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EXECUTION PHASE PROJECT PLAN FOR EARTH OBSERVING SYSTEM (EOS)

September 1993

GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

All funding, manpower, and procurement data have been removed from this version of the Project Plan.

EXECUTION PHASE

PROJECT PLAN

FOR THE

EARTH OBSERVING SYSTEM

(EOS)

GODDARD SPACE FLIGHT CENTER
Greenbelt, Maryland

APPROVAL RECORD

Project: MTPE

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
EXECUTION PHASE
PROJECT PLAN
FOR THE
EARTH OBSERVING SYSTEM (EOS)

FOREWORD

This Execution Phase Project Plan is the Goddard Space Flight Center (GSFC) Plan for the Earth Observing System (EOS). It defines the requirements for accomplishing the EOS mission and is issued in compliance with Space Flight Program and Project Management, National Aeronautics and Space Administration (NASA) Management Instruction (NMI) 7120.3. When formally approved, this Project Plan will serve as the basic agreement for EOS between the Program Associate Administrator (PAA), Office of Mission to Planet Earth (OMTPE) and the Director of the Goddard Space Flight Center, the Field Installation Director (FID), and defines the guidelines and constraints under which the EOS mission will be executed. It is the responsibility of the Director, GSFC Mission to Planet Earth Office to maintain this Project Plan by timely revisions, consistent with the procedures outlined in the EOS Configuration Management Plan (420-02-02).

As a result of a NASA internal review completed in the summer of 1992, EOS became recognized as a cost driven program. Each element of the program was assigned a budget for its accomplishment with a goal to achieve the highest scientific return within the available funding. This strategy requires EOS project management to establish very precise limits on the funds available to accomplish individual project tasks and to ensure that these limits are not exceeded unless timely adjustments are made to other elements of the program.

Schedules and current resource information included in this Project Plan are updated and distributed separately through the EOS Management Information System (MIS) and/or the Program Operating Plan process and the annual Center manpower report to Headquarters.

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ACRONYMS AND ABBREVIATIONS

AA	Associate Administrator
ACRIM	Active Cavity Radiometer Irradiance Monitor
ADC	Affiliated Data Center
AERO	Aerosol
AES	Canadian Atmospheric Environment Service
AIRS	Atmospheric Infrared Sounder
ALT	Altimetry
AM	EOS Morning Flight
AMR	Altimetry Microwave Radiometer
AMSU-A	Advanced Microwave Sounding Unit-A
AMTS	Advanced Meteorological Temperature Sounder
AO	Announcement of Opportunity
APA	Allowance for Program Adjustment
ASF	Alaska SAR Facility
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
ATDRSS	Advanced Tracking and Data Relay Satellite System
AVHRR	Advanced Very High-Resolution Radiometer
BAe	British Aerospace
BIP	Background Information Package
CAPL	Capillary-Pumped Loop
CCD	Charged Coupled Device
CCSDS	Consultative Committee on Space Data Systems
CDCR	Conceptual Design and Cost Review
CDMS	Cryospheric Data Management System
CDOS	Customer Data and Operations System
CDR	Critical Design Review
CEES	Committee on Earth and Environmental Sciences
CEOS	Committee on Earth Observations Satellite
CERES	Clouds and the Earth's Radiant Energy System
CHEM	Chemistry
CIESIN	Consortium for International Earth Science Information Network
CNES	Centre National d'Etudes Spatiales
COLOR	Ocean Color Flight - SeaWiFs
COTR	Contracting Officers Technical Respresentative
CPAF	Cost-Plus-Award-Fee
CSA	Canadian Space Agency
CSF	Chemistry and Special Flights
CSI	Contractor Source Inspector
CSMS	Communications and Systems Management Segment
CTV	Compatibility Test Van
CVCM	Collected Volatile Condensable Materials
CZCS	Coastal Zone Color Scanner

ACRONYMS AND ABBREVIATIONS (Continued)

DAAC	Distributed Active Archive Center
DADS	Data Archive and Distribution System
DAS	Direct Access System
DCC	Developmental Cost Commitment
DEM	Digital Elevation Model
DIF	Data Interface Facility
DOC	Department of Commerce
DoD	Department of Defense
DOE	Department Of Energy
DOI	Department of Interior
DORIS	Doppler Orbitography and Radiopositioning Integrated by Satellite
DPM	Deputy Project Manager
DPM/R	Deputy Project Manager for Resources
DSN	Deep Space Network
EAP	EOSDIS Advisory Panel
ECOM	EOS Communications
ECS	EOSDIS Core System
EDC	EROS Data Center
EDOS	EOS Data and Operations System
EED	Electro-Explosive Device
EEE	Electrical, Electronic, and Electromechanical
ELV	Expendable Launch Vehicle
EO-ICWG	Earth Observations International Coordination Working Group
EOC	EOS Operations Center
EOS	Earth Observing System
EOSDIS	Earth Observing System Data and Information System
EOSP	Earth Observing Scanning Polarimeter
EP	Earth Probe
EPA	Environmental Protection Agency
ERBE	Earth Radiation Budget Experiment
EROS	Earth Resources Observation System
ESA	European Space Agency
ESDIS	Earth Science Data and Information System
ESMO	Earth Science Mission Operation
ESSB	Earth System Sciences Building
ESSC	Earth System Sciences Committee
ETS	EOS Test System
EUMETSAT	European Organization for the Exploitation of Meteorological Satellites
FDF	Flight Dynamics Facility
FI	Facility Instrument
FID	Field Installation Director
FMEA	Failure Mode Effects Analysis
FOO	Flight of Opportunity

ACRONYMS AND ABBREVIATIONS (Continued)

FOS	Flight Operation Segment
FRR	Flight Readiness Review
FSD	Flight Systems Division
FY	Fiscal Year
GCDIS	Global Change Data and Information System
GE	General Electric
GEVS	General Environmental Verification Specification
GEWEX	Global Energy and Water Cycle Experiment
GFE	Government Furnished Equipment
GIA	Government Inspection Agency
GLAS	Geoscience Laser Altimeter System
GLIS	Global Land Information System
GN	Ground Network
GOES	Geostationary Operational Environmental Satellite
GPS	Global Positioning System
GSFC	Goddard Space Flight Center
GSI	Government Source Inspection
GSTDN	Ground Spaceflight Tracking and Data Network
HgCdTe	Mercury Cadmium Telluride
HHS	Department of Health and Human Services
HIRDLS	High-Resolution Dynamics Limb Sounder
HIRIS	High-Resolution Imaging Spectrometer
HMMR	High Resolution Multifrequency Spectrometer Radiometer
ICD	Interface Control Document
ICSU	International Council of Scientific Unions
ID	Inter-Disciplinary
IELV	Intermediate Expendable Launch Vehicle
IEOS	International EOS
IGBP	International Geosphere-Biosphere Program
IMS	Information Management System
IP	International Partner
IPA	Inter-Project Agreement
IR	Infrared
IRD	Interface Requirement Document
ISM	Instrument Systems Manager
IST	Instrument Support Terminal
IV&V	Independent Verification and Validation
IWG	Investigators Working Group
IWGDMGC	Interagency Working Group on Data Management for Global Change
JMA	Japanese Meteorological Agency
JPL	Jet Propulsion Laboratory
JPOP	Japanese Polar-Orbiting Platform
JSC	Joint Scientific Committee

KSC	Kennedy Space Center
LaRC	Langley Research Center
LASA	Lidar Atmospheric Sounder and Altimeter
LAWS	Laser Atmospheric Wind Sounder
LIS	Lightning Imaging Sensor
LOA	Letter of Agreement
MAFB	McGuire Air Force Base
MELV	Medium Expendable Launch Vehicle
MHS	Microwave Humidity Sounder
MIL-STD	Military Standard
MIMR	Multifrequency Imaging Microwave Radiometer
MIS	Management Information System
MISR	Multi-angle Imaging Spectro-Radiometer
MITI	Ministry of International Trade and Industry
MLS	Microwave Limb Sounder
M&O	Maintenance and Operations
MODIS	Moderate-Resolution Imaging Spectroradiometer
MO&DSD	Mission Operations and Data Systems Directorate
MOM	Mission Operations Manager
MOPITT	Measurement of Pollution in The Troposphere
MOR	Mission Operations Review
MOU	Memorandum of Understanding
MSFC	Marshall Space Flight Center
MSR	Monthly Status Report
MTPE	Mission to Planet Earth
NAR	Non-Advocacy Review
NAS	National Academy of Sciences
NASA	National Aeronautics and Space Administration
NASCOM	NASA Communication Network
NASDA	National Space Development Agency of Japan
Nd:YAG	Neodymium: Yttrium-Aluminum-Garnet
NEPA	National Environmental Policy Act
NOA	New Obligation Authority
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
NREN	National Research and Education Network
NSF	National Science Foundation
NSI	NASA Science Internet
NSIDC	National Snow and Ice Data Center
ODIS	Office of Data Information Systems
OMTPE	Office of Mission to Planet Earth
ORNL	Oak Ridge National Laboratory
ORR	Operations Readiness Review
OSSA	Office of Space Science and Applications

ACRONYMS AND ABBREVIATIONS (Continued)

PAA	Program Associate Administrator
PAPL	Program Approved Parts List
PCA	Program Commitment Agreement
PCB	Program Control Board
PDMP	Project Data Management Plan
PDR	Preliminary Design Review
PER	Pre-Environmental Review
PERT	Program Evaluation Review Technique
PGS	Product Generation System
PI	Principal Investigator
PM	EOS Afternoon Flight
PMS	Performance Measurement System
POEM	Polar-Orbit Earth Observation Mission
POES	Polar-Orbiting Operational Satellite
POP	Program Operating Plan
PPL	Preferred Parts List
PSCN	Program Support Communications Network
PSR	Pre-Shipment Review
PV	photovoltaic
RFP	Request for Proposal
RFSOC	Radio Frequency Simulation Opertion Center
RPR	Restructured Program Review
SAGE III	Stratospheric Aerosol and Gas Experiment III
SAR	Synthetic Aperture Radar
SBRC	Santa Barbara Research Center
SCF	Science Computing Facility
SCR	System Concept Review
SDPF	Science Data Processing Facility
SDPS	Science Data Processing Segment
SDR	System Design Review
SEC	Science Executive Committee
SEDAC	Socio-Economic Data and Applications Center
SE&I	Systems Engineering and Integration
SELV	Small Expendable Launch Vehicle
SI	Smithsonian Institution Scientific Instrument
SMRWG	Science and Mission Requirements Working Group
SOC	Simulation Operations Center
SOLSTICE	Solar Stellar Irradiance Comparison Experiment
SPAR	Standard Payload Assurance Requirements
SRMU	Solid Rocket Motor Upgrade
SRR	Systems Requirements Review
SSALT	Solid State Altimeter
SSC	Science Steering Committee

SSF	Space Station Freedom
SSSM	Science Software Systems Manager
STA	Science and Technology Agency
TDRSS	Tracking and Data Relay Satellite System
TES	Tropospheric Emission Spectrometer
TIR	Thermal Infrared
TL	Team Leader
TM	Team Member
TML	Total Mass Loss
TOA	Top of Atmosphere
TOGA	Tropical Ocean Global Atmosphere
TOMS	Total Ozone Mapping Spectrometer
TONS	TDRSS On-board Navigation System
TOPEX	Ocean Topography Experiment
TRMM	Tropical Rainfall Measuring Mission
TRR	Test Readiness Review
TRW	Thompson Ramo-Woolridge
TVA	Tennessee Valley Authority
UARS	Upper Atmosphere Research Satellite
UIID	Unique Instrument Interface Document
UPN	Unique Project Number
U.S.	United States
USAF	United States Air Force
USDA	U.S. Department of Agriculture
USGCRP	United States Global Change Research Program
USGS	U.S. Geological Survey
V0	Version 0
V1	Version 1
V2	Version 2
VAFB	Vandenberg Air Force Base
VAS	Visible Atmospheric Sounder
VISSR	Visible Infrared Spin-Scan Radiometer
WBS	Work Breakdown Structure
WCRP	World Climate Research Program
WFF	Wallops Flight Facility
WMO	World Meteorological Organization
WOCE	World Ocean Circulation Experiment
WP-3	Work Package-3
WRR	Western Range Regulation
WSMC	Western Space and Missile Center
WSMCR	WSMC Regulation
WTR	Western Test Range

EXECUTION PHASE
PROJECT PLAN
FOR THE
EARTH OBSERVING SYSTEM
(EOS)

1. INTRODUCTION

1.1 IDENTIFICATION

The Earth Observing System (EOS) is the Project title designated by the Office of Mission to Planet Earth (OMTPE) of the NASA Headquarters and GSFC. This effort was funded under four Unique Project Numbers (UPNs) assigned by NASA Headquarters for Fiscal Years (FY) 1991 and 1992 of the Execution Phase:

- UPN 426 – EOS Instruments
- UPN 427 – EOS Observatories
- UPN 428 – EOS Data and Information System (EOSDIS)
- UPN 429 – EOS Science

Beginning in FY 1993, NASA Headquarters began funding the EOS Execution Phase effort at GSFC under six separate UPNs:

- UPN 225 – EOS AM Series
- UPN 226 – EOS PM Series
- UPN 227 – EOS Special Flights Series
- UPN 228 – EOS Chemistry Series
- UPN 229 – EOS Science
- UPN 428 – EOS Data and Information System (EOSDIS)

This revised UPN structure is the result of a program restructuring undertaken in 1991 and described in Section 1.2.9 of this plan.

1.2 BACKGROUND

1.2.1 The Earth Observing System Science and Mission Requirements Working Group

EOS Program planning began in 1983 with the definition of the science and mission requirements by the EOS Science and Mission Requirements Working Group (SMRWG). The SMRWG charter was to examine the major Earth science questions for the 1990s and to define the requirements for low-Earth-orbit observations needed to answer these questions on a comprehensive multidisciplinary basis. The SMRWG's report, issued in 1984, listed five basic recommendations concerning Earth science in the 1990's:

- A program must be initiated to ensure that the present time series of Earth science data are maintained and continued. Collection of new data sets should be initiated.
- A data system that provides easy, integrated, and complete access to past, present, and future data must be developed as soon as possible.
- A long-term research effort must be sustained to study and understand these time series of Earth observations.
- The EOS Program should establish an information system to carry out those aspects of the recommendations that go beyond existing and currently planned activities.
- The scientific direction of EOS should be established and continued through an International Scientific Steering Committee.

1.2.2 The Earth System Sciences Committee

The Earth System Sciences Committee (ESSC), chaired by Francis P. Bretherton, was appointed in November 1983 by the NASA Advisory Council to consider directions for NASA's Earth-sciences program. The committee's report, issued in May 1986, recognized EOS as the centerpiece of the future Earth-sciences implementation strategy. It stated the following goal of Earth System Science: "To obtain a scientific understanding of the entire Earth system on a global scale by describing how its component parts and their interactions have evolved, how they function, and how they may be expected to continue to evolve on all timescales." It also identified the following challenge to Earth System Science: "To develop the capability to predict those changes that will occur in the next decade to century, both naturally and in response to human activity."

1.2.3 The Earth Observing System Science Steering Committee

The successor to the SMRWG, the EOS Science Steering Committee (SSC), continued the definition of the EOS Program and provided an overall implementation strategy in its report issued in 1987. Concurrent with the SSC work, NASA included the EOS program under a broader Agency initiative termed Mission to Planet Earth (MTPE), which included other efforts such as the Earth Probe Missions and NASA's participation in the International Geosphere Biosphere Program (IGBP) and the World Climate Research Program (WCRP). By proceeding to carry out the recommendations of the SMRWG and the ESSC, including EOS, the SSC argued that it would be possible to move from a single-discipline research mission to a comprehensive mission addressing all aspects of the Earth as a system. Thus, the concept of an Earth System was adopted as the EOS scientific thrust.

1.2.4 The Earth Observing System Instrument Proposals Selection Process

An Announcement of Opportunity (AO) to propose investigations for the EOS Program was issued in January 1988. The EOS Program objectives were based on the requirements and goals of the SMRWG, SSC, and ESSC. A Background Information Package (BIP) accompanying it included the reports listed in Table 1-1. The reports by specially commissioned EOS science study panels contained extensive conceptual descriptions of the research Facility Instruments (FIs), which would be part of EOS. In responding to the AO, proposers could offer to do Interdisciplinary (ID) studies to carry out integrated Earth system research leading to the development of comprehensive Earth system models, to be members of research facility teams (formed to provide scientific guidance for the development of the research FIs and to analyze and interpret data from them), or to be Principal Investigators (PIs) of proposed instruments and their data products.

The EOS selection process was completed in February 1989 with the selection of 6 Team Leaders (TLs) and 93 Team Members (TMs) for the 6 NASA research FIs, 24 Instrument PIs, and 29 Interdisciplinary Team PI Leaders to participate in the definition phase of the EOS Program. The AO also resulted in the selection of the Clouds and the Earth's Radiant Energy System (CERES) for European Space Agency's (ESA) Polar-Orbit Earth observation Mission (POEM); CERES, Lightning Imaging Sensor (LIS), and Stratospheric Aerosol and Gas Experiment III (SAGE III) for space station as attached payloads and Laser Atmospheric Wind Sounder (LAWS) for Japanese Polar-Orbiting Platform (JPOP).

1.2.5 The Investigators Working Group

The EOS Investigators Working Group (IWG), formed in 1989, consists of PIs (Instrument and Interdisciplinary), and TLs to provide scientific advice and guidance for the program. The Program Scientist (from NASA Headquarters) and the Senior Project Scientist (from GSFC) co-chair the IWG. The working bodies of the IWG include 12 science panels shown in Table 1-2. The chairpersons of each of these panels, together with the Program Scientist and Senior Project Scientist, constitute the Science Executive Committee (SEC) of the IWG. Membership on the panels is generally open to all EOS investigators, including Co-Investigators on any EOS investigation and members of EOS FI teams. Scientists outside the group of EOS investigators are also included in the various panels.

Table 1-1
EOS BIP Reports

Volume	Report
I & Appendix	Science and Mission Requirements Working Group Report
II	From Pattern to Process: The Strategy of the Earth Observing System Science Steering Committee Report
IIa	Data and Information System Panel Report
IIb	MODIS Moderate-Resolution Imaging Spectrometer Instrument Panel Report
IIc	HIRIS High-Resolution Imaging Spectrometer: Science Opportunities for the 1990s Instrument Panel Report
IId	LASA Lidar Atmospheric Sounder and Altimeter Instrument Panel Report
IIe	HMMR High-Resolution Multifrequency Microwave Radiometer Instrument Panel Report
IIf	SAR Synthetic Aperture Radar Instrument Panel Report
IIg	LAWS Laser Atmospheric Wind Sounder Instrument Panel Report
IIh	Altimetric System Panel Report

Table 1-2
Panels Reporting to EOS Investigator Working Group

Panels		
Disciplinary	Inter-Disciplinary	Functional
Atmosphere	Modeling	Calibration and Validation
Biogeochemical Cycling	Physical Climate and Hydrology	EOSDIS Advisory
Land/Biosphere		Instruments
Oceans		Payload Advisory
Solid Earth		Precision Orbit Determination/Mission Design

The IWG plays a leading role in defining the overall science thrust for the EOS Program. It coordinates the research efforts and provides guidance and advice to the EOS Program and Project, as appropriate, concerning all major scientific issues. It will meet regularly throughout the lifetime of the Program.

1.2.6 Assignment of Responsibilities

The EOS Study Project was established at GSFC in 1983. During the Phase A and B study periods, GSFC and the Jet Propulsion Laboratory (JPL) performed mission, data system, and spacecraft studies resulting in a conceptual design of a dual series of spacecraft missions that would satisfy the EOS requirements. The spacecraft were designated EOS-A and EOS-B, with GSFC and JPL having the respective managerial responsibilities. Following the EOS Non-Advocacy Review (NAR), held in June 1989, management responsibilities for the EOS-B series, as well as the project management role for the execution phase of EOS, were transitioned to GSFC. The Synthetic Aperture Radar (SAR), which was an FI to be launched on EOS-B, was identified as an independent mission, to be managed by JPL, and a candidate for separate program approval. In 1990, responsibility for development of the platform was transferred from the Space Station Program to the EOS Project. EOS management became centralized within the EOS Project at GSFC.

1.2.7 Program New Start

The EOS Program was approved by Congress as an FY91 Presidential Initiative. The payload for the first flight (EOS-A1) was selected in January 1991, following Conceptual Design and Cost Reviews (CDCRs) of the selected instruments and IWG Payload Panel recommendations on scientific priorities and synergism. The baseline flight segment consisted of two series of large observatories, EOS-A and -B, in 1:30 PM ascending, sun-synchronous orbit, launched by a Titan-IV with Solid Rocket Motor Upgrades (SRMUs) from the Western Space and Missile Center (WSMC). Each observatory had a 5-year life and each was to be replaced twice to provide a 15-year mission. This Program is described in the 1991 EOS Reference Handbook.

1.2.8 National Research Council Reviews

The National Research Council (NRC) advises the federal government through reports of reviews it conducts using its various committees, which involve the broad community of science and technology experts. Prior to the EOS new start approval in FY91, their report, "The U.S. Global Change Research Program: An Assessment of FY 1991 Plans" provided a critical review of the EOS Program.

In the July 1991 report, "Assessment of Satellite Earth Observation Programs 1991," the NRC was in general agreement with the EOS plan for the large EOS-A observatory and its selected payloads. It expressed concern that the total EOS budget size could lead to potential delays, noted data gaps in key areas, and endorsed the MTPE Earth Probe concept.

These reviews were the beginning of a series of reviews and evaluations of the Program to ensure the proper scientific return on the EOS investment.

1.2.9 EOS Program Restructuring

As part of the FY 1992 budget process, the Committees on Appropriations directed NASA to restructure the EOS program to:

- Focus the science objectives of EOS on the most important problem of global change (i.e., global climate change)
- Increase the resilience and flexibility of EOS by flying the instruments on multiple, smaller platforms rather than a series of large platforms
- Reduce the cost of EOS through FY 2000

In the summer and fall of 1991, NASA conducted a restructuring of the program to meet the Congressional mandate. This process included an independent review by the External Engineering Review Committee, which issued its report in September 1991. The process also involved assessment by the scientists who will use the data from EOS, including both the EOS IWG and the EOS Payload Advisory Panel. The EOS Project at GSFC conducted studies to determine how the EOS instruments could most effectively be configured on small spacecraft. In December 1991, the NASA Administrator reviewed and approved the restructured EOS Program, and in March 1992 NASA submitted its report on the restructured program to Congress. Congress approved the restructured program in 1992.

1.2.10 EOS Program Rescoping

Recognizing that the subsequent budget environment would not support the complete and timely implementation of the restructured EOS Program described in the March 1992 report to Congress, the NASA Administrator directed that the Program be rescoped with a goal of further reducing its costs through FY 2000 by 30 percent. The EOS reassessment was completed in June 1992, satisfying the 30 percent reduction by capitalizing on efficiencies, reducing at-launch science data products, by rephasing work, by increasing international participation, and by deleting the High-Resolution Imaging Spectrometer (HIRIS) FI. As a result of the rescoping process, EOS became recognized by NASA as a cost driven program.

1.3 CLASSIFICATION CRITERIA

The EOS Mission is considered a class "B" mission because of the use of multiple copies of spacecraft and instruments that can be used to support contingencies. The EOS Mission has no plan for on-orbit maintenance, because of the inaccessibility of its orbit to the shuttle.

2. PROGRAM MISSION OBJECTIVES, RELATIONSHIPS, AND INTEGRATION

2.1 PROGRAM MISSION OBJECTIVES

The overall goal of the EOS Program is to advance the scientific understanding of the entire Earth system on a global scale by developing a greater understanding of the components of the system, the interactions between them, and how the Earth system is changing. The EOS Program is the centerpiece and largest part of NASA's MTPE. The MTPE is NASA's contribution to the United States Global Change Research Program (USGCRP). The MTPE and the USGCRP are described in Section 2.2.

The EOS Program mission objectives are:

- To create an integrated scientific observing system emphasizing climate change, causes, processes, and effects that will enable multidisciplinary study of the Earth's critical, life-enabling, interrelated processes involving the atmosphere, oceans, land surface, polar regions, and solid Earth, and the dynamic and energetic interactions between them
- To develop a comprehensive data and information system, including a data retrieval and processing system, to serve the needs of scientists performing an integrated multidisciplinary study of planet Earth
- To acquire and assemble a global database for remote sensing measurements from space over a decade or more to enable definitive and conclusive studies of Earth system attributes

These objectives will be accomplished through a combination of observations made by scientific instruments, which are integrated with the EOS spacecraft, and the archival and processing of those data by the EOSDIS. Scientific research funding by the EOS Program supports postgraduate fellowships and interdisciplinary science investigator grants, as well as instrument investigators. The investigators will use the data gathered by EOSDIS to perform integrated, interdisciplinary studies of the Earth to enhance the capability to predict global change.

The EOS will study the atmosphere, oceans, cryosphere, biosphere, and solid Earth, particularly as their interrelationships are manifested in the flow of energy and in the cycling of water and other biogeochemicals through the Earth system.

2.2 PARENT PROGRAMS AND OTHER RELATIONSHIPS

2.2.1 U.S. Global Change Research Program

The central goal of the USGCRP, as identified in the President's FY 1993 Budget Request, is to help establish the scientific understanding and the basis for national and international policy

making related to natural and human-induced changes in the global Earth system. The highest priority near-term scientific and policy-related issue for the USGCRP is whether and to what extent, human activities are changing, or will change, the global climate system. In addition, the USGCRP continues to support economics research related to global change.

To achieve its goal, the USGCRP addresses three parallel but interconnected streams of activity:

- Documenting Global Change (Observations) through the establishment of an integrated, comprehensive, long-term program of observing and analyzing Earth system change on a global scale
- Enhancing Understanding of Key Processes (Process Research) through a program of focused studies to improve our knowledge of the physical, geological, chemical, biological, and social processes that influence and govern Earth system behavior
- Predicting Global and Regional Environmental Change (Integrated Modeling and Prediction) through the development and application of integrated conceptual and predictive Earth system models

The aim of the USGCRP is to establish the scientific basis for national and international policy making regarding possible change in the global Earth system. The USGCRP incorporates activities from several agencies within the U.S. government, including NASA, the Department of Commerce's (DOC's) National Oceanic and Atmospheric Administration (NOAA), Department of Defense (DoD), Department of Energy (DOE), Department of Health and Human Services (HHS), Department of the Interior (DOI), Environmental Protection Agency (EPA), National Science Foundation (NSF), Smithsonian Institution (SI), the U.S. Department of Agriculture (USDA), and the Tennessee Valley Authority (TVA) in support of the worldwide effort to understand the consequences of natural and anthropogenic activities for the Earth as a system. The summation of U.S. agency activities supporting USGCRP appears in reports of the U.S. Committee on Earth and Environmental Sciences (CEES). The reports present a framework for U.S. global change activities in terms of seven science elements: physical climate and hydrological systems, biogeochemical dynamics, ecological systems, Earth system history, human interactions, solid Earth processes, and solar influences. (See Figure 2-1.) Of these elements, NASA's activities provide primary support to all but Earth system history.

The nature of the USGCRP requires extensive international cooperation. The International Council of Scientific Unions (ICSU) and the World Meteorological Organization (WMO) provide for broad involvement of the international research community

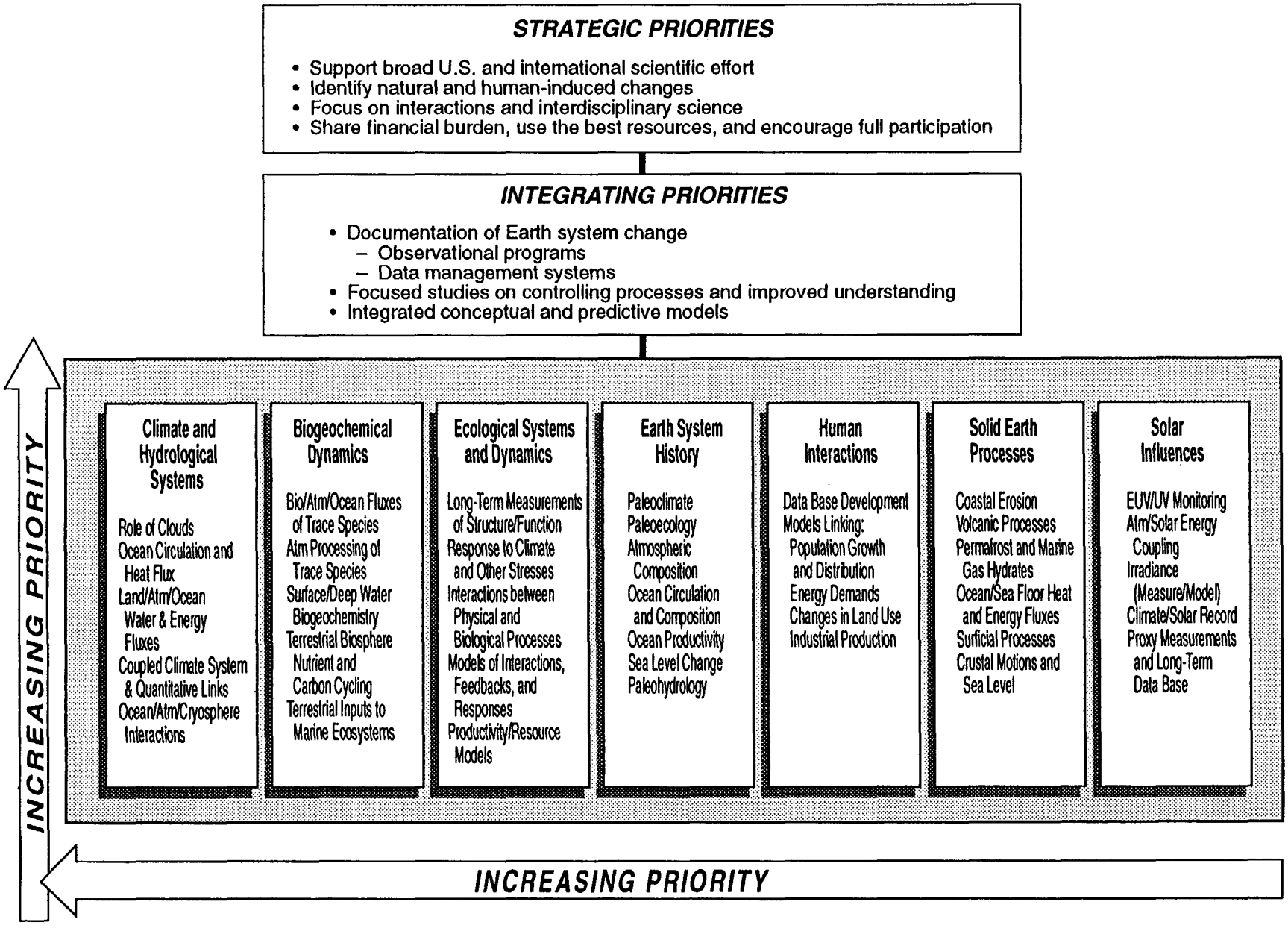


Figure 2-1. U.S. GCRP Research Priorities

in the study of global change. The U.S. National Academy of Sciences (NAS) serves as the primary U.S. liaison to the ICSU; NOAA is the U.S. representative to the WMO.

2.2.2 Mission to Planet Earth

NASA's contribution to the USGCRP, Mission to Planet Earth, represents the largest participation in the program by any single agency. NASA's research efforts are primarily focused on space-based studies of the Earth as an integrated system (Figure 2-2). Phase 1 of the MTPE, which began in September of 1991 with the launch of the Upper Atmosphere Research Satellite (UARS), involves a large number of satellites to be launched by NASA, other U.S. agencies, and international organizations to provide data for use in monitoring the global climate and other Earth system processes that lead to global change. Follow-on EOS flights will build on and extend the capability of Phase 1 flights.

NASA Phase 1 activities include ongoing precursor missions such as UARS, the Ocean Topography Experiment (TOPEX), and the MTPE Earth Probe (EP) flights that precede the first flight of the EOS Program. This space-based activity is integrated with NASA's ongoing ground-based research programs focused on observing, understanding, and modeling radiation, dynamics, and hydrology; ecosystem dynamics and biogeochemical cycles; atmospheric chemistry; and solid Earth science.

The EPs are small satellites designed for use with small launch vehicles to perform specialized Earth studies. EPs include the Total Ozone Mapping Spectrometer (TOMS) and the Tropical Rainfall Measurement Mission (TRMM), a joint venture with the National Space Development Agency (NASDA) of Japan. The TOMS was first launched on Nimbus-7; a second TOMS instrument was launched on August 15, 1991, on a Soviet Meteor-3 spacecraft. The TOMS will allow time series data evaluations to establish trends, with the goal of studying the question of global and regional changes in the ozone. The TOMS instrument will also be launched in 1994. The TRMM will measure diurnal variation of precipitation and evaporation in the tropics, providing an increased understanding of how substantial rainfall affects global climate patterns. Data from all of these sources and the U.S. agency and international sources identified below will be archived and distributed by the EOS ground system.

Other U.S. agencies, including NOAA and DoD, will provide data to be incorporated into NASA's studies of the Earth as an integrated system. Data supplied by NOAA will include global environmental observations from the Geostationary Operational Environmental Satellite (GOES) and other satellites. Data supplied by DoD will include ocean topography and sea-ice observations from Geosat.

Purpose

Determine Extent, Causes, and Regional Consequences of Global Climate Change

Scientific Issues

- The Role of Clouds, Radiation, Water Vapor, and Precipitation
- The Productivity of the Oceans, their Circulation, and Air-Sea Exchange
- The Sources and Sinks of Greenhouse Gases, and their Atmospheric Transformations
- Changes in Land Use, Land Cover, Primary Productivity, and the Water Cycle
- The Role of the Polar Ice Sheets, and Sea Level
- The Coupling of Ozone Chemistry with Climate and the Biosphere
- The Role of Volcanoes in Climate Change

Interdisciplinary Investigations

- LaRC-Radiation & Clouds
- Goddard Institute for Space Studies-Interannual Climate Variability
- NCAR-Climate Modeling
- MRI (Japan)-Atmos/Ocean/Land Interactions
- GSFC-Atmos/Ocean/Land 4-D Data Assimilation
- Penn. State U./MSFC-Water Cycle
- GSFC-Global Water and Energy Cycle
- BMRC (Australia)-Atmospheric Modeling
- U. of Washington-Physical Climate over Oceans
- U. of Texas-Geodynamics
- JPL-Air Sea Interaction
- Woods Hole Ocean. Inst.-Biogeochemical Fluxes over Oceans
- CSIRO (Australia)-Physical and Biological Oceanography
- Chilworth Research (U.K.)-Oceans
- Oregon State U.-Physical and Biological Oceanography
- Cornell U.-Tectonic/Climatic Dynamics
- CCRS (Canada)-Northern Hemisphere Terrestrial Biosphere
- Colorado State U.-Carbon Budget in Grasslands
- U. of New Hampshire-Biogeochemical Cycles
- GSFC-Biosphere-Atmosphere Interactions
- INPE (Brazil)-Amazonia
- University of California at Santa Barbara-Snow Hydrology and Chemistry
- LERTS (France)-Climatic Processes in Arid/Semi-Arid Lands
- U. of Washington-Ocean-Ice-Atmosphere Interactions
- CCRS (Canada)-Cryospheric Monitoring in Canada
- GSFC-Middle Atmosphere Chemistry and Dynamics
- LaRC-Radiative/Chemical/Dynamical Processes in the Atmosphere
- U. of Cambridge (U.K.)-Middle Atmosphere and Thermosphere
- U. of Hawaii-Volcanism and Climate

Distributed Active Archive Centers

- LaRC — Radiation Budget, Aerosols, Tropospheric Chemistry
- MSFC — Hydrology and Hydrodynamics
- GSFC — Upper Atmosphere, Dynamics, Global Biosphere, Geophysics
- JPL — Ocean Circulation, Air/Sea Interaction
- EROS Data Center — Land Processes Imagery
- Alaska SAR Facility — Sea Ice, Polar Processes Imagery
- National Snow and Ice Data Center — Cryosphere, Snow and Ice Data Products at Level 2 and Above
- Oak Ridge National Laboratory — Trace Gas Fluxes

Earth Observing System Spacecraft

- EOS-AM — -Clouds, Aerosols, and Radiative Balance; -Characterization of Terrestrial Surface
- EOS-PM — -Clouds, Precipitation, and Radiative Balance; -Terrestrial Snow and Sea Ice; -Sea-Surface Temperature and Ocean Productivity
- EOS-COLOR — -Oceanic Biomass and Productivity
- EOS-AERO — -Atmospheric Aerosols
- EOS-ALT — -Ocean Circulation; -Ice Sheet Mass Balance
- EOS-CHEM — -Atmospheric Chemical Species and their Transformations; -Solar Output

Phase 1 Spacecraft

NASA

- UARS — Upper Atmosphere
- TOPEX/Poseidon (with France) — Ocean Circulation
- LAGEOS — Laser Geodynamics
- ATLAS Series — Atmos/Solar Effects
- LITE Series — Atmospheric Aerosols
- SRL Series — Surface Radar Images
- TOMS* — Ozone Mapping
- SeaWiFS/SeaStar — Ocean Color
- TRMM* — Clouds, Hydrology, Rain

Other U.S. (Data)

- POES (NOAA) — Global Environment
- GOES (NOAA) — Global Environment
- DMSP (DoD) — Hydrology and Sea Ice
- Geosat (DoD) — Ocean Topography and Sea Ice
- Landsat-6 (EOSAT)
- Landsat-7 (NASA/DoD) — Surface Images

International (Data)

- Meteor-3 (Russia)[1] — Ozone/Radiation Budget
- ERS-1/2 (ESA) — Global Environment
- JERS-1 (Japan) — Sea Ice Characteristics
- Radarsat (Canada)[2] — Sea Ice Characteristics
- ADEOS (Japan)*[3] — Sea Surface/Atmosphere

KEY

*Earth Probes Mission
[1]Includes U.S. TOMS Instrument
[2]Launch by NASA
[3]Includes U.S. TOMS and NSCAT (Sea Surface Winds) Instruments

Figure 2-2. Mission to Planet Earth

In addition, joint NASA/DoD management and implementation of Landsat-7 will make surface-imaging observations available.

International partners, including Japan, Europe, and Canada, will also provide data to be incorporated into NASA's studies of the Earth as an integrated system. More detailed data on the role of the International partners are provided in the following sections.

2.2.3 International Relationships

2.2.3.1 International Scientific Community

The science community provides requirements, recommendations, and findings, and helps to establish priorities in support of global change research programs. Figure 2-3 shows the organizational elements of the global research effort. U.S. scientists work very closely with their foreign counterparts in planning the WCRP. This planning has been led, in many instances, by joint activities of the ICSU and the WMO, especially the Joint Scientific Committee (JSC) for the WCRP. In addition, the ICSU has established a Scientific Committee for the IGBP. As these programs move from planning toward implementation, leadership for oversight and coordination shifts somewhat to intergovernmental organizations which, in concert with the ICSU, are uniquely able to assist in broadening participation and governmental support for global change research.

Specialized global programs of WCRP such as the World Ocean Circulation Experiment (WOCE), the Tropical Ocean Global Atmosphere (TOGA) program, and the Global Energy and Water Cycle Experiment (GEWEX) are central components of the USGCRP and are complementary to the IGBP.

2.2.3.2 Earth Observations International Coordination Working Group

The Earth Observations International Coordination Working Group (EO-ICWG) is the forum within which the U.S., Europe, Japan, and Canada discuss, plan, and negotiate the international cooperation essential for implementation of the International EOS (IEOS) Program in the mid-late 1990s and beyond. The EO-ICWG's objectives are to promote:

1. Development of an integrated observing system that will advance the scientific understanding of the entire Earth system on a global scale
2. Development of future operational services
3. Continuity of operational services that are currently provided by the polar-orbiting NOAA satellites
4. Effective use of the spacecraft dedicated to Earth science

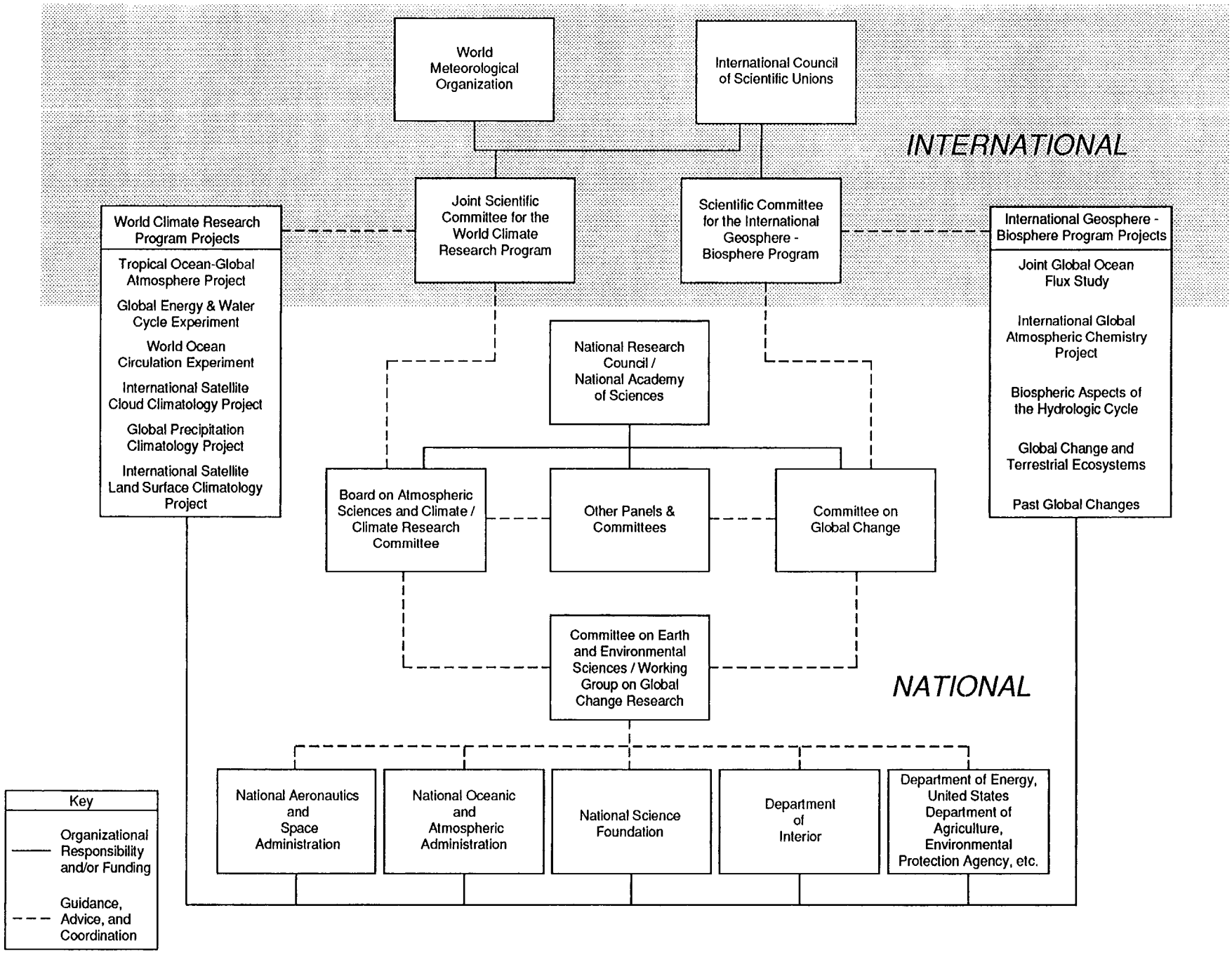


Figure 2-3. Organizational Elements of Global Research

The delegations to the EO-ICWG are led by the Earth observation offices of their respective space agencies: the NASA, ESA, Science and Technology Agency (STA)/NASDA/the Ministry of International Trade and Industry (MITI), and the Canadian Space Agency (CSA). The delegations also include respective operational environmental monitoring agencies: the NOAA, European Organization for the Exploitation of Meteorological Satellites (EUMETSAT), the Japanese Meteorological Agency (JMA), and the Canadian Atmospheric Environmental Service (AES).

A particular role of the EO-ICWG is to provide programmatic coordination among all the elements of the IEOS. The IEOS includes, in addition to the NASA MTPE spacecraft, other spacecraft supplied by outside agencies and nations, specifically NOAA, NASDA, and ESA.

2.3 EOS PROGRAM COMPONENTS

The EOS Program consists of three primary components:

1. The EOS Scientific Program
2. The EOSDIS
3. The EOS Flight Program

Each component has extensive interrelationships with the other two in addition to strong linkages to the Earth science community.

2.3.1 EOS Science

The EOS Scientific Program focuses on defining the state of the Earth system, understanding its basic processes, and developing and applying predictive models of those processes. The science component of EOS consists of both focused-disciplinary research centered around a specific Earth science data set and interdisciplinary research geared toward a broader probe into Earth science systemic functions.

2.3.2 EOSDIS

The EOSDIS provides computing and network facilities to support the EOS research activities, including data interpretation and modeling; processing, distribution, and archiving of EOS data; and command and control of the spacecraft and instruments. Through the Version 0 (prototype) system and subsequent activities, the EOSDIS will also provide access to current and upcoming Earth science data sets. The EOSDIS is eventually expected to serve as the NASA MTPE data system. The EOSDIS will be developed in an evolutionary manner, with extensive input from and testing by the research community. It will be on-line and tested before the launch of the first EOS spacecraft. After the

first launch, the system will continue to evolve in response to the scientific research needs.

2.3.3 EOS Flight Program

The EOS spacecraft, designated morning (AM), afternoon (PM), Altimetry (ALT), Chemistry (CHEM), Ocean Color Flight (COLOR), and Aerosol (AERO), will be flown as flight series, carrying payloads designed to measure physical phenomena from which specific data products can be derived. The physical phenomena to be measured by each flight series is as follows:

- The EOS-AM flights will be placed in a Sun-synchronous polar orbit with a morning Equatorial descending crossing time (hence the "AM" designation). They will fly a payload complement designed to measure physical phenomena associated with clouds, aerosols, and radiative balance. In addition, the EOS-AM will be capable of providing characterization of the terrestrial surface and ocean productivity.
- The EOS-PM flights will be placed in a Sun-synchronous polar orbit with an afternoon Equatorial ascending crossing time. They will fly a payload complement designed to measure physical phenomena associated with atmospheric temperature and humidity, clouds, precipitation, radiative balance, terrestrial snow and sea ice, sea-surface temperature and ocean productivity, soil moisture, and improvement of numerical weather prediction.
- The EOS COLOR flight will measure oceanic biomass and productivity.
- The EOS-AERO flights will be equipped to measure atmospheric aerosols from a 57° inclination, precessing orbit.
- The EOS-ALT flights will perform altimetry measurements focused on evaluating ocean circulation and ice-sheet mass balance.
- The EOS-CHEM flights will perform measurements focused on evaluating atmospheric chemical species and their transformations.

In addition to these EOS spacecraft, there will be EOS-funded instruments that will be flown on other U.S. and international spacecraft.

2.4 EOS PROGRAM INTEGRATION

The accomplishment of the EOS Program mission objectives requires a comprehensive integration of the three Program components of Science, EOSDIS, and Flight Program to ensure that the EOS requirements are satisfied in the broader context of NASA's MTPE and the USGCRP. Program integration is the iterative process of unifying separate but related requirements and information; assessing the requirements and related information within known technical, cost, and schedule constraints; defining and

confirming a workable program; and disseminating the resultant knowledge. Integration within the EOS Program ensures that the programmatic and technical aspects of the system are compatible with cost, schedule, and technological constraints. It also ensures that programmatic linkages are established and maintained with other organizations within NASA, affiliated U.S. Agencies and Offices, U.S. non-government institutions, and international organizations.

The integration of the EOS Program components and the elements within each component is a coordinated effort by the NASA Headquarters Office of MTPE and the GSFC MTPE Office working with other NASA organizations, U.S. agencies (e.g., NOAA and DOD), and international partners (e.g., CSA, NASDA, and ESA). More detail on this coordinated integration effort is provided in the EOS Program Management Plan and in other sections of this Project Plan.

3. CONTROLLED ITEMS

Controlled Items are those items specified as requiring approval at the senior management level before they can be changed. The following paragraphs list the controlled items and the level of management approval required before changes can be made.

3.1 PROGRAM COMMITMENT AGREEMENT

The Program Commitment Agreement (PCA) documents the agreement between the Administrator and the Program Associate Administrator (PAA) regarding the following items:

- Program objectives
- Number of flights
- Launch vehicle
- Launch dates
- Program cost by fiscal year and total
- Data and Information System phased capability commitment dates

3.2 PROJECT PLAN

The Project Plan documents the agreement between the PAA and the Field Installation Director (FID) regarding the following items:

- Total Project funding by fiscal year
- Scope of work to be accomplished including Level 1 Requirments
- Science objectives, science team(s), and major scientific instrumentation
- L-1 Year and L-2 Year review dates

3.3 PROGRAM CONTROL BOARD

Changes in the Level 1 requirements identified in Sections 4, 5, 6, 7, and 8 will be controlled through the NASA Headquarters Program Control Board.

3.4 GSFC PROJECT-CONTROLLED ITEMS

In addition to the previously identified Headquarters-controlled items, the EOS Project Office(s) at GSFC will control implementation documents below the Project Plan level required to design, develop, procure, manufacture, integrate, and test the spacecraft, instruments, and ground system. These documents are identified in the GSFC EOS Documentation Tree (420-02-04).

4. EOS PROGRAM

4.1 PROJECT SUMMARY

In the original EOS Program, the instruments were to be flown on two series of large platforms each containing about 15 instruments. As a result of the program restructuring and rescoping process outlined in Section 1.2, EOS has been reconfigured to fly the instruments required for global climate studies on (1) intermediate spacecraft that can be launched on Intermediate Expendable Launch Vehicle (IELV)-class vehicles, (2) medium spacecraft to be launched on Medium Expendable Launch Vehicle (MELV)-class vehicles, and (3) small spacecraft to be launched on Small Expendable Launch Vehicle (SELV)-class vehicles. The names of the spacecraft, their launch vehicles, and their purposes are as follows:

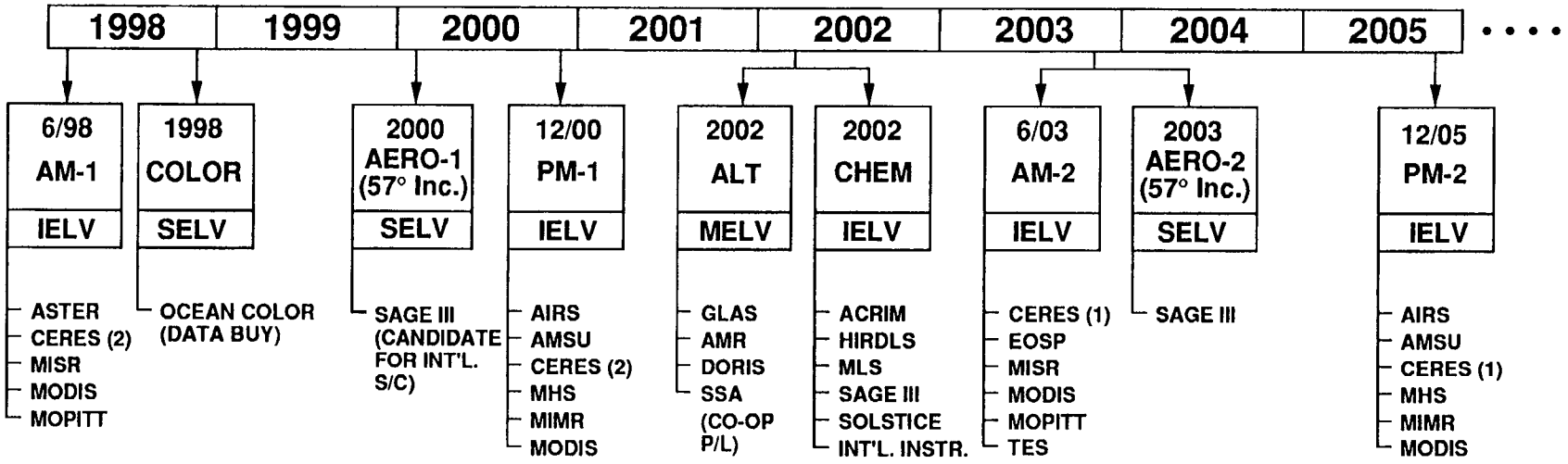
- EOS AM (IELV-class) – Characterization of the terrestrial and oceanic surface, clouds, aerosols, radiation balance, and monitoring of volcanoes
- EOS PM (IELV-class) – Clouds, precipitation, radiative balance; terrestrial snow and sea ice; sea-surface temperature and ocean productivity
- EOS COLOR (SELV-class) – Ocean color and productivity (data buy)
- EOS AERO (SELV-class) – Atmospheric aerosols
- EOS ALT (MELV-class) – Ocean circulation and ice sheet mass balance
- EOS CHEM (IELV-class) – Atmospheric chemical species and their transformations

The launch profile through 2005 and instrument sets applicable to each flight are shown in Figure 4-1. Each of these series of spacecraft is discussed in more detail in Sections 5, 6, and 7 of this plan.

In addition to the flight elements summarized above, the EOS Program includes the ground system, EOSDIS, as well as the science element. The EOSDIS provides a vital resource to the Earth-science research community and is described in detail in Section 8 of this plan. A listing of all EOS data products including science parameters, is contained in the EOS Science Plan (170-01-02).

4.2 EOS GENERAL LEVEL 1 REQUIREMENTS

The EOS General Level 1 requirements are shown below. The specific Level 1 requirements applicable to each individual EOS Project [AM, PM, Chemistry and Special Flights (CSF), Earth Science Data and Information System (ESDIS)] are shown in Sections 5, 6, 7, and 8 of this project plan. Any proposal to change a Level 1 requirement or any failure to meet Level 1



IELV - INTERMEDIATE EXPENDABLE LAUNCH VEHICLE
MELV - MEDUIM EXPENDABLE LAUNCH VEHICLE
SELV - SMALL EXPENDABLE LAUNCH VEHICLE

NOTE:

- **SPACECRAFT REFLIGHTS CONTINUE BEYOND 2005 TO SUPPORT GENERATION OF THE 15-YEAR SCIENCE DATA SET**
- **CERES AND LIS ARE FUNDED FOR THE TRMM MISSION PLANNED FOR LAUNCH IN 1997**
- **SEAWINDS IS FUNDED FOR 1998 DELIVERY TO THE ADEOS II MISSION**
- **CERES IS FUNDED FOR A MID-INCLINATION FLIGHT PLANNED FOR 2000**

Figure 4-1. EOS Mission Profile

requirements will be referred to the Program Control Board (PCB) for disposition. For those issues requiring Project level decisions, the procedures defined in the EOS Configuration Management Plan (420-02-02) will be followed. Items controlled by the Administrator and PAA are identified in Section 3 of this plan.

4.2.1 Consultative Committee on Space Data Systems Standards

EOS, where appropriate, shall conform to the Consultative Committee on Space Data Systems (CCSDS) recommended standards. Only those portions of the CCSDS recommendations that pertain to EOS flight requirements shall be implemented.

4.2.2 Intercomparison of Science Data

EOS shall provide EOS data from each instrument series with algorithms calibrated in a controlled environment prior to each launch, so as to quantify differences. The purpose of the ground calibration is to minimize differences in measured radiances and geophysical parameters for each instrument throughout the length of investigation.

4.2.3 Data Formats

EOS shall utilize standardized data formats in communications between spacecraft subsystems, instruments, and ground support equipment.

4.2.4 Data Transmission

EOS shall be capable of delivering not less than 95% of all payload-related data to the ground during any two consecutive orbits.

4.2.5 Operational Data

EOS shall be capable of delivering the raw data from instruments with potential for operational use to NOAA at a White Sands Terminal pick-up point within 3 hours of observation.

4.2.6 Communications

The EOS AM, PM, and Chemistry spacecraft and ground segments shall be designed to communicate via the Tracking and Data Relay Satellite System (TDRSS) and the Deep Space Network (DSN).

4.2.7 Ground Back-up

The DSN and Ground Network (GN) shall be used as a back-up for health, safety, and command data.

4.2.8 System Testing

EOS shall provide the capability to test the functionality and performance of the end-to-end system to verify system changes and upgrades, without the interruption of operational support.

4.2.9 Technology Transfer

EOS shall, subject to U.S. Technology Transfer Policy, make appropriate technology available to the International Partner agencies participating through the EO-ICWG in the development of the IEOS.

4.2.10 Orbital Debris

EOS spacecraft and instruments shall be designed to minimize generation of orbital debris.

4.2.11 EOS Data Policy

EOS shall require all EOS investigators to adhere to the EOS Data Policy (see Appendix C) for research use by affiliated users.

4.2.12 Data Distribution

EOS shall make Level 0 data available for higher level processing within 24 hours from observation.

4.3 ORGANIZATION

Management responsibilities and procedures for the EOS Program are established in accordance with Space Flight Program and Project Management, NMI 7120.3.

4.3.1 NASA Headquarters Organizational Assignments

The Associate Administrator (AA) for the OMTPE, NASA Headquarters, represents the administrator in managing the EOS Program. The PAA is responsible for assigning program and project responsibilities to the field installation, assuring agreed project funding is provided; providing overall direction, control, and oversight of program/project implementation; including serving as the chairman of the Program Control Board (PCB) and assessing project execution performance. The primary components of the EOS Program are the EOS Flight Program, EOSDIS, and the EOS Scientific Program. The PAA has assigned Headquarters responsibility for the EOS Program to a management team led by the Deputy AA, MTPE. This management team consists of the Director, MTPE Flight Systems Division (FSD); the Director, MTPE Operations, Data and Information Systems (ODIS) Division; and the EOS Program Scientist, within the MTPE Science Division (see Figure 4-2). The management team reports to the

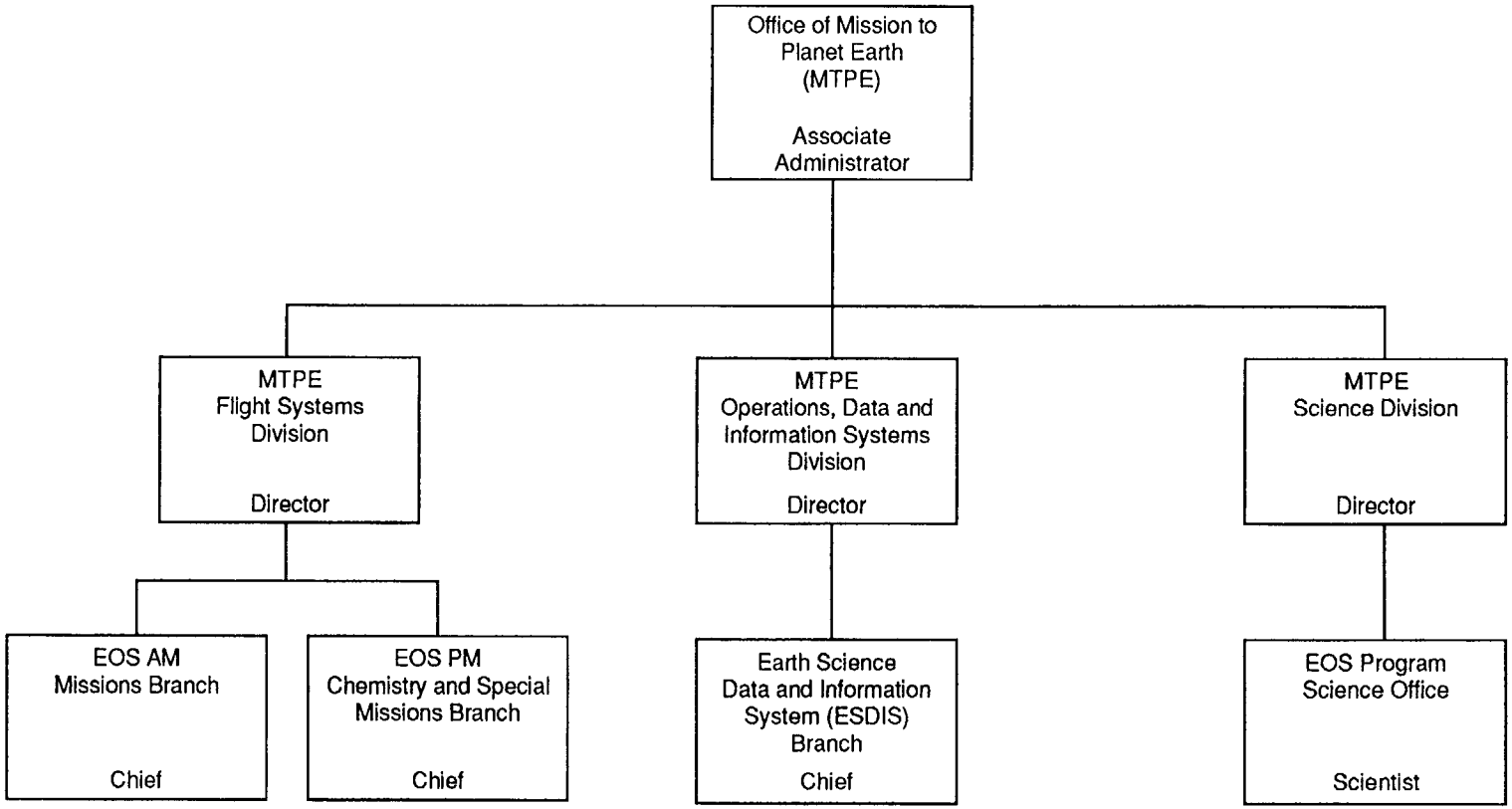


Figure 4-2. MTPE Management Organization Chart for EOS Program

Deputy AA on the plans and status for implementation of the EOS Program.

4.3.1.1 MTPE Flight Systems Division Director

The MTPE FSD Director is responsible for program formulation and for developing and administering the Headquarters policies, guidelines, and controls for implementing the flight projects comprising the EOS Program. The FSD Director's authority includes the following:

- Formulation and advocacy of the EOS flight program budget and funding priorities.
- Coordinating te EOS Flight Program within NASA and serving as the NASA representative for the Flight Program with other government, non-government, and international agencies.
- Development of the PCA and Development Cost Commitment (DCC) for signature by the PAA and Administrator.
- Recommending approval of the Preliminary and Final Project Plans and associated changes to these documents.

The FSD Director is supported by the Chief, EOS-AM Missions Branch and the Chief, EOS-PM, Chemistry, and Special Missions Branch. The Program Managers within these branches perform the day-to-day oversight, communications, and coordination with the EOS Project Managers at GSFC for implementation of the flight projects. The FSD Program Manager's authority includes the following:

- Coordinating flight program component activities with other Headquarters program components and serving as the NASA representative for the flight program with other government, non-government, and international entities.
- Recommending flight systems objectives, requirements and implementation guidelines, and Headquarters controlled milestones.
- Recommending and advocating the flight program component budget and the Allowance for Program Adjustment (APA) including preparation of testimony and justification for Presidential and Congressional authorization.
- Reviewing all elements of the performance of flight projects to verify satisfactory implementation.
- Apprising NASA Headquarters management of the status of the flight systems and preparing status reports and other documents required by the PAA.

4.3.1.2 MTPE Operations, Data and Information Systems Division Director

The MTPE ODIS Director is responsible for program formulation and for developing and administering the Headquarters guidelines and controls for implementing the ESDIS Project. The ODIS Director's authority includes the following:

- Coordinating ESDIS program components with other Headquarters elements and serving as the NASA representative for the ESDIS program with other government, non-government, and international entities.

The ODIS Director is supported by the Chief, ESDIS Branch, who serves as the Program Manager for the ESDIS. The Program Manager performs the day-to-day communications and coordination with the EOS Project Managers at GSFC for the implementation of the ESDIS Project. The ESDIS Program Manager's authority includes the following:

- Recommending ESDIS objectives, requirements and implementation guidelines, and Headquarters controlled milestones.
- Recommending and advocating the ESDIS Program component budget and the APA, including preparation of testimony and justification for Presidential and Congressional authorization.
- Reviewing performance of ESDIS Project to verify satisfactory implementation.
- Apprising the PAA of the ESDIS program status and preparing status reports and other documents required by the PAA.

4.3.1.3 <u>EOS Program Scientist</u>

The EOS Program Scientist is responsible for formulation of the EOS scientific mission and for developing the Headquarters guidelines for implementing the science program component activities. The EOS Program Scientist's authority includes the following:

- Recommending science objectives, requirements and implementation guidelines, and related Headquarters controlled milestones.
- Recommending and advocating the science program component budget and the APA, including preparation of testimony and justification for Presidential and Congressional authorization.
- Coordinating the science program component with other Headquarters program components and serving as the NASA representative for the science program with other government, non-government, and foreign entities.

The EOS Program Scientist provides scientific leadership to the Program; supports the management of the Program, including direct management of the Interdisciplinary Science Investigations; and educates interested parties on the Program and its scientific capabilities. As the key science advisor for the EOS Program, the Program Scientist monitors the evolution of the design of the EOS to ensure the scientific capabilities are maintained. The Program Scientist works with the FSD Director and the ODIS Director to determine the programmatically-optimal solutions to

resolve technical, budget, and schedule problems that impact the Program's scientific capabilities.

4.3.2 GSFC Organizational Assignments

Within NASA, GSFC is responsible for development and operation of the EOS remote sensing spacecraft, instruments, and data and information system for the conduct of Earth science investigations using the data from all Earth-observing sources. The MTPE Office has been established within the Office of the Director, GSFC, to provide overall management, guidance, and coordination of the EOS activities. These activities include the following:

- EOS AM Project
- EOS PM Project
- EOS Chemistry and Special Flights (CSF) Project
- Earth Science Data and Information System (ESDIS) Project
- Earth Science Mission Operations (ESMO) Project
- EOS Science
- GSFC Distributed Active Archive Center (DAAC)

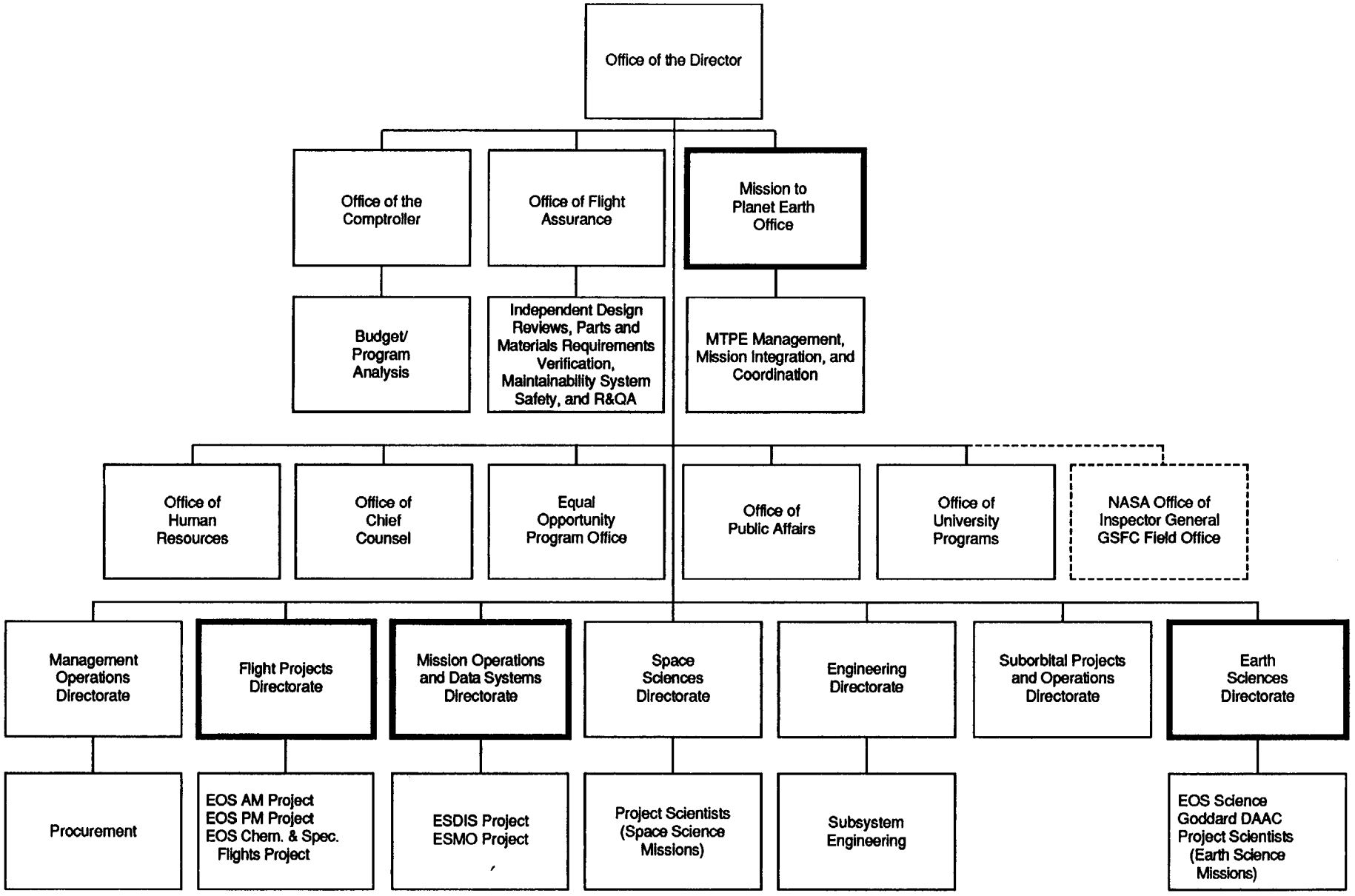
Figure 4-3 shows the location of the MTPE Office within the GSFC organization.

The GSFC MTPE Office management organization is shown in Figure 4-4. The EOS flight projects reside in the Flight Projects Directorate, and the EOS ground system and operations projects reside in the Mission Operations and Data Systems Directorate (MO&DSD). Responsibility for EOS science activities and the Goddard DAAC reside with the Earth Sciences Directorate. The Director for each of these three Directorates, together with the Director, MTPE Office, have overall responsibility for the successful implementation of all EOS activities at GSFC.

4.3.2.1 Director, Mission to Planet Earth Office

The Director, MTPE Office, as shown in Figure 4-3, is responsible for overall program management, planning, guidance, monitoring, and coordination of EOS activities at GSFC. The incumbent is responsible for coordination across all mission elements including budget planning and control, program-wide schedule management, and reporting. The incumbent serves as the primary interface to NASA Headquarters for GSFC MTPE programatic activities, participates in negotiation of MTPE partnership agreements, and serves as a liaison with the external communities.

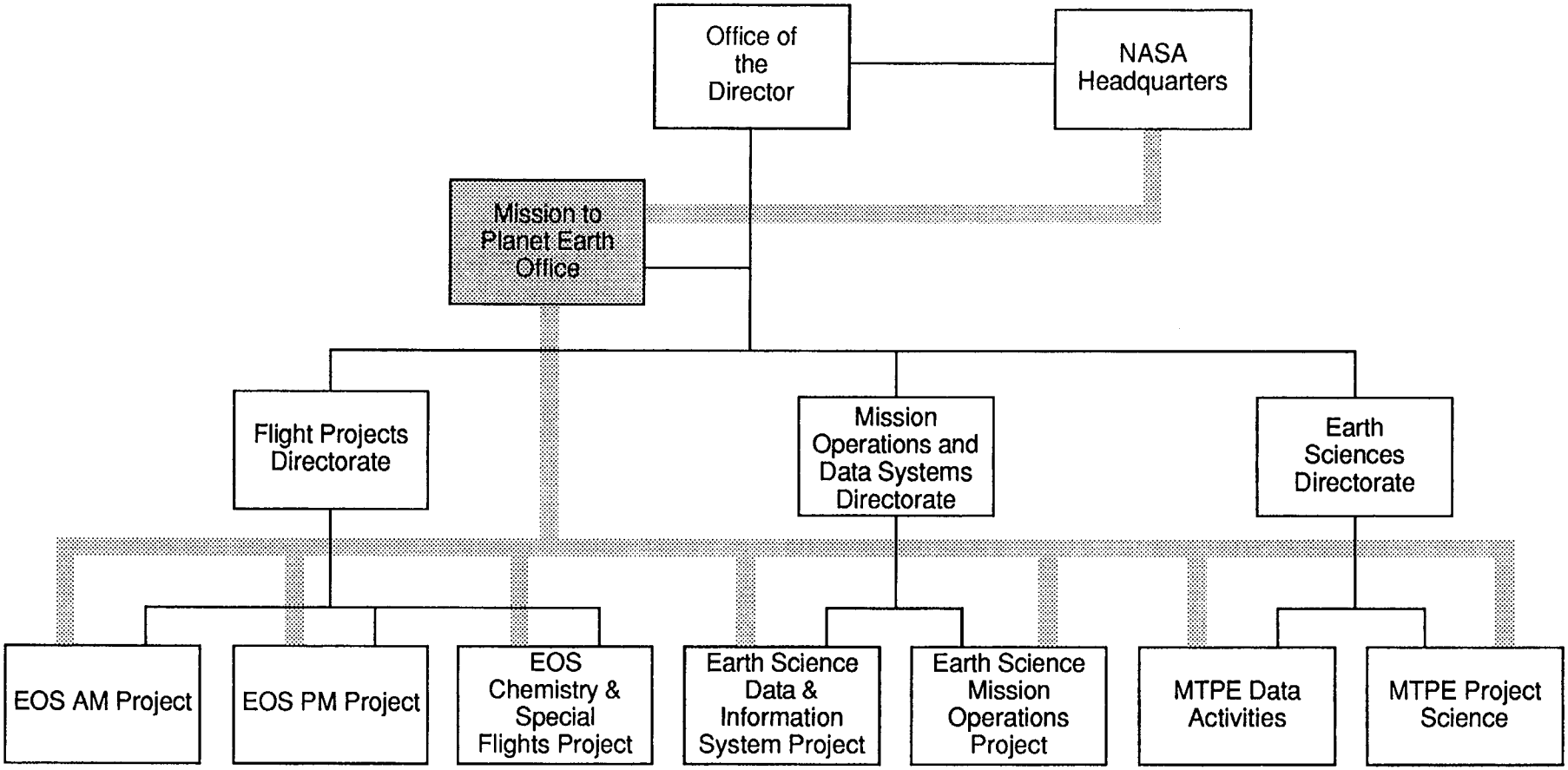
The Director, MTPE Office, is also responsible for overall mission integration including assignment of Level 1 requirements responsibility, system management across all mission elements, system-wide interface and configuration coordination as well as overall trade study and system verification planning.



Legend:

------ Support Position
——— Line Position

Figure 4-3. Support Interfaces Within the GSFC Organization



Legend: Programmatic Responsibility

Implementation Responsibility

Figure 4-4. Mission to Planet Earth Office Management Organization

The Director, MTPE Office, also assures the appropriate utilization and infusion of new technology into the EOS program and monitors and controls technology transfer.

The Director, MTPE Office, is assisted by a small staff of senior engineering, science, and resources management personnel including the Deputy Director and the Deputy Director, Resources.

4.3.2.2 Deputy Director, Mission to Planet Earth
The Deputy Director supports the Director, MTPE Office, in the overall program management, planning, guidance, monitoring, and coordination of EOS activities of GSFC. The incumbent provides guidance and advice to the MTPE Project Managers and their staff to assure timely resolution of issues and accomplishment of MTPE program commitments. Specific responsibilities for EOS include coordination of activities among the EOS elements, verification of Level 1 requirements, coordination of trade studies, procurements, and resolution of technical versus programmatic issues. In the absence of the Director, the Deputy Director assumes full responsibility for the MTPE Office.

4.3.2.3 Deputy Director (Resources) Mission to Planet Earth
The Deputy Director (Resources) is responsible to the Director, MTPE Office, for planning, coordinating, and leading the business, administrative, and management control functions of the MTPE Office. The incumbent provides overall guidance to a team of senior managers and specialists assigned to provide resource management leadership and expertise for the MTPE projects. The incumbent is responsible for integrating all MTPE functional resource activities (i.e., finance, procurement, and general business support) for all elements of the MTPE Office to ensure effective overall resource planning, implementation, monitoring, and reporting. The incumbent may act for the Director, MTPE Office, in his/her absence and in the absence of the Deputy Director.

4.3.2.4 EOS Project Managers
The duties and responsibilities of the EOS Project Managers are shown in Sections 5, 6, 7, and 8 of this plan. The ESMO Project is a division level element within the MTPE organization as shown in Figure 4-4. A separate Project Plan will be issued for ESMO Project activities, including Landsat 7. Earth Science Directorate responsibilities for EOS science are addressed below in Section 4.3.2.8. Goddard DAAC responsibilities are outlined separately in Appendix B.

4.3.2.5 EOS Senior Project Scientist
The EOS Senior Project Scientist, from the Earth Sciences Directorate (Code 900) at GSFC, is responsible for ensuring the satisfactory accomplishment of the scientific objectives of the mission. The Senior Project Scientist reviews all science planning and implementation activities to ensure that the total

mission is consistent with the overall scientific objectives. The incumbent provides leadership in ensuring that the scientific data are used effectively and the scientific results of the mission are produced expeditiously, and provides appropriate inputs to the Project Data Management Plan (PDMP). The Senior Project Scientist evaluates all scientific requirements and provides scientific guidance to the Director of Earth Sciences and others involved in the Program. The Senior Project Scientist and the Program Scientist communicate and coordinate on science issues on a regular basis and share assignments such as co-chairing the EOS IWG and SEC. The functions of the Senior Project Scientist are specifically outlined in Announcement of Opportunity Process – Acquisition and Administration of Space Science and Applications Investigations, NMI 7100.11A, and also include:

- Recommending and advocating the science budget, science computing facility budget, and contingency amongst the approved EOS Science Teams.

- Guiding and coordinating the science activities and advice of the Project Scientists for EOS AM, PM, Chemistry, Color, Altimetry, and EOSDIS, and the Calibration and Instrument Scientists.

4.4 SUMMARY WORK BREAKDOWN STRUCTURE

The EOS Summary Work Breakdown Structure (WBS), as shown in Figure 4-5, is organized into six UPNs, referred to in Section 1.1, each having discrete project management and support tasks. The detailed WBS applicable to each EOS project is contained in the appropriate sections of this plan:

- UPN 225 - EOS AM Series, Section 5.4.3
- UPN 226 - EOS PM Series, Section 6.4.3
- UPN 227 - EOS Special Flight Series, Section 7.4.3
- UPN 228 - EOS Chemistry Series, Section 7.4.3
- UPN 229 - EOS Science, Section 4.4
- UPN 428 - EOSDIS, Section 8.4.2

Each EOS flight project is responsible for administering the applicable science algorithm development and related activities. Funding for this effort is contained in UPN 229 (EOS Science) and is allocated to each project by the GSFC Mission to Planet Earth Office, following the recommendation of the EOS Senior Project Scientist. The detailed EOS Science WBS is shown in Figure 4-6. The applicable EOS science procurement summaries are contained in Sections 5, 6, and 7 of this plan.

A description and the scope of each EOS WBS task are found in the EOS WBS Dictionary (420-02-01).

4.5 RESOURCE SUMMARY

4.5.1 Funding Requirements

The funding requirements for all EOS activities at GSFC are shown in Table 4-1. The funding allocated for the EOS science (UPN 229) is shown in Table 4-2. These requirements are consistent with the revised UPN structure shown in Section 1.1 and the Summary WBS shown in Figure 4-5.

Revisions to these requirements will be submitted through the Program Operating Plan (POP) process.

4.5.2 Manpower Requirements

The Civil Service Manpower requirements for all EOS activities at GSFC are shown in Table 4-3. The manpower allocated for the EOS Science (UPN 229) is shown in Table 4-4. Revisions to these requirements will be submitted as part of the annual manpower budget process.

4.6 SCHEDULES

The NASA Headquarters-controlled milestones are identified in Figure 4-7. The indivdual EOS Project schedules supporting these milestones are contained in Sections 5, 6, 7, and 8 of this plan.

Table 4-1
EOS Projects POP 93-1 Budget Summary (NOA; $M)

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Table 4-2
EOS Science POP 93-1 Budget Summary (NOA; $M)

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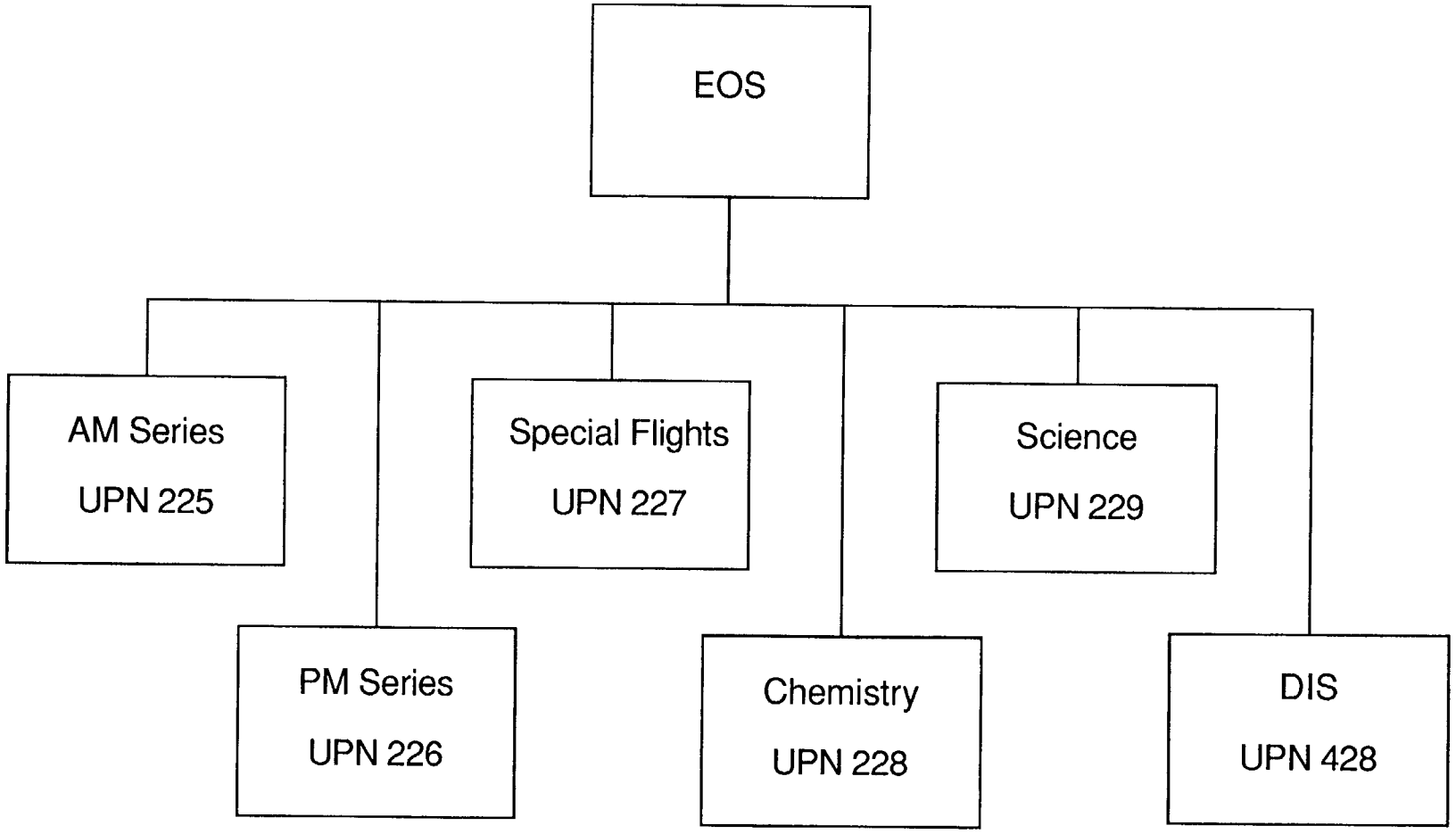

Figure 4-5. EOS Summary WBS

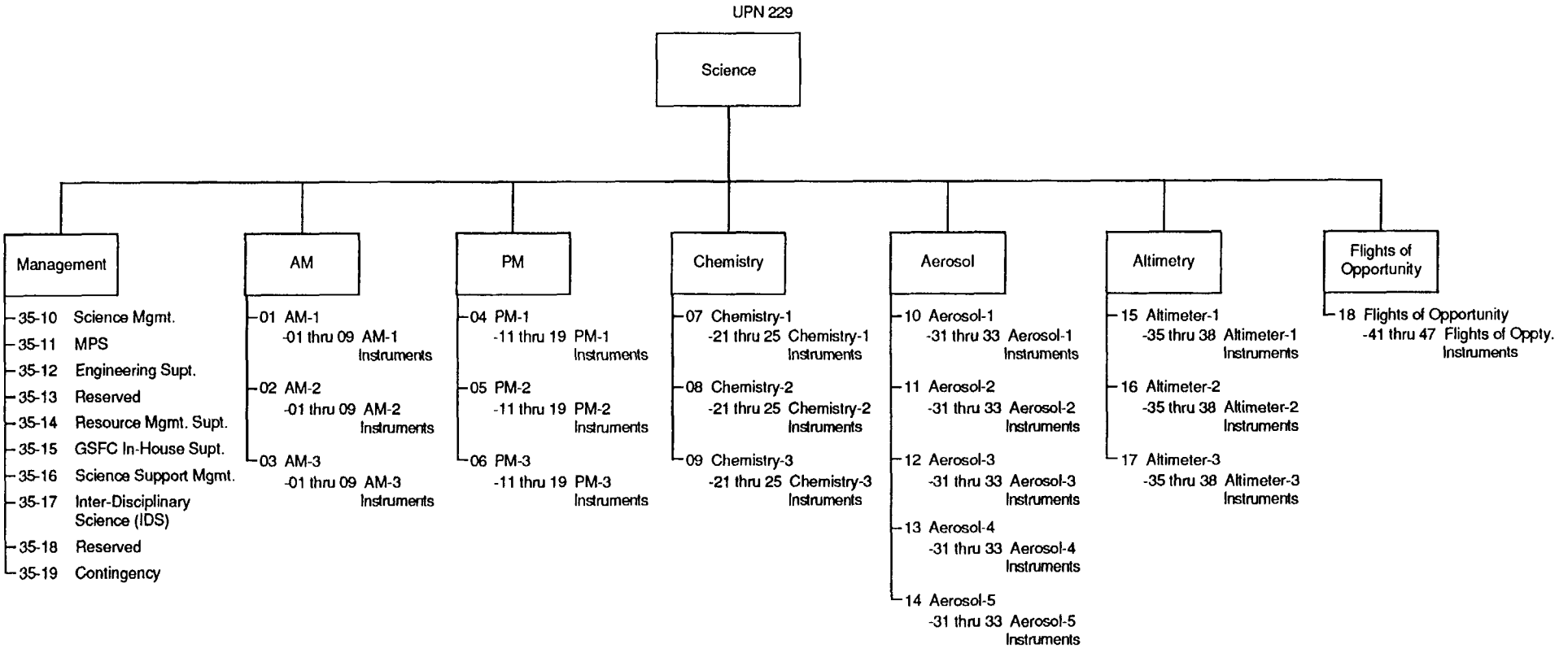

Figure 4-6. EOS Science Detailed WBS

Table 4-3
Goddard Civil Service Summary Manpower Requirements for the EOS Projects
FY93 through FY00

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Table 4-4
Goddard Civil Service Summary Manpower Requirements for EOS Science
FY93 through FY00

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APPROVAL: TILFORD
ACCOMP.: PRICE

EOS HEADQUARTERS CONTROLLED MILESTONES

PAGE 1 OF 1

ORIG. APPVL:
LAST CHANGE:
STATUS AS OF: 9/9/93

	MILESTONES	CY 93				94				95				96				97				98				99				00				01				02			
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01	EOS ANNUAL REVIEW	▼				▽				▽				▽				▽				▽				▽				▽				▽				▽			
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Figure 4-7. EOS Headquarters Controlled Milestones

5. EOS AM PROJECT

5.1 PROJECT CHARACTERISTICS

The EOS Program will develop and launch a space-based Earth Observing System that will provide global science data from a low-altitude sun-synchronous orbit on a long-term sustained basis. The focus for the EOS AM Project is the multidisciplinary study of the Earth's interrelated processes (atmosphere, oceans, and land-surface) and their relationship to Earth system changes. The global change research emphasized with the AM instrument data sets includes cloud physics and atmospheric radiation properties in addition to terrestrial and oceanic surface characteristics.

5.2 EOS AM PROJECT LEVEL 1 REQUIREMENTS

The Level 1 requirements for the EOS AM Project are comprised of the general requirements in Section 4.2 and those shown below. These requirements serve as the baseline for the derivation of lower level performance requirements. Any proposal by the EOS AM Project to change a Level 1 requirement or any failure to meet Level 1 requirements will be referred to the EOS PCB for disposition. For those issues requiring Project level decisions, the procedures defined in the EOS Configuration Management Plan (420-02-02) will be followed. Items controlled by the Administrator and PAA are identified in Section 3 of this plan.

5.2.1 EOS AM Series

The EOS AM spacecraft series, including the instruments, shall consist of three spacecraft designated EOS AM-1, EOS AM-2, and EOS AM-3, each of which shall have a design lifetime of 5 years. An artist's concept of EOS AM-1 in orbit is shown in Figure 5-1.

5.2.2 Duration of Series

The EOS AM spacecraft series shall be capable of replacing each on-orbit spacecraft every 5 years to provide observations of the Earth for not less than 15 years beginning with the launch of the EOS AM-1 spacecraft in June 1998.

5.2.3 Operational Overlap

The AM Project shall plan for a 6-month period of overlap in observations to enhance the capability to intercompare data from successive versions of EOS instruments.

5.2.4 Launch of Spacecraft

The EOS AM spacecraft shall be designed to be launched by IELVs.

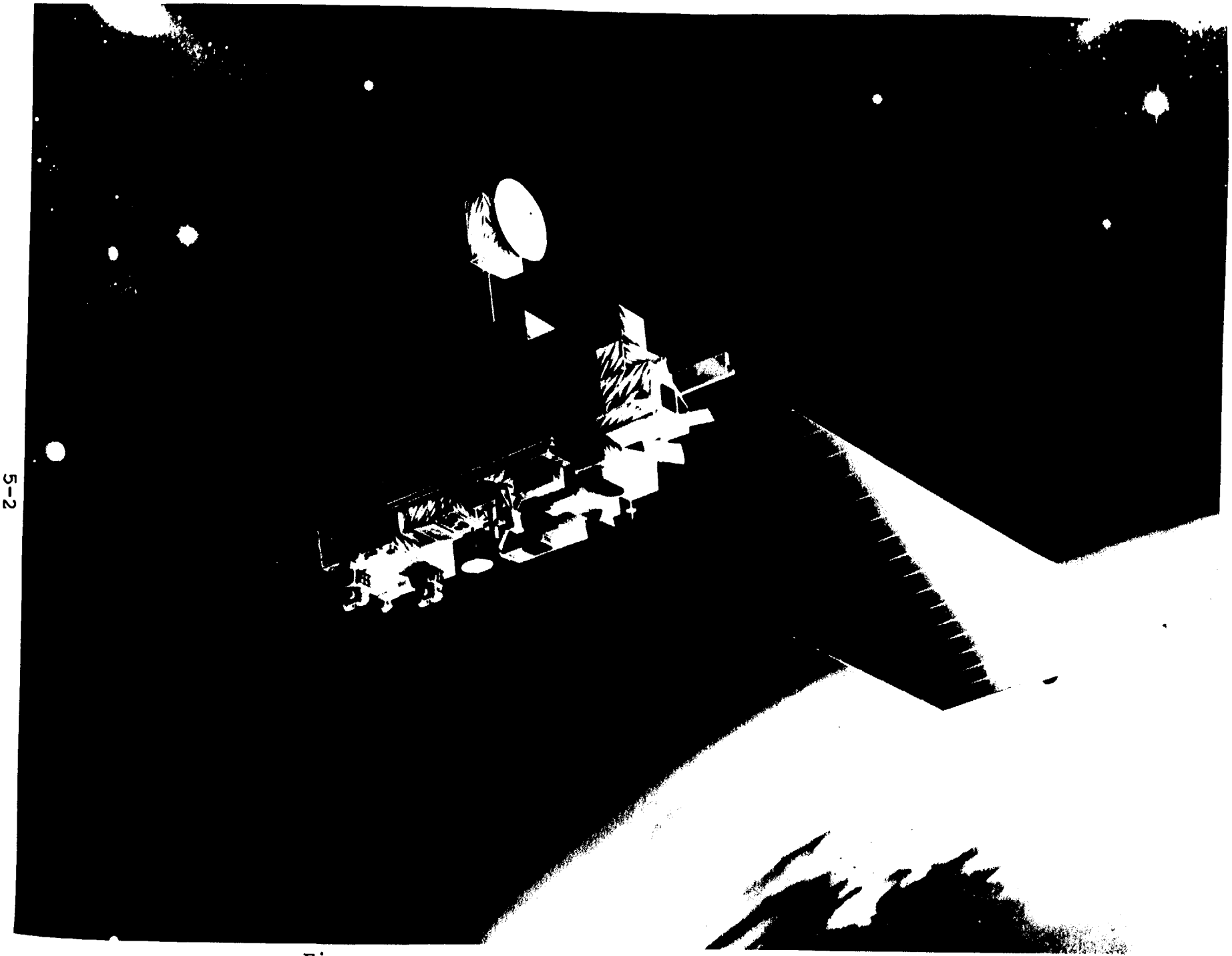

Figure 5-1. Artist's concept of EOS AM-1 in Orbit

5.2.5 Orbit of Spacecraft

The EOS AM spacecraft series shall be inserted into a 16-day, 233-orbit repeat sun-synchronous orbit with 10:30 am ±15 minutes descending nodal crossing time (nominally 705 km, 98.2° inclination).

5.2.6 Instrument Payload

The EOS AM spacecraft series shall include the instruments shown in Table 5-1. The instrument characteristics and standard data products applicable to each investigation are defined in Section 5.3.2.

Table 5-1
EOS AM Payload Complement

Instrument	AM-1	AM-2	AM-3
ASTER	X	—	—
CERES	X(2)	X(1)	X(1)
EOSP	—	X	X
MISR	X	X	X
MODIS	X	X	X
MOPITT	X	X	—
TES	—	X	X

Note: CERES can fly as one or two scanning units

5.2.7 Direct Downlink

The EOS AM-1 spacecraft shall support intermittent direct downlink of the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) science data.

5.2.8 Direct Broadcast

All EOS AM spacecraft shall support an X-band continuous direct-to-ground broadcast of Moderate Resolution Imaging Spectrometer (MODIS) science data and ancillary data.

5.2.9 Direct Playback

All EOS AM spacecraft shall support the intermittent direct-to-ground downlink of real-time or stored on-board data (both science and engineering data) as a backup should the prime TDRSS science downlink fail.

5.2.10 NMI Exception

As an exception to the Use of the Metric System of Measurement in NASA Programs (NMI 8010.2A), the EOS AM-1 spacecraft may be designed, constructed, documented, and reviewed in inch-pound units; however, spacecraft/instrument payload interfaces shall be hard metric.

5.2.11 Spacecraft Health and Safety

The spacecraft shall support detection, isolation, and recovery capabilities for any single fault to ensure the health and safety of the spacecraft (except for structure, pressure vessels, etc.).

5.2.12 Instrument Technology Improvement

The EOS AM instruments shall be designed to permit technological improvements to be incorporated into the subsequent flight copies of each instrument. Any such improvements shall be allowable only if it can be demonstrated that the improvements do not degrade data continuity. Waivers for improvements shall be reviewed by the EOS PCB.

5.2.13 Investigator Responsibilities

The TLs and TMs for each EOS AM FI and the PIs shall be responsible for the development and maintenance of algorithms and source code to generate the respective Standard Data Products listed in each instrument's section.

5.3 TECHNICAL SUMMARY

5.3.1 Spacecraft

The EOS AM spacecraft subsystems are described in Sections 5.3.1.1 through 5.3.1.8.

5.3.1.1 Structures and Mechanisms Subsystem

The spacecraft structure consists of a graphite epoxy truss with titanium node fittings and carbon composite instrument mounting plates. The mechanisms are the solar array drive and the high-gain antenna gimbal and deployment system.

5.3.1.2 Electrical Power Subsystem

The spacecraft power system collects power via a single gallium arsenide solar array that is supported by a deployable mast. Nickel hydrogen batteries are used for energy storage.

5.3.1.3 Thermal Control Subsystem

The thermal control subsystem provides temperature control for spacecraft subsystems and instruments. Passive thermal control techniques are used in the subsystem modules. Capillary pumped

heat transport units will be provided to move the heat from components of the ASTER and Measurement of Pollution in the Troposphere (MOPITT) instruments to side-mounted radiators.

5.3.1.4 Command and Data Handling Subsystem
The command and data handling subsystem provides command processing, telemetry formatting, and data storage. Commands, health and safety telemetry, and science data are routed through standard interfaces between spacecraft subsystems and instruments.

5.3.1.5 Communications Subsystem
The communications subsystem provides forward and return spacecraft communications.

Primary forward (up-link) commanding is by TDRSS S-band single access. A contingency TDRSS S-band multiple access link is also available. Emergency command is available using S-band omni antennas via the Ground Network, the Deep Space Network, or the Wallops Tracking Station.

Primary science data return (down-link) is through the Ku-band single access TDRSS link. Health and safety data are available through the TDRSS S-band single access return link.

A Direct Access System (DAS) uses one or more X-band transmitters and one or more fixed nadir antennas to provide the intermittent direct playback of all stored science data, the continuous direct broadcast of MODIS science data, and the intermittent direct downlink of ASTER science data.

5.3.1.6 Guidance Navigation and Control Subsystem
The guidance, navigation, and control subsystem provides orbit position through the TDRSS On-board Navigation System (TONS) and provides attitude determination and control through the use of star trackers, inertial reference unit, Earth/Sun sensors, 3-axis magnetometer, reaction wheels, magnetic torque rods, and the reaction control system.

5.3.1.7 Propulsion Subsystem
The spacecraft uses a mono-propellant hydrazine propulsion system for orbit circularization and orbit maintenance. The propulsion system can also provide contingency momentum management and attitude control.

5.3.1.8 Electrical Accommodations Subsystem
The electrical accommodations subsystem provides all harnessing between spacecraft subsystems and instruments including all pyrotechnic functions.

5.3.2 Instruments

Table 5-1 lists the instrument complements for the EOS AM series spacecraft. These instruments are described in Sections 5.3.2.1 through 5.3.2.6. Inclusion of EOSP on subsequent flights is pending science review and confirmation.

5.3.2.1 Advanced Spaceborne Thermal Emission and Reflection Radiometer

5.3.2.1.1 Description

The ASTER instrument is a high-resolution multi-spectral imaging radiometer. The ASTER is an FI provided under an MOU with the MITI of Japan. The ASTER science objectives include the investigation of land use patterns and vegetation characteristics, evapotranspiration, temporal land-cover classification, volcano monitoring, the study of coral reefs, glaciers and ocean temperatures, surface temperature emissivity and reflectivity, and cloud-top temperature and structure.

5.3.2.1.2 Level 1 Requirements

The ASTER shall provide reflected sunlight images of the Earth in selected bands in the visible (15 meter resolution) and shortwave infrared (60 meter resolution), high resolution thermal infrared (90 meter resolution) multispectral images, and cloud height and local surface digital elevation model (DEM) information by stereography. The ASTER shall be designed to operate with a measurement mode duty cycle of not less than 8 percent and it shall be provided a direct-to-ground intermittent down-link capability for data transmission. The ASTER shall provide the Standard Data Products shown in Table 5-2.

5.3.2.2 Clouds and the Earth's Radiant Energy System

5.3.2.2.1 Description

For AM-1, the CERES instrument, a PI instrument, consists of two scanning radiometers, each with three separate telescope units. When two scanners are flown, this configuration will allow one scanner to operate in the crosstrack mode for complete spatial coverage from limb to limb, and the other to operate with a rotating scan plane as well as in the crosstrack mode (biaxial) to provide angular sampling. When one scanner is flown (AM-2 and AM-3), it will operate primarily in the cross-track mode. The CERES science objectives are to generate data products that provide cloud-radiative forcing inputs to climate system models, and an observational baseline of clear-sky radiative fluxes and radiative input to atmospheric and ocean energy models.

Table 5-2
EOS AM-1 Standard Data Products
Preliminary

Instrument	Product Name	Units	Accuracy Abs :: Rel	Temporal Resolution	Horizontal Resol. :: Cover. *	Vertical Resol. :: Cover. **
ASTER	Level-1A Radiance, Decommutated & Reformatted	counts			15, 30, 90 m :: G	
	Level 1B Radiance, Registered at Sensor (Between Telescopes)	W/m^2/sr/µm	TBD :: TBD	1/(2-16 day)	15, 30, 90 m :: G	N/A :: at sensor
	Surface Emissivity	dimensionless	0.05-0.1 :: 0.005	1/(0.5-16 day)	90 m :: L	N/A :: Sfc
	Surface Reflectance	dimensionless	4% :: 1%	1/mo	15, 30 m :: Land/R,L	N/A :: Sfc
	Decorrelation Stretch - Browse Product	dimensionless		1/(0.5-16 day)	15, 30, 90 m :: Land/R,L	N/A :: Sfc
	Surface Radiance	W/m^2/sr/µm	2% :: 2%	1/(2-16 day)	15, 30, 90 m :: Land/R,L	N/A :: Sfc
	Digital Elevation	m	<50 m :: <30 m	1/mission	15 m :: Land/R,L	30 m :: Sfc
CERES	Bi-Directional Scan (BDS) Radiance	W/m^2/sr	1-2% :: 0.005	1/6.6 sec	25 km :: G	N/A :: TOA
	ES-8 ERBE-Like Product			1/6.6 sec	25 km :: G	N/A :: TOA

* G, R, and L represent Global, Regional, and Local Coverage, respectively.

** TOA, Trop, Atmos, and Sfc represent Top of Atmosphere, Troposphere, Atmosphere (Troposphere & Stratosphere), and Surface, respectively.

Note: These standard data products are preliminary pending negotiation and agreement with the responsible EOS investigators.

Table 5-2
EOS AM-1 Standard Data Products
Preliminary

Instrument	Product Name	Units	Accuracy Abs :: Rel	Temporal Resolution	Horizontal Resol. :: Cover. *	Vertical Resol. :: Cover. **
CERES	ES-9 ERBE-Like Product	W/m^2		1 & 24/mo [Avg]	2.5 x 2.5 dg :: R,G	N/A :: TOA
MISR	Level-1A Radiance		3% :: 1%	1/(2-9 day) [d]	275 m, 1.1 km :: G (275 m :: R)	N/A :: TOA
	Level-1B1 Radiance	W/m^2/sr/µm	3% (@ equivalent reflectance of 1.0), 6% (@ 0.05) ::	1/(2-9 day) [d]	275 m, 1.1 km :: G (275 m :: R)	N/A :: TOA
	Level-1B2 Product			1/(2-9 day) [d]	275 m - 17.6 km :: G, R	N/A :: TOA
	TOA and Cloud Product			1/(2-9 day) [d]	2.2, 17.6, 35.2 km :: G	N/A :: Trop
	Aerosol Product			1/(2-9 day) [d]	17.6 km (Land), 2.2 km (Ocean) :: G	Column :: Atmos
MODIS	Level-1A Radiance				0.25, 0.5, 1 km :: G	
	Level-1B Radiance, Calibrated Geolocated	W/m^2/sr/µm	5%(1Σ) :: RMS<NEΔL	1/day	0.25, 0.5, 1 km :: G	N/A :: N/A
	Aerosol Product			1/day	50 km (Land), 5 km (Ocean) :: G	N/A :: Atmos

* G, R, and L represent Global, Regional, and Local Coverage, respectively.

** TOA, Trop, Atmos, and Sfc represent Top of Atmosphere, Troposphere, Atmosphere (Troposphere & Stratosphere), and Surface, respectively.

Note: These standard data products are preliminary pending negotiation and agreement with the responsible EOS investigators.

Table 5-2
EOS AM-1 Standard Data Products
Preliminary

Instrument	Product Name	Units	Accuracy Abs :: Rel	Temporal Resolution	Horizontal Resol. :: Cover. *	Vertical Resol. :: Cover. **
MODIS	Cloud Product			1-2/day	5, 50 km :: G	N/A :: Cloud
	Surface Reflectance			1-9/day	1 km :: Land	N/A :: Sfc
	Snow Cover	km^2	10% ::	1/day	1 km :: Land	N/A :: Sfc
	Land_sfc Temperature/Emissivity			1/day, 1/wk, 1/mo	1 km :: Land/R	N/A :: Sfc
	Land_Cover Type	categorical fraction	10% ::	1/(3 mo)	1 km :: Land	N/A :: Sfc
	Geolocation Fields			1/day	1 km :: G	
	Pigment Concentration, "CZCS"	mg/m^3	100% (Global); 35% (Case I, Clear Atmos) :: TBD	1/day, 1/wk, 1/mo	1, 20 km :: Ocean/G,R,L	N/A ::
	Level-2 Radiance, Water-leaving	mW/cm^2/sr/µm	0.0015 ::	1/day, 1/wk, 1/mo	1 km :: Ocean/R,L	N/A :: Sfc
	PAR		5-10% ::	1/day [d]	1 km :: Ocean/G	N/A :: Sfc, Atmos

* G, R, and L represent Global, Regional, and Local Coverage, respectively.

** TOA, Trop, Atmos, and Sfc represent Top of Atmosphere, Troposphere, Atmosphere (Troposphere & Stratosphere), and Surface, respectively.

Note: These standard data products are preliminary pending negotiation and agreement with the responsible EOS investigators.

Table 5-2
EOS AM-1 Standard Data Products
Preliminary

Instrument	Product Name	Units	Accuracy Abs :: Rel	Temporal Resolution	Horizontal Resol. :: Cover. *	Vertical Resol. :: Cover. **
MODIS	Sea_sfc Temperature (SST)	K	0.3-0.5 K ::	1/day, 1/wk, 1/mo	1 km :: Ocean/L	N/A :: Sfc
MOPITT	Level-1B Radiance (+ Ancillary Data including CR Pressure)	W/m^2/sr/µm		1 view/0.4 sec	22 km :: G	:: Atmos
	CH4 Column (Total Burden)	ppbv	1% :: 1%	1 view/0.4 sec	25 km :: G	Column :: Atmos
	CO Profiles	ppbv	10% :: 10%	1 view/0.4 sec	25 km :: G	4 km :: 0-15 km
	CO Column (Total Burden)	ppbv	10% :: 10%	1 view/0.4 sec	25 km :: G	Column :: Atmos

* G, R, and L represent Global, Regional, and Local Coverage, respectively.

** TOA, Trop, Atmos, and Sfc represent Top of Atmosphere, Troposphere, Atmosphere (Troposphere & Stratosphere), and Surface, respectively.

Note: These standard data products are preliminary pending negotiation and agreement with the responsible EOS investigators.

5.3.2.2.2 Level 1 Requirements
The CERES shall measure the global distribution of reflected solar (shortwave) and emitted (longwave) radiant flux from the Earth to extend the long-term record of the components of the Earth's radiation budget initiated by the Earth Radiation Budget Experiment (ERBE). The CERES shall provide the Standard Data Products shown in Table 5-2.

5.3.2.3 Multi-Angle Imaging Spectro-Radiometer

5.3.2.3.1 Description
The Multi-Angle Imaging Spectro-Radiometer (MISR) instrument, a PI instrument, uses nine charge-coupled device (CCD)-based pushbroom cameras to acquire global multispectral imagery at nine viewing angles. The MISR will measure the abundance and properties of tropospheric aerosols, thus providing important information for assessing the global impact of aerosols on the Earth's shortwave radiation budget. Multi-angle reflectance measurements of different cloud types, classifiable by their spatial characterisitics as seen in the high-resolution MISR imagery and by cloud height distributions retrieved using stereo techniques, will improve our understanding of the effects of clouds on the Earth's climate. Surface bidirectional reflectances obtained from MISR will provide estimates of albedo, leading to more accurate methods of representing surface-atmosphere interactions in climate models, particularly over vegetated terrain. Multi-angle observations also are sensistive to the geometric characteristics of the surface, enabling new approaches to surface cover classification.

5.3.2.3.2 Level 1 Requirements
The MISR shall provide global measurements of multi-angle bidirectional reflectances at the surface and for various climatically significant cloud covers, global estimates of spectral hemispherical albedo at the top of atmosphere (TOA) and at the surface, and global retrievals of aerosol opacities and scattering properties over land and ocean. Global topographic elevations at medium resolution and optically thick cloud heights will also be provided from stereo imagery. The MISR shall provide the Standard Data Products shown in Table 5-2.

5.3.2.4 Moderate Resolution Imaging Spectroradiometer

5.3.2.4.1 Description
The Moderate Resolution Imaging Spectroradiometer (MODIS) instrument, an FI, is an imaging spectroradiometer. The MODIS science objective is to conduct long-term observations of the Earth in order to develop an improved understanding of global dynamics and processes occurring on the surface and in the lower atmosphere.

5.3.2.4.2 Level 1 Requirements

The MODIS shall provide over the portion of the electromagnetic spectrum from 0.415 to 14.235μm observations of reflected solar radiation in 20 bands at least every two days and observations of emitted thermal radiation in 16 bands every day for any point on the Earth. The spatial resolution of these observations shall be from 250m to 1 km at nadir and the absolute radiance accuracy will be from ± 1/2% in the thermal infrared and to ± 5% in the visible and near-infrared. The data products from MODIS shall be better or at least equivalent in all respects to the same or similar products now derived from the heritage instruments such as the NOAA Advanced Very High-Resolution Radiometer (AVHRR) and the Nimbus Coastal Zone Color Scanner (CZCS). The MODIS shall be provided with a direct-to-ground continuous broadcast capability for data transmission. The MODIS shall provide the Standard Data Products shown in Table 5-2.

5.3.2.5 Measurement of Pollution in the Troposphere

5.3.2.5.1 Description

The MOPITT instrument is a cross-track scanning four channel correlation spectrometer. The MOPITT is an FI provided under a Memorandum of Understanding (MOU) with the CSA. The MOPITT science objectives are to measure tropospheric CO and CH_4 concentrations in order to improve our understanding of the sources, sinks and life cycle (chemistry) of these gases. These sources, sinks and chemical processes are all influenced by the rest of the atmosphere, the land surface, the biosphere, and the oceans.

The MOPITT measure upwelling infrared radiance in the 2.3μm and 4.7μm wavelength regions and uses correlation spectroscopy to enhance sensistivity to the gases measured. It cannot measure in the presence of cloud. The 2.3μm channels are inoperative at night, since the radiation source is the Sun.

5.3.2.5.2 Level 1 Requirements

The MOPITT shall measure the column abundance and profiles of CO and the column amount of CH_4 in the troposphere. Profiles will be measured at all times, the column amounts will only be available during daylight.

The MOPITT pixel size will be 22km x 22km.

The MOPITT scanning system will scan through a maximum of ±14 pixels on either side of nadir. The scanning will be arranged such that a continuous swat of pixels can be aquired.

Quoted accuracies are after full calibration and validation activities. The MOPITT shall provide the Standard Data Products shown in Table 5-2.

5.3.2.6 Troposphere Emission Spectrometer

5.3.2.6.1 Description

The Tropospheric Emission Spectrometer (TES) instrument, a PI instrument, is a high spectral resolution infrared imaging Fourier transform spectrometer. The TES science objectives include the investigation of biochemical cycles of the interaction of the lower atmosphere and the biosphere, global climate modification due to greenhouse gases, acid disposition precursors, the exchange of gases between stratosphere and troposphere, and the distribution of tropospheric ozone and carbon monoxide.

5.3.2.6.2 Level 1 Requirements

The TES shall obtain global profiles of infrared-active species (including greenhouse gases, tropospheric ozone, acid rain precursors, and gases involved in stratospheric ozone depletion) from the surface to the lower stratosphere. The planned Standard Data Products for TES are shown in Appendix D.

5.3.2.7 Earth Observing Scanning Polarimeter

5.3.2.7.1 Description

The Earth Observing Scanning Polarimeter (EOSP) instrument, a PI instrument, is a cross-track scanning polarimeter. The EOSP science objectives include the retrieval of cloud and aerosol properties, including optical thickness, particle size, liquid/ ice phase, and cloudtop pressures.

5.3.2.7.2 Level 1 Requirements

The EOSP shall determine cloud properties including optical thickness, particle size, liquid/ice phase, cloudtop pressure, and determine the global distribution and optical thickness of aerosols and hazes and collect polarization imagery of the Earth for applications research. The planned Standard Data Products for EOSP are shown in Appendix D.

5.3.3 Observatory System Integration and Test

An observatory level test program will be conducted to demonstrate that the observatory can withstand and perform properly when subjected to the expected launch and orbit environments. This test program will include an end-to-end system test, which will simulate orbital performance and verify compatibility of the total flight and ground segments.

5.4 IMPLEMENTATION APPROACH

The implementation approach for each of the major elements of the EOS AM Project is described in the following sections. The approach conforms to the UPN structure identified in Section 1.1 and the WBS described in Section 5.4.3.

5.4.1 Spacecraft

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5.4.2 Instruments

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5.4.3 EOS AM Work Breakdown Structure

The EOS AM Project Summary WBS, as shown in Figure 5-2, is organized into the following elements:

- EOS AM-1 spacecraft
- EOS AM-2 spacecraft
- EOS AM-3 spacecraft

The WBS incorporates the EOS AM Project responsibilities: spacecraft, instruments, and the associated project management of each spacecraft. EOS AM instrument science algorithm development

Table 5-3
EOS AM Project Procurement Summary

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Table 5-3
EOS AM Project Procurement Summary (Continued)

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Table 5-3
EOS AM Project Procurement Summary (Continued)

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Table 5-3
EOS AM Project Procurement Summary (Continued)

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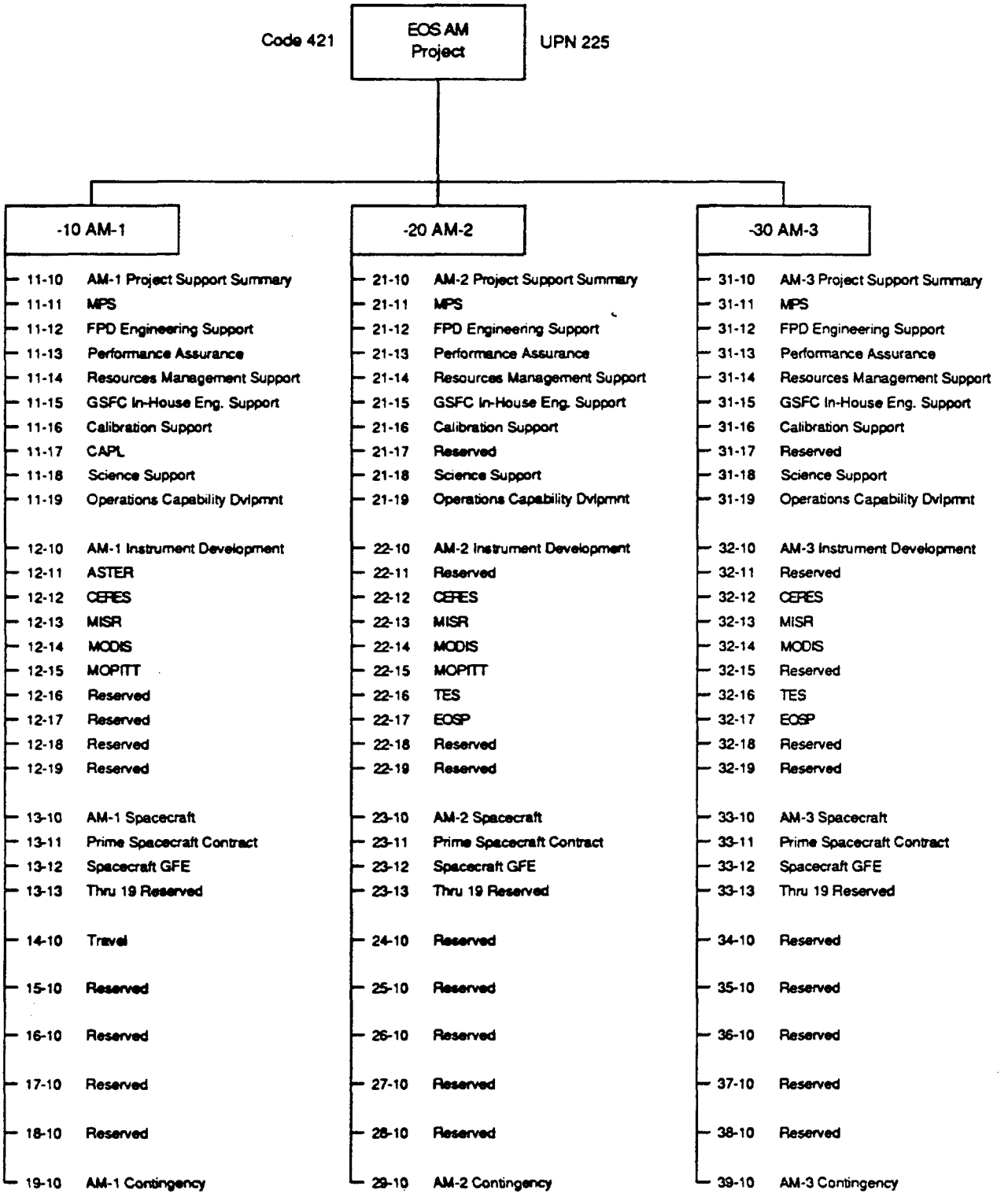

Figure 5-2. EOS AM Project WBS

and related activities are also the responsibility of the EOS AM Project. Funding for this effort is part of UPN 229 (EOS Science) and is allocated to the project by the GSFC Mission to Planet Earth Office, following the recommendations of the EOS Senior Project Scientist. Science Computing Facility (SCF) funds needed in support of overall science activity are provided as part of the ESDIS budget under UPN 428. A WBS Dictionary for the entire EOS Project is found in document 420-02-01.

5.5 PROCUREMENT SUMMARY

A summary of the major EOS AM Project procurements is shown in Table 5-3. These procurements consist of the spacecraft, instruments, and science agreements applicable to the EOS AM Project.

5.6 EOS AM PROJECT MANAGEMENT RESPONSIBILITIES AND ORGANIZATION

Management responsibilities and procedures for the EOS AM Project are established in accordance with Space Flight Program and Project Management, NMI 7120.3. Within GSFC, the Flight Projects Directorate includes the EOS AM Project. The EOS AM Project staff interfaces with functional GSFC directorates and facilities to plan, implement, and coordinate development of the EOS AM Project. The OMTPE/EOS AM Project organization charts are given in Figures 5-3 and 5-4.

5.6.1 EOS AM Project Manager

The EOS AM Project organization shown in Figure 5-4 is headed by a Project Manager who is the senior official at GSFC exclusively responsible for managing execution of the project life-cycle. The EOS AM Project Manager has full authority to carry out this responsibility within guidelines and controls prescribed by the Director of Flight Projects, the Director of the Mission to Planet Earth Office, and the GSFC Director.

Specific responsibilities include directing and overseeing:

- Preparation and maintenance of project plans, specifications, schedules, and budgets.
- Acquisition and utilization of participating contractors.
- Execution of project plans by government, contractor, and university participants in conformance with all project commitments and constraints and with all agency policies.
- Performing project level Systems Engineering and Integration (SE&I)

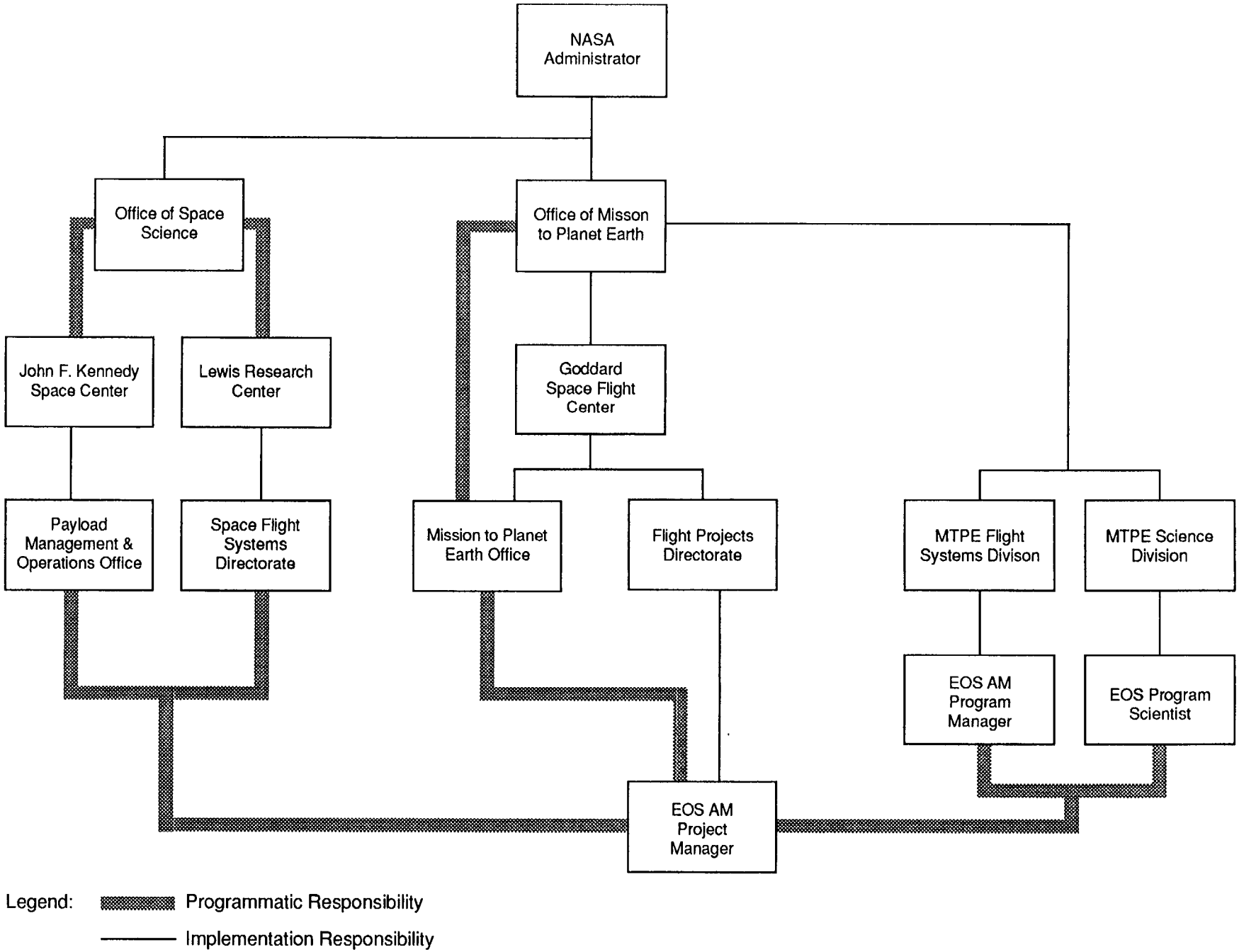

Figure 5-3. MTPE / GSFC Project Management Organization Chart for EOS

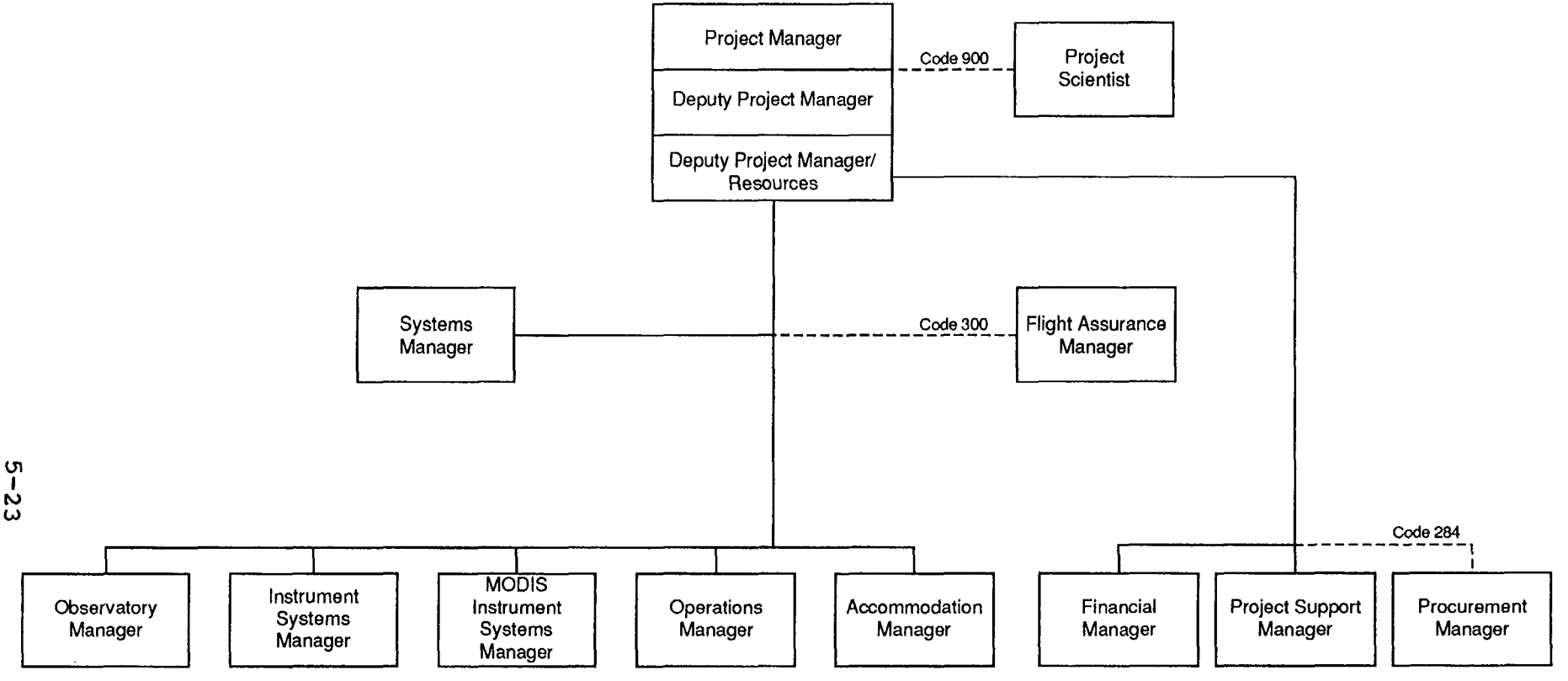

Figure 5-4. EOS AM Project Organization Chart

- Reporting project status and contractor performance as required.
- Establishing and maintaining a close and effective working relationship with the Program Manager.

The EOS AM Project Manager discharges the responsibilities with the assistance and support of individuals and organizations assigned either administratively or functionally to the EOS AM Project. The EOS AM Project Manager is also responsible for the development of the CERES and MODIS instruments for EOS and other Earth science missions.

5.6.2 EOS AM Deputy Project Manager

The EOS AM Deputy Project Manager (DPM) is responsible to the EOS AM Project Manager and is an integral member of the management team for the AM Project. The EOS AM DPM supports the EOS AM Project Manager in directing all phases of the EOS AM Project and has Projectwide responsibility for personnel management and planning and evaluating all EOS AM Project activities on a day-to-day basis.

The incumbent provides technical management to the team of technically skilled specialists and their supporting personnel in order to meet cost and schedule commitments. In the absence of the Project Manager, the DPM assumes full responsibility for the Project.

5.6.3 EOS AM Deputy Project Manager/Resources

The EOS AM Deputy Project Manager/Resources (DPM/R) is responsible to the EOS AM Project Manager and is an integral member of the management team for the EOS AM Project. The EOS AM DPM/R contributes business management expertise to the establishment of technical program objectives and is responsible for the application of business, financial management, and performance measurement techniques to the accomplishment of those objectives. The EOS AM DPM/R supervises a team of specialists in the areas of finance, budget, performance measurement, scheduling, pricing, configuration management, etc., and is responsible for the application of sound business techniques to the accomplishment of EOS AM Project objectives. In addition, the EOS AM DPM/R provides requirements to the EOS AM Project Procurement Manager on Project-related matters. In the absence of the EOS AM Project Manager and the EOS AM DPM, the EOS AM DPM/R may act for the EOS AM Project Manager.

5.6.4 EOS AM Project Scientist

The EOS AM Project Scientist, from the Earth Sciences Directorate at GSFC, is responsible for ensuring the satisfactory accomplishment of the scientific objectives of the EOS AM

mission. The EOS AM Project Scientist reviews the planning and implementation of the EOS AM Project to ensure that the total mission is consistent with the overall scientific objectives. The EOS AM Project Scientist provides leadership in ensuring that the scientific data are used effectively and the scientific results of the mission are produced expeditiously. The EOS AM Project Scientist provides appropriate inputs to the PDMP. The EOS AM Project Scientist evaluates all scientific requirements placed on the EOS AM Project, provides scientific guidance to the EOS AM Project Manager, and provides information and recommendations to the EOS Senior Project Scientist and others involved in the Program. The AM Project Scientist's authority includes serving as the primary Project liaison to the Instrument Science Teams, and making recommendations to the EOS Senior Project Scientist on science funding levels appropriate for calibration, product validation and algorithm development for appropriate Science Teams. The EOS AM Project Scientist and the Program Scientist communicate and coordinate on science issues.

5.6.5 EOS AM Systems Manager

The EOS AM Systems Manager is responsible to the EOS AM Project Manager for all systems aspects of the flight and ground segment systems. The incumbent is responsible for developing the systems design of the spacecraft/observatory system, and for ensuring that it is compatible with the scientific instruments, launch vehicle, ground system, and reliability objectives. The incumbent establishes interface constraints and requirements for subsystems; resolves interface and system level performance questions and problems; reviews and approves for manufacture the mechanical and electrical flight hardware designs; and oversees the integration and test of the AM spacecraft. The incumbent reviews performance data and measurements throughout the Project to ensure that flight and ground systems meet stated requirements and objectives. Specifically, the incumbent has review and signoff responsibilities for all major system-level functional performance and design specifications; performs risk assessments, and evaluates design margins and inadequacies; reviews all major test plans and procedures; compares predicted and actual performance of systems; and reports routinely to the AM Project Manager on the status of system engineering activities. The incumbent serves as chairperson for major failure-review committees, and advises the Director of Flight Projects as to major (critical) aspects of these assignments.

5.6.6 EOS AM Flight Assurance Manager

The EOS AM Project Flight Assurance Manager, from the Office of Flight Assurance, is responsible to the EOS AM Project Manager for all flight assurance disciplines of the AM Project to ensure that the spacecraft, instruments, and ground system equipment (hardware and software) will meet their intended performance

objectives. These disciplines include quality assurance, design review, reliability, system safety, parts, materials, processes, contamination control, and verification testing. The incumbent is responsible for the coordination of GSFC Resident or Government Inspection Agency (GIA) personnel.

5.6.7 EOS AM Observatory Manager

The EOS AM Project Observatory Manager, responsible to the EOS AM Project Manager, coordinates and directs the efforts of a team of government and industry specialists to identify and specify the mission-imposed observatory requirements; to develop subsystems and systems to fully meet those requirements; and to demonstrate that the AM observatory and its components meet their functional performance goals in the launch and space environments. The incumbent ensures that the facilities, tools, fixtures, test equipment, and automated data processing hardware and software required in the fabricating, assembling, integrating, and testing of the subsystems and of the AM observatory, are procured or developed and available at the appropriate times and places. The AM Observatory Manager is responsible for planning and managing these tasks so that they will be completed on schedule, and within the available resources.

5.6.8 EOS AM Instrument Systems Manager

The EOS AM Instrument Systems Manager (ISM) is responsible to the EOS AM Project Manager for close liaison and monitoring of the instrument development performed by GFSC Directorates or by outside institutions such as universities or contractors and for evaluation of instrument performance after launch. The EOS AM Instrument Systems Manager must ensure, through coordination and technical review of designs, that the instruments meet the technical performance, cost, and schedule parameters for the basic EOS AM mission requirements. The EOS AM ISM is responsible for coordinating the spacecraft bus/instrument interfaces and for ensuring that the related ground support equipment is provided. The EOS AM ISM has overall responsibility for managing and directing the contracts and agreements for science and instrument development, and works with the Science Software Systems Manager to assure that algorithms and science software are delivered on schedule and within budget. The EOS AM ISM provides a single point of contact to the EOS AM Project instrument vendors and scientists, with the exception of MODIS, for all NASA functions.

5.6.9 EOS AM MODIS Instrument Systems Manager

The EOS AM MODIS ISM is responsible to the EOS AM Project Manager for close liaison and monitoring of the MODIS instrument development and for evaluation of instrument performance after launch. The MODIS ISM must ensure, through coordination and technical review of the design, that the MODIS instrument meets the technical performance, cost, and schedule parameters for the basic EOS AM and other mission requirements. The MODIS ISM is responsible for coordinating the spacecraft bus/MODIS instrument interfaces and for ensuring that the related ground support equipment is provided. The MODIS ISM has overall responsibility for managing and directing the contracts and agreements for science and instrument development and works with the Science Software Systems Manager to assure timely delivery of algorithms and science software within budget. The EOS AM MODIS ISM provides a single point of contact to the MODIS instrument vendor and MODIS scientists for all NASA functions.

5.6.10 EOS AM Operations Manager

The EOS AM Operations Manager is responsible to the EOS AM Project Manager for the development and coordination of the operations concepts and requirements for the EOS AM spacecraft and instruments and their interfaces to the ground system. This responsibility includes close coordination of activities, requirements, schedules, and resources with the EOS Mission Operations Manager (MOM) and other systems managers within the ESDIS Project. The Operations Manager also assists the AM ISM in evaluating instrument science algorithm progress and coordinating the development with the ESDIS Project.

5.6.11 EOS AM Accommodation Manager

The EOS AM Accommodation Manager is responsible to the Project Manager for ensuring that the spacecraft accommodations for the AM instruments meet the resources, fields of view, etc. requirements of the instruments in order to fulfill their scientific objectives. The Accommodation Manager must work with instrument and spacecraft personnel to ensure interface problems are resolved optimally at the project level. The Accommodation Manager is also responsible for Project coordination on launch services.

5.6.12 EOS AM Project Support Manager

The EOS AM Project Support Manager is a member of the business support team reporting to the EOS AM DPM/R. The EOS AM Project Support Manager is responsible for scheduling, configuration management, logistics management, manpower analysis, property management, and control, and other general administrative and overall EOS AM Project planning activities.

5.6.13 EOS AM Project Financial Manager

The EOS AM Project Financial Manager is a member of the business support team and reports to the EOS AM DPM/R. The EOS AM Project Financial Manager is responsible for the application of sound financial management principles in the areas of cost control, performance measurement analysis, financial analysis, budget preparation and execution, and pricing.

5.6.14 EOS AM Project Procurement Manager

The EOS AM Project Procurement Manager, from the Management Operations Directorate, is responsible for all procurement functions of the EOS AM Project including planning, directing, coordinating, and evaluating all EOS AM Project procurement activities in accordance with NASA authoritative guidelines and coordinating these activities with the EOS AM DPM/R.

5.7 RESOURCE SUMMARY

5.7.1 Funding Requirements

Table 5-4 shows the New Obligation Authority (NOA) requirements for the EOS AM Project through FY 2000. Revisions to these requirements will be submitted through the POP process.

5.7.2 Manpower

The civil service manpower requirements for the EOS AM Project are shown in Table 5-5. Revisions will be through the annual center budget update.

5.8 SCHEDULES

The EOS AM Project Master Schedule is shown in Figure 5-5 and includes the planning milestones for each of the EOS AM flights. Figure 5-6 is a master schedule for the EOS AM-1 flight only.

5.9 LOGISTICS

Shipment of the EOS AM-1 spacecraft from the Martin Marietta facility at East Windsor, NJ, requires an environmentally controlled shipping container, a special lowboy trailer, and a C-5A aircraft. The EOS AM-1 spacecraft will be installed in the shipping container and the lowboy trailer and will be moved by a planned highway route selected for freedom from obstructions from East Windsor to McGuire Air Force Base (MAFB), where the spacecraft will be loaded onto a C-5A aircraft. The EOS AM-1 spacecraft will then be flown to Vandenberg Air Force Base (VAFB) and unloaded onto the same type of trailer for transport to the launch preparation facilities.

Table 5-4
EOS AM Project POP 93-1 Budget Summary (NOA; $M)

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Table 5-5
Goddard Civil Service Manpower Requirements for EOS AM Project
FY93 Through FY00 (FY93 Plan)

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Table 5-5
Other Center's Manpower Requirements for EOS
FY93 Through FY00 (FY93 Plan) (Continued)

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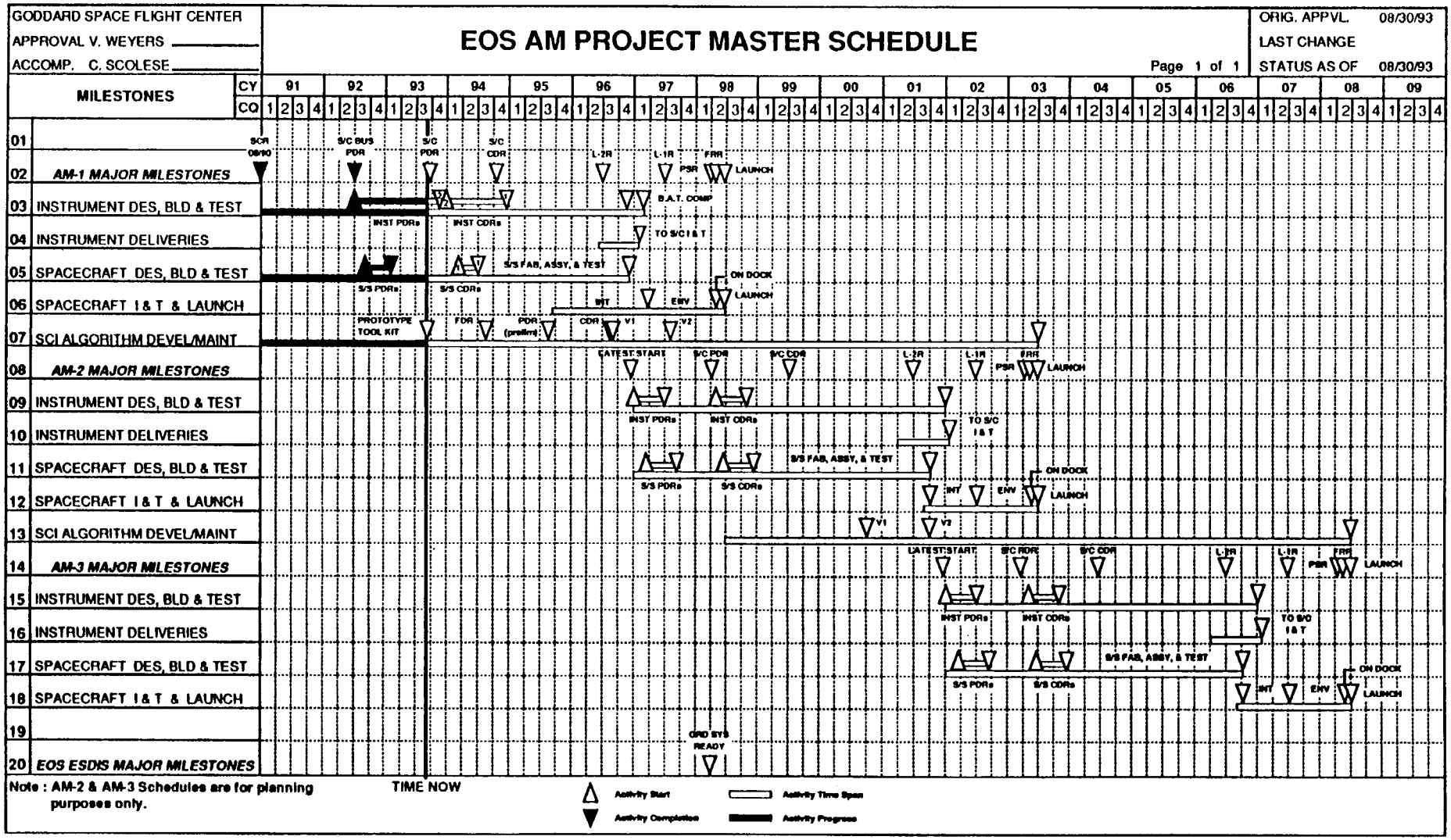


Note : AM-2 & AM-3 Schedules are for planning purposes only.

Figure 5-5. EOS AM Project Master Schedule

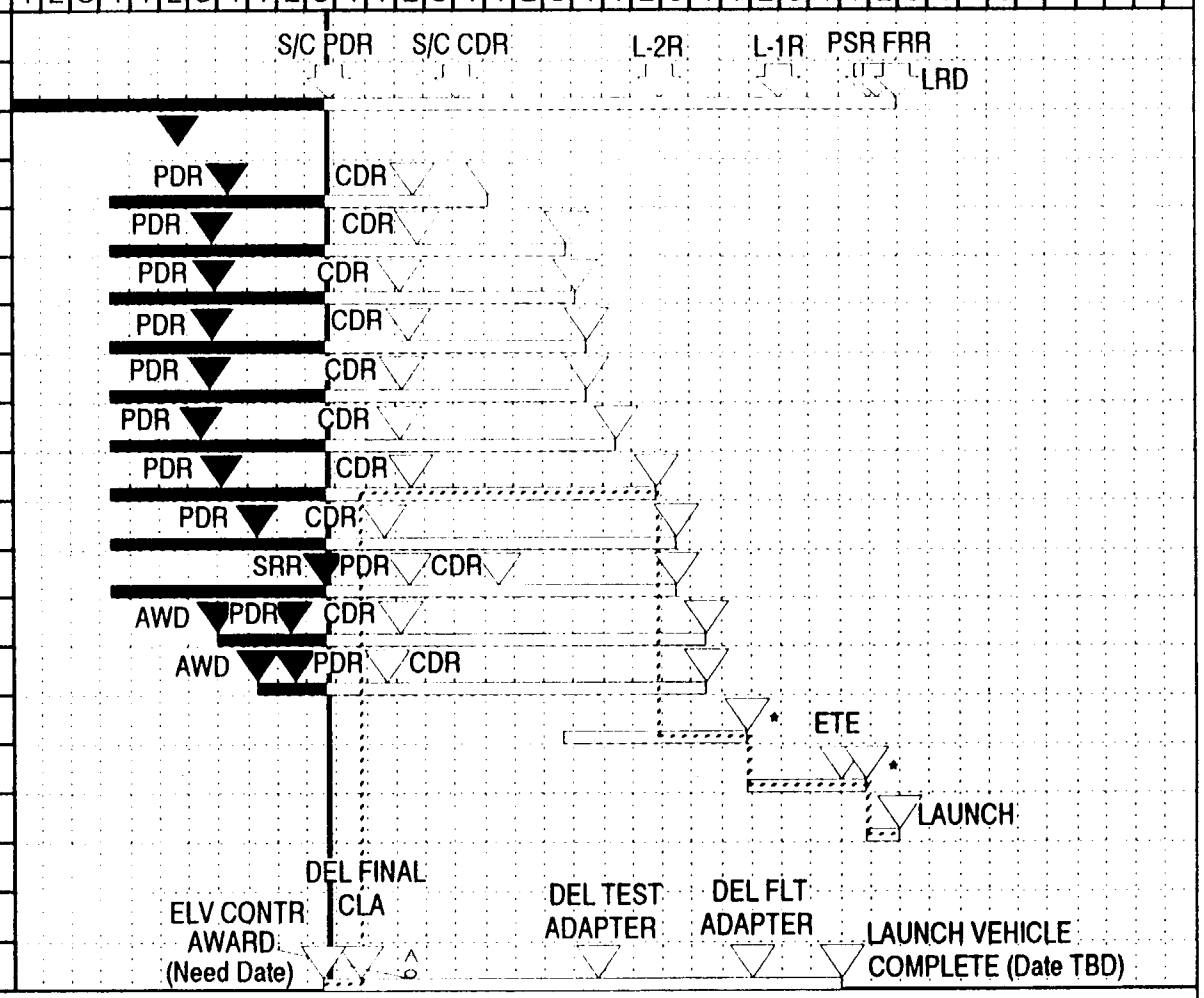
GODDARD SPACE FLIGHT CENTER
APPROVAL V. WEYERS
ACCOMP. C. SCOLESE

MASTER SCHEDULE
EOS AM-1 SPACECRAFT

Page 1 of 2

ORIG. APPVL. 08/30/93
LAST CHANGE / /
STATUS AS OF 08/30/93

	MILESTONES	Year / Quarter
1		
2	EOS AM-1 MAJOR MILESTONES	
3	S/C BUS DESIGN, FAB & TEST:	
4	THERMAL	
5	ELECTRICAL ACCOMMODATIONS	
6	GUIDANCE, NAV. & CONTROL	
7	POWER	
8	COMMAND & DATA HANDLING	
9	COMMUNICATIONS	
10	STRUCTURES & MECHANISMS	
11	PROPULSION MODULE	
12	FLIGHT SOFTWARE	
13	HIGH GAIN ANTENNA	
14	SOLAR ARRAY	
15	S/C BUS & INSTRUMENT INT & TEST	
16	S/C ENVIRONMENTAL TEST	
17	LAUNCH SITE OPERATIONS	
18		
19		
20	ELV CONTR. MAJOR MILESTONES	



NOTE: * 3 Month Schedule Contingency In Integration & Test

Legend: - Supporting - HQTR Controlled - Latest Comp. Date - Mgt. Assessed Comp. Date - Changed
Slack Critical Path

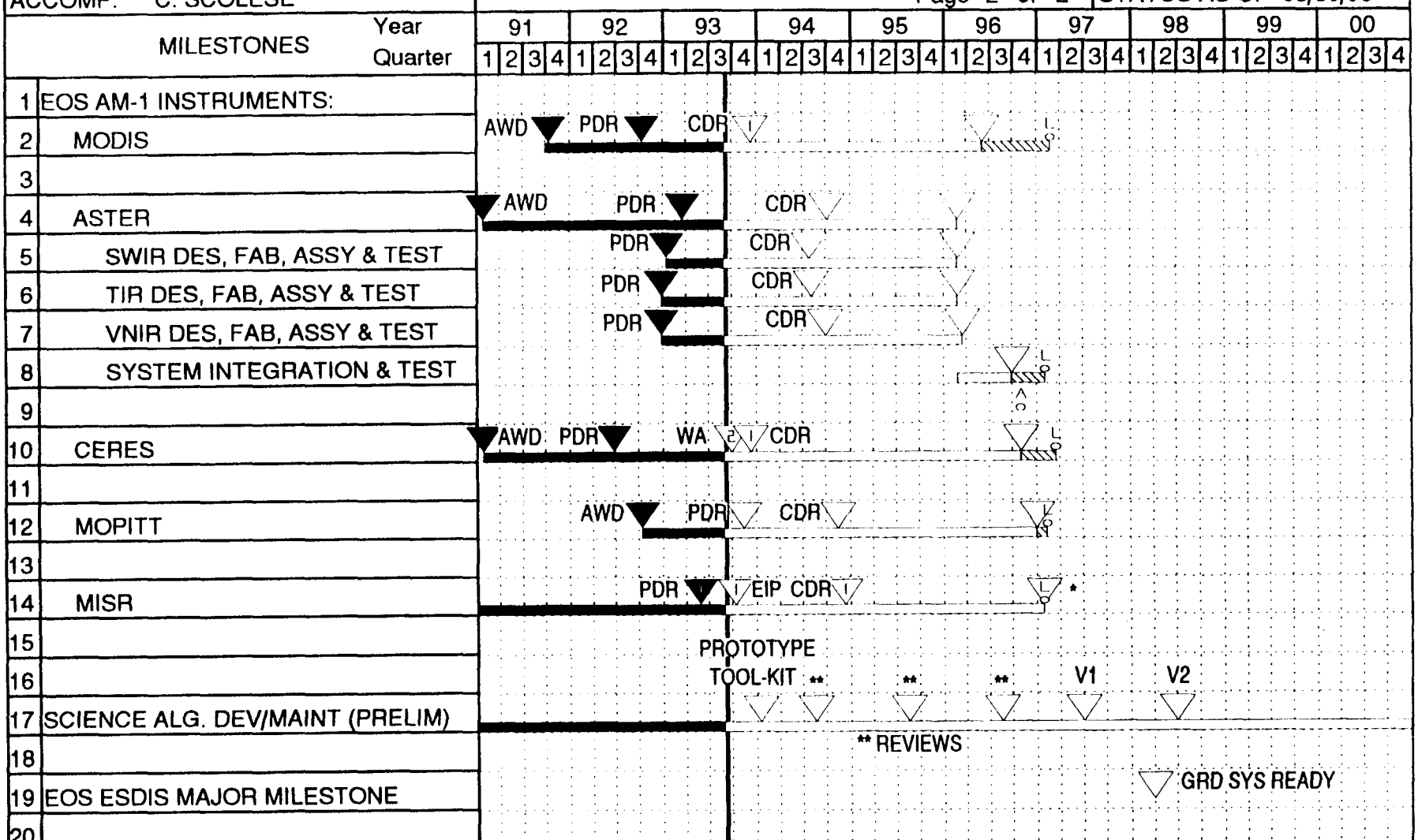
Figure 5-6. EOS AM-1 Spacecraft Master Schedule

GODDARD SPACE FLIGHT CENTER
APPROVAL V. WEYERS
ACCOMP. C. SCOLESE

MASTER SCHEDULE
EOS AM-1 SPACECRAFT

Page 2 of 2

ORIG. APPVL. 08/30/93
LAST CHANGE / /
STATUS AS OF 08/30/93



NOTE: * 4 Month Schedule Contigency at JPL for MISR Delivery

Legend: - Supporting - HQTR Controlled - Latest Comp. Date - Mgt. Assessed Comp. Date - Changed
Slack ..... Critical Path

Figure 5-6. EOS AM-1 Spacecraft Master Schedule (Continued)

It is anticipated that similar logistics arrangements will be established for the EOS AM-2 and EOS AM-3 spacecraft.

5.10 FACILITIES

The EOS AM Project will use a combination of NASA and contractor facilities during fabrication, test, checkout, launch, and tracking and data acquisition. Table 5-6 lists the GSFC and system facilities necessary for use in supporting the EOS AM effort. Currently, facilities for prelaunch processing at VAFB have been identified as Building 1610. It is assumed that Building 1610 or an equivalent facility will be available at no cost to the EOS AM Project.

5.11 RISK ASSESSMENT

Risk is associated with those advanced-design components or systems that have not yet been demonstrated or that must operate in environments over which the Project has little control. These components and systems have been identified for the AM Project and are discussed in the following subsections.

5.11.1 Spacecraft

Risk areas associated with the spacecraft development are identified below. In addition, the launch capability could be affected by inadequate payload processing facilities at the launch site.

5.11.1.1 Capillary-Pumped Loop

The Capillary-Pumped Loop (CAPL) concept has been proven analytically, in a one G test bed, and components have been successfully flown on the shuttle. In addition, the CAPL flight experiment will fly in 1993 to demonstrate operational requirements.

5.11.1.2 High Rate Data Storage

The data capacity and rates required for the EOS AM spacecraft stretch the capabilities of previously flown solid state recorders. These risks will be mitigated by early development of machines meeting EOS requirements, and by using a DAS.

5.11.2 Launch Facilities

The WSMC is under U. S. Air Force (USAF) control and may have many conflicting and unpredictable demands on its limited and potentially inadequate facilities. Also, EOS is not its highest priority. An MOU is the main basis for reducing this risk. In addition, options with the Kennedy Space Center (KSC), which will allow EOS to construct facilities for payload processing at WSMC to support the EOS launch, are being pursued in the event that Air Force facilities are not provided.

Table 5-6
EOS AM Project Facility Requirements

Item	Requirement	Location	Need Date
EOS AM Project Management	Office Space	GSFC, Greenbelt, MD	1/92 - TBD
EOS AM-1 Spacecraft Contractor	Office Space, I&T Facilities	Martin Marietta, East Windsor, NJ and Valley Forge, PA	1/92 - TBD
CERES Instrument	Office Space	LaRC, Langley, VA	1/92 - 3/15
CERES Instrument Developer	Office Space, Fab, I&T Facilities	TRW, Redondo Beach, CA	1/92 - 3/15
MODIS Instrument Developer	Office Space, Fab, I&T Facilities	SBRC, Santa Barbara, CA	1/92 - 3/15
Launch Support	Office Space, Launch Facilities	VAFB, Lompoc, CA	90 days before and after launch
TDRSS / GSTDN / ATDRSS	Spacecraft Communications	White Sands, NM	As required
MOPITT	Office Space, Fab, I&T Facilities	CSA, Canada	1/92 - TBD
MISR	Office Space, Fab, I&T Facilities	JPL, Pasadena, CA	1/92 - TBD
ASTER	Office Space, Fab, I&T Facilities	MITI, Japan	1/92 - 4/97
TES	Office Space, Fab, I&T Facilities	JPL, Pasadena, CA	TBD
EOSP	TBD	TBD	TBD

5.11.3 Instruments

The instrument development effort has two major risk areas, the mechanical coolers and long-wavelength focal planes. Both risk areas were identified early in the Phase A study effort, and steps were taken to offset the risks.

5.11.3.1 Coolers

The mechanical cooler risks extend to the MOPITT and ASTER instruments. Development is required for 80 K coolers for these instruments. The immediate development/qualification tasks are for the 80 K coolers for MOPITT. The coolers for ASTER will be developed independently through the MITI in Japan.

5.11.3.2 Focal Planes

The long-wavelength focal plane risk applies to MODIS and ASTER. Like the coolers, the ASTER focal plane will be developed through MITI in Japan. This risk primarily involves the Thermal Infrared (TIR) (8 to 12 μm) instrument module. The application is not demanding, and focal planes in this wavelength have been flown on previous satellites.

The long-wavelength focal plane on MODIS (approximately 13 to 14.54 μm) represents similar risks. The MODIS uses a passive radiant cooler for low-temperature operation; this cooler has a direct bearing on infrared detector performance. Also on the MODIS, the focal plane development risk is offset by the selected instrument developer, a well-recognized sensor and detector manufacturer. The selected instrument developer is also one of the three recognized leaders in Mercury Cadmium Telluride (HgCdTe) development and has direct NASA experience in this wavelength range, having successfully developed the Visible Infrared Spin-Scan Radiometer (VISSR) Atmospheric Sounder (VAS) for NASA. The selected instrument developer is a recognized leader in the radiant cooler field and holds several design patents.

5.11.4 Launch Vehicle

The EOS launch vehicle will be selected from among the IELVs via a competitive procurement. However, there is only a remote possibility that the Expendable Launch Vehicle (ELV) for AM-1 will be selected in CY 1993. The continued delay in launch vehicle selection is imposing constraints on the design and development of the EOS AM spacecraft and the late selection is adding to the risk of some redesign if interfaces must be changed after a launch vehicle interface is defined. None of the IELVs, are currently supported at WSMC. The launch vehicle selection will not be made until after instrument and spacecraft subsystem Preliminary Design Reviews (PDRs).

To mitigate these risks, the spacecraft is being designed to the most constraining environments of the known IELVs and discussions with the USAF and NASA HQ continue to resolve the launch vehicle availability and support.

5.12 ENVIRONMENTAL IMPACT

The environmental impact assessment and statements and a Hazardous Waste Minimization Plan will be coordinated with the GSFC Environmental Coordinator.

5.12.1 Expendable Launch Vehicle

In accordance with the National Environmental Policy Act (NEPA) of 1969, the OSSA Director of Launch Vehicles and Propulsion Programs issued an Environmental Impact Statement, dated July 1973, describing the known and anticipated environmental effects of the various ELVs used by NASA.

The EOS AM spacecraft will be launched on an IELV, the effects of which are described in detail in the July 1973 Environmental Impact Statement. The environmental impact of the EOS AM launches, even in the event of failure or abort, is not considered to be significant in that the effects are limited in extent, duration, and intensity.

5.12.2 EOS-AM Spacecraft

An environmental assessment of the EOS spacecraft will be prepared by the EOS AM Project. The spacecraft disposal is planned to be consistent with the disposal outlined in the draft titled Safety Policy for Space Debris, NMI 1700. The following fluids will be used: fuels (hydrazine), pressurant (helium), and coolant (ammonia). No environmental impact or requirement for an environmental impact statement is anticipated.

6. EOS PM PROJECT

6.1 PROJECT CHARACTERISTICS

The EOS Program will develop and launch a space-based Earth Observing System that will provide global science data from a low-altitude sun-synchronous orbit on a long-term sustained basis. The focus for the EOS PM Project is the multi-disciplinary study of the Earth's interrelated processes (atmosphere, oceans, and land-surface) and their relationship to Earth system changes. The global change research emphasized with the PM instrument data sets include atmospheric temperatures and humidities clouds, precipitation, and radiative balance; terrestrial snow and sea ice; sea-surface temperature and ocean productivity; soil moisture; and the improvement of numerical weather prediction.

6.2 EOS PM PROJECT LEVEL 1 REQUIREMENTS

The Level 1 Requirements for the EOS PM Project are comprised of the general requirements in Section 4.2 and those shown below. These requirements serve as the baseline for derivation of lower level performance requirements. Any proposal by the EOS PM Project to change a Level 1 Requirement or any failure to meet Level 1 Requirements will be referred to the EOS PCB for disposition. For those issues requiring Level 2 decisions, the procedures defined in the EOS Configuration Management Plan (420-02-02) will be followed. Items controlled by the Deputy Administrator are identified in Section 3 of this Plan.

6.2.1 EOS PM Spacecraft Series

The EOS PM spacecraft series, including the instruments, shall consist of three spacecraft designated EOS PM-1, EOS PM-2, and EOS PM-3, each of which shall have a design lifetime of 5 years. An artist's concept of the EOS PM-1 spacecraft deployed is shown in Figure 6-1.

6.2.2 Duration of Series

The EOS PM spacecraft series shall be capable of replacing each on-orbit spacecraft every 5 years to provide observations of the Earth for not less than 15 years beginning with the launch of the EOS PM-1 spacecraft in December 2000.

6.2.3 Operational Overlap

The PM Project shall plan for a 6-month period of overlap in observations to enhance the capability to intercompare data from successive versions of EOS instruments.

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Figure 6-1. Artist's Concept of EOS PM-1 Spacecraft

6.2.4 Launch of Spacecraft

The EOS PM spacecraft shall be designed to be launched by an IELV.

6.2.5 Orbit of Spacecraft

The EOS PM spacecraft series shall be inserted into a 16-day, 233-orbit repeat sun-synchronous orbit with 1:30 pm ±15 minutes ascending nodal crossing (nominally 705 km, 98.2° inclination).

6.2.6 Instrument Payload

The EOS PM spacecraft series shall include the instruments shown in Table 6-1. The instrument characteristics and standard data products applicable to each investigation are defined in Section 6.3.2.

Table 6-1
EOS PM Payload Complement

Instrument	PM-1	PM-2	PM-3
AIRS	X	X	X
AMSU	X	X	X
CERES	X(2)	X(1)	X(1)
MHS	X	X	X
MIMR	X	X	X
MODIS	X	X	X

Note: CERES can fly as one or two scanning units

6.2.7 Direct Broadcast

All EOS PM spacecraft shall support an X-band direct-to-ground continuous broadcast for the instruments identified in Table 6-1.

6.2.8 Direct Playback

All EOS PM spacecraft shall support the intermittent direct-to-ground downlink of real-time or stored on-orbit data (both science and engineering data) as a backup should the prime TDRSS science downlink fail.

6.2.9 Spacecraft Health and Safety

The spacecraft shall support detection, isolation, and recovery capabilities for any single fault to ensure the health and safety of the spacecraft.

6.2.10 Instrument Technology Improvement

The EOS PM instruments shall be designed to permit technological improvements to be incorporated into the subsequent flight copies of each instrument. Any such improvements shall be allowable only if it can be demonstrated that the improvements do not degrade data continuity. Waivers for improvements shall be reviewed by the EOS PCB.

6.2.11 Investigator Responsibilities

The TL and TMs for each EOS PM FI and the PIs shall be responsible for the development and maintenance of algorithms and source code to generate the respective Standard Data Products listed in each instrument's section.

6.3 TECHNICAL SUMMARY

The EOS PM spacecraft, instruments, and system integration and test segments are described in Sections 6.3.1 through 6.3.3.

6.3.1 Spacecraft

Specific subsystem functional requirements for the EOS PM spacecraft are being developed; when the Phase C/D activities are negotiated, this plan will be revised accordingly.

Primary forward (up-link) commanding will be via TDRSS S-band single access, with a contingency S-band multiple access link available. Emergency command will be available using S-band omni antennas via the Ground network, the Deep Space Network, or the Wallops Tracking Station. Primary science data return (down-link) will be through the Ku-band single access TDRSS link. Health and safety data will be available through the TDRSS S-band single access return link.

6.3.2 Instruments

Table 6-1 lists the instrument complements for the EOS PM series spacecraft.

6.3.2.1 Atmospheric Infrared Sounder

6.3.2.1.1 Description

The Atmospheric Infrared Sounder (AIRS) instrument, an FI, is a shared aperture, grating-array spectrometer. The AIRS science objectives are the detection of the effects of greenhouse gases, improvement of numerical weather prediction, study of the global energy and water cycles, investigation of atmosphere-surface interactions, and monitoring of climate variations and trends.

6.3.2.1.2 Level 1 Requirements
The AIRS shall measure tropospheric and stratospheric temperature, day-and-night sides globally, every 2 days with 13.5-km horizontal resolution at nadir. The AIRS shall be provided with a direct-to-ground continuous broadcast capability for data transmission. The AIRS shall provide the Standard Data Products shown in Table 6-2.

6.3.2.2 Advanced Microwave Sounding Unit

6.3.2.2.1 Description
The Advanced Microwave Sounding Unit (AMSU-A) instrument, an FI, is a microwave radiometer. The AMSU-A science objective is to measure the temperature profile of the atmosphere from 0- to 45-km altitude and provide atmospheric water vapor/precipitation estimates.

6.3.2.2.2 Level 1 Requirements
The AMSU-A shall sample atmospheric temperature from the surface to 45-km altitude, day and night sides globally, every 2 days with 45-km horizontal resolution at nadir. The AMSU-A shall be provided with a direct-to-ground continuous broadcast capability for data transmission. The AMSU-A shall provide the Standard Data Products shown in Table 6-2.

6.3.2.3 Clouds and the Earth's Radiant Energy System

6.3.2.3.1 Description
For PM-1 the CERES instrument, a PI instrument, consists of two scanning radiometers, each with three separate telescope units. When two scanners are flown, this configuration will allow one scanner to operate in the crosstrack mode for complete spatial coverage from limb to limb, and the other to operate with a rotating scan plane as well as in the crosstrack mode (biaxial) to provide angular sampling. When one scanner is flown (PM-2 and PM-3), it will operate primarily in the crosstrack mode. The CERES science objectives are to generate data products that provide cloud-radiative and forcing inputs to the climate system models, and observational baseline of clear-sky radiative fluxes and radiative input to atmospheric and ocean energy models.

6.3.2.3.2 Level 1 Requirements
The CERES shall measure the global distribution of reflected solar (shortwave) and emitted (longwave) radiant flux from the Earth to extend the long-term record of the components of the Earth's radiation budget initiated by the ERBE. The CERES shall provide the Standard Data Products shown in Table 6-2.

6.3.2.4 Microwave Humidity Sounder

Table 6-2
EOS PM-1 Standard Data Products
Preliminary

Instrument	Product Name	Units	Accuracy Abs :: Rel	Temporal Resolution	Horizontal Resol. :: Cover. *	Vertical Resol. :: Cover. **
AIRS	Level-1B Radiance	W/m^2/sr/µm	0.2 K NEdT :: 0.2 K NEdT	2/day [d,n]	15 km :: G	N/A :: N/A
	Cloud Product			2/day [d,n]	50 km :: G	N/A :: Cloud
	Humidity Product			2/day [d,n]	50 km :: G	N/A, 2 km :: Atmos
	Temperature Product	K		2/day [d,n]	50 km :: Land, Ocean	N/A :: Sfc (1 km :: Atmos)
AMSU/MHS	Level-1B Radiance, AMSU	K	0.2 K NEdT :: 0.2 K NEdT	2/day [d,n]	40 km :: G	N/A :: N/A
	Level-1B Radiance, MHS	K	0.2 K NEdT :: 0.2 K NEdT	2/day [d,n]	15 km :: G	N/A :: N/A
CERES	Bi-Directional Scan (BDS) Radiance	W/m^2/sr	1-2% :: 0.005	1/6.6 sec	25 km :: G	N/A :: TOA
	ES-8 ERBE-Like Product			1/6.6 sec	25 km :: G	N/A :: TOA
	ES-9 ERBE-Like Product	W/m^2		1 & 24/mo [Avg]	2.5 x 2.5 dg :: R,G	N/A :: TOA

* G, R, and L represent Global, Regional, and Local Coverage, respectively.

** TOA, Trop, Atmos, and Sfc represent Top of Atmosphere, Troposphere, Atmosphere (Troposphere & Stratosphere), and Surface, respectively.

Note: These standard data products are preliminary pending negotiation and agreement with the responsible EOS investigators.

Table 6-2
EOS PM-1 Standard Data Products
Preliminary

Instrument	Product Name	Units	Accuracy Abs :: Rel	Temporal Resolution	Horizontal Resol. :: Cover. *	Vertical Resol. :: Cover. **
MIMR	Level-1B Brightness Temperature	K	0.2-0.7 K ::		6-60 km :: Global	N/A ::
	Precipitation		20-40% ::		12 km (Land), 38 km (Ocean) :: G	N/A :: Sfc
	Oceanic Cloud Water	mg/cm^2	3 mg/cm^2		23 km :: Ocean	N/A :: Trop
	Oceanic Water Vapor	g/cm^2	0.2 g/cm^2 ::		23 km :: Ocean	Column :: Trop
	Oceanic Surface Wind Speed	m/s	1.5 m/s ::		12 km :: Ocean	N/A :: Sfc
	Sea Surface Temperature	K	0.5 K ::		60 km :: Ocean	N/A :: Sfc
	Sea Ice Concentration		7% ::		12 km :: Ocean/Cryo	N/A :: Sfc
MODIS	Level-1A Radiance				0.25, 0.5, 1 km :: G	
	Level-1B Radiance, Calibrated Geolocated	W/m^2/sr/μm	5%(1Σ) :: RMS<NEΔL	1/day	0.25, 0.5, 1 km :: G	N/A :: N/A

* G, R, and L represent Global, Regional, and Local Coverage, respectively.

** TOA, Trop, Atmos, and Sfc represent Top of Atmosphere, Troposphere, Atmosphere (Troposphere & Stratosphere), and Surface, respectively.

Note: These standard data products are preliminary pending negotiation and agreement with the responsible EOS investigators.

Table 6-2
EOS PM-1 Standard Data Products
Preliminary

Instrument	Product Name	Units	Accuracy Abs :: Rel	Temporal Resolution	Horizontal Resol. :: Cover. *	Vertical Resol. :: Cover. **
MODIS	Aerosol Product			1/day	50 km (Land), 5 km (Ocean) :: G	N/A :: Atmos
	Cloud Product			1-2/day	5, 50 km :: G	N/A :: Cloud
	Surface Reflectance			1-9/day	1 km :: Land	N/A :: Sfc
	Snow Cover	km^2	10% ::	1/day	1 km :: Land	N/A :: Sfc
	Land_sfc Temperature/Emissivity			1/day, 1/wk, 1/mo	1 km :: Land/R	N/A :: Sfc
	Land_Cover Type	categorical fraction	10% ::	1/(3 mo)	1 km :: Land	N/A :: Sfc
	Geolocation Fields			1/day	1 km :: G	
	Pigment Concentration, "CZCS"	mg/m^3	100% (Global); 35% (Case I, Clear Atmos) :: TBD	1/day, 1/wk, 1/mo	1, 20 km :: Ocean/G,R,L	N/A ::
	Level-2 Radiance, Water-leaving	mW/cm^2/sr/µm	0.0015 ::	1/day, 1/wk, 1/mo	1 km :: Ocean/R,L	N/A :: Sfc

* G, R, and L represent Global, Regional, and Local Coverage, respectively.

** TOA, Trop, Atmos, and Sfc represent Top of Atmosphere, Troposphere, Atmosphere (Troposphere & Stratosphere), and Surface, respectively.

Note: These standard data products are preliminary pending negotiation and agreement with the responsible EOS investigators.

Table 6-2
EOS PM-1 Standard Data Products
Preliminary

Instrument	Product Name	Units	Accuracy Abs :: Rel	Temporal Resolution	Horizontal Resol. :: Cover. *	Vertical Resol. :: Cover. **
MODIS	PAR		5-10% ::	1/day [d]	1 km :: Ocean/G	N/A :: Sfc, Atmos
	Sea_sfc Temperature (SST)	K	0.3-0.5 K ::	1/day, 1/wk, 1/mo	1 km :: Ocean/L	N/A :: Sfc

* G, R, and L represent Global, Regional, and Local Coverage, respectively.

** TOA, Trop, Atmos, and Sfc represent Top of Atmosphere, Troposphere, Atmosphere (Troposphere & Stratosphere), and Surface, respectively.

Note: These standard data products are preliminary pending negotiation and agreement with the responsible EOS investigators.

6.3.2.4.1 Description
The Microwave Humidity Sounder (MHS) instrument is a microwave radiometer. It is an FI, to be provided under a Letter of Agreement (LOA) with the EUMETSAT. The MHS science objective is to provide global humidity data for weather forecasting.

6.3.2.4.2 Level 1 Requirements
The MHS shall measure atmospheric water vapor distribution, day and night sides globally, every 2 days with 15-km horizontal resolution at nadir. The MHS shall be provided with a direct-to-ground continuous broadcast capability for data transmission. The MHS shall provide the Standard Data Products shown in Table 6-2.

6.3.2.5 Multifrequency Imaging Microwave Radiometer

6.3.2.5.1 Description
The Multifrequency Imaging Microwave Radiometer (MIMR) instrument is a microwave spectrometer. The MIMR is an FI, provided under an MOU with the ESA. The MIMR science objectives are to measure precipitation rates, cloud water, water vapor, sea-surface temperatures, sea ice and snow cover, sea-surface winds, and soil moisture.

6.3.2.5.2 Level 1 Requirements
The MIMR shall provide microwave measurements for studying the hydrological cycle, including precipitation, soil moisture, global ice and snow cover, sea-surface temperature, atmospheric cloud water and water vapor. The MIMR shall be provided with a direct-to-ground continuous broadcast capability for data transmission. The MIMR shall provide the Standard Data Products shown in Table 6-2.

6.3.2.6 Moderate-Resolution Imaging Spectroradiometer

6.3.2.6.1 Description
The MODIS instrument, an FI, is an imaging spectroradiometer. The MODIS science objective is to conduct long-term observations of the Earth in order to develop an improved understanding of global dynamics and processes occurring on the surface and in the lower atmosphere.

6.3.2.6.2 Level 1 Requirements
The MODIS shall provide over the portion of the electromagnetic spectrum from 0.415 to 14.235μm observations of reflected solar radiation in 20 bands at least every two days and observations of emitted thermal radiation in 16 bands every day for any point on the Earth. The spatial resolution of these observations shall be from 250m to 1 km at nadir and the absolute radiance accuracy will be from ± 1/2% in the thermal IR and to ± 5% in the visible- and near-IR. The data products from MODIS shall be better or at least equivalent in all respects to the same or similar products

now derived from the heritage instruments such as the NOAA Advanced Very High-Resolution Radiometer (AVHRR) and the Nimbus Coastal Zone Color Scanner (CZCS). The MODIS shall be provided with a direct-to-ground continuous broadcast capability for data transmission. The MODIS shall provide the Standard Data Products shown in Table 6-2.

6.3.3 Observatory System Integration and Test

An observatory level test program will be conducted to demonstrate that the observatory can withstand and perform properly when subjected to the expected launch and orbit environments. This test program will include an end-to-end system test, which will simulate orbital performance and verify compatibility of the total flight and ground segments.

6.4 IMPLEMENTATION APPROACH

The implementation approach for each major element of the EOS PM Project is described in the following sections. The approach conforms to the UPN structure identified in Section 1.1 and the WBS described in Section 6.4.3.

6.4.1 Spacecraft

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6.4.2 Instruments

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6.4.3 Work Breakdown Structure

The EOS PM Project WBS is shown in Figure 6-2 and is organized into three spacecraft, PM-1, PM-2, and PM-3. The WBS incorporates the EOS PM Project responsibilities: spacecraft, instruments, and the associated project management of each spacecraft. EOS PM instrument science algorithm development and related activities are also the responsibility of the EOS PM Project. Funding for this effort is part of UPN 229 (EOS science) and is allocated to the project by the GSFC Mission to Planet Earth Office. SCF funds needed in support of the overall science activity are provided as part of the ESDIS budget under UPN 428. A WBS Dictionary for the entire EOS Project is found in document 420-02-01.

6.5 PROCUREMENT SUMMARY

A summary of the major EOS PM Project procurements is shown in Table 6-3. The procurements consist of the spacecraft, instruments, and science agreements applicable to the EOS PM Project.

6.6 EOS PM PROJECT MANAGEMENT RESPONSIBILITIES AND ORGANIZATION

Management responsibilities and procedures for the EOS PM Project are established in accordance with Space Flight Program and Project Management, NMI 7120.4. Within GSFC, the Flight Projects Directorate includes the EOS PM Project. The EOS PM Project staff interfaces with functional GSFC directorates and facilities to plan, implement, and coordinate development of the EOS PM Project. The OMTPE/EOS PM Project organization charts are given in Figures 6-3 and 6-4.

6.6.1 EOS PM Project Manager

The EOS PM Project organization shown in Figure 6-3 is headed by a Project Manager who is the senior official at GSFC exclusively

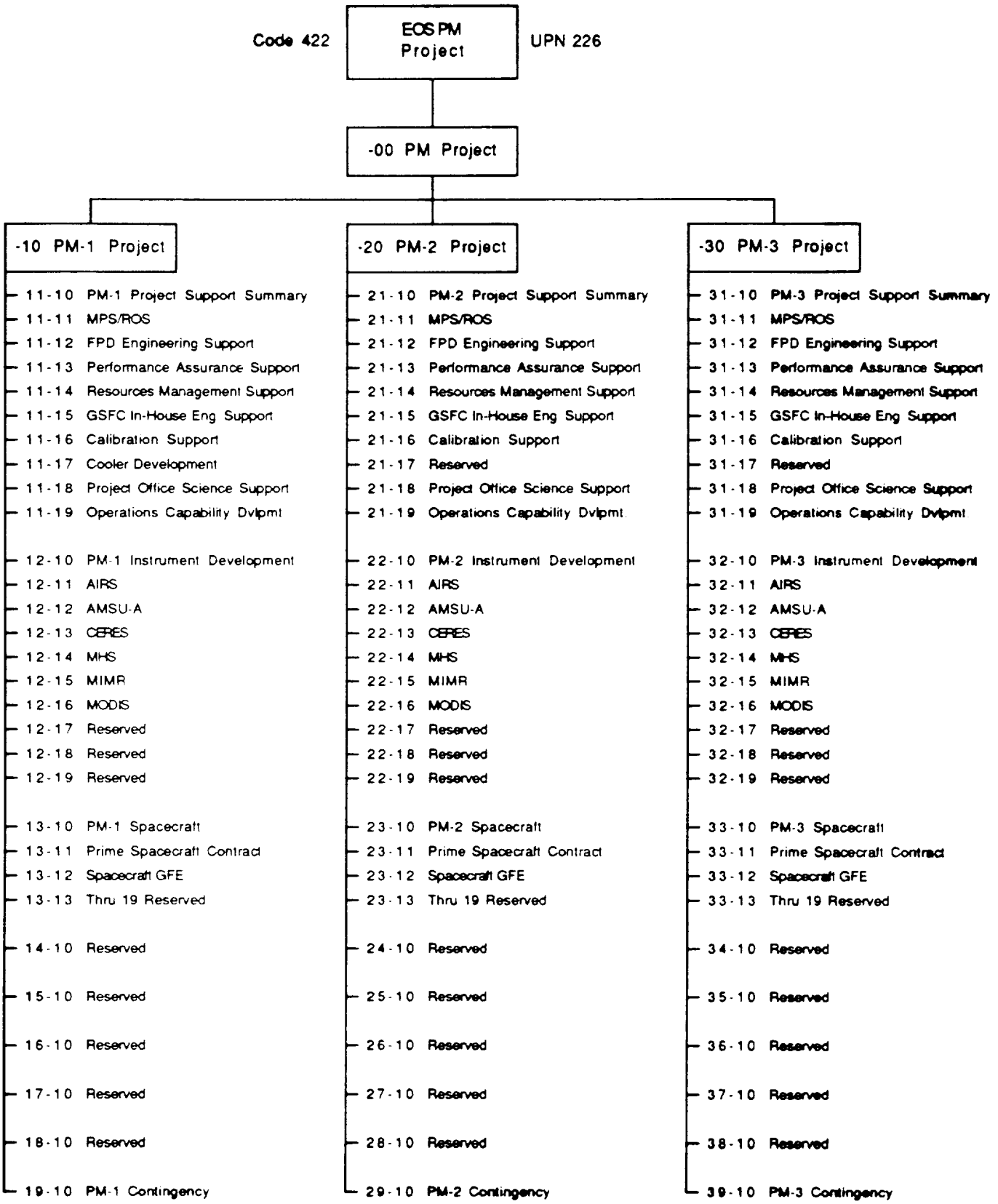

Figure 6-2. EOS PM Project WBS

Table 6-3
EOS PM Project Procurement Summary

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Table 6-3
EOS PM Project Procurement Summary (Continued)

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Table 6-3
EOS PM Project Procurement Summary (Continued)

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Figure 6-3. MTPE / GSFC Project Management Organization Chart for EOS

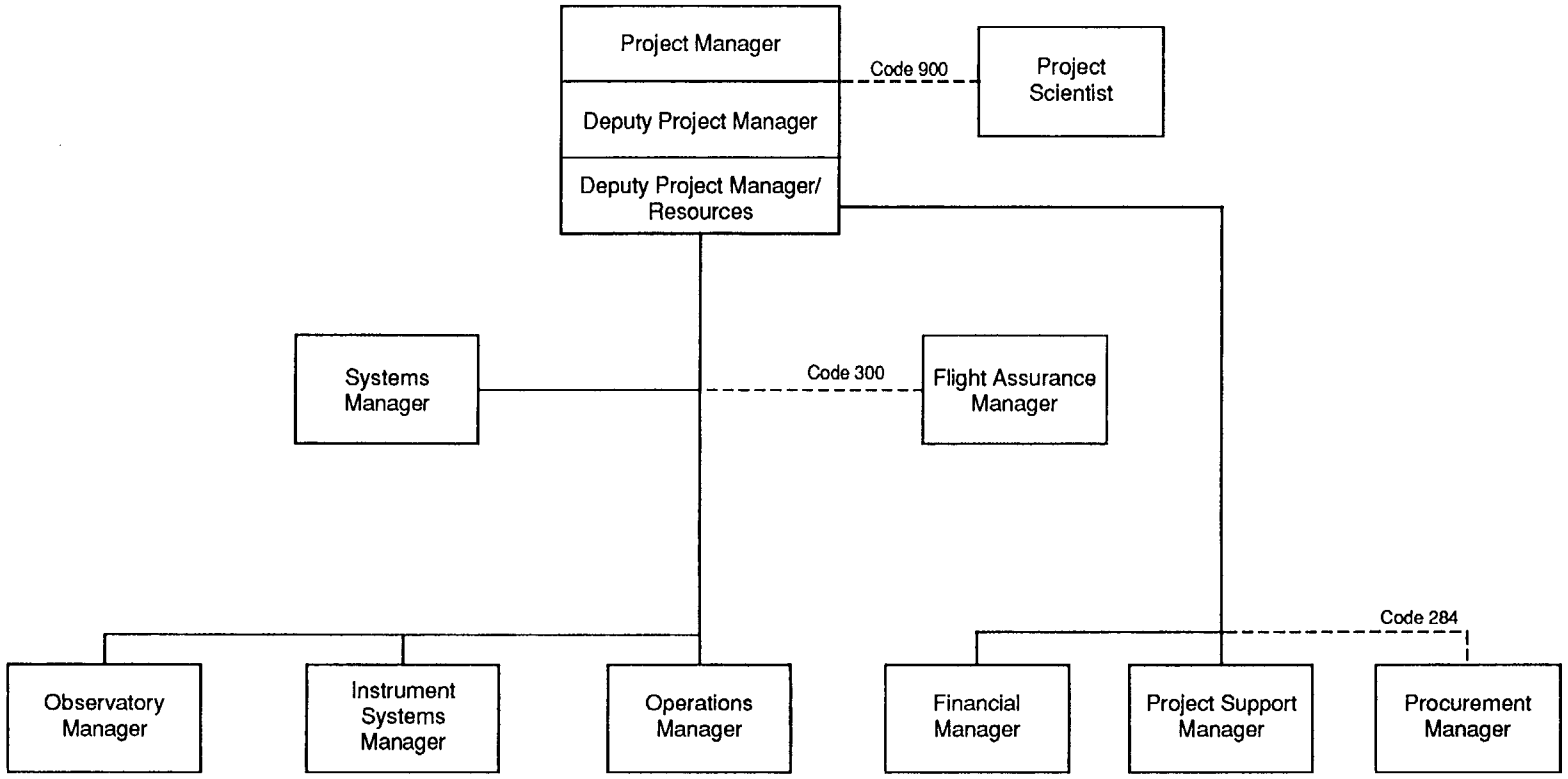


Figure 6-4. EOS PM Project Organization Chart

responsible for managing execution of the project life-cycle. The EOS PM Project Manager has full authority to carry out this responsibility within guidelines and controls prescribed by the Director of Flight Projects, The Director of the Mission to Planet Earth Office, and the GSFC Director.

Specific responsibilities include directing and overseeing:

- Preparation and maintenance of project plans, specifications, schedules, and budgets.
- Acquisition and utilization of participating contractors.
- Execution of project plans by government, contractor, and university participants in conformance with all project commitments and constraints and with all agency policies.
- Performing project level SE&I
- Reporting project status and contractor performance as required.
- Establishing and maintaining a close and effective working relationship with the Program Manager.

The EOS PM Project Manager discharges the responsibilities with the assistance and support of individuals and organizations assigned either administratively or functionally to the EOS PM Project.

6.6.2 EOS PM Deputy Project Manager

The EOS PM DPM is responsible to the EOS PM Project Manager and is an integral member of the management team for the PM Project. The EOS PM DPM supports the EOS PM Project Manager in directing all phases of the EOS PM Project and has Projectwide responsibility for personnel management and planning and evaluating all EOS PM Project activities on a day-to-day basis.

The incumbent provides technical management to the team of technically skilled specialists and their supporting personnel in order to meet performance cost and schedule commitments. In the absence of the Project Manager, the DPM assumes full responsibility for the Project.

6.6.3 EOS PM Deputy Project Manager/Resources

The EOS PM DPM/R is responsible to the EOS PM Project Manager and is an integral member of the management team for the EOS PM Project. The EOS PM DPM/R contributes business management expertise to the establishment of technical program objectives and is responsible for the application of business, financial management, and performance measurement techniques to the accomplishment of those objectives. The EOS PM DPM/R supervises a team of specialists in the areas of finance, budget,

performance measurement, scheduling, pricing, configuration management, etc., and is responsible for the application of sound business techniques to the accomplishment of EOS PM Project objectives. In addition, the EOS PM DPM/R provides requirements to the EOS PM Project Procurement Manager on Project-related matters. In the absence of the EOS PM Project Manager and the EOS PM DPM, the EOS PM DPM/R may act for the EOS PM Project Manager.

6.6.4 EOS PM Project Scientist

The EOS PM Project Scientist, from the Earth Sciences Directorate at GSFC, is responsible for ensuring the satisfactory accomplishment of the scientific objectives of the EOS PM mission and is an integral member of the management team for the PM Project. The EOS PM Project Scientist reviews the planning and implementation of the EOS PM Project to ensure that the total mission is consistent with the overall EOS scientific objectives. The EOS PM Project Scientist provides leadership in ensuring that the scientific data are used effectively and the scientific results of the mission are produced expeditiously. The EOS PM Project Scientist provides appropriate inputs to the PDMP. The EOS PM Project Scientist evaluates all scientific requirements placed on the EOS PM Project, provides scientific guidance to the EOS PM Project Manager, and provides information and recommendations to the EOS Senior Project Scientist and others involved in the Program. The PM Project Scientist's authority includes serving as the primary Project liaison to the Instrument Science Teams, and making recommendations to the EOS Senior Project Scientist on science funding levels appropriate for calibration, product validation and algorithm development for appropriate Science Teams. The EOS PM Project Scientist and the Program Scientist communicate and coordinate on science issues.

6.6.5 EOS PM Systems Manager

The EOS PM Systems Manager is responsible to the EOS PM Project Manager for all systems aspects of the flight and ground segment systems. The incumbent is responsible for developing the systems design of the spacecraft/observatory system, and for ensuring that it is compatible with the scientific instruments, launch vehicle, ground system, and reliability objectives. The incumbent establishes interface constraints and requirements for subsystems; resolves interface and system level performance questions and problems; reviews and approves for manufacture, the electrical flight hardware designs; and oversees the electrical integration and test of the PM spacecraft. The incumbent reviews performance data and measurements throughout the Project to ensure that flight and ground systems meet stated requirements and objectives. Specifically, the incumbent has review and signoff responsibilities for all major system-level functional performance and design specifications; performs risk assessments,

and evaluates design margins and inadequacies; reviews all major test plans and procedures; compares predicted and actual performance of systems; and reports routinely to the PM Project Manager on the status of system engineering activities. The incumbent serves as chairperson for major failure-review committees, and advises the Director of Flight Projects as to major (critical) aspects of these assignments.

6.6.6 EOS PM Flight Assurance Manager

The EOS PM Project Flight Assurance Manager, from the Office of Flight Assurance, is responsible to the EOS PM Project Manager for all flight assurance disciplines of the PM Project to ensure that the spacecraft, instruments, and ground system equipment (hardware and software) will meet their intended performance objectives. These disciplines include quality assurance, design review, reliability, system safety, parts, materials, processes, contamination control, and verification testing. The incumbent is responsible for the coordination of GSFC Resident or GIA personnel.

6.6.7 EOS PM Observatory Manager

The EOS PM Project Observatory Manager, responsible to the EOS PM Project Manager, coordinates and directs the efforts of a team of government and industry specialists to identify and specify the mission-imposed observatory requirements; to develop subsystems and systems to meet those requirements fully; and to demonstrate that the PM observatory, the "common" spacecraft, and its components meet their functional performance goals in the launch and space environments. The incumbent ensures that the facilities, tools, fixtures, test equipment, and automated data processing hardware and software required in the fabricating, assembling, integrating, and testing of the subsystems and of the "common" spacecraft, are procured or developed and available at the appropriate times and places to support the launches of the PM and Chemistry missions and the AM-2 and AM-3 missions. The PM Observatory Manager is responsible for planning and managing these tasks so that they will be completed on schedule, and within the available resources.

6.6.8 EOS PM Instrument Systems Manager

The EOS PM ISM is responsible to the EOS PM Project Manager for close liaison and monitoring of the instrument development performed by GSFC Directorates or by outside institutions such as universities or contractors and for evaluation of instrument performance after launch. The EOS PM ISM must ensure, through coordination and technical review of designs, that the instruments meet the technical performance, cost, and schedule parameters for the basic EOS PM mission requirements. The EOS PM ISM is responsible for coordinating the spacecraft bus/instrument

interfaces and for ensuring that the related ground support equipment is provided. The EOS PM ISM has overall responsibility for managing and directing the contracts and agreements for instrument development and science, and works with the Science Software Systems Manager to assure timely delivery of algorithms and science software are within budget. The EOS PM ISM provides a single point of contact to the EOS PM Project instrument vendors and scientists, for all NASA functions, including science funding, with the exception of MODIS and CERES.

6.6.9 EOS PM Operations Manager

The EOS PM Operations Manager is responsible to the EOS PM Project Manager for the development and coordination of the operations concepts and requirements for the EOS PM spacecraft and instruments and their interfaces to the ground system. This responsibility includes close coordination of activities, requirements, schedules, and resources with the EOS MOM and other systems managers within the ESDIS Project. The Operations Manager also assits the EOS PM ISM in evaluating instrument science algorithm progress and coordinating the development with the ESDIS Project.

6.6.10 EOS PM Project Support Manager

The EOS PM Project Support Manager is a member of the business support team reporting to the EOS PM DPM/R. The EOS PM Project Support Manager is responsible for scheduling, configuration management, logistics management, manpower analysis, property management, and control, and other general administration and overall EOS PM Project planning activities.

6.6.11 EOS PM Project Financial Manager

The EOS PM Project Financial Manager is a member of the business support team and reports to the EOS PM DPM/R. The EOS PM Project Financial Manager is responsible for the application of sound financial management principles in the areas of cost control, performance measurement analysis, financial analysis, budget preparation and execution, and pricing.

6.6.12 EOS PM Project Procurement Manager

The EOS PM Project Procurement Manager, from the Management Operations Directorate, is responsible for all procurement functions of the EOS PM Project including planning, directing, coordinating, and evaluating all EOS PM Project procurement activities in accordance with NASA authoritative guidelines and coordinating these activities with the EOS PM DPM/R.

6.7 RESOURCE SUMMARY

6.7.1 Funding Requirements

The NOA requirements for the EOS PM Project through FY 2000 are shown in Table 6-4. Revisions to these requirements will be submitted through the POP process.

6.7.2 Manpower

The Civil Service Manpower requirements for the EOS PM Project are shown in Table 6-5. Revisions will be through the Annual Center Budget update.

6.8 SCHEDULES

The EOS PM Project Master Schedule is shown in Figure 6-5 and includes the planning milestones for each of the EOS PM flights. Figure 6-6 is a master schedule for the EOS PM-1 flight only.

6.9 LOGISTICS

Transportation of the EOS PM spacecraft to the WSMC will be the responsibility of the EOS PM spacecraft contractor. The spacecraft will be shipped in an environmentally controlled shipping container and delivered to the WSMC.

6.10 FACILITIES

The EOS PM Project will use a combination of NASA and contractor facilities during instrument and spacecraft design, fabrication, assembly, test, checkout, launch, and tracking and data acquisition. Table 6-6 lists the facilities necessary for the EOS PM Project.

6.11 RISK ASSESSMENT

Risk is associated with those advanced-design components or systems that have not yet been demonstrated or that must operate in environments over which the EOS PM Project has little control. These components and systems have been identified and are discussed in the following subsections.

6.11.1 Spacecraft

No identified risk areas at this point in time.

Table 6-4
EOS PM Project POP 93-1 Budget Summary (NOA; $M)

DATA DELETED FROM THIS VERSION OF THE PLAN

Table 6-5
Goddard Civil Service Manpower Requirements for the EOS PM Project
FY93 Through FY00

DATA DELETED FROM THIS VERSION OF THE PLAN

Table 6-5
Other Center's Manpower Requirements for the EOS PM Project
FY93 Through FY00 (Continued)

DATA DELETED FROM THIS VERSION OF THE PLAN

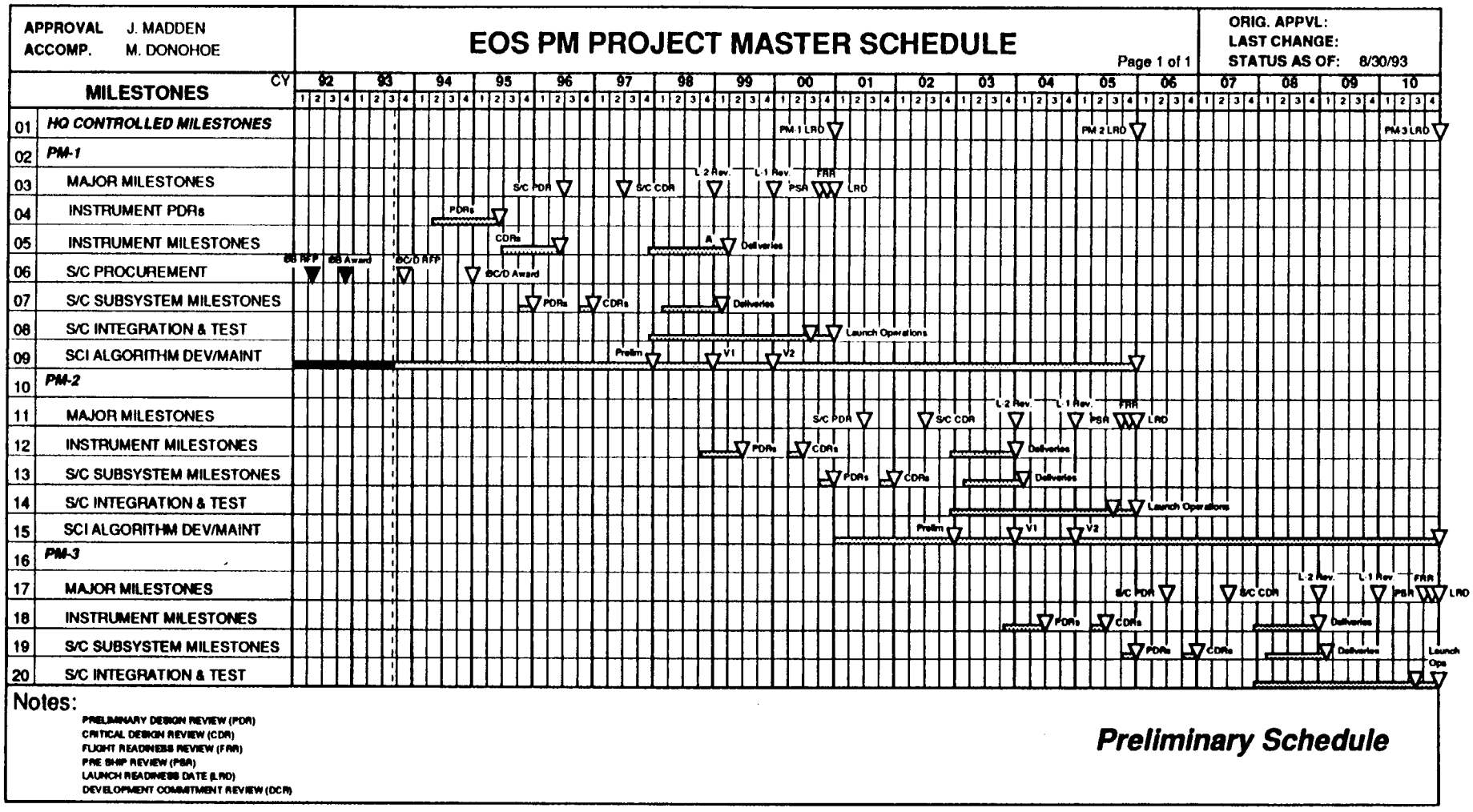


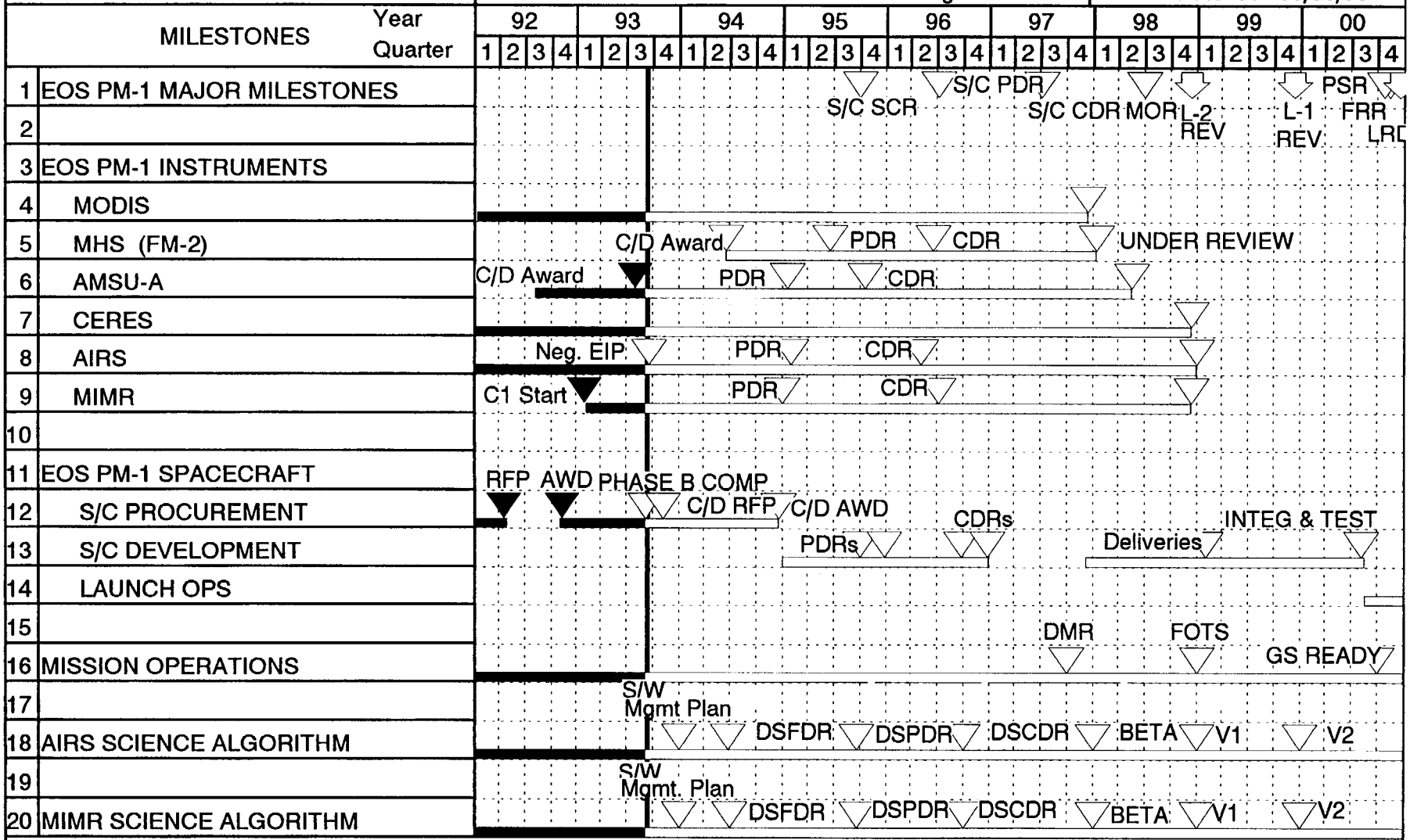
Figure 6-5. EOS PM Project Master Schedule

GODDARD SPACE FLIGHT CENTER
APPROVAL WEYERS
ACCOMP. DONOHOE

EOS PM-1 PROJECT PLANNING SCHEDULE (LEVEL 1)

Page 1 of 1

ORIG. APPVL. 08/30/93
LAST CHANGE / /
STATUS AS OF 08/30/93



NOTE: PRELIMINARY DESIGN REVIEW (PDR) DATA SYSTEM (DS) FUNCTIONAL DESIGN REVIEW (DSFDR) FLT OPS TRAIN SIM (FOT
CRITICAL DESIGN REVIEW (CDR) MIMR SCIENCE S/W & MGMT. PLAN (MSSMP)
FLIGHT READINESS REVIEW (FRR) DETAIL MISSION REQ. (DMR)
PRE-SHIP REVIEW (PSR) A - PROJECT MANAGERS ASSESSMENT

Legend: ▽ - Supporting ⇩ - HQTR Controlled L - Latest Comp. Date A - Mgt. Assessed Comp. Date ⊘ - Changed
Slack ..... Critical Path

812XX26M.mls

Figure 6-6. EOS PM-1 Master Schedule

Table 6-6
EOS PM Project Facility Requirements

Item	Requirement	Location	Need Date
EOS PM Project Management	Office Space	GSFC, Greenbelt, MD	1/95 - 3/15
EOS PM Spacecraft Contractor	Office Space, I&T Facilities	TBD	1/95 - 3/15
AIRS Instrument	Office Space	JPL, Pasadena, CA	1/92 - 3/15
AIRS Instrument Developer (LIRIS)	Office Space, Fab, I&T Facilities	LIRIS, Lexington, MA	1/92 - 3/15
AMSU Instrument Developer (Aerojet)	Office Space, Fab, I&T Facilities	Aerojet, Azusa, CA	11/92 - 3/15
CERES Instrument	Office Space	LaRC, Langley, VA	1/92 - 3/15
CERES Instrument Developer (TRW)	Office Space, Fab, I&T Facilities	TRW, Redondo Beach, CA	1/92 - 3/15
MHS Instrument	Office Space	EUMETSAT, Germany	6/94 - 3/15
MHS Instrument Developer (TBD)	Office Space, Fab, I&T Facilities	TBD	6/94 - 3/15
MIMR Instrument	Office Space	ESA, Netherlands	1/93 - 3/15
MIMR Instrument Developer (TBD)	Office Space, Fab, I&T Facilities	Alenio Spazio, Italy	1/93 - 3/15
MODIS Instrument	Office Space	GSFC, Greenbelt, MD	1/92 - 3/15
MODIS Instrument Developer (SBRC)	Office Space, Fab, I&T Facilities	SBRC, Santa Barbara, CA	1/92 - 3/15
Launch Support	Office Space, Launch Facilities	WSMC, Lompoc, CA	90 days before and after launch
TDRSS / GSTDN / TDRSS-II	Spacecraft Communications	White Sands, NM	As required

6.11.2 Launch Facilities

Whereas, the EOS PM Project will use the same launch facilities as the EOS AM Project, which will launch earlier than the EOS PM Project, any modification(s) required to the WSMC will have already been completed.

6.11.3 Instruments

The instrument development effort has three major risk areas: the mechanical refrigerators for the AIRS instrument, long-wavelength focal planes for the AIRS and MODIS, and the MIMR torque disturbance into the spacecraft resulting from its rotary motion.These risk areas were identified early in the EOS Phase A/B study efforts, and steps were taken to offset the risks.

6.11.3.1 Coolers

The cooler risks apply to the AIRS instrument on EOS PM-1. Development is required for a 55-K cooler for the AIRS. The immediate development/qualification tasks are for the 55-K and 80-K coolers in support of the AIRS instrument.

The following efforts are currently being undertaken to offset the risk of the AIRS cooler: a characterization laboratory effort at JPL has produced meaningful results on the existing, commercially available British Aerospace (BAe) cooler (80-K); two Phase B study efforts with BAe and Lockheed/Lucas on a 55-K cooler design, which have physically demonstrated success on the two key specification requirements of achieving thermal lift capacity and vibration control; and the formation of a cooler working group (involving the GSFC Cryogenics Branch, JPL, a U. S. Air Force cooler development study group, the respective PI developers requiring the mechanical coolers, and the EOS PM Project Office for accommodation impact) to disseminate information and coordinate the various cooler efforts.

The 80-K cooler effort is being handled at GSFC with Lockheed/ Lucas currently under contract for breadboarding of an 80-K cooler applicable to EOS. This cooler has demonstrated the capability to be back-up to the AIRS 55-K cooler. In addition to the U. S. efforts on the 55-K and 80-K designs, BAe, the chief supplier of the Stirling cooler technology, is conducting an extensive test and qualification program, the results of which will be available to the EOS PM Project. Recent flights of the BAe coolers on ERS-1 and UARS have been successful and are being monitored for performance application to EOS.

In summary, the cooler risks are being actively addressed and will be further assessed before the AIRS instrument PDR.

6.11.3.2 Focal Planes

The long-wavelength focal plane risk applies to the MODIS and AIRS.

The long-wavelength focal plane for the AIRS (approximately 13 to 15.4 μm) and for the MODIS (approximately 13 to 14.54 μm) represent similar risks. On AIRS, the risk was identified early in the Phase B study and previously in the precursor Advanced Meteorological Temperature Sounder (AMTS) study effort from which AIRS is derived. An internal research and development effort at the selected instrument developer, supported by NASA Headquarters and internal contractor funding, has offset this risk area. Preliminary breadboard detector measurements indicate promising detector performance levels and the possibility of using photovoltaic (PV) cells in a larger portion of the instrument spectral range. In addition, the selected instrument developer for the AIRS, has a long history of HgCdTe research and development and is one of the three recognized U. S. suppliers of advanced focal planes, besides being an infrared sensor developer. The combination is formidable and is exactly what is needed to lower the identified risks on the AIRS instrument.

The MODIS uses a passive radiant cooler for low-temperature operation; the focal plane operating temperature has a direct bearing on infrared detector performance. Preliminary thermal analysis indicates a conservative control point of 85K, and HgCdTe material tests are currently underway to determine any system trade-offs. On MODIS, the focal plane development risk is also offset by the selected instrument developer, another well-recognized sensor and detector manufacturer. The MODIS selected instrument developer is also one of the three recognized leaders in HgCdTe development and has direct NASA experience in this wavelength range, having successfully developed the VISSR and the VAS for NASA. The MODIS instrument provider is a recognized leader in the radiant cooler field and holds several design patents.

6.11.3.3 Torque Disturbances

The sinusoidal torque disturbance resulting from the rotating portions of the MIMR instrument, when transformed into balancing requirements, shall not exceed the values contained in the Unique Instrument Interface Document (UIID).

To compensate for the torque disturbance, an on-orbit balancing mechanism is being developed as part of the instrument activities. To reduce risk and test this concept, a breadboard model of the mechanism has been built by the selected instrument developer. Testing is proceeding to verify proof of this concept. Test data to date indicate an acceptable level of unbalanced torque into the spacecraft structure.

6.12 ENVIRONMENTAL IMPACT

The Environmental Impact Assessment and Statement and a Hazardous Waste Minimization Plan will be coordinated with the GSFC Environmental Coordinator.

6.12.1 Expendable Launch Vehicle

In accordance with the NEPA of 1969, the OSSA Director of Launch Vehicles and Propulsion Programs issued an Environmental Impact Statement, dated July 1973, describing the known and anticipated environmental effects of the various ELVs used by NASA.

The EOS PM spacecraft will be launched by an intermediate class IELV, the effects of which are described in detail in the July 1973 Environmental Impact Statement. The environmental impact of the EOS PM launches, even in the event of failure or abort, is not considered to be significant in that the effects are limited in extent, duration, and intensity.

6.12.2 EOS PM Spacecraft

An environmental assessment of the EOS spacecraft will be prepared by the EOS PM Project. The spacecraft is planned to be designed to be consistent with the disposal policy outlined in the draft titled Safety Policy for Space Debris, NMI 1700. No environmental impact or requirement for an environmental impact statement is anticipated.

7. EOS CHEMISTRY AND SPECIAL FLIGHTS PROJECT

7.1 PROJECT CHARACTERISTICS

The EOS CSF Project will develop and launch three series of spacecraft, each of which will comprise an element of the space-based EOS, which will provide global science data from low altitude orbits on a long-term sustained basis. The Project will also develop and manage elements of the EOS that constitute Flights of Opportunity (FOO). These include scientific instruments for which flights have not yet been assigned as well as a data buy mission (COLOR). In the case of COLOR, the CSF Project will acquire scientific data from private industry as was done for SeaWiFs.

The focus of the CSF Project is the multidisciplinary study of the Earth's interrelated processes (atmosphere, oceans, and ice sheets) and their relationship to Earth system changes. The global change research emphasized with the CSF Project instrument data sets includes atmospheric chemical species and their transformations, atmospheric aerosols, ocean circulation, ice-sheet mass balance, ocean biomass and productivity, cloud physics, atmospheric radiation properties, ocean-surface stress, and lightning.

7.2 EOS CSF PROJECT LEVEL 1 REQUIREMENTS

The Level 1 requirements for the EOS CSF Project are comprised of the general requirements in Section 4.2 and those shown below. These requirements serve as the baseline for derivation of lower level performance requirements. Any proposal by the EOS CSF Project to change a Level 1 requirement or any failure to meet Level 1 requirements will be referred to the EOS PCB for disposition by the EOS Program Director. For those issues requiring Level 2 decisions, the procedures defined in the EOS Configuration Management Plan (420-02-02) will be followed. Items controlled by the Deputy Administrator and PAA are identified in Section 3 of this plan.

7.2.1 EOS Chemistry Spacecraft Series

The EOS Chemistry spacecraft series, including the instruments, shall consist of three spacecraft designated EOS CHEM-1, EOS CHEM-2, and EOS CHEM-3, each of which shall have a design lifetime of 5 years. The related Level 1 requirements for this spacecraft series are as follows.

7.2.1.1 Duration of Series

The EOS Chemistry spacecraft series shall be capable of replacing each on-orbit spacecraft every 5 years to provide observations of the Earth for not less than 15 years beginning with the launch of the CHEM-1 spacecraft in 2002.

7.2.1.2 Operational Overlap
The Chemistry Flight Series shall plan for a 6-month period of overlap in observations to enhance the capability to intercompare data from successive versions of EOS instruments.

7.2.1.3 Launch of Spacecraft
The EOS Chemistry spacecraft shall be designed to be launched by an intermediate class ELV.

7.2.1.4 Orbit of Spacecraft
The EOS Chemistry spacecraft series shall be inserted into a 16-day, 233-orbit repeat sun-synchronous orbit with 1:30 pm ±15 minutes ascending nodal crossing (nominally 705 km, 98.2° inclination).

7.2.1.5 Instrument Payload
The EOS Chemistry spacecraft series includes the instruments shown in Table 7-1. The instrument characteristics and standard data products applicable to each investigation are defined in Section 7.3.5.

Table 7-1
EOS Chemistry Payload Complement

Instrument	CHEM-1	CHEM-2	CHEM-3
HIRDLS	X	X	X
SAGE III	X	X	X
ACRIM	X	X	X
MLS	X	X	X
SOLSTICE	X	X	X
International Instrument	X	X	X

7.2.1.6 Direct Playback
All EOS Chemistry spacecraft shall support the intermittent direct-to-ground downlink of real-time or stored on-board data (both science and engineering data) as a backup should the prime TDRSS science downlink fail.

7.2.1.7 Spacecraft Health and Safety
The spacecraft shall support detection, isolation, and recovery capabilities for any single fault to ensure the health and safety of the spacecraft.

7.2.1.8 Instrument Technology Improvement
The Chemistry Flight Series instruments shall be designed to permit technological improvements to be incorporated into the subsequent flight copies of each instrument. Any such improvements shall be allowable only if it can be demonstrated

that the improvements do not degrade data continuity. Waivers for improvements shall be reviewed by the EOS PCB.

7.2.1.9 Investigator Responsibilities
The TL and TMs for each Chemistry Flight Series PIs shall be responsible for the development and maintenance of algorithms and source code to generate the respective Standard Data Products listed in each instrument's section.

7.2.2 EOS Special Spacecraft Series (Aerosol)

The EOS Aerosol spacecraft series, including the instruments, shall consist of five spacecraft designated EOS AERO-1, EOS AERO-2, EOS AERO-3, EOS AERO-4, and EOS AERO-5, each of which shall have a design lifetime of 3 years. The related Level 1 requirements for this spacecraft are as follows.

7.2.2.1 Duration of Series
The EOS Aerosol spacecraft series shall be capable of replacing each on-orbit spacecraft every 3 years to provide observations of the Earth for not less than 15 years beginning with the launch of the EOS AERO-1 spacecraft in 2000.

7.2.2.2 Operational Overlap
The EOS Aerosol Flights shall plan for a 6-month period of overlap in observations to enhance the capability to intercompare data from successive versions of EOS instruments.

7.2.2.3 Launch of Spacecraft
The EOS Aerosol spacecraft series shall be designed to be launched by an SELV.

7.2.2.4 Orbit of Spacecraft
The EOS Aerosol spacecraft series shall be inserted into a 57° inclined, 705 km orbit.

7.2.2.5 Instrument Payload
The EOS Aerosol spacecraft series includes the instruments shown in Table 7-2. The instrument characteristics and standard data products applicable to each investigation are defined in Section 7.3.3.

Table 7-2
EOS Aerosol Payload Complement

Instrument	AERO-1	AERO-2	AERO-3	AERO-4	AERO-5
SAGE III	X	X	X	X	X
TBD	X	X	X	X	X

7.2.2.6 Direct Playback
All EOS Aerosol spacecraft shall support the intermittent direct-to-ground playback of all instrument and spacecraft data utilizing one Earth contact per 2 to 6 orbits.

7.2.2.7 Spacecraft Health and Safety
The spacecraft shall support detection, isolation, and recovery capabilities for any single fault to ensure the health and safety of the spacecraft.

7.2.2.8 Instrument Technology Improvement
The Aerosol instruments shall be designed to permit technological improvements to be incorporated into the subsequent flight copies of each instrument. Any such improvements shall be allowable only if it can be demonstrated that the improvements do not degrade data continuity. Waivers for improvements shall be reviewed by the EOS PCB.

7.2.2.9 Investigator Responsibilities
The TL and TMs for each Aerosol FI and PIs shall be responsible for the development and maintenance of algorithms and source code to generate Standard Data Products including the standard data products listed in each instrument's section.

7.2.3 EOS Special Spacecraft Series (Altimetry)

The EOS Altimetry spacecraft series, including the instruments, shall consist of three spacecraft designated EOS ALT-1, EOS ALT-2, and EOS ALT-3, each of which shall have a design lifetime of 5 years. The related Level 1 requirements for this spacecraft are as follows.

7.2.3.1 Duration of Series
The EOS Altimetry spacecraft series shall be capable of replacing each on-orbit spacecraft every 5 years to provide observations of the Earth for not less than 15 years beginning with the launch of the ALT-1 spacecraft in 2002.

7.2.3.2 Operational Overlap
The Altimetry Flights shall plan for a 6-month period of overlap in observations to enhance the capability to intercompare data from successive versions of EOS instruments.

7.2.3.3 Launch of Spacecraft
The EOS Altimetry spacecraft shall be designed to be launched by an MELV.

7.2.3.4 Orbit of Spacecraft
The EOS Altimetry spacecraft series shall be inserted into a TBD orbit.

7.2.3.5 Instrument Payload

The EOS Altimetry spacecraft series includes the instruments shown in Table 7-3. The instrument characteristics and standard data products applicable to each investigation are defined in Section 7.3.4.

Table 7-3
EOS Altimetry Payload Complement

Instrument	ALT-1	ALT-2	ALT-3
GLAS	X	X	X
AMR	X	X	X
SSALT	X	X	X
DORIS	X	X	X

7.2.3.6 Direct Playback

All EOS Altimetry spacecraft shall support the intermittent downlink of real-time or stored on-board data (both science and engineering data).

7.2.3.7 Spacecraft Health and Safety

The spacecraft shall support detection, isolation, and recovery capabilities for any single fault to ensure the health and safety of the spacecraft.

7.2.3.8 Instrument Technology Improvement

The Altimetry instruments shall be designed to permit technological improvements to be incorporated into the subsequent flight copies of each instrument. Any such improvements shall be allowable only if it can be demonstrated that the improvements do not degrade data continuity. Waivers for improvements shall be reviewed by the EOS PCB.

7.2.3.9 Investigator Responsibilities

The TL and TMs for each Altimetry FI shall be responsible for the development and maintenance of algorithms and source code to generate Standard Data Products including the standard data products listed in each instrument's section.

7.3 TECHNICAL SUMMARY

In order to complete the suite of measurements needed to support the scientific goals of the MTPE, the CSF Project was formed to oversee the definition and development of the specialized flights for aerosol (AERO), altimetry (ALT), and atmospheric chemistry (CHEM) investigations, and to oversee the development of instruments designated as FOO.

- The Aerosol flights focus on the effect of atmospheric aerosols on the greenhouse effect. To study the diurnal variability of aerosols, a mid-inclination orbit is planned. In order to satisfy the Level 1 requirement for a 15 year data set, a series of five spacecraft, each designed for a 3-year operation lifetime, is planned.
- The purpose of the Altimetry flights is to study the exchange of energy and chemicals between the ocean and atmosphere, and to begin the study of mass balance measurements of the glaciers and ice sheets. A near-polar orbit is planned. In order to satisfy the Level 1 requirement for a 15 year data set, a series of three spacecraft, each designed for a 5-year operation lifetime, is planned.
- The Chemistry Flights concentrate on the measurement of the transformation of atmospheric trace gases. These measurements will be critical to the understanding of changes in global climate and stratospheric ozone. A polar orbit is planned. In order to satisfy the Level 1 requirement for a 15-year data set, a series of three spacecraft, each designed for a 5-year operation lifetime, is planned.
- Two Special Flights instruments, CERES and LIS, will be flown on the TRMM spacecraft. The NASA Scatterometer (SeaWinds) is a FOO but is being studied for launch on the Japanese ADEOS-2 spacecraft. The COLOR flight is planned for launch on a small-class ELV. The COLOR data set is to overlap both SeaWiFs and the second MODIS on the PM platform.

The EOS CSF Project spacecraft, instruments (including instrument Level 1 requirements), and system integration and test segments are described in Sections 7.3.1 through 7.3.3.

7.3.1 Spacecraft

Specific subsystem functional requirements for the EOS CSF Project spacecraft were developed through the Phase B studies described below.

7.3.1.1 Chemistry Flights

Data deleted from this version of the Project Plan.

7.3.1.2 Aerosol Flights

The AERO Flights spacecraft has been designated as an international contribution.

7.3.1.3 Altimetry Flights
In-house studies for the ALT flights spacecraft are being defined. The results of the in-house studies will lead to competitive Phase B definition studies for the ALT spacecraft.

7.3.2 Instruments

Table 7-4 lists the instrument complements for the CSF Project series of spacecraft.

Table 7-4
EOS Chemistry and Special Flights Instruments

Instrument	AERO	ALT	CHEM	FOO
ACRIM	–	–	X	
CERES	–	–	–	X
DORIS	–	X	–	
GLAS	–	X	–	
HIRDLS	–	–	X	
LIS	–	–	–	X
MLS	–	–	X	
SAGE III	X	–	X	
COLOR	–	–	–	X
SOLSTICE	–	–	X	
SSALT	–	X	–	
SeaWindS	–		–	X
AMR	–	X	–	
International Instrument	–	–	X	

7.3.3 Aerosol Flight Instruments

7.3.3.1 Stratospheric Aerosol and Gas Experiment

7.3.3.1.1 Description
The SAGE III instrument, a PI instrument, is an Earth-limb viewing near UV-visible-near IR spectrometer. The SAGE III science objectives are to monitor climate and ozone chemistry changes from the mid-troposphere through the mesophere.

7.3.3.1.2 Level 1 Requirements
Using solar and lunar occultation, SAGE-III measurements shall be self-calibrating and have high vertical resolution (<1 km), both necessary for determining long term trends in species and atmospheric parameters required for understanding climate and ozone chemistry changes. The planned Standard Data Products for SAGE-III are shown in Appendix D.

7.3.4 Altimetry Flight Instruments

7.3.4.1 Geoscience Laser Altimeter System

7.3.4.1.1 Description

The Geoscience Laser Altimeter System (GLAS) instrument, an FI, is a solid-state neodymium: yttrium-aluminum-garnet (Nd:YAG) laser altimeter including integral star trackers and Global Positioning Systems (GPSs) for precise attitude and orbit determinations. The GLAS science objectives include ice sheet topography and mass balance, land surface or vegetation topography profiles and measurement of cloudtop and base heights and optical densities.

7.3.4.1.2 Level 1 Requirements

The GLAS shall determine ice sheet topography profiles and changes and land surface or vegetation canopy profiles and changes, and measure multiple cloudtops, base heights, and optical densities. The GLAS shall be designed to operate with a measurement mode duty cycle of not less than 100 percent. The planned Standard Data Products for GLAS are shown in Appendix D.

7.3.4.2 Solid State Altimeter

7.3.4.2.1 Description

The Solid State Altimeter (SSALT) instrument is an international instrument provided by Centre National d'Etudes Spatiales (CNES). The SSALT is a microwave altimeter. The SSALT science objective is to map the topography of the sea surface and the polar ice sheets.

7.3.4.2.2 Level 1 Requirements

The SSALT shall map the topography of the sea surface and the polar ice sheets. The planned Standard Data Products for SSALT are shown in Appendix D.

7.3.4.3 Doppler Orbitography and Radiopositioning Integrated by Satellite

7.3.4.3.1 Description

The Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS) instrument is an international instrument provided by CNES. The DORIS science objective is to provide precise orbital position information for the EOS Altimetry spacecraft, especially as a reference for the SSALT and GLAS.

7.3.4.3.2 Level 1 Requirements

The DORIS shall provide precise orbital position information for the EOS Altimetry spacecraft, especially as a reference for the SSALT and GLAS. The planned Standard Data Products for DORIS are shown in Appendix D.

7.3.4.4 Altimetry Microwave Radiometer

7.3.4.4.1 Description
The Altimetry Microwave Radiometer (AMR) measures the radiometric brightness temperature related to water vapor and liquid water in the same field-of-view as the microwave altimeter. The AMR operates at frequencies of 18, 21, and 37 GHz.

7.3.4.4.2 Level 1 Requirements

The planned Standard Data Products for AMR are shown in Appendix D.

7.3.5 Chemistry Flight Instruments

7.3.5.1 Active Cavity Radiometer Irradiance Monitor

7.3.5.1.1 Description
The Active Cavity Radiometer Irradiance Monitor (ACRIM) instrument, a PI instrument, consists of three total irradiance detectors. The ACRIM science objective is to monitor the variability of total solar irradiance.

7.3.5.1.2 Level 1 Requirement
The ACRIM shall measure the total solar irradiance. The ACRIM standard data products include Level 1B irradiance reference data set and measurements of the total (bolometric) solar irradiance above the atmosphere, with the goals of 0.3 percent absolute accuracy and 0.0005 percent long-term precision per year. The planned Standard Data Products for ACRIM are shown in Appendix D.

7.3.5.2 High Resolution Dynamics Limb Sounder

7.3.5.2.1 Description
The High Resolution Dynamics Limb Sounder (HIRDLS) instrument, a PI instrument, is an infrared limb-scanning radiometer. The HIRDLS science objectives are to sound the upper troposphere, stratosphere, and mesosphere to determine temperature, the concentrations of atmospheric species and aerosols and the locations of polar stratospheric clouds and cloudtops.

7.3.5.2.2 Level 1 Requirements
The HIRDLS shall contribute to understanding the physical and chemical fluxes between the troposphere and stratosphere and to understanding the upper tropospheric chemistry. The planned Standard Data Products for HIRDLS are shown in Appendix D.

7.3.5.3 Microwave Limb Sounder

7.3.5.3.1 Description
The Microwave Limb Sounder (MLS) instrument, a PI instrument, is a passive radiometer/spectrometer which measure millimeter and submillimeter wavelength radiation from the atmospheric limb. The MLS science objectives are to provide crucial information on ozone depletion and radiational forcing of climate at altitudes from the upper troposphere to the mesophere. An important feature of the MLS measurements is that they are not degraded by clouds or volcanic aerosols.

7.3.5.3.2 Level 1 Requirements
The MLS shall make measurements that are critical for understanding global change in the upper troposphere, stratosphere, and mesosphere. These measurements shall be transformed to usable geophysical data products from which scientific information is extracted and communicated to the scientific community and policy makers. The planned Standard Data Products for MLS are shown in Appendix D.

7.3.5.4 Stratospheric Aerosol and Gas Experiment

7.3.5.4.1 Description
The SAGE III instrument, a PI instrument, is an Earth-limb viewing near UV-visible-near IR spectrometer. The SAGE III science objectives are to monitor climate and ozone chemistry changes from the mid-troposphere through the mesophere.

7.3.5.4.2 Level 1 Requirements
Using solar and lunar occultation, the SAGE III measurements shall be self-calibrating and have high vertical resolution (<1 km), both necessary for determining long term trends in species and atmospheric parameters required for understanding climate and ozone chemistry changes. The planned Standard Data Products for SAGE III are shown in Appendix D.

7.3.5.5 Solar Stellar Irradiance Comparison Experiment

7.3.5.5.1 Description
The Solar Stellar Irradiance Comparison Experiment (SOLSTICE), a PI instrument, is an ultraviolet spectrometer. The SOLSTICE science objectives are the measurements of the solar ultraviolet irradiance between 115 and 420 nm. Radiation below 300 nm is completely absorbed by the Earth's atmosphere and even small changes in the amount of this radiation will result in corresponding changes in the photochemistry, dynamics, and energy balance of the atmosphere. The EOS SOLSTICE observations will be an extension of similar observations made by the SOLSTICE on UARS. Moreover, through the stellar comparison technique these two data sets can be intercompared with an accuracy on the order of 1%.

7.3.5.5.2 Level 1 Requirements
The SOLSTICE will determine the absolute solar ultraviolet flux above the atmosphere and measure its variability on all time scales. The sensitivity of the instrument will be tracked with a precision and long term relative accuracy, far better than 1%, repeated observation of a set of standard stars. The planned Standard Data Products for SOLSTICE are shown in Appendix D.

7.3.5.6 Chemistry International Instrument
This international investigation is currently undefined but is expected to be provided by NASDA in reciprocation for Sea Winds flying on ADEOS II.

7.3.6 Flights of Opportunity

7.3.6.1 SeaWindS Scatterometer

7.3.6.1.1 Description
The SeaWindS, a PI instrument, is a rotating, dual spot beam, Ku-band scatterometer scheduled for flight on the ADEOS II spacecraft. The SeaWindS science objectives are to acquire all-weather measurements of global backscatter cross-section and near-surface wind velocity (both speed and direction) over the ice-free oceans. These measurements provide critical atmospheric forcing inputs to ocean circulation and air-sea interaction models, and serves as stringent boundary conditions when assimilated into atmospheric circulation models.

7.3.6.1.2 Level 1 Requirements
The SeaWindS shall measure global radar backscatter cross-section and all-weather, near-surface vector winds over the ice-free oceans, to extend the data sets begun by ESA's ERS-1/2 AMI and NASA's NSCAT instruments. The SeaWindS shall provide the Standard Data Products shown in Table 7-5.

7.3.6.2 Clouds and the Earth's Radiant Energy System

7.3.6.2.1 Description
The CERES instrument, a PI instrument funded separately under UPN 227 that will fly on the TRMM spacecraft, consists of a scanning radiometer, with three separate telescope units. This configuration will allow the scanner to operate in the crosstrack or biaxial mode. The CERES science objectives are to generate data products that provide cloud-radiative and forcing-feedback inputs to the climate system models, and observational baseline of clear-sky radiative fluxes and radiative input to atmospheric and ocean energy models.

Table 7-5
Flights of Opportunity Standard Data Products
Preliminary

Instrument	Product Name	Units	Accuracy Abs :: Rel	Temporal Resolution	Horizontal Resol. :: Cover. *	Vertical Resol. :: Cover. **
CERES	Bi-Directional Scan (BDS) Radiance	W/m^2/sr	1-2% :: 0.005	1/6.6 sec	25 km :: G	N/A :: TOA
	ES-8 ERBE-Like Product			1/6.6 sec	25 km :: G	N/A :: TOA
	ES-9 ERBE-Like Product	W/m^2		1 & 24/mo [Avg]	2.5 x 2.5 dg :: R,G	N/A :: TOA
LIS	Level-1A Product	counts	:: 2.4 x 10^-4	1/2 ms	3.5 km :: G	
	Level-1 Lightning Product			1/2 ms	0.07 dg :: Tropics	N/A :: Atmos
SeaWinds	Level-1B Backscatter Power				50 km :: G	N/A :: Sfc
	Global Backscatter Cross Section (Sigma-0)	dB	:: 0.25 dB		~50 km :: G	N/A :: Sfc
	Near Surface Vector Winds in Measurement Swath	m/s, dg	<2 m/s or 10% (speed); 20 dg (direction) ::	1/(2 day) repeat coverage	~50 km :: Ocean (within swath width of 1600 km, comprising two bands 500 km wide on either side of satellite track)	N/A :: Near_Sfc

* G, R, and L represent Global, Regional, and Local Coverage, respectively.

** TOA, Trop, Atmos, and Sfc represent Top of Atmosphere, Troposphere, Atmosphere (Troposphere & Stratosphere), and Surface, respectively.

Note: These standard data products are preliminary pending negotiation and agreement with the responsible EOS investigators.

7.3.6.2.2 Level 1 Requirements
The CERES shall measure the global distribution of hemispheric reflected solar (shortwave) and emitted (long-wave) radiant flux from the Earth to extend the long-term record of the components of the Earth's radiation budget initiated by the ERBE. The CERES shall provide the Standard Data Products shown in Table 7-5.

7.3.6.3 Lightning Imaging Sensor

7.3.6.3.1 Description
The LIS instrument, a PI instrument that will fly on the TRMM spacecraft, is a staring telescope/ filter imaging system. The LIS science objectives are to investigate the distribution of lightning over the Earth.

7.3.6.3.2 Level 1 Requirements
The LIS shall determine the incidence of lightning, its correlation with rainfall, and its relationship with the global electric circuit. The LIS shall provide the Standard Data Products shown in Table 7-5.

7.3.6.4 EOS Color Flight

7.3.6.4.1 Description
The COLOR mission is a data purchase. The minimum period of data acquisition is from mid-1998 to the certification of MODIS on the PM-1 platform. As with SeaWiFs, NASA will be responsible for calibration and certification of the data, data processing, data archival, and distribution. The COLOR science objectives include measurements of chlorophyll-a and phytoplankton biomass to improve the understanding of the transformation of inorganic carbon into carbon forms as a part of the global carbon cycle.

7.3.6.4.2 Level 1 Requirements
The COLOR shall provide visible and near-infrared imaging observations of the upper ocean, without sun glint, for the purpose of estimating chlorophyll-a and phytoplankton concentrations. The planned Standard Data Products for COLOR are shown in Appendix D.

7.3.7 Observatory System Integration and Test

For each CSF Project spacecraft, an observatory level test program will be conducted to demonstrate that the observatory can withstand and perform properly when subjected to the expected launch and orbit environments. This test program will include an end-to-end system test, which will simulate orbital performance and verify compatibility of the total flight and ground segments.

7.4 IMPLEMENTATION APPROACH

The implementation approach for each major element of the EOS CSF Project is described in the following sections. The approach conforms to the UPN structure identified in Section 1.1 and the WBS described in Section 7.4.3.

7.4.1 Spacecraft

7.4.1.1 Chemistry

Data deleted from this version of the Project Plan.

7.4.1.2 Aerosol

Data deleted from this version of the Project Plan.

7.4.1.3 Altimetry

Data deleted from this version of the Project Plan.

7.4.2 Instruments

Data deleted from this version of the Project Plan.

7.4.3 Work Breakdown Structure

The EOS CSF Project WBSs are shown in Figures 7-1 and 7-2. The WBS is organized into two UPNs. The Chemistry Flights covers the Chemistry series of spacecraft; the Special Flights covers the Aerosols and Altimetry series of spacecraft, as well as the FOOs. It incorporates the EOS CSF Project responsibilities: spacecraft, instruments, and the associated project management of each spacecraft. EOS CSF instrument science algorithm development and related activities are also the responsibility of the EOS CSF Project. Funding for this effort is part of UPN 229 (EOS Science) and is allocated to the project by the GSFC Mission to Planet Earth Office. SCF funds needed in support of overall science activity are provided as part of the ESDIS budget under UPN 428. A WBS Dictionary for the entire EOS is found in document 420-02-01, Revision A.

7.5 PROCUREMENT SUMMARY

A summary of the major EOS CSF Project procurements is shown in Tables 7-6, 7-7, 7-8, and 7-9. The procurements consist of the spacecraft, instruments, and science agreements applicable to the CSF Project.

EOS CHEMISTRY

Work Breakdown Structure

Code 424 — **EOS Chemistry Project** — UPN 228

-10 CHEM-1 Flight		-20 CHEM-2 Flight		-30 CHEM-3 Flight	
11-10	CHEM-1 Project Support Summary	21-10	CHEM-2 Project Support Summary	31-10	CHEM-3 Project Support Summary
11-11	MPS/ROS	21-11	MPS/ROS	31-11	MPS/ROS
11-12	FPD Engineering Support	21-12	FPD Engineering Support	31-12	FPD Engineering Support
11-13	Performance Assurance	21-13	Performance Assurance	31-13	Performance Assurance
11-14	Resources Management Support	21-14	Resources Management Support	31-14	Resources Management Support
11-15	GSFC In-House Eng. Support	21-15	GSFC In-House Eng. Support	31-15	GSFC In-House Eng. Support
11-16	Calibration Support	21-16	Calibration Support	31-16	Calibration Support
11-17	Reserved	21-17	Reserved	31-17	Reserved
11-18	Project Office Science Support	21-18	Project Office Science Support	31-18	Project Office Science Support
11-19	Operations Capability Development	21-19	Operations Capability Development	31-19	Operations Capability Development
12-20	CHEM-1 Instrument Development	22-20	CHEM-2 Instrument Development	32-20	CHEM-3 Instrument Development
12-21	HIRDLS	22-21	HIRDLS	32-21	HIRDLS
12-22	SAGE III	22-22	SAGE III	32-22	SAGE III
12-23	ACRIM	22-23	ACRIM	32-23	ACRIM
12-24	MLS	22-24	MLS	32-24	MLS
12-25	SOLSTICE	22-25	SOLSTICE	32-25	SOLSTICE
12-26	Reserved	22-26	Reserved	32-26	Reserved
12-27	Reserved	22-27	Reserved	32-27	Reserved
12-28	Reserved	22-28	Reserved	32-28	Reserved
12-29	Reserved	22-29	Reserved	32-29	Reserved
13-10	CHEM-1 Spacecraft	23-10	CHEM-2 Spacecraft	33-10	CHEM-3 Spacecraft
13-11	Prime Spacecraft Contract	23-11	Prime Spacecraft Contract	33-11	Prime Spacecraft Contract
13-12	Spacecraft GFE	23-12	Spacecraft GFE	33-12	Spacecraft GFE
13-13	Thru 19 Reserved	23-13	Thru 19 Reserved	33-13	Thru 19 Reserved
14-10	Reserved	24-10	Reserved	34-10	Reserved
15-10	Reserved	25-10	Reserved	35-10	Reserved
16-10	Reserved	26-10	Reserved	36-10	Reserved
17-10	Reserved	27-10	Reserved	37-10	Reserved
18-10	Reserved	28-10	Reserved	38-10	Reserved
19-10	CHEM-1 Contingency	29-10	CHEM-2 Contingency	39-10	CHEM-3 Contingency

Figure 7-1. EOS Chemistry Flights Project WBS

EOS CHEMISTRY AND SPECIAL FLIGHTS PROJECT

Work Breakdown Structure

Code 424 — **EOS Special Flights Project** — UPN 227

-10 AEROSOLS-1 Project

- 11-10 AERO-1 Project Support Summary
- 11-11 MPS/ROS
- 11-12 FPD Engineering Support
- 11-13 Performance Assurance
- 11-14 Resources Management Support
- 11-15 GSFC In-House Eng. Support
- 11-16 Calibration Support
- 11-17 Reserved
- 11-18 Project Office Science Support
- 11-19 Operations Capability Development
- 12-30 AERO-1 Instrument Development
- 12-31 Reserved
- 12-32 SAGE III
- 12-33 Reserved
- 12-34 Reserved
- 13-10 AERO-1 Spacecraft
- 13-11 Prime Spacecraft Contract
- 13-12 Spacecraft GFE
- 13-13 Thru 19 Reserved
- 14-10 Reserved
- 15-10 Reserved
- 16-10 Reserved
- 17-10 Reserved
- 18-10 Reserved
- 19-10 AERO-1 Contingency

-20 AEROSOLS-2 Project

- 21-10 AERO-2 Project Support Summary
- 21-11 MPS/ROS
- 21-12 FPD Engineering Support
- 21-13 Performance Assurance
- 21-14 Resources Management Support
- 21-15 GSFC In-House Eng. Support
- 21-16 Calibration Support
- 21-17 Reserved
- 21-18 Project Office Science Support
- 21-19 Operations Capability Development
- 22-30 AERO-2 Instrument Development
- 22-31 Reserved
- 22-32 SAGE III
- 22-33 Reserved
- 22-34 Reserved
- 23-10 AERO-2 Spacecraft
- 23-11 Prime Spacecraft Contract
- 23-12 Spacecraft GFE
- 23-13 Thru 19 Reserved
- 24-10 Reserved
- 25-10 Reserved
- 26-10 Reserved
- 27-10 Reserved
- 28-10 Reserved
- 29-10 AERO-2 Contingency

-30 AEROSOLS-3 Project

- 31-10 AERO-3 Project Support Summary
- 31-11 MPS/ROS
- 31-12 FPD Engineering Support
- 31-13 Performance Assurance
- 31-14 Resources Management Support
- 31-15 GSFC In-House Eng. Support
- 31-16 Calibration Support
- 31-17 Reserved
- 31-18 Project Office Science Support
- 31-19 Operations Capability Development
- 32-30 AERO-3 Instrument Development
- 32-31 Reserved
- 32-32 SAGE III
- 32-33 Reserved
- 32-34 Reserved
- 33-10 AERO-3 Spacecraft
- 33-11 Prime Spacecraft Contract
- 33-12 Spacecraft GFE
- 33-13 Thru 19 Reserved
- 34-10 Reserved
- 35-10 Reserved
- 36-10 Reserved
- 37-10 Reserved
- 38-10 Reserved
- 39-10 AERO-3 Contingency

Figure 7-2. EOS Special Flights Project WBS

EOS SPECIAL FLIGHTS

Work Breakdown Structure

Code 424 | EOS Special Flights Project | UPN 227

-40 AEROSOLS-4 Flight

- 41-10 AERO-4 Project Support Summary
- 41-11 MPS/ROS
- 41-12 FPD Engineering Support
- 41-13 Performance Assurance
- 41-14 Resources Management Support
- 41-15 GSFC In-House Eng. Support
- 41-16 Calibration Support
- 41-17 Reserved
- 41-18 Project Office Science Support
- 41-19 Operations Capability Development
- 42-30 AERO-4 Instrument Development
- 42-31 Reserved
- 42-32 SAGE III
- 42-33 Reserved
- 42-34 Reserved
- 43-10 AERO-4 Spacecraft
- 43-11 Prime Spacecraft Contract
- 43-12 Spacecraft GFE
- 43-13 Thru 19 Reserved
- 44-10 Reserved
- 45-10 Reserved
- 46-10 Reserved
- 47-10 Reserved
- 48-10 Reserved
- 49-10 AERO-4 Contingency

-50 AEROSOLS-5 Flight

- 51-10 AERO-5 Project Support Summary
- 51-11 MPS/ROS
- 51-12 FPD Engineering Support
- 51-13 Performance Assurance
- 51-14 Resources Management Support
- 51-15 GSFC In-House Eng. Support
- 51-16 Calibration Support
- 51-17 Reserved
- 51-18 Project Office Science Support
- 51-19 Operations Capability Development
- 52-30 AERO-5 Instrument Development
- 52-31 Reserved
- 52-32 SAGE III
- 52-33 Reserved
- 52-34 Reserved
- 53-10 AERO-5 Spacecraft
- 53-11 Prime Spacecraft Contract
- 53-12 Spacecraft GFE
- 53-13 Thru 19 Reserved
- 54-10 Reserved
- 55-10 Reserved
- 56-10 Reserved
- 57-10 Reserved
- 58-10 Reserved
- 59-10 AERO-5 Contingency

Figure 7-2. EOS Special Flights Project WBS (Continued)

EOS SPECIAL FLIGHTS

Work Breakdown Structure

Code 424 — **EOS Special Flights Project** — UPN 227

-60 ALTIMETRY-1 Flight

- 61-10 ALT-1 Project Support Summary
- 61-11 MPS/ROS
- 61-12 FPD Engineering Support
- 61-13 Performance Assurance
- 61-14 Resources Management Support
- 61-15 GSFC In-House Eng. Support
- 61-16 Calibration Support
- 61-17 Reserved
- 61-18 Project Office Science Support
- 61-19 Operations Capability Development

- 62-30 ALT-1 Instrument Development
- 62-35 SSA
- 62-36 DORIS
- 62-37 GLAS
- 62-38 AMR
- 62-39 Reserved

- 63-10 ALT-1 Spacecraft
- 63-11 Prime Spacecraft Contract
- 63-12 Spacecraft GFE
- 63-13 Phase A Altimetry Laser Study
- 63-14 Phase A Altimetry Laser Study
- 63-15 Phase A Altimetry Laser Study
- 63-16 Thru 19 Reserved

- 64-10 Reserved
- 65-10 Reserved
- 66-10 Reserved
- 67-10 Reserved
- 68-10 Reserved
- 69-10 ALT-1 Contingency

-70 ALTIMETRY-2 Flight

- 71-10 ALT-2 Project Support Summary
- 71-11 MPS/ROS
- 71-12 FPD Engineering Support
- 71-13 Performance Assurance
- 71-14 Resources Management Support
- 71-15 GSFC In-House Eng. Support
- 71-16 Calibration Support
- 71-17 Reserved
- 71-18 Project Office Science Support
- 71-19 Operations Capability Development

- 72-30 ALT-2 Instrument Development
- 72-35 SSA
- 72-36 DORIS
- 72-37 GLAS
- 72-38 AMR
- 72-39 Reserved

- 73-10 ALT-2 Spacecraft
- 73-11 Prime Spacecraft Contract
- 73-12 Spacecraft GFE
- 73-13 Thru 19 Reserved

- 74-10 Reserved
- 75-10 Reserved
- 76-10 Reserved
- 77-10 Reserved
- 78-10 Reserved
- 79-10 ALT-2 Contingency

-80 ALTIMETRY-3 Flight

- 81-10 ALT-3 Project Support Summary
- 81-11 MPS/ROS
- 81-12 FPD Engineering Support
- 81-13 Performance Assurance
- 81-14 Resources Management Support
- 81-15 GSFC In-House Eng. Support
- 81-16 Calibration Support
- 81-17 Reserved
- 81-18 Project Office Science Support
- 81-19 Operations Capability Development

- 82-30 ALT-3 Instrument Development
- 82-35 SSA
- 82-36 DORIS
- 82-37 GLAS
- 82-38 AMR
- 82-39 Reserved

- 83-10 ALT-3 Spacecraft
- 83-11 Prime Spacecraft Contract
- 83-12 Spacecraft GFE
- 83-13 Thru 19 Reserved

- 84-10 Reserved
- 85-10 Reserved
- 86-10 Reserved
- 87-10 Reserved
- 88-10 Reserved
- 89-10 ALT-3 Contingency

Figure 7-2. EOS Special Flights Project WBS (Continued)

EOS SPECIAL FLIGHTS

Work Breakdown Structure

Code 424 | EOS Special Flights Project | UPN 227

-90 Flights of Opportunity

- 91-10 FOO Project Support Summary
- 91-11 MPS/ROS
- 91-12 FPD Engineering Support
- 91-13 Performance Assurance
- 91-14 Resources Management Support
- 91-15 GSFC In-House Eng. Support
- 91-16 Calibration Support
- 91-17 Reserved
- 91-18 Project Office Science Support
- 91-19 Operations Capability Development

- 92-40 FOO Instrument Development
- 92-41 SeaWinds
- 92-42 Reserved
- 92-43 Reserved
- 92-44 Reserved
- 92-45 CERES - TRMM1
- 92-46 LIS - TRMM1
- 92-47 CERES - TRMM2
- 92-48 Reserved
- 92-49 Reserved

- 93-10 Reserved
- 93-11 Reserved
- 93-12 Reserved
- 93-13 Thru 19 Reserved

- 94-10 COLOR

- 95-10 Reserved

- 96-10 HQ Reserved

- 97-10 HQ Reserved

- 98-10 HQ Reserved

- 99-10 FOO Contingency

- 99-11 COLOR Contingency

- 99-12 TRMM Contingency

Figure 7-2. EOS Special Flights Project WBS (Continued)

Table 7-6
EOS Chemistry and Special Flights Project Aerosol Procurement Summary

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Table 7-7
EOS Chemistry and Special Flights Project Altimetry Procurement Summary

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Table 7-8
EOS Chemistry and Special Flights Project Chemistry Procurement Summary

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Table 7-9
EOS Chemistry and Special Flights Project Science Procurement Summary

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7.6 EOS CSF PROJECT MANAGEMENT RESPONSIBILITIES AND ORGANIZATION

Management responsibilities and procedures for the EOS CSF Project are established in accordance with Space Flight Program and Project Management, NMI 7120.3. Within GSFC, the Flight Projects Directorate includes the EOS CSF Project. The EOS CSF Project staff interfaces with functional GSFC directorates and facilities to plan, implement, and coordinate development of the EOS CSF Project. The OMTPE/EOS CSF Project organization charts are given in Figures 7-3 and 7-4.

7.6.1 EOS CSF Project Manager

The EOS CSF Project organization shown in Figure 7-4 is headed by a Project Manager who is the senior official at GSFC exclusively responsible for managing execution of the project life-cycle. The EOS CSF Project Manager has full authority to carry out this responsibility within guidelines and controls prescribed by the Director of Flight Projects, The Director of the Mission to Planet Earth Office, and the GSFC Director.

Specific responsibilities include directing and overseeing:

- Preparation and maintenance of project plans, specifications, schedules, and budgets.
- Acquisition and utilization of participating contractors.
- Execution of project plans by government, contractor, and university participants in conformance with all project commitments and constraints and with all agency policies.
- Performing project level SE&I
- Reporting project status and contractor performance as required.
- Establishing and maintaining a close and effective working relationship with the Program Manager.

The EOS CSF Project Manager discharges the responsibilities with the assistance and support of individuals and organizations assigned either administratively or functionally to the EOS CSF Project. The EOS CSF Project Manager is also responsible for the development of the NSCAT II (ADEOS II), LIS (TRMM), and COLOR flights.

7.6.2 EOS CSF Deputy Project Manager

The EOS CSF DPM is responsible to the EOS CSF Project Manager and is an integral member of the management team for the CSF Project. The EOS CSF DPM supports the EOS CSF Project Manager in directing all phases of the EOS CSF Project and has Project wide responsibility for personnel management and planning and evaluating all EOS CSF Project activities on a day-to-day basis. The DPM provides technical management to the team of technically skilled specialists and their supporting personnel in order to

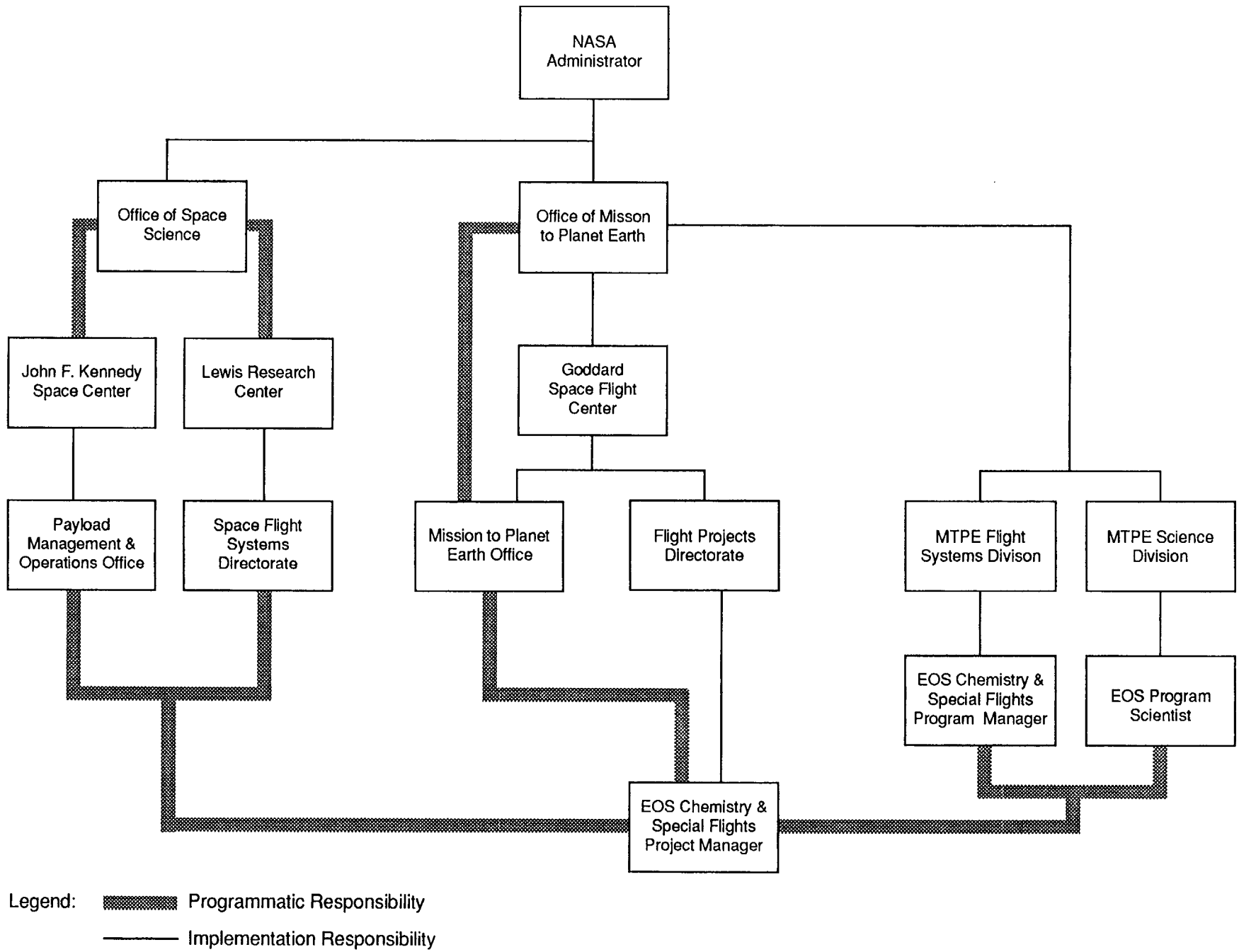

Figure 7-3. MTPE / GSFC Project Management Organization Chart for EOS

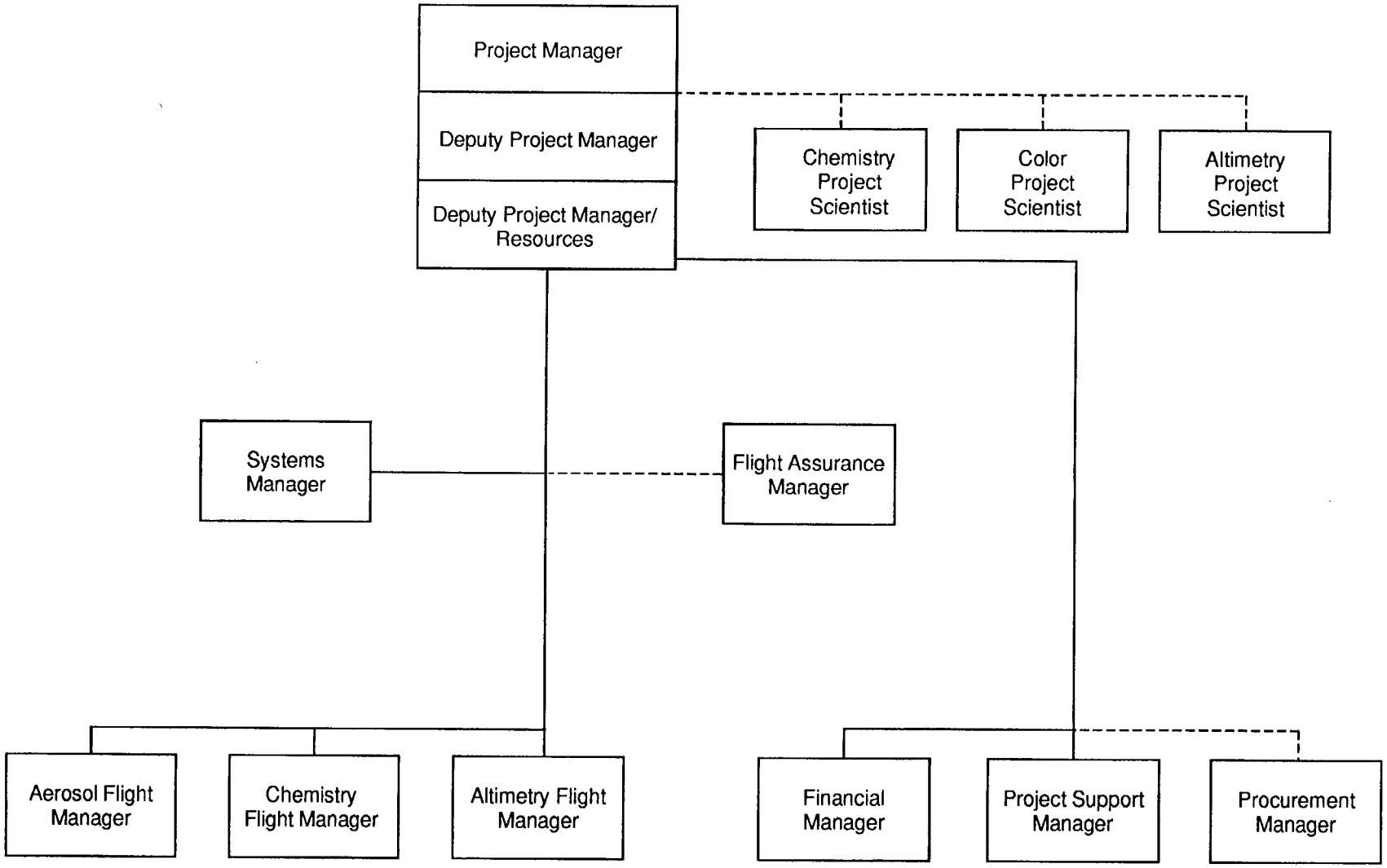

Figure 7-4. EOS Chemistry and Special Flights Project

meet performance cost and schedule commitments. In the absence of the Project Manager, the DPM assumes full responsibility for the Project.

7.6.3 EOS CSF Deputy Project Manager/Resources

The EOS CSF DPM/R is responsible to the EOS CSF Project Manager and is an integral member of the management team for the EOS CSF Project. The EOS CSF DPM/R contributes business management expertise to the establishment of technical program objectives and is responsible for the application of business, financial management, and performance measurement techniques to the accomplishment of those objectives. The EOS CSF DPM/R supervises a team of specialists in the areas of finance, budget, performance measurement, scheduling, pricing, configuration management, etc., and is responsible for the application of sound business techniques to the accomplishment of EOS CSF Project objectives. In addition, the EOS CSF DPM/R provides requirements to the EOS CSF Project Procurement Manager on Project-related matters. In the absence of the EOS CSF Project Manager and the EOS CSF DPM, the EOS CSF DPM/R may act for the EOS CSF Project Manager.

7.6.4 EOS CSF Project Scientists

The EOS CSF Project Scientists, from the Earth Sciences Directorate at GSFC, are responsible for ensuring the satisfactory accomplishment of the scientific objectives of EOS CSF missions and are integral members of the management team for the EOS CSF Project. The EOS CSF Project Scientists review the planning and implementation of the EOS CSF Project to ensure that the total mission is consistent with the overall scientific objectives. The EOS CSF Project Scientists provide leadership in ensuring that the scientific data are used effectively and the scientific results of the mission are produced expeditiously. The Project Scientists provide appropriate inputs to the PDMP's. The EOS CSF Project Scientists evaluate all scientific requirements placed on the EOS CSF Project, provide scientific guidance to the EOS CSF Project Manager, and provide information and recommendations to the EOS Senior Project Scientist and others involved in the Program. The EOS CSF Project Scientist's authority includes serving as the primary Project liaison to the Instrument Science Teams, and making recommendations to the EOS Senior Project Scientist on science funding levels appropriate for calibration, product validation and algorithm development for appropriate Science Teams. The EOS CSF Project Scientists and the Program Scientist communicate and coordinate on science issues.

7.6.5 EOS CSF Project Systems Manager

The EOS CSF Project Systems Manager is responsible to the EOS CSF Project Manager for all systems aspects of the flight and ground segment systems. The incumbent is responsible for developing the systems design of the spacecraft/observatory system, and for ensuring that it is compatible with the scientific instruments, launch vehicle, ground system, and reliability objectives. The incumbent establishes interface constraints and requirements for subsystems; resolves interface and system level performance questions and problems; reviews and approves for manufacture, the electrical flight hardware designs; and oversees the electrical integration and test of the CSF spacecraft. The incumbent reviews performance data and measurements throughout the Project to ensure that flight and ground systems meet stated requirements and objectives. Specifically, the CSF Systems Manager has review and signoff responsibilities for all major system-level functional performance and design specifications; performs risk assessments, and evaluates design margins and inadequacies; reviews all major test plans and procedures; compares predicted and actual performance of systems; and reports routinely to the CSF Project Manager on the status of system engineering activities. The incumbent serves as chairman for major failure-review committees, and advises the Director of Flight Projects as to major (critical) aspects of these assignments.

7.6.6 EOS CSF Project Flight Assurance Manager

The EOS CSF Project Flight Assurance Manager, from the Office of Flight Assurance, is responsible to the EOS CSF Project Manager for all flight assurance disciplines of the CSF Project to ensure that the spacecraft, instruments, and ground system equipment (hardware and software) will meet their intended performance objectives. These disciplines include quality assurance, design review, reliability, system safety, parts, materials, processes, contamination control, and verification testing. The incumbent is responsible for the coordination of GSFC Resident or GIA personnel.

7.6.7 EOS CSF Project Flight Managers

The Flight Managers are responsible to the CSF Project Manager for planning, organizing, and directing all aspects of the CHEM, AERO, and ALT flights. The Flight Managers develop the overall plan for the definition, development, design, and implementation of the respective flights. The flight includes the spacecraft, applications software, and the completion of science instruments. The Flight Managers provide flight segment requirements and interface definition for the planning and development of the spacecraft, science instruments, ground system, and mission operations. As such, the incumbent directs the efforts of a team of government and industry specialists to identify and specify the mission-imposed spacecraft and instrument requirements, and

to develop systems and subsystems to meet these requirements in the launch and space environments. The Flight Manager ensures that the facilities, tools, test equipment, and data processing hardware and software required to fabricate, assemble, integrate, test, and calibrate the spacecraft subsystems and science instruments are procured or developed within the schedule and resource constraints of the program.

7.6.8 EOS CSF Project Support Manager

The EOS CSF Project Support Manager, is a member of the business support team reporting to the EOS CSF DPM/R. The EOS CSF Project Support Manager is responsible for scheduling, configuration management, logistics management, manpower analysis, property management, and control, and other general administration and overall EOS CSF Project planning activities.

7.6.9 EOS CSF Project Financial Manager

The EOS CSF Project Financial Manager is a member of the business support team and reports to the EOS CSF DPM/R. The EOS CSF Project Financial Manager is responsible for the application of sound financial management principles in the areas of cost control, performance measurements, financial analysis, budget preparation and execution, and pricing.

7.6.10 EOS CSF Project Procurement Manager

The EOS CSF Project Procurement Manager, from the Management Operations Directorate, is responsible for all procurement functions of the EOS CSF Project including planning, directing, coordinating, and evaluating all EOS CSF Project procurement activities in accordance with NASA authoritative guidelines and coordinating these activities with the EOS CSF DPM/R.

7.7 RESOURCES SUMMARY

7.7.1 Funding Requirements

The NOA requirements for the EOS CSF Project through FY 2000 are shown in Tables 7-10 and 7-11. Revisions to these requirements will be submitted through the POP process.

7.7.2 Manpower

The Civil Service Manpower requirements for the EOS CSF Project are shown in Table 7-12. Revisions will be made through the annual budget update.

Table 7-10
EOS Chemistry Mission POP 93-1 Budget Summary (NOA; $M)

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Table 7-11
EOS Special Flights Mission POP 93-1 Budget Summary (NOA; $M)

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Table 7-12
Goddard Civil Service Manpower Requirements for EOS C&SF Project
FY93 through FY))

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7.8 SCHEDULES

The CSF Project Master Schedule is included in Section 4.5, and identifies major NASA Headquarters controlled milestones. The EOS CSF Project CHEM Master Schedule is shown in Figure 7-5. The EOS CSF Project AERO Master Schedule is shown in Figure 7-6. The EOS CSF Project ALT Master Schedule is shown in Figure 7-7. The EOS CSF Project FOO Master Schedule is shown in Figure 7-8.

7.9 LOGISTICS

The transportation of the EOS CSF Project CHEM spacecraft to the WTR at VAFB is the responsibility of the EOS CSF Project CHEM spacecraft contractor. The spacecraft will be shipped in an environmentally controlled shipping container and delivered to the WTR at VAFB by an appropriate means of transportation.

The transportation of the EOS CSF Project AERO spacecraft to the WFF is the responsibility of the EOS CSF Project AERO spacecraft contractor. The spacecraft will be shipped in an environmentally controlled shipping container and delivered to the WFF by an appropriate means of transportation.

The transportation of the EOS CSF Project ALT spacecraft to the WTR at VAFB is the responsibility of the EOS CSF Project ALT spacecraft contractor. The spacecraft will be shipped in an environmentally controlled shipping container and delivered to the WTR at VAFB by an appropriate means of transportation.

7.10 FACILITIES

The EOS CSF Project CHEM, AERO, and ALT flights will use a combination of NASA, USAF, International, and contractor facilities during instrument and spacecraft design, fabrication, assembly, integration and test, calibration, checkout, launch, and tracking and data acquisition. The specific facilities necessary for the EOS CSF Project AERO, ALT, and CHEM flights are TBD.

7.11 RISK ASSESSMENT

Risk is associated with any advanced design components or systems that have not been developed or proven in the space environment. In addition, management challenges exist on the international instruments.

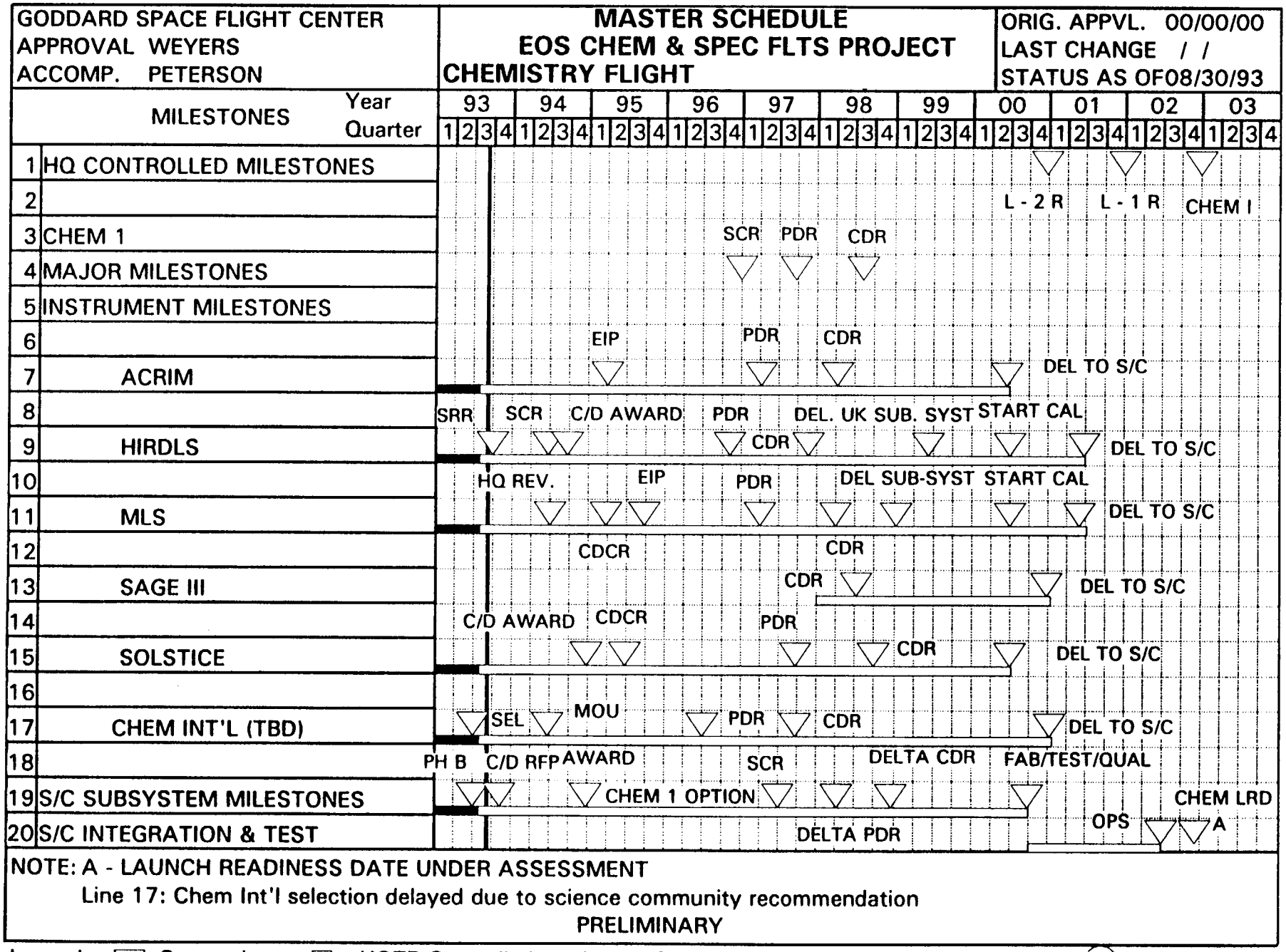

Figure 7-5. EOS CSF Project CHEM Master Schedule

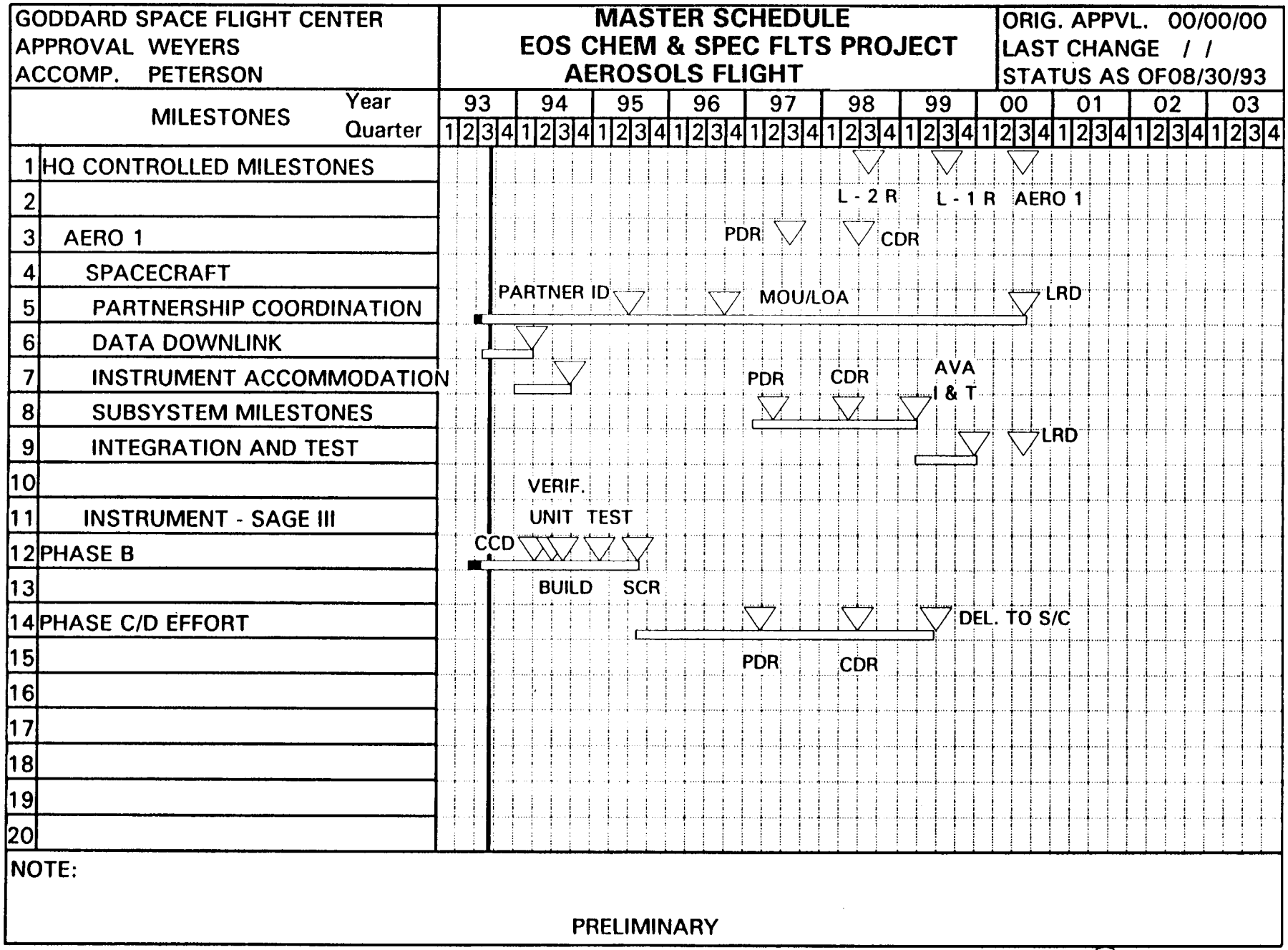

Figure 7-6. EOS CSF Project AERO Master Schedule

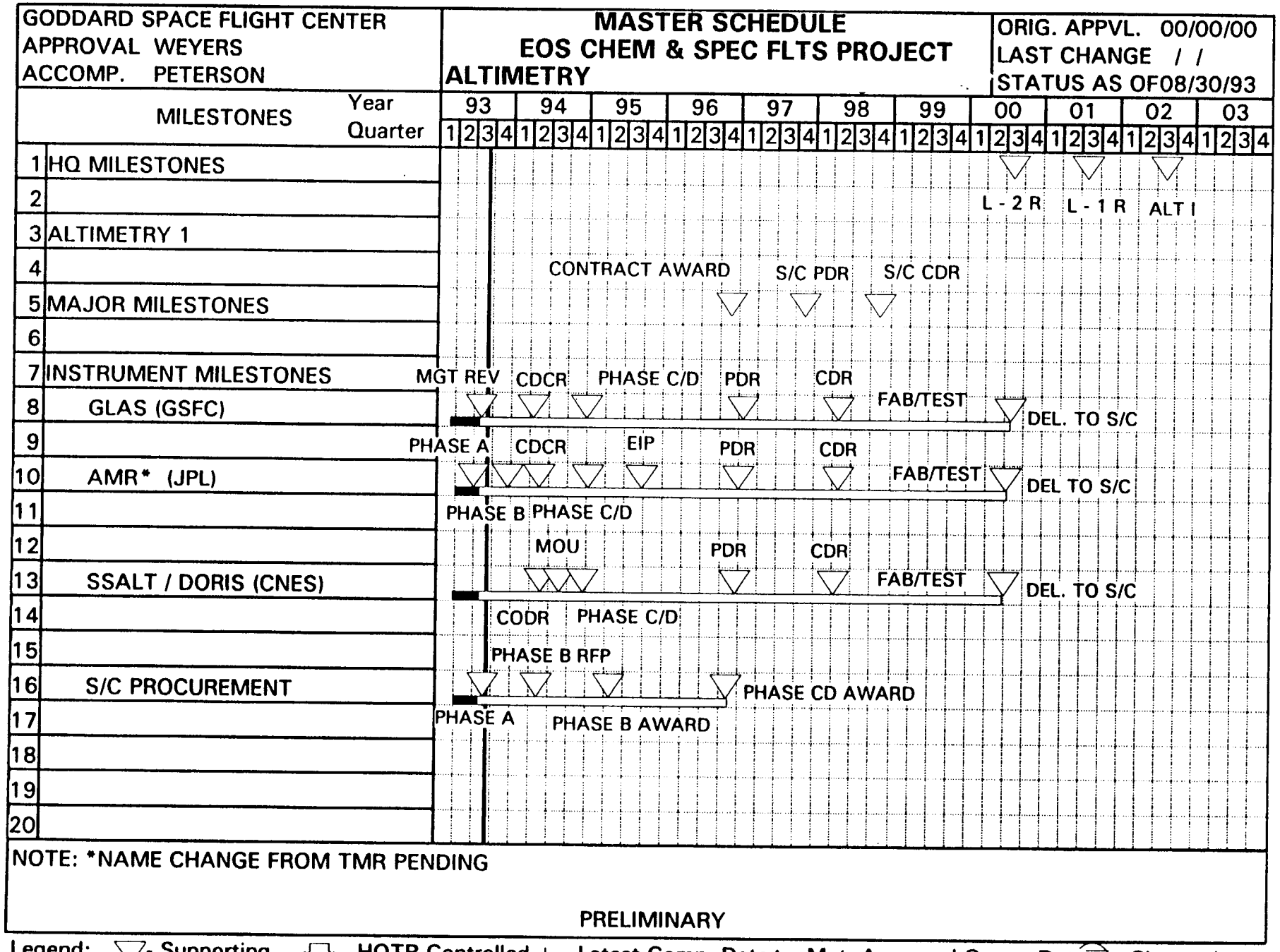

Figure 7-7. EOS CSF Project ALT Master Schedule

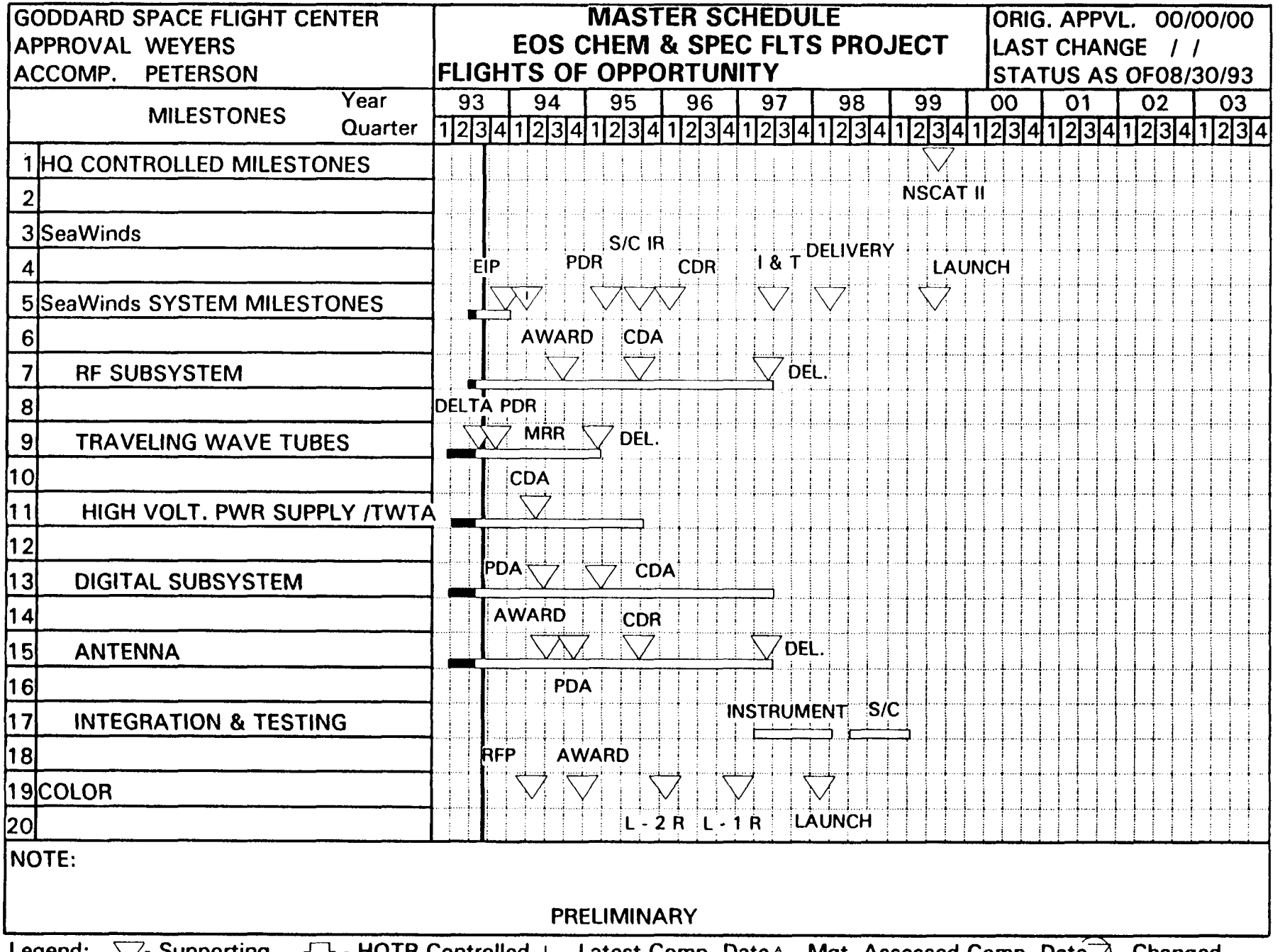

Figure 7-8. EOS CSF Project FOO Master Schedule

7.11.1 Aerosol Flights Risk Identification

The launch system for this series of flights is a SELV. This is a new system for NASA and is undergoing development. Several issues have been identified. These issues may pose some schedule and technical risk. In addition, with the spacecraft designated to be supplied by an international partner (IP), management, cost, and schedule risk may arise.

7.11.2 Altimetry Flights Risk

One instrument assigned to this series of flights, the GLAS, has not had a CDCR. The development risks have not been fully analyzed. Additional risk is involved with internationally supplied instruments, SSALT and DORIS, as to their capabilities and development of a dual frequency radiometer.

7.11.3 Chemistry Flights Risk

The EOS AM and EOS PM Projects have enumerated the risks associated with the launch vehicle and payload processing areas. Currently there are no identified spacecraft risk areas.

7.12 ENVIRONMENTAL IMPACT

The environmental impact assessment and statements and a hazardous waste minimization plan will be coordinated with the GSFC Environmental Coordinator.

7.12.1 Expendable Launch Vehicles

In accordance with the NEPA of 1969, the OSSA Director of Launch Vehicles and Propulsion Programs issued an Environmental Impact Statement, dated July 1973, describing the known and anticipated environmental effects of the various ELVs used by NASA.

The EOS CSF Project spacecraft will be launched by either small, medium, or intermediate class ELVs or equivalent, the effects of which are described in detail in the July 1973 Environmental Impact Statement. The environmental impact of the EOS CSF Project launched, even in the event of failure or abort, is not considered to be significant in that the effects are limited in extent, duration, and intensity.

7.12.2 EOS CSF Project Spacecraft

An environmental assessment of the EOS spacecraft will be prepared by the EOS CSF Project. The spacecraft is planned to be designed to be consistent with the disposal policy outlined in the draft titled Safety Policy for Space Debris, NMI 1700. No environmental impact or requirement for an environmental impact statement is anticipated.

8. EARTH SCIENCE DATA AND INFORMATION SYSTEM PROJECT

8.1 PROJECT CHARACTERISTICS

The ESDIS Project will develop and operate a data and information system for NASA's Earth science data to support multidisciplinary research in global change. This system, called the EOSDIS, will be NASA's component of the interagency Global Change Data and Information System (GCDIS) to archive, manage, and distribute data to a broad user community. The EOSDIS will support the operations of the EOS spacecraft and instruments, processing of data from EOS instruments into scientifically useful products, and archival, information management, and distribution of all of NASA's Earth science data according to the mission baseline maintained by the Office of Data Information Systems (ODIS) Program Office and the ESDIS Project (see section 8.2.2.1). Also, operations and data handling of non-EOS spacecraft and instruments will be supported to the extent specified herein.

8.2 LEVEL 1 REQUIREMENTS

The Level 1 requirements for the ESDIS Project are comprised of the General Requirements in Section 4.2 and those shown below. These requirements serve as the baseline for derivation of lower level performance requirements. Any proposal by the ESDIS Project to change a Level 1 requirement or any failure to meet Level 1 requirements will be referred to the MTPE PCB for disposition. For those issues requiring Level 2 decisions, the procedures defined in the EOS Configuration Management Plan (420-02-02) will be followed. Items controlled by the Deputy Administrator and PAA are identified in Section 3 of this Plan.

8.2.1 Data Acquisition and Access

The EOS data policy (see Appendix C) is designed to further the MTPE and EOS objectives of acquiring a comprehensive, global data set; maximizing data utility for scientific purposes; and simplifying long-term access to and analysis of EOS data.

a. The ESDIS Project shall acquire and process data from EOS instruments according to priorities established by the EOS Program and Project Scientists based upon recommendations received from the IWG and IPs.
b. The EOSDIS shall provide U.S. users with access to data from International Partner instruments on EOS spacecraft, pursuant to International Partner agreements.
c. The EOSDIS shall make available EOS Standard, Prototype, and Special Data Products to all users according to EOS data policy.

d. The EOSDIS shall adhere to any applicable restrictions for data consistent with agreements with data providers.
e. The EOSDIS shall make data from international instruments on EOS spacecraft available to the responsible international agency at the agreed upon pick-up point.
f. The ESDIS Project shall make available data from non-NASA instruments on NASA spacecraft at the agreed pick-up point.
g. The ESDIS Project shall receive Level 0 data from U.S. Facility and PI instruments flown on non-U.S. spacecraft from international spacecraft operators.

8.2.2 EOS Data and Information System Requirements

The requirements for EOSDIS define the information system infrastructure needed to support the collection, processing, archival, distribution, analysis, and management of the EOS science data, the operation of the space- and ground-based EOS systems, and archiving, distribution, and management of Landsat-7 and other NASA Earth science data.

8.2.2.1 General Requirements

a. The EOSDIS shall serve as NASA's Earth science discipline data system for information management, archival, and distribution of NASA digital Earth science data identified in Table 8-1. The EOSDIS shall support the EOS spacecraft and instruments identified in Section 4. A baseline of information sources, products, and services to be supported within budget guidelines shall be maintained by the NASA Headquarters ODIS Program Office and the ESDIS Project.
b. The ESDIS Project shall maintain its data system functions for EOS data until 3 years beyond the end of the EOS observing mission.
c. The ESDIS Project shall provide an SCF to each U.S. EOS science investigation that it manages.
d. The ESDIS Project shall maintain, in a separate location, a secure backup archive of all Level 0 data or higher level data from which Level 0 can be recovered. The ESDIS Project shall maintain, in a separate location, a secure backup archive of ancillary data needed to generate higher-level data products, production software, and supporting documentation.
e. The EOSDIS shall be designed with an open system architecture.
f. The ESDIS Project Independent Verification and Validation (IV&V) activity shall maximize its use of the NASA Facility at Fairmont, West Virginia.

Table 8-1
MTPE Flights Supported by the ESDIS Project

Flight	Forward/Return Link Processing	Flight Operations	Processing	Archival	Distribution
ERS-1				X	X
METEOR3				X	X
UARS				X	X
TOPEX/POSEIDON				X	X
JERS-1				X	X
SeaWiFS				X	X
ERS-2				X	X
Atlas				X	X
SIR-C/XSAR				X	X
ERBS				X	X
Nimbus-7				X	X
TOMS - EP				X	X
Radarsat				X	X
ADEOS				X	X
TRMM			X[1]	X	X
Landsat-7				X[2]	X
EOS-AM	X	X	X	X	X
COLOR			X	X	X
AERO	X	X	X	X	X
EOS-PM	X	X	X	X	X
ALT	X	X	X	X	X
CHEM	X	X	X	X	X

1. CERES and LIS instruments only
2. Archive browse and meta data only. Products generated on demand.

g. The ESDIS Project shall maintain its data system functions for Landsat-7 data until 3 years beyond the end of the Landsat-7 observing mission.
h. The EOSDIS shall provide metrics to monitor system performance.

8.2.2.2 Command and Control

a. The EOS command and control capability shall provide individual support to all simultaneously operating spacecraft, including spacecraft in the integration, test, and launch preparation phases.
b. The ESDIS Project shall establish functional interfaces for command and control of the International Partner instruments to be flown on NASA EOS spacecraft.
c. The ESDIS Project shall establish functional interfaces for command and control of the NASA EOS instruments to be flown on International Partner spacecraft.

8.2.2.3 Science Data Processing and Product Generation

a. The EOSDIS shall perform routine processing and reprocessing of EOS data to Standard Data Products at the EOSDIS DAACs according to assignment of responsibility by the MTPE Operations, Data, and Information Systems Division (see Section 8.2.2.7).
b. The EOSDIS shall use data processing software developed and tested by the EOS investigators at their SCFs to generate standard data products.
c. The ESDIS Project shall process and reprocess EOS standard data products according to priorities set by the EOS Program and Project Scientists based upon recommendations received from the IWG and IPs.
d. The ESDIS Project shall acquire, archive, and distribute non-EOS data of critical importance to the EOS research program as specified by the IWG, with approval of the OMTPE.
e. Following the post-launch checkout period, each of the EOS Level 1, 2, and 3 Standard Data Products shall be available to all users within 24 hours after availability within EOSDIS of all input data necessary for producing that product.
f. Following the post-launch checkout period, each of the EOS Level 4 Standard Data Products shall be made available to all users within 1 week after the availability within EOSDIS of all input data necessary for producing that product.
g. The EOSDIS shall be capable of performing reprocessing in parallel with ongoing routine processing at an aggregate rate of at least twice the rate at which the incoming data are processed.

8.2.2.4 Information Management

a. The EOSDIS shall provide Authorized Users with electronic access to data set directory, guide, and inventory information using EOSDIS-established capabilities and standards to provide catalog, browse, accounting, and ordering services to all its data holdings.
b. The EOSDIS shall provide the same view of the system and its data and product holdings from all user access nodes.
c. The EOSDIS shall provide a mechanism for on-line ordering of data.

8.2.2.5 Data Product Archiving
The EOSDIS shall archive all standard data products, together with their associated models, algorithms, source code, and documentation produced as part of the MTPE flights shown in Table 8-1.

8.2.2.6 Data Product Distribution

a. The ESDIS Project shall provide data holdings to carriers for shipping/transmission within 72 hours of request for at least 98 percent of all requests.
b. The ESDIS Project shall communicate pending decisions on data format standards to the Committee on Earth Observations Satellites (CEOS), and shall use best effort to implement CEOS recommendations and to use CEOS-adopted formats in the development of EOSDIS.
c. The EOSDIS shall provide, with a delay no greater than the equivalent of one orbit period from the receipt of data at White Sands, quicklook data at Level 0.
d. The EOSDIS shall provide expedited processing of quicklook data to higher levels as required.

8.2.2.7 EOSDIS Distributed Active Archive Centers

a. The EOSDIS Distributed Active Archive Centers (DAACs) shall perform the science data processing and product generation functions described in Section 8.2.2.3, applicable information management functions described in Section 8.2.2.4, and applicable data product archive and distribution functions described in Sections 8.2.2.5 and 8.2.2.6 respectively of this document. The product generation by the DAACs will be phased to be consistent with the EOS flight schedule.
b. The following institutions shall be designated as EOSDIS DAACs.

    1. Earth Resources Observation System (EROS) Data Center (EDC) Land Processes Imagery: data

products from Landsat 7 and ASTER; data products pertaining to land from MODIS at Level 2 and above; data products pertaining to land from synthetic aperture radars.

2. GSFC Upper Atmosphere, Atmospheric Dynamics, Global Biosphere, Geophysics: data products from MODIS, AIRS, AMSU-A, MHS, GLAS, SOLSTICE II, HIRDLS, Ocean Color, and MLS.
3. JPL Ocean Circulation and Air-Sea Interaction: data products from Scatterometer, precision location system, and ALT.
4. LaRC Radiation Budget, Aerosols, Tropospheric Chemistry: data products from CERES, SAGE III, MISR, EOSP, ACRIM, TES, and MOPITT.
5. Marshall Space Flight Center (MSFC) Hydrology: data products from MIMR and LIS.
6. Oak Ridge National Laboratory (ORNL): Biogeochemical Dynamics: ground-based data products relating to biogeochemical dynamics. ORNL shall have an additional specific responsibility for provision of generic support for field experiments.
7. University of Alaska-Fairbanks Sea Ice, Polar Processes Imagery: data products pertaining to ice and snow from synthetic aperture radars.
8. University of Colorado Cryosphere (non-SAR): data products pertaining to snow and ice from MIMR, GLAS, and MODIS at Level 2 and above.

c. The ESDIS Project shall use the NASA Science Internet and other existing and developmental network resources to provide the open access network for EOSDIS.

8.2.2.8 <u>Evolutionary Implementation of EOSDIS</u>

a. The EOSDIS shall be implemented by a progressive, evolutionary process that ensures that lessons learned from user experience with existing NASA data systems, earlier versions of EOSDIS, results of prototyping, and other studies are incorporated into the design.
b. The ESDIS Project shall prototype all functions and standards that are user-sensitive, high risk, or involve untried approaches or technology.

   1. The ESDIS Project shall migrate prototypes to the operational environment only following successful demonstrations to and acceptance by the relevant user community.

c. The ESDIS Project shall provide a Version 0 (V0).

   1. V0 shall improve access to current data products.

2. V0 shall support production, archive, and distribution of Pathfinder Data sets.
3. V0 shall make interoperable the capabilities of the Pilot Land Data System, NASA Climate Data System, NASA Ocean Data System, the Cryospheric Data Management System (CDMS), Global Land Information System (GLIS), and the Alaska SAR Facility (ASF).
4. V0 shall sustain the 5-year WetNet experiment.
5. The EOSDIS V0 shall include substantial information management service, limited product generation, and substantial data archive and distribution functionality (including limited production and distribution of existing or experimental search and order browse products) at all EOSDIS DAACs.
6. V0 shall network electronically all EOS DAACs.
7. The EOSDIS V0 shall provide operational functionality for information management, data product distribution, and archive for UARS, TOPEX/Poseidon, ERS-1/2, JERS-1, SeaWiFS, Radarsat, NSCAT, and TOMS on ADEOS.

d. The ESDIS Project shall provide a Version 1 (V1), which shall provide operational functionality for information management; algorithm development and product generation; and data archive and distribution, and take responsibility for existing NASA MTPE digital data at the baseline established with requirement 8.2.2.1. V1 shall support processing of CERES and LIS data from TRMM, archival and distribution of TRMM data, and information management and distribution for Landsat-7 data.

e. The EOSDIS Version 2 (V2) shall provide full functionality and capacity to support full-scale, launch-ready operations with EOS AM-1 and archive and distribute ocean color data from EOS-COLOR, in addition to all data services being provided by V1.

f. The EOSDIS shall have subsequent versions timed to support the full functionality and capacity required by the additional MTPE flight elements shown in Figure 4-1 and Table 8-1, each of which shall also include all services provided by previous versions.

g. The EOSDIS shall establish interoperability with the Consortium of International Earth Science Information Network (CIESIN) Socio-Economic Data and Applications Center (SEDAC) beginning with V0. (Funding for CIESIN is not part of the EOS program.)

The EOSDIS shall use the CIESIN to provide access to socio-economic data and information related to the study of Human Dimensions of Global Changes; and to

provide for enhanced access to EOS information and results by users in education, socio-economic research, Human Dimensions of Global Changes research, policy making, and developing countries.

Note: Funding for CIESIN is not presently included in the Table 8-5 Budget Summary.

8.2.3 EOSDIS Data Operations and Communications

8.2.3.1 General Requirements

a. The EOSDIS shall provide the interface with the Space Network and interface with ground stations supporting EOS.
b. The EOSDIS shall provide an emergency capability for monitoring, and command and control of EOS spacecraft and instruments from a physically separate facility.

8.2.3.2 Return-Link Processing

a. The EOSDIS shall generate Level 0 data products including quicklook data from all EOS spacecraft at the Fairmont, West Virginia NASA facility.

8.2.3.3 Communications

a. The EOS networks shall provide communications connectivity among ground systems.

    1. The EOS networks shall transmit spacecraft command, telemetry, and orbit tracking data among the EOS ground system elements to support the prelaunch test and on-orbit operations.
    2. The EOS networks shall support communications with IP instruments on EOS spacecraft and/or EOS instruments on IP spacecraft/platforms, as specified in the appropriate MOUs between NASA and the IP organizations.
    3. The EOS networks shall transmit processed data among the DAACs and SCFs.

8.2.4 Interface Requirements

8.2.4.1 Interagency Interfaces

a. The ESDIS Project shall support the ODIS Program Office in planning the GCDIS through the Interagency Working Group on Data Management for Global Change (IWGDMGC).
b. The ESDIS Project shall support the transfer of responsibility for permanent active archives from the

appropriate DAACs to NOAA, U.S. Geological Survey (USGS), and DOE.

c. The ESDIS Project shall provide an interface capability permitting high-level interoperability with designated Affiliated Data Centers (ADCs) in a manner consistent and compatible with EOSDIS services.

d. The ESDIS Project shall make EOSDIS technology available to IWGDMGC agencies participating in the development of GCDIS.

8.2.4.2 International Interfaces

The ESDIS Project shall support the ODIS Program Office in planning the IEOS through the EO-ICWG, including interoperable interfaces.

8.2.4.3 User Involvement

Users shall be involved in all aspects of EOSDIS development and operations that affect user services.

8.3 TECHNICAL SUMMARY

The EOSDIS and its interfaces required for the EOS Ground System are shown in Figure 8-1. The EOS Ground System includes EOSDIS (shown inside the bold-lined ellipse in Figure 8-1), the NASA-managed institutional elements, and elements from other government agencies, IPs and user support facilities. The ESDIS Project is responsible for the development and operation of EOSDIS and ensuring that EOSDIS operates in an integrated manner within the EOS Ground System.

Figure 8-2 is a context diagram of EOSDIS showing high-level data flows and connections within the EOS Ground System. The EOSDIS will perform information management, archival, and distribution of NASA's Earth science data including the existing data and those from future non-EOS flights according to the mission baseline maintained by the ODIS Program Office and the ESDIS Project (see Section 8.2.2.1). In the case of the U.S. EOS flights, EOSDIS will command and control the spacecraft and instruments and perform data processing, product generation, information management, data archival, and distribution. In addition, EOSDIS will generate data products from two EOS instruments (CERES and LIS) on TRMM.

The EOSDIS consists of the EOSDIS Core System (ECS), EOS Data and Operations System (EDOS), the EOS Communications (Ecom), DAACs, the SEDAC at CIESIN, SCFs, Scientific Software, and the EOS Test System (ETS). In addition, as a part of the evolutionary development of EOSDIS, a "working prototype with operating elements" called V0 is being developed.

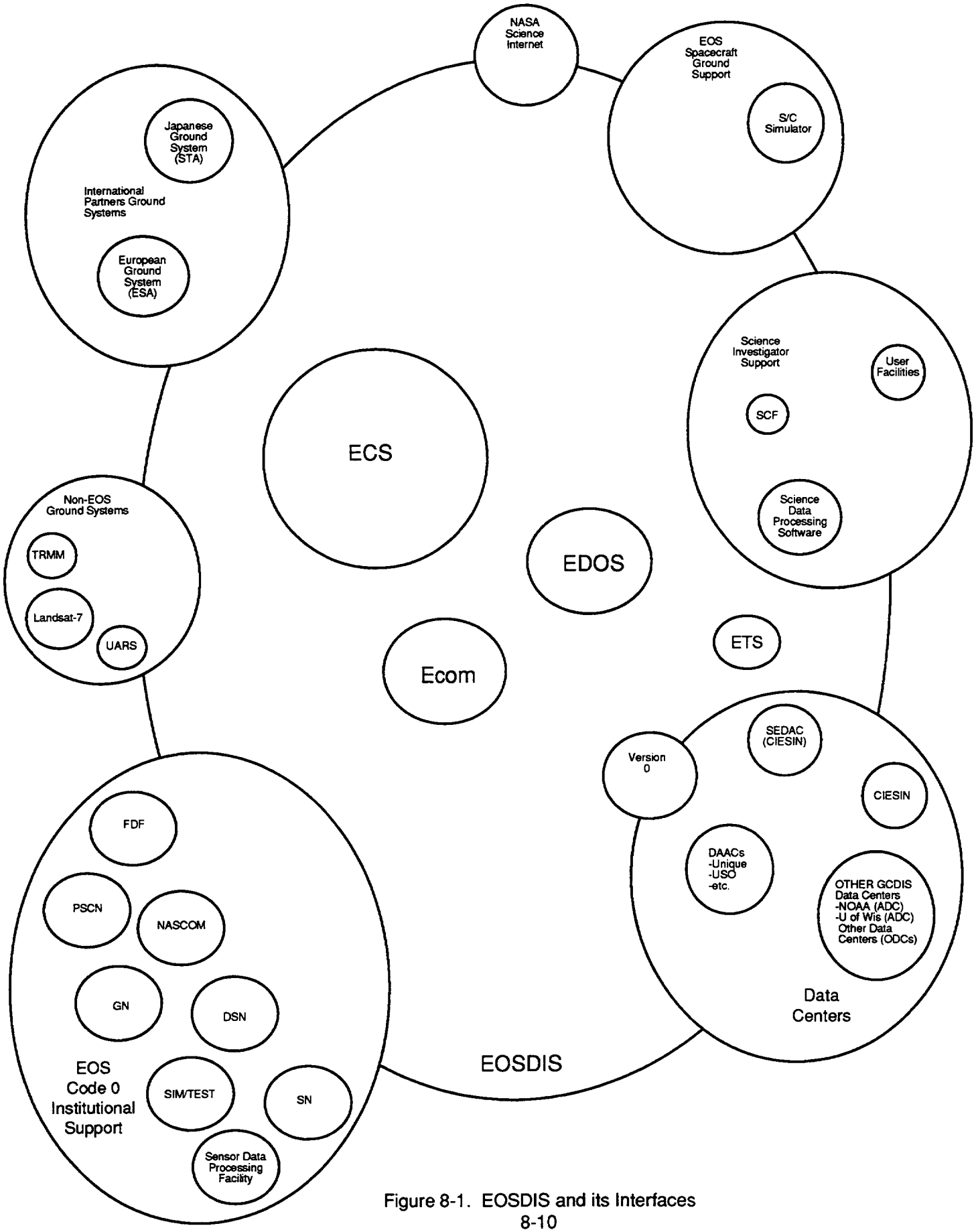

Figure 8-1. EOSDIS and its Interfaces

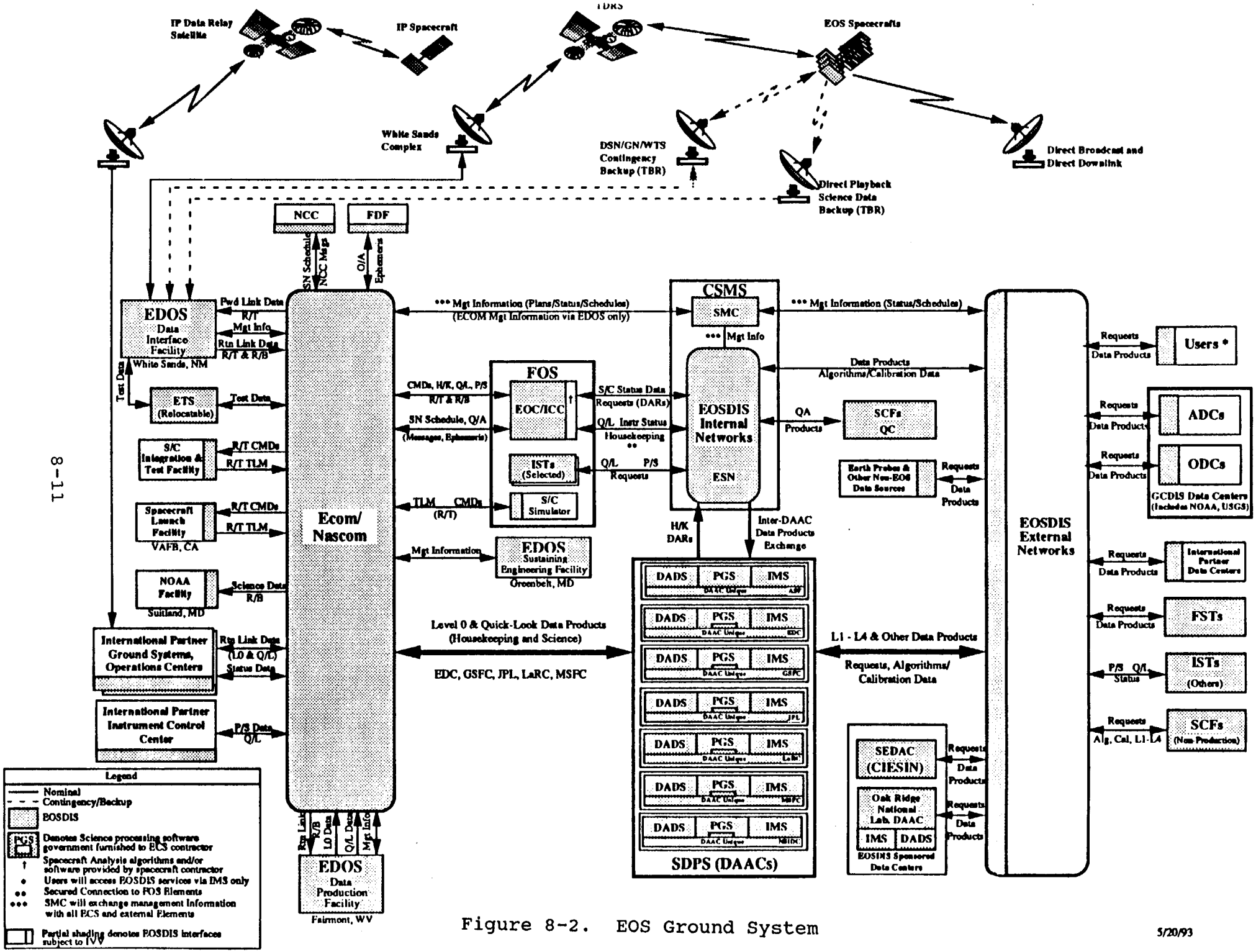

Figure 8-2. EOS Ground System

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The ECS consists of the "core" common capabilities required for performing planning and scheduling, command and control, product generation, information management, data archival and distribution. The EDOS performs forward and return-link telemetry data processing. The Ecom provides communications in support of the forward and return-link telemetry data processing. The DAACs are geographically distributed at institutions throughout the U.S. They participate with the ESDIS Project in the management of the development of ECS, receive hardware and software components of ECS, develop unique capabilities to augment these components, and serve the scientific users in their respective disciplines. The SEDAC provides an interface to the community of users involved in policy making and human dimensions of global change. The SCFs are used by EOS investigators at their home institutions to conduct scientific analysis and develop software for product generation. The communications between users and the DAACs will be through existing external networks including the NASA Science Internet (NSI). The ETS is used for supporting end-to-end testing of EOSDIS. The EOSDIS has interfaces to institutional capabilities provided by Code O in support of the EOS Program. Also, EOSDIS has interfaces to the GCDIS data centers, IPs' data ground systems, and to non-EOS ground systems generating Earth science data products. The above components of EOSDIS are described briefly in subsections 8.3.1 through 8.3.10.

8.3.1 EOSDIS Core System

The ECS is a major component of EOSDIS. It provides "core" common capabilities required for performing planning and scheduling, command and control, product generation, information management, data archival, and distribution to support EOS operations and user access to EOS data. In addition, it provides archiving and distribution and selected data processing for non-EOS Earth science data. The ECS will use, wherever possible, functionality and facilities of institutions and organizations external to EOSDIS where such use will enhance the capabilities of EOSDIS.

The ECS consists of three segments: Flight Operations Segment (FOS), Science Data Processing Segment (SDPS), and Communications and System Management Segment (CSMS). The functions of these segments are discussed briefly below.

The FOS controls all the EOS spacecraft, provides mission planning and scheduling, and monitors health and safety of the spacecraft and instruments. It provides tools to coordinate observations from multiple instruments and develop conflict-free schedules, validate commands to assure safety, accommodate unplanned schedule changes, develop and provide mission timeline, and develop and implement contingency plans. It interfaces with

the IPs' instrument control center(s) for exchange of planning, scheduling, command, and control information.

The SDPS supports product generation, data archival and distribution, and information management. The hardware and software needed to support these functions will be developed as a part of ECS. After development they will be delivered to and operated at the DAACs. The SDPS will generate standard data products in a timely manner using algorithmic software provided by EOS investigators. It will support reprocessing, according to priorities set by the Project Scientist, to generate revised data products as algorithms and/or processing parameters change. Quick-look processing will be supported as needed (e.g., in support of field experiments). The SDPS will manage information about NASA's Earth science data, and will archive and distribute the data according to the mission baseline maintained by the ODIS Program Office and the ESDIS Project (see Section 8.2.2.1). It will provide an integrated, consistent, and comprehensive view of the data holdings.

The CSMS provides the internal network connecting the DAACs to each other and the DAACs to selected SCFs to support product generation and scientific quality control. The CSMS also provides coordination, status-tracking, and management of the distributed resources of EOSDIS.

8.3.2 The EOS Data and Operations System

The EDOS provides space and ground interfaces between the EOS spacecraft, the Space Network/TDRSS, and the EOS Ground system. It provides forward- and return-link services. The forward-link services include:

- Handling real-time command and control data
- CCSDS protocol processing
- Delivering data to TDRSS Ground Terminals for uplink to EOS spacecraft

The return-link services include near real-time services provided by the Data Interface Facility (DIF) at White Sands, New Mexico, and "average-rate" services provided by the Data Processing Facility at Fairmont, West Virginia. The near real-time services provided by the DIF are:

- Receive and capture return-link data
- Process real-time and playback data to remove artifacts
- Perform rate buffering
- Provide quick look data

The "average-rate" services provided by the Data Processing Facility in Fairmont, West Virginia are:

- Separate packets by instrument
- Arrange packets in chronological sequence
- Remove redundancies
- Perform quality checks
- Create and provide back-up archive for Level 0 datasets
- Transmit Level 0 datasets to appropriate DAACs

Continuing engineering activities for EOS will be supported at the Sustaining Engineering Facility at GSFC.

8.3.3 EOS Communications

The Ecom provides all necessary communications circuits and facilities between EDOS and various other elements of the EOS ground system for spacecraft scheduling, maintenance, control, and coordination. It also provides operational telecommunication support for delivery of Level 0 and quicklook data.

8.3.4 Distributed Active Archive Centers

The DAACs, identified in section 8.2.2.7, are centers with expertise and on-going research in specific disciplines within Earth sciences and with a long-term institutional commitment to support science data processing, archival, and distribution functions. Each DAAC will be responsible for a subset of the EOS data stream and/or non-EOS datasets in its respective discipline. Elements of the ECS SDPS will be located and operated at the DAACs. The DAACs may propose and develop additional unique and value-added capabilities to interface with the SDPS elements. They will have User Support Offices to provide consultative assistance to users. Each DAAC will have a User Working Group or an Advisory Panel to provide scientific inputs in addition to those from the EOSDIS Advisory Panel.

8.3.5 Socio-Economic Data and Applications Center

The SEDAC at the CIESIN generates, archives, and distributes data sets supporting policy making decisions regarding human dimensions of global change. It will be the interface to the community of non-Earth science users such as government environmental agencies, legislative bodies, policy makers, educators, and students.

8.3.6 Scientific Computing Facilities

The SCFs, located at science investigator facilities, are used to develop and maintain algorithms and science software, produce special data products, validate data, and analyze and synthesize EOS and other data to expand knowledge about the Earth System and

its components. The interface and algorithm tool kits necessary to support these activities are provided by the EOSDIS Core System. Some SCFs may support an Instrument Support Terminal (IST) tool kit provided by the ECS to support planning and scheduling of instruments. Also, scientific quality assurance of EOS data products is performed at the SCFs of investigators responsible for those products.

8.3.7 Scientific Software

Software for EOS standard science data product generation will be developed by the science investigators responsible for those products at their facilities. Investigator-developed software and algorithms for EOS standard products are integrated with the ECS and installed at the DAACs for routine production. Special products will be produced at the investigator facilities. Investigator-developed software and algorithms for special products that become community accepted may become standard products through an IWG determined assessment. The software for these products will then become integrated into the production environment at the DAACs. This activity will be funded under UPN 229.

8.3.8 EOS Test System

The ETS serves as an early source of CCSDS formatted data during the EOSDIS development effort and supports all phases of ground system testing concerned with flight operations and Level 0 processing.

8.3.9 Version 0

The EOSDIS V0 is an early "working prototype" of selected EOSDIS functionality. It will interconnect existing data systems at the DAACs through electronic networks, integrate catalogs, and introduce common data distribution procedures to ensure better access to data. As a "working prototype," V0 is not intended to have all the functional capabilities, fault tolerance, or reliability provisions of the EOSDIS V1. It will, however, be made available to be used and evaluated by the users to provide feedback regarding the required functional capability of the EOSDIS.

8.3.10 EOSDIS External Interfaces

8.3.10.1 Spacecraft Ground Support

8.3.10.1.1 Spacecraft Simulation

The Spacecraft Simulation provides ground-based simulation capabilities of the EOS spacecraft C&DH subsystem. The simulation capabilities support EOS AM ground system test and training activities and include: support for training control

center operators, testing operational procedures and spacecraft anomaly solutions, support for verification of end-to-end ground systems interfaces, and hosting of spacecraft mission and simulation software.

8.3.10.2 Non-EOSDIS Data Centers

In addition to the EOSDIS data centers that are part of the EOS Program (i.e., the DAACs and the SEDAC), there are several non-EOSDIS data centers with which agreements will be made. These ADCs, which include several of NOAA's data centers, will provide access to non-EOSDIS data or to non-EOSDIS services required by the EOS Program. They will also receive selected EOS data sets from the EOSDIS data centers. As the GCDIS evolves and other non-EOSDIS data centers become part of GCDIS, interoperability with these centers will become available to users.

8.3.10.3 NASA Science Internet

The EOSDIS is supported by several communications networks. The major network is the NSI. This NSI organization provides Internet access (including NSI, NSFnet, National Research and Education Network (NREN), etc.) to science users for accessing EOSDIS data, EOSDIS services, and each other. Selected EOS investigators will be connected to the Internet as part of EOSDIS.

Any other user may get similar access to EOSDIS and the EOS science users by obtaining Internet connectivity. It is also through the NSI that EOSDIS will establish connectivity with additional SCFs, ADCs, and IP Data Centers.

8.3.10.4 International Partner Ground System

The IPs will fly their instruments on EOS platforms. These instruments are: ASTER, provided by Japan, flying on EOS AM-1; MIMR, provided by ESA, flying on the EOS PM series; and MOPITT, provided by Canada, flying on the EOS AM series. For these instruments, the EOSDIS must interface to the IP Ground System to coordinate payload planning and integration, mission management, and payload command and control as well as processing and exchange of data and information. In accordance with ESA operational policy, the control of ESA instruments on U.S. spacecraft is performed at GSFC. Japan will provide planning and scheduling of their instrument on U.S. spacecraft from Japan. These centers will interface with EOSDIS in accordance with joint agreements between NASA and each of the relevant IPs.

In addition, the IPs and NASA have agreed to make data available from ADEOS (Japan), EOS (NASA/U.S.), POEM (ESA), TRMM (NASA and Japan), and Polar-Orbiting Operational Environmental Satellite (POES) (NOAA/U.S.) to users in accordance with an IEOS data policy. The IP MOUs will define the overall relationship between NASA and the IP for access and exchange of these data.

8.3.10.5 Non-EOS Ground Systems

As part of NASA's Mission-to-Planet Earth program, Earth science data from non-EOS projects will be archived and distributed by the EOSDIS. The ground systems for these non-EOS projects will interface with the EOSDIS. The set of flights and the support to be provided will be specified in the mission baseline maintained by the ODIS Program Office and the ESDIS Project (see Section 8.2.2.1).

For example:

- UARS data will be ingested, once available to the general public, into the GSFC DAAC.
- TRMM data products, from instruments other than CERES and LIS, will be produced by the TRMM ground system and archived and distributed by EOSDIS by the GSFC, LaRC, and MSFC DAACs. Data products from CERES and LIS on TRMM will be produced, archived, and distributed by EOSDIS at the LaRC and MSFC DAACs, respectively.
- LANDSAT data will be archived and distributed by the EDC DAAC.

Each of the interfaces between a non-EOS ground system and EOSDIS will be defined by an Inter-Project Agreement (IPA) as each non-EOS ground system is designed. Plans for transition of data from the non-EOS projects will be defined in a Project Data Management Plan, prepared by the non-EOS Project with support from the relevant DAACs.

8.3.10.6 Code O Institutional Support

Code O Institutional Support consists of several space and ground system elements that provide generic services to various projects, of which EOS is one, plus services unique to each project as required. Table 8-2 is a summary of the elements included in Code O support, and a very brief summary of the services each provides. Additionally, agreements are being made to provide emergency and science contingency backup. Code O has agreed to support emergencies by providing direct telemetry and command access (S-band) to the EOC via DSN, GN, or Wallops ground station. Negotiations are still underway to provide backup, in the event of TDRSS failure, of direct access downlink of science data at certain compatible ground stations, and subsequent shipping of those data to White Sands for processing.

8.4 IMPLEMENTATION APPROACH

The EOSDIS will be implemented using an evolutionary development approach. This approach is envisioned as a step-by-step process that will allow the graceful transition of the system from the existing Earth science-related data and information systems to the full scale EOSDIS configuration.

Table 8-2
Summary of Code O Support

Code O Institutional Support	Summary of Services
Space Network (SN): TDRS, TDRSS Ground Terminals, Space Network Control Center	Space and ground communications and tracking services; scheduling for TDRSS support
Flight Dynamics Facility (FDF)	Predictive and definitive orbit, attitude, and navigational computational support services in the spacecraft
NASA Communications (Nascom)	Communications and data transport services between White Sands complex and ground located elements; and communications support for end-to-end spacecraft simulations and training
Deep Space Network (DSN)	Tracking and data acquisition support, including backup RF communications services for relaying housekeeping telemetry and low-bit rate commands
Ground Network (GN)	Backup transmission services to and from the spacecraft, in case of TDRSS malfunction
Program Support Control Network (PSCN)	Backbone for programmatic communications
Sensor Data Processing Facility (SDPF)	Data distribution facility
Simulation & Test Facilities [Compatibility Test Van (CTV), Radio Frequency Simulations Operations Center (RFSOC), SOC]	Provide for testing of space to ground and ground functions

Prototyping and special studies are an integral part of the EOSDIS development approach. As shown in Figure 8-3, focused prototypes and special studies conducted by the ECS, EDOS, and Ecom development teams, by DAAC development teams, by universities, and industry are the foundation supporting phased incremental releases and operational deliveries of EOSDIS.

This approach is an adaptation of the more customary evolutionary development model. In this approach, an operational capability is built in stages. Each stage consists of an expanded increment of the operational system. Directions in evolution are determined by operational experience. This allows and enhances convergence by the system developer and the system user to an appropriate operational capability. The approach incorporates prototyping as a means of communicating with the user to obtain accurate and timely requirements specifications. Successive stages refine user requirements by presenting the user with prototypes of the proposed system or prototypes of components of the proposed system. The approach works well where the user is unsure of or unable to articulate system requirements or the users' needs change along with changing technologies. Change may originate from many sources, for example, from lessons learned from previous releases, from new concepts tried out in

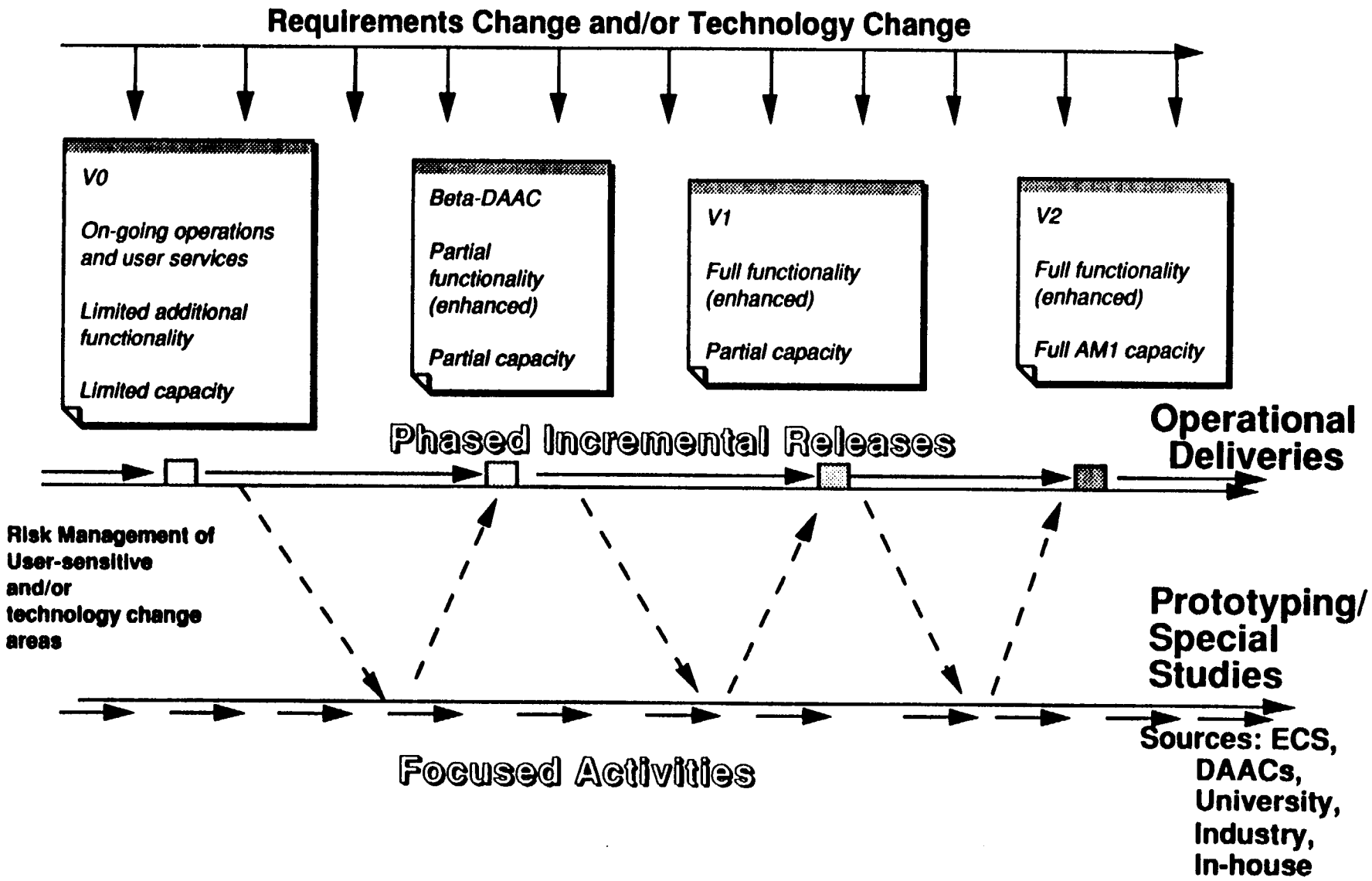

Figure 8-3. ESDIS Development Cycles

prototypes, from continuous iteration with the science user community to solicit its input and feedback, and from innovation originating in the general Earth science and computer technology communities not necessarily directly associated with EOSDIS.

The ESDIS Project uses a refinement of the customary evolutionary model by creating two evolutionary "cycles." One cycle (the upper timeline in Figure 8-3) is planned to a longer development schedule and produces large operational deliveries that are formally released to users. This "operational" cycle is driven by the need to implement operational systems available in time to support critical EOS needs (e.g., spacecraft launch). It accommodates change over a longer time scale as a phased incorporation of proven technologies and accepted user-sensitive designs into an evolving operational capability. The operational cycle provides formal documentation during the development of each operational release. This provides the development rigor and documentation needed by the IV&V and system maintenance activities. The rigor applied in the operational cycle, which is appropriate for a large system development, avoids the "code and fix until you get it right" philosophy inherent during prototyping.

The other cycle (the lower timeline in Figure 8-3) supports a "faster" prototyping pace that addresses many more focused issues. This "prototyping" cycle addresses functions having significant uncertainty in their requirements, functions with high user sensitivity, or functions enhancing the basic requirements. It addresses high-risk activities, explores technology alternatives, and forms a bridge between external research and development and operational capability. Development formality varies depending on the pay-off and complexity of the prototype. High pay-off prototypes that are likely to become operational will be more formal than prototypes aimed at increasing understanding of complex functional areas. The flexibility supported in the prototyping cycle allows sufficient room for exploration and evaluation of requirements and capabilities. These advantages offset the increased cost associated with managing and conducting two development cycles. Figure 8-3 also shows the first four operational EOSDIS versions.

The operational versions of EOSDIS will consist of capabilities needed at various stages to meet the requirements established through the mission baseline referenced in Section 8.2.2.1. In the figure, the terms "partial" and "limited" are comparisons relative to the final, fully-functional EOSDIS. These capabilities are provided by integrating the appropriate releases (or versions) of ECS, EDOS, Ecom, external Networks (NSI), Science Software, and DAAC-unique capabilities. V0 will maintain on-going operations and user services. While it will add some functionality and capacity to capabilities currently available at the DAACs, V0 will emphasize user sensitive areas and the

technology needed to support this emphasis. The most important accomplishment of V0 is that it will link the DAACs together and provide interoperability among them to give users an "Earth science view" across the DAACs for searching and ordering data. The Beta-System will be the first actual major operational prototype of the ECS design within the operational cycle. The Beta-System focuses on providing early archiving, data search, order, and distribution through network and hard media. It will provide representative functionality in the user sensitive areas by extending investigations and capabilities provided during V0. It will investigate the management of large data volumes and provide a significant feedback mechanism for the entire Earth science community. V1 will provide the first fully functional EOSDIS including operational DADS and IMS capabilities at all DAACs. It will reflect user feedback from Beta-System to enhance operations in all areas with special emphasis on user sensitive areas. It will address technology and data volume issues and provide the capacity needed to hold the data available before the launch of EOS satellites. V2 enhances V1 functionality and expands capacity to the level needed to support EOS AM-1. Future versions will improve functionality, increase capacity, and incorporate new technology. The phased incremental releases permit inserting technology proven useful by the prototyping cycle.

Using phased incremental releases requires that even early releases reflect a long-range "design-to" philosophy and not just a short-term "build-to" approach. This means that the EOSDIS is designed to accommodate later technology insertion and functional expansion. During implementation of each release, the "build-to" specification for that release reflects the growth needs of future releases. In this way, additional functionality can be added to, and technology inserted into, the EOSDIS without major rework. The EOSDIS must rigorously define an architecture and incorporate technologies that facilitate this process. These technologies include adherence to standards, software isolation of system dependencies, configuration controlled interface points, portability, etc. The EOSDIS will be built and managed as to adapt effectively to change on an on-going basis, yet achieve the stability required of a system that must manage large volumes of EOS instrument data over the system's lifetime.

The operational and prototype cycles support the ESDIS Project's management development approach to prototyping and special studies by:

- Anticipating insertion points throughout the life cycle
- Building the operational system incrementally and thereby delaying technology commitments
- Providing multiple science software deliverables and a structure that permits rapid investigation and confirmation of user requirements

- Responding to user sensitive areas with specific prototypes that allow the users to articulate their needs tangibly
- Evaluating promising technology in an adaptable prototype environment

The phased series of incremental releases will be defined by the ESDIS Project, with consultation from the DAACs, the Affiliated Data Centers, the EOSDIS Science Advisory Panel, and representatives from the GCDIS community.

The following sections summarize the development approach for each of the components of EOSDIS. Section 8.4.10 describes the integration methodology and responsibilities.

8.4.1 Version 0

Data deleted from this version of the Project Plan.

8.4.2 EOSDIS Core System

Data deleted from this version of the Project Plan.

Data deleted from this version of the Project Plan.

8.4.3 Distributed Active Archive Centers

Data deleted from this version of the Project Plan.

8.4.4 Socio-Economic Data and Applications Center

Data deleted from this version of the Project Plan.

8.4.5 Science Computing Facilities

Data deleted from this version of the Project Plan.

8.4.6 Scientific Software

Data deleted from this version of the Project Plan.

8.4.7 EOS Data and Operations Systems and EOS Communications

Data deleted from this version of the Project Plan.

8.4.8 EOS Test System

Data deleted from this version of the Project Plan.

8.4.9 Independent Verification and Validation

Data deleted from this version of the Project Plan.

8.4.10 System Integration

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Figure 8-4. Integration of EOSDIS

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Table 8-3
Key EOS Ground System Interfaces/Responsibilities

Lead \ Support	DAACs	ADCs	EDOS/ Ecom	Code 0 Inst.	JPL DSN	Spacecraft Contract Ground Elements	PIs, TLs/TMs, IIs	NOAA	ESA*	MITI*	Non-EOS Data Centers	External Networks	SCF	V0	ECS Contract
ECS Contract	± X	± X				X	X	X	X	X	± X	X	X	X	
EDOS/Ecom						X		X	X	X					X
Code 500** Institutional			X					X	X	X					X
Spacecraft Contract (Flight Elements)			X	X	X										X
JPL DSN			X												

NOTES:

* Represents joint interface/agreement without lead/support roles.
± Unique Interface may be needed for each DAAC, ADC, and Non-EOS Data Center.
** Consists of FDF, NCC, NASCOM, TDRSS, WSGT, STGT, GN, DSN, WTS, SDPF.

8.5 WORK BREAKDOWN STRUCTURE

The ESDIS Summary WBS is shown in Figure 8-5 having discrete project management and support tasks (WBSs 10 through 15) and supporting subtier WBS hardware, software, and data elements.

The ESDIS WBS is subdivided into the major system components. A description and the scope of each EOS WBS task are found in the EOS WBS Dictionary (420-02-01).

8.6 PROCUREMENT SUMMARY

Table 8-4 identifies all major procurements for the ESDIS in accordance with the implementation approach described in Section 8.4. Elements of the Project to be procured, the type of procurement, the anticipated contract type, and the source are identified.

Table 8-4
ESDIS Procurement Summary

Data deleted from this version of the Project Plan.

8.7 ESDIS PROJECT MANAGEMENT RESPONSIBILITIES AND ORGANIZATION

Management responsibilities and procedures for the EOS ESDIS Project are established in accordance with Space Flight Program and Project Management, NMI 7120.3. Within GSFC, the Mission Operations and Data Systems Directorate includes the ESDIS Project. The ESDIS Project staff interfaces with functional GSFC directorates and facilities to plan, implement, and coordinate development of the ESDIS Project. The OMTPE and Project organization charts are shown in Figures 8-6 and 8-7 respectively.

DIS — UPN 428

- 10 DIS Management
- 11 MPS
- 12 Engineering Support
- 13 Performance Assurance Support
- 14 Resource Management Support
- 15 GSFC In-House Support
- 16 Science Support
- 17 Reserved
- 18 Reserved
- 19 Contingency

- 20 SCF's
- 21 SCF-Facility Instruments
- 22 SCF-PI Instruments (Set 1)
- 23 SCF-PI Instruments (Set 2)
- 24 SCF-PI Instruments (Set 3)
- 25-29 Reserved

- 30 EOSDIS Development
- 31 OPS CAP DEV
- 32 System Verification
- 33 Version 0
- 34 Special Development/Prototyping
- 35 EOS Data Operating System (EDOS)
- 36 EOS Communications (Ecom)
- 37 EOS Communications-Operations
- 38-39 Reserved

- 40 EOSDIS Core System (ECS)
- 41 ECS Prime
- 42-49 Reserved

- 50 Distributed Active Archive Centers
- 51 Upper Atmosphere-GSFC
- 52 Physical Oceanography-JPL
- 53 Radiation Budget-LaRC
- 54 Snow and Ice-NSIDC
- 55 Land Processing Imagery-EDC
- 56 Sea Ice-ASF
- 57 Hydrologic Cycling-MSFC
- 58 Biogeochemical Dynamics-ONL
- 59 Reserved

- 60 DIS Related Support
- 61 CIESIN
- 62-69 Reserved

- 70 Science Computing Facilities (SCF's) (Continued on Page 8-31)
- 71 SCF-1st Mission Flights
  AM/PM/CHEM/AERO/ALT
  FLT OF OPPR-1
- 72 SCF-2nd Mission Flights
  AM/PM/CHEM/AERO/ALT-2
- 73 SCF-3rd Mission Flights
  AM/PM/CHEM/AERO/ALT-3
- 74 SCF-AEROSOL 4
- 75 SCF-AEROSOL 5
- 76-99 Reserved for NASA Headquarters

Figure 8-5. ESDIS Project Work Breakdown Structure

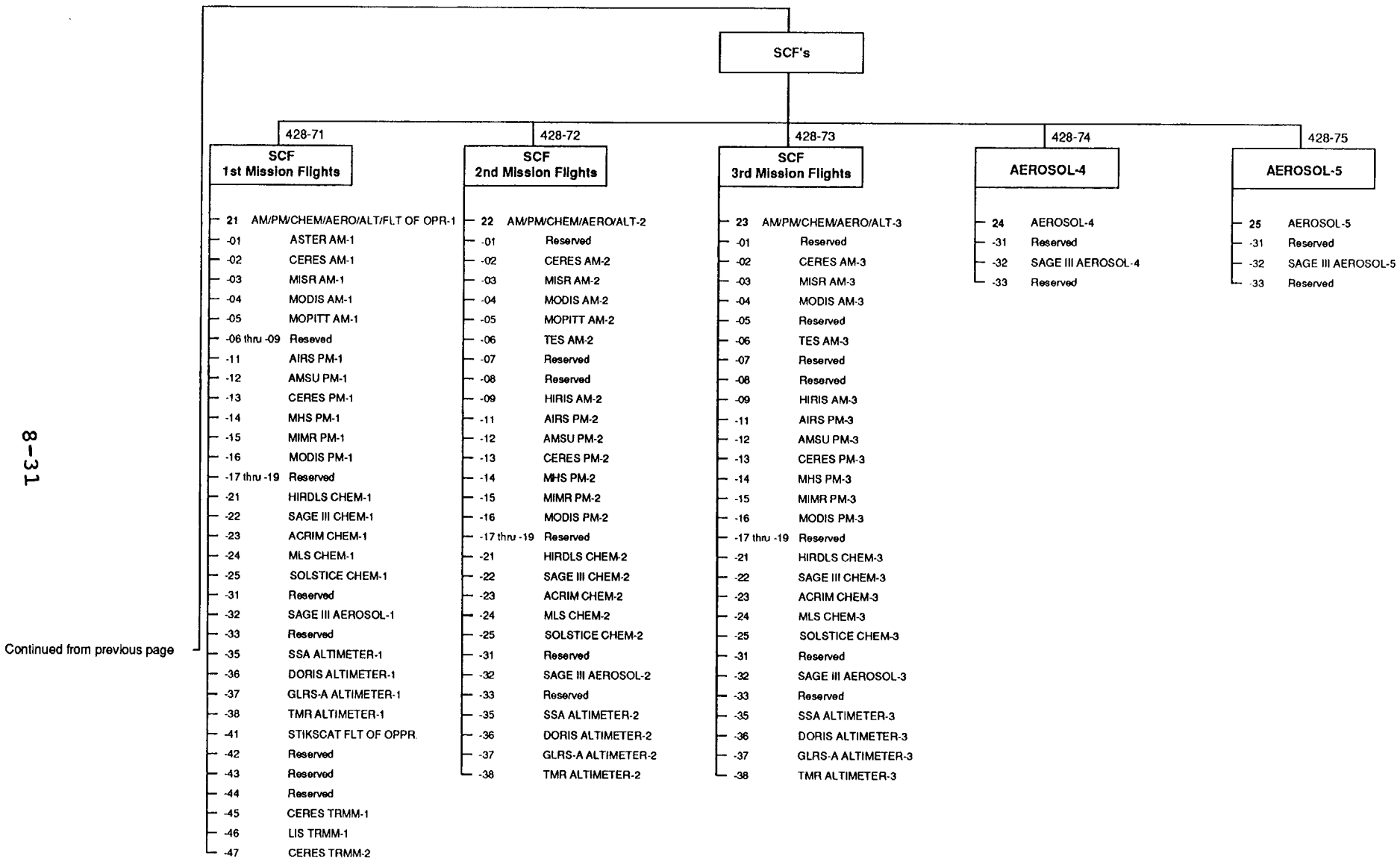

Figure 8-5. ESDIS Project Work Breakdown Structure (Continued)

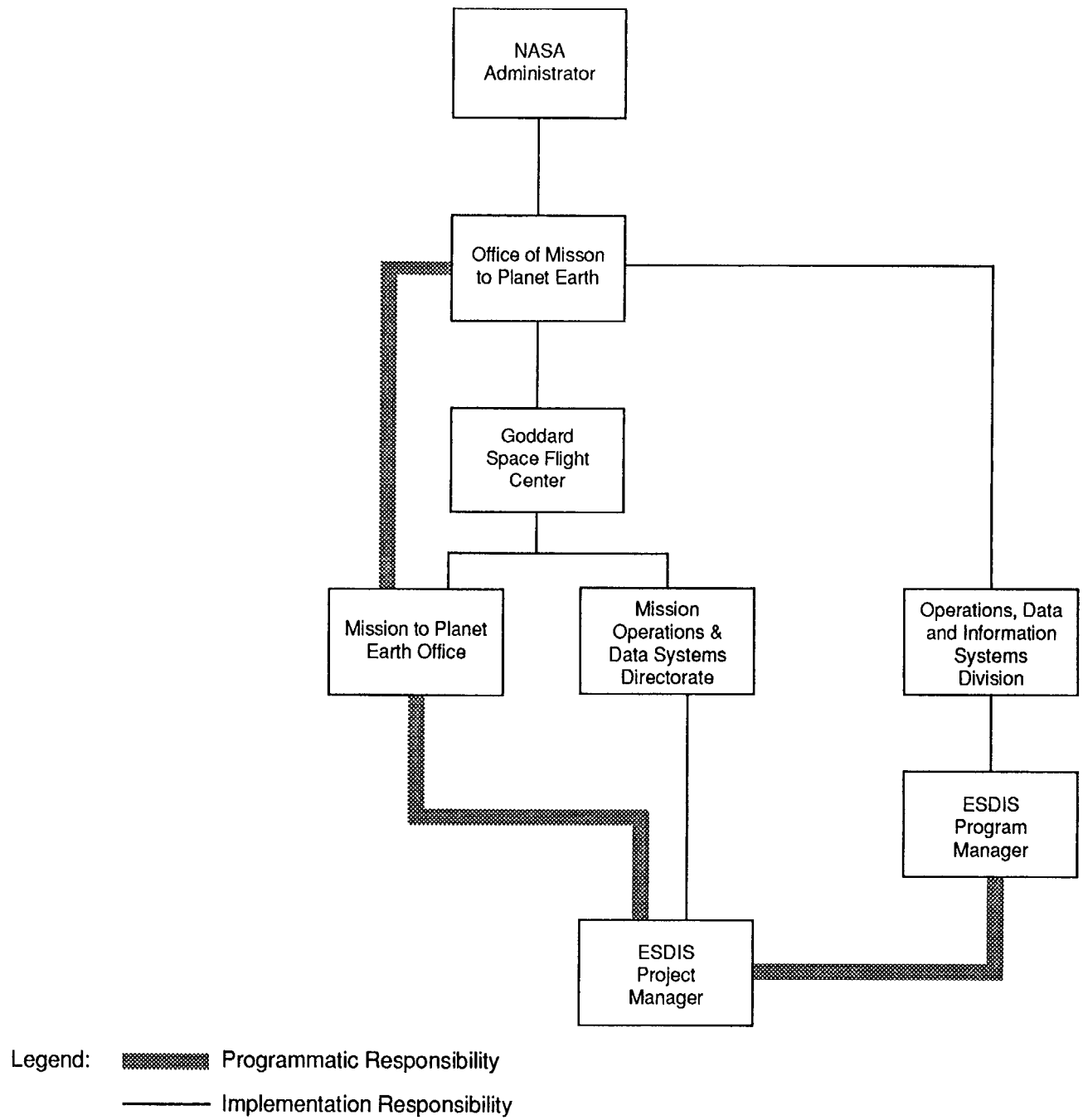

Figure 8-6. MTPE / GSFC Project Management Organization Chart for ESDIS

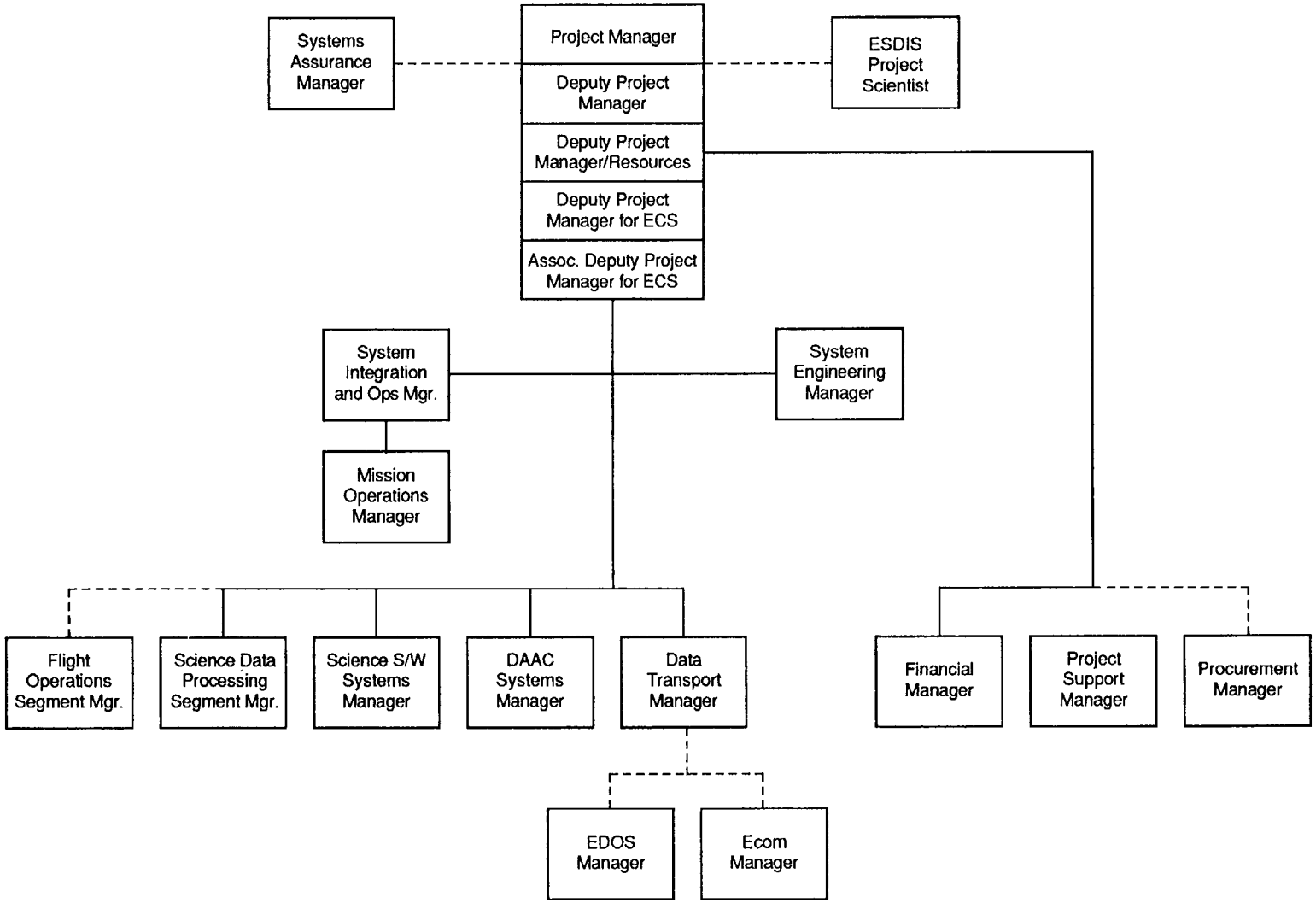

Figure 8-7. ESDIS Project Organization Chart

8.7.1 ESDIS Project Manager

The ESDIS Project organization shown in Figure 8-7 is headed by a Project Manager who is the senior official at GSFC exclusively responsible for managing execution of the project life-cycle. The ESDIS Project Manager has full authority to carry out the responsibility within guidelines assigned by the Director of Mission Operations and Data Systems, the Director of Mission to Planet Earth Office, and the GSFC Director.

Specific responsibilities include directing and overseeing:

- Preparation and maintenance of project plans, specifications, schedules, and budgets.
- Acquisition and utilization of participating contractors.
- Execution of project plans by government, contractor, and university participants in conformance with all project commitments and constraints, and with all agency policies.
- Performing project level SE&I
- Reporting project status and contractor performance as required.
- Establishing and maintaining a close and effective working relationship with the Program Manager.

The ESDIS Project Manager discharges the responsibilities with the assistance and support of individuals and organizations assigned either administratively or functionally to the Project.

8.7.2 Deputy Project Manager

The DPM is responsible to the Project Manager and is an integral member of the management team. The incumbent supports the Project Manager in directing all phases of the Project and has Project-wide responsibility for personnel management and planning, and evaluating all Project activities on a day-to-day basis. The DPM provides technical management to the team of technically skilled specialists and their supporting personnel to meet cost, schedule, and technical commitments. In the absence of the Project Manager, the DPM assumes full responsibility for the Project.

8.7.3 Deputy Project Manager/Resources

The DPM/R is responsible to the Project Manager and is an integral member of the management team. The DPM/R contributes business management expertise to the establishment of technical program objectives and is responsible for the application of business, financial management, and performance measurement techniques to the accomplishment of those objectives. The DPM/R supervises a team of specialists in the areas of finance, budget, performance measurement, scheduling, pricing, configuration

management, etc., and is responsible for the application of sound business techniques to the accomplishment of Project objectives. In addition, the DPM/R provides requirements to the respective Project Procurement Manager on Project-related matters. In the absence of the Project Manager and the DPM, the DPM/R may act for the Project Manager.

8.7.4 Deputy Project Manager for ECS

The DPM for ECS is responsible for the development of requirements, procurement, and management of the ECS contract. The incumbent is the Contracting Officers Technical Representative (COTR) on this contract, and is responsible for supporting integration of ECS with other EOSDIS elements. The DPM for ECS provides technical direction to all members of the project team working on any element of ECS.

8.7.5 Associate DPM for ECS

The associate DPM for ECS is responsible to the DPM for ECS and provides support for the development of requirements, procurements, and management of the ECS contract. In the absence of the DPM for ECS, the incumbent assumes the responsibilities for ECS.

8.7.6 Project Scientist

The Project Scientist, from the Earth Sciences Directorate at GSFC, is responsible for ensuring the satisfactory accomplishment of the scientific objectives of EOSDIS and is an integral member of the management team. The incumbent reviews the planning and implementation of the Project to ensure that the total mission is consistent with the overall scientific objectives. The incumbent provides leadership in ensuring that the scientific data are used effectively and the scientific results of the mission are produced expeditiously. The incumbent provides appropriate inputs to the PDMP.

8.7.7 Systems Assurance Manager

The Systems Assurance Manager is responsible for establishing, managing, directing, and coordinating the Project Assurance Program to ensure that ground equipment hardware and software meet their intended objectives during development, installation, and operation.

8.7.8 System Engineering Manager

The System Engineering Manager has the responsibility for defining and formulating an overall system to meet mission and program requirements. The incumbent is responsible for directing all system engineering on the Project from conceptual through the

operational stage, which includes the overall design of the ground system. The incumbent ensures that:

a. Requirements are well defined, understood, configuration controlled, and mapped to the components of EOSDIS
b. Architecture of and design criteria for EOSDIS are established to accommodate long-term evolution
c. Prototyping and technology insertion are planned and executed to improve the capabilities of EOSDIS at minimal cost

8.7.9 System Integration and Operations Manager

The System Integration and Operations Manager is responsible for ensuring that all the subsystems of EOSDIS, namely, ECS, EDOS, Ecom, DAAC-unique components, and science algorithms for each of the versions of EOSDIS are developed, integrated, tested, independently validated and verified, and accepted on schedule to ensure satisfaction of requirements in support of the ESDIS Project's mission baseline. The incumbent is also responsible for the on-going operation of EOSDIS.

8.7.10 Mission Operations Manager

The MOM is responsible for the development and implementation of mission operations concepts and requirements for both the space and ground segment. The MOM is responsible for the total operational ground system support integrity, including defining Project requirements and reviewing the development of the overall operational ground system. The operational ground system consists of the EOS Operations Center; the Flight Dynamics Facility; and all hardware, software, and communications support needed for command, control, and communications for the spacecraft and its scientific instruments. Prior to launch the MOM is responsible for ensuring that operational requirements are achievable, including the conduct of all necessary tests and validations of the operating system. After launch, the MOM is responsible for the operation of the spacecraft to fulfill the mission objectives. The MOM is responsible for preparing the Mission Requirements Request and Detailed Mission Requirements documents which place EOS support requirements on MO&DSD systems.

8.7.11 Distributed Active Archive Center Systems Manager

The DAAC Systems Manager has the responsibility for managing and directing the implementation of V0 EOSDIS for the processing, archiving, and distribution of non-EOS data in the early phase of the EOS program. The incumbent is responsible for ensuring that such data are disseminated to the science community according to priorities set by the EOS Project Scientist. The incumbent is responsible for the development activities proposed and/or

conducted by DAACs. The incumbent is also responsible for managing the data system activities at CIESIN.

8.7.12 Science Software Systems Manager

The Science Software Systems Manager (SSSM) has the technical management responsibility for the development and testing of all science software for the generation of data products by EOSDIS, and for coordinating the integration of science software into EOSDIS with the DAACs through the DAAC Systems Manager. The SSSM maintains requirements for science data products and external data established by EOS Project Scientists. The SSSM works with the investigator software development teams to develop guidelines and standards for science software development, requirements for tool kits to assure integration into EOSDIS production operations, and resource plans and schedules for development of product generation software to meet mission schedules. The SSSM coordinates science software reviews with the Flight Project ISMs and the Project Scientists leads technical reviews of designs and development progress, and works with the Science Data Processing Segment Manager and investigator teams to assure that EOSDIS Product Generation System configurations and algorithms/software designs are coordinated to meet production requirements at minimum cost. Development of science software by investigators is performed under contracts and agreements under the overall direction of the Flight Project ISMs. The SSSM works with the ISMs to establish resource levels for software development under the Science budget, coordinates science software reviews and progress with the ISMs, and provides science software, data management, and SCF requirements for incorporation by the ISMs into investigator contracts and agreements.

8.7.13 Science Data Processing Segment Manager

The Science Data Processing Segment Manager is responsible for the development and implementation of the Data Archive and Distribution System (DADS)/Product Generation System (PGS)/ Information Management System (IMS) portions of the ECS.

8.7.14 Flight Operations Segment Manager

The Flight Operations Segment Manager is provided by the Mission Operations Division, and manages the development and implementation of the EOS flight operations portion of the ECS.

8.7.15 Data Transport Manager

The Data Transport Manager is responsible for defining and updating requirements for EDOS and Ecom. The incumbent oversees the development, costs, schedules, integration, testing, and acceptance of EDOS and Ecom as an integral part of EOSDIS.

8.7.16 EOS Data and Operations Systems Manager

The EDOS Manager is responsible for the development of requirements for the EDOS, and procurement and management of the EDOS contract. The EDOS Manager is provided by the Information Processing Division.

8.7.17 EOSDIS Communications Manager

The Ecom Manager is responsible for the development and implementation of the EOSDIS Communications System. The Ecom Manager is provided by the NASCOM Division.

8.7.18 Financial Manager

The Project Financial Manager is a member of the business support team and reports to the DPM/R. The incumbent is responsible for the application of sound financial management principles in the areas of cost control, performance measurement, financial analysis, budget preparation and execution, and pricing.

8.7.19 Project Support Manager

The Project Support Manager is a member of the business support team reporting to the DPM/R. The incumbent is responsible for scheduling, configuration management, logistics management, manpower analysis, property management and control, and other general administrative and overall Project planning activities.

8.7.20 Project Procurement Manager

The Project Procurement Manager, from the Management Operations Directorate, is responsible for all procurement functions of the Project, including planning, directing, coordinating, and evaluating all Project procurement activities in accordance with NASA authoritative guidelines, and for coordinating these activities with the DPM/R.

8.8 RESOURCE SUMMARY

8.8.1 Funding Requirements

Table 8-5 shows the NOA requirements for the ESDIS Project through FY 2000. Revisions to these requirements will be submitted through the POP process.

8.8.2 Manpower

The Civil Service Manpower requirements for the ESDIS Project are shown in Table 8-6. Revisions will be made through the annual budget update.

Table 8-5
Earth Science Data & Information System POP 93-1 Budget Summary (NOA; $M)

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Table 8-6
Goddard Civil Service Summary Manpower Requirements for ESDIS Project
FY93 Through FY00

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8.9 SCHEDULE

Figure 8-8 shows the ESDIS Project's Master Schedule. This schedule depicts the major procurements and releases of system versions, which support the EOS AM operational capability in mid-CY 1998. Figure 8-9 shows the master schedule key definitions.

8.10 LOGISTICS

The ECS contractor will be responsible for spare parts provisioning and shipment to the various DAAC and other locations around the country. A logistic plan will be developed by this contractor after selection.

8.11 FACILITIES

Table 8-7 shows the facility requirements to support the ESDIS Project.

8.12 ESDIS RISK ASSESSMENT

The ESDIS Project has identified risk areas associated with data access in EOSDIS development and the development and sizing of science data processing algorithms.

8.12.1 Data Access

A major goal of EOSDIS is to facilitate access to Earth science data, both existing and anticipated, to maximize the scientific return of the data available. Performance in this respect will ultimately be judged by the scientific user community. The potentially large quantity and diversity of data products to be accessible through EOSDIS involve the risk that performance requirements may not be met.

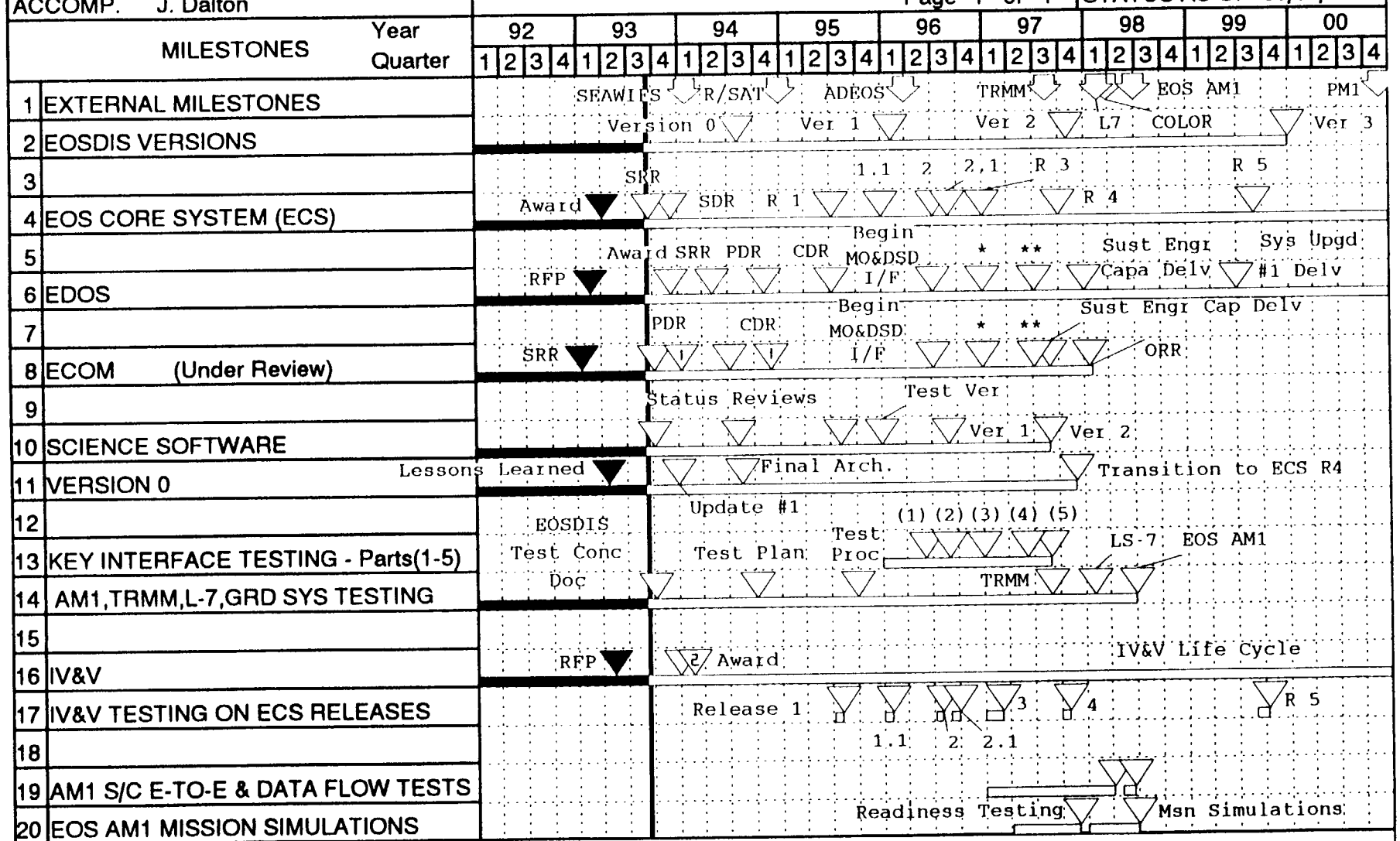
Mitigation of this risk consists of (1) early prototyping with extensive user participation (V0); (2) a highly evolutionary approach to developing the user-sensitive functions of EOSDIS, including continued prototyping in cooperation with users, early release of the data access and distribution elements of the system, and the incorporation of user feedback into all stages of development; (3) requirements for expandability of storage and data access capacities and performance, if necessary, with associated budget contingency; and (4) Project-level systems engineering and management of the communications network to ensure capacities are commensurate with EOSDIS performance.

GODDARD SPACE FLIGHT CENTER
APPROVAL D. Fahnestock
ACCOMP. J. Dalton

EARTH SCIENCE DATA & INFORMATION SYSTEM PROJECT (ESDIS)

Page 1 of 1

ORIG. APPVL. 08/30/93
LAST CHANGE / /
STATUS AS OF 08/30/93



NOTE: * Begin EOS AM1 Ground System Interface Testing
* *EDOS/Ecom Operations Support Capability Deliveries
DIS ORR - 3/98

(1) Version 0 (2) EDOS/Ecom (3) TRMM
(4) ECS/EDOS/Ecom, L-7, COLOR
(5) EOS AM1

Legend: - Supporting - HQTR Controlled - Latest Comp. Date - Mgt. Assessed Comp. Date - Changed
Slack Critical Path

Figure 8-8. ESDIS Project Milestone Chart

SCF-β	Beta Version of PGS tools hosted on SCF
SCF V1	V1 Version of PGS tools hosted on SCF
SCF V2	V2 Version of PGS tools hosted on SCF
ECS-β	Single site beta-DAAC having PGS environment, IMS/DADS and interoperable with V0. Substantially ingested V0 data
ECS V1	Fully distributed DADS/IMS, PGS at 4 sites. Substantially ingested V0 data
ECS V2	AM launch-ready capacity. Fully ingested V0 data
SV1	First delivery of PI software. Interfaces and resource usage correct
SV2	Launch-ready version of PI software
EDOS R1	EDOS with sufficient functionality for interface testing
FV1	FOS with sufficient functionality for interface testing
End-to-End Test	Simulated spacecraft, EDOS, SDPS, FOS integrated testing
SIMS	Launch and normal operations simulations
Communications	Continuing upgrades as required. Policy currently under review

Figure 8-9. Master Schedule Key Definitions

Table 8-7
ESDIS Facility Requirements

Activity / Facility	Location	Required Modification	Duration (Fiscal Year)
ESDIS Project Office	Building 16W	Minor Modification	Present through 1994
EOSDIS Facility	New Building	FY 1994 Site Completion	1994 through 2015
EOSDIS Backup Power Facility	New Facility	Part of the Facility above	1994 through 2015
TDRSS/GSTDN, ATDRSS	White Sands	Existing Capability, enhanced	1996 through 2015
NASCOM/ECOM	Building 14	Existing Capability, enhanced	1994 through 2015
FDF	Building 3	Existing Facility	1997 through 2015
NCC	Building 13	Existing Facility	1996 through 2015
EDOS Data Interface Facility (DIF)	White Sands	New Facility	1994 through 2015
CTV	Transportable	Existing Capability	1997 through 1999
SOC	Building 3	Existing Facility	1996 through 1999
EOS Science Offices	Building 16	Existing Facility	1991 through 1996
ETS	Building 3	Existing Facility	1996 through 1999
EDOS Data Proc. Facility	West Virginia	New Facility	1994 through 2015
GSFC/DAAC	New Facility	Part of EOSDIS Facility	1994 through 2015
JPL/DAAC	Pasadena, CA	Existing Facility	1994 through 2015
LaRC/DAAC	Hampton, VA	New Facility	1994 through 2015
NSIDC/DAAC	University of Colorado	Existing with Modification	1994 through 2015
EDC/DAAC	Sioux Falls, SD	New Facility	1994 through 2015
U of Alaska/DAAC	Fairbanks, AK	Existing Facility, enhanced	1994 through 2015
MSFC/DAAC (Earth Observation Remote Sensing Lab)	Huntsville, AL	New Facility	1994 through 2015
EDOS COM	Building 28	New Facility	1995 through 2015
Backup Basic POCC	Building 28	New Facility	1995 through 2015

8.12.2 Science Data Processing

The development of the scientific data processing software (algorithms) by the investigators in parallel with the development of the ECS processing environment poses a number of related risks: (1) Algorithm processing requirements could increase substantially over the initial estimates used for sizing the ECS (as occurred on UARS); (2) The number and volume of data products generated could increase substantially over the initial estimates; (3) Algorithms developed on investigator SCFs must operate in the ECS-developed PGS environment; (4) ECS development is dependent on the timely delivery and integration of the algorithm to accomplish final testing of the ECS; and (5) Algorithm developers must know the interface between their algorithms and the ECS to design their software.

These risks are mitigated through (1) early delivery of test versions of science software by the investigators; (2) control of the set of standard science data products within the project budget by the Project Scientist; and (3) development of a PGS tool kit to provide a common application program interface to data and system services on both the PGS and SCFs.

8.13 ENVIRONMENTAL IMPACT

An environmental impact plan for the construction and use of the EOSDIS facility was submitted and approved by the state and federal governments. No other environmental impacts are foreseen by the ESDIS Project.

9. EARTH SCIENCE MISSION OPERATIONS PROJECT

The ESMO Project is a division level element within the MTPE organization. A separate project plan will be provided for ESMO Project activities, including Landsat 7.

10. MANAGEMENT REVIEWS AND REPORTING

10.1 STATUS REVIEWS

The EOS Projects will conduct the following monthly reviews and other reviews as required.

10.1.1 Project Status Review

The EOS Projects will conduct an internal monthly Project Status Review beginning at an appropriate time in the development of each Project. The review will encompass cost, schedule, and technical performance aspects of each element.

10.1.2 Pre-Monthly Status Review

The EOS Project Managers make regularly scheduled monthly Project presentations to the Director of Flight Projects, the Director of Mission Operations and Data Systems, and the Director of the Mission to Planet Earth Office. These reviews cover all significant aspects of Project status, including technical progress and management areas such as actual funding and manpower expenditures versus planned values. Emphasis is placed on defining problem areas and applying the necessary measures to resolve them. Representatives from the other Directorates may attend these reviews. NASA Headquarters participation in these reviews is at their discretion.

10.1.3 Monthly Status Review

The MTPE Office and the EOS Project Managers also make Monthly Status Review (MSR) presentations to the Center Director and senior GSFC management. Again, these reviews cover all significant aspects of the technical and resources status of the Project.

10.2 FLIGHT ASSURANCE DESIGN REVIEWS

GMI 8010.1C prescribes policies and general procedures for the mission design review requirements. In summary, it requires each project to undergo a series of reviews by a team of technical specialists selected on a centerwide basis for the specific review.

The review team and review chairman are appointed by the Director of Flight Assurance. The purpose of the reviews is to enhance the probability of mission success by having a group of technical specialists who are independent of the Project evaluate the system.

10.2.1 Spacecraft Reviews

Reviews for the EOS spacecraft will be as follows:

- System Concept Review (SCR) – This review is keyed to the end of the definition study phase and will evaluate the spacecraft design approaches and the operational concepts.
- Preliminary Design Review (PDR) – This review will occur early in the spacecraft design phase but before engineering hardware is manufactured and software is coded. Where applicable, it should include the results of test bedding and breadboard testing and simulation and/or prototyping for software.
- Critical Design Review (CDR) – This review will occur after the design has been frozen but before the manufacture of flight components begins. It will emphasize implementations of the design and verification plans for flight systems, including the results of engineering model verification.
- Pre-Environmental Review (PER) – This review occurs before environmental testing of the spacecraft begins. The primary purposes of this review are to establish the readiness of the integrated flight system for test and to evaluate the environmental test plans.
- Pre-Shipment Review (PSR) – This review will take place before shipment of the spacecraft to the launch site and will concentrate on system performance during acceptance testing.

10.2.2 System Flight Assurance Reviews

The EOS System reviews are as follows:

- Mission Operations Review (MOR) – This mission-oriented review will take place before significant integration of the flight system. The purpose is to review the status of the system components, including the ground system and its operational interfaces with the flight system. Mission operations considerations for the flight instruments will be included. Discussions will include integration and test planning. (GMI 8010.1C refers to this review as the Systems Operations Review.)
- Operations Readiness Review (ORR) – While all of the previous reviews involve operations, this review will emphasize the final orbital operations plans and the compatibility of the spacecraft with ground support equipment and the ground network. It will include summary results of the network compatibility tests. (GMI 8010.1C refers to this review as the Flight Operations Review.)
- Flight Readiness Review (FRR) – The purpose of this review is to assess the overall readiness of the total system to support the flight objectives of the mission, and will be held approximately 3 days before launch.

10.2.3 Instrument Reviews

For each flight instrument, the reviews will be as follows:

- CDCR - This review usually occurs near the end of the definition study phase and evaluates the instruments' design approaches and operational concepts.
- PDR – This review usually occurs early in the instrument's design phase but before the manufacture of engineering-model hardware. Where applicable, it will include the results of test bedding and breadboard testing, and simulation and/or prototyping for software.
- CDR – This review usually occurs after the instrument's design has been frozen but before the manufacture of flight components begins. It will emphasize implementations of the design and verification plans for the instrument, including the results of engineering model verification.
- PER – This review occurs before environmental testing of the protoflight or flight instrument begins. The primary purposes of the review are to establish the readiness of the instrument for test and to evaluate the environmental test plans.
- PSR – This review will take place before the instrument is shipped to the spacecraft for integration and will concentrate on instrument performance during acceptance testing.

10.2.4 Ground System Reviews

As described in Section 8, the EOS Ground System consists of major subsystems constituting EOSDIS and its external interfaces. Each of the subsystems of EOSDIS, namely, ECS, EDOS, and Ecom, will have reviews during their developmental life-cycles. The reviews of ECS are organized to be commensurate with the evolutionary nature of its development and its complexity. Since the evolutionary development of ECS occurs through multiple releases, a series of reviews is held for each release. Due to the size and complexity of ECS its reviews are organized at the system, segment, and element levels. Also, integrated reviews of EOSDIS will be held as a part of system integration and testing. A description of the key reviews of EOSDIS is given below.

System Requirements Reviews (SRRs) – These reviews are held for ECS, EDOS, and Ecom at the end of system requirements analysis phase, prior to implementation to assure adequacy of the requirements' definition of the respective subsystems.

System Design Reviews (SDRs) – Since ECS provides an EOSDIS-wide system framework, an SDR will be held for ECS a few months following the SRR to review the definition and high-level design of the ECS segments and elements, the interfaces between these and external systems, facilities, users, operators, etc. The SDR

will also include a review of how the results of EOSDIS Version 0 and the results of contractor and government prototyping and study efforts are taken into account in the system level design.

Preliminary Design Reviews (PDRs) – In the case of EDOS and Ecom, PDRs will be held early in the design phase to consider planned implementations of the system functions in the design of hardware and software components including off-the-shelf items. These reviews will consider the appropriateness of the planned design, adequacy of the planned purchases, and operational availability provided by the planned design. In the case of ECS, PDRs will be held for the first release of each segment to address the design of segment-level capabilities and element interfaces through all ECS releases. Also, Incremental Design Reviews (IDRs) will be held for each subsequent release. These reviews will address how results of on-going prototyping efforts and user feedback from currently operating releases are incorporated into the design of the next release.

Critical Design Reviews (CDRs) – The CDRs will be held for EDOS, Ecom and, at the element level, for each release of ECS. The CDRs will occur after the hardware and software designs are finalized, but before the hardware integration or software coding. The CDRs will address topics such as detailed design, implementation plans, plans for software testing, and hardware verification.

Prototype Results Reviews (PRRs) – For ECS, PRRs are used to review the capabilities provided by prototypes and to reach conclusions concerning incorporation of prototypes into mainline development. These reviews will include independently developed reports from users about the suitability of the prototypes.

Test Readiness Reviews (TRRs) – These reviews will be held prior to each stage of integration and testing of the major subsystems of EOSDIS as shown in Figure 8-4. The purpose of these reviews is to assess the readiness of the subsystems for integration with other subsystems.

Operational Readiness Reviews (ORRs) – These reviews occur at the end of the system development and transition to operations. One such review will be held for each flight supported by EOSDIS.

10.2.5 System Safety Review

All the foregoing reviews will address flight and ground systems safety at all program phases, including operations, and at all locations. System safety coverage for all flight segment elements will include the development of input material for the launch site safety assessment reports.

10.2.6 Launch Site Safety Reviews

The EOS Flight Projects will assemble the launch site safety assesment reports for the spacecraft flight systems and will compile the Safety Assessment Reports required by Western Range. The flight projects will serve as the primary EOS liaison with Western Range and will participate in the launch-site safety reviews.

10.3 HEADQUARTERS REVIEWS

Reviews will be conducted periodically at the request of the NASA Headquarters Office of Mission to Planet Earth, and will include the following:

10.3.1 Program Review(s)

A Program Review will be conducted annually in conjunction with the POP reviews. A primary emphasis will be to assess the science and technical progress of the program and its compatibility with the program objectives resources plan. The reviews will be attended by program management personnel from NASA Headquarters, GSFC, and as required from other NASA Centers and institutions providing hardware, software, and services to the EOS Projects.

10.3.2 Launch-1 Year and Launch-2 Year Reviews

The Launch-1 Year and Launch-2 Year Reviews will be conducted for each EOS flight in accordance with the EOS Headquarters Controlled Milestones defined in Figure 4-7. These reviews will provide an assessment of the status of the flight and ground systems, with emphasis on end-to-end system-level verification, training, and launch operations, to assure adequate progress to meet the scheduled launch date. These reviews will be attended by program management personnel from NASA Headquarters, GSFC and other NASA Centers, and external organizations providing flight and ground systems and operations services.

10.3.3 ESDIS Reviews

The ESDIS Project will hold periodic, at least semi-annually, reviews to present and assess the status of the EOS ground system, including presentation of system integration approaches and issues to ensure appropriate and timely integration of system elements and external components within the overall EOSDIS. Attendees at these reviews will include ESDIS Project management personnel, MTPE Program Office representatives, DAAC personnel, and external mission/projects interfacing with EOSDIS.

10.4 REPORTING REQUIREMENTS

10.4.1 Management Information System

The EOS will implement an automated MIS that will be documented and used in the day-to-day management of the Projects. The MIS will serve as the basis for monitoring and reporting the cost, schedule, configuration management, and technical performance of the Project. Information contained in the MIS data base can be accessed remotely by appropriate NASA Headquarters management personnel with read only access. The MIS will provide data such as the following:

- Short- and long-term schedules that incorporate all major Project milestones
- Annual and monthly budget and contractor workforce plans versus actual information within the present FY for each major Project effort, including each instrument, each spacecraft, science, and EOSDIS
- Status and historical utilization information of Project contingency
- Civil Service workforce planning information by Directorate
- Configuration management information, including status of contract values and pending actions
- Performance Measurement System (PMS) data (as applicable) for each major contract on instruments, spacecraft, science, and ESDIS
- Historical recordkeeping of budget planning information for all POP submissions and sets of approved program baseline conditions
- Action Item tracking system

10.4.2 Contractor Financial Management Reporting

Manpower and financial reporting from contractors, universities, and nonprofit institutions is applicable to NASA cost-type contracts and is implemented through the NASA 533 series of reports as required by NMI 9501.1E, "NASA Contractor Financial Management Reporting System," and as described in "Procedures for Contractor Reporting of Correlated Cost and Performance Data," NHB 9501.2B. A WBS defines the scope and level of detail required and provides a common framework with schedule reporting. The schedule reporting requirements are consistent with the criteria established for the Program Evaluation Review Technique (PERT) or equivalent systems.

10.4.3 Contractor's Monthly and Quarterly Progress Reports

Contractors submit monthly and quarterly progress reports to GSFC, reviewing the technical status and indicating progress in achieving EOS Project schedule milestones.

The reports generally cover the following:

- Hardware status
- Science algorithm development status
- Procurement status and problems
- Failure reports and analysis
- Synopses of approved design changes
- Synopses of design reviews during the reporting period
- Subcontractor equipment status
- Current manpower and facilities requirements
- Milestone charts indicating delivery schedules
- Updated contractor organization charts
- Status of Performance Assurance Program
- Cost containment reports as outlined in cost containment letters

10.4.4 Technical and Scientific Papers

Technical papers reporting EOS scientific and technical aspects will be prepared promptly and issued as the Project develops. The results of the EOS experiments will be published in technical journals or as NASA publications.

All such EOS publications will acknowledge NASA support through the contract number or through the UPN.

10.4.5 Final Mission Technical and Preliminary Scientific Assessment Reports

Within 6 months after launch, the EOS Project and the Project Scientists will jointly produce a documentary report that will include the flight technical report and a preliminary scientific assessment of the results. This report will include an overall mission analysis and a bibliography of technical and scientific papers.

11. PERFORMANCE ASSURANCE

11.1 GENERAL

The Performance Assurance Program for EOS is based upon the policy and requirements contained in the following documentation:

- Reliability Program Provisions for Aeronautical and Space System Contractors, NHB 5300.4(1A-1)
- Quality Program Provisions for Aeronautical and Space System Contractors, NHB 5300.4(1B)
- Electrical, Electronic, and Electromechanical (EEE) Parts Management and Control Requirements for NASA Space Flight Programs, NHB 5300.4(1F)
- NASA Software Documentation Standard, NASA-STD-2100-91
- Guidelines for Standard Payload Assurance Requirements (SPAR) for GSFC Orbital Projects, SPAR-3
- General Environmental Verification Specification for STS and ELV Payloads, Subsystems, and Components, General Environmental Verification Specification (GEVS)-SE
- GSFC Malfunction Reporting System, GMI 5311.1A
- Western Range Regulation Range Safety Requirements, Western Range Regulation (WRR) 127-1
- ALERT Reporting of GSFC Parts and Materials Problems, GMI 5311.3C
- Quality Assurance Provisions for Delegated Government Agencies, NHB 5400.4(2B)

The basic elements of the Performance Assurance Program have been translated into requirements that are implemented by each instrument, each spacecraft, and the ground system and are contained in the applicable revision of the EOS Performance Assurance Requirements for General Instruments, (420-05-01); Performance Assurance Requirements for the EOS AM Spacecraft, (420-05-02); Performance Requirements for the Common EOS Spacecraft, (420-05-04); and Performance Assurance Requirements for the EOSDIS Core System (ECS), (420-05-03); and Performance Assurance Requirements for the Independent Verification and Validation (IVV) of the EOS Data and Information System (EOSDIS), (420-05-05).

The Performance Assurance Program addresses hardware and software for both the flight and ground segments including the spacecraft bus, instrument payloads and their integration into the spacecraft, airborne and ground support equipment and systems, space and systems control facility, primary processing facility, and their interfaces for the life cycle of the EOS Project, including their design, fabrication, integration, verification, launch, deployment, checkout, and operation.

The contractors and instrumenters are required to formulate definitive implementation plans, which include performance

verification, systems safety, and contamination control to govern the execution phase. These plans will be approved by the appropriate Project Offices before their execution.

11.2 RELIABILITY

The Reliability Program requirements will be directed toward ensuring that the design is compatible with the requirements of the mission. The requirements will follow the reliability program tasks delineated in Reliability Program Provisions for Aeronautical and Space System Contractors, NHB 5300.4(1A-1), as tailored to the needs of the EOS mission by the EOS 420-05 series of documents (Performance Assurance Requirements). An FMEA will be conducted by each contractor and instrumenter for the particular instrument from the component level (blackbox) interface up to the interface with the spacecraft bus. The integration contractor will accomplish a Failure Mode Effects Analysis (FMEA) from the interface through the total spacecraft, including the interfaces with the instruments and spacecraft. Parts stress analyses and worst-case analyses will also be performed.

11.3 QUALITY ASSURANCE

The Quality Assurance Program requirements for EOS will follow the quality tasks delineated in Quality Program Provisions for Aeronautical and Space System Contractors, NHB 5300.4(1B), tailored to the Project and mission requirements by the EOS 420-05 document series (Performance Assurance Requirements).

GSFC will use NASA/DOD Government Source Inspection (GSI)/Contractor Source Inspection (CSI) agencies to provide on-site monitoring of the assurance program implementation by the instrumenters, their contractors, the spacecraft integration contractor, the ground system contractor, and selected subcontractors. GSI participation is governed by Quality Assurance Provisions for Delegated Government Agencies, NHB 5300.4(2B), and CSI is governed by LOA. These tasks are primarily directed to perform the following:

- Conducting inspections of manufacturing operations and test activities
- Monitor and audit compliance with the contractual requirements
- Participate in the Materials Review Board

11.4 PARTS

The EEE Parts Program requirements for EOS flight parts will follow those tasks delineated in Electrical, Electronic, and Electromechanical (EEE) Parts Management and Control Requirements for NASA Space Flight Programs, NHB 5300.4(1F), tailored to the

needs of the EOS Project and mission by the EOS 420-05 series of documents (Performance Assurance Requirements).

Parts whose performance and reliability have been proven or that have demonstrated acceptance for the application shall be used. EEE parts selected from the Grade 2 category of the NASA Standard Electrical, Electronics, and Electromechanical Parts List, Military Standard (MIL-STD)-975, and the GSFC Preferred Parts List (PPL) are considered standard and acceptable for the applications. Parts selected and procured to a GSFC-approved contractor's Program Approved Parts List (PAPL) are also considered acceptable. Any part not included in the listings of MIL-STD-975 or the accepted GSFC PPL is considered non-standard. The use of non-standard parts is limited to only those applications for which a standard part or PAPL part does not fulfill the design requirement. The rationale for selection and the supporting data attesting to the acceptability of the non-standard part for the application (both performance and reliability) is documented by the developer and submitted for approval to the EOS Project.

11.5 MATERIALS AND PROCESSES CONTROL

Materials and processes whose performance and reliability have been proven or demonstrated to be acceptable for the intended application shall be used for EOS. Materials selected from the following guidelines are considered suitable: Materials Selection Guide; An Evaluation of Liquid and Grease Lubricants for Spacecraft Applications, TM 82276; Outgassing Data for Selecting Spacecraft Materials, NASA Reference Publication 1124; and Design Criteria for Controlling Stress Corrosion Cracking, MSFC-SPEC. 522.

Materials must be verified as acceptable for application on the basis of similarity, analysis, test, inspection, and/or existing data if a lack of aerospace experience, insufficient data, or properties exists that may jeopardize performance or reliability of the payload. The EOS design precludes the generation of contaminants that could compromise performance of the flight hardware itself or other hardware in close proximity. Analytical and experimental verification of questionable materials not conforming to the stipulated outgassing requirements of a maximum of 1 percent Total Mass Loss (TML) and 0.10 percent Collected Volatile Condensable Materials (CVCM) is required.

11.6 PERFORMANCE VERIFICATION

11.6.1 Test and Analysis Program

A formal EOS test and analysis program will be conducted to provide assurance that the hardware and software are capable of surviving and performing their mission within specifications

under the various environments to which they will be subjected. This program will demonstrate the validity of design, the positive margins, the quality of workmanship and materials, and the satisfactory performance under the various mission environments with appropriate factors of safety. It will also screen the hardware and software for latent malfunctions. The program will include functional tests at the blackbox and system levels. These tests will be conducted under the ambient and simulated mission conditions, including factors of safety, as applicable. Verification activities will demonstrate compliance with the system safety requirements, as appropriate.

For the ground system, the verification activity includes verification requirements for the hardware and verification and validation of the software (walkthroughs and inspections, as well as tests). In addition, IV&V of the ground system is to be accomplished under a separate contract.

11.6.2 End-to-End Compatibility Tests and Simulations

End-to-end tests will be conducted on the entire EOS and will include all portions of the operational system, such as all flight hardware, with appropriate stimulation of instruments; operational software and ground systems, including the EOC, NASCOM, ECOM, EDOS, EOSDIS internal networks, EOSDIS external networks, and ground processing facilities. These tests demonstrate that the system meets the functional requirements, and that data flow paths and actual data, in an acceptable form, are verified as required for the mission. Also, mission simulation exercises are conducted to validate nominal and contingency mission-operating procedures and to provide for operator familiarization training.

11.7 ADDITIONAL CONTRACTOR REVIEWS

Contractors are defined here as out-of-house instrumenters, industrial contractors and subcontractors, and NASA in-house organizations responsible for providing hardware and/or software. The contractors will conduct reviews for all designs within the components and subsystems for the instruments, the spacecraft bus, and ground segments. In addition to the normal circuit/function reviews for all technical disciplines, these review processes will also stress packaging and manufacturing techniques and processes. Summaries of discussions and decisions reached at these reviews will be provided to the EOS Project Office. The Project Office reserves the right to participate in these reviews. These reviews are in addition to the NASA reviews described in Section 10.

11.8 CONTAMINATION ALLOWANCE AND CONTROL

Contamination Control Plans are required to meet the needs of each EOS Flight Project. The plans include contamination allowances, methods and criteria for control, and analyses showing how the controls will keep contamination within allowable limits. The limits will be based upon an assessment of the sensitivity of the payload to contamination.

11.9 MAINTAINABILITY

In projects where maintenance is a factor in mission success, a maintainability program will be established. A program will be directed towards ensuring that design of the EOSDIS allows for practical and economical maintenance within established program and mission constraints. Emphasis will be placed on the development of a maintenance plan which will identify trade-offs and decisions concerning repair versus replacement. The maintenance plan will identify logistics requirements needed to support its concepts which affect procurement and operation of support/test equipment, training, technical data, and parts.

12. SAFETY

12.1 INDUSTRIAL SAFETY

The safety procedures and requirements to be followed in implementing the EOS Project are in response to and in accordance with the policies and guidelines set forth in GSFC Health and Safety Program, GMI 1700.2C; Basic Safety Manual, NHB 1700.1 (V1-A); and the overall GSFC policy of avoiding injury to people and property loss to the maximum extent practical. To this end, the following measures will be implemented. It is GSFC policy to inform affected personnel of any hazard resulting from involvement in this Project, and to provide all requested hazardous material information.

- Inclusion of the Safety and Health Clause contained in the NASA/Federal Acquisition Regulation Supplement, Subpart 18-23.70, in all resulting EOS contracts
- Submission of industrial safety plans, including plans for hazardous testing, electro-explosive device (EED) use, and hazardous materials use, by contractors for review, comment, and approval by the EOS Project and the GSFC Health, Safety, and Security Office
- Compliance with applicable chapters of the Code of Federal Regulations, the national EPA codes, and the National Fire Protection Association codes when using, handling, storing, or transporting dangerous materials

12.2 SYSTEM SAFETY

The EOS Project will establish a comprehensive System Safety Program for the entire mission in accordance with System Safety for Orbital Flight Projects, GMI 1700.3A; System Safety Program Requirements, MIL-STD-882C; and WRR 127-1. Ground support personnel, test and integration personnel and facilities, hardware and software, and launch operations will be covered.

To these ends, the following measures will be implemented:

- Submission of Launch Site Safety Plans, by instrumenters and contractors, in compliance with Western Range Regulation Range Safety Requirements, WRR 127-1
- Reporting of results of annual self-audits of contractor industrial and system safety programs to ensure compliance with policy and approved plans
- Reporting and investigation of mishaps in accordance with Mishap Reporting and Investigations, NMI 8621.1E
- Reporting of any significant safety risk concerns based upon trend analyses, design and readiness reviews, and safety risk assessments to NASA Headquarters Safety Management

- Accomplishment of the final review of all aspects of mission safety in accordance with the GSFC Design Review Program and in compliance with the Project Safety Plan as required by GMI 1700.3.

13. SECURITY

The security procedures and requirements to be followed in implementing the EOS Project are in response to, and in accordance with, the policies and guidelines set forth in the GSFC Security Manual, GHB 1600.1A; the NASA Physical Security Handbook, NHB 1620.3C; and overall GSFC and national security policy in the protection of government assets and classified information.

13.1 INDUSTRIAL SECURITY

For all EOS contracts requiring the handling of classified information, the following documents will be included in the Directives Documentation 254 (to be completed in coordination with the GSFC Security Office):

- Information Processing Resources Management, NHB 2410.1D
- Industrial Security Manual, DOD 5220.22-M
- NASA Physical Security Manual, NHB 1620.3C
- GSFC Security Manual, GMI 1600.1A
- NASA Automated Information Security Handbook, NHB 2410.9
- Space Network Classification Guide

13.2 PROGRAMMATIC AND COMPUTER SECURITY

As required in Assuring the Security and Integrity of NASA Automated Information Resources, NMI 2410.7A, the EOS Project will establish a comprehensive security plan for the entire mission to ensure all requirements for security are identified and protective measures are in place. Specific subjects that must be covered in the plan are fire protection and physical, personnel, computer, information, communications, and operations security. The plan will be completed in coordination with, and will be approved by, the GSFC Security Office.

APPENDIX A

EOS PROJECT PLAN

GLOSSARY

APPENDIX A

EOS PROJECT PLAN
GLOSSARY

aerosol – A gaseous suspension of fine particles.

Affiliated Data Center (ADC) – A facility not funded by the National Aeronautics and Space Administration (NASA) that processes, archives, and distributes Earth science data useful for Global Change research, with which a working agreement has been negotiated by the EOS Program. The agreement provides for the establishment of the degree of connectivity and interoperability between the Earth Observing System (EOS) Data and Information System (EOSDIS) and the ADC needed to meet the specific data access requirements involved in a manner consistent and compatible with EOSDIS services. Such data-related services to be provided by EOSDIS by the ADC can vary considerably for each specific case.

affiliated user – See user.

ancillary data – Data other than instrument data required to perform an instrument's data processing. They include orbit data, attitude data, time information, spacecraft or platform engineering data, calibration data, data quality information, and data from other instruments.

archived holdings – All EOS and non-EOS data and data products, as well as supporting information, that are archived by EOSDIS, including models, algorithms, documentation, and Level 0 data or higher level data products from which Level 0 may be recovered.

authorized user – See user.

bidirectional reflection distribution function (BRDF) – Theoretically, a four-dimensional function that relates the scattering efficiency of a surface to (1) the incident illumination direction $(\theta, \phi)_I$ and (2) the reflection (observation) direction $(\theta,\phi)_0$. For most naturally occurring surfaces, only azimuth difference $(\phi_I-\phi_0)$ is significant, resulting in a three-dimensional function.

browse data product – Subsets of a larger data set, other than the directory and guide, generated for the purpose of allowing rapid interrogation (i.e., browse) of the larger data set by a potential user. For example, the browse product for an image data set with multiple spectral bands and moderate spatial resolution might be an image in two spectral channels, at a degraded spatial resolution. The form of browse data is generally unique for each type of data set and depends on the

nature of the data and the criteria used for data selection within the relevant scientific disciplines.

dynamic browse – Refers to the generation of a browse product, including subsetting and/or resampling of data, by command of the user engaged in the browse activity. The browse data set is built in real time, or near-real time, as part of the browse activity.

static browse – Refers to interrogation of browse products that have been generated (through subsetting and/or resampling) before any user browses that particular data set.

calibration – 1. The activities involved in adjusting an instrument to be intrinsically accurate, either before or after launch (i.e., instrument calibration). 2. The process of collecting instrument characterization information (scale, offset, nonlinearity, operational, and environmental effects), using either laboratory standards, field standards, or modeling, which is used to interpret instrument measurements (i.e., data calibration). Not to be confused with related terms:

correction – Refers to using instrument characterization information to improve the accuracy of instrument data products (e.g., image correction for geometric distortion).

compensation – Refers to adjusting for measurement effects external to the instrument (e.g., surface color compensation for atmospheric propagation).

interpretation – Refers to applying the correlation between a sensed physical parameter and a related phenomenon (e.g., ocean color interpretation for phytoplankton concentration).

In both cases, calibration may apply to temporal, spatial, radiometric, or any other sensed physical parameter. Ground processing algorithms will often support both types of calibration activities, correction, compensation, and interpretation.

calibration data – Any data required to calibrate an instrument, including subsets of instrument science data, instrument engineering data, spacecraft engineering data, pre-flight instrument calibration measurements, and in-flight ground truth measurements.

catalog interoperability – The capability of the user interface software of one data set directory or catalog to interact with the user interface at another data set directory or catalog.

Three levels of Directory Interoperability are recognized:

Level 1 Interoperability – Simple network interconnectivity among systems.

Level 2 Interoperability – Catalog systems can exchange limited search and user information.

Level 3 Interoperability – Catalog systems exchange standard search protocols. This provides "virtual" similarity between different systems.

catalog system – An implementation of a directory, plus a guide and/or inventories, integrated with user support mechanisms that provide data access and answers to inquires. Capabilities may include browsing, data searches, and placing and taking orders.

commanding – Process of scheduling and issuing instruction for action to be carried out by a space-based instrument or platform.

community consensus algorithm – The current global algorithm or spatial mosaic of algorithms for a Pathfinder data product, as agreed upon by a Pathfinder Science Working Group.

continuous operation – The ability to support continuous data collection by the reliable, repetitive, systematic observation of the Earth features appropriate to the measurement being made. For EOS, continuous operation will allow the entire globe to be monitored not less than once on the day side and once on the night side every 16 days.

control – The functions performed at a ground control center to operate space-based instruments, in conjunction with commanding.

core – The central portion of the Earth, at a depth of approximately 2,900 kilometers (km). Liquid metallic composition.

Data Archive and Distribution System (DADS) – Included in each DAAC and responsible for archiving and distribution of EOS data and information.

data product level – A classification of data products by the sort of processing used in their generation and, to a lesser extent, the sort of uses to which these products might be put. The levels described below are consistent with those defined by the EOS Advisory Panel (EAP) in its report and CODMAC definitions.

raw data – Data in their original packets, as received from the observatory, unprocessed by CDOS.

Level 0 – Reconstructed, unprocessed instrument data at full space-time resolution with all available supplemental information to be used in subsequent processing (e.g., ephemeris, health, and safety).

Level 1A – Unpacked, reformatted Level 0 data at full space-time resolution with all supplemental information to be used in subsequent processing appended.

Level 1B – Radiometrically corrected and calibrated data in physical units at full instrument resolution as acquired.

Level 1C – Level 1B data that have been spatially resampled.

Level 2 – Retrieved environmental variables (e.g., ocean wave height, soil moisture, ice concentration) at the same location and similar resolution as the Level 1 source data.

Level 3 – Data or retrieved environmental variables that have been spatially and/or temporally resampled (i.e., derived from Level 1 and 2 data products). Such resampling may include averaging and compositing.

Level 4 – Model output and/or variables derived from lower level data that are not directly measured by the instruments. For example, new variables based upon a time series of Level 2 or Level 3 data.

data set – A logically meaningful grouping or collection of similar or related data.

data set catalog – See catalog.

data set directory – See directory.

data set documentation – Information describing the characteristics of a data set and its component granules, including format, source instrumentation, calibration, processing, algorithms, etc.

directory – A collection of uniform descriptions that summarize the contents of a large number of data sets. It provides information suitable for making an initial determination of the existence and contents of each data set. Each directory entry contains brief data set information (e.g., type of data, data set name, and time and location bounds).

Distributed Active Archive Center (DAAC) – An EOSDIS facility that generates, archives, and distributes EOS standard data products and related information for the duration of the EOS

mission. An EOSDIS DAAC is managed by an institution such as a NASA field center or a university, as per agreement with NASA. Each DAAC contains functional elements for processing data (the Product Generation System (PGS)), for archiving and disseminating data (the DADS), and for user services and information management (elements of the Information Management System (IMS)). Other (non-NASA) agencies may share management and funding responsibilities for the active archives under terms of agreements negotiated with NASA.

documentation – See data set documentation

EOS data products – Three primary categories of EOS mission data products that will be provided by EOSDIS have been defined, as follows:

prototype data products – Generated as part of a research investigation, of wide research utility, requiring too much data or computer power for generation at the investigator Science Computing Facility (SCF), and accepted as a candidate standard data product by the IWG. Prototype data products will be generated at DAACs, but their routine generation is not guaranteed and will not interfere with standard data product generation.

special data products – Generated as part of a research investigation using EOS data and produced for a limited region or time period, or products that are not accepted as standard by the IWG and NASA Headquarters. They will be generated at research users' computer facilities.

standard data products – Generated as part of a research investigation, of wide research utility, accepted by the IWG and the EOS Program Office, routinely produced, and in general spatially and/or temporally extensive data products. Standard Level 1 data products will be generated for all EOS instruments; standard Level 2 data products will be generated for most EOS instruments. Some EOS interdisciplinary investigations will also generate standard data products.

EOS Data and Operations System (EDOS) – A ground-based interface between Earth-orbiting satellites and TDRSS. It provides for command uplinks through TDRSS and data capture and production processing of telemetry data. Production processing includes the segregation of composite downlink transfer frame data streams into separate payload/instrument data packet streams that have been corrected for artifacts of the telemetry process (i.e., level 0 processing).

EOS Operations Center (EOC) – The facility responsible for EOS mission operations, including command and control of EOS spacecraft, mission planning and scheduling, and coordination of EOS instrument planning and scheduling. All commands for EOS platforms and instruments go through the EOC, for integration and validation, before being sent to the CDOS for transmission to space.

EOS Program – The activity that provides the long-term observations and the supporting information system necessary to develop a comprehensive understanding of the way the Earth functions as a natural system. The EOS Program Office and the EOS Project are included in the EOS Program.

EOS Program Director – The NASA Headquarters official who is the focal point for all Headquarters activities bearing on the EOS Program.

EOS Program Office – The EOS Program Director and his staff. The EOS Program Office is located at NASA Headquarters.

EOS Program Scientist – The NASA Headquarters official assigned to the EOS mission. The roles and responsibilities of this function are defined in NASA Management Instrument (NMI) 7100.11, Attachment D. One of them is to establish the policies for the analysis, dissemination, and archiving of data for the mission.

EOS Project – The EOS Project Manager, his staff, and all other participants in the EOS Program who are located at GSFC.

EOS Project Scientist – The NASA field center or U.S. academic institution scientist assigned to the EOS mission to manage its scientific aspects. The roles and responsibilities of this function are given in NMI 7100.11, Attachment E.

essential data product – A data product that has major significance to the EOS Program and its science users. The EOS Program considers successful production of such data products essential and will use such production as a measurement of performance.

facility instrument (FI) – An instrument defined by NASA as having broad significance to the EOS Program and provided by a designated NASA center or foreign agency.

flight hardware – All active mission hardware in orbit about the Earth. For EOS, includes all EOS observatories and EOS instruments on International Platforms and other spacecraft.

granule – The smallest aggregation of data that is independently managed (i.e., described, inventoried, retrievable). Granules may be managed as logical granules and/or physical granules.

guide – A uniform set of detailed descriptions for one or more data sets and related entities, containing information suitable for determining the location and content of each data set and its potential usefulness for a specific application.

hard metric – The use of rational metric units as the basis of measurement rather than mathematically converted inch-pound units.

Information Management Service (IMS) – The user interface for EOSDIS. It provides information about data, both in EOSDIS and in external archives, on a 24-hour basis; accepts user orders for EOS data; provides information about future data acquisition and processing schedules; accepts and forwards data acquisition and processing requests; and maintains information on system status, management, and coordination.

Instrument Control Center (ICC) – An EOS facility, dedicated to a specific instrument, that plans and schedules instrument operations, generates and validates command sequences, provides the capability to forward commands and to store them for later transmission, monitors the health and safety of the instrument, and provides instrument controllers with status information of their instrument.

Instrument Control Facility (ICF) – A facility containing one or more EOS ICCs.

instrument data – Data specifically associated with an instrument, either because it was generated by the instrument or included in data packets identified with that instrument. Includes instrument science data, instrument engineering data, and, possibly, ancillary data (e.g., ephemeris, health, and safety).

instrument engineering data – Data produced by the engineering sensor(s) of an instrument, used to determine the physical state of an instrument in order to operate it, monitor its health, or aid in processing its science data.

instrument science data – Data produced by the science sensor(s) of an instrument, usually constituting the mission of that instrument.

International Partners – Signatories of the Space Station Memoranda of Understanding (MOUs), which established the initial funding for the international Polar Platforms program to monitor global change, including NASA, ESA, Japan, and Canada.

inventory – A uniform set of descriptions of granules from one or more data sets with information required to select and obtain a subset of those granules. Granule descriptions typically include

temporal and spatial coverage, status indicators, and physical storage information. An inventory may describe physical granules, logical granules, or both, including a mapping between them if they are not identical.

ionosphere — Rarified, ionized region of the Earth's atmosphere, between approximately 50 and 400 km.

level — See DATA PRODUCT LEVEL.

mantle — Layer of the Earth's interior between the core and crust.

measurement mode duty cycle — The fraction of available time during which an instrument is actively performing Earth measurements and producing meaningful data, including incidental calibration and overhead (such as scan retrace). High data rate, high power consumption, and steerable instruments may have small duty cycles. Daylight-only instruments will have measurement mode duty cycles averaging 50 percent. All other instruments will be designed for measurement mode duty cycles of 100 percent.

mesosphere — Region of the atmosphere between approximately 20 and 50 km.

metadata — Descriptive information pertaining to data sets. This information includes data set descriptions in directories, guides, and inventories, plus any additional information that defines the relationships among them.

nadir — Direction toward the center of the Earth. Opposite of zenith.

observatory — The observatory is composed of the payload, platform, and mission-unique equipments required to support the EOS mission. It includes propulsion, separation springs, and user interface equipment to the launch vehicle. It does not include support equipment.

operations — Within EOSDIS, those activities directly related to the acquisition, archival, distribution, and processing of mission-related information.

Pathfinder Data Set — A long-term, global Earth science data set produced from non-EOS data using community consensus algorithms as part of the EOSDIS Program. Selection of Pathfinder Data Sets is made by the EOS Program Office (in consultation with the IWG and the science community).

payload — The complement of instruments that are accommodated on a platform.

permanent archives – See active long-term archive.

platform – The complement of engineering subsystems required to support the mission, including structure, harnessing, and non-replaceable equipment.

platform engineering data – Data produced by the engineering sensor(s) of a platform, used to determine the physical state of the platform in order to operate it or monitor its health.

Principal Investigator (PI) – An individual who is contracted to conduct a specific scientific investigation. (An Instrument PI is the person designated by the EOS Program as ultimately responsible for the delivery and performance of standard data products derived from an EOS instrument investigation.)

Principal Investigator (PI) Instrument – An instrument selected pursuant to the EOS Announcement of Opportunity and provided by a PI and his home institution.

Product Generation System (PGS) – An EOS DAAC element that performs data processing functions, including routine generation of standard data products, routine generation of associated quick-look products, metadata, and browse data sets, reprocessing of data, and retrospective generation of new standard data products. In practice, a PGS should consist of the hardware and application software at a DAAC used for generating data products. The PGS at a DAAC may also provide computational support for research and special product trials.

Project Manager – The GSFC official who has overall responsibility for executing to completion the design, development, test, and operation of the Program within a given set of boundary conditions (technical, cost, schedule, and organization approach). The senior individuals in subordinate installations may also be titled Project Managers, but they are responsible to the GSFC Project Manager.

prototype data products – See EOS data products.

quick-look data – A data product, usually related to a Level 1 or higher standard data product, which is generated and distributed in near-real time.

raw data – See data product level.

reserve – That amount of a resource held by the EOS Program and Project to satisfy unanticipated requirements or objectives.

Science Computing Facility (SCF) – A facility supplied by the EOS Program to an EOS Team Leader (TL), Team Member (TM), or PI (instrument or interdisciplinary) for development and maintenance

of the algorithms and software used to generate standard data products; for quality control of standard data products; for in-flight instrument calibration and data set validation; for scientific analysis, modeling, and research; for generation of special data products; and as an interface to the investigator's institutional facilities.

signal-to-noise (S/N) ratio – For the Moderate Resolution Imaging Spectrometer (MODIS), the ratio between (1) typical cloud-free scene brightness with solar zenith angle Z=70° and (2) all sensor and processing noise contributions. S/N specifications for various scenes (e.g., land, clouds, oceans, and ice) are applicable only in the filter bands associated with those scenes.

special data products – See EOS data products.

standard data products – See EOS data products.

stratosphere – Relatively isothermal layer of the atmosphere between the troposphere and mesosphere.

support equipment – Equipment used to interface with the observatory to simulate the command and telemetry interface that will be present in the EOC and to provide additional status information that may be necessary in the integration and verification processes.

Team Leader (TL) – The person designated by the EOS Program as ultimately responsible for the delivery and performance of standard data products derived from an EOS FI.

Team Member (TM) – A person designated by the EOS Program to develop algorithms for standard data products derived from an EOS FI.

telemetry – A space-to-ground data stream of measured values (including instrument science data, instrument engineering data, and platform engineering data) that does not include command, tracking, computer memory transfer, audio, or video signals.

thermosphere – Outermost layer of the atmosphere, above the mesosphere.

Tracking and Data Relay Satellite System (TDRSS) – A constellation of NASA satellites and ground stations that track and relay data to and from low-altitude, Earth-orbiting satellites (including the Space Shuttle). This NASA system includes specialized communications satellites located in geosynchronous orbit both east and west of the continental United States (providing coverage of virtually the whole globe) and redundant TDRSS ground terminals at White Sands, New Mexico.

tropopause – Boundary between the upper troposphere and the lower stratosphere that varies in altitude between approximately 8 km at the Poles to 18 km at the Equator.

troposphere – Lowest atmospheric layer, between the surface and tropopause.

user – Any person accessing the EOSDIS. Authorized users are users who have viable EOSDIS accounts and who may therefore make EOSDIS data requests. These users may be affiliated or unaffiliated. Affiliated Users are those who are sponsored by one of the parties to the Earth Observations Intentional Coordination Working Group (EO-ICWG) data policy. Each party is responsible for ensuring that all its affiliated users comply with the EO-ICWG data policy. Use of data by affiliated users is classified in one of three categories, defined in the EO-ICWG data policy:

research use – A study or an investigation which the user affirms (1) aims to establish facts or principles; (2) where the data will not be sold or reproduced or provided to anyone not covered by this or another valid affirmation; (3) where the results of the research will be submitted for publication in the scientific literature; and (4) where detailed results of the research will be provided back to the sponsoring platform operator as agreed between the researcher and the sponsoring platform operator. In the context of EOSDIS, this means that NASA-affiliated users must make available to the research community their detailed results, including data, algorithms, and models, at the time their research is accepted for publication and that the data may be copied and shared among other researchers provided that either they are covered by a research agreement or the researcher who obtained the data from EOSDIS is willing to take responsibility for their compliance with the agreement.

Data for affiliated users, research and applications use, will be made available at no more than the marginal cost of reproduction and distribution.

environmental monitoring and operational use – Includes data use by those Government agencies affiliated with the parties that conduct environmental monitoring and/or operational observations for the public good. It can include larger agencies to which the parties belong (i.e., the World Meteorological Organization) or national agencies or their designates involved in other operational forecasting activities that are conducted for the public good (i.e., weather, sea state, sea ice, agriculture, hydrology, etc.).

Environmental monitoring and operational use of data constitutes any use of data to carry out a mandate of environmental observation and prediction as part of an agency's responsibilities to provide for the general welfare. Such use may include the routine downlink or direct broadcast of enhanced and unenhanced data in near-real time within the operational community.

Data for environmental monitoring and operational use shall be provided in real or near-real time without fee and shall be available through international EOS archives for non-real time users for no more than the marginal cost of reproduction and distribution consistent with the access terms for each instrument category.

other users — Those persons requesting data for scientific, operational, applications, or commercial use, who are not directly represented by an EO-ICWG member and who agree to the stipulations on data access and use as set by the EO-ICWG and the EOS Program.

version — EOSDIS versions described herein have been identified to represent major programmatic advances in the implementation of EOSDIS. System-wide updates to EOSDIS may occur in between versions to optimize the implementation process.

APPENDIX B

EOS PROJECT PLAN

GODDARD DISTRIBUTED ACTIVE ARCHIVE CENTER (DAAC) PLAN

APPENDIX B
EOS PROJECT PLAN

GODDARD DISTRIBUTED ACTIVE ARCHIVE CENTER (DAAC) PLAN

Purpose

The purpose of this plan is to describe the EOS Project support to be provided by the Goddard DAAC Facility (Code 902.2). The Goddard DAAC is responsible for the generation, management, and distribution of science data products related to Upper Atmosphere, Atmospheric Dynamics, Global Biosphere, and Geophysics.

Goddard DAAC Facility Responsibilities

The Goddard DAAC will provide line management, civil service staffing, and facility space to support the science data processing and product generation functions, applicable information management functions, and data product distribution and archive functions necessary to support the evolutionary implementation of EOSDIS, starting with V0 and continuing through V1.

V0, a working prototype, will be developed under the direction of the Goddard DAAC staff using a task order support services contract. The V0 system will be operational by the third quarter FY94. V0 data will then be phased into the V1 system.

The EOSDIS V1 system will be developed under the ECS contact under the direction of the EOSDIS Project with requirements, technical direction, and evaluation provided in part by Code 902.2 civil servant staff. The Goddard DAAC staff will also provide requirements, specification, and technical direction for Goddard DAAC specific development activities, also to be supported by the ECS contractor.

The EOSDIS Project will direct and fund the development, implementation, and operation of the Goddard DAAC. Annual plans will be submitted by the Goddard DAAC facility to the EOSDIS Project.

APPENDIX C

EOS PROJECT PLAN

DATA AND INFORMATION POLICY

APPENDIX C

EOS PROJECT PLAN
DATA AND INFORMATION POLICY

The EOS data policy is designed to be consistent with the U.S. National Data Policy and to further the EOS objectives of acquiring a comprehensive global, long-term data set; maximizing data utility for scientific purposes; and simplifying access to and analysis of EOS data. A common set of data exchange principles will cover the Japanese, European, and U.S. missions comprising of IEOS (see Section 2.2.3.2). In realizing this goal, NASA has adopted the following data policy:

- Data from EOS instruments will be acquired according to priorities recommended by IWG and EO-ICWG, and confirmed by NASA Headquarters.
- Where EOS sensors make site-specific observations, EOS will be an "acquire-on-demand" system. Data will only be taken in cases where there is an identified user who has requested and will analyze the data.
- All acquired EOS data will be processed at Level 0 or at a higher level from which Level 0 may be recovered.
- Raw data from instruments designated as having operational potential will be made available to NOAA as soon as they are received on the ground.
- Routine processing and reprocessing of EOS data by the EOS Project to standard products at Levels 2 and above will be done according to science requirements and using algorithms approved by IWG.
- Following the post-launch checkout period, all Level 0 data will be available within 24 hours of observation. Level 1 standard products will be processed and made available by EOSDIS within 24 hours after the Level 0 input data are available; Levels 2 and 3 standard products will be made available within 24 hours after receipt of the required input data. These higher level products will be archived.
- EOS data and products will be available to all users; there will be no period of exclusive access.
- All data requests will incur a modest charge consistent with the actual marginal costs of filling the request. This system will ensure reasonable allocation of EOSDIS resources, while not discouraging full use of EOS data. Data originating from U.S. provided elements will be available for all users on a non-discriminatory basis in terms of prices and timeliness. For internationally provided elements, data will be provided for uses other than research, applications demonstrations, and non-commercial operational public uses on the same scales and at non-discriminatory prices and terms to be

established by the relevant instrument provider and platform operator.

- EOSDIS will provide the capability for archiving and making available all science data products, models, algorithms, and documentation generated as part of the EOS mission. All products derived from EOS data provided for research purposes at the marginal cost of filling the user request, and which are the basis for refereed articles including models, algorithms, and associated documentation must be made available to the research community.
- EOSDIS will include and make available information about the data such as quality assessments, supporting literature references, and catalog and directory entries.
- EOSDIS project management, in consultation with IWG, will establish protocols and standards to encourage and facilitate data software exchange and interoperability.

Data from U.S. provided elements will be provided to all users on a non-discriminatory basis in accordance with OMB Circular A-130, which call for government information to be provided at the cost of dissemination without restrictions. Distribution of data from internationally provided elements will be based on the intended data use. Four general categories of users are expected to access EOS data: Researcher users, including U.S. Government-sponsored and other researchers; non-commercial operational use for the public benefit (e.g., NOAA and EUMETSAT); applications demonstrations (limited proof-of-concept resulting in a published technical report); and other users (primarily commercial)

Research Users. These users will be designated through an AO or similar mechanism based on a brief proposal describing the research activity. Designated research users, whether funded by the EOS Program or through other channels, must sign a "research agreement" and are granted access to the data appropriate for the proposed research from EOS and its international partner programs at no more than the marginal cost of filling the specific user request. The research agreement includes a brief description of the proposed research, and confirms that the data are to be used in a study or investigation for the following purposes.

a) That aims to establish facts or principles
b) Where that data may not be sold, and may be reproduced or provided only to other researchers covered by a research agreement and for whom the researcher takes responsibility
c Where the results of the research will be submitted for publication in the scientific literature
d) Where detailed results including data, algorithms, and models will be made available to the research community at the time they are accepted for publication

Public Sector Agency Users. Operational and environmental monitoring involves non-commercial routine use of data to carry out a mandate of environmental observation and prediction as part of an agency's responsibilities to provide for the general welfare. Such users include those Government agencies affiliated with the parties that conduct environmental monitoring. Operational agencies may obtain real-time access through their own direct readout facilities and/or via relay satellites, or as available from the appropriate data and information systems. Operational users may be asked to report periodically on their activities.

Application Demonstrations. Users who fall into this category are involved in limited proof-of-concept studies to demonstrate new techniques or to test the feasibility of operational applications. Results of applications demonstrations must be published as technical reports and provided to the data system that supplied the data. Data requests for applications demonstrations must include a brief proposal describing the intended use. Selected users will be required to sign an agreement confirming the data will be used only for the proposed applications demonstration, that the data will not be used for commercial purposes, that the data will not be reproduced or provided to third parties without permission, and that the results will be published as a technical report.

Commercial Users. Commercial agreements will be established for each non-U.S. sensor or data set to serve users who do not fit into one of the above categories. Procedures will be in place prior to EOS launch for commercial distribution of all IEOS data on a non-discriminatory basis for "other" users. Users of data from U.S. provided elements will have access on the same terms regardless of intended use.

The data exchange principles described above will ensure access to the full suite of international data and will be included in each of the bilateral MOUs that NASA will have with its international partners. A joint implementation plan is being developed to define the implementation of these principles in the participating agencies.

APPENDIX D

EOS PROJECT PLAN
POLICY FOR INCORPORATION OF DATA PRODUCTS INTO THE EOS PROJECT PLAN AND LEVEL 1 REQUIREMENTS

The EOS is being developed for the primary purpose of providing sustained Earth Science data sets to the research community to facilitate an evaluation of the Earth and its atmosphere as an integrated system. Although there are many sub-systems to EOS, the Standard Data Products which describe the scientific output of EOS are a key metric for overall system performance. These products are the end items which are the principal justification for the EOS development activity.

The EOS Project Plan documents the agreed to commitment by the PAA and the FID for accomplishment of the Program. The Project Plan contains the Level 1 Requirements which state the minimum system performance criteria committed to by the PAA and the FID. Therefore:

- Standard Data Products for approved instruments that are in design and development [Phase C/D; i.e., instruments for AM-1, PM-1, and TRMM (LIS)] are included as Level 1 Requirements in Tables 5-2, 6-2, and 7-5.

- Standard Data Products planned for EOS instruments which are not under a Phase C/D contract are included in Table D-1 of this appendix as planned Level 1 Requirements. These planned data products will be used for the current sizing of the EOSDIS.

- Another review of instrument-specific data products will be held at the time each instrument is approved for Phase C/D development to determine the final list of Standard Data Products to be incorporated as Level 1 Requirements.

A listing of all EOS data products, including science parameters, is contained in the EOS Science Plan (170-01-02).

Appendix D
EOS Planned Standard Data Products
AM Project

Instrument	Product Name	Units	Accuracy Abs :: Rel	Temporal Resolution	Horizontal Resol. :: Cover. *	Vertical Resol. :: Cover. **
EOSP	Level-1B Polarization	dimensionless	0.2% :: 0.1%	1/day [d]	10-70 km :: G	N/A :: N/A
	Level-1B Radiance	W/m^2/sr/µm	5% :: 1%	1/day [d]	10-70 km :: G	N/A :: N/A
	Aerosol Optical Thickness	dimensionless	0.05 :: 10%	1/day [d]	40 km :: G	Column :: Atmos
	Cloud Product			1/day [d]	40-100 km :: G	30 mb, Column :: Cloud
TES	Level-1B Radiance, TES [IR spectra in selected bands 2.3-15.4µm]	W/m^2/sr/µm	1% :: 1%	1/(4 day)	53 x 169 km :: G	
	CH4 Mixing Ratio	ppbv	:: 14-40 ppbv	1/(4 day)	53 x 169 km :: G	2-6 km :: 0-33 km
	CO Mixing Ratio	ppbv	:: 3-15 ppbv	1/(4 day)	53 x 169 km :: G	2-6 km :: 0-33 km
	HNO3 Mixing Ratio	pptv	:: 3 pptv	1/(4 day)	53 x 169 km :: G	2-3 km :: 0-33 km
	N2O Mixing Ratio	ppbv	:: 0.01-20 ppbv	1/(4 day)	53 x 169 km :: G	2-6 km :: 0-33 km

* G, R, and L represent Global, Regional, and Local Coverage, respectively.

** TOA, Trop, Atmos, and Sfc represent Top of Atmosphere, Troposphere, Atmosphere (Troposphere & Stratosphere), and Surface, respectively.

Note: These standard data products are preliminary pending negotiation and agreement with the responsible EOS investigators.

Appendix D
EOS Planned Standard Data Products
AM Project (Continued)

Instrument	Product Name	Units	Accuracy Abs :: Rel	Temporal Resolution	Horizontal Resol. :: Cover. *	Vertical Resol. :: Cover. **
TES	NO Mixing Ratio	pptv	:: 15-25 pptv	1/(4 day)	53 x 169 km :: G	2-3 km :: 0-33 km
	NO2 Mixing Ratio	pptv	:: 500 pptv	1/(4 day)	53 x 169 km :: G	2-3 km :: 0-33 km
	O3 Mixing Ratio	ppbv	:: 3-20 ppbv	1/(4 day)	53 x 169 km :: G	2-6 km :: 0-33 km
	Temperature Profile	K	2 K:: 0.2 K	1/(4 day)	53 x 169 km :: G	4-6 km :: 0-33 km
	H2O/HDO Mixing Ratio	ppmv	:: 0.5-50 ppmv	1/(4 day)	53 x 169 km :: G	2-6 km :: 0-33 km
	Land_sfc Brightness Temperature	K	1 K :: 0.1 K	1/(4 day)	53 x 169 km :: G	N/A :: Sfc
	Level 2 Detection Flags	none			53 x 169 km :: G	

* G, R, and L represent Global, Regional, and Local Coverage, respectively.

** TOA, Trop, Atmos, and Sfc represent Top of Atmosphere, Troposphere, Atmosphere (Troposphere & Stratosphere), and Surface, respectively.

Note: These standard data products are preliminary pending negotiation and agreement with the responsible EOS investigators.

Appendix D
EOS Planned Standard Data Products
Chemistry and Special Flight Projects - Aerosol Mission

Instrument	Product Name	Units	Accuracy Abs :: Rel	Temporal Resolution	Horizontal Resol. :: Cover. *	Vertical Resol. :: Cover. **
SAGE III	Level-1B Transmission Profiles (65 wave lenghts), Solar SAGE-III	dimensionless	0.05% :: 0.05%	1/(2 min), 30/day	200 x 2.5 km :: G	1 km :: 0-100 km
	Aerosol Extinction Profiles (at 7 wavelengths)	/km	5% :: 5%	1/(2 min), 30/day	<2 x <1 deg :: G	1 km :: 0-40 km
	Cloud Height, Top	km	0.2 km :: 5%	1/(2 min), 30/day	<2 x <1 deg :: G	0.5 km :: Strat/Trop
	H2O Conc & Mixing Ratio	Molecule/cc & ppmv	10% :: 15%	1/(2 min), 30/day	<2 x <1 deg :: G	1 km :: 3-50 km
	NO2 Conc & Mixing Ratio	Molecule/cc & ppbv	10% :: 15%	1/(2 min), 30/day	<2 x <1 deg :: G	1 km :: 10-50 km
	NO3 Conc and mixing ratio, Lunar	Molecule/cc &ppbv	10% :: 10%	1/(2 min), 30/day [n]	<2 x <1 deg :: G	1 km :: 20-55 km
	O3 Conc & Mixing Ratio	Molecule/cc & ppmv	6% :: 5 %	1/(2 min), 30/day	<2 x <1 deg :: G	1 km :: 6-85 km
	OClO Conc and mixing ratio, Lunar	Molecule/cc & ppbv	20% :: 20%	1/(2 min), 30/day [n]	<2 x <1 deg :: G	3 km :: 15-25 km
	Pressure	kPa	2% :: 2%	1/(2 min), 30/day	<2 x <1 deg :: G	1 km :: 6-70 km

* G, R, and L represent Global, Regional, and Local Coverage, respectively.

** TOA, Trop, Atmos, and Sfc represent Top of Atmosphere, Troposphere, Atmosphere (Troposphere & Stratosphere), and Surface, respectively.

Note: These standard data products are preliminary pending negotiation and agreement with the responsible EOS investigators.

Appendix D
EOS Planned Standard Data Products
Chemistry and Special Flight Projects - Aerosol Mission (Continued)

Instrument	Product Name	Units	Accuracy Abs :: Rel	Temporal Resolution	Horizontal Resol. :: Cover. *	Vertical Resol. :: Cover. **
SAGE III	Temperature Profile	K	2 K :: 2K	1/(2 min), 30/day	<2 x <1 deg :: G	1 km :: 6-70 km

* G, R, and L represent Global, Regional, and Local Coverage, respectively.

** TOA, Trop, Atmos, and Sfc represent Top of Atmosphere, Troposphere, Atmosphere (Troposphere & Stratosphere), and Surface, respectively.

Note: These standard data products are preliminary pending negotiation and agreement with the responsible EOS investigators.

Appendix D
EOS Planned Standard Data Products
Chemistry and Special Flight Projects - Altimetry Mission

Instrument	Product Name	Units	Accuracy Abs :: Rel	Temporal Resolution	Horizontal Resol. :: Cover. *	Vertical Resol. :: Cover. **
GLAS	Level-1B Product, Atmosphere	mm				
	Aerosol Vertical Structure			1/(2-16 day)	2-100 km :: G	
	Cloud Height For Multiple Layers	m	75 m ::	1/(2-16 day)	0.2-10 km :: G	N/A :: Cloud
	Ice Sheet Elevation	mm	200 mm (single measurement up to 3 deg surface slope)	1/yr	175 m (Along Track) x 5 km (Cross Track) :: Land/Cryo	N/A :: Cryo
	Ice_Sheet Roughness (R)	m	10% R ::	1/mo	50 km :: Land/Cryo	N/A :: Cryo
	Thin Cloud/Aerosol Optical Depth	dimensionless	20% ::	1/(2-16 day)	2-100 km :: G	N/A :: Atmos
	Land Topography	m	1-5 m (single measurement) ::	1/yr	175 m (Along Track) x 15 km (Cross Track) :: Land	N/A :: Sfc
	Altimetry Sensor Data Record	dB	:: 0.25 dB		0.35 km :: Earth	N/A :: Sfc
	Altimetry Geophysical Data Record				7 km :: Ocean	N/A :: Sfc

* G, R, and L represent Global, Regional, and Local Coverage, respectively.

** TOA, Trop, Atmos, and Sfc represent Top of Atmosphere, Troposphere, Atmosphere (Troposphere & Stratosphere), and Surface, respectively.

Note: These standard data products are preliminary pending negotiation and agreement with the responsible EOS investigators.

Appendix D
EOS Planned Standard Data Products
Chemistry and Special Flight Projects - Altimetry Mission (Continued)

Instrument	Product Name	Units	Accuracy Abs :: Rel	Temporal Resolution	Horizontal Resol. :: Cover. *	Vertical Resol. :: Cover. **
GLAS	Sea_sfc Topography Map	cm	5 cm or 10% ::	1/(10 day)	25 km :: Ocean	N/A :: Sfc
SSALT	Altimetry Sensor Data Record	dB	:: 0.25 dB		0.35 km :: Earth	N/A :: Sfc
	Altimetry Geophysical Data Record				7 km :: Ocean	N/A :: Sfc
	Sea_sfc Topography Map	cm	5 cm or 10% ::	1/(10 day)	25 km :: Ocean	N/A :: Sfc

* G, R, and L represent Global, Regional, and Local Coverage, respectively.

** TOA, Trop, Atmos, and Sfc represent Top of Atmosphere, Troposphere, Atmosphere (Troposphere & Stratosphere), and Surface, respectively.

Note: These standard data products are preliminary pending negotiation and agreement with the responsible EOS investigators.

Appendix D
EOS Planned Standard Data Products
Chemistry and Special Flight Projects - Chemistry Mission

Instrument	Product Name	Units	Accuracy Abs :: Rel	Temporal Resolution	Horizontal Resol. :: Cover. *	Vertical Resol. :: Cover. **
ACRIM	Irradiance, Solar, Total	W/m^2	0.1% :: 0.0005%.	1/2 min		NA :: TOA
HIRDLS	Level-1B Product	W/m^2/sr			400 km :: G	
	Aerosol Extinction Coef (4 channels)	/km	5-10% :: 1-10%	2/day [d,n]	400 km :: G	1 km :: 5-60 km (given accuracies for 7-30 km)
	CFC-11(CFCl3) Conc	mixing ratio	5-10% :: 1-10%	2/day [d,n]	400 km :: G	1 km :: 5-50 km (given accuracies for 7-30 km)
	CFC-12(CF2Cl2) Conc	mixing ratio	5-10% :: 1-10%	2/day [d,n]	400 km :: G	1 km :: 5-55 km (given accuracies for 7-30 km)
	CH4 Conc	mixing ratio	5-10% :: 1-10%	2/day [d,n]	400 km :: G	1 km :: 5-65 km (given accuracies for 7-65 km)
	ClONO2	mixing ratio	5-10% :: 3-15%	2/day [d,n]	400 km :: G	1 km :: 15-65 km
	Cloud Top Properties			2/day [d,n]	400 km :: G	
	Geopotential Height-Gradient	m/km	0.04m/km :: 0.04m/km	2/day [d,n]	400 km :: G	1 km :: 5-80 km (given accuracies for 15-80 km)

* G, R, and L represent Global, Regional, and Local Coverage, respectively.

** TOA, Trop, Atmos, and Sfc represent Top of Atmosphere, Troposphere, Atmosphere (Troposphere & Stratosphere), and Surface, respectively.

Note: These standard data products are preliminary pending negotiation and agreement with the responsible EOS investigators.

Appendix D
EOS Planned Standard Data Products
Chemistry and Special Flight Projects - Chemistry Mission (Continued)

Instrument	Product Name	Units	Accuracy Abs :: Rel	Temporal Resolution	Horizontal Resol. :: Cover. *	Vertical Resol. :: Cover. **
HIRDLS	H2O Conc	mixing ratio	5-10% :: 1-10%	2/day [d,n]	400 km :: G	1 km :: 5-70 km (given accuracies for 7-70 km)
	HNO3 Conc	mixing ratio	5-10% :: 1-10%	2/day [d,n]	400 km :: G	1 km :: 5-50 km (given accuracies for 10-40 km)
	N2O Conc	mixing ratio	5-10% :: 1-10%	2/day [d,n]	400 km :: G	1 km :: 5-70 km (given accuracies for 7-60 km)
	N2O5 Conc	mixing ratio	5-10% :: 1-10%	2/day [d,n]	400 km :: G	1 km :: 10-65 km (given accuracies for 15-45 km)
	NO2 Conc	mixing ratio	5-10% :: 3-10%	2/day [d,n]	400 km :: G	1 km :: 5-65 km (given accuracies for 10-55 km)
	O3 Conc	mixing ratio	5-10% :: 1-10%	2/day [d,n]	400 km :: G	1 km :: 5-80 km (given accuracies for 7-80 km)
	Temperature/Pressure Profile			2/day [d,n]	400 km :: G	
MLS	Level-1B Radiance, MLS	K	<3% :: <3%	2/day [d,n]	1.3 x 2.5 deg :: 82N-82S	2 km :: 0-80 km
	Level-2 Data, MLS [Constituents, T, P, Geopotential Height]					

* G, R, and L represent Global, Regional, and Local Coverage, respectively.

** TOA, Trop, Atmos, and Sfc represent Top of Atmosphere, Troposphere, Atmosphere (Troposphere & Stratosphere), and Surface, respectively.

Note: These standard data products are preliminary pending negotiation and agreement with the responsible EOS investigators.

Appendix D
EOS Planned Standard Data Products
Chemistry and Special Flight Projects - Chemistry Mission (Continued)

Instrument	Product Name	Units	Accuracy Abs :: Rel	Temporal Resolution	Horizontal Resol. :: Cover. *	Vertical Resol. :: Cover. **
SAGE III	Level-1B Transmission Profiles (65 wave lenghts), Solar SAGE-III	dimensionless	0.05% :: 0.05%	1/(2 min), 30/day	200 x 2.5 km :: G	1 km :: 0-100 km
	Aerosol Extinction Profiles (at 7 wavelengths)	/km	5% :: 5%	1/(2 min), 30/day	<2 x <1 deg :: G	1 km :: 0-40 km
	Cloud Height, Top	km	0.2 km :: 5%	1/(2 min), 30/day	<2 x <1 deg :: G	0.5 km :: Strat/Trop
	H2O Conc & Mixing Ratio	Molecule/cc & ppmv	10% :: 15%	1/(2 min), 30/day	<2 x <1 deg :: G	1 km :: 3-50 km
	NO2 Conc & Mixing Ratio	Molecule/cc & ppbv	10% :: 15%	1/(2 min), 30/day	<2 x <1 deg :: G	1 km :: 10-50 km
	NO3 Conc and mixing ratio, Lunar	Molecule/cc &ppbv	10% :: 10%	1/(2 min), 30/day [n]	<2 x <1 deg :: G	1 km :: 20-55 km
	O3 Conc & Mixing Ratio	Molecule/cc & ppmv	6% :: 5 %	1/(2 min), 30/day	<2 x <1 deg :: G	1 km :: 6-85 km
	OClO Conc and mixing ratio, Lunar	Molecule/cc & ppbv	20% :: 20%	1/(2 min), 30/day [n]	<2 x <1 deg :: G	3 km :: 15-25 km
	Pressure	kPa	2% :: 2%	1/(2 min), 30/day	<2 x <1 deg :: G	1 km :: 6-70 km

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Note: These standard data products are preliminary pending negotiation and agreement with the responsible EOS investigators.

Appendix D
EOS Planned Standard Data Products
Chemistry and Special Flight Projects - Chemistry Mission (Continued)

Instrument	Product Name	Units	Accuracy Abs :: Rel	Temporal Resolution	Horizontal Resol. :: Cover. *	Vertical Resol. :: Cover. **
SAGE III	Temperature Profile	K	2 K :: 2K	1/(2 min), 30/day	<2 x <1 deg :: G	1 km :: 6-70 km
SOLSTICE	Level-1B Irradiance	W/m^3	10% :: N/A	4/day	2 deg :: G	1 km :: 0-100 km
	Solar UV Irradiance, [1 nm res.]	W/m^3	3-5% :: 1%	1/hr	N/A :: N/A	N/A :: NA

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Note: These standard data products are preliminary pending negotiation and agreement with the responsible EOS investigators.

Appendix D
EOS Planned Standard Data Products
Chemistry and Special Flight Projects - Color

Instrument	Product Name	Units	Accuracy Abs :: Rel	Temporal Resolution	Horizontal Resol. :: Cover. *	Vertical Resol. :: Cover. **
COLOR	Pigment Concentration, "CZCS"	mg/m^3	100% (Global), 35% (Case I, Clear Atmos) :: TBD	1/day, 1/wk, 1/mo	1, 20 km :: Ocean/G, R, L	N/A

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** TOA, Trop, Atmos, and Sfc represent Top of Atmosphere, Troposphere, Atmosphere (Troposphere & Stratosphere), and Surface, respectively.

Note: These standard data products are preliminary pending negotiation and agreement with the responsible EOS investigators.

Appendix D
EOS Planned Standard Data Products
Flights of Opportunity

Instrument	Product Name	Units	Accuracy Abs :: Rel	Temporal Resolution	Horizontal Resol. :: Cover. *	Vertical Resol. :: Cover. **
CERES	Bi-Directional Scan (BDS) Radiance	W/m^2/sr	1-2% :: 0.005	1/6.6 sec	25 km :: G	N/A :: TOA
	ES-8 ERBE-Like Product			1/6.6 sec	25 km :: G	N/A :: TOA
	ES-9 ERBE-Like Product	W/m^2		1 & 24/mo [Avg]	2.5 x 2.5 dg :: R,G	N/A :: TOA
LIS	Level-1A Product	counts	:: 2.4 x 10^-4	1/2 ms	3.5 km :: G	
	Level-1 Lightning Product			1/2 ms	0.07 dg :: Tropics	N/A :: Atmos

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** TOA, Trop, Atmos, and Sfc represent Top of Atmosphere, Troposphere, Atmosphere (Troposphere & Stratosphere), and Surface, respectively.

Note: These standard data products are preliminary pending negotiation and agreement with the responsible EOS investigators.