Clouds and the Earth's Radiant Energy System (CERES)

Data Management Plan

June 1990

Preface

This Data Management Plan is not a stand-alone document. It must be viewed in the context of the entire CERES project documentation. While an overview of the science and instrument objectives are included here, the CERES Execution Phase proposal provides the science rationale for the mission and a more comprehensive discussion of the instrument design. Similarly, the design and implementation of the CERES Data Management System is planned for more detailed documentation as described in Appendix A.

TABLE OF CONTENTS

TABLE OF CONTENTS (cont'd)

Section | Page

TABLE OF CONTENTS

TABLE OF CONTENTS (cont'd)

Section | Page

List of Tables

1.0 Introduction

The Clouds and the Earth's Radiant Energy System (CERES) experiment is designed to provide the NASA Earth Observing System (EOS) with a consistent data base of accurately known fields of radiation and clouds which will increase our understanding of the Earth as a system. The EOS Program is driven by two major objectives: (1) to acquire essential, global Earth science data on a long term basis; and (2) to provide the Earth science research community with efficient and reliable access to a complete set of data from U.S. and international platforms through the EOS Data and Information System (EOSDIS). The CERES experiment contributes significantly to both objectives. The first is fulfilled by the CERES measurements of the global distribution of the energy input to and the energy output from the Earth. CERES satisfies the second objective by providing data products from the three separate platforms within the EOSDIS environment. The data products include CERES Scanner Data, Instantaneous Clouds and Radiation Data, Synoptic Clouds and Radiation, and Daily and Monthly Averaged Data. CERES provides data required to understand the relative importance of different cloud processes and their interaction with the Earth's climate. These data allow definition of trends in the clear-sky fluxes and the impact of clouds on the Earth's climate and radiation budget. They will also be fundamental data for experiments in long-range weather forecasting and climate prediction.

The CERES project management and implementation responsibility is at NASA Langley Research Center (LaRC). Three other EOS instrument experiments are also being conducted by LaRC: the Stratospheric Aerosol and Gas Experiment III (SAGE III), the Tropospheric Radiometer for Atmospheric Chemistry and Environmental Research (TRACER), and the Spectroscopy of the Atmosphere Using Far Infrared Emission (SAFIRE). An EOSDIS Distributed Active Archive Center (DAAC) will be located at LaRC with a Central Data Handling Facility (CDHF) and a Data Archival and Distribution System (DADS) for radiation and upper atmosphere data.

The purpose of the CERES Data Management Plan is to describe the manner in which the CERES instrument data will be acquired, processed, and archived for access by the scientific community. The CERES Data Management System will include acquisition, integration, and processing of all other relevant instrument data, ancillary input, and product tracking data. While the global CERES instrument data products address most of the cloud and climate studies, the CERES interdisciplinary science investigation will produce more intensive regional data products. The Data Management Plan addresses the acquisition and processing for both the instrument and interdisciplinary science data. This plan is presented in five sections: introduction, experiment description, data flow and processing, computer resources and software tools, and the organizational structure and implementation approach. A complete list and description of the CERES Data Management System documentation and other related documentation to be developed is provided in Appendix A. A list of abbreviations and acronyms is contained in Appendix B.

Section 2.0 provides a description of the CERES experiment including the mission objectives and overview, the instrument design, and the in-flight instrument operations and calibration.

Section 3.0 describes the entire data flow from its origin at the instrument on the platform to the science product archival and distribution. An overview of the processing system is provided within the context of EOSDIS. The Data Flow and Processing Section includes input data and algorithm requirements and sources, such as CERES instrument, platform, ancillary, and test data. Major aspects of the CERES data management system are described, including on board data handling and transmission, ephemeris data handling, the LaRC data processing system within EOSDIS, and data traceability.

Section 4.0 discusses the computer hardware and software environment anticipated for the EOS era. The hardware aspects include communications network and data interfaces between EOSDIS and LaRC facilities, data rates and volume, and computational and storage requirements. Illustrations and descriptions of the existing LaRC computer resources are provided. Estimates of processing requirements are tabulated in terms of lines of job control and source code and computer processor storage and operations.

Section 5.0 provides the top level LaRC EOS Project organizational structure including the CERES Project and the Science and Data Management Teams. The responsibilities of the Science Team and Data Management Team members are identified. The approach for implementing the data processing system is described for the definition, prelaunch execution, and postlaunch execution phases of the project. Task descriptions are provided for the major Data Management Team functions. These functions include: input data interface specification, science algorithm design and development, operational processing system design and implementation, processing system and data product validation, output product management and archival, computer resource integration and management, and documentation.

The Data Management Plan is based on the current understanding of the EOS mission, EOSDIS, and the CERES project, and assumptions have been made in areas which have not yet been fully defined. Subsequent documents associated with the project will provide the specific details regarding the data interfaces, processing algorithms, output products, instrument design and calibration, and science investigations as they are developed through the project life cycle.

2.0 Experiment Description

2.1 Science and Mission Overview

The CERES experiment will help reduce one of the major uncertainties in predicting long-term changes in the Earth's climate: how clouds affect the flow of radiant energy through the Earth-atmosphere system. Radiant fluxes at the top of the Earth's atmosphere (TOA) were measured by the Earth Radiation Budget Experiment (ERBE), not merely as an undifferentiated field, but with reasonable separation between fluxes originating from clear and cloudy atmospheres. We learned from ERBE that clouds have a greater effect on the TOA fluxes than was previously believed, but details of the processes are not yet understood. The CERES experiment will provide a better understanding of how different cloud processes, such as convective activity and boundary-layer meteorology, affect the TOA fluxes. This understanding will help determine the radiative flux divergence, which enters directly into physically based, extended-range weather and climate forecasting. CERES will also provide information to determine the surface radiation budget, which is important in atmospheric energetics, studies of biological productivity, and air-sea energy transfer.

The CERES instruments will extend the record of accurate radiance measurements that was begun by the ERBE instruments. Radiance measurements from the CERES instrument will be complemented by data from other instruments aboard the EOS platforms, and CERES data processing will take advantage of meteorological and climatological data from near-polar and geostationary satellites operated by the National Oceanic and Atmospheric Administration (NOAA). Cloud properties required in CERES data processing are determined from high resolution spectral radiances obtained with the Moderate Resolution Imaging Spectrometer (MODIS) and the equivalent high resolution instruments that will fly on EOS platforms. Algorithms used to determine the radiative flux divergence within the atmosphere use measured cloud properties and gridded temperatures and humidity profiles provided by NOAA.

A pair of CERES instruments will fly on the NASA Sun synchronous Polar Orbiting Platform (EOS-A) (Figure 2-1), another pair will fly on the Space Station Freedom, and one instrument will fly on the European Space Agency (ESA) platform (also in a Sun synchronous orbit). CERES instruments on the two polar platforms provide spatial sampling of the Earth's radiative energy at high latitudes and at four different local times at low and mid latitudes. The Space Station Freedom will fly in a low inclination (28.5 degrees) orbit with a precessional period of the line of nodes of about 24 days. This platform provides sampling as a function of local time in the low and mid latitudinal bands, which receive maximum solar input and have a large variability in radiation output.

One instrument on each platform normally operates at a fixed azimuth beam position for cross-track scanning. Cross-track scanning provides maximum spatial sampling coverage and assures continuity with measurements from the ERBE scanner instruments. The second CERES instrument on a platform takes measurements while the azimuth beam rotates back and forth between two angles 180 degrees apart. Data from the rotating azimuth instrument provides angular

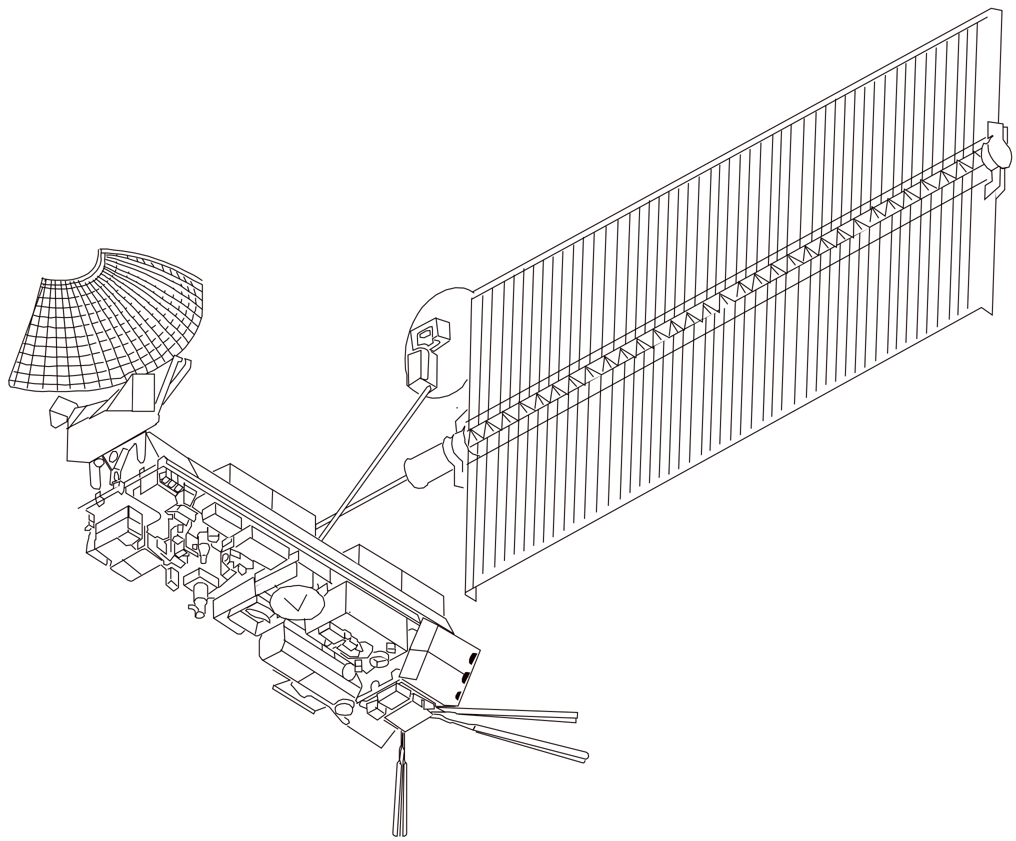


Figure 2-1. NASA Polar Orbiting Platform, EOS-A

sampling for improving Angular Dependence Models (ADM's) of the Earth's radiation field. This sampling will help reduce directional modeling errors which occur during CERES data processing.

2.2 Instrument Design

The CERES instrument (Figure 2-2) draws heavily on ERBE heritage, both in design and in the way the instruments are operated in flight. The proposed radiometer sensor system consists of three co-aligned broadband thermistor bolometer detectors, each with an active and a compensating flake. The three proposed detectors are identical except for optical filters on two detectors (longwave and shortwave) which restrict their spectral ranges to a portion of the Earth's radiation bandwidth. The spectral ranges and spatial fields-of-view proposed for the three detectors are given in Table 2-1. Smaller detector fields-of-view and a reduction in aliasing effects increase the resolution of the CERES instruments over that of ERBE. More importantly, the CERES instrument will have a significant reduction in the electronic noise output by the detectors.

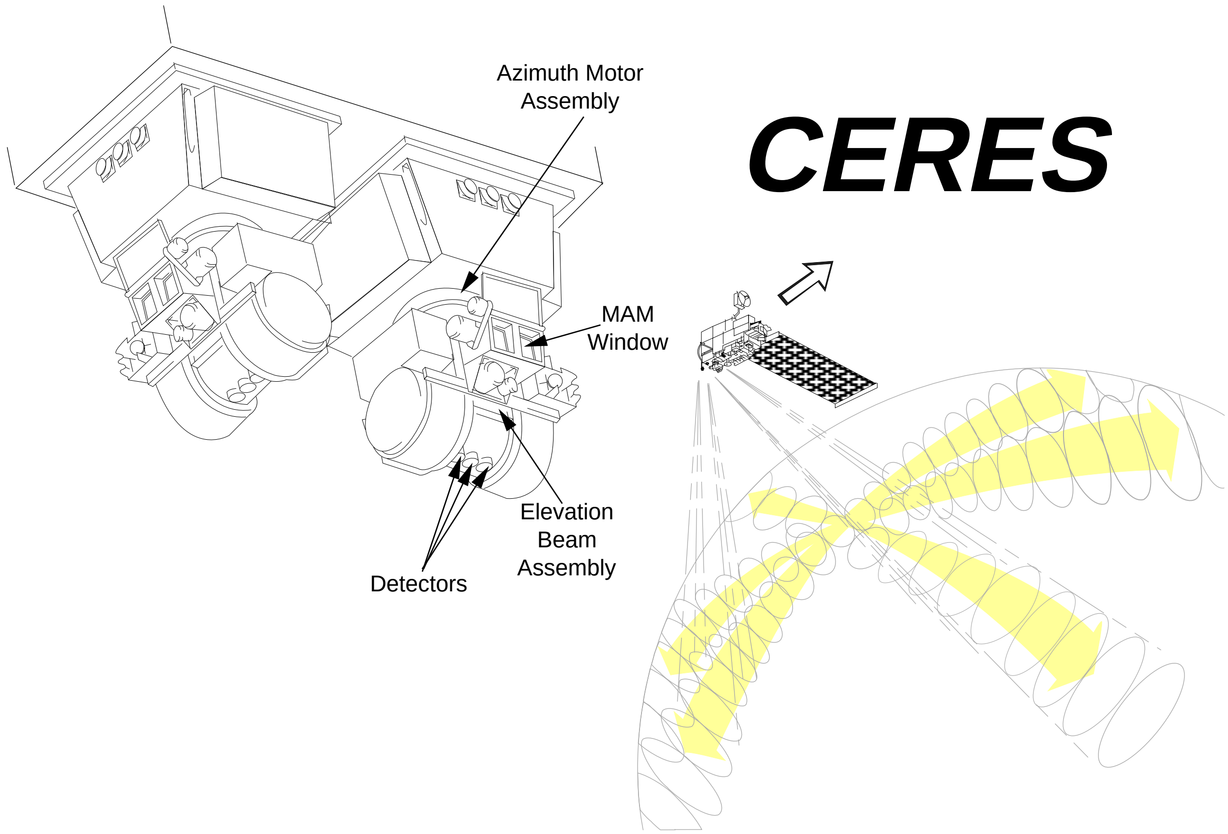


Figure 2-2. Proposed CERES Instrument

Table 2-1. Spectral Ranges and Fields-of-View of Proposed CERES Detectors

DETECTOR	SPECTRAL RANGE (Microns)	FIELD-OF-VIEW (Degrees)
Total	0.3 - 50.0	2.3 X 3.4 hexagon
Shortwave	0.3 - 3.5	2.3 X 3.4 hexagon
Longwave	8.0 - 12.0	2.3 X 3.4 hexagon

Internal calibration sources consist of blackbodies for calibrating the longwave and total radiometric detectors and a Shortwave Internal Calibration Source (SWICS) for calibrating the shortwave detectors. An additional calibration source, the Mirror Attenuator Mosaic (MAM), reflects attenuated, diffuse solar energy and will significantly increase the CERES instrument's calibration capabilities.

An instrument can scan while the azimuth beam is positioned at a fixed azimuth angle or while the azimuth beam rotates back and forth between any two azimuth angles. The proposed instrument design employs a bidirectional scan cycle in which the elevation beam rotates at the same speed in both rotation directions (see Figure 2-3(a) and 2-3(b)). A complete scan period (both scan directions) is 6.0 seconds, and each detector is sampled 100 times per second in all scan modes. In a normal Earth scan mode (Figure 2-3(a)) the detectors view space two times (once on each side of the instrument) and view the internal calibration sources one time. Sun avoidance modes are included, which limit the scan beam position to angles below the Earth's horizon on one side of the instrument when the Sun is in a position to be viewed by the detectors between the Earth and spacecraft horizons. Sun sensors detect the position of the Sun and automatically direct the instrument to switch to a Sun-avoidance mode of operation. In the solar scan mode, (Figure 2-3(b)) used during solar calibration, the detectors view the attenuated output of the Sun in the MAM window, the internal calibration sources, and space during each 6.0 second scan cycle.

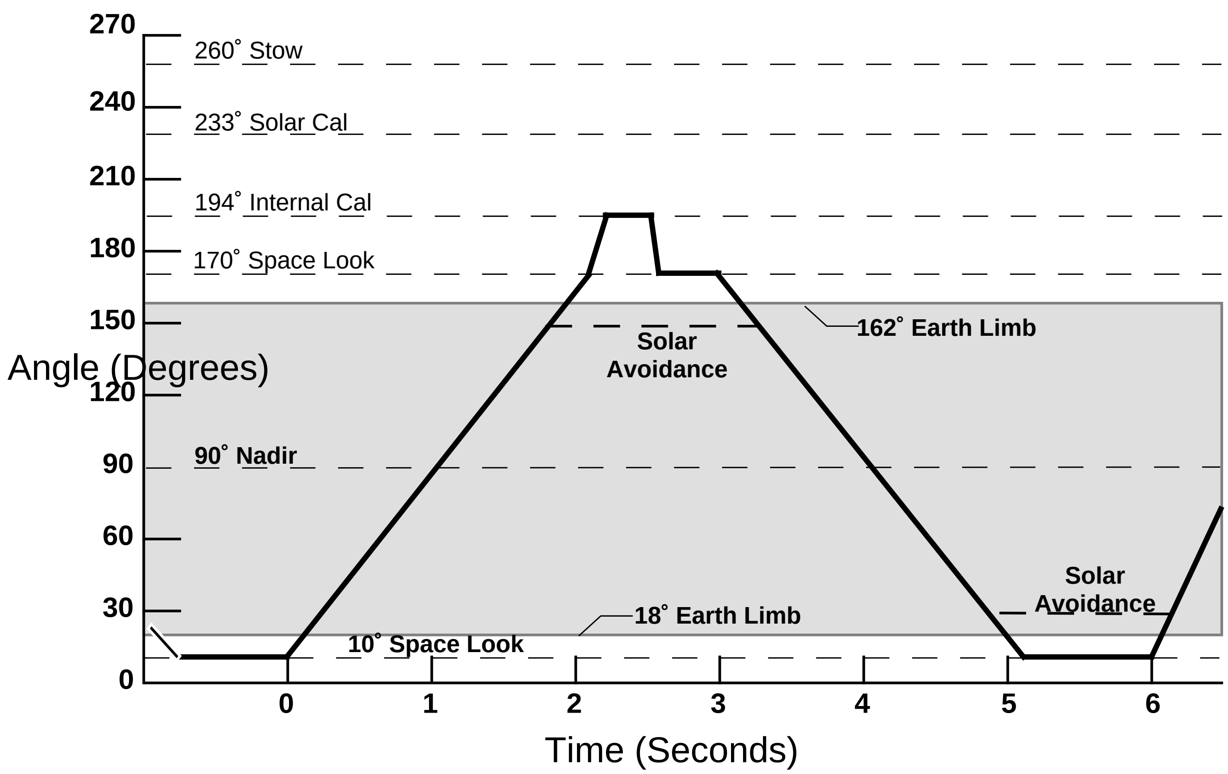


Figure 2-3(a). Scan Profiles of Proposed CERES Instrument - Earth Scan Mode

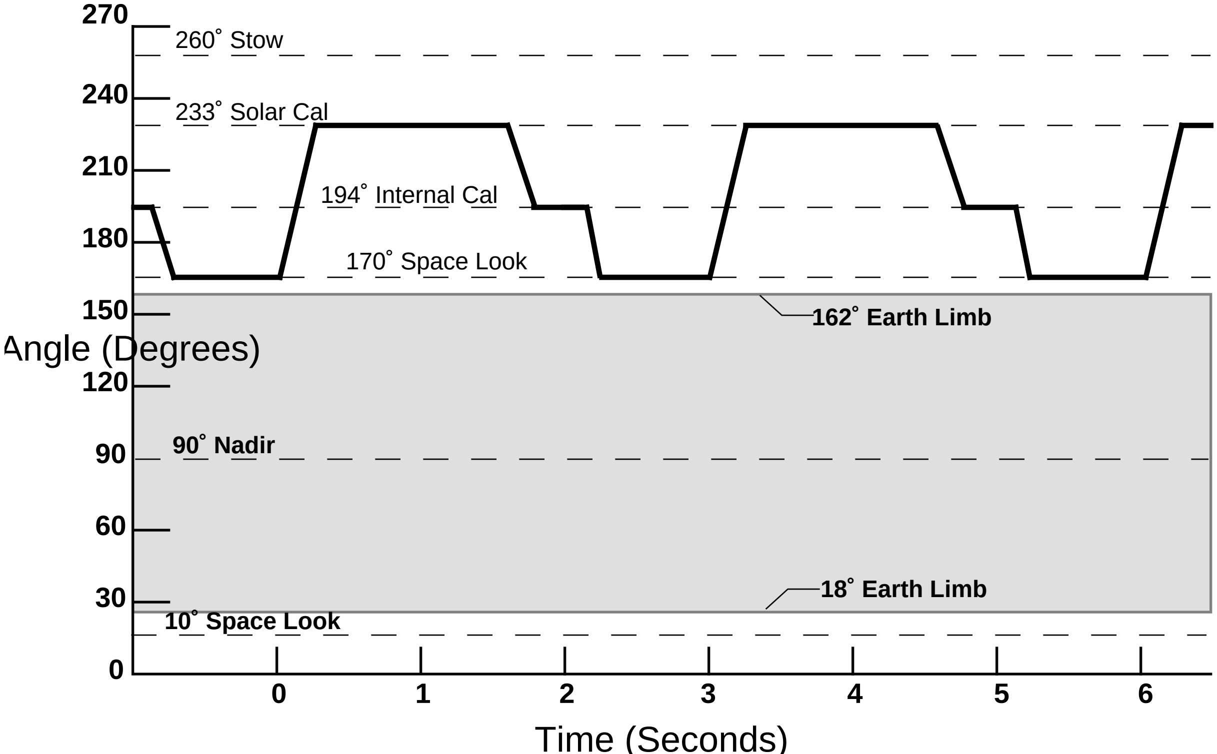


Figure 2-3(b). Scan Profiles of Proposed CERES Instrument - Solar Calibration Mode

Each CERES instrument will have dedicated computers for controlling and directing instrument operations. These operations include formatting instrument data output, changing and directing mode operations, and executing stored sequences of commands, such as those required for instrument calibration. All instrument commands can be executed by direct command to the computer or from commands stored in the platform computer memory. The computer is reprogrammable by ground commands to permit restoration of command tables and to add new command sequences or to modify old ones.

2.3 In-Flight Operations and Calibrations

In flight, all CERES instruments operate routinely in the normal Earth scan mode (see Figure 2-3(a)). In this mode, measurements are made as the elevation beam scans in each direction across the Earth, at the space position on both ends of the scan, and at the internal calibration position. The elevation rotation motion of the rotating azimuth instrument is interrupted when the instrument is directed into a Sun-avoidance scan mode. The requirement for Sun-avoidance occurs when the Sun is in the scan plane and between the horizons of the Earth and platform. While in the Sun-avoidance mode, the internal calibration and space measurements are eliminated on the Sun-side of the spacecraft.

3.0 Data Flow And Processing

One primary objective of the EOS Program is to provide the Earth science research community with easy, affordable, and reliable access to the full suite of Earth science data from the U.S. and international partner platforms through the EOS Data and Information System, EOSDIS. EOSDIS will support a series of processing and distribution centers, also known as Distributed Active Archive Centers, (DAAC) for science data. One of the DAAC sites for processing EOS data will be located at LaRC. The DAAC consists of a Central Data Handling Facility (CDHF) and a Data Archive and Distribution System (DADS). The DADS is the data storage and distribution element of the DAAC. It also stages the data required by the CDHF processing. The CDHF is the data ingest and processing element of the DAAC. The CDHF conducts the routine processing of CERES standard data products and the quick-look processing of priority data. The DADS stores CERES data sets for the lifetime of the EOSDIS project, provides remote and local access to the data, and distributes data to the users.

The CERES Data Management System will both use and supply data products within the EOSDIS environment. This section describes the requirements and sources for input data and algorithms, the data processing necessary to produce usable global and regional science products, and the dissemination and archival of the science products. This section also discusses methods for maintaining the DADS inventory and for controlling data access. Figure 3-1 illustrates an overview of the flow of data from the point of data acquisition on the in-orbit platforms to the point of data products dissemination. The flow of required auxiliary data from NOAA is also shown.

3.1 Requirements and Sources For Input Data and Algorithms

The design, testing, and implementation of the CERES Data Processing System require extensive amounts of input data and algorithms. Table 3-1 lists the types of input data and algorithms required and the organizations which will provide the information. Most of the algorithms and much of the data are generated by the CERES Science Team, but external organizations are the source of some algorithms and several types of data. The subsystem numbers in Table 3-1 identify the subsystems in the CERES processing system where the algorithms and data are required. These processes are explained in Section 3.2. The CERES Science and Data Management Teams will document procedures for obtaining the required information. The documents will include specification of data format and content, storage requirements, and method of access. Some of the documentation is in the form of interface agreements between the CERES Data Management Team and those organizations (both internal and external) which provide the data or algorithms. These agreements also define procedures for making timely modifications to the input data and algorithms.

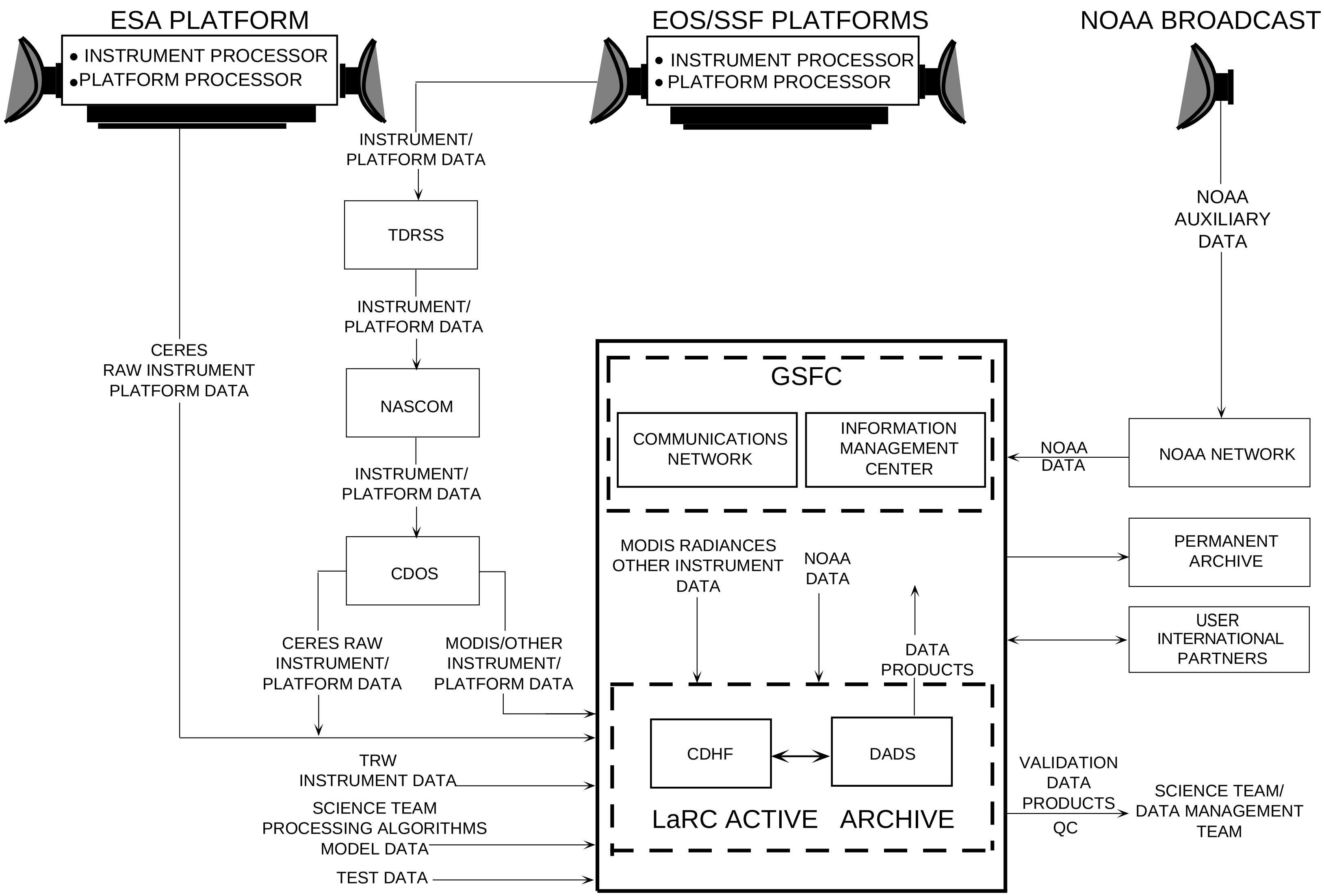


Figure 3-1. Overall CERES Data Flow from Acquisition through Dissemination

Table 3-1. CERES Data, External Sources (1 of 2)

CERES DATA	SOURCE	SUBSYSTEM NUMBER***
CERES LEVEL 0 AND PLATFORM DATA		
CERES Instrument Data (Radiometric & Housekeeping)	CDOS	1
Platform Data (Attitude & Housekeeping)	CDOS	1
Ephemeris Data (Platform & Solar)	CDOS/FDF	1
ASUXILIARY DATA		
High Resolution Cloud Image Data (MODIS or Equivalent)	EOSDIS	5
GOES Radiance Data	EOSDIS	5
Cloud Liquid Water/Precipitation (HIMSS or equivalent)	EOSDIS	5
Snow/Ice Map	EOSDIS/NOAA	3, 5, 6
Temperature, Humidity	EOSDIS/NOAA	5 - 7
Gridded Winds and Geopotential	EOSDIS/NOAA	7
Carbon Dioxide	EOSDIS/NOAA	5
Ozone, Aerosols	EOSDIS/NOAA	5, 6
Surface Topography	EOSDIS	5, 6
Surface Albedo	EOSDIS/ScTeam*	5, 6
Surface Temperature (Ocean, Land)	EOSDIS	5
Land Surface Emissivity	EOSDIS	5
PROCESSING ALGORITHMS		
Reformat, Evaluate Data Quality	Sc/DMTeam**	1 - 7
Instrument/Platform Operational Status	Sc/DMTeam	1, 5
Merge Data Streams	Sc/DMTeam	1, 5
Convert/Edit Platform/Instrument Data	TRW/Sc/DMTeam	1
Analyze Calibration/Special Events	Sc/DMTeam	1, 5
Calculate Measurement Locations	Sc/DMTeam	1
Science Identification	Sc/DMTeam	3, 5
Reduce Data to TOA Flux	Sc/DMTeam	3, 5
Cloud Retrieval	Sc/DMTeam	5
Surface Flux	Sc/DMTeam	6
Flux Divergence	Dc/DMTeam	6
Average over Time and Space	Sc/DMTeam	4, 7
ALGORITHM INPUT DATA		
Housekeeping Conversion Parameters	TRW/ScTeam	1
Count Conversion Coefficients	TRW/ScTeam	2
Special Correction Coefficients	TRW/ScTeam	3
Angular Dependence Models	ScTeam	3, 5

Table 3-1. CERES Data, External Sources (2 of 2)

CERES DATA	SOURCE	SUBSYSTEM NUMBER***
Directional/Diurnal Models	ScTeam	4
Clear Sky Spectral Albedos	ScTeam	5
Geotype Map	ScTeam	5
Point Spread Function	ScTeam	5
Radiative Transfer Models	ScTeam	5, 6
TEST DATA		
Instrument Test Data	TRW/ScTeam	
NOAA-9/ERBE/AVHRR/HIRS/AMSU	LaRC	
FIRE/GOES/SRB	LaRC	

*ScTeam : Science Team
**DMTeam : Data Management Team

3.1.1 CERES Level 0 and Platform Data

The EOS data products are defined in terms of "levels." Level 0 is the raw instrument and EOS housekeeping data produced by the Customer Data and Operations System (CDOS). The CERES project defines the detailed requirements and specifications for CERES Level 0 instrument data, EOS platform housekeeping data, and platform and solar ephemeris data. Data interface control agreements will be negotiated with TRW (the instrument contractor), the EOS project, and CDOS.

3.1.2 Auxiliary Science Data

The cloud retrieval algorithms require higher resolution data than the CERES instruments provide. These data will be acquired from other instruments aboard the EOS platforms. Data from MODIS-N on EOS-A and equivalent instruments on the ESA and Space Station Freedom platforms will be accessible from the EOSDIS network. GOES data covering selected 10 degree by 10 degree regions on an hourly basis are required for the interdisciplinary regional cloud retrieval process. Cloud liquid water, water vapor, and precipitation rate from the HIMSS or equivalent instrument will be available from EOSDIS. The CERES Science and Data Management Teams will work with representatives from these high resolution instrument projects to insure the timely availability of the data required by CERES.

Several other sets of ancillary EOSDIS data are required in the CERES data processing. Meteorological data include temperature and humidity profiles, wind fields at standard pressure levels, ozone, aerosols, and snow and ice maps. Climatological data include carbon dioxide and surface type geographic maps, such as surface topography and surface albedo. Most of these data are provided to the EOSDIS network by NOAA. EOSDIS is responsible for documenting a description of the data sets and how they can be accessed. The CERES Science and Data

Management Teams will also work with the cognizant NOAA organizations to specify the CERES data requirements.

3.1.3 Processing Algorithms

Software based on the ERBE Data Management System is used where practical for processing CERES data, and new software is developed and tested as required. The CERES Science Team and Data Management Team share the responsibility for the development of all algorithms required to process the CERES data. Documentation is developed to describe the details of the algorithms and their timely delivery to the Data Management Team. However, some of the algorithms, such as those required to convert CERES instrument and EOS platform housekeeping data, are specified by external organizations. TRW specifies the preliminary algorithms for converting raw CERES measurements to radiances at the platform altitude, and the EOS platform contractors specify algorithms for platform housekeeping data conversion. ERBE-type algorithms developed by the Science Team are used to invert the radiances to fluxes at the top of the Earth's atmosphere. New algorithms needed for cloud retrieval and for calculating flux divergence and surface flux have not been tested operationally, and their development and testing will be given high priority by the Science and Data Management Teams.

3.1.4 Input Data For Algorithms

TRW provides preliminary coefficients and other input data required for converting raw instrument housekeeping and radiometric data. TRW and the Science Team provide the inputs required to define the instrument point spread function. The Science Team supplies the scene identification information, spectral coefficients, and angular dependence models required to invert the measured radiances to a reference altitude. The Science Team also provides a dynamic map of clear sky spectral albedos, a static geotype map based on ERBE experience, and the radiative transfer models. EOSDIS provides the surface topography and surface albedo. Written interface agreements will be negotiated between the Data Management and Science Teams, TRW, and EOSDIS which specify the content and format for each of these input data sets.

3.1.5 Test Data

The CERES Science Team and Data Management Team develop data sets to support algorithm testing during each phase of the development life cycle. TRW provides data to validate the instrument modeling algorithms, and data from FIRE and GOES are used to validate specific CERES algorithms. ERBE, AVHRR, and HIRS data from the NOAA-9 spacecraft are used to create simulated sets of CERES/MODIS data for end-to-end testing of the CERES processing system.

3.2 Major Phases In CERES Data Handling and Processing

This section is an overview of the major phases in handling and processing CERES data from the point of platform data acquisition to the production and dissemination of science data products at the DAAC (see Figure 3-1). The discussion is divided into two major sections, data flow prior to entry into the EOSDIS network, and flow inside the EOSDIS network.

3.2.1 Processing of CERES Data Outside the EOSDIS Environment

As shown in Figure 3-1, a significant amount of data processing is performed outside the EOSDIS system. Operation of the EOS platforms and instruments and the flow of data from the platforms is controlled by EOSDIS. However, all uplink and downlink data are transmitted through the Tracking and Data Relay Satellite System (TDRSS) and the NASA Communications (NASCOM) networks. CDOS, which performs processing vital to the success of the EOS mission, is also outside the EOSDIS environment.

3.2.1.1 Handling of CERES Data On Board the Platforms and Transmission to CDOS

A packetized telemetry and telecommunications system will be used by EOS. Platform computers format data from the instruments and platform subsystems into packets of serial digital data for transmission through the TDRSS and NASCOM networks to CDOS. A data packet is a unit of data which is appended with a reference time and information which identifies the type, format, content, and period of the data.

3.2.1.2 Generation of CERES Level 0 Data by CDOS

At CDOS, the packets of data for a specific instrument or platform subsystem are stripped out of the transmitted data and a set of time-ordered level 0 data are created and transmitted to the CDHF. All the data (science and housekeeping) from each CERES instrument is combined in a data set, and platform housekeeping and ephemeris data are in separate data sets. Requirements for the CERES level 0 data sets are discussed in Section 3.1.1.

3.2.2 Processing of CERES Data In the EOSDIS Environment

EOSDIS documents provide information on the overall flow and handling of all data within the EOSDIS network. This section is an overview of the CERES processing system at the DAAC. A detailed description of the processing system will be published during the prelaunch execution phase by the Data Management Team. Figure 3-2 illustrates the processing flow of data through the major processes of the data processing system. The subsystem numbers in Table 3-1 refer to the processes in Figure 3-2 which require the associated data and algorithms. The horizontal processing flow shown in Figure 3-2 follows the ERBE processing system and requires similar algorithms and input data. The vertical processing flow is new for CERES and requires new algorithms and input data. The prefix CERES/ERBE is used to describe ERBE-like algorithms,

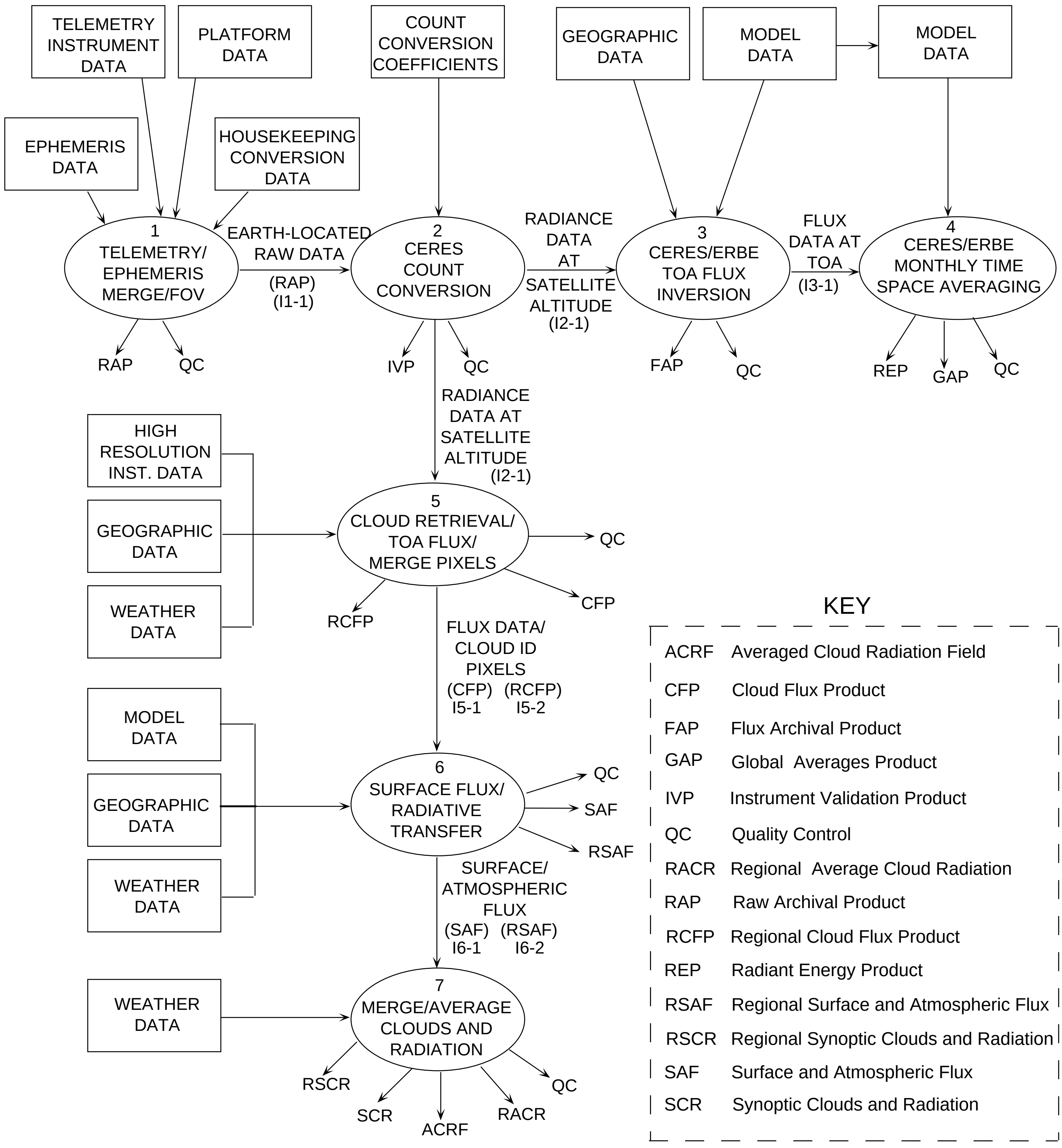


Figure 3-2. Langley CERES Data Processing System Overview

data, and processing; CERES/Original is used to describe those newly developed for the CERES Data Management System.

One of the major tasks in the CERES Data Processing System is to control and coordinate the data flow through the processing system represented in Figure 3-2. This coordination requires a close working relationship between the people responsible for the different subsystems. Data accounting procedures are implemented to track the data through the system and to help identify problem areas and bottlenecks in the system. When data enters the CDHF data processing environment, the data are cataloged and stored in the DADS until needed for further processing.

3.2.2.1 Telemetry, Ephemeris, and Merge/FOV

The first major processing of the CERES data is performed in Subsystem 1: Telemetry, Ephemeris, Merge, and Field-of-View (TEMFOV). TEMFOV functions include data reformatting; quality evaluation; converting instrument housekeeping data; editing instrument, ephemeris, and platform data; and calculating detector pointing vectors in a local horizon system. TEMFOV also merges the telemetry data with the ephemeris and platform housekeeping data, and calculates the location (latitude and longitude) of the measurements on a reference surface above the Earth's atmosphere. An analysis to verify the accuracy of the measurement location calculations is performed.

CERES/ERBE algorithms and data inputs are used in much of the TEMFOV processing. However, new algorithms are required for instrument status determination, data quality evaluation, and calibration data evaluation. The Data Management and Science Teams work closely to insure that the TEMFOV processing requirements are properly specified and implemented. This understanding is especially important in design and operation of the CERES instruments. Extensive quality evaluation of the data is performed. Quality evaluation plots and quality reports designed to highlight probable errors detected during TEMFOV processing are produced routinely and will be accessible on the EOSDIS network. The Data Management Team produces documentation which describes how to access and interpret the quality evaluation data.

TEMFOV processing directly evaluates and analyzes data from calibrations and other special events. The processing includes routine quality evaluation of calibration data to detect instrument and operational problems and to determine if calibrations need to be rescheduled. Analysis and evaluation of the calibration data are performed, leading to the early determination of detector calibration coefficients. As a minimum, the TEMFOV processing detects whether calibration coefficients have changed significantly since the last calibration.

The primary output data product of TEMFOV processing is the Raw Archival Product (RAP), which is the equivalent of the scanner instrument data on the ERBE Raw Archival Tape (RAT). The format and final contents of the data are defined by members of the TEMFOV, Count Conversion, and Inversion Subsystem Teams. The specification for the output data is documented by the CERES Data Management Team for other users on the EOSDIS network. The contents of the primary output data of TEMFOV Processing are listed in Table 3-2.

Table 3-2. Sl-l; Il-l Raw Archival Product (RAP)

DATA DESCRIPTION
Universal Time for each data record
Raw radiometric data measurements for each detector
Detector pointing data (azimuth and elevation angles for each measurement)
Platform attitude and other housekeeping data
Platform and Sun position in Celestial coordinate system
Earth locations of measurements (latitude, longitude, along-track, cross-track)
Calculated detector pointing vectors in a local horizon coordinate system
Instrument status
Instrument housekeeping data
Quality evaluation and editing information (each data item)

3.2.2.2 CERES Count Conversion

The CERES Count Conversion process converts the raw radiometric measurements to filtered radiances in engineering units. TRW produces algorithms for converting the raw data and coefficients for the conversion equations based on ground test and calibration of the detectors. The Science Team evaluates data from on board calibrations, and verifies and adjusts the calibration coefficients as required.

The count conversion process produces the calibration data product: CERES/ERBE Instrument Validation Product (IVP), and an intermediate product (I2-1). A data description for the IVP is shown in Table 3-3 and the description of I2-1 is shown in Table 3-4. The intermediate product, I2-1, continues on two separate processing paths as shown in Figure 3-2. The path to the right leads to the CERES/ERBE Inversion and Averaging and the vertical path leads to CERES/Original processing, which includes the algorithms for cloud property determination, flux divergence, and advanced interpolation and averaging techniques.

Table 3-3. V2-1 Instrument Validation Product (IVP)

DATA DESCRIPTION
Universal Time for each data record
Raw and converted values and flags for radiometric data measurements for each detector
Raw and converted values and flags for spacecraft and instrument housekeeping data
Spacecraft position, velocity, and attitude data
Field-of-view locations and viewing angles for each measurement

Table 3-4. I2-1 Preprocessed Archive Product

DATA DESCRIPTION
Universal Time for each data record
Converted values and flags for radiometric data measurements for Earth-view for each detector
Spacecraft position, velocity, and attitude data
Field-of-view locations and viewing angles for each Earth-view measurement

The Count Conversion Subsystem produces quality reports (Q2-1), which provide statistics for all converted radiometric measurements categorized by operational mode and radiation source. Counters for various conditions detected during the processing run and for failures of various edit checks are included. Each set of statistics accumulated for the edited converted radiometric values over a 24-hour period is written to a file (V2-2), which is appended to a monthly data base. When a month's worth of data is accumulated in the data base, the monthly trends are plotted.

3.2.2.3 CERES/ERBE TOA Flux Inversion

The radiance data at satellite altitude (I2-1) is further processed to produce a flux for each measurement at the reference altitude or TOA. The data inversion is dependent on the Earth surface features, the extent of cloudiness, the relative geometry of the platform, the Sun, and the measurement location geometry. The appropriate spectral correction coefficients are selected to unfilter the scanner measurements from the shortwave, longwave, and total channels. The observed scene is determined by a scene identification algorithm based on these unfiltered measurements using Angular Dependence Models (ADMs) provided by the Science Team. Estimates of the flux at the reference altitude are computed based on scene information, geometrical considerations, the ADMs, and the unfiltered measurements.

The output from the CERES/ERBE TOA Inversion Subsystem includes the CERES/ERBE Flux Archival Product (FAP) and an internal product (I3-1), which contains inverted scanner data for use by the CERES/ERBE Monthly Time and Space Averaging Subsystem. The internal product contains a set of statistics for 1.25 x 1.25 degree geographic regions accumulated within the same hour. The data on the FAP are described in Table 3-5 and the contents of the internal product are shown in Table 3-6..

Table 3-5. S3-l Flux Archival Product (FAP)

DATA DESCRIPTION
Universal time for each data record
Spectrally corrected (unfiltered) radiances at platform altitude
Instantaneous scene type (cloud cover and underlying geography)
Instantaneous estimates of flux densities at reference altitude (TOA)
Spacecraft position and velocity data
FOV locations and viewing angles for each Earth-view measurement

Table 3-6. I3-1 TOA Flux Inverted Data

DATA DESCRIPTION
Region number and scene type
Average Universal time
Estimate of average, minimum, and maximum SW and LW at TOA
Number of SW and LW estimates; SW and LW standard deviation
Scene fraction and albedo of clear sky, partly cloudy, mostly cloudy, and overcast in 1.25 degree region
Average of cosine (solar zenith angle), average of zenith angle, average of relative azimuth angle from target point
Standard deviation of SW albedos and of clear sky LW
Average of clear sky LW, number of clear sky LW

3.2.2.4 CERES/ERBE Monthly Time and Space Averaging

The final step in the CERES/ERBE processing is to obtain daily and monthly averages of the TOA fluxes. The estimates of flux from CERES/ERBE Inversion are sorted into a regional data base for each month. The individual measurements are rounded to the nearest hour and put into "binned" hour boxes for each 1.25 x 1.25 degree region. These binned data are used to produce monthly-daily and monthly averages for each hour of shortwave and longwave fluxes at the top-of-the-atmosphere. Two grand monthly averages (averages of the monthly-daily and monthly-hourly averages) for each geographic region are also produced. Determination of the averages requires the use of the diurnal models supplied by the Science Team.

The monthly and daily hour box averages are output to the CERES/ERBE Earth Radiant Exitance and TOA Albedo Product (REP). The key output data values are shown in Table 3-7. The monthly daily values are monthly means based on daily averages of flux. The monthly hourly values are monthly means based on values averaged over the month at each local hour. The daily values are calculated for each day in the month. The hourly values are calculated at each local hour.

Table 3-7. S4-l Radiant Exitance Product (REP)

DATA DESCRIPTION
Region number, scene type, and scene fraction
Hourly averages of radiant exitance for each day within each region.
Monthly daily, monthly hourly, daily, and hourly statistics for each radiometric channel including number of measurements, mean value, minimum, maximum, and standard deviation.

Regional, zonal, and global averages are calculated for each platform and for combinations of platforms at varying resolutions and are output to the CERES/ERBE Regional, Zonal, and Global Averages Product (GAP) as shown in Table 3-8. The regional averages from the 1.25 degree resolution are nested into 2.5 degree regions. The zonal averages are data from all the regions in a 1.25 or 2.5 degree latitudinal band that can be accumulated..

Table 3-8. S4-2 Regional, Zonal, and Global Averages Product (GAP)

DATA DESCRIPTION
Region Number, Date, Platform
Monthly daily, monthly hourly, daily, and hourly averages for each of the following: total solar incidence SW, LW, NET flux and albedo Clear sky

3.2.2.5 CERES Cloud Pixel Retrieval, CERES TOA Inversion, and Merge with Scan Pixels

One of the CERES goals is to simultaneously observe clouds and the Earth's radiation fields to determine the feedback effect of clouds on climate. The radiation data is the CERES data output from the Count Conversion Subsystem (I2-1). The cloud data is retrieved from EOS higher spatial and spectral resolution instruments (MODIS or equivalent) on the same platforms that carry the CERES scanner instruments. The preliminary cloud retrieval algorithms use a LW and SW threshold technique for cloud retrievals, along with the 15 micron band carbon dioxide radiances, to improve cirrus detection. Refined algorithms supplied by the Science Team include spatial coherence, hybrid bi-spectral threshold, and texture analysis for further improving cloud property retrievals.

While the global CERES instrument data products will address most of the cloud and climate studies, there will be a need for more intensive regional data sets over limited time periods. These data are needed for validation of the global data products, for regional process and climate studies, and to support regional field experiments. Regions 10 degrees latitude by 10 degrees longitude will be used. Examples are the Saudi Arabian desert, stratocumulus clouds off the west coast of the U.S., Indonesian tropical convection, the Indian monsoon, and tropical convection over Brazil. These regions will be finalized in concert with other EOS Interdisciplinary science groups. Some of the regions will be dynamically selectable to allow coordination with future field experiments. Within each of these regions, the regional intensive data will:

- Use full resolution MODIS data (not sampled as for the global data).
- Produce top, surface, and atmosphere radiation budget for each CERES pixel (global product is for 1.25 degrees latitude/longitude regions).
- Use geostationary data for regions within view of GOES or Meteosat to improve the diurnal sampling, thereby reducing the error of daily averaged cloud and radiative budget data.

The format of these output products will be similar to the global products, but on finer time and space scales.

The next step is the derivation of top of atmosphere flux estimates for the global and regional data products. The CERES/Original derivation differs from the CERES/ERBE determination discussed in Section 3.2.2.3 in two ways. First, more complete and accurate cloud properties derived primarily from MODIS (or equivalent) data are used to determine the appropriate cloud conditions for each CERES scanner pixel. Second, the angular dependence models used are from a more complete set, which is derived using the rotating azimuth plane CERES scanner data in conjunction with the cloud identification. The CERES/Original TOA flux estimates should be a substantial improvement over the CERES/ERBE estimates due to more advanced ADMs for a more complete set of cloud conditions. Also, the cloud spatial structure, cloud fraction, and cloud height improve the estimate of the outgoing radiative fluxes. The high resolution scan lines of clouds and cloud properties are merged with the CERES radiances and TOA fluxes, forming the Instantaneous Cloud and Flux Pixel product (CFP), or the Regional Cloud and Flux Pixel product

(RCFP). The CFP and RCFP are also the internal products (I5-1 and I5-2), which are passed on to the next subsystem. The key parameters on the CFP for each CERES Pixel are shown in Table 3-9 and those for the regional product are shown in Table 3-10.

Table 3-9. S5-l; I5-l Cloud Flux Product (CFP)

DATA DESCRIPTION
For each CERES pixel
Universal time
Filtered radiances TOT, SW, LW at platform altitude
Unfiltered radiances TOT, SW, LW at platform altitude
SW and LW fluxes at TOA
Colatitude and longitude
Viewing and solar zenith angle
Viewing azimuth angle
For each cloud layer
Fractional cloud cover within CERES footprint
Cloud top and bottom altitude
Shortwave and longwave cloud optical depth
Cloud average droplet radius
Liquid/solid cloud particle phase
Cloud and spatial structure class
Texture class

Table 3-10. S5-2; I5-2 Regional Cloud Flux Product (RCFP) (1 of 2)

DATA DESCRIPTION
For each 10 degree by 10 degree region, hourly
For each CERES pixel or GOES 0.312 degree region
Universal time
Filtered radiances TOT, SW, LW at platform altitude
Unfiltered radiances TOT, SW, LW at platform altitude
SW and LW fluxes at TOA
Colatitude and longitude
Viewing and solar zenith angle
Viewing azimuth angle
For each cloud layer
Fractional cloud cover within CERES footprint/GOES region
Cloud top and bottom altitude
Shortwave and longwave cloud optical depth

Table 3-10. S5-2; I5-2 Regional Cloud Flux Product (RCFP) (2 of 2)

DATA DESCRIPTION
Cloud average droplet radius
Liquid/solid cloud particle phase
Cloud and spatial structure class
Texture class

3.2.2.6 Surface Flux and Radiative Transfer

The shortwave TOA net fluxes contained in the global and regional Cloud Flux Products are used to compute the shortwave surface flux at the Earth's surface, using algorithms, estimations of surface albedo, and emissivity which are provided by the Science Team. The individual CERES pixels are averaged to produce a spatially averaged structure.

The next step is to calculate the instantaneous radiative flux profile within the atmosphere. The cloud structure temperature and humidity profiles are used to produce the SW and LW flux distribution at standard levels in the atmosphere, at the tops and bottoms of the identified clouds, and at the surface. The upward and downward flux components within the vertical structure of the atmosphere are taken into account by defining cloud layers. This subsystem deals with overlapping cloud layers by identifying dominant and subordinate layers.

The third step of the flux divergence process is consistency checking. The surface and atmosphere fluxes are integrated to obtain predicted TOA fluxes, which are compared with the measured TOA fluxes as a consistency check. Depending upon the discrepancies found from these checks within any geographic region, the surface albedo, cloud optical depth, water vapor, and surface emissivity properties are adjusted. Using the adjusted properties, the flux divergences and surface budget are recomputed, producing an instantaneous geographic product containing adjusted surface and atmospheric fluxes (SAF). Some of the key parameters contained on the SAF and the regional product, RSAF, are shown in Tables 3-11 and 3-12.

Table 3-11. S6-1; I6-l Surface and Atmospheric Flux (SAF) S7-1
Synoptic Adjusted Cloud/Radiation Field (SCR) (1 of 2)

DATA DESCRIPTION
For each 1.25 x 1.25 degree region:
Number of cloud layers
Fraction of area in overlapped cloud layers
For each cloud layer, the average of the cloud output parameters
The average of cloud output parameters

Table 3-11. S6-1; I6-l Surface and Atmospheric Flux (SAF) S7-1 Synoptic Adjusted Cloud/Radiation Field (SCR) (2 of 2)

DATA DESCRIPTION
SW and LW surface fluxes; net, up, and down
Adjusted surface emissivity
For each standard atmospheric layer:
SW and LW flux difference
Input temperature profile
Input and adjusted humidity profile
Adjusted SW and LW optical depth
Adjusted condensed water areal density

Table 3-12. S6-2; I6-2 Regional Surface and Atmospheric Flux (RSAF) S7-2 Regional Synoptic Adjusted Cloud/Radiation Field (RSCR)

DATA DESCRIPTION
For each 10-degree by 10-degree region, hourly
For each CERES pixel or GOES 0.312 degree region
Number of cloud layers
Fraction of area in overlapped cloud layers
For each cloud layer, the average of the cloud output parameters
The average of cloud output parameters SW and LW surface fluxes: net, up, and down Adjusted surface emissivity
For each standard atmospheric layer:
SW and LW flux difference
Input temperature profile
Input and adjusted humidity profile
Adjusted SW and LW optical depth
Adjusted condensed water areal density

3.2.2.7 Merge/Average Clouds and Radiation

The clouds and radiation fields produced by the previous processing in the form of instantaneous, geographic averages are now averaged over time. All of the variables are reduced to an assumed time at the midpoint of an 1.5-hour time interval, which is approximately one orbit. The regional data from different platforms are merged together, providing coverage of geographic areas with complete vertical structure at the midpoint of 1.5-hour time intervals in the observed regions for each platform. Since there will be regions that have no observations, the missing portions of the maps will be filled in by interpolation. The gridded temperature, humidity, and wind products will be interpolated to the CERES Adjusted Cloud Radiation Field times. An estimate of cloud locations can be predicted from the previous observations of clouds, winds, temperature, and humidity fields. Operationally produced wind fields will also allow cloud field interpolation. The product will contain filled-in spatially empty map regions. Thus, there are estimates over the entire globe for each 1.5-hour time interval. Flags accompanying the data distinguish between measured or interpolated data. The parameters shown in Table 3-11 are averaged and then interpolated to the map times 0, 6, 12, and 18 hours to form the Synoptic Adjusted Clouds and Radiation (ACR) archival product. The regional archival product (RACR), is shown in Table 3-12.

Finally, a process similar to CERES/ERBE Monthly and Time Space Averaging described above is performed, producing the global and regional Time Averaged Cloud and Radiation Field archival products (ACRF) and RACR. The ACRF contains the monthly daily, monthly hourly, daily, and monthly averages of the cloud and radiation parameters for each 1.25 x 1.25 degree region, for each 1.25 degree latitudinal zone, and on a global basis as shown in Table 3-13.

Table 3-13. S7-3 Time Averaged Cloud and Radiation Field (ACRF)
S7-4 Regional Time Averaged Cloud and Radiation Field (RACR)

DATA DESCRIPTION
Region Number, Date, Platform
Monthly daily, monthly hourly, daily and hourly averages for each of the following:
The average of cloud output parameters
SW and LW surface fluxes: net, up, and down
Adjusted surface emissivity
For each standard atmospheric layer:
SW and LW flux difference
Input temperature profile
Input and adjusted humidity profile
Adjusted SW and LW optical depth
Adjusted condensed water areal density

Each of the subsystems produce printed reports and summaries, plots, color graphics, and data files, in addition to the validation, intermediate, and archival products discussed.

3.2.3 Data Flow Traceability

Data traceability within EOSDIS and throughout the CERES data processing system is essential. The DAAC interfaces with the Information Management Center (IMC) Cataloging System. Meta data describing all data products, quality control reports, and science algorithms that reside in the DADS are included in the catalog system. The cataloging information enables the user to determine the availability of data and to order data.

A common physical header format established by EOSDIS for all data products establishes standardization among the many users and producers of the data. EOSDIS also specifies the format of the data accountability information that each Active Archive provides to the Information Management Center. The data accountability system provides information concerning the location of any data within the data handling system, generates accountability reports, maintains an historical record of processing, and provides summary reports. In addition, the Data Management Team establishes and implements procedures and data base management systems in accordance with EOSDIS standards to handle the volume of data input to and generated by the CERES Project. Storage and handling of this data is the function of the Active Archive at LaRC.

3.2.3.1 Incoming Data Base

Data external to the CERES data processing system must be accounted for as it is received. The CERES Data Management Team will design an incoming data base system which records the type of data received, data date, date received, source agency, date generated, storage medium, and platform identification. The data will be given a product label which can be cross-referenced with any products.

3.2.3.2 Active Archive Data Base

All data produced by the CERES data processing system are automatically cataloged into an active archive data base. As each data set is processed, attribute and accountability information is compiled, including product label, instrument name, platform identification, data starting and ending times, processing level, processing date, version number, number of records processed, and the percentage of data processed successfully.

This information forms the basis of the inventory data base maintained by the IMC Cataloging System. All data product descriptions, processing summary reports, and algorithms are available to the user.

3.2.3.3 Outgoing Data Base

Catalog data for all data transmitted by the CERES Data Management System is recorded in an outgoing data base. The catalog data contains information similar to the incoming data base for each validation and archival data product, reports, and algorithms that are distributed to the user community.

3.2.3.4 Graphics and Printed Products Library

EOSDIS will maintain data on-line for two years for remote users to access interactively. In addition, copies of output graphics and quality reports will be retained on microfiche by the CERES Data Management Team, and a library will be maintained.

3.3 Data Distribution and Archival

The data products produced by the CERES Data Management System will provide EOS with a consistent data base of accurately known fields of radiation and clouds. The previous section presented the key parameters contained in each standard data product and a discussion of the algorithms used to produce the product. This section summarizes the data products produced along with a plan for distributing the products to EOSDIS.

3.3.1 Data Products

The CERES Data Management System will produce various output products for the Science Team, for the Data Management Team, and for archival in EOSDIS. The data products are categorized as science products (S#), validation products (V#), internal or intermediate products (I#), and quality control products (Q#), where the # represents the subsystem number that produces the product.

3.3.1.1 Science Products

The 12 science products listed in Table 3-14 are selected to address the science requirements of the CERES project and for their potential usefulness to the science community. Four of the standard CERES data products are direct descendents of the ERBE products: The Raw Archival Product (RAP), the Flux Archival Product (FAP), the Radiant Exitance Product (REP), and the Global monthly Average Product (GAP). Eight of the standard data products are new to the CERES investigation: four global instrument products and four regional interdisciplinary products. The instantaneous Cloud radiation Flux Product (CFP, RCFP) combines high resolution data for cloud identification with the broadband fluxes from the CERES instruments. The Surface and Atmospheric Flux Product (SAF, RSAF) and the Synoptic adjusted Cloud and Radiation field product (SCR, RSCR) provide the best estimates of synoptic cloud and radiation fields throughout the atmosphere, based on all available satellite information used in the CERES processing. The fourth new product is a monthly average of the cloud and radiation fields (ACRF, RACR).

Table 3-14. Science Products

ID CODE	DESCRIPTION	SUB SYS	PLATFORM	FREQ	SIZE (MB)
S1-1	Raw Archival Product (RAP)	1	Each	Daily	65
S3-1	Flux Archival Product (FAP)	3	Each	Daily	72
S4-1	Radiant Exitance Product (REP)	4	Comb	Monthly	40
S4-2	Regional, Zonal, and Global Averages Product (GAP)	4	Each Comb	Monthly	30
S5-1	Cloud Flux Product (CFP)	5	Each	Daily	115
S5-2	Regional Cloud Flux Product (RCFP)	5	Comb	Daily	15
S6-1	Surface and Atmospheric Flux (SAF)	6	Each	Daily	140
S6-2	Regional Surface and Atmospheric Flux (RSAF)	6	Comb	Daily	70
S7-1	Synoptic Adjusted Cloud/Rad Field (SCR)	7	Comb	Daily	175
S7-2	Regional Synoptic Adjusted Cloud/ Radiation Field (RSCR)	7	Comb	Daily	25
S7-3	Time Averaged Cloud/Radiation Field (ACRF)	7	Comb	Monthly	50
S7-4	Regional Time Averaged Cloud/ Radiation Field (RACR)	7	Comb	Monthly	10

After the instrument and algorithm validation phase, these standard products will be routinely produced at the CDHF within 72 hours after all input data are available and will be stored in the DADS.

3.3.1.2 Validation Products

The validation products listed in Table 3-15 provide the Science and Data Management Teams with data to validate the CERES instruments and algorithms. The Instrument Validation Product (IVP) is discussed in Section 3.2.2. In addition, each subsystem accumulates pertinent parameters into time-history files for validation purposes. For example, TEMFOV accumulates telemetry monthly and yearly instrument statistics from the daily runs to form the V1-1 product; V1-2 contains the accumulation of daily orbital and platform position parameters into a yearly time-history file; and V2-2 contains statistics from the instrument count conversion process accumulated over a month of processing. After a month or a year of processing, time-history data plots are produced for trend analysis, instrument and count conversion analysis, and scene identification.

Table 3-15. Validation Products

ID CODE	DESCRIPTION	SUB SYS	PLATFORM	FREQ	SIZE (MB)
V1-1	Telemetry Time-History Data	1	Each	Monthly	175
V1-2	Ephemeris Time-History Data	1	Each	Yearly	50
V2-1	Instrument Validation Product (IVP)	2	Each	Daily	40
V2-2	24-Hour Summary Statistics	2	Each	Monthly	2
V3-1	Inversion Processing Statistics	3	Each	Monthly	2
V4-1	Monthly Difference Statistics	4	Each/ Combined	Monthly	10
V5-1	Monthly Cloud Statistics	5	Each	Monthly	37
V6-1	Surface/Atmospheric Statistics	6	Each	Monthly	50
V7-1	Cloud/Radiation Data Base	7	Each/ Combined	Monthly	35

3.3.1.3 Internal Products

The internal products are intermediate data files that pass from one subsystem to another in the data processing system. These products are listed in Table 3-16. Note that the internal products I1-1, I5-1, I5-2, I6-1, and I6-2 are also science archival products that correspond to the RAP, CFP, RCFP, SAF, and RSAF.

Table 3-16. Internal Products

ID CODE	DESCRIPTION	SUB SYS	PLATFORM	FREQ	SIZE (MB)
I1-1	Raw Archival Product (RAP)	1	Each	Daily	65
I2-1	Satellite Altitude Count Converted Data	2	Each	Daily	72
I3-1	TOA Flux Inverted Data	3	Each	Daily	50
I5-1	Cloud Flux Product (CFP)	5	Each	Daily	115
I5-2	Regional Cloud Flux Product (RCFP)	5	Comb	Daily	15
I6-1	Surface/Atmospheric Flux Field (SAF)	6	Each	Daily	140
I6-2	Regional Surface/Atmospheric Flux (RSAF)	6	Comb	Daily	70

3.3.1.4 Quality Control Report/Plot Products

The quality control products listed in Table 3-17 include a variety of printed reports and plots that provide statistical summaries, comparison results, and any anomalies found during processing. Careful review of these products is important to the product validation. Some of the statistics reported in Q1-1, for example, are the number of samples, mean, standard deviation, and minimum and maximum values for both the raw measurements and the successfully edited measurements. The measurements failing editing are enumerated for the various checks, such as lower or upper limit checks and the rate of change checks. These products are useful in evaluating the accuracy of algorithms, instrument models, and coefficients.

Table 3-17. Quality Control Products

ID CODE	DESCRIPTION	SUB SYS	PLATFORM	FREQ	SIZE (MB)
Q1-1	Telemetry Processing Summary	1	Each	Daily	0.1
Q1-2	Ephemeris Processing Summary	1	Each	Daily	0.1
Q1-3	Merge/FOV Processing Summary	1	Each	Daily	0.1
Q2-1	Count Conversion Summary	2	Each	Daily	0.1
Q3-1	CERES/ERBE Inversion Summary	3	Each	Daily	0.1
Q4-1	Time/Space Averaging Reports	4	Combined	Monthly	0.1
Q4-2	SC-4 Global Summary	4	Combined	Monthly	0.1
Q5-1	Cloud ID Quality Summary	5	Each	Daily	0.1
Q5-2	Cloud Merge Quality Summary	5	Each	Daily	01
Q5-3	CERES Pixel Inversion Summary	5	Each	Daily	0.1
Q6-1	Flux Divergence Quality Report	6	Each	Daily	0.1
Q7-1	Synoptic Cloud/Rad Summary	7	Combined	Monthly	0.1
Q7-2	T/S Averaged Cloud/Radiation Summary	7	Combined	Monthly	0.1

The Inversion process reports scene identification statistics in Q3-1 and Q5-3 quality summaries. These reports include histograms of the number of samples for each 10 degrees of latitude and each scene type (ocean, land, snow, desert) and cloud classification (clear, partly cloudy, mostly cloudy, overcast). Cloud classification statistics are also reported as a function of solar zenith angle and viewing zenith angle.

The Cloud Retrieval Subsystem reports statistics on the vertical and horizontal structure of the cloud fields. Examples of the parameters calculated and reported in Q5-1 are cloud size distributions, cloud fraction, vertical cloud variation, optical depth, and cloud top and bottom height. The Flux Divergence Subsystem report, Q6-1, includes a tabulation of TOA and surface fluxes and flux divergence profiles. The climatological and gridded input parameters, such as surface albedo and emissivity maps; aerosol, temperature, water vapor, and ozone profiles; and cloud statistics are summarized and reported. An important quality report is the result of the consistency checks the divergence processing performs.

The monthly processing reports include global summaries of the regions sampled by the CERES instrument for each platform and for all platforms combined. The daily, monthly-hourly, and grand monthly statistics for the shortwave and longwave measurements for a given region are produced. A synoptic map at specified time intervals is also produced. These are only examples of the type of information that will be reported by the CERES processing system.

CERES data products will provide a major contribution to investigations of the atmosphere and the oceans during the EOS time frame. Table 3-18 shows a sampling of the communities that may be expected to use the CERES data products. The science products are referred to by their acronyms in the text and in Figure 3-2. These acronyms are listed on Table 3-14 in parentheses.

3.3.2 Data Dissemination

The CERES data processing system is planned to be complete and ready for operational processing before the launch of the CERES scanner instruments. After launch, modifications will be made as necessary to account for operational problems that arise. A validation period of six months to one year after the launch of each instrument is allocated for validation of instrument data by the Science Team. During this period, Science Team members will use several months of instrument data to verify calibration coefficients and to ensure that all analysis algorithms are performing properly. After Science Team validation is complete, the operational data processing phase will begin. During this phase, routine production of the standard science data products will begin. The daily Table 3-18. CERES DATA PRODUCTS USER COMMUNITY products will be transmitted to EOSDIS within 72 hours after receipt of the necessary input data. The monthly products will take slightly longer to accumulate the necessary monthly data and ancillary files. The backlog of data that accumulates during the validation phase will be processed simultaneously with real-time data as computer resources allow.

Table 3-18. CERES Data Products User Community

COMMUNITY	CERES DATA	PRODUCT
Climate Modelers	Annual average TOA Fluxes and Cloud Forcing; Cloud Properties	ACRF, CAP, CFP
GCM Modelers	Clear and Cloudy Flexes and Cloud Properties	FAP, CFP
Biologists	Clear-sky Fluxes, Surface Albedos, and SW Surface Energy Budgets	SAF, SCR
Oceanographers	SW and LW Surface Fluxes and TOA Net Radiation	SAF
Weather Forecasters	Radiative Flux Divergences	SAF, SCR
Climate Forecasters	Surface Energy Budget and Oceanic Heat Storage	SAF, SCR, ACRF

The CERES Science Products and the Quality Control summaries and plots will be available to the CERES Science Team members and to the science community at large through the DAAC. Cataloging information will be transmitted to the Information Management Center so that the science community can obtain information concerning data and report availability. Validation products are primarily for use by members of the CERES Science and Data Management Teams. Internal data products will not be permanently retained, but will be kept temporarily at the DAAC.

4.0 Computer Resources and Software Tools for Ceres Algorithm Development, Data Processing and Analysis

Operational EOSDIS facilities at LaRC will include a Distributed Active Archive Center (CDHF and DADS) to process, store, and analyze data from CERES, SAGE III, TRACER, SAFIRE, and other instruments aboard the EOS Platforms as designated by the EOS Project. EOSDIS will provide the mainframe and storage devices and necessary supporting resources, such as workstations, software tools, and network capabilities. Specifications of computer resource requirements for the Active Archive at LaRC must be defined well in advance of the expected date of the procurement and installation of the system (1993-1994). Therefore, prior to the installation of the EOSDIS Active Archive system, existing computer resources at LaRC must support the EOS mission in the development and testing of algorithms for EOS data processing and analysis. During this period, existing ERBE data and procedures will be used to demonstrate the feasibility of some functions of the CERES Data Management System in a simulated EOSDIS environment. This simulation (or prototyping) will help determine what resources will be required for the development and testing of CERES data processing and analysis algorithms.

Figure 4-1 depicts current computer systems in the LaRC operating environment which will be used in the development and testing of CERES algorithms. It also shows new elements, identified by a star, which are unique to the EOS environment and do not yet exist in the current LaRC configuration. It is assumed that these resources are provided by EOSDIS. The current resources are interconnected using the Langley distributed computer network, LaRCNET. Interactive access and transfer of files is accomplished using the Xerox Network System (XNS), DECNET, or Transmission Control Protocol/Internet Protocol (TCP/IP). The protocol of choice for EOSDIS will be TCP/IP. This section discusses the application of each of the existing and new computer resources for the development and testing of CERES algorithms. In addition, the section describes processing requirements and software tools required by the CERES Science and Data Management Teams in the EOSDIS environment.

4.1 External Networks

Several external communication networks currently link computer resources within the LaRCNET network (see Figure 4-2) to resources outside the local network. Examples of these networks include the Space Physics Analysis Network (SPAN), and the Southern Universities Research Association Network (SURANET). These networks are available for exchange of data and information between CERES Science Team members at LaRC and members located at other sites. One such network will be selected to transmit data from TRW (instrument contractor) to the CERES Instrument Design Team, Science Team, and Data Management Team at LaRC.

The SURANET network has been selected for use during the definition phase to transmit level 0 ERBE data from GSFC to LaRC. This network uses a connection with the Continuous Electron Beam Accelerator Facility (CEBAF) in nearby Newport News and currently transmits data at 56 Kbps; however, it will be upgraded to a transmission rate of 1.5 Mbps in 1990. This communication network will permit the demonstration of electronic transfer of data sets similar to CERES and help to determine the specifications of the link required to transfer EOS data in the

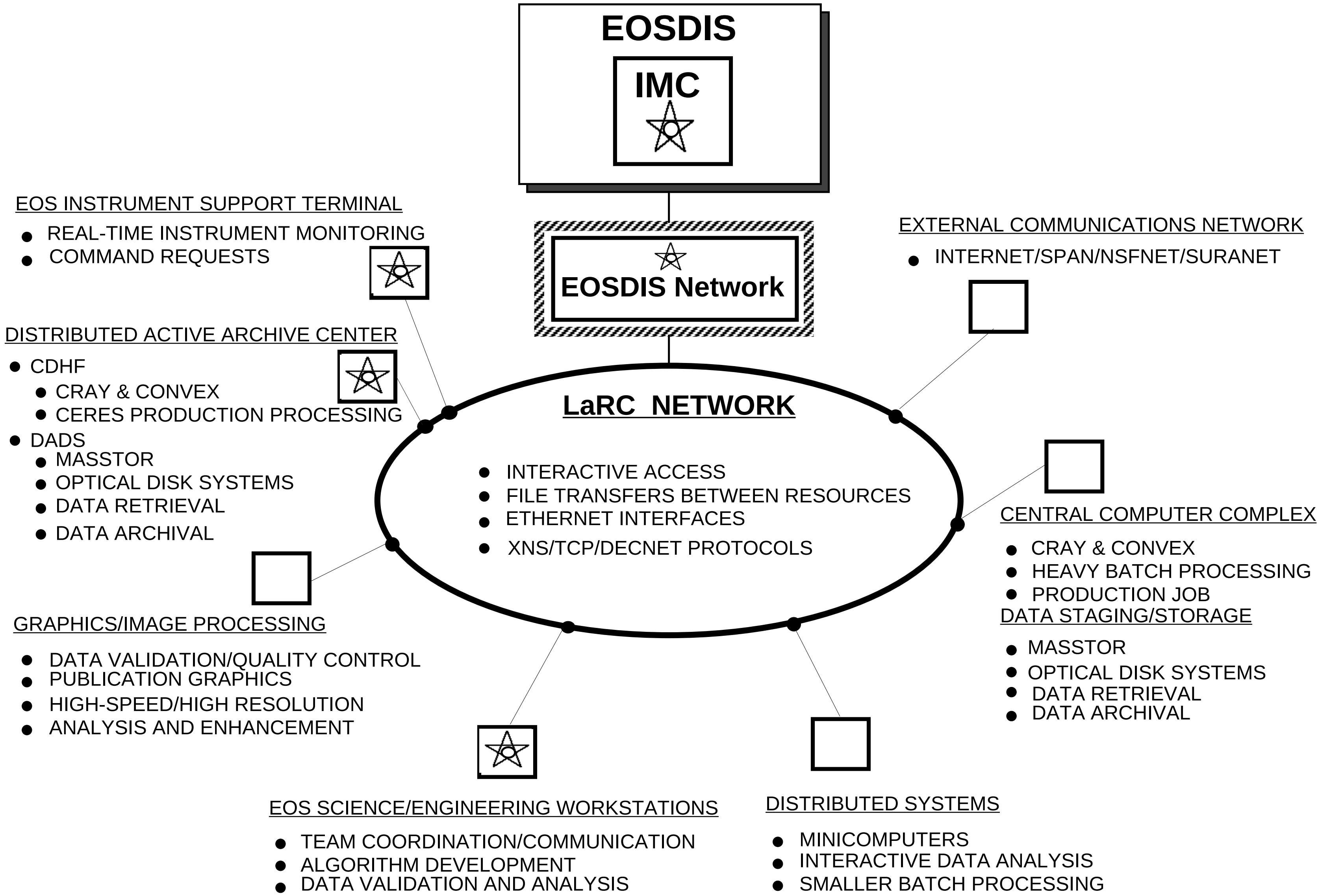


Figure 4-1. Current/Planned EOSDIS LaRC Computer Resources

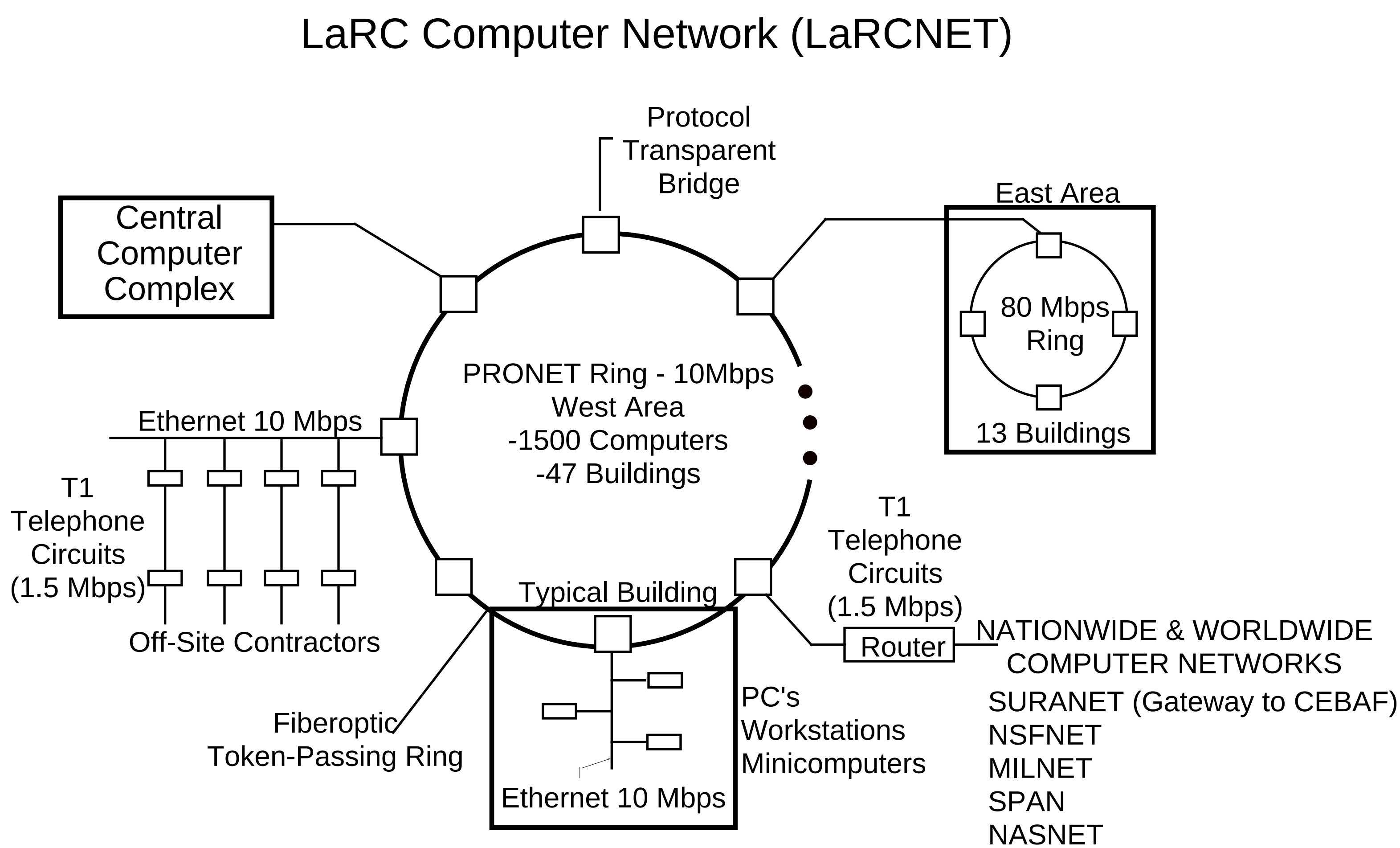


Figure 4-2. LaRCNET Network

EOS environment. EOSDIS will replace the SURANET with the EOS Science Network about two years before the launch of the first EOS Platform.

4.2 Central Complex Computers and CDHF

Langley has several high-performance computers in its central computer complex as shown in Figure 4-3. The Supercomputing Network Subsystem (SNS) has been identified as the prototype system for EOSDIS. This subsystem includes a Cray-2S supercomputer, a Convex C120, and two Convex C210's. An IBM 4381 is also used in conjunction with the MASSTOR storage devices. The Cray computer uses the CRAY UNICOS operating system. Convex computers run a UNIX-based operating system. These computers support most of the traditional features of UNIX and the FORTRAN programming language which are proposed for the EOSDIS operating environment. Temporary data storage associated with these computers allow very fast access to local data files during processing. However, they currently have essentially no accommodation for long-term storage of data in the volume required by EOSDIS and it is imperative that files requiring permanent storage be transferred to another mass storage device.

The UNIX-based Convex computers at the LaRC Central Computing Complex will be used to support the CERES software development and testing and to simulate the computers in the CDHF for EOS. Sections of ERBE software will be migrated to these machines and used to process the ERBE data received over the SURANET network from GSFC. The information and experience gained during the simulation will be invaluable in the selection of computers to be used in the EOS environment.

4.3 Data Storage and Dads

Large amounts of mass storage capability are needed for the CERES data processing. Table 4-1 is a summary of the storage requirements for the CERES data products on a monthly basis. The proposed primary capability for storing large data files during the development and testing of the CERES processing system is the 440-Gbyte on-line cartridge storage device developed by MASSTOR Systems Corporation. Storage space on this device is accessible from the Cray and the Convex computers and will be expanded as future requirements are identified. During the definition phase, MASSTOR is used to store ERBE data transferred electronically from GSFC and processed by LaRC existing resources, providing inputs on requirements for mass storage capability in the EOSDIS environment.

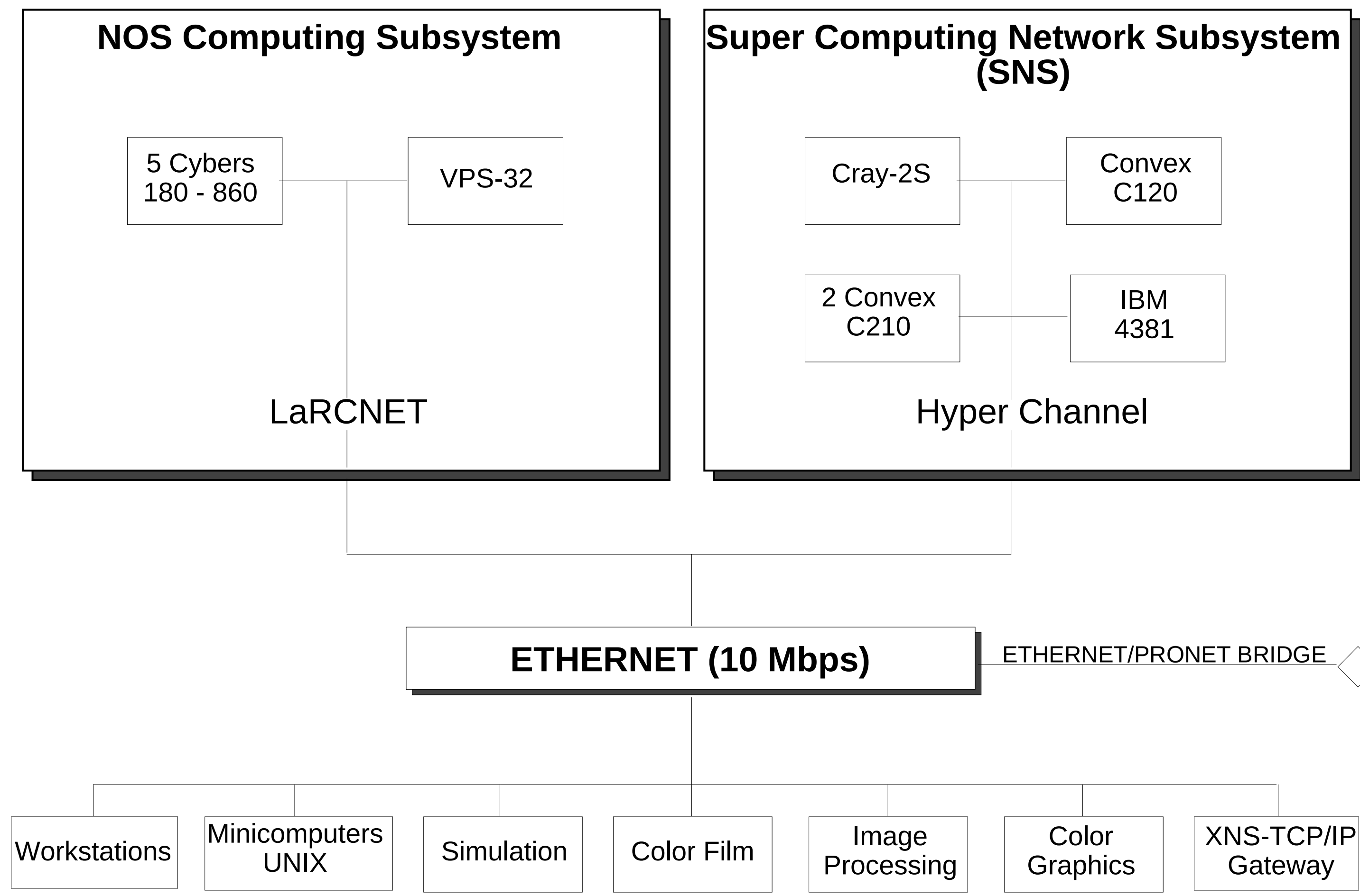


Figure 4-3. LaRC Central Computer Complex

Table 4-1. CERES Output Products Storage Requirements for Three Platforms

DESCRIPTION	FREQUENCY	SIZE (MB)
Science Products	Monthly	44,130
Validation Products	Monthly	4,570
Internal Products	Monthly	11,000
Quality Control Products	Monthly	500
Total		60,200

4.4 Distributed Computers

In addition to the Central Computer Complex, LaRC has distributed computer systems. The Network Operating System (NOS) Computing Subsystem which is comprised of four Control Data Corporation Cyber 180 class computers and two MASSTOR cartridge storage devices is available to support the CERES prototyping effort in the distributed computing environment. LaRC also has several mini-computers, such as the Digital Equipment Corporation systems, which provide general support for interactive and batch computing needs. The mini-computers also provide high-quality graphics and word processing. They have been used successfully for interactive data analysis for the ERBE mission, and they will support development and testing of CERES algorithms.

4.5 Interactive Terminals and Work Stations

Existing computer terminals used to develop and test ERBE algorithms permit moderately high-speed interaction with other resources within the LaRCNET environment and are a valuable resource to support the initial development of CERES software. However, upgraded workstations with the latest available technology will be provided by EOSDIS for each PI/CO-I.

4.6 Graphics/Image Processing

Specialized systems which provide interactive color display and analysis of data include two Superset minicomputers and two International Imaging System image processors with a VAX 3500 host. The image processors have hardware capable of performing advanced mathematical and statistical operations on two-dimensional satellite images. Analysis of extensive amounts of satellite data sets using these systems has shown them to be extremely useful in identifying and correcting instrument and processing system anomalies. These graphics and imaging systems have been used for high-resolution display and analysis of ERBE data products and will also be used in the analysis of CERES data products.

4.7 Instrument Support Terminal (IST)

An Instrument Support Terminal will be provided by EOSDIS to monitor the in-orbit health and safety of each of the EOS instruments supported by the DAAC. This terminal will be compatible with the EOS Mission Operations Center at GSFC to provide screen displays similar to those available at the EMOC. These displays will be used to monitor routine instrument operation as well as calibrations and other special instrument operations. Requests for special calibrations or changes to instrument operational modes will be submitted through this terminal to the Instrument Control Center. The IST will be required two years prior to launch of the first EOS platform for pre-flight testing.

4.8 Information Management Center (IMC)

The Information Management Center is the focal point of EOSDIS. The IMC is not the facility for storage of actual science data; instead it is the facility which stores catalog information for science products, quality control reports, and algorithms and provides the means for accessing that data. The IMC consists of a multiuser system through which Science and Data Management Team members at LaRC and other EOS sites can gain access to EOS data information including directory, metadata, and catalog information. Users can also browse data sets using the IMC.

4.9 Software Development Tools

It is important that the Science and Data Management Team members use standard software languages, development standards, and development tools during all phases of the CERES mission. The NASA Software Management and Assurance Program will be used as a guide in implementing rigorous software methodology standards, verification and validation procedures, and documentation standards throughout the entire software development life cycle. The current ANSI Standard FORTRAN has been adopted as the baseline for CERES software to take advantage of the large body of existing ERBE FORTRAN code. ADA will be considered as the language for new code development based on tradeoffs related to software life cycle costs and user productivity. Software development will emphasize structured programming concepts. The software development process can be more accurate and productive through the use of development tools, such as the Computer-Aided Software Engineering (CASE) tools. Standard program definition languages, structured FORTRAN syntax aids, and language-sensitive editors can significantly improve the productivity of the software development activity.

4.10 Processing Requirements

The seven processing subsystems within CERES are shown in Figure 3-2. Table 4-2 lists each subsystem and the estimated lines of software for each. The software storage requirements, the number of computer operations per data day, and the frequency at which each subsystem will be processed are tabulated. An estimated total of 593,000 lines of code will be used for CERES. The estimate for the Job Control Language or UNIX Shell Script associated with executing this software is 65,000 lines. These estimates are based on the ERBE processing subsystems.

Table 4-2. Processing Resource Estimates

SUBSYSTEM	LINES OF CODE			CODE SIZE MB	OPERATIONS PER DATA DAY $X10^{10}$	FREQUENCY
	CONTENTS	EXECUTABLE CODE	TOTAL			
Telemetry/Ephemeris Merge/FOV	41000	30000	71600	19	2	Daily
Count Conversion	8000	5000	13000	4	1	Daily
TOA Flux Inversion	19000	12000	31000	8	1	Daily
Time Space Averaging	34000	28000	62000	17	1	Daily/Monthly
Cloud Pixel Retrieval/TOA Flux/ Merge	36000	28000	64000	18	50	Daily
Inversion/Radiative Transfer	40000	32000	72000	20	115	Daily
Merge/Average Clouds & Radiation	64000	48000	112000	30	6	Daily/Monthly
Utilities	10000	8000	18000	5		
Total Production	252000	191000	443000	121	176	
Total Non-Production	80000	70000	150000	40	95	
Total Software	332000	261000	593000	161	261	
Job Control Production	11000	41000	52000	14		
Non-Production	3500	9500	13000	35		
Total JCL	14500	50500	65000	49		

The operations per data day can be translated to about 30 million floating point operations per second (MFLOPS) for a single platform. With three CERES platforms flying at the same time, the total processing load is about 90 MFLOPS.

5.0 Organization and Implementation Approach

5.1 CERES Project Organization

The CERES Project is part of the Langley Research Center (LaRC) EOS Project Organization as shown in Table 5-1. Each of the four LaRC experiments (CERES, SAFIRE, SAGE III, and TRACER) selected for the definition phase of the EOS Mission has a project office within the Space Experiments Office of the Electronics Directorate. Primary responsibility for the system required to handle CERES data and to produce scientific products is shared by the CERES Science and Data Management Teams with support from the Instrument Team and the Analysis and Computation Division (ACD).

The Science Team provides the science rationale for the data system and specifies the science output data products. It is responsible for defining and specifying science algorithms and for validating those algorithms and their output data products. The Data Management Team (DMT) is responsible for the design, implementation, and operation of the end-to-end data handling and processing system and for the dissemination and archival of data products. Final approval of the archival products is the responsibility of the Science Team. The Instrument Team is responsible for data interfaces with the EOS platform contractors and the CERES instrument contractor for both test and flight data. ACD manages the LaRC computer resources, including interfaces with EOSDIS, and supports CERES data system development and data processing.

5.2 Implementation Tasks

Implementation of the data handling and processing tasks is divided into seven main functions as shown in Table 5-1. Table 5-1 also shows what specific tasks are performed for each function during the three major phases of the EOSDIS mission: definition, prelaunch execution, and postlaunch execution. The first five functions include the tasks required to design, develop, and operate the system to support the processing and data flow described in Section 3.0 of this document. The tasks for function 6 are required to support the hardware integration and management activity described in Section 4.0, and the tasks for function 7 deal with the documentation effort described in Appendix A. This section gives more detail on the implementation of the tasks listed in Table 5-1.

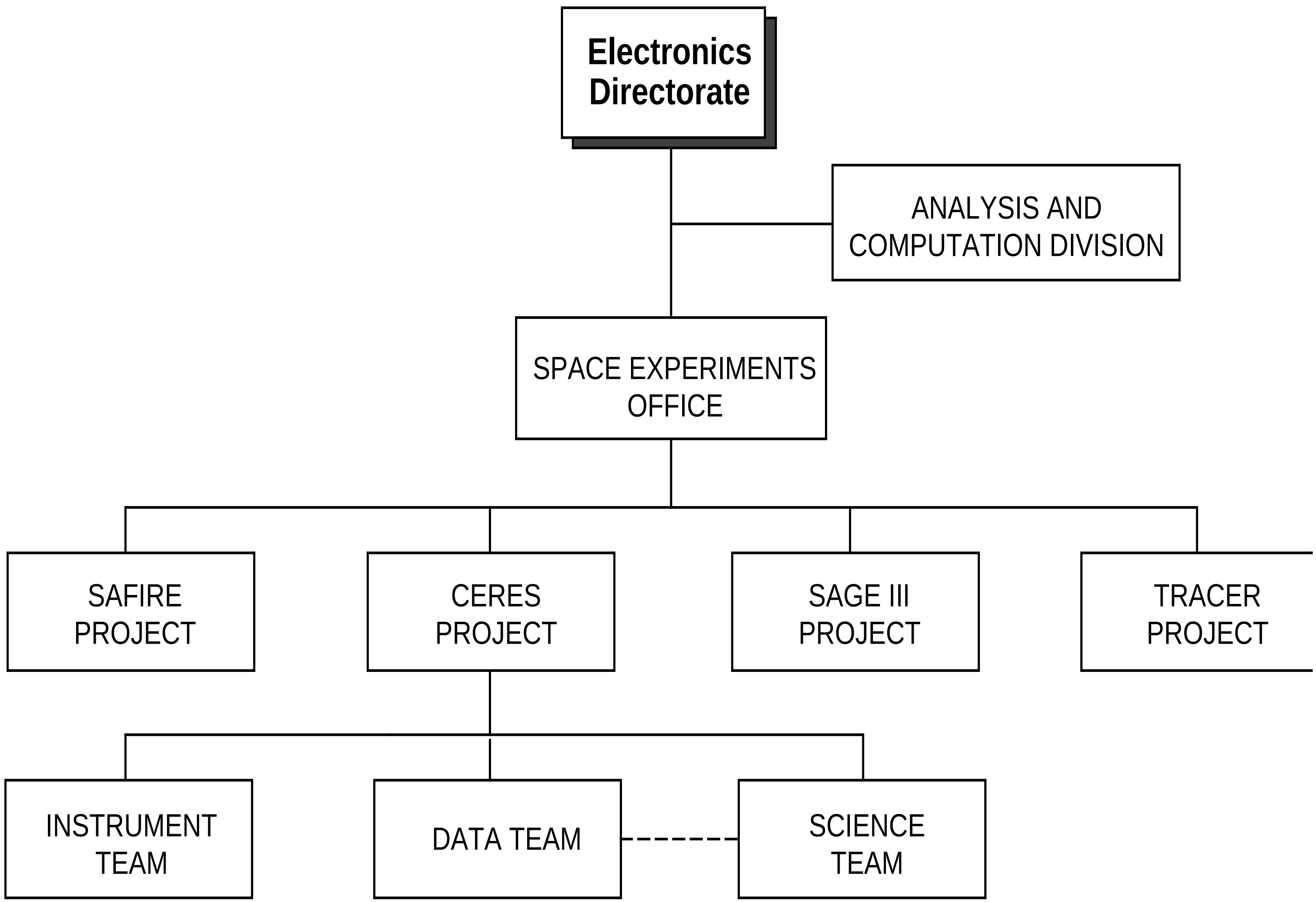


Figure 5-1. EOS Project Organization at LaRC

Table 5-1. CERES Data management System Functions and Implementation

1990——1991——1997——2015

Phase / Function	Definition	Prelaunch Execution	Postlaunch Execution
1. Specification of input data interfaces	Study requirements	Negotiate and document	Placed under configuration control, monitor
2. Science algorithm design and development	Evaluate existing algorithms	Integrate existing algorithms. Design and develop new algorithms	Validate, refine, and update algorithms
3. Design and implementation of operational processing system	Design initial CERES/ERBE processing system in Convex/ UNIX environment	Design, develop, test, and document system. Deliver to active archive	Maintain and update system. Operational processing
4. Validation of the processing system and data products	Define on-line validation software requirements	Integrate analysis software into operational processing system	Validate instrument inflight performance. Validate operational system and data products
5. Management and archival of output data products	Define format, content, size of products	Update specifications and distribute test data products	Distribute and archive data products
6. Computer resource integration and management	Specify requirements and begin prototyping	Install, integrate, and test resources	Operate, monitor, and update system
7. Documentation	Document: Data Management Plan Data Products Catalog (Prelim) Software Development Standards Configuration Management Plan	Document: Data Interface Documents Software Design Documents Data Products Catalog (Final) Test Plans/Test Results Data Product User's Guides	Document: Reference Manuals Operator's Guides Analyst's Guides Archival Product Summaries

5.2.1 Specification of Input Data Interfaces

Table 3-1 shows the data inputs required to generate the CERES science data products. During the definition phase, interface requirements are studied and defined for the data from external sources. During the prelaunch execution phase, data interface agreements are negotiated with external organizations and documented. These documents specify the content, format, transfer technique, and scheduling requirements for each required data set. The internal data interfaces between the various subsystems of the CERES Data Processing System (See Figure 3-2) are also defined and documented during this phase. Beginning with the launch of the first EOS platform, the external and internal agreements are placed under configuration control and all data interfaces are monitored.

5.2.2 Science Algorithm Design and Development

During the definition phase, the Science Team evaluates existing ERBE algorithms as candidates for CERES data processing using simulated CERES scanner data. The ERBE input and output products and subsystem interfaces are reviewed for changes needed for CERES processing. They also define the input and output data requirements for the newer more advanced CERES processing algorithms. During the prelaunch phase, the Science Team performs science studies critical to development of the new algorithms, such as cloud and radiative flux retrieval algorithms. New strategies for improving the ADMs and dealing with time interpolation and averaging are undertaken. These studies use existing global data (NIMBUS 6 & 7, ERBE, ISCCP, HIRS, AVHRR, AMSU) and regional data, primarily FIRE data. Results of the algorithm studies form the basis for the design and development of the more complicated processing required by CERES. Algorithm specifications are documented for integration into the CERES processing software (See Figure 3-2).

After launch, the Science Team performs extensive algorithm and data product validation. Additional data sets will be used to validate the models. For example, GLRS may provide cloud height validation measurements and MISR may provide validation of the CERES angular models. The Science Team will also conduct further algorithm research and refinement. For example, new ADMs will be developed with the data from two CERES scanners in conjunction with scene identification data obtained from other EOS instruments.

During each of these phases, one or more members of the Data Management Team are assigned to work directly with each Science Team Working Group which is responsible for a portion of the operational processing system.

5.2.3 Design and Implementation of Operational Processing System

During the definition phase, members of the DMT interact with the Science Team working groups to acquire scientific background and algorithm specifications to begin the CERES software development. This phase is also a training period to prepare for processing CERES data in the EOSDIS environment. Software is written to reformat data for transferring between the current and Convex computing environments. Portions of the ERBE processing system are converted to the Convex/UNIX environment to gain experience with UNIX control language, file transfer techniques between NOS and Convex, and system-unique features of Convex.

During the prelaunch phase, the CERES Data Processing System is designed, developed, tested, and documented, using the structured methodology developed for the ERBE Data Processing System. Early in this phase, sections of existing ERBE software approved by the Science Team are modified to represent the initial CERES processing system as shown by the horizontal flow on Figure 3-2. This partial system is then migrated to the LaRC Convex system, relevant ERBE job control language is converted to UNIX shell script, and the system is extensively tested by following a documented test plan. The existing ERBE documents are copied and modified according to the CERES specific software changes made to become the design documents for the converted ERBE/CERES software. The early availability of the CERES/ERBE portion of the CERES Data Management System permits early EOSDIS prototyping activities to identify migration problems and to establish integration procedures. As the Science Team specifies the new CERES/original science algorithms and input and output data requirements, the DMT begins the initial design of the portion of CERES processing represented by the vertical flow shown on Figure 3-2. The CERES/original software is developed using an iterative development cycle, with a preliminary and final release. Each release includes definition, design, implementation, and testing steps accompanied by design reviews, published design documents, implementation reviews, and test plans.

After all subsystems are integrated into the CERES Data Processing System, they are tested from end-to-end for both releases. Global one-month simulation of the CERES and MODIS data are constructed from ERBE, AVHRR, and HIRS data from the NOAA-9 spacecraft for April, July, and October 1985 and January 1986. The end-to-end test output data products are distributed to the Science and Data Management Teams for analysis. Analysis of these test results helps to uncover processing and software problems, coding or algorithm errors, and data interface problems. The test results also provide computer resource timing and storage information.

Both versions of the CERES Data Processing System will be migrated to the EOSDIS computing environment. The preliminary version will aid in working toward streamlined production procedures in the actual environment and will provide realistic estimates of run costs. The final release will be delivered to the DAAC at least nine months prior to launch for integration into EOSDIS. The end-to-end test is repeated at the Active Archive and test results are compared to the previous end-to-end test to determine differences due to the different computing environments. Procedures to integrate software from the development environment to the Active Archive environment are evaluated and improved.

Throughout the postlaunch execution phase, algorithm modifications, software errors, or processing anomalies which require changes to the CERES Data Processing System are coordinated with EOSDIS and updates made according to configuration control procedures. After an initial validation period, the DMT is responsible for the routine operational processing of CERES instrument data to produce archival data products. Section 3.2 discusses the archival products and their dissemination. A discussion of validation is in the following section.

5.2.4 Validation of the Processing System and Data Products

During the definition phase, ERBE analysis software and quality control procedures are evaluated, and requirements for new software and procedures to validate CERES data are defined. Emphasis is on incorporating existing off-line analysis and validation software into the operational processing system. Particular attention is given to automating procedures for monitoring and analyzing in-flight calibration data and for making comparisons of data from the three radiometric detectors.

During the prelaunch execution phase, data validation software is designed, developed, and tested as a part of the operational processing system. The design includes software for generating comprehensive quality evaluation and validation reports. The on-line CERES validation software is verified by comparing its results to results from the equivalent ERBE off-line software. Additional off-line validation tools and quality control procedures are required to evaluate the CERES data products. Software is designed to plot and analyze data accumulated from the daily processing into time-history files. Software is also designed to allow intercomparisons of the CERES data products with other data sources.

The immediate focus after the launch of a CERES instrument aboard an EOS platform is evaluation of the in-flight performance and instrument output data. Validation software is used to analyze data obtained during frequent calibrations and other operations required to check out the instrument's in-flight performance. This early postlaunch period is used to test the effectiveness of the validation software to help characterize the instrument's performance and operation. The quality report products (Table 3-17) list or graphically display statistical parameters which are used to evaluate the quality of the data elements at various points in the processing flow.

Analysis and validation of science algorithms and the data they produce begins immediately after launch. Plans for progressively more rigorous validation phases will result in three updated versions of the postlaunch data processing system. Within each validation phase, the algorithms and output data are evaluated systematically in the order of data processing, that is, subsystem-by-subsystem.

5.2.5 Management and Archival of Output Data ProductS

The CERES output products produced by the CERES Data Processing System are listed in Tables 3-14 through 3-17. These products include the standard data products, internal products required to support the flow of data through the CERES Data Processing System, quality control products, and validation products. During the definition phase, the CERES Science and Data Management Teams work together to define the product content, format, and size of each type of output product.

During the prelaunch phase, the CERES output product specifications are reviewed for additions and modifications resulting from the algorithm development process. Updated archival product sizing estimates are provided to EOSDIS. The simulated output data products produced by case studies are distributed to an EOS designated facility.

After launch, the operational CERES data products are generated and stored at the DAAC for approximately two years before they are placed into the permanent archival. Data products are available at the Active Archive for local or remote access prior to permanent archival. Information about the CERES data products, such as processing status information, meta data, and browse data sets are sent to the IMC at GSFC.

5.2.6 Computer Resource Integration and Management

Preliminary requirements and sizing estimates for computer facilities and communication links at the DAAC are defined during the definition phase (See Section 4.0). Software and hardware tools which automate and streamline the software development are identified, and programming design languages, data definition languages, language sensitive editors, word processors, and Computer-Aided Software Engineering (CASE) tools are evaluated. The software and communication requirements to monitor and control the instrument in the EOSDIS environment are also defined during this phase.

During the prelaunch phase, software and hardware are procured to support algorithm development and prototyping activities, which include electronic transfer of ERBE data from GSFC. In 1993, communication links will connect the Science and the Data Management Teams to the first version of the EOSDIS network to test the system using ERBE data. In 1994, the DAAC and workstations will be installed to support migration of the CERES Data Processing Software System to EOSDIS and for use in the postlaunch environment. An operational processing plan is developed for use in scheduling and processing during the postlaunch operational phase.

After the launch of the first EOS platform, postlaunch operational processing is performed in the EOSDIS environment at the DAAC. Monitoring of the operational processing system and data analysis and validation is supported by LaRC distributed computer resources, which include EOSDIS provided work stations and software tools. The system resources are updated to meet the greater demands as additional platforms are launched.

5.2.7 Documentation

Plans and activities of the CERES data handling and processing effort are documented and distributed during the three phases of the EOS Project. Appendix A contains a list of the documents, when they will be published, and a brief description of their contents.

5.3 Data Management Team Organization

It is the fundamental responsibility of the CERES Data Management Team to develop the end-to-end processing system that produces useful scientific results from CERES instrument measurements. The Data Management Team performs the tasks outlined in Table 5-1 for the three project phases in order to produce these products. This section describes the Data Management Team organization, as shown in Figure 5-2.

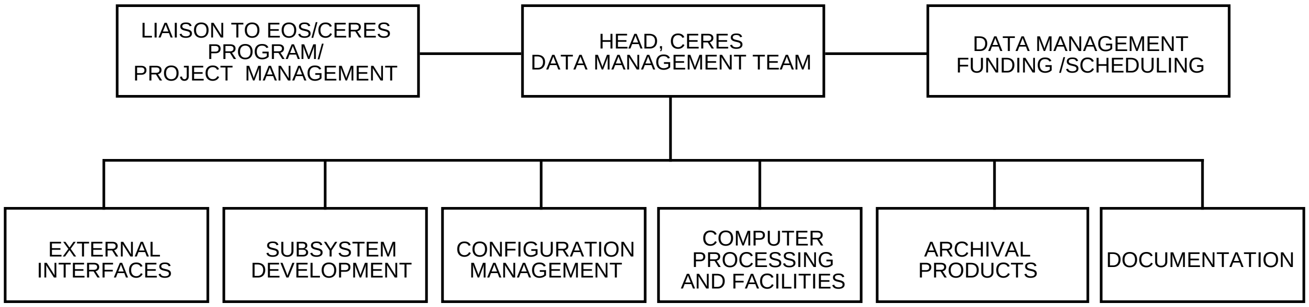


Figure 5-2. CERES Data Management Team Organization

5.3.1 Data Management Team Head

The Head of the DMT reports to the CERES Project Manager and is responsible for all data management activities. The Head is directly responsible for data management funding and scheduling, and is a liaison to the Science Team to coordinate Data Management Team tasks and activities with Science Team requirements, serving as an ex officio member of the Science Team.

5.3.2 External Interface

Interfaces with sources of external input data must be defined and managed to accommodate a smooth flow of input data throughout the life of the project. It is the responsibility of the External Interfaces Coordinator to establish data interfaces and to coordinate data requirements and flow of input data with cognizant personnel.

5.3.3 Subsystem Development

Major processing steps of the CERES Processing System are designated as subsystems. Members of the DMT are responsible for the complete software life cycle of each subsystem, including the tasks necessary for bringing the subsystem up to, and maintaining it at, an effective operational processing status. These tasks include:

- develop algorithm specifications
- migrate existing software to EOSDIS environment
- develop new software through design, implementation, and testing
- prepare QC, analysis, and diagnostic software tools

- integrate executable software on the Active Archive
- maintain all subsystem software

Each subsystem group develops algorithm and ancillary input data specifications in concert with the CERES Science Team, ensures the primary input data stream satisfies all specification requirements, and determines what parameters and format are needed to satisfy output product requirements. Each subsystem then designs and develops a system including both application software and control language that meets the scientific requirements and computer resource constraints. During software development, the software is maintained under an informal level of configuration control, and the software is executed and tested. Software tools are prepared to validate results, to analyze the data, and to diagnose problems. After integration at the Active Archive, formal configuration control procedures are followed to implement changes required during the validation and maintenance phases.

5.3.4 Configuration Management

The Configuration Management Coordinator is responsible for the preparation and implementation of the CERES Configuration Management Plan. The Configuration Management Plan covers all CERES operational software, all required input data and all output data products, and all associated CERES Data Management Team documentation. It is also the responsibility of the Configuration Management Coordinator to ensure that the CERES plan is in compliance with the EOS Project's Configuration Management Plan and governing policies.

5.3.5 Computer Processing And Facilities

EOSDIS and the DAAC will have the operational responsibility of providing and managing data storage resources, data processing and output product tracking and dissemination, and data archival. It is the responsibility of the Computer Processing and Facilities Coordinator to provide the DMT interface with the Active Archive. Prior to software migration and operational processing at the CDHF, it is this coordinator's responsibility to manage these functions in the LaRC data processing environment. Additional pre-migration responsibilities include subsystem integration, software optimization, and integrated system testing and validation. Following software migration to CDHF, the coordinator's responsibility is to maintain the interface with the LaRC processing facility to analyze, test, and validate runs with the subsystem leads and to manage the required computer resources needed to support these activities. The Coordinator is also responsible for establishing an interface between the CDHF and the DMT for software migration, routine production processing, output product evaluation, software maintenance, and quality control.

5.3.6 Archival Products

The Archival Coordinator is the point of contact for CERES validation efforts and provides the Data Management Team interface with the DAAC regarding the availability of CERES archivable data.

5.3.7 Documentation

The Documentation Coordinator is responsible for defining, maintaining, and implementing CERES Data Management Team documentation standards, and for scheduling and monitoring the preparation and distribution of CERES Data Management Team documentation. These documents are described in Appendix A.

5.4 Implementation Schedule

One goal of all EOS software development is to produce systems which are operational prior to the first platform launch. Since CERES instruments are to fly on three platforms, targeting to three shifting launch dates will be a schedule constraint throughout the development phase. For this plan, the following assumptions are made:

ESA Platform	April 1997
EOS-A Platform	December 1997
Space Station Freedom Attached Payload	December 1998

As these dates are modified, planning schedules and budgets will be adjusted accordingly.

CERES Data Management System implementation tasks are described in Section 5.2. Table 5-2 is an overall time schedule for these activities.

Table 5-2. Overall CERES Data Management Schedule (Page 1 of 2)

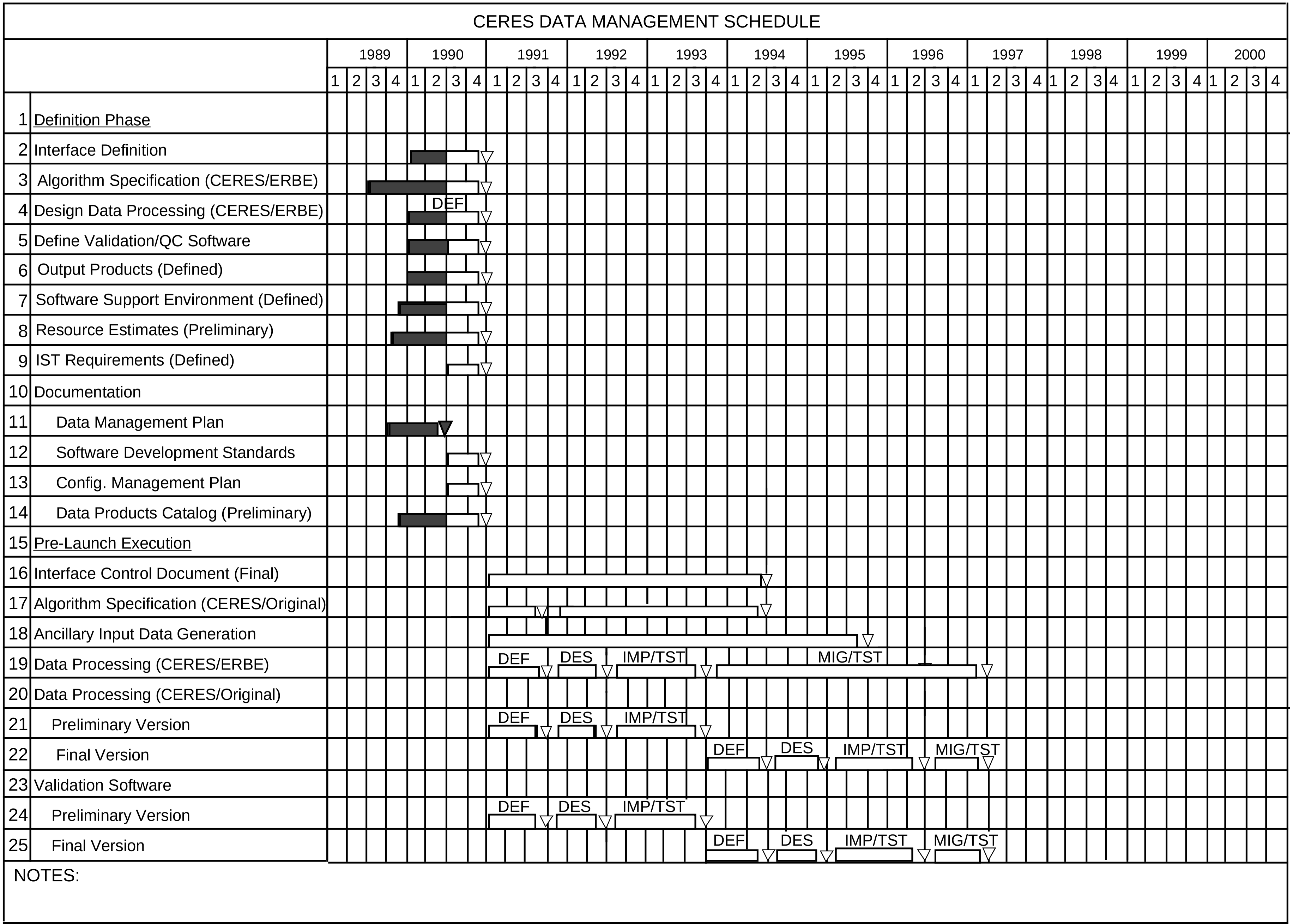
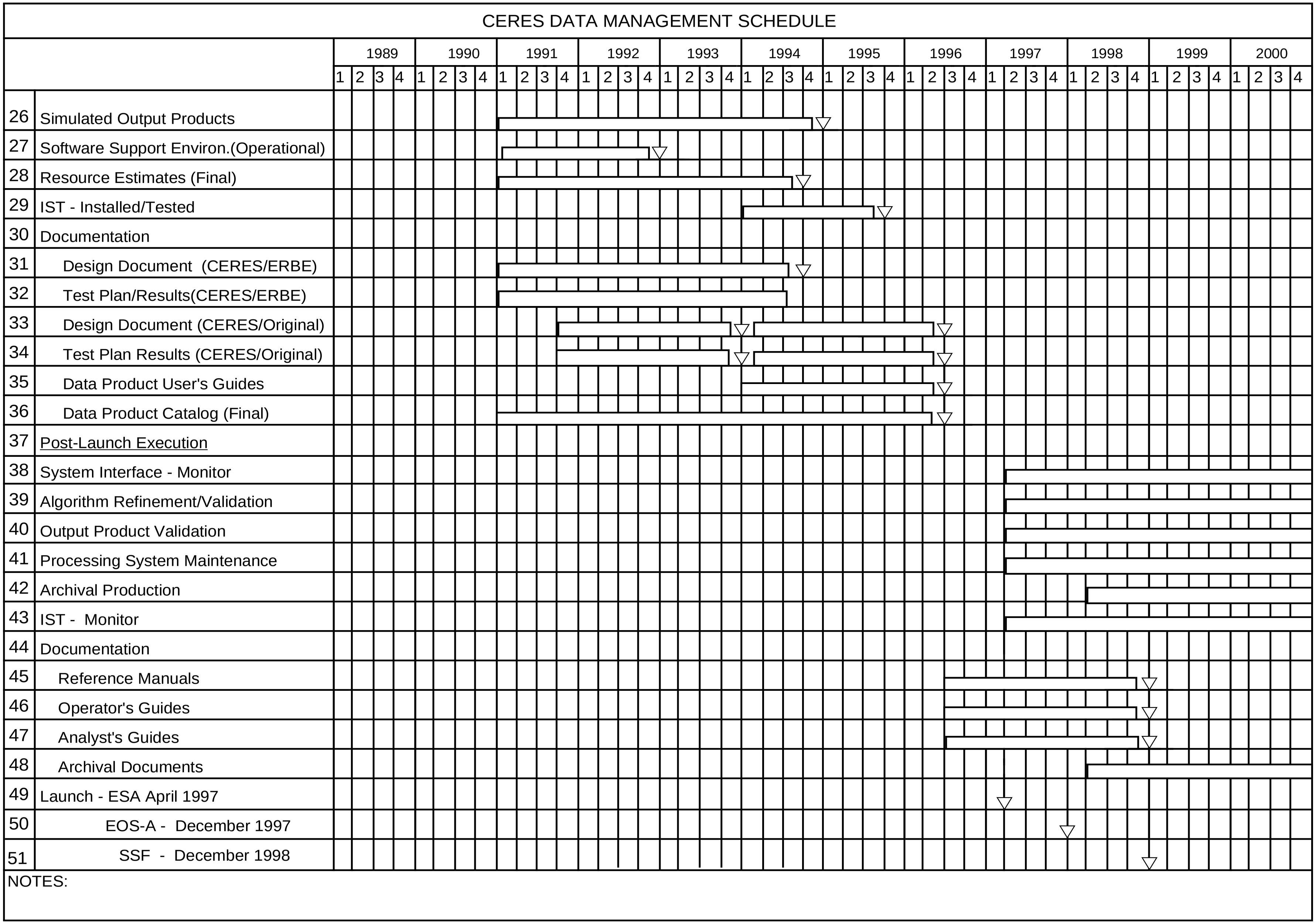


Table 5-2 . Overall CERES Data Manatement Schedule (Page 2 of 2)



Appendix A

Documentation In Support of CERES

Appendix A
Documentation In Support Of Ceres

Following is a list of documents, and a brief description of each, which will be published by the CERES Data Management Team. Documentation will be ongoing through the Definition, Prelaunch, and Postlaunch phases of the CERES project and will provide a complete history of Data Management Team efforts and products from the planning stage through design, testing, and validation. Also included is a list and brief description of other documentation associated with the CERES project. These documents will be archived in the DADS for electronic access and distribution.

Definition Phase

Data Management Plan: This document outlines the data management requirements and procedures for managing the data produced by the Clouds and the Earth's Radiant Energy System (CERES). In this context, data management means tracking, controlling, and processing all data, primary and secondary, from their points of origin to the Science Team for data validation and ultimately to an archive for use by all scientific investigators. This plan reflects the current understanding of the key elements of the data processing system and of the interfaces between that system and external data sources and data users.

Data Products Catalog: This document is evolutionary and will be updated as the Data Management System progresses. In this Phase, all major data products expected to be produced by CERES will be listed and briefly described. The catalog will be produced by the Data Management Team interacting with the Science Team.

Software Development Standards: This document will contain programming and coding standards which are to be followed in the design and development of all data reduction programs written for the CERES Project. The standards will be the result of a joint effort among the Earth Observing System (EOS) participants at Langley Research Center.

Configuration Management Plan: The Configuration Plan will allow for the identification, control, maintenance, and implementation of any changes to the CERES software system and associated documentation. The Plan will include descriptions of the configuration management organization, responsibilities, and procedures as they apply to the CERES Project, and in particular, to the Data Management Team.

Prelaunch Development Phase

Interface Control Documents: These documents will define the interface agreements reached among the CERES Science Team, Data Management Team, and several outside sources of input data. The documents will define required data sets; establish data storage requirements in EOS-DIS; define communication links; provide procedures for timely corrections or modifications to the CERES processing data software; and provide procedures during the checkout, validation, and production data processing phases.

Design Document: A design document will be provided for each subsystem comprising the CERES Project. They will be evolutionary documents reflecting the design, coding, and testing of the subsystems as they progress. A design document will be published in conjunction with each software release; and a final document (Reference Manual) which will reflect the final changes resulting from coding and testing of the flight data processing system will also be published. In addition, a System Utilities and User's Guide will be published which will list and describe library functions which are common to all subsystems.

Data Products Catalog: In this Phase, the document will be updated to provide additional names and descriptions of the output products produced by the CERES Data Management System. If sample products are available in this Phase, they will be included in the catalog; if they are not available, the catalog will be updated in the next Phase and sample products will be included at that time.

Data Products User's Guide: This document will be provided for each product produced by the CERES Data Management System. It will describe the format and content of the product and provide the user with the necessary information to use the CERES data for scientific research studies. This document will be updated in conjunction with the Design Document/Reference Manual.

Software Test Plan: This plan will outline the objectives and procedures for the total system integration and test for the CERES Data Management System. It will provide a general description of the test data sets, a testing scenario to be followed for each subsystem, and sample test submission and documentation.

Postlaunch Operations Phase

Reference Manual: These documents will describe the CERES Data Management System "as built." They will reflect the final changes resulting from coding and testing of the flight data processing system for each subsystem.

Data Products Catalog: In this Phase, the catalog will be revised to reflect changes in either the output products or the descriptions of the products which may have evolved from the previous phases. At this time, samples of all the products will be included in the catalog.

Operator's Guides: This document will identify the operational steps necessary for a production run of a subsystem, or to create a CERES product. A separate section will be provided for each subsystem. A brief description of the subsystem will be provided along with sample forms which will be used by the analyst to initiate a request for production processing and completed by the operations personnel at the time they perform the run. This document will also contain the procedures to be followed by the CDHF operations personnel to perform a production run for each CERES subsystem. This document will have limited, internal distribution.

Analyst's Guides: This document will provide data specific to analysis and verification of the CERES production processing. The information contained in this guide is to be used in conjunction with other CERES documents to provide CERES analysts with the information required to verify accurate data processing by the CERES Software System. An analyst's guide will be provided for each CERES Subsystem.

Monthly Archival Product Summaries: Monthly product summaries will be published for certain archival products which will be specified by the Science Team. The contents of these summaries will provide an explanation of the data coverage for the month, in-orbit calibration dates, a data inventory, the orbit ground track plots, the number of daily records, summaries of processing statistics for each day, and other information deemed necessary as the project progresses.

Documentation Revisions: As software changes are made through the validation cycle, all documents will be revised to reflect the changes, and revised pages with instructions will be distributed to the users.

Other Documentation

These documents will be published by the CERES Science Team or Instrument Teams.

Science Management Plan: This plan will consolidate the various tasks and activities that comprise the CERES Science Program. Some of the subjects which will be covered are: measurements requirements, CERES instruments, science rationale, major tasks, science investigations, science implementation, resources, documentation, and milestones and schedule.

Validation Plan: This plan will describe the CERES validation requirements and the premises from which to verify the CERES results. It will provide specific validation standards, the tasks required to meet these standards, and associated resources and schedule to validate the results consistent with both the CERES launch schedules and the goals established in the Announcement of Opportunity OSSA-1-88, dated January 19, 1988.

Science Reference Manual: This document will provide a record of both the instruments and the data processing specifications as well as background material helpful to understanding the choices made in producing the data processing algorithms.

Science Implementation Plan: This document will delineate the various tasks and programmatic activities that comprise the CERES Science Program. Specific topics to be addressed are those outlined in the Science Management Plan, but now with emphasis on actual implementation of those requirements and any others that may have been added as CERES Science Planning progresses.

Ceres Scanner Final Calibration Report: This document will provide detailed design and calibration information for each scanner instrument. The information will be provided and accumulated as construction and testing of the instruments progresses.

Correlative Measurements Plan: This document will provide a description of the CERES correlative measurements program for both validating the CERES measurements and supporting scientific investigations. This plan will concentrate on all measurements other than CERES that are required to meet the project objectives which include: specific correlative measurements requirements, description of the satellite sensor combinations required to provide the measurements, management/implementation plans, specific responsibilities, archival support, major milestones and schedules, and associated resources for meeting the milestones and schedules.

Appendix B

Abbreviations/Acronyms

Abbreviations/Acronyms

A/D	Analog/Digital
ACD	Analysis and Computation Division
ACR	Active Cavity Radiometer
ACRF	Averaged Cloud Radiation Field
ADM	Angular Dependence Model
ALT	Altimeter (Altitude)
AMSU	Advanced Microwave Sounding Unit
AVHRR	Advanced Very High Resolution Radiometer
BB	Blackbody
CASE	Computer-Aided Software Engineering
CCC	Central Computing Complex
C&DH	Control and Data Handling
CCR's	Configuration Change Requests
CDA	Command and Data Acquisition
CDHF	Central Data Handling Facility
CDOS	Customer Data and Operations System
CDR	Critical Design Review
CEBAF	Continuous Electron Beam Accelerator Facility
CERES	Clouds and the Earth's Radiant Energy System
CFP	Cloud Flux Product
CM	Correlative Measurements
CMDS	Commands
CO-I	Co-Investigator
COLAT	Colatitude
CR	Correlation Radiometer
CVP	Cloud Validation Product
D/L	Downlink
DAAC	Distributed Active Archive Center
DADS	Data Archive and Distribution System
DDB	Daily Data Base
DHC	Data Handling Center
DIF	Data Interface Facility
DMT	Data Management Team
EMOC	EOS Mission Operations Center
EOS	Earth Observing System
EOSDIS	EOS Data and Information System
ERB	Earth Radiation Budget
ERBE	Earth Radiation Budget Experiment

ERBI	Earth Radiation Budget Instrument
ERBS	Earth Radiation Budget Satellite
ESSC	Earth System Sciences Committee
FAP	Flux Archival Product
FDF	Flight Dynamics Facility
FIRE	First ISCCP Regional Experiment
FM's	Flight Models
FORTRAN	Formula Translator
FOV	Field-of-View
GAP	Global Averages Product
GCM	General Circulation Model
GLRS	Geoscience Laser Ranging System
GOES	Geostationary Operational Environmental Satellite
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
HIRS	High Resolution Infrared Radiation Scanner
ICC	Instrument Control Center
ICD	Interface Control Document
IFWG	Interface Working Group
IGR	Instantaneous Geographic Region
IICF	Interdisciplinary Investigator Computing Facility
IIWG	International Investigator Working Group
IMC	Information Management Center
I/O	Input/Output
IPE	Instrumentation Project Engineer
IS	Integrating Sphere
ISCCP	International Satellite Cloud Climatology Project
ISTs	Instrument Support Terminals
IVP	Instrument Validation Product
IWG	Investigator Working Group
JCL	Job Control Language
LaRC	Langley Research Center
LW	Longwave
MAM	Mirror Attenuator Mosaic
MEA	Main Electronics Assembly
MFOV	Medium Field-of-View
MISR	Multi-angle Imaging Spectro-Radiometer
MODIS	Moderate Resolution Imaging Spectrometer
MRBB	Master Reference Blackbody
MTSA	Monthly Time Space Averaging

MTF	Modulation Transfer Function
NASA	National Aeronautics and Space Administration
NASCOM	NASA Communications
NCAR	National Center for Atmospheric Research
NCC	Network Control Center
NCDS	National Climate Data System
NESDIS	National Earth Satellite Data Information Service
NF	Numerical Filter
NFOV	Narrow Field-of-View
NMC	National Meteorological Center
NOAA	National Oceanic and Atmospheric Administration
NOS	Network Operating System
NPOP-1	NASA Polar Orbiting Platform Eos-A
NPOP-2	NASA Polar Orbiting Platform Eos-B
NS	Nonscanner
NSSDC	National Space Science Data Center
OLR	Outgoing Longwave Radiation
P/S	Planning/Scheduling
P/F	Platform
PDR	Preliminary Design Review
PFM	Proto-flight Model
PI	Principal Investigator
PICF	Principal Investigator Computing Facility
PM	Project Manager
PSC	Platform Support Center
PSF	Point Spread Function
QC	Quality Control
RAP	Raw Archival Product
RAT	Raw Archival Tape
REP	Radiant Energy Product
RICC	Remote Instrument Control Center
RMS, rms	Root-Mean-Squared
RSS, rss	Root-Sum-Square
SAF	Surface and Atmospheric Flux
SAFIRE	Spectroscopy of the Atmosphere Using Far Infrared Emission
SAGE	Stratospheric Aerosol and Gas Experiment
S/C	Spacecraft
SC	Scanner
S&MRWG	Science and Mission Requirements Working Group
SCR	Synoptic Clouds and Radiation

SNS	Supercomputing Network Subsystem
SPAN	Space Physics Analysis Network
SRB	Surface Radiation Budget
SSC	Science Steering Committee
SURANET	Southern Universities Research Association Network
SW	Shortwave
SWICS	Shortwave Internal Calibration Source
TCP/IP	Transmission Control Protocol/Internet Protocol
TDRSS	Tracking and Data Relay Satellite System
TGT	TDRSS Ground Terminal
TMCF	Team Member Computing Facility
TOA	Top-of-the-Atmosphere
TRACER	Tropospheric Radiometer for Atmospheric Chemistry and Environmental Research
UNIX	A computer software operating system
XNS	Xerox Network System