301-CD-002-003

EOSDIS Core System Project

System Implementation Plan for the ECS Project

January 1995

Hughes Applied Information Systems
Landover, Maryland

System Implementation Plan for the ECS Project

January 1995

Prepared Under Contract NAS5-60000
CDRL Item 042

SUBMITTED BY

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301-CD-002-003

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Preface

This document is a contract deliverable requiring Government review and approval prior to acceptance and use. The document has been approved; however, this final publication incorporates several changes recommended by the Government. This is the final publication of this document.

This document is under ECS Project Configuration Control. Any questions should be addressed to:

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Abstract

This plan outlines the steps by which the implementation of ECS will be accomplished. This plan is compliant with requirements for an evolutionary process including phased, multi-track implementation with continual, active, and iterative participation by users; with prototyping, special studies, and the use of standards; and with approaches to hardware and software that facilitate evolution of the ECS. This plan recognizes that the development must be based on experience gained from implementation of the Version 0 system, and that the resulting system must incorporate the benefits of experience gained from studies and prototyping efforts performed by the ECS contractor and others. This plan accommodates the fact that some essential parts of the system, such as the user interface, will evolve throughout the development cycle.

The ECS Project recognizes that technology and external events can change rapidly and chooses to embrace these changes instead of being forced to react to changes. One of the objectives of this document is to show how feedback from both the normal development cycle, as well as coincident work performed both inside and outside of the normal ECS domain, is used to improve the ECS Project product as well as mitigate risk.

ECS will mainly be distributed in quanta described as releases. Each release will add specific capabilities for each site. The primary sites are referred to as Distributed Active Archive Centers (DAACs). The release installation is actually part of a release-specific cycle consisting of a requirements/ prototyping (concept definition, system analysis) phase followed by design/ implementation and integration phases. Release implementation decision points are dependent on validation of predefined risk-reduction requirements, and an incremental, build/release process that allows changes concurrent with implementation. This document describes the mechanisms, and necessary steps, that will provide the ECS product to the sites and the general ECS community.

Keywords: implementation, evolution, development,. integration, design, software, cycle, build, release, prototype

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Change Information Page

List of Effective Pages	
Page Number	**Issue**
Title	Final
iii through xii	Final
1-1 and 1-2	Final
2-1 and 2-2	Final
3-1 through 3-20	Final
4-1 through 4-18	Final
5-1 through 5-12	Final
6-1 through 6-4	Final
AB-1 through AB-6	Final
GL-1 through GL-3	Final

Document History			
Document Number	**Status/Issue**	**Publication Date**	**CCR Number**
101-301-DV1-001	Pre-approval	May 1993	
101-301-DV1-002	Pre-approval	August 1993	
194-301-DV1-002	Original	May 1994	94EC-0016
301-CD-002-003	Final	January 1995	94-0164 A

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Contents

Preface

Abstract

1. Introduction

2. Related Documentation

3. Evolutionary Development

4. Installation Implementation Strategy

5. Driving Requirements/Milestones for ECS Releases

6. Reviews and Documentation

Figures

Tables

Abbreviations and Acronyms

Glossary

1. Introduction

1.1 Identification

This System Implementation Plan, CDRL item 042, whose requirements are specified in Data Item Description (DID) 301/DV1, is a required deliverable under the EOSDIS Core System (ECS) contract (NAS5-60000). This document was previously submitted as identified in the Document History, page vii of this submittal.

1.2 Scope

This plan outlines the steps by which the implementation of ECS will be accomplished. This plan is compliant with requirements for an evolutionary process including phased, multi-track implementation with continual, active, and iterative participation by users; with prototyping, special studies, and the use of standards; and with approaches to hardware and software that facilitate evolution of the ECS. This plan recognizes that the development must be based on experience gained from implementation of the Version 0 system, and that the resulting system must incorporate the benefits of experience gained from studies and prototyping efforts performed by the ECS contractor and others. This plan accommodates the fact that some essential parts of the system, such as the user interface, will evolve throughout the development cycle.

1.3 Purpose and Objectives

The ECS Project recognizes that technology and external events can change rapidly and chooses to embrace these changes instead of being forced to react to changes. One of the objectives of this document is to show how feedback from both the normal development cycle, as well as coincident work performed both inside and outside of the normal ECS domain, is used to improve the ECS Project product as well as mitigate risk.

ECS will mainly be distributed in quanta described as releases. Each release will add specific capabilities for each site. The primary sites are referred to as Distributed Active Archive Centers (DAACs) and currently consist of eight facilities: Goddard Space Flight Center (GSFC), EROS Data Center (EDC), Marshall Space Flight Center (MSFC), Jet Propulsion Laboratory (JPL), Langley Research Center (LaRC), National Snow and Ice Data Center (NSIDC), Oak Ridge National Laboratory (ORNL), and the Alaska SAR Facility (ASF). At GSFC, the ESDIS facility houses the EOS Operations Center (EOC), Instrument Control Center (ICC), and the System Management Center (SMC).

The release installation is actually part of a release-specific cycle consisting of a requirements/ prototyping (concept definition, system analysis) phase followed by design/ implementation and integration phases. Release implementation decision points are dependent on validation of predefined risk-reduction requirements, and an incremental, build/release process that allows changes concurrent with implementation. This document describes the mechanisms, and necessary steps, that will provide the ECS product to the sites and the general ECS community.

1.4 Status and Schedule

The System Implementation Plan was previously released once for Project Management Review (PMR) and once for the Systems Requirement Review (SRR). This document was approved by the Government in Fall 1994; however, this issue incorporates several changes recommended by the Government at the time of their approval, and also incorporates concepts and data contained in the Multi-track Development for the ECS Project white paper and the Release Plan Content Description white paper. This is the final publication of this document.

1.5 Document Organization

Section 1 describes the structure and scope of the document, identifies the topics covered, purpose and objectives, and the document organization.

Section 2 describes parent, applicable and information documents that are useful in understanding the details of subjects discussed in this document.

Section 3 discusses the evolutionary development of the ECS.

Section 4 describes the site installation release strategy, previewing the release schedule, development process steps, system transitions, and outlining integration and test activities.

Section 5 focuses on the external driving requirements and milestones that structure the release schedule. Specific drivers include satellite support, IV&V support, Version 0 integration, and DAAC site activation.

Section 6 describes the major reviews of the ECS project development.

This document avoids duplicating detailed information found in other documents. Even though this is an implementation plan, specific dates are generally absent. The Summary Schedule (DID 107/MG1) is a living document and has the accurate dates of all significant ECS events.

2. Related Documentation

As shown in Figure 2-1, the focus of each document graduates from general to specific. The associated arrows signify the increasing level of detail for the ECS design and implementation. The parenthetical acronyms specify the review with which the document is associated. Section 12 describes the reviews in more detail. Documents listed below which have been generated by the ECS project are generally available in electronic form via the ECS Data Handling System (EDHS), accessible at Universal Resource Locator: http://edhs1.gsfc.nasa.gov.

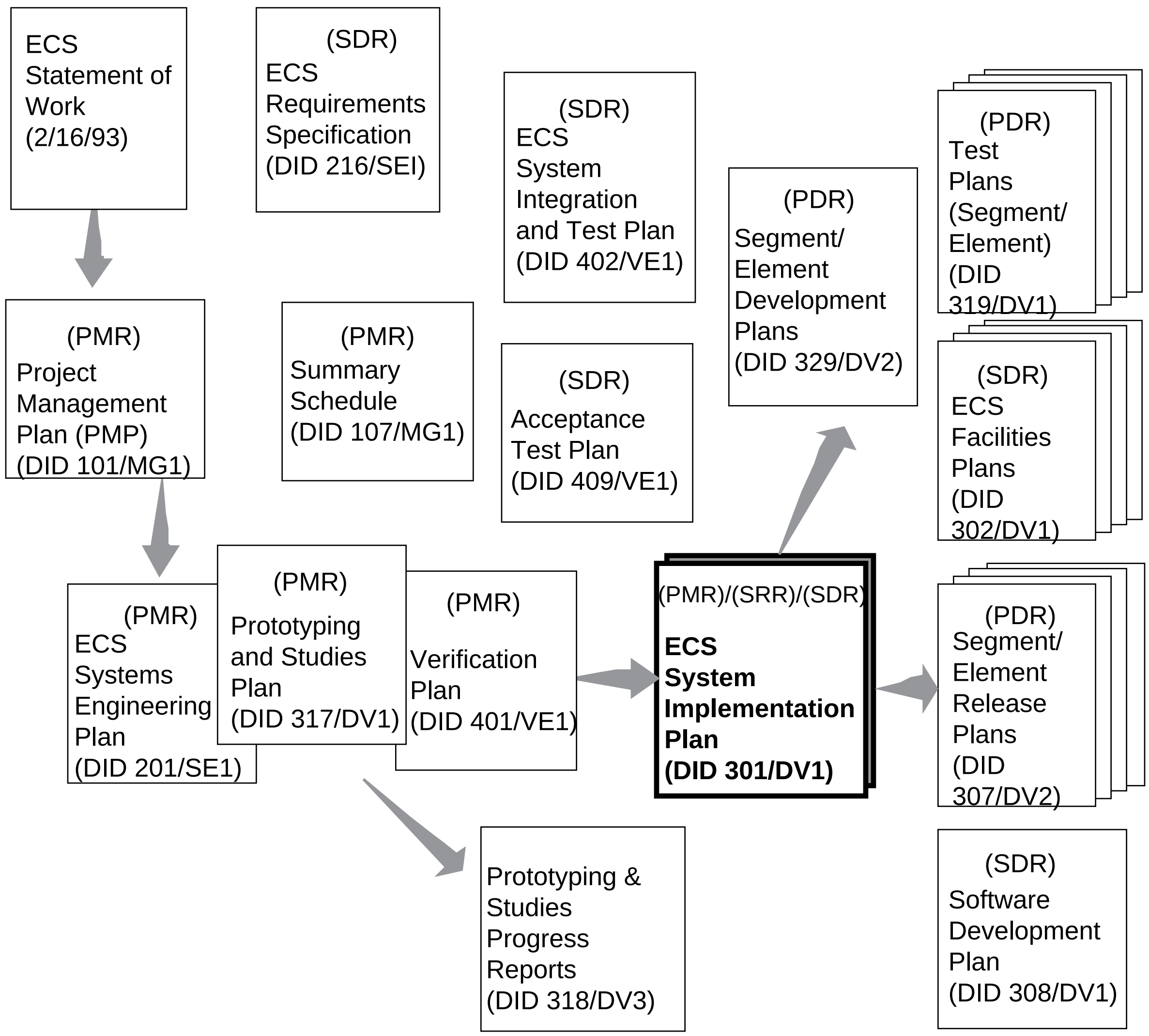

Figure 2-1. ECS Document Relationships

2.1 Parent Documents

As shown in Figure 2-1 the following documents are the parent from which this document's scope and content derive:

193-101-MG1-001	Project Management Plan
193-201-SE1-001	ECS Systems Engineering Plan
193-317-DV1-001	Prototyping and Studies Plan
193-401-VE1-001	Verification Plan
GSFC 423-41-01	EOSDIS Core System (ECS) Statement of Work, 2/16/93
GSFC 423-41-02	Functional and Requirements Specification for the ECS Project, Revision A, 6/02/94

2.2 Applicable Documents

The following documents are referenced herein and are directly applicable to this plan. In the event of conflict between any of these documents and this plan, this plan shall take precedence.

329-CD-001-001	FOS Development Plans for the ECS Project (Review Copy)
329-CD-002-001	SDPS Development Plans for the ECS Project (Review Copy)
329-CD-003-001	CSMS Development Plans for the ECS Project (Review Copy)
307-CD-001-001	FOS Release Plan for the ECS Project (Review Copy)
307-CD-002-001	SDPS Release Plan for the ECS Project (Review Copy)
307-CD-003-001	CSMS Release Plan for the ECS Project (Review Copy)
107-CD-001-007	Summary Schedule for the ECS Project
308-CD-001-003	Software Development Plan for the ECS Project

2.3 Information Documents

The following documents, although not directly applicable, amplify or clarify the information presented in this document, but are not binding:

194-402-VE1-001	System Integration and Test Plan for the ECS Project
194-206-SE2-001	Version 0 Analysis Report
194-409-VE1-001	Overall System Acceptance Test Plan for the ECS Project
318-CD-000	Prototyping & Studies Progress Reports, submitted periodically
194-208-SE1-001	Methodology for Definition of External Interfaces for the ECS Project
194-102-MG1-001	Configuration Management Plan for the ECS Project
111-CD-000	Monthly Progress Reports for the ECS Project

3. Evolutionary Development

Evolution is a necessary and inevitable process for large systems. The ability to evolve a system protects the investment in the system by minimizing the cost of modifications and prolonging its life expectancy. Due to the operational length and scientific nature of ECS, evolution is essential. User experience, new technologies, and scientific exploration result in new requirements for the system. ECS evolutionary development explicitly allows new inputs, while providing structures which allow controlled change. This balance, shown in Figure 3-1, allows the system to grow throughout its life cycle without becoming unmanageable, which would result in high risk of cost and schedule overruns. Section 3, addressing the stabilizing structures (Section 3.1) and the design drivers (Section 3.2), recognizes that the challenge to achieving controlled evolution is to maintain the system development activity between over controlled (allowing no change) and chaos (too much change, too fast).

The ECS evolutionary development approach provides a phased implementation with continual, active, and iterative participation by users. The approach responds to the evolving needs of the diverse science community while satisfying NASA's overall performance, cost and schedule objectives. ECS evolves from existing systems, including V0 and the evaluation packages, in concert with EOS science.

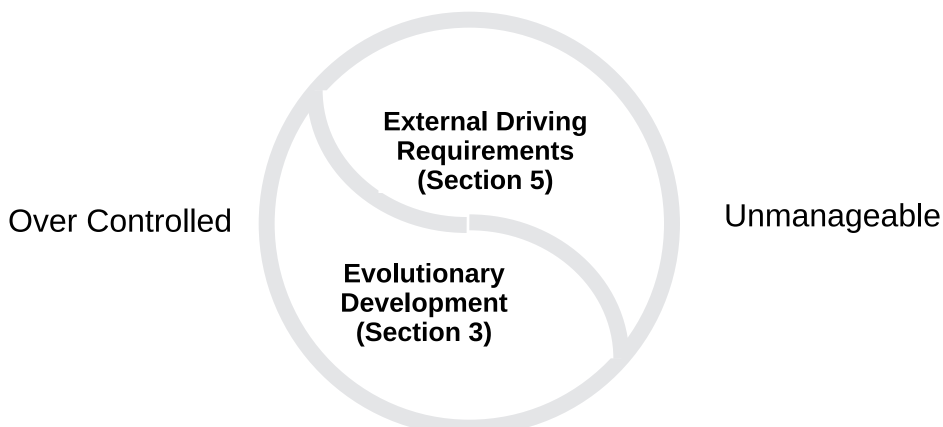

Figure 3-1. ECS Balanced Evolutionary Development

The incremental evolutionary life cycle approach ensures achieving science user utility within acceptable risk by using the following features:

- Incremental, evolutionary system growth with user involvement in requirements exploration, design review, and system evaluation.
- Working prototypes and evaluation packages to derive consensus on functional design and capabilities before committing to full scale implementation.

- Continuous measurable improvement (cmi) techniques to improve the development process and ECS capabilities.
- Build/thread methodology to provide a phased implementation process that responds easily to evolution and focuses early on high risk functions.

3.1 Evolutionary Development Strategy

The ECS architecture and design strategies that provide an environment for evolution include component isolation to identify and insulate critically affected design elements, and standardization (via industry standards, common software and layered models) to allow elements on one side of an interface to grow and evolve without effecting other elements. These strategies guide design choices to areas where flexibility and modularity are emphasized, such as the layered architecture discussed in the following Sections. New technologies can be inserted and software evolved easily without redesign by using the ECS architecture and design strategies.

The configuration change process used to control requirement baselines, including the processes for initiation, generation and approval of Configuration Change Request (CCR), and Engineering Change Proposals (ECP), are documented in the Configuration Management Plan (DID 102/MG1).

3.1.1 Evolutionary Development Approach, Multiple Release Environment

The ECS will be developed using an evolutionary development process with multiple releases (see Figure 3-2). The multiple releases provide for a build-up of functionality as well as a means to evolve the system either to meet operational feedback or to allow technology insertion. Additional key components of this process are Requirements Analysis, System Design, and Release Planning; Prototypes and Studies; and the User Evaluation Feedback process.

Requirements Analysis, System Design, and Release Planning activities provide consistency across releases by maintaining the Level 3 ECS System Requirements, a cohesive system design with interface control, definition of systems structure and allocation of requirements to the components, and an assignment of the Level 3 requirements to releases. How these activities relate to a multi-track environment is described in section 3.1.2.

The Prototypes and Studies support the evolutionary development process. Prototypes are focused developments of some aspect of the system which may advance evolutionary change. In particular, prototypes provide a basis for making decisions about the next or future steps in the development process. Three types of prototypes are defined: 1) technology analysis prototypes, 2) engineering prototypes, and 3) advanced prototypes. For further information see paragraph 3.2.2.

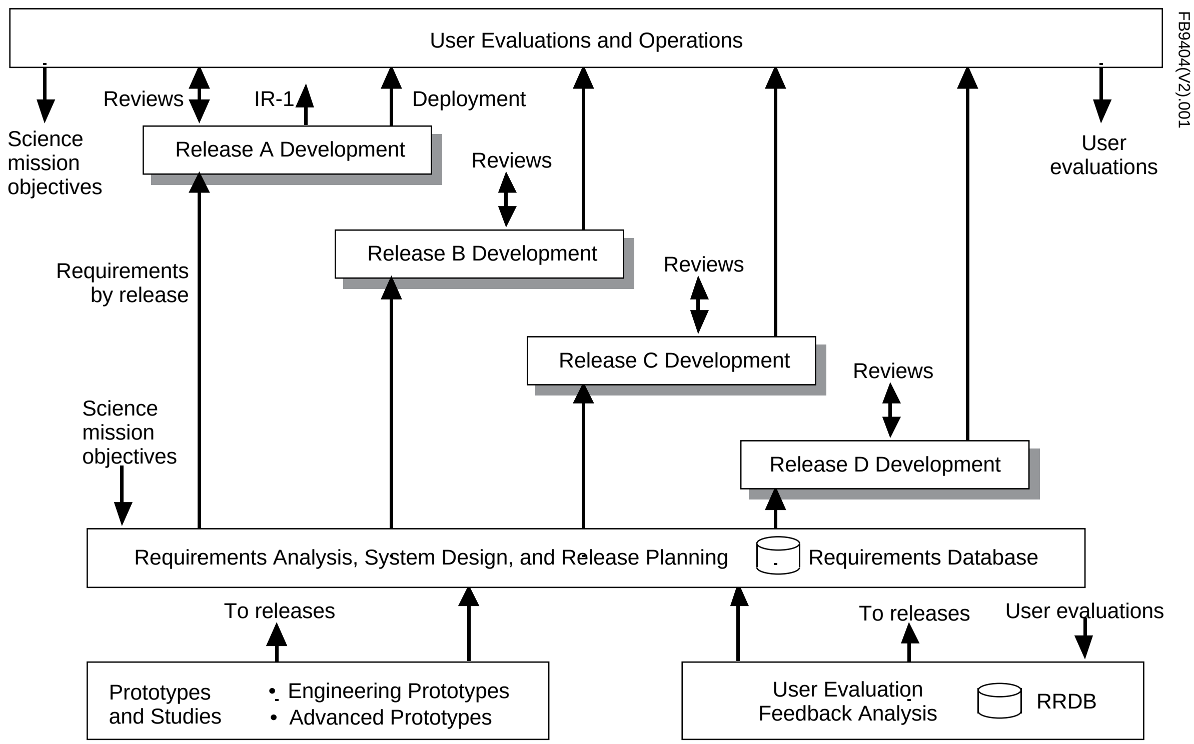

Figure 3-2. ECS Multiple Release Development Process

The User Evaluation and Feedback Process provides a systematic and publicly visible mechanism for capturing, evaluating and, as appropriate, implementing user feedback. The heart of this process is the Recommended Requirements Data Base (RRDB). The RRDB evaluation process is described in the System Engineering Plan (201/SE1). Release planning drivers, release content, and release schedules are specified in sections 5 through 11.

3.1.2 Multi-Track Development for a Release

For a specific release, two main development processes will be used: the Formal Development Process and the Incremental Development Process (see Figure 3-3). These two processes support multiple activities. The remainder of this section describes the two development processes and the supporting activities.

The approach of using two methodologies for operational software development was selected because it provides the best way of maximizing user satisfaction and minimizing development risk. The approach is to use incremental development for those areas of the system where requirements are less well understood and formal development where requirements are believed to be more stable. The premise behind multi-track development for ECS is that these two differing requirement types can be best implemented through differing development processes tailored to their individual needs.

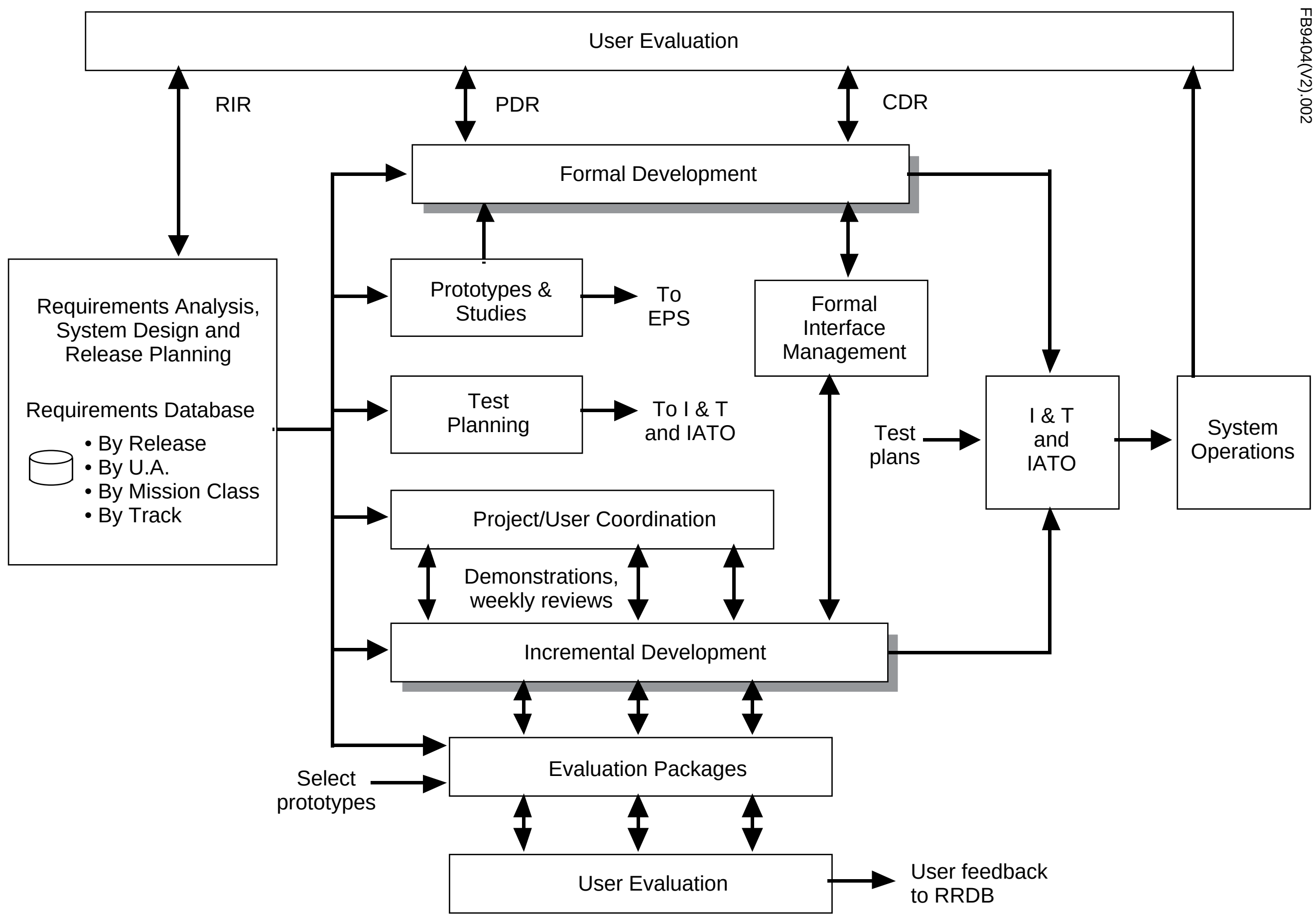

Figure 3-3. ECS Multi-Track Development Process for a Release

Based on these criteria, candidate areas for incremental development include toolkits and data management and access services. Candidates for formal development include flight operations, data production services, archive services, and system management services. However, it should be noted that some components need to be developed incrementally in order to provide the necessary infrastructure to support other incrementally developed components. For example, the communication services will likely be developed incrementally because they are required to support data management and access services.

Both formal and incremental development tracks will be implemented in a way that provides: 1) compliance with acknowledged requirements, 2) traceability of requirements allocation to tracks, 3) a development methodology that allows modular development, 4) an integration process that brings the separately developed pieces together into an integrated whole, and 5) a process for control of interfaces that supports integration. Above all, there must be clear visibility into the process at the outset, as it is implemented, and at the end of major phases (releases) when products are formally developed to support operational needs.

All ECS products which enter operational use are developed from a common requirements database and a common system design. All requirements analysis is done in a common process at the front-end of development cycles. Requirements traceability for the whole system is done from one common database which serves both tracks. A complete and consistent system design is developed and documented in the system design specification. These features are illustrated in Figure 3-4, Development Track Linkage, a conceptual simplification. They are discussed in more detail in the System Engineering Plan (DID 201/SE1).

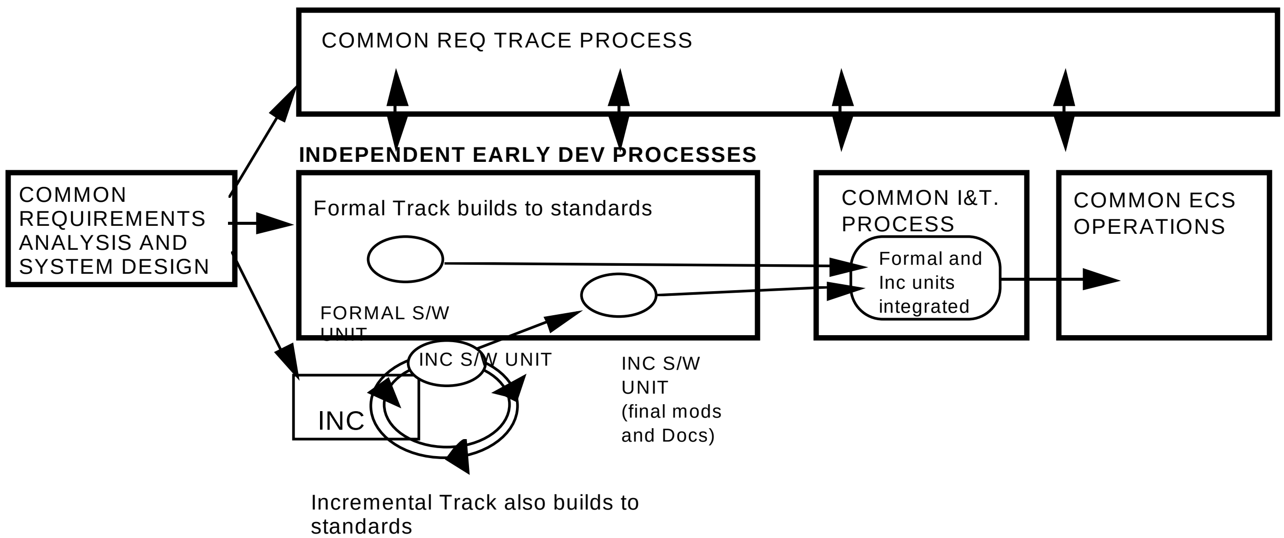

Figure 3-4. Development Track Linkage

It becomes obvious from viewing this figure that the multi-track process is not a radical departure from previously proposed methods into widely divergent paths, but merely a specialized implementation of rapid prototyping in an incremental service building process which is tracked with, and merged with, the Formal Track. The incremental track provides the means for experimentation with alternate implementations of services, evaluation of those implementations by users, and iterative refinement and capability extension until satisfactory products are achieved. As noted in the figure, both tracks employ software standards to assure minimum "throw away" code on the incremental track and ease of final modification and integration.

With the concept of Development Track Linkage (Figure 3-4), the progression through the two tracks along with the supporting activities of Multi-Track Development are clearer (Figure 3-3). Both of the development tracks are guided by the requirements analysis, system design and release planning. The prototypes support both the formal track through the early proof of concepts or design and the incremental track through the Evaluation Packages (EP). Test planning is begun in parallel for both development tracks. Formal interface management maintains continuity of the interfaces which connect incrementally developed components with formally developed components.

Products from the incremental track form a growing baseline of delivered capability as they are first deployed as part of an Evaluation Package along with selected prototypes, and as they are revised in ensuing increment development based on evaluation results. All incrementally developed products flow to the User Evaluation arena in the figure as part of an Evaluation Package. They are re-released as part of a Formal Release for operational status when they have been optimized through the EP process to meet external driving operational requirements, e.g. support to spacecraft instrument data processing.

The incremental development track results in production quality software on a medium cycle time (six to nine months) to provide user evaluation of real, fully functioning products. Cycle time is reduced by reducing the formality of design reviews, and by deferring formal documentation until each product is accepted from the evaluation process, and the product migrates to the formal release track in accordance with previously defined schedules. Maximum customer involvement and influence on incrementally developed products is designed into the incremental process. Developer personnel on the incremental track receive participatory customer and user community input and guidance in monthly demonstrations and reviews which communicate objectives, designs, and development progress. They also hold weekly status and planning sessions with customer people via teleconferencing and video teleconferencing media.

A major communication event, the EP Readiness Review, occurs at the turnover point in the development process where development of one EP has just been completed, and objectives for the next EP are being validated. The Evaluation Package Strategic Plan White Paper includes a section outlining the process by which incremental products are evaluated by customers and users and their opinions and suggestions are gathered, analyzed, and fed back to engineering and development personnel in a structured, controlled process.

Those areas where requirements are well understood at the beginning of development and where the design must meet those requirements for mission support are developed on the formal track. Eventually, all ECS products, including those which are first developed on the incremental track, are fielded through the formal track process. Formal development is characterized by longer development cycles (18-24 months) with formal reviews, documentation, and testing.

The Integration and Test function is crucial to the success of the multi-track development process. There are three types of I&T in the multi-track process along with an acceptance test process. The first type of I&T is in support of the deployment of an increment and selected prototypes as part of an evaluation package. This I&T is conducted by a combined team of Segment and System I&T organizations and supports the EPRR. The second type of I&T is the integration of incrementally developed components with formally developed components. Segment I&T conducts this activity after TRRs for both the formal and incremental components. The third type of I&T is that performed by System I&T after the Segments conduct an ETR. This third I&T combines the results of multiple segments and concludes with CSR. Starting with Release A, IATO conducts acceptance tests to the Level 3 requirements assigned to that release.

Table 3-1 summarizes the characteristics of the two types of development process.

Table 3-1. Comparison of Formal and Incremental Development

	Formal	Incremental
Overview	Methodical process driven by defined requirements	Iterative process focused on early adaptation of implementation to user evaluation
Life Cycle Structure	Single waterfall of sub-phases each terminated by formal milestone review	Multiple waterfalls of identical sub-phases with on-going demonstrations and reviews
Reviews	Formal with large cross-section of community with RIDs	Weekly planning and status meetings Monthly Demonstrations EP Readiness Reviews
Feedback	Tirekicker involvement, Formal reviews, RRDB, operational experience	Extensive demonstrations to tirekickers and others, RRDB, operational experience
Interface Control	Formal ICDs both internal and external	Formal ICDs to any interfaces external to incremental developments
Specifications	Level 4 requirements and design developed prior to implementation, as-built materials for RRR	Draft Level 4 Specifications during development Final Level 4 Specifications developed as-built before CSR
Code	Developed to standards, assessed using metrics	Developed to standards, assessed using basic metrics
Integration and Test	System I&T to procedures based on Level 3 requirements Segment I&T to procedures based on Level 4 requirements	For I&T for EP delivery: joint segment and system I&T to expert procedures based on increment objectives. For migration to formal release: Segment I&T to expert procedures based on increment objectives Prior field experience through evaluation packages System I&T to procedures based on Level 3 requirements
CM	Programmer and segment team leader control prior to TRR; CMO control thereafter	Programmer and segment team leader control prior to TRR; Site M&O and CMO control at evaluation sites
QA	Audits	Audits
Risks	Longer cycle time for user evaluation of implementation	Reliability of integration, Functionality for a release, Maintainability, Complexity of CM

3.1.3 Build/Thread Concept

The evolutionary paradigm adds incremental deliveries to an evolving system baseline. The build/thread methodology supports this paradigm, with incremental integration whose flexibility readily accommodates changes in release content and implementation. This user-oriented, incremental integration offers early demonstration of ECS functionality, early validation of interfaces, and ongoing resilience to change.

Incremental integration provides, through early and ongoing demonstrations of ECS capabilities, greater management visibility into integration status. By observing the evolving ECS, NASA can track progress on the basis of actual system capabilities. Early integration of functions with high user value are emphasized as protection against changes in schedules or funding.

The build/thread approach has several advantages: 1) it provides for early integration and testing of high-risk functions, 2) it accommodates new requirements easily via new threads and builds, and 3) it focuses on functions so component implementations evolve without impact to integration and test (I&T) plans.

Build/thread methodology relies heavily on the concept of a "thread"—the set of operational procedures that implement a function. Threads are tested individually to facilitate requirements verification and to simplify problem resolution. As shown in Figure 3-5, thread testing shortens integration time by reducing candidate causes of anomalies and allows for pipelining of the development/I&T functions. By starting the testing cycle on the threads with the higher risk, risk can be controlled, as well as allowing system I&T to be performed as soon as the segment I&T on the necessary threads is complete. Shared components get tested in several threads, resulting in thorough testing of core functions.

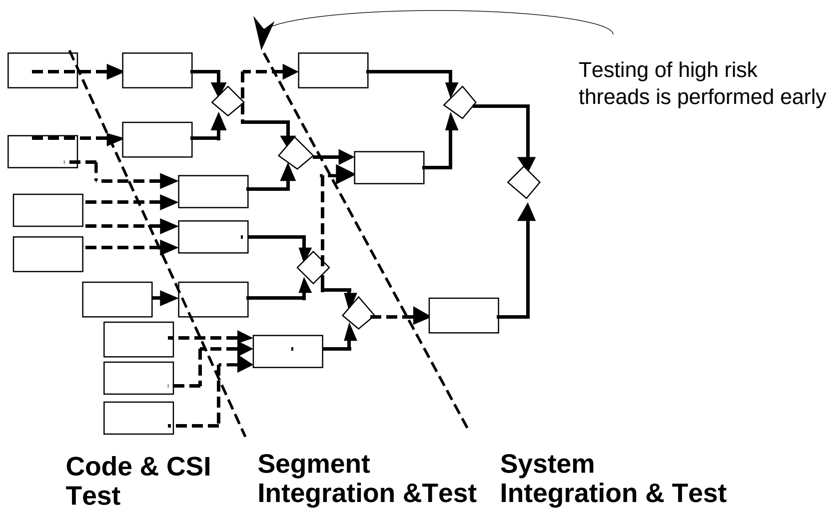

Figure 3-5. Build/Thread Methodology

Successfully integrated components (software, hardware, and data) that execute threads are merged with other threads in a gradual buildup of system capabilities—a build. Build tests prove interoperability of threads in the evolving ECS and reverify new functions in their expanded environment. Regression tests confirm that newly combined functions do not degrade service from previously integrated components.

Regression tests are special tests—outside the normal test hierarchy—performed at any time after element and segment level tests. They verify that continuing ECS development, enhancement and repair activities do not result in any system degradation. Regression tests are particularly useful to verify that a new release does not effect the performance of elements of the previous release that are "unchanged" in the new release.

The build/thread methodology provides a comprehensive, yet efficient, integration and test (I&T) program. The two-tier build/thread method (Figure 3-5) provides comprehensive integration and test of ECS releases. First-level testing validates consistency to the designs and assigned functionality of subsystems, elements, and segments. Second-level testing validates ECS design against overall requirements and user needs. Both levels of testing can be performed in parallel.

The scheduling of thread development and test is partially determined by the risk associated with that function.

The segment I&T organization performs first-level aggregation: element and segment level build/thread integration and test. At this level, unit-tested components (CSUs, data bases, segment hardware, and COTS software) are combined into subsystem, element, and eventually, segment releases. Functional conformance to approved specifications is verified. Many functions cross element borders, so these are integrated directly at the segment level. This strategy avoids “throw-away code” (stub routines and test drivers) and accelerates interface testing. This approach provides the most cost-efficient incremental implementation of ECS.

The second level of I&T combines subsystem and segment releases into a system release. System I&T validates the services provided by the system release to science and operational users. System test threads will functionally verify the operational threads previously used for lower level testing. After successful completion of system I&T, the complete system is turned over to the independent acceptance test organization (IATO) for acceptance testing.

A set of “operational threads” will be defined to capture the operational aspects of the ECS and used to validate the evolving design. The operational thread development begins with major functions of the system, such as Data Order and Distribution. This set will be expanded to capture variations in the functional category, such as EOS and Non-EOS Data Order and Distribution. During integration planning the “operational threads” will be analyzed to determine their appropriateness as integration threads. The first step in the analysis will be to determine if the set is adequate to integrate and test the system. The operational threads will be limited to the users’ and operators’ views of the system and will not specifically test lower level services, such as communications. Additional threads will be added to ensure these services are explicitly tested.

The next step will be to allocate the threads to releases. Each thread is intended to be tested in one release, so if only partial capabilities of a thread are required in a release the thread will be subdivided into two separate threads.

The next step will be to compare the threads to the evolving design. Although the threads are "functionally oriented," there still must be a reasonable collection of software, hardware, and procedures to conduct integration testing. A thread that contains too many "new" components (not previously integrated) will have a high schedule risk; however, creating too many threads will increase the cost because each thread and build has a certain overhead related to it (test plans, procedures, conduct, CM, etc.). A matrix will be developed mapping proposed hardware CIs and software CSIs to threads. Where necessary, complex threads will be split and threads containing the same components will be combined.

The "final" steps will be to sequence the integration of the threads into builds (this also indirectly sequences the implementation activities) and to develop the initial System Build/Thread Plan.

- As previously stated, high risk threads will be integrated early. This statement refers primarily to integration and program risks. For example, the need to ingest various data for Release A is seen as a high priority, so the ingest and archive threads will be placed early in the integration. This allows ingest to begin early in the EDF, reducing program risk. Also, components with complex interfaces would pose an integration risk and will be integrated as soon as possible to allow for corrective action. The communication services will be incorporated in most other functionality and thus are integrated early. However, some threads that may have technical risks based on evolving standards or technologies may be scheduled as late as feasible to allow for the technologies or standards to stabilize. The thread/risk analysis will be done as part of PDR.
- Another focus in the initial plan is user needs. The capabilities that are of the most value to the user (in the initial assessment) will be scheduled early. This minimizes schedule risk; if a capability of less significance to the user is not ready in time, the release can still be delivered if directed.
- Thread dependencies play an important role in integration sequencing. The basic communication services will be used in most thread integration. By integrating these first, they are available for the subsequent integration. This will provide a better verification of the communication services and interfaces than a communications simulator and reduces test tool costs.
- Finally, there must be a reasonable implementation schedule. A thread that requires many custom components may be scheduled late to ensure adequate development time. Threads that contain a significant amount of COTS will be integrated early while development is in process. This allows more parallelism in the development and integration process.

As stated above, the definition of threads and the sequencing of the integration is an evolutionary process. Thread definitions will be adjusted as the Program evolves. The sequencing will also be adjusted as the design evolves, and the releases are better defined. As the functionality of each release is stabilized, at SDR for Release A and IDR for subsequent releases, the System

Build/Thread Plan for that release should also stabilize since the primary driver for the threads is functionality, rather than software structure. Within the limits of the thread dependencies, some shifting of threads within the sequence may occur in response to integration and development progress. This is consistent with attempting to integrate high risk threads early to allow more time for problem resolution.

3.1.4 Standards and Technology Integration

One of the keys to leveraging the evolutionary framework described above is through the use of standards in supporting technology integration. However, the issue of standards is a complex one in any state-of-the-art information system. On one hand, network communities rely extensively on the adoption of common conventions and standards for their successful interoperation. However, there seems to also exist a continual flow of new organizations developing new and often competing standards -- there is no single, universally accepted set of standards. For example, Internet conventions are often at odds with standards used in other communities, including ongoing international standardization efforts such as the OSI.

Commercial vendors often promote their own “standards”, either because the standards process lags behind their product development schedules, or because they can add value (performance or functionality) to a product by circumventing, modifying, or interpreting portions of a standard. As a result, products based on the same standard are often not truly compatible.

As a system, ECS will depend upon making optimal use of standards-based commercially available off-the-shelf software and hardware, and where appropriate, public domain software, or freeware. Hence, this standards landscape requires ECS to closely track and participate in the development of key standards where they exist, and to help push the development of new standards where none currently exist. Hence ECS is active in tracking key technology standards in areas such as distributed computing (OSF/DCE, CORBA), high performance computing (HPF and FORTRAN90), database technologies (SQL3), distributed file systems (OSF/DFS), and mass storage systems (IEEE Mass Storage Reference Model. Additionally, we will be helping to define and develop new standards in, for example, the definition of an earth science data language and earth science data formats. In such efforts, we will attempt to identify and team with organizations that have begun, or are doing, similar work in these areas. Put simply, the ECS mission in the area of standards is to:

- *adopt* appropriate existing standards
- *track* proximal proposed standards
- *contribute* to the development of promising standards efforts
- *drive* efforts to develop new standards where none exist

While ECS will have to rely on the adoption of community-wide conventions and standards for its ultimate success, the architecture also needs to isolate itself from the issues introduced by over reliance on standards or commercial products. This is done through application level abstractions on underlying standards-based services.

3.1.5 Architecture for Evolvability

Studies of multiple types of systems indicate several traits of a system for optimal evolution: 1) Complexity of the system will increase to provide additional functions, 2) the system needs a mixture of stable and changing substructures and 3) the desirable level of changes is at a boundary layer between stagnant and chaotic.

3.1.5.1 Increasing System Complexity

Complexity tends to increase as functions and modifications are added to a system to break through limitations, handle exceptional circumstances or adapt to a more complex world. Where forces exist to weed out useless functions, increasing complexity delivers a smooth efficient system. Where they do not it merely encumbers. With continual reexamination of the system, system complexity growth is often followed by renewed simplicity in a slow back and forth dance, with completion usually gaining a net edge over time. ECS development can anticipate this behavior as more functions are desired by users and designers find simpler ways to achieve previous deployed functionality.

3.1.5.2 Mixture of Substructure Dynamics

Complex systems develop and evolve within an overall architecture much more rapidly if there are stable intermediate forms than if there are not. Evolving systems have islands of relative stability around which elements are changing more rapidly to provide adaptation to the environment. To facilitate change, evolvable architectures are characterized by small, modular components with changes focused at the component level.

Part of the system architecture is the identification of the stable structures. The remaining components are allowed to change during the development. Prime components for change are those with incomplete or suspect requirements. The services previously identified for the incremental track are examples of changing elements. Candidates for core structures are: Posix compliant operating systems; CSMS interfaces at the application and network levels of the ISO OSI Reference model; most of the FOS segment; and level 0 data ingest and storage services. These structures will change slower than other portions of the system, but changes will occur. An example of changes to a core structure is providing CORBA interfaces in addition to DCE interfaces for the application layer interfaces.

3.1.5.3 Boundary Layer of Volatility

The behavior of systems changes markedly as a function of the volatility present in the system. Too little change and the system does not change to meet users needs. Too much change and the system is of no value. Optimum user satisfaction will be achieved if the volatility in the system lies in a region bounded by stagnation on the low end and chaos on the upper end. A challenge for EOSDIS development is to maintain the system in this boundary layer to achieve optimal evolution.

3.1.6 Architecture Change Analysis

Architecture change analysis is a process for looking "near-term" and "far-term" simultaneously and iteratively. This process is an active consideration of the changes in evolutionary categories 2 and 3. This process will start at SDR where the system analysis will be evaluated for changes in the later releases. This analysis will also be considered at the beginning of each release with review at the RIR. The steps of Architecture Change Analysis include:

- Start with the present architecture
- Identify applicable evolvability tests
- Identify impact to the system and develop transition plans for the evolvability test
- Recommend architecture modifications to minimize potential costs of transition

3.2 Evolving Design Drivers

Section 3.1 detailed the mechanisms of control and structure used to manage and contain ECS development, this section describes the forces of potential change, and how *managed* change can be used to improve the ECS product.

3.2.1 Previous Release Experience

ECS takes advantage of all previous release experience as the system progresses. This experience is of three types: EOSDIS Version 0, evaluation packages, and staged ECS Releases. Each of these three are discussed by:

- describing the applicable release experience
- identifying the methods for collecting the experience
- identifying the methods for implementing the experience in future releases

3.2.1.1 EOSDIS Version 0 (V0)

3.2.1.1.1 Applicability of Previous Release Experience

NASA is developing an initial EOSDIS capability Version 0. V0 will continue the existing operational capabilities at the DAACs, improve access to existing data, and prototype working elements that integrate services across DAACs to provide users with an integrated Earth sciences view. From a single interface, users will be able to search for data across all DAACs. In addition, from this same interface, they may place requests for data from all DAACs without having to contact the DAACs individually. Version 0 provides a graphical user interface for users with X-window compatible terminals and adequate network connectivity and bandwidth.

EOSDIS Version 0 will be implemented by the EOSDIS Project, the DAACs, and the science investigators under ongoing review and advice from the Science Advisory Panel for EOSDIS and DAAC science advisory groups. The EOSDIS Version 0 process began in 1990 and will continue until completion of a transition of Version 0 data services to ECS Version 1 (Release A). The document Version 0 EOSDIS Implementation Plan (NASA GSFC) has a complete description of V0 activities.

3.2.1.1.2 Collecting Previous Release Experience

The Version 0 Analysis Report (DID 206/SE2) is the primary mechanism for identifying the portions of V0 to be incorporated into the ECS development process. This is augmented by system engineering tasks such as modeling and tasks the ECS site representative may perform.

The ECS Project is working with the ESDIS Project Office to establish regular science user workshops (similar to the NCDS user workshops held each year) to acquire and document feedback. The ECS Project will use benchmarking and modeling of several different V0 scenarios to evaluate alternative solutions. All analysis results are documented in the Version 0 Analysis Report (DID 206/SE2)

Version 0 statistics, such as the distribution of users over time and types of queries, provide inputs to staffing estimates and system modeling efforts. The early implementation of Version 0, with an operational Information Management System (IMS), provides valuable input to the ECS development process.

It is a goal to acquire information on EOSDIS Version 0 (V0) in an unobtrusive manner, that is, not to impede the ongoing forward process of V0 activities. The ECS site representatives will support the V0-V1 transition directly at each DAAC. Several methods are available to support the acquisition of information on the V0 process without interrupting ongoing work. The specifics methods are detailed in the *V0-V1 Transition Plan White Paper*, but include:

- Attending meetings pertaining to V0, including all Technical Exchange Meetings
- Using ECS system site representatives to collect information and statistics
- DAAC visits for first hand observations and user comments
- Analysis of the V0 lessons learned document and LaRC DAAC handbook
- Hands on use of the V0 systems
- Modeling of V0 data and metadata
- Other pre-ECS contract technical notes, white papers, reports, and presentations

3.2.1.1.3 Implementing Previous Release Experience

Version 0 is embedded in the ECS Project's engineering process. Analysis results will be presented at the regular monthly meetings, in risk analysis reports, and design reviews. Code will be brought into the Science and Technology Lab (STL) for evaluation and transition to ECS.

The ECS Project will migrate scientific data, associated browse data, and descriptive metadata (or metadata-only as necessary) from EOSDIS Version 0 to Version 1 in a cooperative effort with the supplier of the data. Responsibility for effective migration, however, will be with the ECS Project. Where it is found that non-EOS data products to be ingested into ECS are not in conformance with ECS standards, engineering support will be provided, as directed by the ESDIS Project Office, for the translation of such data.

As data migrates into ECS, users will be provided access commensurate with ECS functions and performance. ECS Release B will provide the capabilities to perform EOSDIS Version 0 functions and services which are incorporated into the ECS design, as well as additional functions not included in Version 0 but required by relevant Sections of the ECS Specification.

3.2.1.2 Evaluation Packages

3.2.1.2.1 Applicability of Previous Release Experience

The evaluation packages contain early partial versions of ECS functionality and useful science data. By providing evaluation packages to the beta test group, the ECS Project will use the lessons learned and feedback gleaned to refine ECS before Release A.

Software with high reuse potential will be passed from prototypes into development of the evaluation packages, delivering science capabilities into the hands of evaluators early.

The EDF evaluation packages, linked to workstations at each of the DAACs, will link science research into the development process. The evaluation packages will address the operational capabilities of the IMS, the science processing facility, mission operations, networks, and system management.

3.2.1.2.2 Collecting Previous Release Experience

The primary mechanism for evaluation package evaluation will be electronic questionnaires via Internet. Frequent, iterative, hands-on user involvement during the critical requirements exploration phase preceding Release A will provide valuable feedback on potential risk areas.

After Release A, the user feedback loop, spearheaded by the evaluation packages, will continue to elicit user involvement, provide rapid implementation of approved changes, and aid in containing costs and risks of subsequent release implementation.

3.2.1.2.3 Implementing Previous Release Experience

Evaluation packages will flow into Release A. Feedback on the evaluation packages will be gathered and made part of the release process by using the Recommended Requirements Data Base (RRDB) and starting with Evaluation Package 3, the Interactive Evaluation Tool (IET). (See the ECS Systems Engineering Plan for more information on the RRDB.)

3.2.1.3 Staged ECS Releases

3.2.1.3.1 Applicability of Previous Release Experience

ECS will achieve full functionality with a series of incremental releases. Figure 3-6, Evolutionary Releases, shows the phasing of the first four major releases.

3.2.1.3.2 Collecting Previous Release Experience

The maintenance and operations phase provides full operational use and evaluation of the ECS release by science users, system operators, and the sustaining engineering organization. User satisfaction is continually monitored. A Release Experience Report (DID 332/DV3) is prepared documenting the evaluations of the science advisory panels and other science and system users and incorporating the M&O team recommendations for subsequent follow-up and action. As experience and understanding of operational scenarios accrues, issues that have major impact on the ECS system performance or that apply to future requirements and long-term objectives of current system are referred back to system planning, linking the ECS M&O phase back to ECS system planning and implementation phases. Maintenance and critical upgrades are handled through sustaining engineering and feedback to the development organization for incorporation in later releases.

After the first release the process is repeated focusing on new or modified requirements and design evolution from lessons learned and documented in the Project Development History (DID 218/SE3) and Release Experience Report (DID 332/DV3).

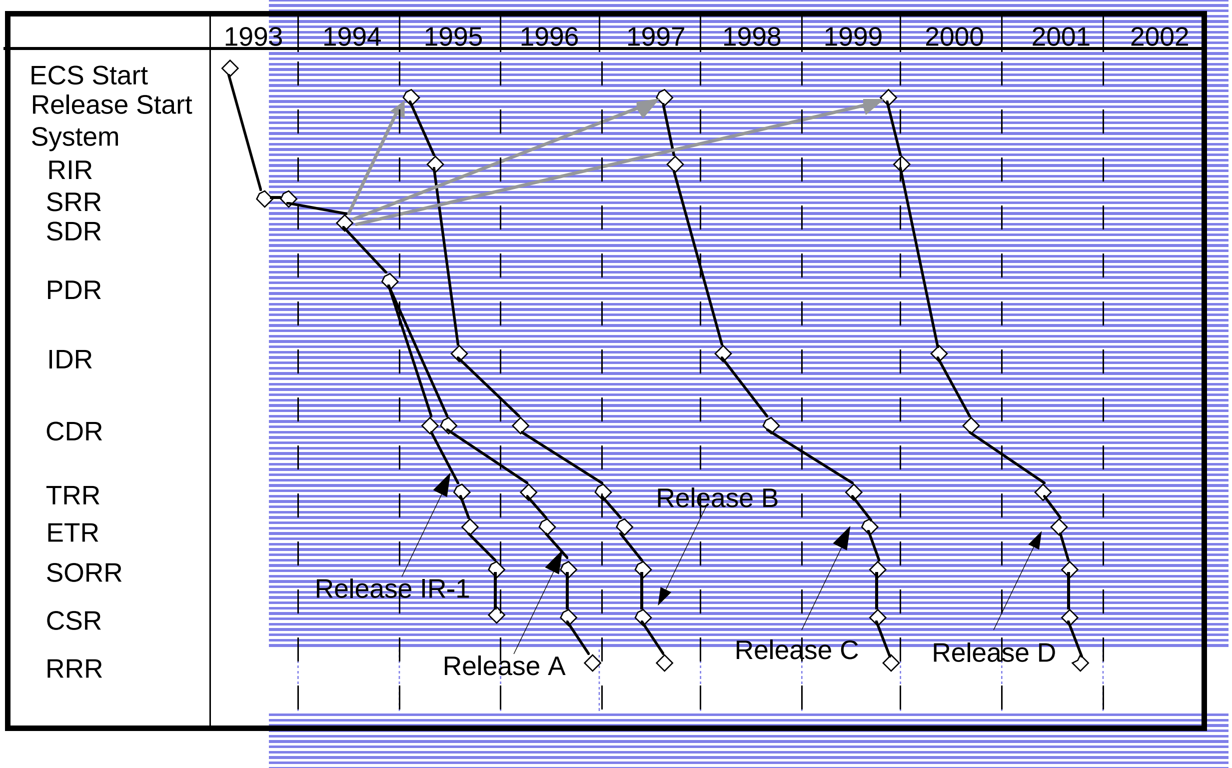

Figure 3-6. Evolutionary Releases

3.2.1.3.3 Implementing Previous Release Experience

Experience from previous ECS releases will affect later releases in two ways: experience gained after a release (i.e. RRR) and experience from each subphase of a release. Waiting for a complete release is valuable to the results of a complete release cycle but it requires a long time delay not supporting quick feedback. Quicker feedback will be gained from each subphase. Release B shall be delivered with a subset of Version 0 data (in addition to Interim Release 1 data) for access by the science community. Total migration of metadata and data from EOSDIS Version 0 to ECS Release B will commence when ECS Release B delivery has been accomplished and when the ESDIS Project Office acceptance is complete.

Feedback from a full release cycle into the next available initiation of a release will be incorporated according to the impact of the change. High impact changes may need to be incorporated at a later release.

3.2.2 ECS Prototypes and Studies

A prototype is a working model representing a subset of a system's functionality that is comprised of hardware and/or software components which may or may not be used as part of the final deliverable system. The purpose of prototyping is to test and evaluate alternative concepts, approaches, or implementations (which may involve newly developed technology) of Earth Observation System Data and Information System (EOSDIS) Core System (ECS) functions. Prototyping is a proof-of-concept technique directed toward the validation of requirements, the product design, and interfaces, before making a commitment to the final product. It embodies all three quality techniques: engineering, reviewing, and testing.

Studies are an analysis of a subset of the requirements, design or implementation of the ECS. The purpose of studies, in many cases, is to investigate an alternative requirement, design approach or implementation solution to be used in the development of the ECS. Studies on the ECS project are often followed by a prototype effort which provides a more in-depth investigation of the proposed alternative.

Prototyping and studies are fundamental components of the overall multi-track concept being used for the development of ECS and will offer greater opportunity to solicit and incorporate user input from the science community. Prototypes and studies will be used on the ECS project to:

- Evaluate the feasibility of a concept or process
- Investigate potential new requirements
- Promote design evolution
- Converge user requirements with system functionality taking into account user sensitivities
- Investigate re-allocation of requirements
- Trade design and implementation alternatives
- Mitigate risks by prototyping prior to design commitment

The Prototyping and Studies Plan (DID 317/DV1) describes the identification, selection, execution/evaluation, and incorporation activities associated with all prototyping and studies that support evolutionary ECS development. The plan also includes the roles and responsibilities of government and contractor organizations in this process. The process described in the plan is applicable to prototypes funded by the ECS contractor team, National Aeronautics and Space Administration (NASA), and University Outreach.

Prototypes and Studies supporting the design and development of ECS will be classified as one of the following: Advanced Prototypes and Studies, Technology Analysis Prototypes and Studies, and Engineering Prototypes and Studies.

Advanced prototypes and studies will be used to evaluate the feasibility of a new or alternative concept, with the focus on investigating the potential of new requirements or alternative implementations of the ECS. They will require significant government involvement to approve, evaluate and incorporate results. In many cases, the user and/or scientist will play a direct role in the evaluation of the advanced prototype. The results of advanced prototypes will generally impact the requirements phase of the ECS development cycle. Advanced prototypes will be developed in partnership with varying levels of ECS segment and external organizations. These external organizations include commercial labs, universities, and other government agencies. Advanced prototypes should not be constrained by the desire to easily incorporate results back into a specific ECS release. Advanced prototypes should be free to explore a wide range of alternative designs. The goal of advanced prototypes will be to explore potential significant improvement in ECS efficiency. Because of the potential free-ranging nature of the advanced prototypes, the government and user community will play a key role in keeping these prototype and study efforts on track and productive.

Technology Analysis prototypes and studies will be used to evaluate Commercial-Off-The-Shelf (COTS) products, shareware, other prototypes, and new technologies. Results are targeted to a specific delivery date or release. These prototypes and studies *test-drive* new technologies for inclusion in the ECS design. The results of these efforts will provide a more in-depth look at a particular technology and how it applies to the ECS design than that information presented at the quarterly technology reviews. Technology analysis prototypes generally impact the design phase of the ECS development cycle.

Engineering prototypes and studies will be used to enhance the ECS development cycle by minimizing cost and schedule or defining/mitigating design and performance risks. These types of prototypes and studies will test the feasibility of a design or implementation concept. These prototypes are more conservative than advanced prototypes and are started early in the development cycle with the intention of producing results by specific delivery dates. Engineering prototypes include efforts to trade designs, incorporate user needs, converge requirements and consider design alternatives. Engineering studies may include the incorporation of external (to the EOSDIS Project) prototype efforts. Engineering prototypes generally impact the implementation phase of the ECS development cycle.

3.2.3 Science Community Feedback

A major challenge is integrating feedback from the user community into the design without overloading the change control system. To accomplish this, recommendations from the user community are screened before submitting them to the configuration change process. The Recommended Requirements Data Base (RRDB) provides a focal point for collecting and tracking requirements. Recommended requirements are screened and assessed to understand the full scope of technical, schedule, and cost implications. With this basis, the preboard (RRDB screening board) can effectively evaluate and recommend disposition. Acceptable requirements are entered into the formal configuration control process.

The RRDB tracks, controls, and synthesizes proposed requirements additions or modifications before submission to the ESDIS Project Office CCB. The central control point provided by the

RRDB allows rapid review, assessment, and status determination. A complete history is kept for each entry, and after CCB approval, the entire record is incorporated into the Technical Management Database (TMDB).

3.2.4 Technology Insertion

Continuous evaluation of new technology using the Science and Technology Laboratory and real time integrated testbed ensures selection of the most effective, lowest risk choices at the best price. With some key technologies evolving in as little as 18 months, ECS will experience many technology generations during its life cycle. Technology insertion is the introduction of new hardware, software and/or methodology into ECS.

The Science and Technology Laboratory (STL) supplies the ECS Project with a facility for benchmark testing and hands-on evaluation of new technology products. The team and representatives of the science community evaluate new technologies in the STL and determine if, and how, they benefit science research, improve ECS performance, lower costs, or reduce risks. As an added benefit to the research community, the STL provides EOS scientists the opportunity for hands-on evaluation of tools and technologies not previously available to them to expand their knowledge of technology applicable at their facility.

As depicted in Figure 3-7, technology insertion has a strong relationship with the Risk Assessment Report (DID 210/SE3) and the Prototyping and Studies Plan (DID 317/DV1). Technology insertion can be initiated with annual technology review recommendations, the Prototyping and Studies Plan, or the monthly Project management status review. All changes to the current baseline will adhere to the procedures specified in the Configuration Management Plan (DID 102/MG1), and ultimately require approval of ESDIS Project Office.

3.2.5 Heritage Systems

Heritage systems save, extend, and leverage existing systems, technology, and techniques from previous projects and apply these features as the foundation for tomorrow's systems. Heritage systems provide a migration for the insertion of current and future technology. The ECS Project will take advantage of heritage systems from each of its team members, as well as other Federal programs as appropriate.

The ECS Project participants have established a heritage in developing control centers, and data archiving systems. The knowledge gained, the concepts and techniques developed, and the architectures and designs created on those systems will be used throughout the development of the ECS Project. The following paragraphs outline the mechanisms for reuse of concepts and design, and code as it relates to ECS.

Concepts are items that are most easily carried forward from prior programs. After re-evaluation in light of current technology, they can give a significant boost to product reliability and reduced implementation time. As an example, the Flight Operation Segment (FOS) design will be a fifth generation control center based on a flexible distributed network architecture. Previous control center Projects developed by the ECS contractors such as NASA's Hubble Space Telescope (HST) and NOAA's next series of Geostationary Operational Environmental Satellite (GOES) weather satellites will be evaluated to identify similar features in design, technique, and concept with the ECS FOS Control Center. When similar features in design, technique, and concept are identified these features will be migrated where applicable into the ECS system design at the segment level. The extent of system concept and design reuse are reflected in the PDR presentations.

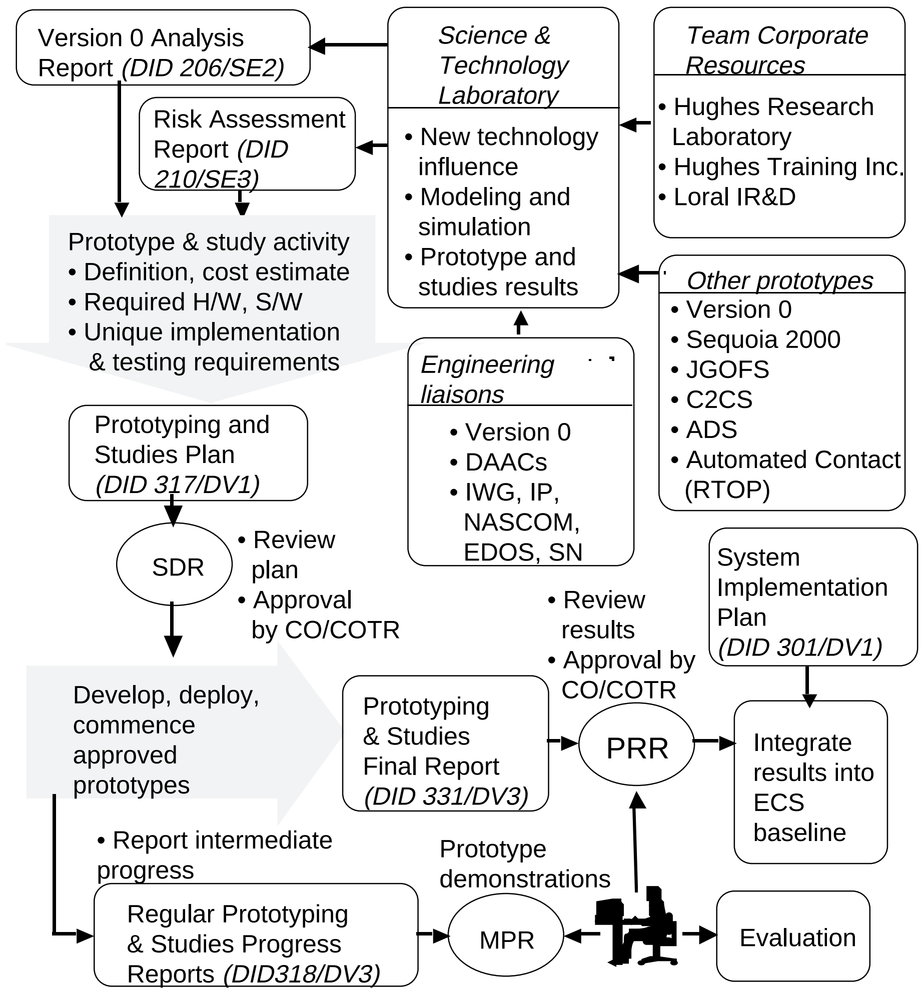

Figure 3-7. ECS Evolution Mechanisms

Due to technology changes and the POSIX compliant nature of ECS routines, extensive reuse of actual code from previous programs is not expected to be common, except for non-operational utilities. Utilities from previous programs, related to the ECS design will be reviewed and mapped against existing systems. As an example, generic as well as specific FOS utilities for existing control center systems such as telemetry processing, commanding, configuration management, data structures, off-line processing utilities, and spacecraft monitoring will be evaluated, edited, and implemented into the ECS FOS control center design. The reuse of these features are reflected in the PDR reviews.

4. Installation Implementation Strategy

This section of the ECS System Implementation Plan, concentrates on the strategies that minimize user and site impact, while maximizing the timely availability of the ECS product.

4.1 Implementation Schedule

The ECS master schedule, presented and maintained in the Summary Schedule (DID 107/MG1), provides the schedule milestones and task duration for each release development and the operations activities. Each release provides increased functionality or data with no service degradation. Sufficient development time is allocated for all releases to support the phased implementation plan, evolutionary enhancement, and risk mitigation. The functional capabilities provided at each release are implemented as system integration threads. Section 10 describes the planned functional capabilities provided in each release and the sequence for integrating them into the ECS.

The ECS system engineering lifecycle is a continuous process of analysis, design, implementation, integration, and demonstration with incremental deployments and design evolution. Though each release proceeds through the lifecycle phases, continuous system-level planning and concurrent implementation and integration exists between releases as depicted earlier in Figure 3-2. Strict control of requirement and design baselines for each release is used to ensure the success of the incremental development.

This section provides an overview of the activities performed during the ECS release development lifecycle. Detailed description of the ECS development processes are found in the documents pertaining to the particular activities such as, the System Engineering Plan (DID 201/SE1), Software Development Plan (DID 308/DV1), Prototyping & Studies Plan (DID 317/DV1), Segment/Element Development Plans (DID 329/DV2), Segment/Element Integration & Test Plan (DID 319/DV1), Verification Plan (DID 401/VE1), ECS System Integration and Test Plan (DID 402/VE2), Acceptance Testing Management Plan (DID 415/VE1), and the Maintenance Plan (DID 613/OP1).

4.1.1 Concept Definition

The ECS concept definition has evolved over time through refinement of NASA's initial concepts, the Phase A and B studies, and operational experience with existing systems and prototypes. This resulted in the ECS Functional and Performance Requirements Specification (F&PRS) and the ECS Operations Concept Document (DID 604/OP1). This evolution will continue throughout the life of the program to incorporate operation experience gained with EOSDIS operational systems, including: V0, and evaluation packages, prototypes and technology assessments, ECS releases; and evolution of the science process. Incremental evaluation packages are provided for science use and evaluation to refine ECS concepts prior to Release A.

Operations concept scenarios are defined as a mechanism to communicate with users and operations personnel. They define the interactions of the ECS system with the users and operators for a set of operational situations. The science community participates in the definition of the operational situation to ensure the system is responsive to their needs. The operational scenarios are also the basis for test, implemented in threads and builds, so visibility is maintained by the system test organization.

4.1.2 System Design

The requirements in the F&PRS are analyzed and refined to provide an initial baseline at the Systems Requirements Review (SRR). As part of the evolutionary development process, the requirements assigned to Release A are agreed upon by System Engineering and the ESDIS Project Office at the System Design Review (SDR). The requirements to be implemented in each of the future releases are baselined at the release's RIR.

Interface requirements are specified in corresponding Interface Requirements Documents (IRDs) and Interface Control Documents (ICDs). The current schedule and status for the production of the IRDs are listed in Table 4-1.

Table 4-1. Interface Requirements Documents (IRDs) Schedule

IRD	Schedule	Status as of 11/01/94
Version-0 System	6/94	Completed
SCFs	6/94	Completed
NSI	6/94	Completed
ADC	9/30/94	Completed
TRMM	6/94	Completed
AM-1	8/94	Completed
ASTER	9/30/94	Completed
Landsat-7	2/15/95	
Color	To be coordinated with ESDIS	
ADEOS-II	10/95	
IPs	To be coordinated with ESDIS	

Note that the Version-0 System IRD serves as the prototype IRD for DAACs; specific DAAC ICDs will be developed in the future. As of 11/01/94, the ECS Project has also provided requirement inputs for interfaces to external systems, e.g., EDOS, Ecom, PSCN and NASA Institutional Support Systems (NISS).

Prototyping is used to "flesh out" requirements, providing a common understanding and definition of requirements. Structured and object analysis techniques are used to provide a graphic representation of the ECS requirements and textual requirements are maintained in a database to provide traceability throughout the development lifecycle. Allocation of requirements to lower level products and additional analysis proceeds concurrently with the design activities discussed in the following Section.

Hardware performance is modeled to match evolving ECS requirements with modern technology. Performance models are the primary source of derived performance and capacity requirements that complement the F&PRS. Performance estimations, system design, operations concept, and RMA analysis are combined to derive quantities of hardware to satisfy these requirements.

4.1.3 Development

4.1.3.1 Formal Development

The ECS design process systematically advances a design by top-down refinement. Engineers characterize program efficiency, data access, and interfaces before coding begins. The methodology begins with 1) top-down structured and object analysis and design, and 2) design by discipline for maximum commonalty and consistency. Structured analysis and design refines requirements and higher level components (software, hardware, and database) into lower level components in a way that ensures modular and complete implementation. Functional requirements analysis captures ECS data and interfaces. Data flow diagrams are mapped to a physical design represented in structure charts. During each design phase this process is refined to additional levels of detail. A computer-aided system engineering (CASE) tool is used to generate data flow diagrams, structure charts, and entity relationships diagrams, and to export them into documents. The design process supports evolution with a flexible expandable architecture down to the component level for software, hardware, and data. Incremental ECS releases allow early and continuous feedback from users. The development methodology is flexible enough to accept such feedback, but controlled enough to ensure robustness, portability, and adaptability to changing requirements. This process advances segment implementation from requirements through CDR.

To minimize risks the process stresses well-defined subsystems and interfaces, adherence to standards, and a layered architecture that supports incorporation of changes. The ECS layered architecture and well-defined interfaces allow incremental development and evolution of ECS components. Consistency is maintained across all levels throughout the life cycle to enhance productivity as components evolve. Design interface standards ensure flexibility of this design in meeting evolutionary requirements. Adherence to standards (e.g., from NIST and ANSI) and encapsulation techniques enhance robustness and portability. Analysis and tradeoffs ensure the maximum practical use of COTS software and hardware.

Database design has three distinct and sequential phases: conceptual, logical, and physical. All phases recognize that user involvement is essential to success; all accommodate evolution.

Conceptual design determines which requirements data can best satisfy, followed by information modeling to define the user view. Information models provide a database interpretation of users' real-world activities. ECS has several user classes each with its own view of data. During conceptual design, the entities that comprise user views and the relationships (interactions) between entities are defined. Entity-relationship (E-R) modeling provides a top-level definition of data needed to satisfy users' needs. This step is repeated until the E-R model matches users' views of the data. (As activities evolve, the users' views of the data changes.) Next, the E-R model is refined with attributes that describe entity classes: identification keys and descriptive characteristics. Finally, the data is normalized to identify any anomalies (e.g., redundancies, nonspecific relationships) that might cause problems in physical design.

In logical design, transaction analysis identifies potential road blocks to satisfying functional and performance requirements. The analysis verifies that a path exists to all data and confirms that all transactions meet performance requirements. Simulation models and data base simulation tools define the initial physical structures. Distribution models determine the best location for data and the degree of data replication required. The logical data model can easily be modified to simulate changing user-access patterns.

Physical design translates the logical model into physical data structures and schema that depend on the selected hardware and DBMS. This model prescribes physical data locations, data characteristics, and storage-organization characteristics. Performance is then measured using actual queries and other transactions to support tuning for optimal performance. Modifications to physical design do not impact users' views of data.

The ECS design process (Figure 4-1) comprises activities leading to a CDR for each release. After the first release, the process is repeated focusing on 1) new or modified requirements and 2) design evolution from lessons learned and documented in the Project Development History (DID 218/SE3) and Release Experience Report (DID 332/DV3).

4.1.3.2 Incremental Development

The incremental development track allows evolution of emerging technology and rapid development of selected ECS software with minimal documentation generated during the development period. This evolutionary approach supports the iteration of design and implementation with the development of Level 4 requirements -- initially stated as objectives. Instead of a single waterfall of sub-phases, the incremental process uses multiple incremental development cycles, including user evaluation prior, to integration with formal release. Figure 4-2 illustrates how multiple incremental development cycles support a release The number of increments shown in Figure 4-2 is illustrative with the specific number of increments for a release based on specific release plans. Figure 4-2 shows the participation of the incremental development teams in the Formal Interface Management. Although not shown in the figure, the incremental development teams participate in the formal reviews.

Incremental development is used to mitigate technical and development risks inherent in software with ill-defined requirements, with extensive interactive software, or with an immature technology or standards heritage. As such, toolkits, selected ECS components, and supporting infrastructure will be developed using the incremental process. Hardware will be implemented and tested only in so far as is necessary to implement incremental software. The incremental process will require early development of the infrastructure of the data management and communication components of the ECS system. The plans for deploying increments as part of Evaluation Packages are contained in the EP Strategic Plan (Reference Section 6.5.3 of the System Engineering Plan, DID 201).

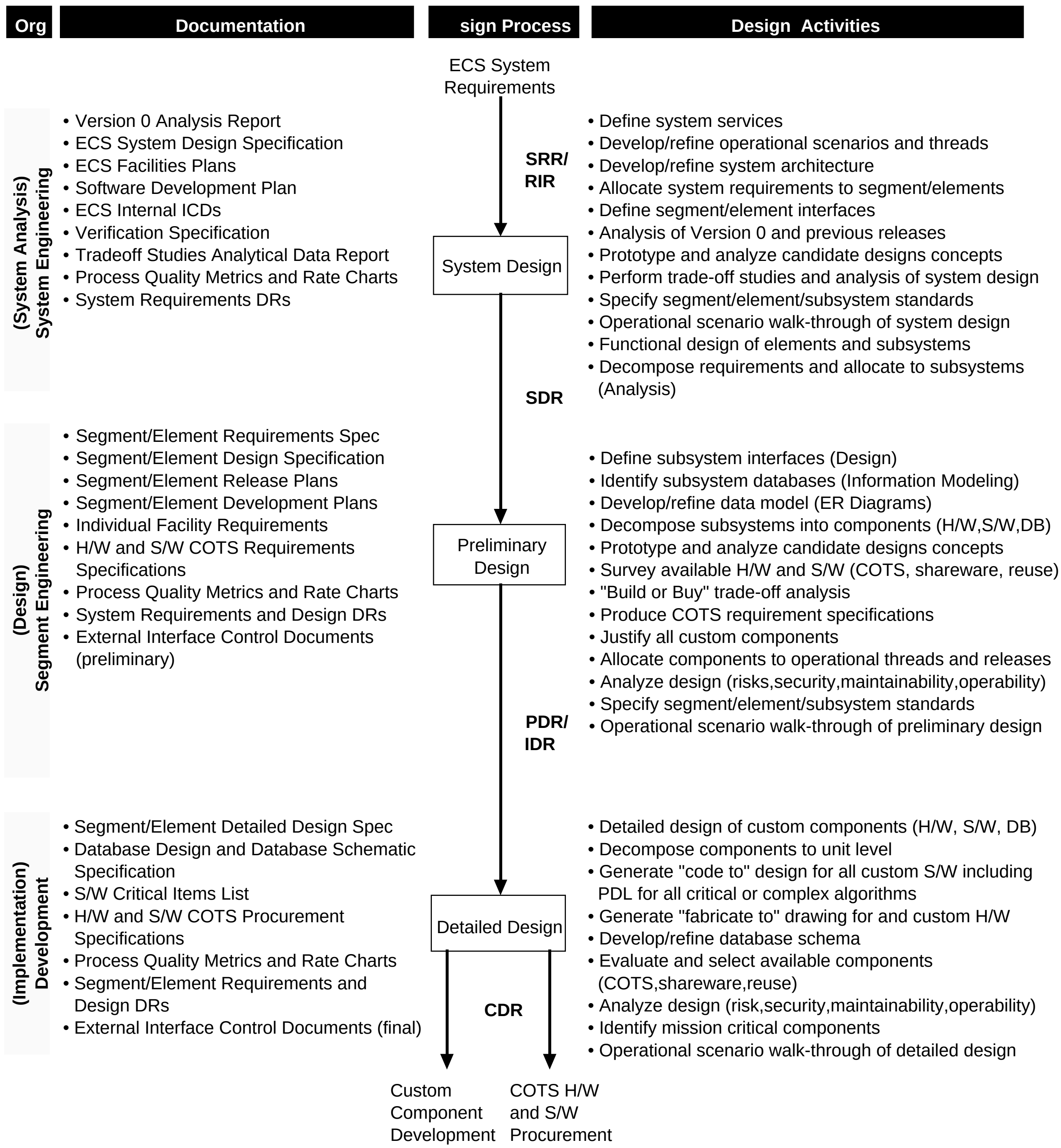

Figure 4-1. ECS Design Process Overview

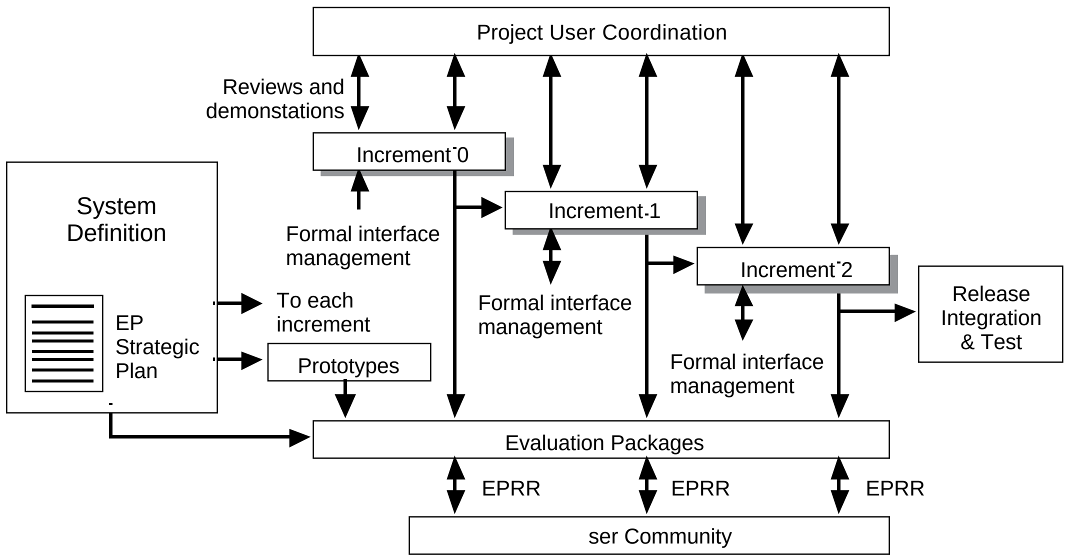

Figure 4-2. Incremental Developments for a Release

An incremental development approach involves a small customer selected segment of the user community in the process of product evolution. Capabilities are demonstrated frequently in a "build and test a little, evaluate a little" development progression. Software built in one increment supersedes and provides more capabilities than the software in the previous increment. The incremental development process leads up to the integration of incrementally developed components into a formal release via conformance to design standards and the migration of documentation into the formal process. The direction and progress of the development is verified during each increment, verifying that user requirements are understood and correctly implemented. Lessons learned in one incremental development cycle may be used to improve software in the subsequent incremental development cycle. The amount of M&O required to be performed between increments is limited. The capabilities that are built and evaluated by a small group (customer-selected-users, ECS M&O and Science Office) are not yet operational nor available outside this selected group. Maintenance will be limited to customer selected/high priority items (versus maintenance of all problems that may occur after installation at the small number of selected sites). In addition, training of these selected users/tirekickers will not be necessary, due to their early involvement and demo experiences, and due to fact that the user interface itself must be self-evident/user friendly so as not to require training nor an extensive user's guide/manual.

A single incremental development cycle has stages similar to those found in formal development (see Figure 4-3). Incremental development starts with objective definition and Level 3 requirements trace, generally corresponding to requirements development in the preliminary design stage of formal development. Both incremental development and formal development have design, implementation, integration and test, and maintenance and operations stages.

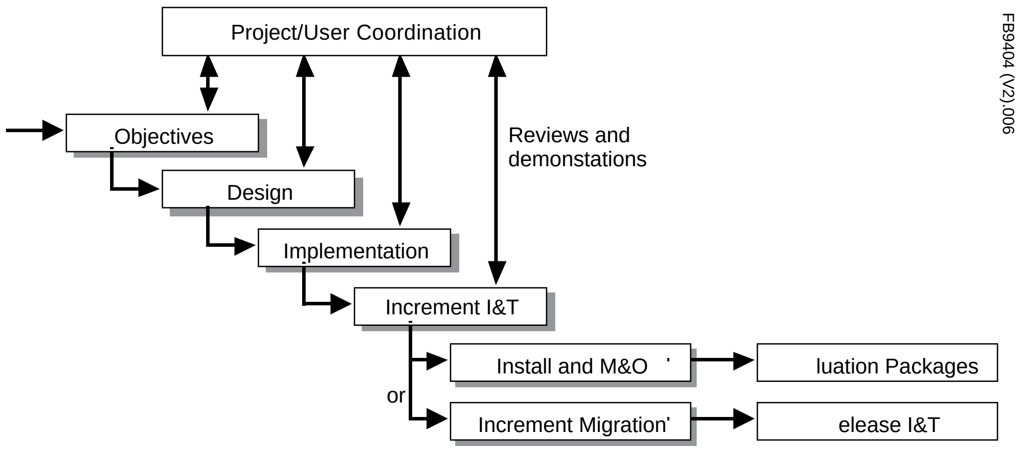

Figure 4-3. Incremental Development Stages

However, the contents of each of the above cycles differs between formal and incremental development due to the iterative nature of the incremental track. In particular, documentation generated during incremental development is initially produced in a more streamlined fashion, e.g., in development "notebooks" maintained by developers, in white papers, in briefing charts, and in system demonstrations. Also, reviews are accomplished as a part of regularly scheduled coordination meetings.

The incremental development process involves rapid development of software. Therefore, in most cases, not all requirements are finalized before design begins. Similarly, not all the thread designs must be complete before implementation begins. The testing of a thread may likewise proceed prior to completion of implementation of all threads.

In addition, incremental software will be integrated into the formal track, after the initial increments are complete (System Engineering Plan, Section 7 discusses the integration of incrementally developed components into the formal track). After all increments are complete for a given release, the full set of formal documentation required for long-term maintainability is generated and migrated to the formal track. This full set of formal documentation includes the complete set of Level 4 requirements and design specifications.

The purposes and the responsible organizations differ for each increment. The initial increment for the first release has three purposes: (a) implementation and validation of parts of the data management and communication components of the ECS architecture, which is being defined in parallel with the first incremental cycle; (b) refinement and validation of the incremental development methodology through actual implementation and improvement of the concepts described herein; and (c) development of some of the services necessary to support the Interim Release.

In the initial increment, the objectives and threads will be reviewed to be consistent with the allocated Level 3 requirements and with the system design. This review is part of the system design and architecture activities in support of the SDR and the RIR. With the support of the

Segment Development organizations, the Segment Engineering organizations define the services for this increment, and the Science Office defines the science objectives for the initial increment.

The purposes of the second and subsequent incremental cycles are evolution of the Data Management and communication architecture, mitigation of the technical risks, definition of the COTS mechanisms needed to support the architecture, development of services necessary to support the next formal Release, and evolution of the design based upon user evaluation fed back from the Evaluation Package deployment.

In the second and subsequent incremental cycles, the Segment Architecture organization, the Segment Engineering organizations, and the Science Office, with the support of the Development organizations, define the architecture, services, and science objectives, respectively, for each cycle. The list of threads to be implemented are thus defined by these organizations. In addition, the modeling organizations assist the Development organizations with the performance parameters, and the Engineering organizations define the scenario descriptions. The Science Office provides the science data. The quality metrics for the cycle are defined and implemented by segment development organizations with assistance with Quality Assurance as defined in the Software Development Plan (308/DV2). Quality Assurance also performs quality verification of all development folders, and performs the internal audit which occurs at the end of each EP prior to installation for evaluation. The configuration management specifics required for the cycle are planned and implemented by the Configuration Management organization. The development builds are defined and implemented by the Software Development organizations, and the plan for the qualification of these builds is defined and implemented by the Test organizations. The customer and DAACs and specific scientists are involved in this process.

Documentation, in the form of folders, may be formated as white papers, briefing charts, or annotated charts, available electronically or hard copy, as appropriate to convey the information. Templates will be provided by ECS Configuration Management. To allow for ease of generation of formal documentation, priority is given to using a template during the increment that is in the formal documentation format, or if not in the same format, that will allow the contents of the folder to contain the information expected to be placed in formal format prior to incremental migration to the formal track. The purpose of the templates is to allow for ease of generation of minimal documentation with minimal impact to the implementation.

4.1.4 Implementation

The implementation process carries each incremental implementation from CDR through software unit testing. Proven software standards and procedures (documented per ECS Standards and Procedures, (DID 202/SE1) and maintained in engineering notebooks) provide consistent quality of software and database development. In addition to new subsystems and components, incremental releases include modifications to existing software. Software development files (SDFs) are used to maintain these baselines.

Coding standards and style guides are included in the engineering notebooks. Audits using random sampling ensure that developers follow coding standards and style guides. For consistency and maintainability, heritage code (from previous programs, Version 0, and prototypes) is productized, by ensuring compliance with ECS standards. All ECS development uses ANSI-certified compilers and SQL for database development.

The coder and a review team walk through all completed code and its unit test procedures. Unit test follows with an internal test results review upon completion. The unit and its SDF then become subject to configuration control.

4.1.5 Integration and Test

The integration and test activity consists of the System Integration and Test (SI&T) group and the Independent Acceptance Test Organization (IATO). Segment integration and test is performed by the respective segments. Section 4.5 of this document describes the steps associated with I&T as well as the associated documents.

4.1.6 Maintenance and Operations

The M&O organization is formed at contract start and supports the development process by instilling operational experience while gaining an in depth understanding that carries forward into the operational phases. Shortly after contract start, personnel with engineering and scientific backgrounds are assigned to each of the DAACs to provide daily interfaces with the NASA/university DAAC on-site personnel, data center site managers, and the science users. Early on M&O personnel are assigned to the engineering organizations to support development of operations plans, scenarios, and training plans. This contingent of personnel establish the initial links between operations and engineering.

M&O provides the team that operates and maintains ECS and interfaces with the NASA institutional organizations and, through NASA, with the user community. At each DAAC site, an informal Technical Assistance Group (TAG) is formed with key Hughes team members and Government personnel as members. The TAGs provide a strong interface for both operational and scientific users resulting in improved understanding and system usability.

As each site becomes operational, it receives the same SDPS functional capabilities and LSM and networking capabilities. In addition, GSFC has installed EOC and SMC capabilities not required at the other sites.

4.1.7 System Evaluation

The maintenance and operations phase provides full operational use and evaluation of the ECS release by science users, system operators, and the sustaining engineering organization, as described in Section 3.2.1.3. After the first release, the process is repeated, focusing on:

- New or modified requirements
- Design evolution from lessons learned and documented in the Project Development History (DID 218/SE3) and Release Experience Report (DID 332/DV3).

4.2 Prior to Installation

The plans for supporting smooth transitions between releases are:

- Anticipatory planning of release transitions and data migration.
- Methods for supporting upwards compatibility of operations and functionality.
- User assistance services providing uninterrupted support.
- Well-orchestrated, easy-to-follow installations procedures for ECS and user sites.
- Use of the evaluation packages to reduce the cost and risk of transitioning to Release A.
- Regression testing of operational procedures.
- Validation of processing capabilities and algorithms, databases, interfaces, and total functionality.
- Early installation of hardware, COTS software, and databases.

Hardware is acquired over time to allow for new technologies to be developed and evaluated and costs to be distributed and reduced. For each release, the hardware configuration is established at CDR and installed with COTS software before custom software delivery. This staged installation minimizes cost by allowing an efficient integration of custom software into a functioning hardware base.

Software and database installation is performed under the supervision of Configuration Management after COTR authorization at the CSR. The software that was used for the factory acceptance testing rehearsal is installed by Configuration Management to ensure consistency in the reverification tests. Test databases are updated, under configuration control, to reflect the site configuration.

Release operational training sessions are held at the ECS sites prior to RRR, to train the operations staff on the new release capabilities and M&O/user procedures.

4.3 System Transitions

System transition plans provide for smooth integration of new services, hardware and data, without impact to existing facilities or ongoing operations at the DAACs. ECS transitions to new releases begin with site testing, followed by IV&V, operational exercises/rehearsals, user training, and culminate with the switch over to the new release. Some releases include migration of data, e.g., Release A. Planning each release transition is coordinated with on-site operations support and is tailored to individual release complexities.

4.3.1 Assuring Operational and Functional Upward Compatibility

The design methodology and release transition approach ensures functional and operational upward compatibility. The methods for supporting system transitions between releases include:

- Design methodology facilitating functional compatibility
- Assessing functions contained in a release for compatibility

- Synchronizing the core baseline and on-site baselines before the start of IV&V
- Regression testing of the merged baseline before switch over to ensure no loss of functional or operational capabilities
- Review and walkthrough of user and operations positions procedures to minimize change

The multi-track design strategy makes it possible to add or modify capability with minimal impact to existing software, reducing time spent in integration and test. Tailorable and consistent interfaces reduce the need to retrain users and operators due to modifications to underlying ECS functions.

Assessing the impact of new functionality on existing operational capabilities includes identifying site specific aspects suitable for incorporation into the core baseline for the release. New functions are reviewed to ensure they are consistent with upwardly compatible design strategies. Additionally, the core baseline at the EDF representing the general functionality contained in a release is updated with site specific changes, minimizing the time required for on-site integration into a merged baseline.

After consent to ship review (CSR), synchronization of site specific changes with the release baseline is performed before starting acceptance testing and IV&V.

New operational and procedural aspects of each release are reviewed for compatibility with existing operations. Delivery of services to the users and ECS operators is stepped through and reviewed in the context of prior operations during site acceptance testing at the site. Based on this analysis, necessary training and orientation is prepared and coordinated with each of the sites before the start of IV&V.

4.3.2 Assuring Uninterrupted User Support

The user services provided during normal operations are augmented during release transitions to provide additional support to users. The schedule of operations staff during release transitions will be coordinated so that users will not experience disruption in service or planned activities. The ECS Bulletin Board informs users well in advance of release upgrade modifications and schedules for operations exercizes/rehearsals and toolkit installation. It is accessible to users at ASCII terminals without direct or NASA Science Internet connectivity to ECS as well as networked users at SCFs.

4.4 Software and Hardware Installation

Prior to SDR, release installation schedules are developed in concert with the ECS design, development, and integration groups and the operations and user staff at the DAACs, EOS and SMC. Prior to PDR installation planning will begin. These drawings go into the Individual Facility Requirements (DID 303/DV1) and the ECS Facilities Plan (DID 302/DV1). They include facility requirements and an overall physical plan for the site. During site surveys, we also review site-specific requirements, policies, and codes to be considered in the installation planning.

At SDR, the ECS system design and the release implementation schedule are approved. On-site staff and equipment vendors coordinate to obtain information that will affect the installations (e.g., space, power, and cooling required). Installation schedules are developed for review at PDR and approval at CDR. All subsystems planned for installation are evaluated at the EDF before CDR to verify that all ECS, user, and site requirements are satisfied. At CDR the COTR authorization to purchase the COTS products for the next installation is obtained. Vendor purchases are phased by procurement lead times to get the best price and latest models and versions.

After CDR detailed installation planning begins with internal planning reviews involving the installation staff, on-site NASA and site personnel, and the ECS developers. Installation plans developed for each site include:

- The detailed site installation tasks, roles/responsibilities, and schedule
- Bill of materials and equipment/software delivery dates
- Facility drawings of the current and to-be-installed configuration
- Site-specific installation requirements
- Applicable site policies and codes
- Plans/procedures for shipping/receiving, CM, property management, local communications support, personnel access and administrative support, library/publications support

These plans are coordinated with the ESDIS Project Office and ECS site personnel to ensure schedules are compatible and that required GFE interfaces are provided. The final site installation plan is reviewed and approved during an internal installation readiness review (IRR) with each site's government manager 30 days before installation. IRRs confirm that

- facility preparation will be complete by the scheduled installation date,
- subsystems to be installed meet ECS and site requirements in EDF tests,
- necessary coordination with site personnel has been effected, and
- COTS component delivery dates are on track.

During the IRR, installation responsibilities are assigned and the installation plan is reviewed to ensure that schedule or resource conflicts are identified and resolved. The site installation plan is provided to the installation teams for further detailed planning and execution.

ECS system software undergoes final integration testing at the EDF before being installed at the sites. While the COTS hardware and software is being installed, a CSR is conducted to verify the ECS software is ready for release to the sites and to obtain COTR consent to ship the release to the sites for integration and test.

4.4.1 Initial ECS Site Installations

The process of staging initial site installations ensures delivered components conform to site standards and minimize impact to site operations. During staging, the equipment and software is inspected, inventoried, and tagged at a staging site to ensure the hardware and software is complete, serviceable, and of the correct model/version. Its receipt is recorded and reported to the site property manager to initiate property accountability and to prepare it for shipment to the site. Some hardware, such as supercomputers and large data archive equipment, is shipped by the vendor direct to the site and is installed by vendor personnel. These shipments are coordinated with the vendor to ensure their timely arrival. For staged components, the site installation process is initiated by dispatching the COTS hardware and system software from the staging site.

Three teams per site are used to install ECS releases: a COTS installation team for COTS hardware and system software followed by a System Integration and Test (SI&T) team for installing, integrating, and testing the ECS custom software, COTS software, test databases, and toolkits, followed by the IATO team for acceptance test performance.

The installation of each ECS software release is coordinated with the IATO and site operations personnel to ensure affected parties understand the timing and the requirements of the installation. All site LANs are installed during the initial installation at each site. Tests are performed to verify the proper installation, operation, and configuration. Procedures and tests are verified during preinstallation testing performed at the EDF and validated at the segment and element test reviews.

Before releasing the system to the SI&T, the COTS installation team perform tests to ensure the hardware and software has been properly installed, configured, and is fully operational. These tests are usually operational threads selected to exercise representative end-to-end system functionality. The COTS hardware and software installation team leader then certifies to the SI&T that the system is ready for ECS applications software integration and then acceptance testing.

Site Configuration Management supervises the installation of custom software and databases approved by the CO/COTR at CSR. The SI&T team then begins their integration and test activities, integrating the ECS applications software and databases with the COTS hardware and software and performing system testing. Upon completion of the system integration and test, the IATO team performs the acceptance test.

4.4.2 ECS Site Upgrades

The methods for upgrading the sites in a controlled manner ensure a stable system while increasing ECS capability. Several integration methods, including off-shift installations, use of backup equipment, and transparent installation and switch-over, are used to coordinate installation of site upgrades while minimizing impact on site operations, on-site staff, and users. On-site staff gather site-specific user and operational requirements to develop updated transition plans at each ECS release and to upgrade the Individual Facilities Requirements (DID 303/DV1). These drawings and site requirements provide the baseline from which upgrades are planned. Releases are delivered only after the switch-over process has been thoroughly tested at the EDF and coordinated with on-site operations personnel and users. If site upgrade activities extend into the operational support hours, installation will be scheduled around nonpeak hours to limit the impact to users, or users will be rerouted to another DAAC.

4.4.3 Data Access Toolkits

Toolkits are released prior to ECS Release IR-1 to provide early support for algorithm development, integration and test. Toolkit release dates are shown in the Summary Schedule, (DID 107/MG1). Toolkit release identification and functionality are shown in Table 4-2. Additional toolkits are released concurrently with the ECS releases to provide access to the additional functionality provided by the release; the toolkits are available electronically .

Modular, upwardly compatible toolkits, easy to follow installation procedures, and accessible user assistance services ensure continuous service during release transitions. ECS toolkits will be distributed internationally to user sites serving educational users, commercial users, policy makers, as well as the science investigators. Workstation hardware at these sites is provided by the users according to the standards set by the Project (i.e., POSIX compliant), and the users are responsible for installing and integrating the toolkits. The installation makefiles and support by the Technical Assistance Group, which will be in placve after Release A, make this installation easy for users to perform themselves, thus ensuring continuous service through system upgrades. ECS toolkit design ensures upward compatibility, so users can run a release behind until they have upgraded their toolkits at their convenience.

Toolkit software installation is facilitated by tested, certified, and documented makefiles that automate the installation at the user site for a limited number of POSIX compliant workstations, relieving the user from setting up directories, command files, and logical assignments . In addition, the code is in source form so that it will integrate the toolkit with any POSIX compliant workstation and/or integrate with other COTs software.

The Technical Assistance Group (TAG), trained in the new features and their installations, provide a user support hotline accessible via telephone. The TAG can optionally perform remote installation and initial checkout of the ECS toolkit software by shipping X-Windows resource files to the user and by executing the makefile via remote login. Training materials (videos, manuals, on-line tutorials) also enable each site to grow their own resident experts on toolkit installation and integration procedures. In addition, each DAAC hosts training sessions for toolkit installation on a walk-in basis.

Table 4-2. Release IR-1 PGS Toolkits

Toolkit	Release	Functionality/Capacity
Algorithm Development	TK 1	Algorithm development HMI, COTS tools (math library and statistical analysis packages), libraries
Algorithm Development	TK 2	Geolocation routines; File I/O and error/status message handling; Users Guide and HDF primer for Version 1
Algorithm Development	TK 3	Preliminary ancillary data ingest interface and metadata access and manipulation; coordinate conversion; complete gerneic I/O and error/status message handling for SCF development environment; HDF API design document; toolkit modifications based on user feedback and requirements of the new architecture
Algorithm I&T	TK 3	Initial algorithm I&T environment Toolkit: generic file access
Algorithm Development	TK 4	Preliminary HDF library; additional ancillary and metadata access and manipulation; geophysical coordinate conversion; Level 0 data ingest emulation and acess tools; geolocation tools using Level 0 data
Algorithm I&T	TK 5	Full PGS toolkit interface; satisfaction of requirements identified; modifications to previous tools
Algorithm I&T	Release A	Full algorithm integration Toolkit at PGS with manual process initiation

4.5 Integration and Test Activities

The Integration and Test Activity consists of the System Integration and Test (SI&T) group and the Independent Acceptance Test Organization (IATO). Figure 4-4 shows the flow of the Integration and Test Activity and delineates the responsibilities for each. SI&T and IATO are responsible for the installation and integration of ECS at the operational sites. These organizations are responsible for multiple documents that provide the details of test and integration at each site. These documents include:

401/VE1	Verification Plan
402/VE1	ECS System Integration and Test Plan
403/VE1	Verification Specification
409/VE1	ECS Overall System Acceptance Plan
411/VE1	ECS Overall System Acceptance Procedures
414/VE1	ECS System Integration and Test Procedures

The responsibilities of each organization, and the relative steps necessary to install and integrate an ECS release at a site, are specified in the ECS Systems Engineering Plan.

Preparation of the acceptance test takes place at the EDF. Acceptance testing consists of end-to-end operational scenarios. The prime focus of acceptance testing is the verification of ECS

Level 3 functional, operational and performance requirements. Discrepancies are tracked via system-level DRs. Delivered code is transferred to the DAAC library within the CM system. The next section describes the IATO role in system acceptance testing.

4.5.1 IATO Activities

There is a different approach to verification between the SI&T and IATO organizations. SI&T is focused on integrating the developed components of the ECS, software builds/threads and hardware, into a functional whole called a Release. The IATO is responsible for demonstrating that each formal release satisfies the Functional and Performance Requirements throught the use of science and operational scenarios. Included in this is verification of the external interfaces through testing involving simulators and/or the actual external systems, if available.

Preparation of the acceptance test takes place at the EDF. Acceptance testing consists of end-to-end operational scenarios. The prime focus of acceptance testing is the verification of ECS Level-3 functional, operational and performance requirements. Discrepancies are tracked via system-level DRs. Informal walk-thoroughs of the system acceptance test at the EDF is a prerequisite for transfer of acceptance testing to the operational sites. Delivered code is transferred to the DAAC library within the CM system. The formal site acceptance process is preceded by a checkout of the testing environment on the site-specific hardware. This provides additional confidence that the release is ready for formal acceptance testing.

ECS releases are formally accceptance tested at some or all of the following operational sites, depending upon the content of the release:

- The System Management Center (SMC)
- The EOS Operations Center (EOC) and Instrument Control Centers (ICCs)
- The Distributed Active Archive Centers.

The actual sequence of testing is defined in the ECS System Acceptance Test Plan (409/VE1)

Two phases of acceptance testing are performed at ECS sites for a formal release: site-specific testing, where the focus is on each indiviudal site, and “all up” testing, where all sites associated with the release are tested simultaneoulsy as a unit. In order to minimize the total time required to accomplish overall acceptance testing for these release, several teams perform site-specific testing at the same time. Nevertheless, there might not be enough teams to test all sites simultaneuously, so several cycles of site-specific testing might be necessary.

Site-specific acceptance testing begins with a formal checkout of the testing environment. The formal acceptance test is then initiated. Formal execution is then witnessed by the local members of the Government Acceptance Team (GATT) and the IV&V contractor. If possible, personnel from DAAC customer operations and M&O operations are included in the team to serve as test personnel. This provides them with early visibility into the new release and a smoother transition of the new code into operations. A post test meeting is held to discuss results. The local team members formulate a quicklook report upon test completion and forward it to the rest of the GATT.

Upon completion of all site-specific testing for a formal release, the test teams are dispersed so there is representation at each site for “all-up” acceptance testing. This testing is executed to verify interfaces and interoperability among the DAACs, EOC, ICCs, and SMC and to ensure that the entire release functions and performs as required.

The acceptance testing of the EOC and ICCs is fundamentally different due to the critical nature of flight and instrument control systems. As such, EOC and ICC testing at GSFC are conducted in parallel with the site-specific testing at the DAACs. The EOC and ICCs participate in the all-up testing with the DAACs in order to demonstrate interoperability for storing of historical data and for processing DARs.

SMC testing also covers the entire period, though the reasons are different. After the first test period, the SMC participates in remote site testing by virtue of the functions it performs in configuring the environments for each remote site. Finally, during the all-up testing, SMC's ability to orchestrate the overall network of DAACs is verified.

Following site-specific and all-up acceptance testing for the formal releases, the full results of the test are collected into a single test report. Recommendations are formulated and forwarded to the GATT. The GATT meets to assess success/failure. All problem reports are dispositioned either to each DAACs tracking system for M&O action or to the ECS Project for resolution in the next release. The GATT presents its conclusions to the COTR at the Release Readiness Review (RRR). Completion of RRR constitutes ECS contractual acceptance.

4.5.2 I V & V Support Activities

The Independent Verification & Validation (IV&V) contractor will assist GSFC in further tests of the ECS after the IATO performs acceptance testing. When formal acceptance testing is complete and a successful Release Readiness Review (RRR) has been conducted, GSFC intends to perform EOSDIS system-wide testing during which ECS external elements will be tested and adherence to Level 2 requirements will be validated.

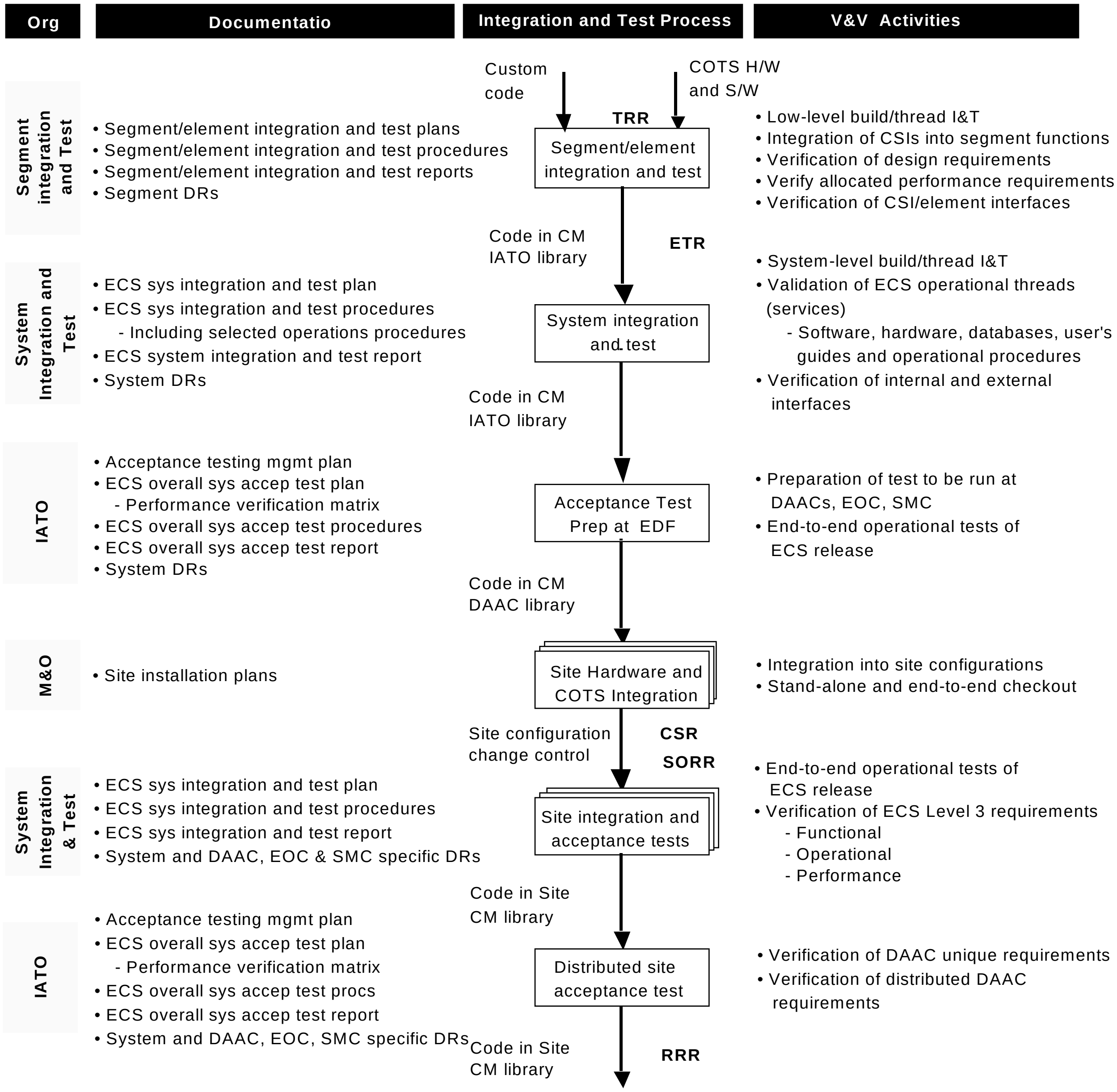

Figure 4-4. ECS Integration and Test Program

5. Driving Requirements/Milestones for ECS Releases

ECS will mainly be distributed in quanta described as releases. Each release will add specific capabilities for each site. The primary sites are referred to as Distributed Active Archive Centers (DAACs) and currently consist of eight facilities: Goddard Space Flight Center (GSFC), EROS Data Center (EDC), Marshall Space Flight Center (MSFC), Jet Propulsion Laboratory (JPL), Langley Research Center (LaRC), National Snow and Ice Data Center (NSIDC), Oak Ridge National Laboratory (ORNL), and the Alaska SAR Facility (ASF). At GSFC, the ESDIS facility houses the EOS Operations Center (EOC), Instrument Control Center (ICC), and the System Management Center (SMC). This section describes the external ECS requirements/milestones that drive the release of ECS functional capabilities. This section includes requirements to support mission operations and mission data processing, and it includes requirements to support IV&V testing and operational EOS ground system interface testing. Finally, this section addresses the requirement to provide onsite management and logistics support services e.g. fault management, security, performance management, configuration management, scheduling management, inventory/property management, policies/procedures management, and report generation. Detailed release planning activities are provided in the ECS Release Plan White Paper.

5.1 TRMM Launch Support

TRMM (Tropical Rainfall Measurement Mission) is a platform scheduled for launch in August 1997 which relies on ECS to support its mission. As shown in Figure 5-1, the Level 0 data from the three TRMM instruments (PR, TMI, and VIRS) will be higher level processed by TSDIS, a production system provided by the TRMM project. ECS will provide the data archive for this data; PR and TMI data will be archived at the MSFC DAAC and VIRS at the GSCF DAAC. Additionally, ECS will provide the production facilities for Level 1 and higher level processing for two other instruments of opportunity on TRMM, CERES and LIS, at the LaRC and MSFC DAACs respectively. ECS will provide the data archive for these data as well. ECS also will provide data search, order and distribution services to science users for information derived from all 5 instruments stored in the archives. The interfaces shown in the figure must be operational in time to support the TRMM launch.

Driven by the launch date but prior to it, some ECS capabilities must be available for early interface testing. Recommended TRMM interfaces for these tests are marked with an asterisk in Figure 5-1. Data interfaces marked with an asterisk may be simulated for the TRMM early interface testing support Per the EOS Ground System Integration Plan, the ECS functions to support early interface testing of these TRMM interfaces must be available by 1/3/96.

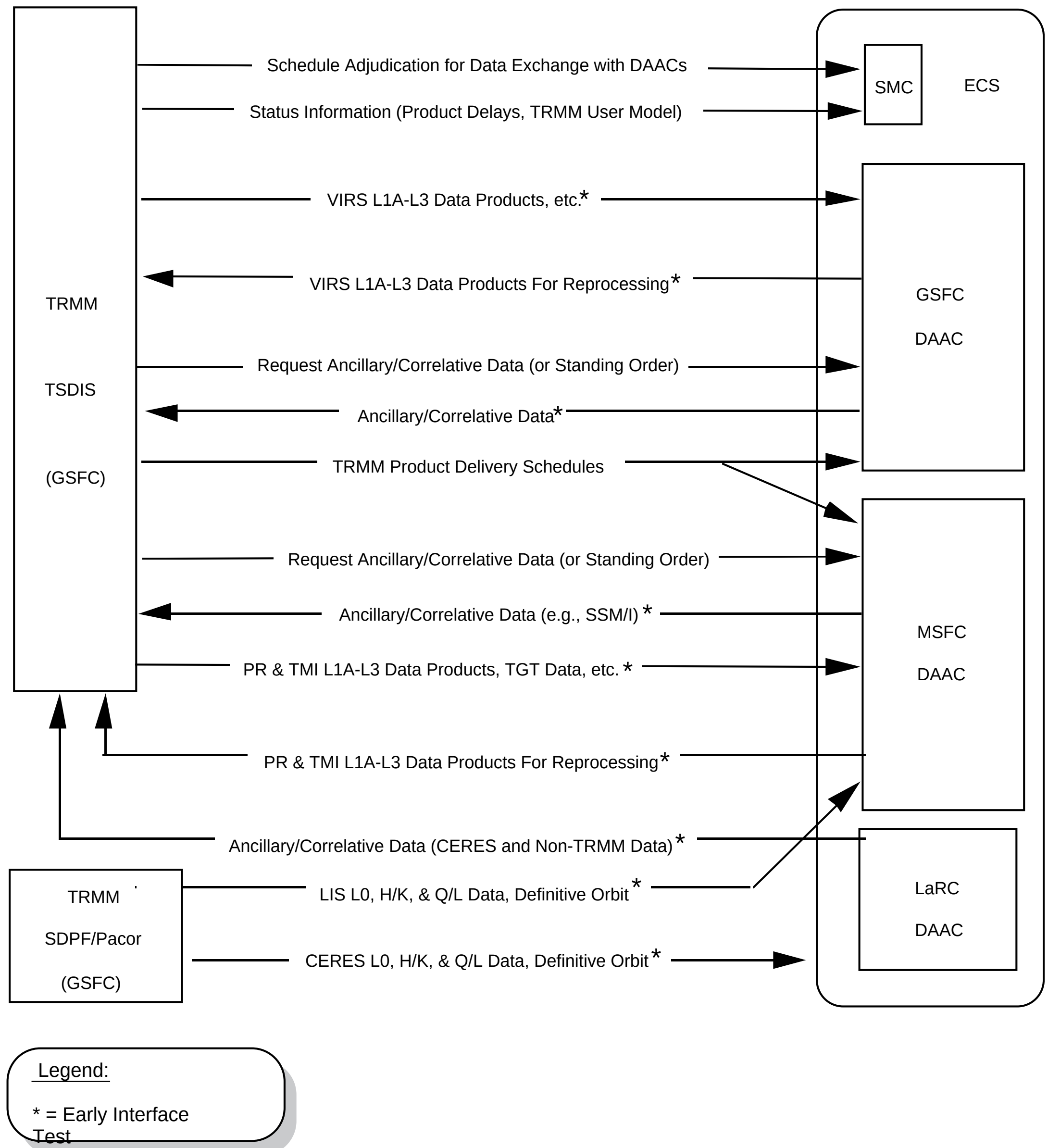

Figure 5-1. ECS TRMM Interfaces

5.2 Landsat-7 Support

Landsat-7 is currently scheduled for launch in May, 1998 and will rely on ECS for support. Landsat-7 produces Level 0R data, which is a viewable image product with radiometric and geometric information appended, but not applied. Landsat-7 provides ECS calibration data, Level 0R data and corresponding browse data and metadata for storage at the EDC DAAC. The ECS shall have the throughput capacity to ingest and archive up to 12 hours of Landsat-7 Level 0R data within 8 hours of receipt of the data availability notice from the Landsat-7 Processing System (LPS).

The ECS provides the Level 0R data search, data order and data distribution services to users of Landsat-7 data. International Ground Stations (IGSs) also provide metadata and browse data to ECS. The ECS will store the IGS metadata and browse data. The ECS will not, however, provide the product order and distribution services for IGS-held Landsat-7 data.

5.3 Color Support

The Color platform is scheduled for launch in October 1998. ECS support for Color is not currently in the ECS baseline, but is assumed to be similar to the V0 DAAC support for SeaWiFS. Under this assumption, an ECS DAAC (GSCF) will be responsible for receiving higher level (level 1A and above) color instrument data from a Color production facility. Presumably this would include associated metadata and browse. The DAAC would be responsible for archiving the data and providing data search, order and distribution services to authorized Color users. In SeaWiFS, the Version 0 DAAC also provides regular user access and distribution reports back to the production facility. This interface may also be required for Color. These interfaces must be operational in time to support the Color launch. Additionally, user data search, order and distribution services on Color data must available by launch.

Some ECS capabilities must be available for early Color interface testing. Recommended Color interfaces for these tests are to be determined. Per the EOS Ground System Integration Plan, the ECS functions to support early interface testing of key ECS-Color interfaces must be available by 2/1/97.

5.4 EOS AM-1 Support

AM-1 is scheduled for launch in June 1998. Figures 5-2 and 5-3 summarize the external interfaces required to support the AM-1 launch for the FOS and SDPS/CSMS segments respectively. The full set of ECS functionality must be operational to support AM-1 launch. This includes FOS planning, scheduling, command, control and monitoring of the AM-1 spacecraft; SDPS data ingest, production, archive, query and distribution; and CSMS system management and communications infrastructure.

A number of ECS capabilities must be available for early AM-1 interface testing. Recommended interfaces for these tests are marked with an asterisk in Figures 5-2 and 5-3. The Flight Operations Segment (FOS) will support early interface testing with the spacecraft, instruments, EDOS and ECOM. These tests are directed by the spacecraft contractor. They include spacecraft and spacecraft bus comprehensive performance tests, EOC and spacecraft compatibility tests, the spacecraft thermal vacuum test, the spacecraft end to end test, mission operations simulation and a post ship spacecraft comprehensive performance test. In addition, interface testing with NASA institutional support (FDF, NCC, WTS, etc.) will occur as part of the ESDIS ground systems integration.

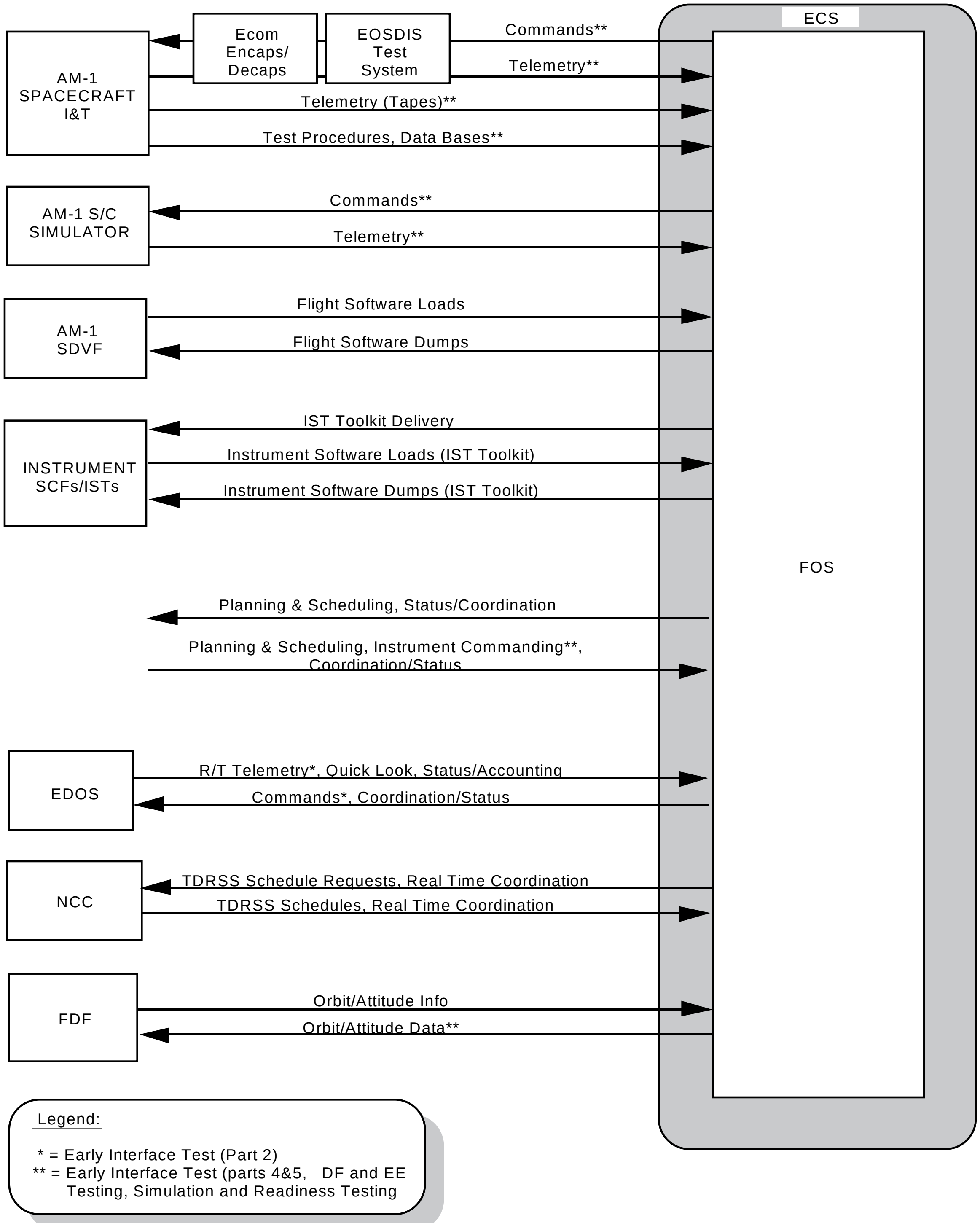

Figure 5-2. FOS AM-1 Interfaces

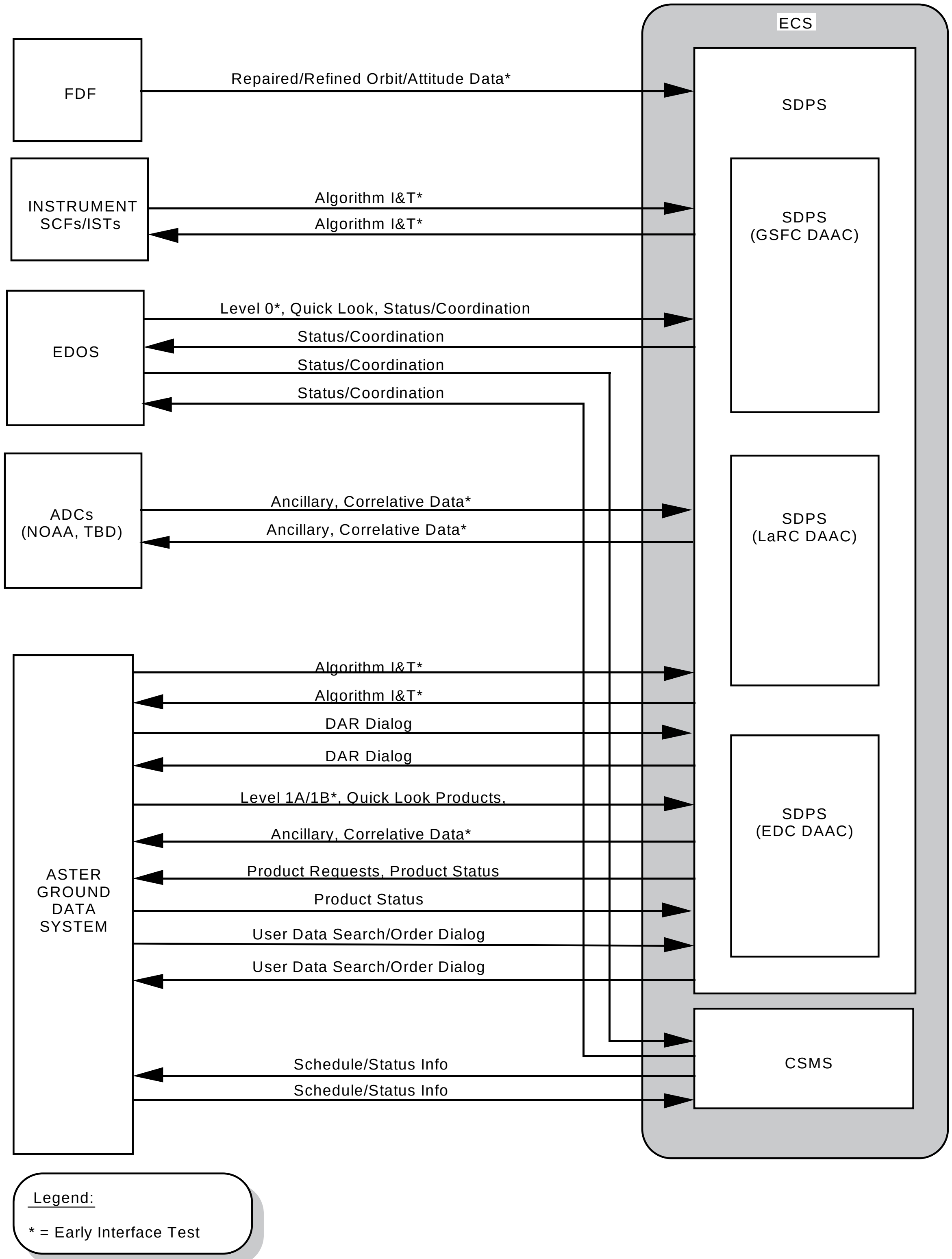

Figure 5-3. DPS/CSMS AM-1 Interfaces

The ground system integration tests require initial mission operations interface support from the FOS beginning with key interface tests part 2. The FOS role in the ESDIS key interface tests part 2 is at a minimal communications level. The total FOS functionality involves the ability to transport a command from the EOC out through ECOM and EDOS to WSC and the JPL DSN, and to ingest telemetry sent from WSC and the JPL DSN, through EDOS and ECOM back at the EOC. The interface testing to support the spacecraft contractor begins at launch - 19 months. This coincides with the delivery of ECS Release A. All FOS functionality needed for the spacecraft and spacecraft bus performance tests, EOC and spacecraft compatibility tests and the thermal vacuum test will be included in Release A. All other spacecraft tests occur after Release B when full FOS AM-1 support functionality will exist.

Similar to FOS, certain SDPS and CSMS functions must be available to support early interface testing per the EOS Ground System Integration Plan. These include science algorithm integration and test support (described more fully in section 5.11), Level 0 ingest from EDOS, and data interfaces with external systems such as the ASTER GDS and the ADCs. Per the plan, the functions supporting these interfaces, marked with an asterisk in Figure 5-2 must be ready starting January 1996.

5.5 Independent Verification and Validation (IV&V) Support

Prior to the Release Readiness Review (RRR), the IV&V contractor can witness and/or monitor release acceptance testing and document nonconformances. Upon successful completion of the RRR, the IV&V contractor verifies that the ECS release operates correctly within the EOS Ground System (EGS). The ECS contractor, specifically the Independent Acceptance Test Organization (IATO), supports the IV&V contractor in this effort following RRR at the operational sites. The ECS M&O contractor coordinates personnel, facilities, and equipment support in the resolution of ECS nonconformances identified during IV&V testing. ECS contractor M&O site personnel also participate in IV&V test activities at operational centers, as available.

5.6 V0/ADC Interoperability

Two-way interoperability involves two different capabilities. First, outgoing interoperability allows users to log into the ECS and access ECS IMS services, including the ability to access non-ECS data products from a site external to ECS directly from the ECS user interface. Second, incoming interoperability allows users, who are logged into a non-ECS site, to access ECS data products directly from the non-ECS user interface, using non-ECS IMS services.

The SOW (page 34) states that interoperability with Version 0 networks and functions is required at the original Release 1. That maps to the proposed Release A (1996). The SOW (pages 34, 38, and 39) states that interoperability with ADCs is required at the original Release A. That also maps to the proposed Release 1. An undetermined number of ADCs are to be integrated, but the Consortium for International Earth Science Information Network (CIESIN) and the University of Wisconsin NOAA site are specifically mentioned. The SOW (page 39) states that additional TBD NOAA data centers and TBD other sites will be made interoperable to the extent practical in Release 2 (maps to Release A) and in Release 4 (Release B) and Release 5 (Release C).

NASA has agreed that interoperability is not reasonable until ECS-unique data holdings are available. That would not occur until ECS integrates with TRMM and other platforms (Release A).

5.7 Science Software Support

The first set of driving dates define hardware installation dependencies. The following hardware installations are required to support the availability requirement:

- I&T hardware at GSFC to support MODIS Version 1 I&T
- I&T hardware at LaRC to support CERES Version 1 I&T and TRMM-CERES Version 1 I&T
- I&T hardware at MSFC to support TRMM-LIS Version 1 I&T
- I&T hardware at EDC to support ASTER and MODIS Version 1 I&T
- I&T hardware at NSIDC to support MODIS Version 1 I&T

Similarly, if new hardware is required for Version 2 algorithms, the hardware installations for a site must be in place several months in advance of an algorithm's Version 2 integration at that site.

In addition, to support full end-to-end testing of the algorithms, ECS infrastructure software (ancillary/auxiliary data ingest and preparation, DAAC-to-DAAC data transfers, Level 0 data validation, algorithm delivery, and algorithm product QA services) must be in place at the end of the Version 2 I&T for each instrument. Version 2 I&T for MODIS (GSFC), CERES (LaRC), MISR (LaRC), MOPITT (LaRC), and MODIS (NSIDC) is scheduled for mid-1997. The tested Version 2 algorithms will be integrated with other ECS components at that time.

PGS toolkit deliveries must be made twelve months prior to the Beta reviews for each AM-1 algorithm and twelve months prior to Version 1 delivery for TRMM algorithms:

- TRMM-CERES and TRMM-LIS Version 1 delivery --end of 1995
- ASTER, MODIS, CERES, MISR, MOPITT Beta reviews --end of 1995

Therefore, major capabilities (e.g. file I/O software, error-handling software, etc.) must be in place to support TRMM and AM-1 by the end of 1994.

5.8 Building from Version 0

Building on Version 0 for Release A implies that the first formal ECS release will be capable of matching (in general) the functionality of Version 0 plus adding some features that Version 0 does not have (i.e. “building on to” (or enhancing) existing Version 0 capabilities). This does not mean that Release A must match every individual function/capability of Version 0. It will be possible (through interoperability) to access some Version 0 functions, without having to make them part of ECS. It does imply, however, that Release A must provide, overall, functionality that is comparable to Version 0, and that it should contain some features important to the user community not accessible through Version 0.

In some cases, Version 0 functions (software, hardware, design, processes and procedures) will be reused in ECS. The exact candidate components will be described in CDRL 206, Version 0 Analysis Report, due at SDR (a draft will be available in late February for review). There are still significant questions about the timing and type of integration (enveloped, shared, interface, reuse) of Version 0 components. These questions will not be answered until the SDR time frame.

In order to build on Version 0, it is critical to have a good understanding of what Version 0 functions/capabilities will be in July of 1994 when it is expected that Version 0 will go into general operations. That understanding has been derived from the Version 0 analysis task that is currently in progress. That task is being performed by a team of ECS engineers, with close cooperation from the ECS DAAC liaison staff and the active participation of each Version 0 DAAC.

The Release Plan White Paper contains a description of the functions/capabilities that ECS will be providing for SDPS and CSMS (The lists includes all major functions, not allocated by Release) and describes corresponding functions/capabilities in Version.

5.9 DAAC Site Integration

The ECS contract will provide support to eight Distributed Active Archive Centers (DAACs). The DAACs are tasked with generating EOS standard data products and carrying out NASA's responsibilities for data archive, distribution and information management. The DAACs serve as the primary user interface to EOSDIS. These DAACs are located at: Goddard Space Flight Center (GSFC) Greenbelt, MD; Langley Research Center (LaRC) Hampton, VA; Oak Ridge National Laboratory (ORNL) Oak Ridge, TN; Marshall Space Flight Center (MSFC) Huntsville, AL; EROS Data Center (EDC) Sioux Falls, SD; National Snow and Ice Data Center (NSIDC) Boulder, CO; Jet Propulsion Laboratory (JPL) Pasadena, CA; and the Alaska Synthetic Aperature Radar Facility.

ECS site integration depends on the following factors: site coordination visits; hardware and software procurement; facility access and beneficial occupancy dates (BODs); Government furnished equipment (GFE) communications installation; hardware and software installation; integration and testing; and site M&O staffing and training.

It is important to recognize the needs of maintenance and operations when planning all releases. The dynamics of the multi-track environment could cause major perturbations at the sites, including the DAACs, and EOC and SMC host organizations. Facility, operations, maintenance, and management considerations will have to be addressed. For example, Release A will provide operational capabilities that are critical to the TRMM and Landsat 7 missions. Positive control of Release A (and subsequent evaluation package and release contents) will be necessary to ensure operational integrity.

ECS objectives for site integration are as follows:

- Minimize impact on existing site operations

- Provide adequate tools and documentation to operate, administer and manage the ECS resources
- Provide site staffing that is compatible with site operations requirements

These objectives are discussed in the following sections.

5.9.1 Impact on DAAC Operations

The EOSDIS DAACs have the mission of processing, archiving and distributing earth science data. ECS provides many of the tools to accomplish this mission, but does not provide the only tools. For example, the EROS Data Center already distributes LANDSAT data using an existing data system. Similarly, the Jet Propulsion Lab DAAC distributes SSM/I and other data sets.

The ECS contractor will schedule a series of site coordination trips to all DAACs. The objective of these trips is to ensure that the ECS contractor and the DAAC managers are in agreement with all operational issues. When ECS starts to deliver its systems to the sites, ECS works with the host organizations to ensure that hardware and software installation and segment and system testing all occur in a pre-planned manner that is sensitive to the mission of the host organization. Coordination topics include facility requirements, locations of ECS equipment and personnel, installation and test periods, etc.

Configuration management of the on-line systems at the sites is also an issue. The capability to control use of software and hardware needs to be addressed. Access to prototypes, evaluation packages, and formal releases will be addressed in Release A planning. The same multi-track development approach is contemplated for future releases to allow user feedback and evaluation during ECS operations.

5.9.2 ECS Tools and Documentation for Operations, System Administration and Management

As responsibility for Release A transitions from the development to maintenance and operations (M&O) , the needs of the M&O personnel to operate, administer and manage the system must be considered. On-line performance monitoring tools are necessary to ensure that the product generation, archival and distribution functions are meeting the Release A requirements. Similarly, performance data collection, analysis and reporting tools are necessary so that the DAAC staff have visibility into ECS performance. Adequate tools must also be available to support CM, fault detection and management, logistics, property control, security and accounting. Adequate M&O documentation must be developed and validated during the operations exercises/rehearsals.

5.9.3 Staffing Issues

Staffing is a major factor in site activation and operations. This staffing includes host organization and ECS personnel. Requirements for personnel and training to operate, administer and maintain the ECS site components are factored into the ECS release plan.

Staffing at each site by the ECS contractor will gradually build up from 1996 on. A Release A that demands excessive manual actions to monitor and control performance, or to collect, analyze and report critical performance parameters will make management, administration, and operations very difficult and not provide a firm foundation for the operational system. It also risks cost increases by requiring that higher qualified individuals (e.g., senior versus junior technicians) be hired.

Adequate training on ECS products is critical because of the potential impact on DAAC operations and user support. Training on COTS hardware and software, and application software, regardless of the development track, is an absolute necessity. If the site's user services are unable to handle issues about an ECS product, additional demands on developers' time will be made to isolate, remedy, or suggest work-arounds to the issues.

5.9.4 COTS Procurement and Installation

Procurement of ECS hardware and software to be installed at ECS sites involves two cycles. Normal COTS procurement cycles are 3.5 to 4 months, while long lead-time procurements vary from 4.5 months to 8.5 months. COTS procurement cycles include requirements analysis, RFP preparation and release, product evaluation and selection, sub-contracting with winning vendor(s), purchase order approval by NASA, release of the purchase order to the vendor, and delivery to the site.

The facility access dates must be at least 2 months prior to the scheduled initial installation date to provide time for site verification inspection, completion Government facility preparations, and receiving of COTS HW and SW. Installations of HW and SW take between 2 and 6 weeks depending on whether the site is an initial installation (requiring LAN installation) and the quantity and complexity of the configurations to be installed.

After installation, staffing and training of the maintenance and operations staff is accomplished. M&O training occurs in conjunction with the 3-month system integration and acceptance testing.

5.10 Release Identification

This section identifies the missions that are supported by each ECS Release and it provides a mapping of the driving requirements/milestones (defined earlier in this section) to ECS Releases. The ECS will be delivered in four Releases (A to D) and an Interim Release (IR-1). The four Releases support the missions shown in Table 5-1 The Interim Release is an early release of the ECS to support early interface testing.

Table 5-1. Release Missions

Release	Mission(s) Supported
Interim Release 1	TRMM, Landsat 7, COLOR, and EOS AM-1 Early Interface Testing
Release A	TRMM, Landsat 7 and COLOR Missions; EOS AM-1 Interface Testing, Data Flow & End-to-End Testing and Simulation Readiness Testing
Release B	EOS AM-1
Release C	AERO, EOS PM-1
Release D	ALT, CHEM

Note that Release A serves the dual purpose of supporting the TRMM, Landsat 7 and COLOR missions and it provides sufficient FOS capability to support EOS AM-1 testing.

A mapping of the driving requirements/milestones identified earlier in this section to the ECS Releases identified above is depicted in Table 5-2. This mapping provides the basis for a detailed mapping of the ECS functional capabilities and services to releases (reference the ECS Release Plan White Paper). Note that several of the driving requirements/milestones are supported by Release A & B. The Data Flow and End-to-End Testing and the Simulation Readiness Testing is supported early-on by Release A, and is supported by Release B during the final phases of testing. V0 interoperability is supported by Release A for GSFC, MSFC, LaRC and EDC DAACs. V0 interoperability for the remaining DAACs is supported by Release A shortly after interoperability is achieved at the GSFC, MSFC, LaRC, and EDC DAACs.

5.11 Releases and ECS Evaluation Packages

A portion of ECS functionality is developed on the Incremental Track and is first deployed to users for evaluation as part of Evaluation Packages (EPs). An EP is a delivery mechanism that provides functional capabilities over a short time period for user evaluation and feedback of suggested improvements in subsequent incremental cycles. A description of the EP process and the identification of planned EPs and their functionality is provided in a white paper entitled "ECS Evaluation Packages Plan; a Process in Support of Evolutionary Development".

The Master Schedule (DID 107/MG1) identifies EPs 1 through 6. Additional EPs will likely be defined to provide functionality required after Release A. The EPs will be integrated with the software on the formal track for IR-1 and Release A, and will go through System I&T prior to the Consent to Ship for the Release. It is generally accepted that EPs will be defined to provide similar evaluations of functionality and feedback for Releases B through D, but their content has not been projected at this time.

Table 5-2. Mapping of Driving Requirements/Milestones to Releases

Driving Requirement/ Milestone	ECS Release
TRMM Support	
- Early Interface Testing	Interim Release 1
- Mission Support/Ground System Testing	Release A
Landsat 7 Support	
-Early Interface Testing	Interim Release 1
- Mission Support/Ground System Testing	Release A
COLOR Support	
- Early Interface Testing	Interim Release 1
- Mission Support/Ground System Testing	Release A
EOS AM-1 Support	
- Early Interface Testing	Interim Release 1 & A
- DF & EE Testing	Releases A&B
- Simulation Readiness Testing	Releases A&B
- Mission Support/Ground System Testing	Release B
V0/ADC Interoperability	
- V0 Interoperability	Release A
- ADC Interoperability	Releases A&B
V0 Leapfrog	
- Cross DAAC Coincident Search	Release A
- Search Using Combinations of Logical Operators	Release A
- Display of Data Timeline	Release A
- Search on Attributes across DAACs & Data Sets	Release A
- Results from Search across DAACs & Data Sets	Release A
- Simultaneous Display of Multiple Browse Data	Release A
- Automated Authentication for Data Distribution	Release A
- Order History Across DAACs	Release A
- Manage Storage System Resource Utilization	Release A
- Generate Accounting Info. for Data Distribution	Release A
- API for Update, Query and DBA Utilities	Release A
- Data Visualization Capabilities	Release A
- On-line User Survey at all Sites	Release A
- Tracking of Specific Data Granules	Release A
- SCF Interface/Access	Release A
- Multiple DAAC Orders	Release A
Science Software Support	
- TRMM Version 1 Algorithm I&T	n/a (Toolkit 5)
- TRMM Version 2 Algorithm I&T	Interim Release 1
- EOS AM-1 Version 1 Algorithm I&T	Interim Release 1
- EOS AM-1 Version 2 Algorithm I&T	Release A

6. Reviews and Documentation

The ECS review process has been defined to allow the ESDIS Project Office, the ECS Science Office, the GSFC COTR, and representatives of the Earth science and V0 operations community to review the evolving ECS design and development at key points and to provide feedback to be incorporated into the design, development, and operations activities. The reviews are essential for risk management and key to the evolutionary design and operations transition processes. Overall system design concepts will be reviewed early in the program and used as the foundation for subsequent design and development reviews for each of the major system releases. The reviews, summarized in Table 6-1, will be held at different levels of detail. Participants for each review will be selected based upon their backgrounds, responsibilities, and abilities to contribute to the subject matter of the particular review. The purpose of these reviews is to:

- Review delivered and accepted capabilities
- Identify the need for changes in the approach to the project
- Establish priorities for the next release
- Review operator and user satisfaction
- Serve as an evolutionary development check point, as well as a risk management technique
- Demonstrate that the next planned release meets system requirements and science objectives
- Demonstrate that compatibility exists among V0 and ECS segments and their elements

The reviews are scheduled to coincide with various activities associated with each phase of the development and operations transition life cycle. Any schedule deviation will be publicized early enough to allow sufficient time for the reviewing community (ESDIS Project Office, operations, science community, etc.) to plan accordingly.

The initial reviews, the Project Management Review (PMR), System Requirements Review (SRR), and System Design Review (SDR), are conducted at the system level, assuring that overall system concepts are reviewed and agreed upon early in the program. These reviews are followed by the Preliminary Design Review (PDR) or an Incremental Design Review (IDR), reviewing the design of each ECS segment. The PDR/IDR is followed by a Critical Design Review (CDR) for each element in the ECS. At each of the descending levels in the review process, from system to segment to element, the scope of the review will narrow to become focused on smaller portions of the ECS, while the discussion material will be more detailed. This is intended to permit complete oversight of the planning, design and implementation at increasing levels of detail. This review approach parallels the traditional SRR, PDR, and CDR reviews used for most large systems with iteration for the multiple releases of ECS.

A primary source of material for each review is the set of documents specified by the Contract Data Requirements List (CDRL) and defined by the Data Item Description (DID). These documents are by-products of the system design and development process and capture the results of the process. In some areas, where the design is evolving, contents of the documents will be tailored for the event that they are supporting. In this case, the initial version of the document will specify when and how the information specified by the DID will be satisfied. The Data Management Office (DMO) maintains the status of all CDRLs, and provides this information to the COTR via the monthly Document Delivery Status Report.

Table 6-1. Review Summary (1 of 3)

Review	Level	Significance	Comments
CRR	Project	Capabilities and Rqmts Review Assessment of EOSDIS annual Project level capabilities and requirements	CRR is conducted to determine if ECS is meeting its objectives and provides evolutionary direction for new or modified requirements. Current information is provided on how ECS supports the EOS mission.
PMR	Project	Program Mgmt Review Formal start of ECS design activities	The PMR is held to ensure a common understanding of how the ECS development effort will be managed.
PSR	Project	Project Status Review Monthly status review	An extension to the PMR, this review provides the mechanism to manage the program resources associated with all other ECS reviews. This review is the forum for timely risk management and possible adjustments to the schedule.
RIR	System	Release Initiation Review Initiates next release cycle	For each release after Release A, a system-level RIR is held to establish the baseline for initiating the next release cycle. This will allow for the incorporation of feedback from prototyping and prior release experience into the development cycle. The RIR for Release A is presented at the SRR.
SRR	System	System Rqmts Review Creation of initial ECS System baseline	The SRR encompasses a complete review of the ECS specification and the EOS/EOSDIS Requirements (Level 2) that drive the specification, it promotes a common understanding between the Project and the Contractor of the capabilities that ECS must provide.
SDR	System	System Design Review Completion of initial ECS system design	The SDR addresses the top-level ECS design. The SDR includes the definition and high-level design of ECS segments and elements, the interfaces between these and the interfaces between these and external systems, facilities, users, operators, etc.
PRR	System	Prototyping Results Review Completion of prototype and its availability for inclusion into design	PRRs are held to publicize results of specific prototyping activities. The PRRs are timed to mesh with the points in the development cycle where information regarding the prototype (or prototypes) will be needed. A PRR is used to reach conclusions concerning incorporation of the prototype into the mainline system development.

Table 6-1. Review Summary (2 of 3)

Review	Level	Significance	Comments
PDR	Seg/Elem	Preliminary Design Review Completion of initial segment level design	PDR is held for each ECS Segment. The PDR addresses the design of the segment-level capabilities and element interfaces through all ECS releases. The PDR also addresses prototyping results and how the results of both Contractor and Government prototyping efforts, studies, and user experience with EOSDIS Version 0 have been incorporated into the ECS design for each respective Segment.
IDR	Seg/Elem	Incremental Design Review Evolution of system and segment design for subsequent releases	IDRs are held to evaluate the segment designs planned for the next increment in the system evolutionary cycle. The IDRs represent updates to the original segment PDRs and add detail related to the next release.
CDR	Seg/Elem	Critical Design Review Element/subsystem ready to begin development	There are a series of CDRs for each element in the ECS, with one CDR for each release. A review will be conducted prior to undertaking final coding of software for each system release. Each CDR addresses detailed element-level design, including such details as Program Design Language (PDL) for key software modules, and element interfaces for the next release.
TRR	Seg/Elem	Test Readiness Review Element/subsystem ready for testing	TRR is conducted at the EDF for each element and/or segment to be tested for each release. The TRR is conducted after the first element/subsystem has been built, the test procedures have been written and the element/subsystem has been prepared for testing. The TRRs involve reviews of the documentation and results of unit testing to ensure that the software and hardware components are ready for integration testing.
ETR	Seg/Elem	Element Test Review Element/segment successfully completed development level testing	ETRs are conducted at the EDF for each element and/or segment following completion of the element-level tests. The reviews shall ensure that elements tested meet segment requirements, that the element is operating properly and is ready for integration into the ECS segment, and that test documentation is complete.
CSR	System	Consent to Ship Review Release ready to transition to site for integration testing	Consent to Ship Review conducted at the EDF at the conclusion of system I&T to determine the readiness to ship the hardware and software from the EDF to the operation site(s) on the basis of satisfactory completion of system I&T, acceptable plans and procedures for installation and checkout, approved CSR CDRL documents, readiness of site(s) to receive equipment and support testing, and satisfactory operational readiness status. Chaired by the ECS COTR.

Table 6-1. Review Summary (3 of 3)

Review	Level	Significance	Comments
RRR	System	Release Readiness Review Release ready for transition to IV&V	Release Readiness Review conducted at the operational test sites at the conclusion of Acceptance Testing to determine the acceptability of the Acceptance Test Results, review the readiness of IV&V test plans, procedures, staff, external participants, operational support elements, and operational readiness planning status. Chaired by ESDIS management.
SORR	Site (s)	Segment Operational Readiness Review Sites ready to begin operations	Segment operational Readiness Review (SORR). SORRs shall be conducted to review the readiness of site operations to receive ECS software for a release. SORR may be held coincident with CSR. Responsibility for review is site management. The review shall focus on functional capabilities, performance and operational characteristics of each segment. The SORR shall concentrate on operational procedures, human interfaces and operational readiness.

Abbreviations and Acronyms

ADC	Affiliated Data Center
ADS	Archive Data Set
ALT	Altimeter
ASCII	American Standard Code for Information Exchange
ASF	Alaska SAR Facility
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer (formerly ITIR)
AVHRR	Advanced Very High Resolution Radiometer
BB	broad band
BOD	Beneficial Occupancy Date
CCR	Commitment, Concurrency, and Recovery protocol; Configuration Change Request
CD	Compact Disk (optical disk)
CDR	Critical Design Review
CDRL	Contract Data Requirements List
CERES	Clouds and Earth's Radiant Energy System
CIESIN	Consortium for International Earth Science Information Network
CLCW	Command Link Control Word
CM	Configuration Management; Corrective Maintenance
COTS	Commercial Off-the-Shelf (hardware or software)
CRR	Capability Requirements Review
CSA	Canada Space Agency; Configuration Status Accounting
CSMS	Communications and Systems Management Segment (ECS)
CSR	Consent to Ship Review
DAAC	Distributed Active Archive Center
DADS	Data Archive and Distribution System (ECS)
DAR	Data Acquisition Request
DBA	Data Base Administrator
DBMS	Data Base Management System

DCE	Distributed Computing Environment
DID	Data Item Description
DME	Distributed Management Environment
DORRAN	Distributed Ordering, Reporting, Researching, and Accounting Network
DSN	Deep Space Network
EAP	EOSDIS Advisory Panel
Ecom	EOS Communications
ECS	EOSDIS Core System
EDC	EROS Data Center
EDF	ECS Development Facility
EDHS	ECS Data Handling System
EDOS	EOS Data and Operations System
EGS	EOS Ground System
E-mail	Electronic mail
EOC	Earth Observation Center (Japan); EOS Operations Center (ECS)
EOS	Earth Observing System
EOS AERO	EOS Aerosol Project
EOS AM	EOS AM Project (morning spacecraft series)
EOS CHEM	EOS Chemistry Project
EOS COLOR	EOS Ocean Color Project
EOSDIS	EOS Data and Information System
EP	Evaluation Package
ESDIS	Earth Science Data and Information System
ESN	EOSDIS Science Network (ECS)
ETR	Element Test Review
FDDI	Fiber Distributed Data Interface
FDF	Flight Dynamics Facility
FOS	Flight Operations Segment (ECS)
FSMS	File and Storage Management System
FSMS	File Storage Management System
GCDIS	Global Change Data and Information System

GFE	Government Furnished Equipment
GOES	Geostationary Operational Environmental Satellite
GSFC	Goddard Space Flight Center
GUI	Graphic User Interface
H/K	Housekeeping
H/W	Hardware
HDF	Hierarchical Data Format
HMI	Human Machine Interface
I/O	Input/Output
I&T	Integration and Test
IATO	Independent Acceptance Test Organization
ICC	Instrument Control Center (ECS)
IDR	Incremental Design Review
IMS	Information Management System (ECS)
IP	International Partner; Internet Protocol
IST	Instrument Support Terminal (ECS)
IV&V	Independent Verification and Validation
JPL	Jet Propulsion Laboratory
LAN	Local Area Network
Landsat	Land Remote-Sensing Satellite
LaRC	Langley Research Center
LIS	Lightning Imaging Sensor
L0-L4	Level Zero through Level 4
LSM	Local System Management (ECS)
LTIP	Long-Term Instrument Plan
LTSP	Long-Term Science Plan
M&O	Maintenance and Operations
MISR	Multi-angle Imaging Spectro-Radiometer
MITI	Ministry of International Trade and Industry (Japan)
MODIS	Moderate Resolution Imaging Spectrometer
MOPITT	Measurements of Pollution in the Troposphere

MSFC	Marshall Space Flight Center
MSU	Mass Storage Unit, Microwave Sounding Unit
NASA	National Aeronautics and Space Administration
Nascom	NASA Communications Network
NASDA	National Space Development Agency (Japan)
NCC	Network Control Center
NESDIS	National Environmental Satellite Data and Information Service
NOAA	National Oceanic and Atmospheric Administration
NSI	NASA Science Internet
NSIDC	National Snow and Ice Data Center
ODC	Other Data Center
OOD	Object Oriented Design
ORNL	Oak Ridge National Laboratory
OSF	Open Systems Foundation
P&S	Planning and Scheduling
Pacor	Packet processor
PB	Petabyte (10^{15})
PDR	Preliminary Design Review
PDS	Planetary Data System; production data set; Platform Data System
PGS	Product Generation System (ECS)
PM	Preventive Maintenance; Program/project Manager
PMR	Program Management Review
PR	Precipitation Radar (TRMM)
PRR	Prototyping Results Review
PSR	Program Status Review
QA	Quality Assurance
Q/L	Quick Look
R/T	Real Time
RAID	Redundant Array of Inexpensive Disks
RFP	Request for Proposal
RID	Review Item Discrepancy

RIR	Release Initiation Review
RRDB	Recommended Requirements Database
RRR	Release Readiness Review
S/C	Spacecraft
S/W	Software
SA	Single Access
SAR	Synthetic Aperture Radar; system architecture review
SCF	Science Computing Facility
SDPS	Science Data Processing Segment
SDR	Software Design Review; System Design Review
SeaWiFS	Sea-Viewing Wide Field-of-View Sensor
SIP	System Integration and Planning
SMC	System Management Center (ECS)
SN	Space Network
SORR	Segment Operational Readiness Review
SOW	Statement of Work
SRR	System Requirements Review
SSM/I	Special Sensor for Microwave/Imaging (DMSP)
TB	Terabyte (10^{12})
TBD	To Be Defined; To Be Determined
TBR	To Be Replaced/resolved/reviewed
TBS	To Be Supplied
Tbyte	Terabyte
TCP/IP	Transmission Control Protocol/Internet Protocol
TGT	TDRSS Ground Terminal
TMI	TRMM Microwave Image
TOVS	TIROS Operational Vertical Sounder
TRMM	Tropical Rainfall Measuring Mission (joint US-Japan)
TRR	Test Readiness Review
TSDIS	TRMM Science Data and Information System
VIRS	Visible Infrared Scanner (TRMM)

V0	Version 0
WAN	Wide Area Network
WSC	White Sands Complex

Glossary

acceptance testing	Verification that is conducted to determine whether a release satisfies its acceptance criteria and that provides the Government with information for determining whether the release should be accepted. Acceptance testing also applies to toolkits, science algorithm integration, and unit-level verification of COTS products.
baseline	Identification and control of the configuration of software (i.e. selected software work products and their descriptions) at given points in time.
Capabilities and Requirements Review (CRR)	Assessment of EOSDIS annual Project level capabilities and requirements. CRR is conducted to determine if ECS is meeting its objectives and provides evolutionary direction for new or modified requirements. Current information is provided on how ECS supports the EOS mission.
Consent to Ship Review (CSR)	Review to determine the readiness of a release for transition to sites for integration testing.
Critical Design Review (CDR)	A detailed review of the element/segment-level design, including such details as program design language (PDL) for key software modules, and element interfaces associated with a release.
Distributed Active Archive Center (DAAC)	An EOSDIS facility which generates, archives, and distributes EOS Standard Products and related information for the duration of the EOS mission. An EOSDIS DAAC is managed by an institution such as a NASA field center or a university, per agreement with NASA. Each DAAC contains functional elements for processing data (the PGS), for archiving and disseminating data (the DADS), and for user services and information management (elements of the IMS). DAAC Sites: EDC -- EROS Data Center ASF -- Alaska SAR Facility LaRC -- Langley Research Center GSFC -- Goddard Space Flight Center JPL -- Jet Propulsion Laboratory MSFC -- Marshall Space Flight Center NSIDC -- National Snow and Ice Data Center

ECS evolutionary development	The process for delivering and evolving ECS functionality through the used of multiple development tracks and delivery mechanisms. Use of development tracks and delivery mechanisms are tailored to the goals of the particular portion of the system of the system, with an overall goal of providing relatively stable portions of the system in comparison to portions which are rapidly adapting to the system's environment.
Element Test Review (ETR)	Determines if development level testing (for each release) has successfully been completed.
formal release	A formal release shall be a system-wide update to the ECS, delivered and tested as a part of the EOSDIS. ECS Releases will represent the ECS portion of EOSDIS Versions. (ECS SOW). Formal releases are the product of the formal development track.
Incremental Design Review (IDR)	Review conducted to evaluate segment designs associated with a release.
incremental development track	A development process distinguished by multiple iterations of requirements, design, and implementation with frequent user evaluations via demonstrations. Documentation and reviews are streamlined. Documentation of non-mission critical is created after development has completed. Each increment is developed with the potential of being integrated into the formal track for a release. The incremental development track has a cycle time between the formal development and prototypes.
independent verification and validation (IV&V)	Verification and validation performed by a contractor or government agency that is not responsible for developing the product or performing the activity being evaluated. IV&V is an activity that is conducted separately from the software development activities governed by the ECS contract.
interim release	The delivery of system capability resulting from early efforts on the formal track development to the customer for testing of EOS functionality prior to an operational version.
Preliminary Design Review (PDR)	PDR is held for each ECS Segment. The PDR addresses the design of the segment-level capabilities and element interfaces through all ECS releases. The PDR also addresses prototyping results and how the results of both Contractor and Government prototyping efforts, studies, and user experience with EOSDIS Version 0 have been incorporated into the ECS design for each respective Segment.
Program Management Review (PMR)	Formal start of ECS design activities. The PMR is held to ensure a common understanding of how the ECS development effort will be managed.

Project Status Review (PSR)	An extension to the PMR, this review provides the mechanism to manage the program resources associated with all other ECS reviews. This review is the forum for timely risk management and possible adjustments to the schedule.
prototype	Prototypes are focused developments of some aspect of the system which may advance evolutionary change. Prototypes may be developed without anticipation of the resulting software being directly included in a formal release. Prototypes are developed on a faster time scale than the incremental and formal development track.
prototyping	The construction of a solution of a design or implementation problem, the feasibility of which needs to be determined as early as possible in order to arrive at a critical decision.
Prototyping Results Review (PRR)	PRRs are held to publicize results of specific prototyping activities. The PRRs are timed to mesh with the points in the development cycle where information regarding the prototype (or prototypes) will be needed. A PRR is used to reach conclusions concerning incorporation of the prototype into the mainline system development.
Release Initiation Review (RIR)	An internal review conducted at the start of the development phase of a release to revisit the requirements and issues associated with that particular release.
Release Readiness Review (RRR)	Conducted at the ECS system level for a GSFC project review team upon completion of release acceptance testing. The IATO leads the RRR to determine, with the GATT and the COTR, if the release is ready to be delivered, installed, and incorporated into the operational system.
Segment Operational Readiness Review (SORR)	SORRs shall be conducted to review the readiness of site operations to receive ECS software for a release. SORR may be held coincident with CSR. Responsibility for review is site management. The review shall focus on functional capabilities, performance and operational characteristics of each segment. The SORR shall concentrate on operational procedures, human interfaces and operational readiness.
System Requirements Review (SRR)	The SRR encompasses a complete review of the ECS specification and the EOS/EOSDIS Requirements (Level 2) that drive the specification, it promotes a common understanding between the Project and the Contractor of the capabilities that ECS must provide.
Test Readiness Review (TRR)	Conducted by the project for each release at the segment and element levels to review the plans for the integration and verification of the subsystems with the elements and the elements with their segments.
thread	A set of operational procedures that implement a function.