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

Data Management System (DMS)

Software Management Plan

Version 1

for

National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP)

October 2008

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

Data Management System

Stakeholder-Commitment Sheet for the CERES Software Management Plan

This Stakeholder-Commitment Sheet is to demonstrate that the relevant stakeholders as identified in the CERES Data Management Plan are aware of and support the CERES processes described in the CERES Software Management Plan.

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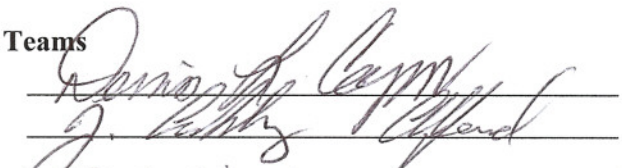
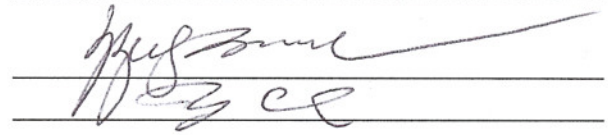
Instrument		(Denise L. Cooper, Lead) (J. Ashley Alford)
ERBE-like		(Dale R. Walikainen, Lead)
Clouds		(Sunny Sun-Mack, Lead) (Yan Chen)

Document Revision Record

The Document Revision Record contains information pertaining to approved document changes. The table lists the Version Number, the date of the last revision, a short description of the revision, and the revised sections. The document authors are listed on the cover.

Document Revision Record

Version Number	Date	Description of Revision	Section(s) Affected
V0	08/04/2008	• Initial version of the CERES NPP Software Management Plan (draft).	All
V1	10/09/2008	• Added stakeholders.	Stakeholder-Commitment Sheet
		• Modified wording.	Sec. 2.12.1.4
		• Added Table 3-1 and Figure 3-1.	Sec. 3.0
		• Added QStats and TOA.	App. A
		• The DFD chart has been modified to add the ISCCP-D2like products. (10/27/2008)	Figure 1-2

Preface

The CERES DMS supports the data processing needs of the CERES Science Team to increase understanding of the Earth's climate and radiant environment. The CERES DMT works with the CERES Science Team to develop the software necessary to support the science algorithms. This software, being developed to operate at the Langley ASDC, produces an extensive set of science data products. The DMS consists of 12 subsystems each of which contains one or more PGEs.

The purpose of the CERES Software Management Plan is to describe the CERES software development processes that are in place for the current support of processing CERES data from Terra and Aqua and the processes that are being put in place for integrating the CERES-NPP/FM5 software into the CERES DMS for successfully processing CERES data from the FM5 instrument to be flown on NPP.

The CERES Data Management Plan provides overall guidance to the CERES DMT.

Acknowledgements

This document reflects the collaborative efforts of the CERES DMT (in conjunction, as appropriate, with the CERES Science Team). The primary contributors to this document are:

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1.0 Introduction

CERES is a key component of EOS and NPP. The first CERES instrument (PFM) flew on TRMM, four instruments are currently operating on the EOS Terra (FM1 and FM2) and Aqua (FM3 and FM4) platforms, and FM5 will fly on the NPP platform currently scheduled for launch in June 2010. CERES measures radiances in three broadband channels: a shortwave channel (0.3 - 5 μm), a total channel (0.3 - 200 μm), and an infrared window channel (8 - 12 μm). The last data processed from the PFM instrument aboard TRMM was March 2000; no additional data are expected. Until June 2005, one instrument on each EOS platform operated in a fixed azimuth scanning mode and the other operated in a rotating azimuth scanning mode; now all are typically operating in the fixed azimuth scanning mode. The NPP platform will carry the FM5 instrument, which will operate in the fixed azimuth scanning mode though it will have the capability to operate in a rotating azimuth scanning mode.

CERES climate data records involve an unprecedented level of data fusion: CERES measurements are combined with imager data (e.g., MODIS on Terra and Aqua, VIIRS on NPP), 4-D weather assimilation data, microwave sea-ice observations, and measurements from five geostationary satellites to produce climate-quality radiative fluxes at the top-of-atmosphere, within the atmosphere and at the surface, together with the associated cloud and aerosol properties.

The CERES project management and implementation responsibility is at NASA Langley. The CERES Science Team is responsible for the instrument design and the derivation and validation of the scientific algorithms used to produce the data products distributed to the atmospheric sciences community. The CERES DMT is responsible for the development and maintenance of the software that implements the science team's algorithms in the production environment to produce CERES data products. The Langley ASDC is responsible for the production environment, data ingest, and the processing, archival, and distribution of the CERES data products.

The purpose of this document is to describe the CERES DM software development processes as will be used for FM5, as well as to provide an overview of the CERES processes that are already in place (see Section 1.2). This document will make frequent reference to the existing CERES DM process plans that thoroughly document the processes used by the CERES DMT in developing and maintaining the CERES software and providing the software to the Langley ASDC where it is used to generate the CERES climate-quality data products. In developing this document, Chapter 5 of NPR 7150.2 (see Reference 1) was relied on heavily for guidance.

All acronyms used in this document are defined in Appendix A. They are not defined in the text.

This document is organized as follows:

Section 1.0 – Introduction
Section 2.0 – CERES Software Development Process
Section 3.0 – Approach for CERES FM5
Appendix A – Acronyms

1.1 Organization

The key organizational elements that are involved in the CERES software development and data processing effort are shown in Figure 1-1. The CERES Science Team and WG chairs are included in the "Science" area. The CERES DMT, which consists of subsystem teams, the CM Team, and the Documentation Team, is included in the "Data Management" area. Members of the CERES working groups may be from the Science Team or DMT. Typically, the NASA personnel are located at NASA LaRC in Building 1250, and the contractor personnel are located in an off-site facility. The computer environment that supports both the Science Team and the Data Management Team in both locations is the SCF.

The goal of these teams is to prepare software which implements the CERES algorithms as defined by the CERES Science Team as represented in the data flow diagram shown in Figure 1-2 and to execute this software operationally to produce the CERES data products (see Reference 2). Operational data processing is conducted at the ASDC. The computer environment at the ASDC is referred to in this document as the production environment. In addition to operational data processing, software testing (validation) is also performed in the production environment as this is the computer environment where the operational data processing will ultimately take place. Testing is also performed at the SCF.

1.2 CERES Software Development Processes

The CERES DMT developed and follows a set of customized processes for developing, testing, controlling, delivering, and maintaining the CERES production science software that is run operationally at the ASDC. These processes are described in eight process plans (see Reference 3) and were approved by the SEI as a result of the successful completion of a SCAMPI A Appraisal (Appraisal# 8991) by the CERES DMT under NASA Contract#: NAS1-02058; see SEI "Published Appraisal Results" website (see Reference 4) under "National Aeronautics and Space Administration - Langley's CERES/ASRATSS Project: CERES Data Management Task." The support provided by the CERES DMT at the time of publication of this document is under NASA Contract#: NNL07AA00C; the same team under the same task leadership is providing the CERES data management support in accordance with these process plans.

The CERES Software Management Plan supplements the existing plans (that will be referenced throughout this document) to specify specific work to be done in modifying the CERES science software system's baseline configuration to accommodate operational processing of NPP CERES FM5 data and to specifically address the scope, effort, resources, and schedule to support NPP CERES FM5.

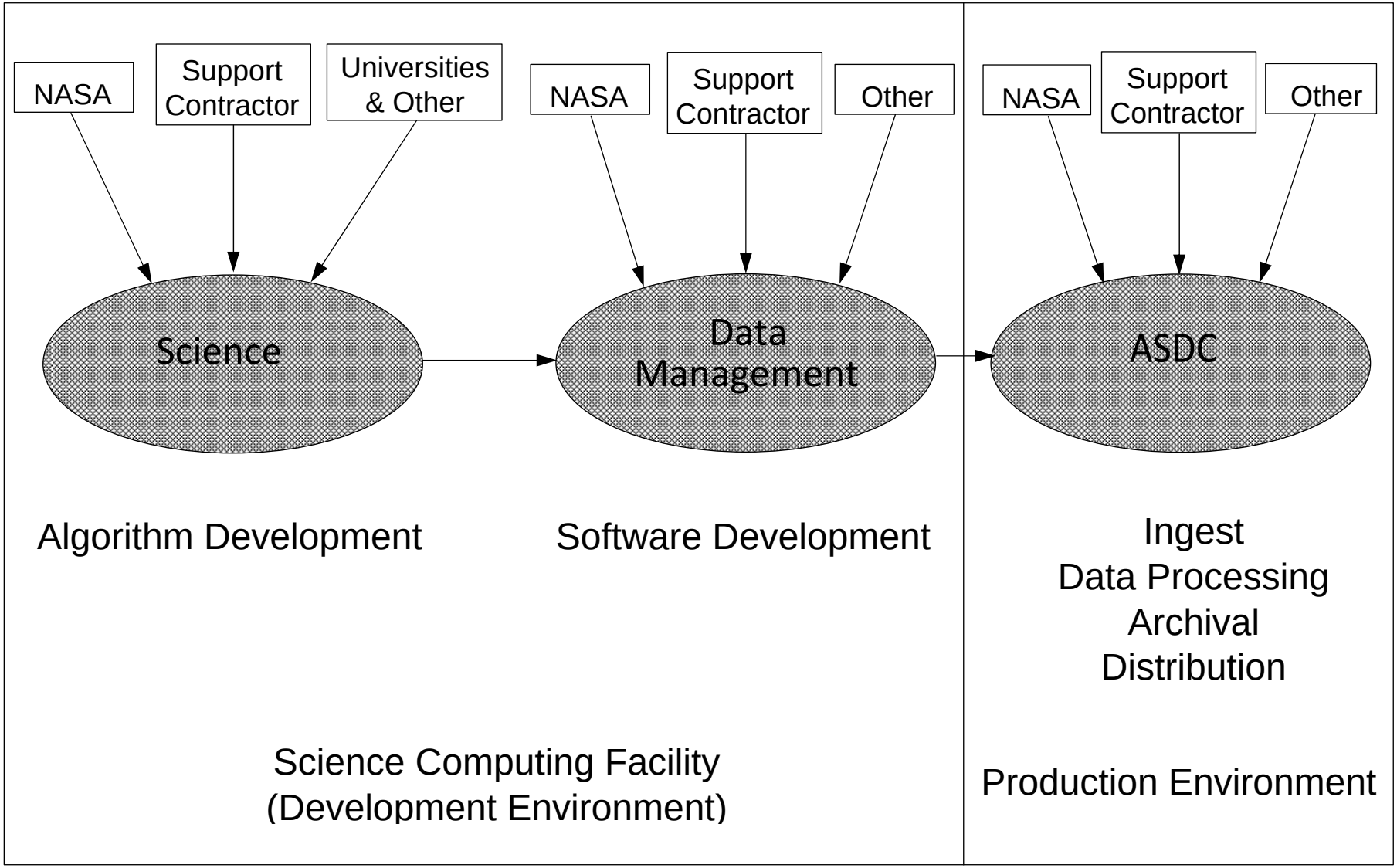
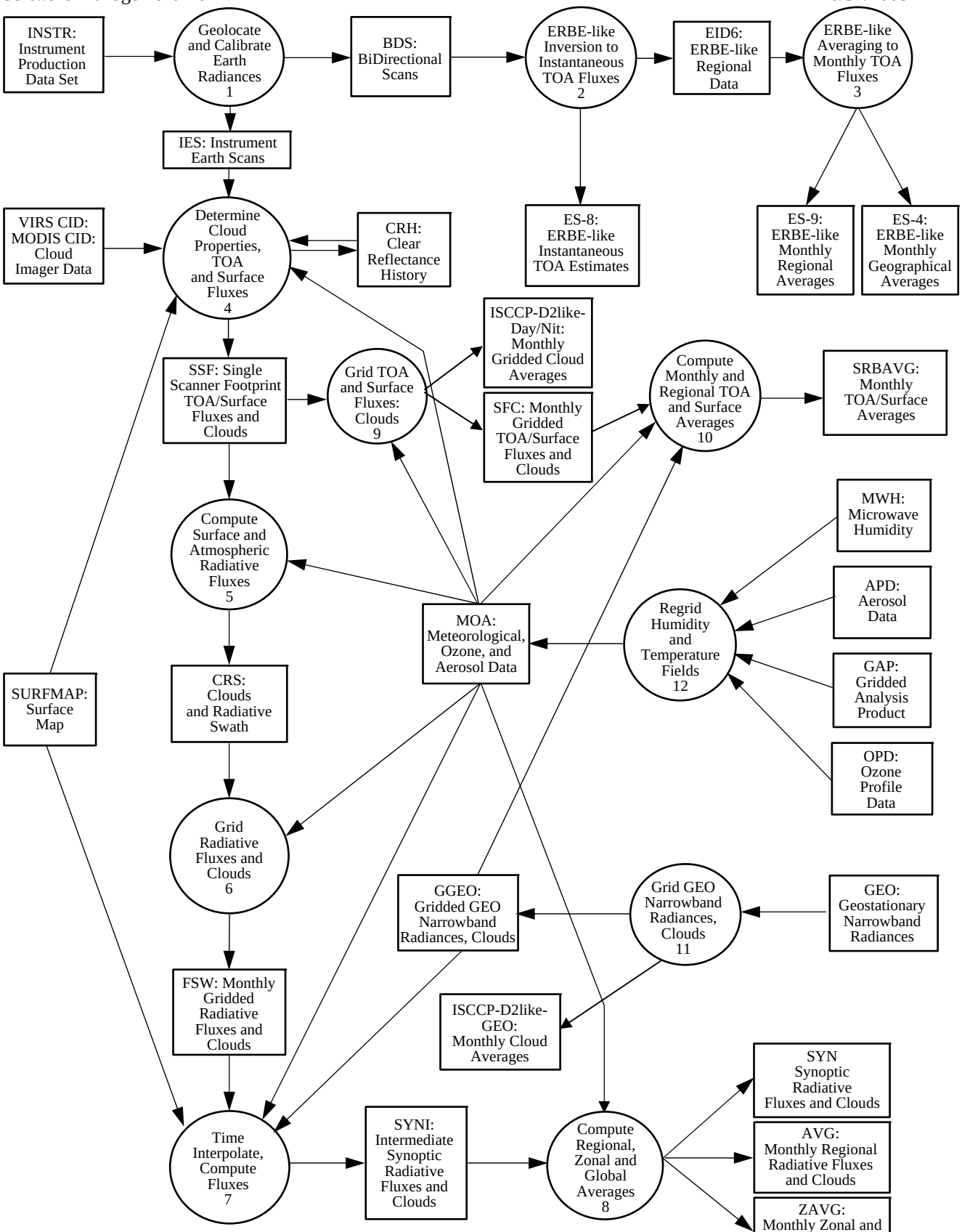


Figure 1-1. Organizational Components for CERES Software Development and Data Processing



Modified Date: October 2008

Figure 1-2. CERES Top Level Data Flow Diagram

2.0 CERES Software Development Process

The CERES software development process is defined by the following documents which are available on the Web (see Reference 3).

1. Configuration Management Plan
2. Data Management Plan
3. Measurement and Analysis Plan
4. Process and Product Quality Assurance Plan
5. Requirements Management Plan
6. Risk Management Plan
7. Software Development Plan
8. Training Management Plan

These documents will be referenced throughout this document as appropriate.

2.1 CERES Software Classification

The CERES software that comprises the CERES data processing system is Class C - Mission Support Software (see Reference 5). As described in Section 2.1.1, the existing CERES software should also be considered as "heritage" or "legacy" software as it is based on the ERBE data processing system.

2.1.1 ERBE Heritage

ERBE was a multi-satellite system designed to measure the Earth's radiation budget. The ERBE instruments flew on a low-inclination NASA satellite (ERBS) and two sun-synchronous satellites (NOAA-9 and NOAA-10). Each satellite carried both a scanner and a nonscanner instrument package.

ERBE software and concepts were reused by the CERES software development team. For example, early on the CERES Inversion and TISA Subsystems relied heavily on reused ERBE code. CERES also derived much of the initial set of CERES documentation and documentation standards from the documentation set developed for the ERBE project. A complete list of CERES documentation can be found in the Data Management Plan and on the CERES On-Line Documentation website (see Reference 6).

2.2 Engineering Environment

The Science Team derives, maintains, and refines science algorithms to produce climate-quality data products from the CERES instruments to characterize Global Climate Change; the DMT implements these research science algorithms as operational software to be run at the ASDC. The CERES operational software development environment is the SCF which is described in the following two IT security plans.

1. Security Plan for the Science Directorate Servers - **SC-008-M-LRC-1002**
   Issue Date: 09-23-2007 v1.2
   Effective Date: 09-23-2007
2. Security Plan for the Science Directorate Computing Environment - **SC-011-M-LRC-1001**
   Issue Date: 09-24-2007 v1.2
   Effective Date: 09-24-2007

The CERES software resides at the SCF where it is backed up and protected from outside attack.

The data processing production environment is provided by the Langley ASDC. The ASDC provides the capability to ingest, process, archive, and disseminate the climate-quality data products.

2.3 Manage Quality Characteristics of Software Products

The CERES DMS Process and Product Quality Assurance Plan is used to ensure that the CERES DMT follows processes defined in the various CERES DMS plans during the development and maintenance of CERES software and that the highest quality products are delivered to the ASDC.

For reference, the high-level definition of Process and Product Quality Assurance follows (see Reference 7).

The purpose of Process and Product Quality Assurance is to provide staff and management with objective insight into processes and associated work products.

The CERES approach to Process and Product Quality Assurance is described in the CERES DMS Process and Product Quality Assurance Plan.

2.4 Process for Scheduling, Tracking, and Reporting

The CERES DMT schedules and tracks several different items, and this scheduling and tracking falls under several different process areas and, consequently, is described in different CERES process plans. Several of the plans that address schedules and tracking are listed below along with the schedules, tracking, and reporting information that is contained in each. For reference, the section number where this information can be found is also provided.

2.4.1 Configuration Management Plan

- The CM Team tracks the defects identified during CM testing along with the causes of these defects and records the occurrence of defects in Test Results Logs (Section 2.3 of the Configuration Management Plan).
- The CM Team maintains schedules for software and coefficient deliveries (Section 4.0 of the Configuration Management Plan).

2.4.2 Measurement and Analysis Plan

- The CERES CM Team tracks the scheduled delivery dates, the actual dates of deliveries to CM, and the dates the CM Team releases the deliveries to the ASDC SIT Team in the Delivered Files Tracking document (Section 2.1 of the Measurement and Analysis Plan).
- The QStats Report is prepared quarterly and contains a summary of the information in the Test Results Log and Delivered Files Tracking document (Section 4.0 of the Measurement and Analysis Plan).

2.4.3 Process and Product Quality Assurance Plan

- QA audits for processes will be scheduled for six-month periods that begin in January and July (Section 3.0 of the Process and Product Quality Assurance Plan).
- Any CERES DMT product that is identified to be audited in the Process and Product Quality Assurance Plan will be audited when provided to the CERES Documentation Team for delivery to the ASDC. The audit must be completed before the product is provided to the ASDC (Section 3.4 of the Process and Product Quality Assurance Plan).
- A QA checklist will be completed during each audit (Section 5.2 of the Process and Product Quality Assurance Plan).
- The QA Action Item Log will be maintained by the CERES QA Lead. It will identify corrective action requested during QA audits, responsible person, action required, and the current status (Section 5.3 of the Process and Product Quality Assurance Plan).
- By the 15th of the month following the end of each calendar quarter, the CERES QA Lead will generate the QA Status Report and provide it to the CERES DMT Lead, the designated CERES DMT Supervisor, and the Contract Program Manager and QA Manager (Section 5.4 of the Process and Product Quality Assurance Plan).
- The reports and schedule produced as a result of the Process and Product Quality Assurance Plan are maintained electronically on the CERES QA Lead's workstation. QA checklists are scanned to allow them to be maintained electronically. Hardcopies of QA audits including Verifiable Objective Evidence will be stored in the CERES QA Lead's office (Section 5.5 of the Process and Product Quality Assurance Plan).

2.4.4 Requirements Management Plan

- Requirements Logs are maintained by each CERES DM subsystem team to track and manage subsystem requirements (Section 3.0 of the Requirements Management Plan).

2.5 Verification and Validation

For reference, high-level definitions of the Verification and Validation CMMI process areas follow (see Reference 7).

The purpose of Verification is to ensure that selected work products meet their specified require-ments.

The purpose of Validation is to demonstrate that a product or product component fulfills its intended use when placed in its intended environment.

Verification and Validation as used in the CERES software development process are described in some detail in the CERES Software Development Plan. The following table (Table 2-1) shows the mapping between the various CERES software development processes and the associated CMMI process areas.

Table 2-1. Map of CERES Processes to CMMI Process Areas

CERES Process	Process Environment	CMMI Process Area	Computer Environment	Section in SDP[a]
New Requirement Received and Analyzed	Subsystem	Requirements Management	SCF	2.1
Requirement Accepted and Assigned	Subsystem	Requirements Management	SCF	2.2
Updates Made and Unit Tested	Subsystem	Verification	SCF	3.1
Updates Integrated into Baseline	Subsystem	Product Integration	SCF	3.2
Subsystem Science Testing	Subsystem	Product Integration Verification	SCF	3.3
Pre-CM Testing	Subsystem	Validation	ASDC	3.4
Delivery to CERES CM	Subsystem	Product Integration	SCF	3.5
CM Testing	CM	Validation	ASDC	4.1
Release to SIT	CM	Product Integration	ASDC	4.2
Operational Testing at ASDC[b]	ASDC	Validation	ASDC[a]	5.1
ValRx Testing	Subsystem Science Team ASDC	Validation Verification	ASDC	5.2

a. Software Development Plan
b. Informational only, “Operational Testing at ASDC” is not a CERES Data Management process.

The table indicates which working level or organization (Process Environment) performs each CERES process and lists in which Computer Environment the process is performed. For reference, the last column shows where in the Software Development Plan the CERES process is discussed. In general, Verification is covered in Sections 1, 3, and 5; Validation is covered in Sections 1, 3, 4, and 5 of the Software Development Plan.

2.6 Stakeholder Involvement

Stakeholder involvement is discussed in the CERES DMS Data Management Plan (Draft).

2.7 Risk Management

For reference, the high-level definition of Risk Management follows (see Reference 7).

The purpose of Risk Management is to identify potential problems before they occur so that risk-handling activities can be planned and invoked as needed across the life of the product or project to mitigate adverse impacts on achieving objectives.

The CERES approach to Risk Management is described in the CERES DMS Risk Management Plan.

2.8 Security Policy

IT security is discussed in Section 2.2 (Engineering Environment) above.

2.9 Training

Training falls under CMMI Generic Practice 2.5 – Train the people performing or supporting the process as needed. For reference, the high-level definition of "Train People" follows (see Reference 7).

The purpose of training is to ensure that the people have the necessary skills and expertise to perform or support the process (whichever one it may be).

The CERES approach to training is described in the CERES DMS Training Management Plan.

2.10 Configuration Management

For reference, the high-level definition of CM follows (see Reference 7).

The purpose of CM is to establish and maintain the integrity of work products using configuration identification, configuration control, configuration status accounting, and configuration audits.

The CERES approach to CM is described in the CERES DMS Configuration Management Plan.

2.11 Software Metrics (Measurement and Analysis)

For reference, the high-level definition of Measurement and Analysis follows (see Reference 7). The purpose of Measurement and Analysis is to develop and sustain a measurement capability that is used to support management information needs.

The CERES approach to Measurement and Analysis is described in the CERES DMS Measurement and Analysis Plan.

2.12 Software Documentation Tree

CERES documentation can be accessed via the CERES On-Line Documentation website (see Reference 6). Pertinent CERES DM documentation there includes CERES system-level documentation and subsystem-level documentation which are described in Sections 2.12.1 and 2.12.2 below. Section 2.12.3 contains descriptions of other pertinent DM documentation that are on the "CERES on NPP" Web page under the CERES On-Line Documentation website.

2.12.1 System-level Documents

2.12.1.1 Data Management Plan

This is the original CERES Data Management Plan; it is dated June 1990. The purpose of this CERES Data Management Plan was to describe the manner in which the CERES instrument data would be acquired, processed, and archived for access by the scientific community. The CERES Data Management Plan is being updated. The updated version is discussed in the next section.

2.12.1.2 Data Management Process Plans

- Configuration Management Plan

The CERES approach to CM is described in the CERES DMS Configuration Management Plan which is available online (see Reference 3). The CM Plan describes the responsibilities of the CM Team and the CERES approach to configuration control and the CERES CM process, configuration identification, baselines, and CERES CM audits. The CM Plan also describes the CERES SCCR form and procedure, CM Testing at the ASDC (this is considered part of the CERES Validation process), release of CERES CIs to the ASDC, recapture of CIs to the CERES CM storage repository, control and maintenance of records of CI updates, and CERES delivery schedules. In addition, CERES CM process audits are described in the CERES DMS Process and Product Quality Assurance Plan as one of the system-level process audits.

- Data Management Plan - Draft

This is an updated draft of the CERES Data Management Plan; it has not yet been peer reviewed.

The purpose of this CERES Data Management Plan is to provide overall guidance on the development of the operational software delivered to the Langley ASDC.

- Measurement and Analysis Plan

The CERES approach to Measurement and Analysis is described in the CERES DMS Measurement and Analysis Plan which is available online (see Reference 3). Metrics have been identified by CERES to evaluate adherence to the software delivery schedule and defects associated with the software delivery. The Measurement and Analysis Plan describes what is measured, how the measurements are accomplished, and the metric analysis and reporting mechanism.

- Process and Product Quality Assurance Plan

The purpose of the Process and Product Quality Assurance Plan is to provide processes that if followed will help to ensure that the CERES DMT follows the processes defined in the various CERES DMS plans during the development and maintenance of CERES software and delivers the highest quality products to the ASDC. Topics covered in this plan include QA Audit Schedule, QA Procedures, and QA Reporting.

- Requirements Management Plan

The purpose of the Requirements Management Plan is to provide specific guidance to the DMT regarding the Requirements Management process of receiving, accepting, and implementing requirements for the development of CERES DM software that will be delivered to the ASDC. The Requirements Management Plan discusses the basis for all requirements received by the DMT, how these requirements are to be conveyed to and accepted by the DMT, and how the DMT tracks these requirements via subsystem-level requirements logs. This plan further discusses how the DMT maintains bidirectional traceability using these requirements logs and CERES SCCRs.

- Risk Management Plan

The CERES approach to Risk Management is described in the CERES DMS Risk Management Plan which is available online (see Reference 3). The Risk Management Plan describes risk identification including risk categories, sources, and mitigation strategies, risk assessment factors and risk assessment reports including generation, distribution, and storage.

- Software Development Plan

The Software Development Plan defines the processes followed by the CERES DMT while developing and maintaining the CERES DMS. Additional documents associated with the project 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. These documents are accessible from the CERES On-Line Documentation page (see Reference 6). The stages and steps of the CERES software development process which is shown in the Software Development Plan is shown here as Figure 2-1.

Each of these stages is described in detail in Section 2.0 through Section 5.0 of the Software Development Plan. The assignment of responsibility for each stage can be found in the CERES Software Development Responsibility Matrix of the Software Development Plan and shown here as Table 2-2.

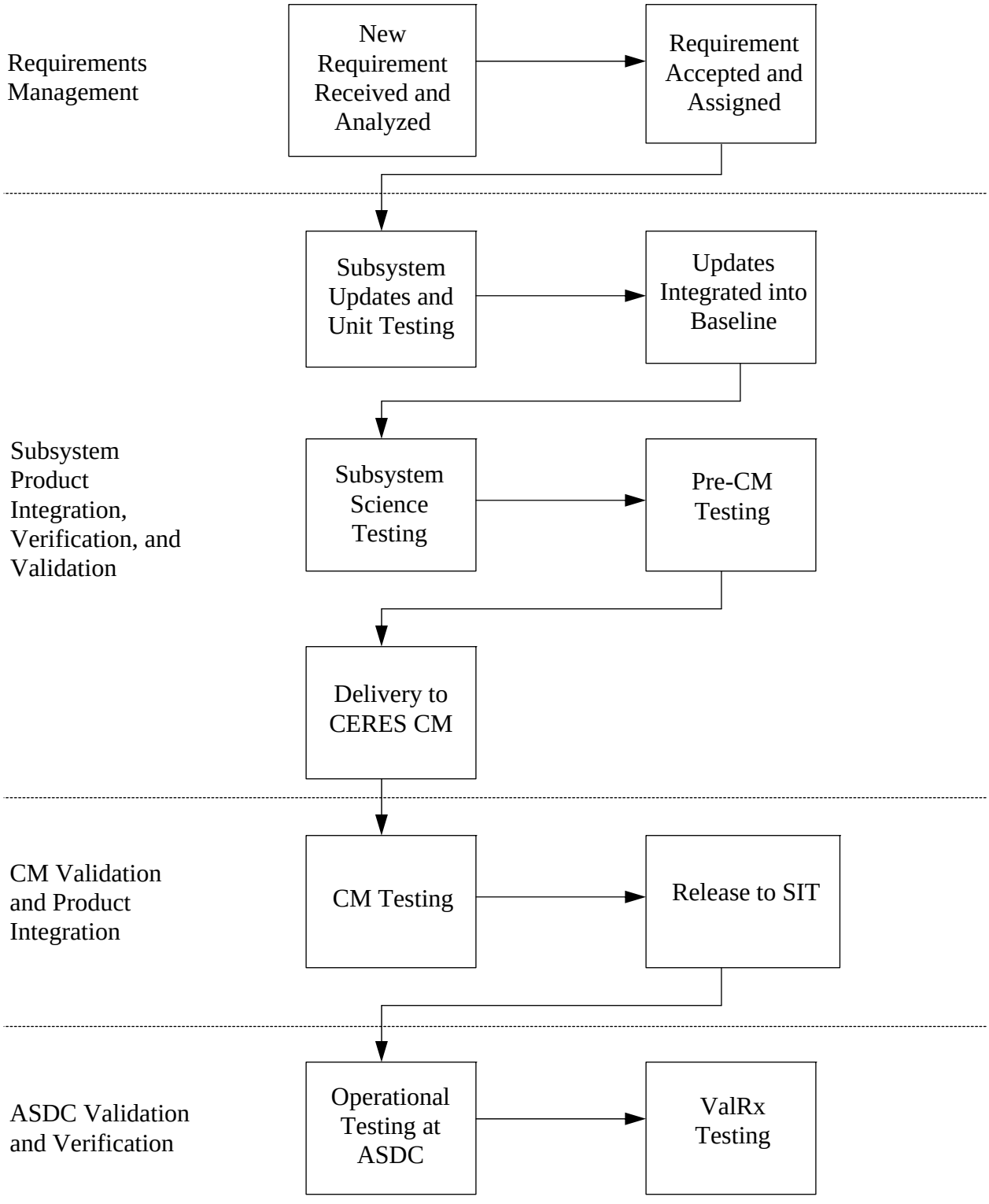


Figure 2-1. CERES Software Development Process Flow Diagram

Table 2-2. CERES Software Development Responsibility Matrix

Task	Subsystem Team	Subsystem Integrator	Science Team	CM Team	ASDC
New Requirement Received and Analyzed	P	S	S		
Requirement Accepted and Assigned	P	S	S		
Updates made and Unit Tested	P				
Updates Integrated into Baseline	S	P			
SS Science Testing	S	P	S		
Pre-CM Testing		P			
Delivery to CERES CM		P		S	
CM Testing		S		P	
Release to SIT				P	S
Operational Testing		S		S	P
ValRx Testing	P	S	P		P

P – Primary
S – Secondary

Other topics in the CERES Software Development Plan include,

- CERES Software Development Process Flow
- CMMI Process Areas Mapped to CERES
- ERBE Heritage (of the CERES code)
- Requirements Management Stage
- Subsystem-level Product Integration, Verification, and Validation Stage
- CM Validation and Product Integration Stage
- Operational and “ValRx” Testing at the ASDC
- Checklist for Public Release of Data Products
- CERES DMT Peer Reviews

- Training Management Plan

The CERES approach to training is described in the CERES DMS Training Management Plan, which is available online (see Reference 3).

2.12.1.3 Data Products Catalog

The CERES Data Products Catalog contains information on the following categories of formal CERES data products.

1. Primary Output Data Products that are archived and distributed by the ASDC
2. Internal Data Products that are generated during processing
3. Ancillary Data Products that are generated external to CERES and needed for CERES data processing

The data products in each category are described in the Data Products Catalog along with the following attributes.

- Level - The CERES data products are defined in terms of "levels"
  Level 0: raw instrument data at full sensor resolution.
  Level 1A: raw instrument data at full sensor resolution, time-referenced, and annotated with ancillary information (including radiometric calibration coefficients and geolocation parameters such as platform ephemeris) computed and appended but not applied to the Level-0 data.
  Level 1B: Level-1A data processed to sensor units and geolocated.
  Level 2: derived geophysical variables at the same resolution and location as the Level-1 source data.
  Level 3: geophysical variables mapped on uniform space-time grids, usually with some completeness and consistency.
  Level 4: model output or results from analyses of lower-level data, e.g., variables derived from multiple measurements.
- Type - Data type (Primary, Internal, or Ancillary)
- Frequency - How often the product is received or produced
- Time Interval Covered -
  File - Time period covered within this file
  Record - Time period covered within one record of this file
- Portion of Globe Covered -
  File - Portion of the globe covered within this file
  Record - Portion of the globe covered within a record of this file
- Portion of Atmosphere Covered -
  File - Portion of the atmosphere covered within this file (surface, top-of-the-atmosphere, etc.)

Attributes provided for the parameters contained on the various data products include,

- Description - A textual description of the parameter
- Parameter Number - Arbitrary number assigned to the parameter
- Units - Units of the parameter value
- Range - Range of values for the parameter

- Elements/Record - Elements per record for this parameter (array definition)
- Bits/Element - Number of bits used to describe this parameter
- Elem Num - Element Number, a numbering of each element in the file/record

2.12.1.4 Software Coding Guidelines

The purpose of the Software Coding Guidelines document is to provide a set of guidelines for source code development for the CERES data processing system to standardize software development practices within the CERES DMT. The guidelines contained in this document are intended to be followed by all CERES subsystems, however, it is recognized that there will be times when these guidelines must be tailored in the interest of performance, reusability, or other mitigating circumstance.

2.12.2 Subsystem-level Documents

2.12.2.1 Algorithm Theoretical Basis Documents (ATBDs)

The ATBDs are intended to describe the physical and mathematical description of the algorithms to be used in the generation of CERES data products.

2.12.2.2 Collection Guides

The CERES Collection Guides are written at the data product level and are intended to give an overview of the science product along with definitions of each of the parameters included within the product.

2.12.2.3 Operator's Manuals

The CERES Operator's Manuals are written by the DMT for the data-processing group at the ASDC. Further, there is a Test Plan associated with each delivery of the subsystem's software. Each volume describes all PGEs for a particular CERES subsystem and contains the Runtime Parameters, Production Request Parameters, the required inputs, the steps used to execute, and the expected outputs for each executable included for the subsystem. In addition, all subsystem error messages and subsequent actions required by the ASDC data-processing group are included.

2.12.2.4 Requirements Logs

CERES Requirements Logs are maintained at the subsystem level and are used to track software requirements and to provide a link between each requirement and the associated CERES SCCR. The following eleven data fields are maintained in each requirement log.

1. Requirement Number
2. Requirement
3. SCCR
4. Provider
5. Responsible Subsystem
6. Responsible Person
7. How was the new requirement conveyed to the subsystem team
8. When was the new requirement received by the subsystem team

9. When was the new requirement accepted by the subsystem team
10. When was the requirement completed
11. The current status of the requirement

2.12.2.5 Software Design Documents

These documents were prepared to record the architectural design of each of the Subsystems for the CERES Release 1 code development activity. At the time of their writing they were considered preliminary and were intended for internal distribution only to document what was done to accomplish Release 1 development and were to be used as a reference for the Release 2 development effort. The notable exceptions are the "design documents" for the ERBE-like Subsystems. As this code was largely reused code from ERBE, it was essentially complete when these design documents were being prepared, thus, the ERBE Reference Manuals were made available through the Software Design Documents website. The ERBE Reference Manuals provide a detailed description of the final software release of the ERBE DMS.

2.12.2.6 Software Requirements Documents

The CERES DMS Software Requirements Documents were prepared by the CERES DMT for each CERES subsystem. The purpose of these documents is to provide a basis for the software design by providing a complete set of requirements to guide the design and further development of the subsystem. The requirements are based on the CERES Science Team's ATBDs.

2.12.2.7 Test Plans

The CERES DMS Test Plans are prepared by the CERES DMT for each CERES subsystem. The CERES Test Plans are part of the CERES delivery package provided to the ASDC. They provide a description of the subsystem software and supporting data files and explain the procedures for installing, executing, and testing the software. There is also a section included on validating the results of executing the software.

2.12.2.8 Data Quality Summaries

For each publicly released CERES data set there is a Data Quality Summary document which can be accessed from the CERES On-Line Documentation page (see Reference 6). This document summarizes the key validation results to date for each archived and validated data set. It also may have links to ongoing validation websites maintained by the CERES working groups or to journal or conference papers and presentations as they become published.

All data sets are reviewed by the CERES Science Team before release as a validated Edition version. These Data Quality Summaries are meant to be the minimum set of information necessary to understand the strengths and weaknesses of the data sets. The more complete reports of validation results are typically published in the peer reviewed scientific literature, but take much longer to make available to the science community. The Data Quality Summary was a concept developed and implemented by the CERES team to facilitate more rapid and rigorous scientific use of the data sets for climate research.

2.12.3 Other CERES DM Documentation

2.12.3.1 CERES Science and Data Products Working Agreement

This is the working agreement between the NPP Project Office at NASA/GSFC and the CERES Project Team at NASA/LaRC. This working agreement defines the execution/operations phase responsibilities and program milestones of the CERES Investigation Team for the CERES FM5 instrument. The work it describes includes, but is not limited to, developing and maintaining scientific software to produce standard and special data products from CERES instrument observations; generating standard and special data products; ingesting input data; archiving and distributing standard and special data products; validating the data products; leading the scientific research to support the NPP Science Plan; and providing support for the operation of the instrument. This agreement further identifies the responsibilities, deliverable items, and data products to be provided by the Investigation Team as well as the resources to be supplied by the NPP SDS.

At the time of this writing the working agreement had not received its final approval. After it is approved (all eleven signatures on the signature page are collected) a copy will be placed on NX (see Reference 8).

3.0 Approach for CERES FM5

The formal, publicly available CERES output products are shown in Table 3-1.

Table 3-1. CERES Publicly Available Output Products

Index	Data Product	Data Product Name	File Freq.
1	BDS	Bidirectional Scan	1/day
2	ES-8	ERBE-like Filtered & Unfiltered Radiances & TOA Fluxes	1/day
3	ES-9	ERBE-like Monthly Regional Averages	1/mo
4	ES-4	ERBE-like Monthly Geographical Averages	1/mo
5	SSF	Single Scanner Footprint TOA/Surface Fluxes & Clouds	1/hr
6	SFC	Monthly Gridded Radiative Fluxes & Clouds	36/mo
7	SRBAVG	Monthly TOA/Surface Averages	5/mo
8	CRS	Clouds and Radiative Swath	1/hr
9	FSW	Monthly Gridded Radiative Fluxes & Clouds	60/mo
10	SYN	Synoptic Radiative Fluxes & Clouds	1/day
11	AVG	Monthly Regional Radiative Fluxes & Clouds	1/mo
12	ZAVG	Monthly Zonal and Global Radiative Fluxes & Clouds	1/mo

The following somewhat simplified CERES processing-flow diagram (see Figure 3-1) shows where in the system these products are generated and also the parts of the system (Instrument Subsystem and Clouds Subsystem) that will be impacted by new NPP-era input data.

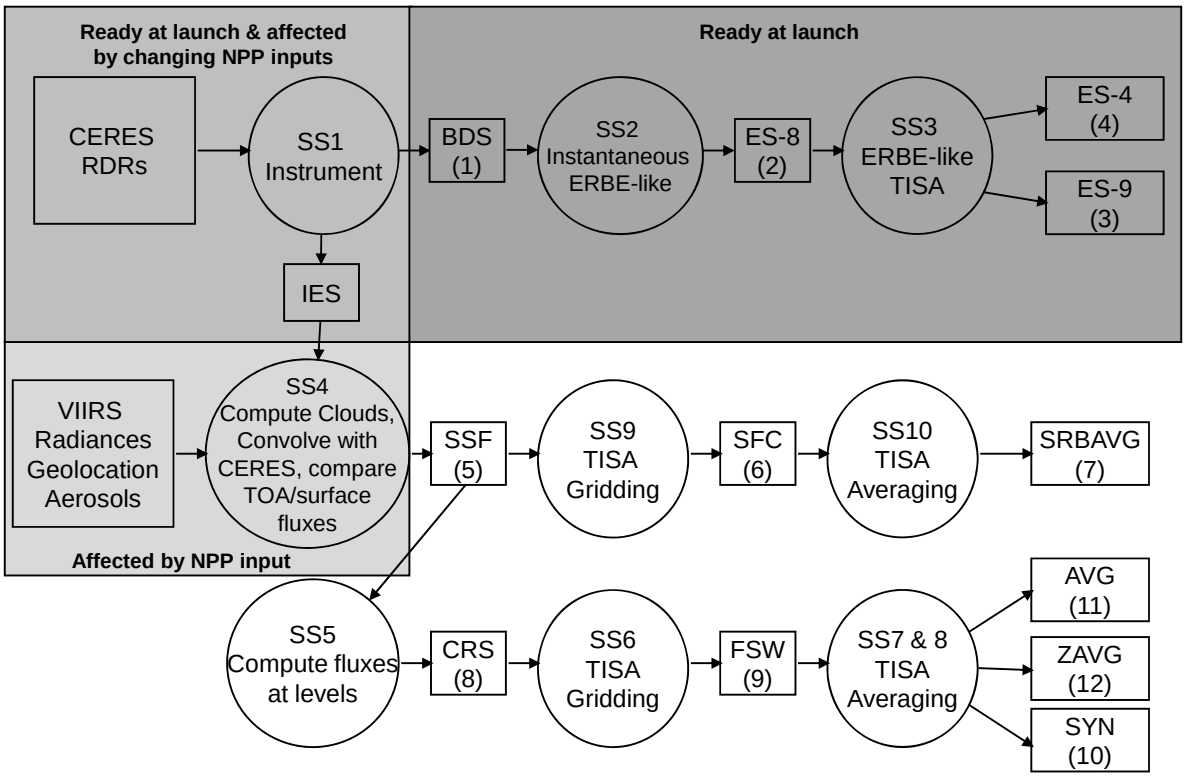


Figure 3-1. Simplified CERES Processing Flow

The remainder of this section addresses the specific work to be done in modifying the CERES science software system's baseline configuration (see Figure 3-1) to accommodate operational processing of NPP CERES FM5 data as well as the scope, effort, resources, and schedule to support NPP CERES FM5. These items are addressed in the following sub-sections which are structured after the CERES DM WBS elements indicated by the element numbers shown in parenthesis with each sub-section title.

The highest level WBS element (#4.4) for CERES DM is "Algorithm & Production CERES NPP Code Development and Maintenance" which states,

> Modify and maintain existing models, algorithms, and CERES code converted to run on the Science Directorate cluster computing environments at the SCF and ASDC (the assumption is that this code conversion has been completed) to accommodate characteristics of the CERES FM5 instrument and NPP instrument suite and to produce NPP data products. This element also includes development of production strategies for CERES NPP data processing.

The remainder of this section describes each of the fundamental FM5 software development tasks contained in the WBS and for each of the lower-level WBS elements provides a **description** of the task, the **technical approach** the CERES DMT will follow in accomplishing the task, **staffing** resources needed to complete the task on schedule, and the task **schedule** goals according to the "CERES FM5 on NPP Integrated Master Schedule" as of the publication date of this document. Master schedule Unique IDs are included in parentheses where appropriate; the "L" included in the Unique IDs indicates that the schedule item was initiated by the CERES Team at Langley.

3.1 Instrument and ERBE-like Subsystems (4.4.1)

WBS element #4.4.1 states - Develop pre-processors for NPP-era input data, modify production code to produce CERES NPP data products, and maintain the production codes.

3.1.1 Production Pre-processors for NPP RDRs, Attitude, and Ephemeris (4.4.1.1)

- **Description** - Develop new production-quality codes and scripts to convert CERES FM5 instrument RDRs into CERES Level-0 data products which are suitable for use by the Instrument Subsystem in the production of CERES NPP data products.

  Provide new production-quality codes and scripts to convert NPP attitude and ephemeris files into those expected by the Instrument Subsystem.

- **Technical Approach** - The CERES RDRs will contain 100 packets of Level-0 CERES FM5 data and the associated ephemeris and attitude data. Processing of the RDRs will be done on a daily basis once all RDRs for the data date are received and ingested at the LaRC ASDC. Each data date should be covered by 131 to 133 RDRs depending on the amount of data from the previous/next data date in the first and last RDR for each data date. All the RDRs will be read and the packets for each of the three APIDs (Science, Diagnostic, and Calibration) will be separated into their own Level-0 data files and structured in the same format as the Level-0 data files used for CERES Aqua data processing. The ephemeris and attitude data will be formatted into a format that can be read by the existing SDP Toolkit to minimize the changes in the current CERES data processing software.
- **Staffing** – To meet the schedule for this effort it was determined that the conversion of the Level-0 portion of the RDRs will require 1.0 FTE for 24 months. The conversion of the ephemeris and attitude portion of this effort to an Aqua-like format will take approximately 0.5 FTE for 3 - 4 months, which will include training of additional personnel to be able to maintain this portion of the effort.
- **Schedule** – From the "CERES FM5 on NPP Integrated Master Schedule" the RDR pre-processor is scheduled to be completed by December 04, 2008 (L165); the attitude and ephemeris pre-processor is scheduled to be completed by December 04, 2008 (L170) as well.

3.1.2 Modify Production Code to use Level-0 data from NPP RDRs (4.4.1.2)

- **Description** – Modify the converted CERES Instrument Subsystem code and the ERBE-like Subsystems' code to accept the new Level-0 data products, the converted NPP attitude and ephemeris data, and other inputs from NPP-era data sources to produce CERES NPP data products and associated quality checks. Perform configuration management and support release of software to the ASDC and promotion of software at the ASDC. This activity is

critical to assessing the health of the instrument. Note that this element may require that the Instrument Ada code be converted to C++ if that conversion has not been accomplished.

- **Technical Approach** – Instrument Subsystem. To meet planned test activities that will take place before a complete conversion of the Ada code to C++ can be completed, the existing Ada code will be updated to handle the new Level-0 data from CERES FM5. Since the new Level-0 format will match the existing CERES Aqua FM3/4 Level-0 data format, only minor updates to support the new APIDs will be required in the Ada code. A parallel effort to convert the Ada packages to C++ classes will take place. The Build 1 version of the new C++ software will contain the classes to handle Level-0, ephemeris, attitude, and ancillary data file input; the conversion of Instrument housekeeping parameters to support the calculation of filtered radiances and geolocation of CERES footprints; and the raw and drift-corrected counts, the associated filtered radiance, and the co-latitude and longitude of the CERES footprints in the HDF BDS data product along with the associated metadata. Under this scenario, if at the time of NCT3 the Build 1 C++ code is not ready, the updated Ada code will be available to support testing. The effort to complete the C++ Build 2 launch-ready code will proceed once the Build 1 code has been delivered to the ASDC.

  ERBE-like Subsystem. Only very minor coding modifications will be required.

- **Staffing** – To meet the NCT3 testing schedule, to complete the Ada to C++ Build 2 launch-ready code, and to support early testing of FM5 at launch will require an effort of 4 – 5 FTE through launch.
- **Schedule** – From the "CERES FM5 on NPP Integrated Master Schedule" the integration and testing of the pre-processors is scheduled to be completed by December 31, 2008 (L175). The modified Instrument Subsystem software is scheduled to be verified at the SCF by January 27, 2009 (L180). The verified Instrument Subsystem software is scheduled to be migrated to the ASDC beginning March 13, 2009 and promoted to the production environment by May 01, 2009 (L185). The promoted Instrument Subsystem software is scheduled to be validated in the production environment by May 15, 2009 (L190 and L195) to support NCT3. The pre-freeze delivery of the Instrument Subsystem software to support launch is scheduled to be completed by November 19, 2009 (L196).

3.1.3 Maintain the Instrument and ERBE-like production codes (4.4.1.3)

- **Description** – Perform maintenance of CERES Instrument Subsystem codes and the ERBE-like Subsystems' codes based on any required changes or adaptations. This includes generating and testing later Edition gains and SRFs.
- **Technical Approach** – As has been done in the past, early in-orbit performance of the FM5 instrument will be evaluated after launch. This evaluation will include processing in the ASDC production environment of the Instrument Subsystem software with scan-dependent offsets set to "zero" and ground-based gain, second-time constant, and SRF values set such that "At Launch" data products that can be analyzed to determine if there are any issues associated with the instrument in orbit after launch. Results from in-orbit tests to be done by the Operations Team before the instrument covers are opened will also be processed and analyzed to ensure that the instrument is performing as expected. Ground-based offsets and other ancillary-input data will be updated, as necessary, as a result in these in-orbit tests. The initial CERES FM5 data will be reprocessed as Edition1 using these updated data and any subsequently received data will be reprocessed as Baseline with these improved data. Data is

processed as Baseline as it arrives on a daily basis at the ASDC. This allows the Instrument team to monitor the health and status of the FM5 instrument while providing time for any latency in the arrival of data from the SDS Land PEATE. Approximtely 2 weeks after the end of the data month, the data for the previous month is reprocessed as Edition1, which will contain all available data for the previous month. For ERBE-like this also allows the "real" snow and ice data to be used in the Edition1 processing as this ancillary data arrives approximately 2 weeks after the end of the data month. A delivery of these values along with any updates required to support on-orbit instrument changes is expected to be made at launch + 6 months. Experience with CERES instruments on both Terra and Aqua has shown that a degradation of the sensors may take place over time, and updates to the gains and spectral responses may be required to provide the best data to the science community. These updates are made on a 6-month to 1-year basis and normally only require a delivery of new ancillary data files containing updated gains and SRFs. Once these new files are delivered, a new set of PGEs is run to reprocess the existing data products to increase their accuracy and to create an Edition2 set of data products. Production of the CERES Terra/Aqua "Baseline" data products is not interrupted and daily processing of the original Baseline data products continues without changes. The process of determining gain and SRF updates continues at intervals of 6-months to 1-year throughout the life of the CERES sensors.

- **Staffing** – The level of effort to support these activities is expected to continue at the 4 – 5 FTE level for at least the first year of on-orbit operations. After that point, the effort may be reduced to a 2 – 3 FTE level throughout the life of the mission**.**
- **Schedule** –
  - Launch + 6 months:
    - Deliver corrected ground-based scan offsets and updated software, if needed, to support any on-orbit changes to the instrument.
    - Reprocess FM5 data from covers open forward as Edition1.
    - Process all forward data as Baseline1-QC and Edition1.
  - Launch + 1 year:
    - Deliver updated gains and SRFs and, if required, updated software.
    - Process Edition2 data products.
    - Continue processing Baseline/Edition1 data products.
  - 1 year and beyond at 6-12 months intervals:
    - Update gains and SRFs as needed to support production of Edition2 data products.

3.2 Clouds and subsequent subsystems (4.4.2)

WBS element #4.4.2 states - Develop pre-processor(s) to generate subsetted VIIRS input data, modify production codes to produce CERES NPP data products, and maintain the production codes

3.2.1 Pre-processor(s) for VIIRS Data Subsetter (4.4.2.1)

- **Description** - Develop new code to further subset (the aggregated) VIIRS radiance and geolocation data subsets generated by the SDS Land PEATE. This code is expected to run at the SDS Land PEATE and produce a subset containing the expected channels and spatial sampling required by CERES. As needed, develop or modify code to aggregate and subset VIIRS radiance and geolocation data arriving via NOAA's CLASS.

- **Technical Approach** - The SDS Land PEATE produces 5-minute VIIRS Radiance and Geolocation files, which contain 22 bands and have a file-size of about 1.5 GB per 5-minute file. CERES needs 13 of these 22 bands and does not require every imager pixel, so sub-channel and sub-sampling at the SDS Land PEATE will reduce the data-volume transmission from there to Langley. Since CERES has provided similar sub-channel and sub-sampling code for MODIS and is experienced and familiar with the associated requirements, it makes sense for CERES to provide the subsetter software. The input products from the SDS Land PEATE to the subsetter are NPP_VIAE (imagery radiance), NPP_VMAE (Moderate radiance and geolocation), and NPP_VDAE (Day Night Band radiance and gelocation).

  The subsetter code and associated scripts will be developed on a Linux system at LaRC and then ported to a system at the SDS Land PEATE where final testing will be performed and modifications made. The delivery process will be a tailored version of the CERES Subsystem Delivery Procedures found in Appendix B of the CERES Configuration Management Plan (Reference 3). Clouds Subsystem personnel will submit an SCCR via the CERES Configuration Management System. After final testing at the SDS Land PEATE is complete, the software delivery package consisting of the subsetter code and scripts plus test input data and expected output data will be provided to CERES CM via cm_move.csh. The code and scripts will be provided in an "src" tar file and will be accompanied by a corresponding "list" file that documents the contents of the "src" tar file. The input and expected output data will be provided in a "data" tar file with a corresponding "list" file. A subsetter Test Plan will be developed by Clouds personnel based on guidelines provided by SDS Land PEATE personnel. This document will be submitted to the CERES Documentation Team who will modify it as necessary to conform to CERES document standards. A PDF version of the Test Plan along with the software delivery package will be placed in a delivery area on an SDS Land PEATE system by CERES CM personnel. Once this delivery is made, an email will be sent by CERES CM personnel notifying the appropriate people of the delivery. SDS Land PEATE personnel will test the delivery and, upon successful completion of testing, will provide an email notifying the appropriate CM and Clouds Subsystem personnel of the acceptance and promotion of the delivery package.

  If problems arise during this stage of testing, SDS Land PEATE personnel will contact Clouds Subsystem personnel for resolution. Updated files will be provided to the CERES CM team who will then, in turn, deliver the updates to the SDS Land PEATE.

  Once the delivery is accepted, SDS Land PEATE personnel will provide final tar files to CERES CM personnel to be stored in the CERES CM repository at LaRC. These tar files will capture the version of the files that were ultimately accepted and used for processing to ensure that CERES CM has the correct files in the repository.
- **Staffing** - We have analyzed the task's requirements against schedule. We have determined the staff requirement to be 1.0-1.5 FTE. We will do this with in-house resources.
- **Schedule** – From the "CERES FM5 on NPP Integrated Master Schedule" the VIIRS Level-1B calibration radiance subsetting software is scheduled to be completed by October 01, 2008 (L205). The software is scheduled to be delivered to and tested at the SDS Land PEATE by December 01, 2008 (L210). Validation for this subsetter software is scheduled to

be completed by January 15, 2009 (L215). The overall time for this task to be completed is expected to be 5½ months.

3.2.2 Modify Production Code to use VIIRS Data (4.4.2.2)

- **Description** - Modify the converted CERES code from the Clouds and subsequent subsystems to accept and use VIIRS data and other inputs from NPP-era data sources to produce the CERES NPP data products. Perform configuration management and support release of software to the ASDC and promotion of software at the ASDC.
- **Technical Approach** - The current CID that now exists in the CERES Clouds Subsystem are TRMM-VIRS, Terra-MODIS and Aqua-MODIS. A new CID, NPP-VIIRS, will be added. A reader package, to read the output from the subsetter mentioned in Section 3.2.1 above, will be written, debugged and tested. An interface between the NPP-VIIRS CID and the rest of CERES cloud system with cloud algorithms will be developed and validated. Software changes needed to accommodate FM5 and VIIRS data are not expected to affect CERES SARB or TISA Subsystems.
- **Staffing** - The estimate for the staff requirement is about 1.0-1.5 FTE.
- **Schedule** – This task is expected to take approximately 6 months following the receipt of VIIRS subset test data at the ASDC.

3.2.3 Maintain Production Code which uses VIIRS Data (4.4.2.3)

- **Description** - Perform maintenance of the CERES NPP software from the Clouds and subsequent subsystems. This may include upgrading MOA when the next generation of input becomes available and updating GGEO as satellites are switched out over time.
- **Technical Approach** – The Clouds, GGEO, and MOA Subsystems' software will be modified, as required, according to CERES software development processes.
- **Staffing** - The estimate for the staff requirement for this activity is about 0.5 FTE/year.
- **Schedule** – Software maintenance will be an ongoing, as needed, activity.

References

1. NPR 7150.2, Chapter 5 (http://nodis3.gsfc.nasa.gov/displayDir.cfm?Internal_ID=N_PR_7150_0002_&page_name=Chapter5)
2. CERES Data Products Catalog (http://science.larc.nasa.gov/ceres/DPC/DPC_current/index.html)
3. Data Management Process Plans (http://science.larc.nasa.gov/ceres/DMP_Plans/index.html)
4. Software Engineering Institute (Carnegie Mellon University) – Published Appraisal Results (http://sas.sei.cmu.edu/pars/pars.aspx)
5. NPR 7150.2, Appendix B (http://nodis3.gsfc.nasa.gov/displayDir.cfm?Internal_ID=N_PR_7150_0002_&page_name=AppendixB)
6. CERES On-Line Documentation website (http://science.larc.nasa.gov/ceres/docs.html)
7. Guidelines for Process Integration and Product Improvement, Second Edition (CMMI for Development, Version 1.2), Mary Beth Chrissis, Mike Konrad, and Sandy Shrum
8. NX – LaRC Document Management System (https://nx.larc.nasa.gov/dsweb/HomePage)

Appendix A
Acronyms

APID	Application ID
ASDC	Atmospheric Science Data Center
ASRATSS	Atmospheric Sciences Research and Technology Support Services
ATBD	Algorithm Theoretical Basis Document
BDS	BiDirectional Scan (data product)
CARS	Climate Analysis Research System
CERES	Clouds and the Earth's Radiant Energy System
CI	Configuration Item
CID	Cloud Imagery Data
CLASS	Comprehensive Large Array-data Stewardship System
CM	Configuration Management
CMMI	Capability Maturity Model Integrated
DM	Data Management
DMS	Data Management System
DMT	Data Management Team
EOS	Earth Observing System
ERBE	Earth Radiation Budget Experiment
ERBS	Earth Radiation Budget Satellite
FM	Flight Model
FTE	Full-Time Equivalent
GGEO	Gridded Geostationary Narrowband Radiances (data product)
GSFC	Goddard Space Flight Center
HDF	Hierarchical Data Format
IT	Information Technology
LaRC	Langley Research Center
MOA	Meteorological, Ozone, and Aerosols (data product)
MODIS	Moderate Resolution Imaging Spectroradiometer
NASA	National Aeronautics and Space Administration
NCT	NPP Compatibility Test
NOAA	National Oceanic and Atmospheric Administration
NPOESS	National Polar-orbiting Operational Environmental Satellite System
NPP	NPOESS Preparatory Project
NPR	NASA Procedural Requirement
PDF	Portable Document Format

PEATE	Product Evaluation and Analysis Tools Element
PFM	Prototype Flight Model
PGE	Production Generation Executive
QA	Quality Assurance
QC	Quality Control
QStats	Quarterly Statistics (report)
RDR	Raw Data Record
SARB	Surface and Atmospheric Radiation Budget (subsystem)
SCAMPI	Standard CMMI Appraisal Method for Process Improvement
SCCR	Software Configuration Change Request
SCF	Science Computing Facility
SDP	Science Data Processing (Toolkit)
SDS	Science Data Segment
SEI	Software Engineering Institute
SIT	Software Integration and Testing
SRF	Spectral Response Function
SSAI	Science Systems and Applications, Inc.
TISA	Time Interpolation and Space Averaging (subsystem)
TOA	Top of Atmosphere
TRMM	Tropical Rain Measuring Mission
VIIRS	Visible Infrared Imaging Radiometer Suite
VIRS	Visible Infrared Scanner
WBS	Work Breakdown Structure
WG	Working Group