbacks. While the tropospheric water vapor climate feedback is well represented in global models, predictions of future changes in stratospheric humidity are highly uncertain because of gaps in our understanding of physical processes occurring in the region of the atmosphere that controls the composition of the stratosphere, the Tropical Tropopause Layer. Uncertainties in the Tropical Tropopause Layer region's chemical composition also limit our ability to predict future changes in stratospheric ozone. By improving our understanding of the processes that control how much water vapor gets into this region from lower in the atmosphere, the ATTREX investigation will directly address these uncertainties in our knowledge of the climate system.

The proposed instruments will provide measurements to trace the movement of reactive halogen-containing compounds and other important chemical species, the size and shape of cirrus cloud particles, water vapor, and winds in three dimensions through the Tropical Tropopause Layer. In particular, bromine-containing gases will be measured to improve our understanding of stratospheric ozone. ATTREX will consist of four NASA Global Hawk Uninhabited Aerial System (UAS) campaigns deployed from NASA's Dryden Flight Research Center (DFRC) in Edwards, CA, Guam, Hawaii, and Darwin, Australia taking place in Boreal summer, winter, fall, and summer, respectively.

The proposed investigation fills several significant gaps in atmospheric science identified in the 2007 Decadal Survey involving climate change, stratospheric ozone, and stratosphere-troposphere exchange.

ATTREX uses a Cloud Physics LIDAR (CPL) to provide aerosol/cloud backscatter. The ATTREX instrument is a copy of one which first deployed in 2000 and is currently awaiting its first flight. An absorption photometer measures ozone and has flown on several WB-57 missions. An Advanced Whole Air Sampler (AWAS) measurers tracers with varying lifetimes and will need to be modified for this series of missions. A UAS Chromatograph for Atmospheric Trace Species (UCATS) measures O_3, CH_4, N_2O, SF_6, H_2O, and CO and has flown on multiple missions. A Picarro Cavity Ring-Down Spectrometer (PCRS) will measure CO and CO_2. The hardware flew as a prototype in 2009 and is considered to be TRL 7 and 8. A UAS Laser Hygrometer (ULH) and a Diode Laser Hygrometer (DLH) measure H_2O. The DLH has flown for 15 years while the ULH predecessor flew in 2007. Hawkeye measures ice crystal properties. The Solar Spectral Flux Radiometer (SSFR) measures radiation fluxes and has flown on many missions. The Meteorological Measurement System (MMS) measures temperature and winds and has flown for two decades. The Microwave Temperature Profiler (MTP) measures temperature profile and has flown on five airborne platforms, but has not yet flown on Global

Hawk. The Differential Optical Absorption Spectrometer (DOAS) measures BrO_3^-, NO_2, OClO, and IO and is a new instrument.

The PI is from Ames Research Center (ARC), and ARC is responsible for project management.

Cost: $29.3M over five years (2010-2015)

Appendix N Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE)

N.1 CARVE DESCRIPTION

The carbon budget of Arctic ecosystems is not known with confidence since fundamental elements of the complex Arctic biological-climatologic-hydrologic system are poorly quantified. CARVE will collect detailed measurements of important greenhouse gases on local to regional scales in the Alaskan Arctic and demonstrate new remote sensing and improved modeling capabilities to quantify Arctic carbon fluxes and carbon cycle-climate processes. Ultimately, CARVE will provide an integrated set of data that will provide unprecedented experimental insights into Arctic carbon cycling.

CARVE will use the Arctic-proven De Havilland DHC-6 Twin Otter aircraft to fly an innovative airborne remote sensing payload. It includes an L-band radiometer/radar and a nadir-viewing spectrometer to deliver the first simultaneous measurements of surface parameters that control gas emissions (i.e., soil moisture, freeze/thaw state, surface temperature) and total atmospheric columns of carbon dioxide, methane, and carbon monoxide. The aircraft payload also includes a gas analyzer that links greenhouse gas measurements directly to World Meteorological Organization standards. Deployments will occur during the spring, summer, and early fall when Arctic carbon fluxes are large and change rapidly. Further, at these times, the sensitivities of ecosystems to external forces such as fire and anomalous variability of temperature and precipitation are maximized. Continuous ground-based measurements provide temporal and regional context as well as calibration for CARVE airborne measurements.

CARVE science fills a critical gap in Earth Science knowledge and satisfies high priority objectives across NASA's Carbon Cycle & Ecosystems, Atmospheric Composition, and Climate Variability & Change focus areas as well as the Air Quality and Ecosystems elements of the Applied Sciences program. CARVE complements and enhances the science return from current NASA and non-NASA satellite sensors.

A Passive Active L-band System (PALS) provides measurements of soil moisture, inundation state, surface freeze-that state and surface temperature and has been flying since 1998. A Tsukuba airborne Fourier Transform Spectrometer (FTS) measures the total column of CO_2, CH_4 and CO. An In situ Gas Analyzer (ISGA) provides measurements of CO_2, CH_4 and CO and was demonstrated in the Balanço Atmosférico Regional de Carbono na Amazôni (BARCA) campaign. A Programmable Flash Pack (PFP) provides CO_2, CH_4 and CO. Both the ISGA and the PFP are COTS instrumentation.

The PI is from JPL, and JPL is responsible for project management.

Cost: $27.9M over five years (2010-2015)

Appendix O Deriving Information on Surface Conditions from Column and Vertically Resolved Observations Relevant to Air Quality (DISCOVER-AQ)

O.1 DISCOVER-AQ DESCRIPTION

The overarching objective of the DISCOVER-AQ investigation is to improve the interpretation of satellite observations to diagnose near-surface conditions relating to air quality. To diagnose air quality conditions from space, reliable satellite information on aerosols and ozone precursors needs to be compared to surface- and aircraft-based measurements at highly-correlated times and locations. DISCOVER-AQ will provide an integrated dataset of airborne and surface observations relevant to the diagnosis of surface air quality conditions from space.

DISCOVER-AQ will provide systematic and concurrent observations of column-integrated, surface, and vertically-resolved distributions of aerosols and trace gases relevant to air quality as they evolve throughout the day. This will be accomplished with a combination of two NASA airborne platforms (B-200 and P-3B) sampling in coordination with re-locatable and fixed surface networks. One aircraft will be used for extensive in-situ profiling of the atmosphere while the other will conduct both passive and active remote sensing of the atmospheric column extending below the aircraft to the surface. These aircraft will repeatedly overfly instrumented surface locations continuously monitoring both column and surface conditions for select variables throughout the day.

DISCOVER-AQ will focus on NASA's goals to study the Earth from space to increase fundamental understanding and to enable the application of satellite data for societal benefit. DISCOVER-AQ aligns with priorities for both the Atmospheric Composition Focus Area and the Applied Sciences Air Quality Program at NASA. Fundamentally, DISCOVER-AQ will provide data needed to critically examine the ability to determine surface air quality conditions from space.

The P-3B in-situ trace gas measurement techniques are: thermal disassociation, laser induced fluorescence, chemiluminescence, IR absorption spectrometer, LI-COR 6252, diode laser spectrometer, and hygrometer and proton transfer reaction-mass spectrometer. Measurements are NO_2, peroxynitrates, alkyl nitrates, HNO_3, O_3, NO_x, CH_2O, CO_2, CO, CH_4, H_2O, methanol, acetaldehyde, acetone, isoprene, acetonitrile, benzene, toluene, C8 aromatics, and C9 aromatics.

The P-3B airborne in situ aerosol measurement techniques are: condensation particle counter, mobility particle sizers, Droplet Measurement Technologies (DMT) spectrometer, optical particle counter, aerodynamic particle sizer, condensation nuclei counter, nephelometer, soot absorption photometer, Radiance Research (RR) nephelometer, DMT particle soot photometer, particle into liquid sampler chromatograph and total organic carbon. Measurements are ultrafine NV CN; particle size; CN spectra; scattering at 450, 550, and 700nm; absorption at 467, 530, and 660 nm; humidity dependence of scattering; black carbon; soluble ion composition; and water soluble organic carbon.

The P-3B meteorological measurements are: pressure, wind speed, ground speed, temperature, dew/frost point, and NO_2 photolysis frequency.

The ground station instruments are: Pandora, Cleo, and Native. The measurements are: O_3 total column, NO_2, CH_2O, SO_2, H_2O, BrO, O_3 profile, NO_2 profile and aerosol properties.

The B-200 remote sensing instruments are: High Spectral Resolution LIDAR (HSRL) and Airborne Compact Atmospheric Mapper (ACAM). The measurements are: aerosol backscatter at 532 and 1064 nm, aerosol extinction at 532 nm, aerosol optical depth at 532 nm, O_3, NO_2, and CH_2O.

All instrumentation is in the TRL-9 category and has a flight heritage of a decade or longer.

The PI is from LaRC, and LaRC is responsible for project management.

Cost: $30.0M (2010-2015)

Appendix P Hurricane and Severe Storm Sentinel (HS3)

P.1 HS3 DESCRIPTION

Close to 100 million Americans now live within 50 miles of a coastline, thus exposing them to the potential destruction caused by a land-falling hurricane. While hurricane track prediction has improved in recent decades, improvements in hurricane intensity prediction have lagged, primarily as a result of a poor understanding of the processes involved in storm intensity change. The Hurricane and Severe Storm Sentinel (HS3) is a five-year project targeted to enhance our understanding of the processes that underlie hurricane intensity change in the Atlantic Ocean basin. HS3 will determine the extent to which either the environment or the processes internal to the storm are significant to intensity change.

The investigation objectives will be achieved using two Global Hawk (GH) Uninhabited Aerial Systems (UAS) with separate comprehensive environmental and over-storm payloads. The high Global Hawk flight altitudes allow over-flights of most vertical storm convection and sampling of upper-tropospheric winds. Deployments from NASA's Wallops Flight Facility and 30-hour flight durations will provide access to unrestricted air space, coverage of the entire Atlantic Ocean basin, and on-station times up to 10-24 hours depending on storm location. Deployments will be from mid-August to mid-September 2012-2014, with ten 30-hour flights per deployment, providing an unprecedented and comprehensive data set for approximately nine to twelve hurricanes.

HS3 is focused on the fundamental NASA Earth Science goal to "Study Earth from space to advance scientific understanding and meet societal needs" and NASA's Research Objective to "enable improved predictive capability for weather and extreme weather events." HS3 complements NASA's Weather Focus Area and Hurricane Science Research Program.

A Scanning High-resolution Interferometer Sounder (S-HIS) will provide temperature and relative humidity and has flown on four different platforms since 1998. A Tropospheric Wind LIDAR Technology Experiment (TWiLiTE) Doppler LIDAR will provide continuous wind profile and is building a new telescope under the ESTO Program to fit within the GH compartment. An Airborne Vertical Atmosphere Profiling System (AVAPS) dropsonde will provide wind, temperature and humidity profiles and has been used for several decades. A CPL will provide aerosol and cloud layer vertical structure and was first deployed in 2000. A High-Altitude Imaging Wind and Rain Airborne Radar (HIWRAP) scanning Doppler radar will provide 3-D wind and precipitation fields and was designed for GH in 2007. A Hurricane Imaging Radiometer (HIRAD) hurricane imaging multi-frequency interferometric radiometer will provide surface winds and rainfall and is based on the stepped frequency microwave radiometer (SFMR) and flies on the WB-57 at the end of 2009. A High Altitude MMIC sounding radiometer (HAMSR) will provide temperature, water vapor, liquid water profiles, total precipitated water, sea surface temperature, and vertical precipitation profiles first flew in 2001.

The PI and the relevant Center Management Council are at GSFC; the Project Manager and project management responsibilities are at ARC.

Cost: $29.7M over five years (2010-2015)

Appendix Q Future EV Projects

Q.1 PROJECTS DESCRIPTION

The 2007 Decadal Survey first characterized the Venture class missions, describing them as follows:

> *"Priority would be given to cost-effective, innovative missions rather than those with excessive scientific and technological requirements. The Venture class could include stand-alone missions that use simple, small instruments, spacecraft, and launch vehicles; more complex instruments of opportunity flown on partner spacecraft and launch vehicles; or complex sets of instruments flown on suitable sub-orbital platforms to address focused sets of scientific questions. These missions could focus on establishing new research avenues or on demonstrating key application-oriented measurements. Key to the success of such a program will be maintaining a steady stream of opportunities for community participation in the development of innovative ideas, which requires that strict schedule and cost guidelines be enforced for the program participants."*

In response to this recommendation, NASA established the EV portfolio of investigations and assigned the investigations to the ESSP Program. The EV-1 NRA was released during 2009 and five proposals were selected during 2010 (see Appendices L through P.)

Future EV investigations will be competed annually (depending on funding) and are broadly categorized as either Orbital, Sub-orbital or Instrument investigations.

- Orbital: EV Orbital investigations are stand-alone investigations that use simple, small instruments, spacecraft, and launch vehicles. EV five-year orbital investigations will be competed every four years, and will be cost-capped at approximately $150M. The Announcement of Opportunity (AO) procurement process is expected to occur in two steps, where the first step narrows the field to three offerors and the second step competitively down-selects to a single selection.

- Sub-orbital: EV Sub-orbital five-year investigations are composed of complex sets of instruments flown on suitable sub-orbital platforms to address focused sets of scientific questions. EV sub-orbital investigations will be competed every four years, and will be cost-capped at approximately $150M total for up to five selections. Each individual selection will be cost-capped at approximately $30M, and the NRA procurement process is expected to occur in one step.

- Instrument: EV Instrument investigations are composed of more complex instruments of opportunity flown on partner spacecraft and launch vehicles. EV instrument investigations will be competed every year, and will be cost-capped at approximately $90M total. The Stand-Alone Mission of Opportunity Notice (SALMON) procurement process will occur in one step, resulting in one or more selections. Each selection will be for a duration of five years, which does not include flight operations or science data activities.

Table Q-1 details the schedule for EV solicitations during the next several years.

Table Q-1: Future EV Projects Development

EV Name	Type	Solicitation	Selection	Launch/Delivery
EV-2	Full Orbital	2011	2012	LRD ~2017
EV-I1	Instrument Only	2011	2012	Del ~2016
EV-I2	Instrument Only	2012	2013	Del ~2017
EV-3	Sub-orbital	2013	2014	
EV-I3	Instrument Only	2013	2014	Del ~2018
EV-I4	Instrument Only	2014	2015	Del ~2019
EV-4	Full Orbital	2015	2016	LRD ~2021
EV-I5	Instrument Only	2015	2016	Del ~2020
EV-I6	Instrument Only	2016	2017	Del ~2021
EV-5	Sub-orbital	2017	2018	

Appendix R Functional Assignments for ESSP Personnel

Table R-1: ESSP Management Responsibilities

Assignment	ESSP Program Office	ESD	Notes
Communicate Project performance issues and risks to Mission Directorate management and present recovery plans.		X	Program Office communicates issues and risks to ESD management. ESD has the lead to communicate Project issues to SMD AA. The Program Office supports ESD as needed in reporting to the SMD AA.
Conduct planning, etc. to support the SMD AA in initiating the project selections process.		X	ESD has the lead to work Phase A. ESD works directly with the SMD AA in implementing the project selection process. The Program Office supports the selection process as directed by ESD, such as performing studies to assess the announcement release dates, putting contract in place, shadowing the selection process for understanding risk, etc.
Manage program resources.		X	ESD controls the program futures line. Program Office controls Program Office budget to conduct oversight activities.
Maintain programmatic oversight of the Projects and report their status periodically.	X	X	Program Office provides programmatic oversight of Projects. Program Office provides weekly notes and monthly report to ESD. ESD provides programmatic oversight of the Program and the PEs report status of projects at the Flight Projects Review.
Provide KDP recommendation on Projects to AA per NPR 7120.5	X	X	Program Office provides a Program Office recommendation to the AA at KDPs B to F. ESD provides Division recommendation at KDPs A to F.
Manage/direct Program contracts/task orders.	X	X	Program Office function. Program Office manages and directs Program contracts and task orders with Projects. ESD Program Executive signs JPL task plans.
Provide programmatic direction to ESSP Projects.	X		Program Office has authority to issue direction to the Projects as needed. Program Office should make ESD aware of direction as appropriate.

Assignment	**ESSP Program Office**	**ESD**	**Notes**
Serve as NASA Point of contact ESSP Projects.	X		Actions and direction to the Projects come from the Program Office. PE/PS/PA and ESSP MMs should work as a team to coordinate communication with Projects. The PE/PS/PA may contact the Project directly, but will keep the appropriate MM informed.
Assess/monitor Project performance and take action, as appropriate, to mitigate risks.	X		Program Office has authority to take action or provide Project direction to mitigate risks. Program Office should make ESD aware of direction, as appropriate.
Conduct monthly review with Projects	X		Where there are existing meetings and forums that the Program Office can leverage, the Program Office will take advantage of these. If the Program Office is not receiving all needed information, a mechanism for receiving such information will be established.
Establish Project technical, schedule and cost status reporting.	X		Program Office has the lead to establish appropriate level and content of Project reporting to the Program and will coordinate with the PE/PS/PA to ensure their requirements are captured.

Table R-2: ESSP Technical Responsibilities

Assignment	**ESSP Program Office**	**ESD**	**Notes**
Communicate Project technical issues and risks with recovery plans to the SMD AA.		X	Program Office communicates through ESD. ESD has lead role to communicate with the SMD AA.
Perform technical evaluation of proposed mission concepts.		X	ESD performs this using Phase A TMCO process. Pre-solicitation release, Program Office is supporting this activity. Post-solicitation release Program Office is observing.
Direct institution to perform technical evaluation of a Project within the Program.	X		Program Office function

Assignment	ESSP Program Office	ESD	Notes
Perform Program acceptance of resolution of high risk Project technical issues.	X		Program Office has authority to conduct reviews and accept Project technical assessments within the baseline. Program Office briefs ESD management on Program Office review and acceptance. Program Office to coordinate when "high risk" requires ESD management prior to acceptance.
Direct Project to perform special studies of high risk issues.	X		Program Office function
Independently assess Project for technical risk.	X		Program Office function
Maintain technical oversight of the Projects.	X		Program Office function

Table R-3: ESSP Schedule Responsibilities

Assignment	ESSP Program Office	ESD	Notes
Assess Program schedule performance.		X	Program Office provides inputs (such as launch frequency assessments) to ESD. ESD conducts final evaluation of Program schedule performance.
Control Level 1 Project Milestones.		X	This is performed through the Program-Level Requirements Appendix to the Program Plan. Program Office provides inputs. SMD performs final approval.
Establish/recommend Program Schedule Milestones (Announcement release, Project timing, etc.)	X	X	Program Office performs studies of funding availability against Program cost threats and projected new Project cost profiles, and provides recommendations to ESD as to program-level schedule. ESD establishes final program-level milestones (i.e. announcement release dates).
Assess monthly Project schedule performance.	X		Program Office function
Assess Project schedule for overall implementation strategy and credibility.	X		Program Office function

Assignment	ESSP Program Office	ESD	Notes
Establish/control significant Project schedule milestones.	X		Program Office coordinates with Project and approves milestone dates which are not Level 1-controlled PLRA.

Table R-4: ESSP Cost Responsibilities

Assignment	ESSP Program Office	ESD	Notes
Program budget strategic planning.		X	ESD function. Program Office supports.
Final decisions and recommendations to SMD AA.		X	ESD function
Assess program-level cost performance.		X	ESD leads this function. Program Office supports with data and analysis.
Manage Program reserves.	X		Program Office controls Program reserves. ESD approves Program reserves line.
Assess total Program liens and threats.	X		Program Office identifies and assesses Project and Program liens and threats related to Project implementation.
Establish funding priorities between Projects.		X	ESD makes final decisions. Program Office has involvement and input into establishing priorities.
Perform Risks and Trades analysis of Program budget impacts.	X		Program Office performs analysis using ESD supplied guidelines and cost data.
Perform cost studies to recommend announcement release timing or project start dates.	X		Program Office function
Perform independent cost evaluation of poor performing projects.	X		Program Office function
Independently assess project for liens and threats, track those with program impacts.	X		Program Office function. Program Office provides assessments to ESD.
Review and approve annual project budget submission to ESD.	X		Program Office function
Gather project data and PPBE inputs.	X		Program Office function
Assess monthly cost performance.	X		Program Office function

Table R-5: ESSP Risk Responsibilities

Assignment	**ESSP Program Office**	**ESD**	**Notes**
Accept Program risks.		X	ESD function. Program Office provides assessment and recommendations.
Perform program-level risk assessment and conduct activities to mitigate.	X		Program Office function.
Utilize Program resources to assist in mitigation of Project risks	X		Program Office function. Program Office uses combination of existing office core support staff and modulated technical support to assist Project in mitigating risks and reserves.
Accept Project risks.	X		Program Office has authority to review and accept risks within the baseline. Program Office briefs ESD management as appropriate. Program Office uses discretion on when "high risk" requires coordination with ESD management prior to acceptance.
Independently assess Projects for risks.	X		Program Office function
Assess adequacy of Project risk mitigation plans.	X		Program Office function

Appendix S Project Information Needed for Monthly Assessments and Reporting

(As of the end of the monthly period; where appropriate for schedule or trend, show current at middle of 12-month period; variance explanation required for ≥±10% variation)

- Schedule
  - 3 shortest critical paths
  - Schedule slack vs. plan trend and variance explanation
  - Progress vs. plan for meeting critical milestones and variance explanation
  - Scheduled events completed vs. planned and variance explanation
  - New vendor/contractor deliveries vs. plan and variance explanation
- Technical
  - Performance measurement trends
  - Deviations and waivers submitted, approved
  - Newly opened and closed action items
  - New documents available vs. plan
  - Documents or drawings released vs. plan
  - CBE vs. allocation for major project elements and margin vs. plan for mass, power, data, CPU, etc.
- Financial
  - Earned Value
  - Estimate to complete
  - Cost variance; commitments, obligations and costs vs. plan and variance explanation
  - Total at completion and variance explanation
  - Outstanding new liens and encumbrances
  - Reserve funds available vs. used
  - Funding available vs. plan
  - Provide WBS breakdown of cost accruals, obligations, and commitments period when variance for total project first exceeds ± 10% and for succeeding periods until all WBS breakdowns indicate variance of less than ± 5%
  - For first period when a new plan (baseline) is used, provide monthly projection of total Project cost accrual, obligations, and commitments to Project completion along with explanation for any anticipated variance from current contract value of 5% at completion.
- Risk
  - 5 × 5 matrix
  - New or revised individual risk descriptions
  - New mitigation effort plans
  - New top 10 risks items
- Staffing
  - Complement onboard vs. plan and explanation of variance
- SMA
  - New and closed problem/failure reports
  - Identifying government mandatory inspection points for next period

- Number of material inspections planned vs. completed for period
- Number of MRB actions completed per period and number pending for next period
- Number of deviations and waivers initiated for period vs. number approved vs. number recycled for revisions
- Number of planned vs. completed audits/assessments and open vs. closed findings

- Science
  - Days of new raw data available vs. plan
  - Days of new Level 1 product available vs. plan
  - Days of raw and processed data into archive vs. plan
  - Completed coding lines of code vs. plan
  - Completed testing/validation lines of code vs. plan
- Other
  - CCNs submitted and completed
  - Contractor new concerns/issues
  - Contract new modifications
  - New contracts vs. plan and variance explanation
  - Support readiness/issues of other organizations
  - New threats to Level 1 requirements
  - Pending near term key events
  - New Lessons Learned documents
  - New dissents in work
  - New documents baselined vs. plan and variance explanation
- Project Manager’s Assessment
  - G,Y,R assessment for Technical, Cost, Schedule, Risk, Programmatic, Overall
  - Significant accomplishments
  - Significant new status
  - New Problems

Appendix T ESSP Management Approach for EV-1 Projects

The EV-1 Projects are managed by the ESSP Program Office. The primary goal of the ESSP Program Office is to facilitate Project success. This is accomplished by continually assessing risks to ensure project-level processes and practices are commensurate with NASA investment and risk tolerance. The ESSP Program Office also provides technical expertise to assess ESSP Project risk and performance, identifies and realizes synergistic opportunities across Projects, advocates for Projects, and works closely with HQ on behalf of the Projects.

The term "Projects" is used to describe these activities. However, the management approach of EV-1 applies NPR 7120.8, as well as best practices from the sub-orbital community, the implementing Centers and NPR 7120.5. The ESSP Program Office will provide guidance on review plans, practices and procedures, and the Projects shall propose plans that will be assessed by the ESSP Program Office to ensure they are commensurate with the NASA investment and risk tolerance.

An ITA is the required mechanism for agreement between Center PIs and the ESSP Program Office to release funds to the NASA implementing Centers. Agreements with JPL PIs will be in the form of Task Plans. Agreements with University PIs will be in the form of contracts. For agreements within the Project Team, the ESSP Program Office will have funds transferred to FFRDCs, other Centers and other agencies, but the PI is responsible for developing and finalizing all agreements between the PI and the implementers.

Each EV-1 Project is cost capped and schedule constrained, so management of cost, schedule, reserves and de-scopes is critical. The overall schedule and budget reserves and de-scope options are identified in its selection proposals. The PI has two choices for managing reserves: (1) to manage all project-level reserves as proposed in his/her selection proposal or (2) to keep the reserves at ESD and potentially "pool" those reserves with other PIs. For EV-1 Projects where the PI is not at the same institution as the implementing organization, the reserves are to be held at ESD until direction from the PI to disperse those funds is received. The PI may choose when during the project life cycle to disperse those funds to the implementing organization. When de-scopes are indicated, the ESSP Program Office assesses them against the mission success criteria and minimum mission success criteria. At the Investigation Concept Review (ICR), the ESSP Program Office assesses the cost and schedule along with the cost/schedule reserves and descope options. The Programmatic Baseline will be approved at KDP C. The ESSP Program Office continually monitors progress through weekly, monthly, and quarterly reports/meetings/telecons. If at any time the projected cost exceeds the cost cap, or minimum Level 1 requirements are not being met, the Program Manager may recommend a Termination Review to the SMD AA.

The PI shall support weekly telecons with the ESSP Program Office to focus on tasks, progress, and issues. The PI shall provide monthly reports to the ESSP Program Office and conduct monthly status review meetings that the ESSP Program Office will attend. These monthly meetings may be held in conjunction with Center management meetings, if deemed appropriate. In addition to the monthly meeting, there are quarterly face-to-face meetings held among the PI, PS, and the ESSP Program Office to discuss science and programmatic strategic planning that will assure successful completion of Level 1 requirements. The PI or the ESSP Program Office may convene ad hoc meetings when needed.

Monthly reports shall include but are not limited to:

- Technical Performance
    - Major Accomplishments
    - Science Status
    - Top ten problems status
    - Risks and risk mitigation status
- Schedule performance
    - Schedule progress at WBS level 3
    - Schedule slack status
    - Schedule reserve status
    - Schedule variance and explanation
- Financial
    - Funding Status
    - Cost Performance at WBS level 3
    - Funding actual vs. planned (committed, obligated and costed)
    - Variance explanations
    - Funding reserve status – Liens & encumbrances
- Programmatic
    - Contractor concerns/issues
    - Staffing, and variance explanations
    - Facility/Asset status report – discuss status of facilities, airborne assets, instruments and other necessary assets or equipment
    - Other

The ESSP Program Office will provide guidance on the EV-1 Projects review process (derived from NPR 7120.8 and EV-1 NRA). The PI shall develop a plan based on this guidance, and the plan will be reviewed for approval by the ESSP Program Office.

There will be an IRT that assesses the EV-1 Projects at life cycle reviews. The Chair for this IRT will be nominated by the ESSP Program Office and approved by the SMD AA. The IRT Chair and the ESSP Program Office will document the planned interaction with the Projects in a ToR. The remaining review team members will be nominated by the ESSP Program Office and the Chair and then approved by the SMD AA. This Review Team may participate in the Projects' internal reviews and will be in place for the Investigation Concept Review.

The Level 1 Requirements will be developed among the PI, PS, PE, and the ESSP Program Office. The Level 1 Requirements will identify the minimum mission success criteria and full mission success criteria in order to assess de-scope options.

The EV-1 Projects shall use a documented process to identify risks, assess likelihood and consequence, and develop mitigation plans. Significant risks will have mitigation plans which will be reviewed monthly by the ESSP Program Office.

Appendix U Education and Public Outreach Policy

Science Mission Directorate Policy

Policy and Requirements for the
Education and Public Outreach Programs of SMD Missions

SMD Policy Document SPD-18

Recommended by SMD Science Management Council, January 28, 2010
Approved by SMD Associate Administrator, Edward J. Weiler, January 28, 2010

Responsible SMD Official: SMD Lead for Education and Public Outreach

1. Overview

1.1 Principles

SMD requires that all missions have robust and substantial education and public outreach (E/PO) programs. These E/PO programs must be consistent with SMD's principles for mission E/PO:

- SMD missions must have an E/PO program that supports NASA's strategic goals and objectives for education and outreach, contributes to NASA's education portfolio, and is aligned with SMD's E/PO portfolio.
- SMD missions must have an E/PO program whose quality has been demonstrated through independent, external review and assessment.
- SMD missions must have an E/PO program that is funded with at least 1% of the total prime mission cost excluding launch vehicle.
- SMD missions will designate an E/PO Lead who has the qualifications and experience necessary to successfully implement the mission's E/PO program.
- SMD missions will partner with NASA and non-NASA organizations as appropriate in order to increase the quality and reach of the E/PO program.

1.2 Rationale for Mission E/PO Requirements

The SMD E/PO lead is required to report on the SMD E/PO portfolio and show that it aligns with the NASA Education portfolio. The Lead is responsible for reporting E/PO metrics for SMD and reporting how SMD E/PO funding is contributing to the NASA Education portfolio's outcomes and objectives. This reporting is a component of NASA's PART measures that are required by OMB. This responsibility cannot be delegated to the Programs or the Centers.

1.3 Management Handbook

The governing project requirements (NPR 7120.5, SMD Management Handbook) are incomplete in specifying how such E/PO programs will be approved, managed, and reviewed. This document supplements NPR 7120.5 and the SMD Management Handbook in order to provide the necessary policies and requirements.

The requirements in this document are added to the KDP checklists in the SMD Management Handbook.

2. Requirements

2.1 Management requirements

(a) SMD missions must designate an E/PO Lead (or point of contact) responsible for developing and implementing the Mission E/PO program. The mission E/PO Lead must report E/PO activities, progress, and accomplishments to the SMD Division E/PO Lead. This reporting may be through a designated member of the mission project management team, e.g. the PI or project scientist.

(b) SMD missions must have an E/PO plan that addresses NASA and SMD E/PO goals and objectives, draws from the mission's science and technical content, and is aligned with NASA and SMD E/PO portfolio. The mission E/PO plan must be approved by the SMD Science Division Director and SMD Lead for E/PO.

(c) SMD Science Divisions may provide additional requirements or guidelines according to their needs.

(d) In the case of a tightly focused program of strategic missions, the SMD Science Division Director may recommend that E/PO leadership and planning for all missions in the program be delegated to the Program Office. Such delegation requires concurrence by the SMD Lead for E/PO and approval by the SMD AA. The Program Office is required to meet all E/PO management/planning and reporting requirements for all missions in the program. In addition the Program Office is required to submit an E/PO PPBE annually.

(e) Additional policy guidelines for AO-selected missions. AOs provide the initial guidance for the E/PO policies governing PI-led missions or PI-led instrument investigations. Default policies are

- PI-led missions will allocate at least 1% of the PI-managed mission cost cap to the core E/PO program. No E/PO plan is due with the Step 1 proposal. An initial E/PO plan including identification of an E/PO lead is due with the Step 2 Concept Study Report (CSR). Student collaborations, while encouraged, are not considered part of the core E/PO program.
- PI-led instrument investigations will not generally have independent core E/PO programs. Selected instrument teams will participate in the mission E/PO program. Activities will be negotiated after selection and the funding for E/PO activities will come from the mission E/PO budget, not the instrument team budget.
- With approval by the SMD AA, AOs may have different policies from these default policies.

SMD may levy E/PO requirements on AO-selected PI-led missions and instruments beyond those in the AO. For instance, for missions selected from AOs with an E/PO requirement of less than 1%, SMD can provide additional funding to accompany a requirement that E/PO spending be raised from the AO's minimum to 1%.

2.2 Funding requirements

(a) SMD missions must have an E/PO program that is funded with at least 1% of the total prime mission cost excluding launch vehicle. Exceptions require approval by the SMD AA.

(b) The E/PO budget is fenced off from the rest of the project budget. Reductions to the approved E/PO budget require the concurrence of the SMD E/PO Lead and the SMD Science Division Director.

(c) SMD mission E/PO budgets must be distributed throughout the mission development and operation phases. No E/PO funding will be available before KDP-C except for the nominal funding required to develop the E/PO plan. No more than 35% of E/PO funding (through prime mission) may be allocated before launch; at least 65% of the budget must be allocated for Phase E. Exceptions require approval by the SMD Science Division Director and SMD Lead for E/PO.

(d) For SMD missions that were Confirmed prior to the effective date of this Policy and do not meet the minimum funding requirement, the Division can provide additional funding to accompany a requirement that E/PO spending be raised from the AO's minimum to 1%.

3. Reporting, Review, and Approval

3.1 Development and Approval of the Mission E/PO Plan

(a) The preliminary E/PO plan must be developed during Phase A. Review and comment (not approval) of the initial E/PO plan is a KDP-B gateway product. Review and comment is provided by the Division E/PO lead. For missions downselected through a competitive Phase A, review and comment is also provided by the E/PO evaluation panel.

(b) The final E/PO plan must be developed during Phase B and must address/resolve the comments and feedback provided at KDP-B. Approval of the final E/PO plan is a KDP-C gateway product. Review and concurrence is provided by the Program Scientist/Program Executive and the Division E/PO lead. Approval is provided by the SMD Science Division Director and SMD Lead for E/PO.

(c) On the basis of the final E/PO plan an implementation plan must be developed. The implementation plan shall include detailed budgets, milestones, and timelines. Approval of the final E/PO plan is a CDR gateway product. Review and concurrence is provided by the Program Scientist/Program Executive and the Division E/PO lead. Approval is provided by the SMD Science Division Director and SMD Lead for E/PO.

3.2 Reporting for the Mission E/PO Program

(a) Requirements for regular (weekly, monthly, quarterly, etc.) reporting of the mission's E/PO activities will be per the E/PO plan. Such reporting will be from the mission or program (e.g.

E/PO lead through the PI/PM) to the Division E/PO lead with copy to the Division E/PO forum and the Program Executive/Program Scientist.

(b) Missions are also expected to provide reporting as appropriate in other venues: project reports, science team meetings, Division E/PO forum meetings, etc. Mission E/PO leads are also expected to participate in monthly Division E/PO forum telecons. The Division E/PO lead is responsible for tracking reporting (from program office, forums, science team meetings).

(c) The Division E/PO lead will ensure that the SMD Lead for E/PO receives a summary of Division E/PO reports.

(d) SMD is responsible for NASA Office of Education reporting and portfolio management. Reporting will be aided by the Division E/PO forums and the Division E/PO leads. Division E/PO forums, in consultation with Division E/PO leads, will assist mission E/PO leads in reporting through OEPM (Office of Education Program Management) for Office of Education reporting and portfolio management.

3.3 Assessment and Review

(a) Mission E/PO programs are expected to include evaluation plans. These evaluation plans will be described in the final E/PO plan and funded within the mission E/PO budget.

(b) Mission E/PO programs will be reviewed as part of a Division's Senior Review for operating missions. When divisions do not have bi-annual Senior Reviews, operating mission E/PO programs will be reviewed biannually through a standalone E/PO-only senior review-like process.

3.4 Canonical Timeline for Development and Approval of a Mission E/PO Plan

	PI-led (AO competed) Mission	Strategic (directed) Mission
E/PO statement of commitment	Step 1 proposal	N/A
Preliminary E/PO plan	Step 2 CSR	Phase A
Review and comment of preliminary plan	Downselect	KDP-B
Final E/PO plan	Phase B	Phase B
Approval of final plan	KDP-C	KDP-C
Implementation plan	Phase C	Phase C
Approval of implementation plan	CDR	CDR

3.5 Approval Authority for a Mission E/PO Plan

	Review and Concurrence	Approval
Preliminary E/PO plan	Division E/PO Lead (review only)	N/A
Final E/PO plan	Program Scientist / Program Executive; Division E/PO Lead	Division Director; SMD E/PO Lead
Implementation plan	Program Scientist / Program Executive; Division E/PO Lead	Division Director; SMD E/PO Lead
Delegation to Program Office	Division Director; SMD E/PO Lead	SMD AA
Exception to 1% budget requirement		SMD AA
Reductions to E/PO budget	Division Director; SMD E/PO Lead	(budget process)
Exceptions to budget phasing requirement		Division Director; SMD E/PO Lead