9/15/03

Code 580 Rev H

Information Systems Division

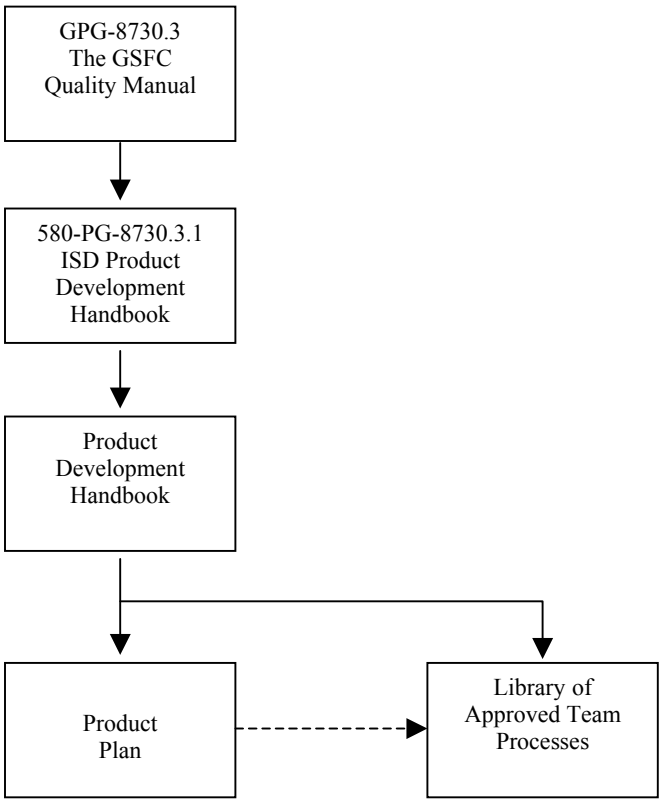
Controlled documentation is available on-line at:
http://isc.gsfc.nasa.gov/ISO9k/pdh/PDH.pdf

It is the user's responsibility to verify that the version of any printed documentation matches the on-line version. This document is referenced by 580-PG-8730.3.1.

Product Development

Handbook

Document Hierarchy



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Approved by: Joseph Hennessy

Chief, Information Systems Division

Preface

The Information Systems Division (ISD) Product Development Handbook is under ISD configuration control. Approved changes to this document should be listed on this page as follows:

Revision	Section	Description of Change
A (3/26/99)	1.1	GSFC Quality Policy, scope now listed by reference to GSFC QMS web page
A (3/26/99)	1.4	Deleted
A (3/26/99)	2.0	Roles & Responsibilities updated to respond to changes in GPGs
A (3/26/99)	3.0	Roles & Responsibilities updated to respond to changes in GPGs
A 3/26/99)	3.1	Clarification of Product Plan scopes
		Updated definition of Quality Planning Document
A (3/26/99)	6.1	Deleted
A (3/26/99)	6.2	Roles & Responsibilities updated to respond to changes in GPGs
A (3/26/99)	6.2	Library Modification Process updated
A (3/26/99)	Appendix B	References to appropriate GPGs added
A (3/26/99)	Appendix C	Team Organization Chart added to Product Plan Table of Contents; GPG references added
A (3/26/99)	Appendix D	Updated Quality Records list and Instructions to respond to GPG changes
A (3/26/99)	Appendix E	Mandatory metrics simplified
A (3/26/99)	Appendix G	Roles & Responsibilities updated to respond to changes in GPGs
A (3/26/99)	Appendix I	Web addresses updated
B (5/12/99)	3.0	Roles & Responsibilities updated to add Statistical Techniques requirements and clarify NCR reporting requirements
B (5/12/99)	Appendix B	Aligned Required Team Process Criteria names with the names used in the Library of Approved Team Processes
B (5/12/99)	Appendix C	Updated to document statistical techniques needs of ISC (5/12/99) Appendix E Mandatory Metrics revised
B(5/12/99)	Appendix G	Added Statistical Techniques Requirements; Clarified NCR reporting Requirements

Revision	Section	Description of Change
C (7/27/99)	All, I	Updated URL references
C (7/27/99)	Title, 1.1	Removed PG number, replaced with revision letter
C (7/27/99)	All	Updated GPG titles and reference numbers
C (7/27/99)	6.1	Updated configuration management process
C (7/27/99)	Appendix A	Added mapping of Product Plan to ISO 9000-3
C (7/27/99)	Appendix C	Updated Product Plan instructions
C(7/27/99)	3.1	Updated customer agreement requirements
D (9/01/99)	All	Updated reference GPGs
D (9/01/99)	Title page	Updated reference PG, added document traceability diagram
D (9/01/99)	All	Updated training requirements for management and Team Lead
D (9/01/99)	Appendices	Reordered all appendices and deleted Appendix F (Customer Involvement Considerations)
E (2/23/00)	Appendix A, B, E	Major revisions
E (2/23/00)	Appendix F	Appendix F deleted, Appendix G, H re-lettered as Appendix F, G, respectively
E (2/23/00)	All	Editorial changes to improve clarity
F (6/15/02)	Cover Sheet	Changed signature approval, corrected GPG references in Document Hierarchy
F (6/15/02)	Change Sheet	Added dates of Revisions
F (6/15/02)	1	Removed Yearly Action Planning Process, System Support Process and change name of Strategic Implementation Process to Strategic Planning Process, changed all references to them, and update figure 1.1
F (6/15/02)	2	Changed wording to add location of “official” and “unofficial” personnel folders
F (6/15/02)	5.4	Update Section 5.4 (new 4.4) to remove GPG 1410.2 reference
F (6/15/02)	4/5/6	Deleted Section 4, Changes sections 5/6 to 4/5 and updated all references to them accordingly
F (6/15/02)	Appendix A	Changed reference in Section 4.2 from GPG 8700.2 to GPG 1410.2
G(2/23/03)	All	Change Information Systems Center to Information Systems Division

G(2/23/03)	Appendices	Relettered Appendices A through G as Appendices C through I, respectively. Added Appendices A and B (Software Development Process and Software Maintenance Process, respectively)
G(2/23/03)	1.2	Added definitions for Appendices A and B
G(2/23/03)	4.2	Changed responsibility for Software Methodology Assessment from Software Engineering Laboratory to GSFC Engineering Process Group (EPG)
H(9/15/03)	Appendices	Add requirement to follow Electrical Engineering Division policies and practices for connecting to flight hardware

Changes or questions concerning this document should be addressed to the ISD/Quality Management System Representative.

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ISD Product Development Handbook

1.0 Scope of Document

This document is intended for use by ISD personnel working with or without contract support to produce a software product for a customer. It does not include services such as consultation or management oversight of contractor development activities. When working for projects being directed outside ISD, ISD personnel and support contractors shall follow that project's processes except as delegated to ISD by the project manager.

1.1 Purpose

This document is intended to serve as a single reference guide which describes the ISD end-to-end processes for providing software products to our customers. These processes are consistent with the GSFC Quality Manual (QM) directive (GPG 8730.3) and Directives and Documentation Management (GPG 1410.1). References to the QM will be shown as "(QM 4-x)" where relevant. Detailed documentation associated with the GSFC Quality Management System (QMS) (for ISO 9001) may be found on the Web at: http://arioch.gsfc.nasa.gov/ISO9000/index.htm

The current versions of this handbook may be found on the Web at the following URL: http://isc.gsfc.nasa.gov/ISO9k/pdh/PDH.pdf

Each version will be dated and will contain a revision letter. Notification of updates will be made via e-mail to all Code 580 personnel and Document Configuration Manager.

1.2 Definitions

- **Build**: A version of a system or component that incorporates a specified subset of the capabilities that the final product will provide.
- **Configuration Management (CM)**: A discipline applying technical and administrative direction and surveillance to: identify and document the functional and physical characteristics of a configuration item; control changes to those characteristics; and record and report change processing and implementation status.
- **Cross-Cutting Activities**: Activities that are performed throughout the life of the project and apply to all phases of a development or maintenance project.
- **Customer**: Any individual, group, or organization that receives and/or pays for a product or service, or arranges to have the product or service provided
- **Design/ Development:** For software, this encompasses all the activities that occur during the design, implementation, and testing of the product prior to validation.
- **Engineering Peer Review (EPR)**: A focused, in-depth technical review that supports the evolving design and development of a product subsystem or lower level of assembly. The purpose of an EPR is to add value and reduce risk through expert knowledge infusion, confirmation of approach, and specific recommendations. An EPR provides a penetrating examination of design, analysis, manufacturing, integration, test and operational details, drawings, processes and data.

- **Functional Specification**: A document that specifies a function that a system or system component must be able to perform.
- **Glue-ware**: Software designed to implement integration of government or commercial off the shelf components into a software system.
- **Integrated Independent Review (IIR)**: One of a series of system level reviews conducted at critical project/product milestones in accordance with GPG 8700.4. IIR's build upon the results of a robust set of EPR's.
- **ISD Management Team**: Includes the ISD Chief, and Associate Chiefs, Assistant for Technology, Institutional Support Manager, Senior Staff Engineers, Senior Administrative Officer, Senior Resource Analyst, Branch Heads and Associate Branch Heads
- **Object Code**: "The output of a code generator (e.g., compiler)... This code may take a variety of forms: an absolute machine-language program, a relocatable machine-language program, an assembly-language program, or perhaps a program in some other programming language." (Aho and Ullman, Principles of Compiler Design, p. 518.)
- **Order**: The description of the product that ISD agrees to deliver to the customer
- **Product**: The output of a project that fills a customer's order
- **Product Development Lead (PDL)**: The manager or leader with overall responsibility for managing the software development activities, including managing the technical and organizational interfaces, and forming and leading the product development team (PDT). For a maintenance project the lead is known as the Product Maintenance Lead (PML).
- **Product Development Team (PDT)**: The team with overall responsibility for the software development activities. This team is equivalent to the QMS Product Design Team. For a maintenance project the team is called a Product Maintenance Team (PMT).
- **Product Manager (PM)**: The individual designated as having management responsibility for a product. A Product Manager may be assigned to any directorate and have a title such as project manager, principal investigator, or RTOP manager
- **Product Plan**: A description of the work to be performed and the resources needed to accomplish the goals and objectives established in the customer agreement (Appendix C)
- **Project**: The set of management, administrative, and technical activities leading to the delivery of a Center product in response to customer requirements and in accordance with Agency and GSFC requirements (see NPG 7120.5A). A Team Lead and Team are formed to assemble and deliver a product that satisfies an order.
- **Qualified Individual**: One who is capable of performing assigned tasks on the basis of appropriate education, training, and/or experience.
- **Release**: A particular version of a configuration item that is made available for use outside the development team.
- **Resources**: Supplies needed to fill the order such as skilled people, money, facilities, etc.

- **Software Library**: A controlled collection of software and related documentation designed to aid in software development, use, or maintenance. (IEEE Std 610.12-1990)
- **Software Management Plan**: A description of the work to be performed and the resources needed to meet a customer's requirements. The Software Management Plan includes the *design planning information* and the *process management information*. It may be gathered together as a single document, consist of multiple documents, or be a portion of a more comprehensive document, such as a Project, Product, Implementation, or equivalent Plans. In the case where the product is the result of a software development or software maintenance, the Software Management Plan is the Product Plan.
- **Team**: One or more qualified individuals assigned to a project, who work at the direction of the Team Lead in filling a customer's order. (This is equivalent to a Product Development Team)
- **Team Lead**: A qualified individual assigned responsibility and given authority to ensure that the Team fills an order (This is equivalent to the Product Development Lead)
- **Validation**: In design and development, validation is the process of examining the product to determine conformity with the user's functional requirements. This includes product inspections, functional and operational tests, and environmental simulations.
- **Verification:** In design and development, verification is the process of examining the design to determine conformity with the documented design requirements. This includes reviewing documentation prior to release, performing alternate evaluations to verify the original analysis, and performing physical tests of hardware and operational tests of software.

ISO 9001 in Brief

An ISO 9001 compliant organization has in place a quality management system that ensures quality is built into each of the processes throughout the organization. This requires that we must:

SAY IT!

Document what we say we are going to do

DO IT!

Exactly as we said we would

PROVE IT!

That we did what we said we would

IMPROVE IT!

That we take every opportunity to make our processes better

1.3 Business Development Process Overview

The overall process, known as the **Business Development Process** (Figure 1.1) is composed of a number of subprocesses, the first of which is the Strategic Implementation Process. The output from the Strategic Planning Process is the Information Systems Division (ISD) Strategic Plan, which is, aligned with the AETD, GSFC and NASA strategic plans. The high level ISD Business process consists of four main subprocesses.

- Strategic Planning Process
- Business Selection Process
- Order Fulfillment Process
- Assessment Process

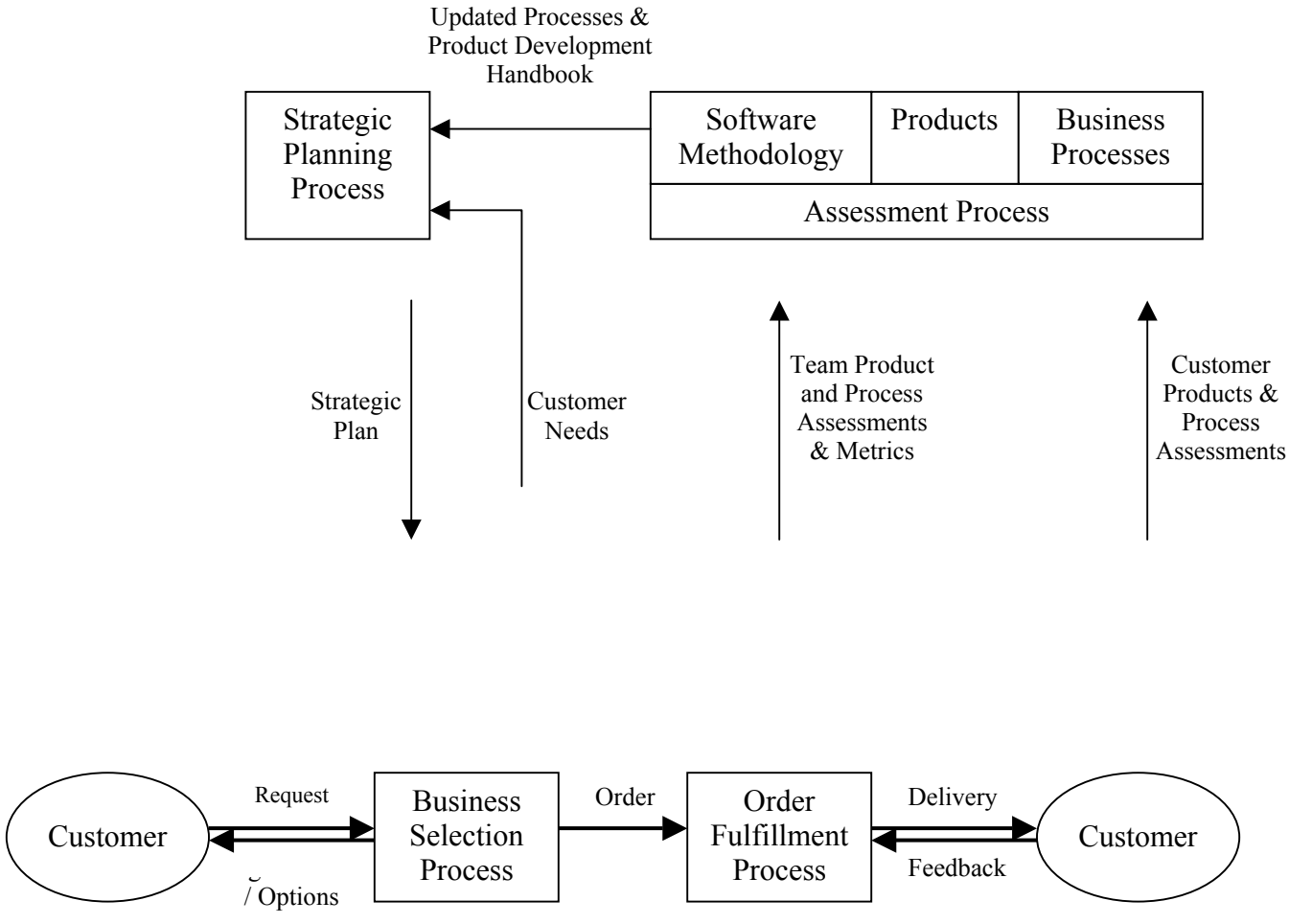

Figure 1.1 Information Systems Division Business Development Process

This document focuses on the processes directly associated with fulfilling a customer's product order.

The **Strategic Planning Process** continuously and systematically reviews and evaluates ISD's mission, vision, and strategic goals; and ISD's success in meeting organizational objectives and customer feedback. Based on analysis, the ISD Management Team determines the organization's future and focus for time, energy and resources. Also, within this process, the ISD Management Team evaluates the organization's progress in meeting the objectives, and assessing the state of ISD's alignment with the NASA and GSFC's strategic objectives. The output from this process is the updated ISD Strategic Plan that may periodically validate the existing plan, or may revise the plan to reflect changes and refinements in the strategic direction. The Strategic Plan may be found on the web at http://isc.gsfc.nasa.gov/Intro/Intro.htm.

The **Business Selection Process** (Section 2) describes the processing of a customer's request, and if accepted, selecting the Team and Team Lead to complete the order. When a customer requests a specific product of ISD, the ISD Management Team determines whether to accept the request by using the Business Selection Process or to present alternatives to the customer. The Business Selection Process also requires logging or recording all customer requests, whether accepted or rejected. Recording the request closes the process loop and serves as feedback into the Strategic Planning Process. If the order is accepted, a Team Lead and Team are selected to work with the customer to provide the requested product using the Order Fulfillment Process.

The **Order Fulfillment Process** (Section 3) describes the processes to produce the requested product, beginning with the logging of an order and continuing through to delivery. This section also details the contents of the Team Product Plan.

The **Assessment Process** (Section 4) is used to evaluate the product development process and the products in order to improve both. The Team provides assessments for Business Process, Software Methodology, and the product. In addition, the customer supplies an independent assessment of the process and product. Appropriate information from this process is used to update the Product Development Handbook and is also used as input to the Strategic Planning Process.

1.4 Operating Structure Overview

- ISD will form a Team to fill ALL customer orders (Note: A Team may consist of one person).
- Product Plans are written for all products covered by this handbook.
- Metrics for both the processes and products shall be collected and analyzed for project management, process improvement, and quality assurance.
- Team progress is evaluated using metrics.
- The customer and the Team agree upon content, formality, and number of reviews.
- ISD Management Team will work with the Team Leads to ensure the product meets the customer's needs.
- The Team Lead has responsibility, accountability, and authority for the quality of the product delivered, and the responsibility to identify issues and concerns to the customer and appropriate ISD Management Team member.

2.0 Business Selection Process

Overview

The ISD Management Team has the primary responsibility for initiating and completing this process which begins with the reception of a request for software from a customer and ends with the selection of a Team Lead and Team to fill the order for those requests accepted (Reference Figure 2.1).

Roles and Responsibilities

Below are listed the roles and responsibilities associated with this process. Team and Team Lead roles have been expanded upon in Appendix E.

ISD Chief

- Ensure a Team Lead is identified.
- Ensure the Team Lead and Team consists of qualified individuals.

ISD Management Team

- Develop individual skills, Team skills and centers of expertise.
- Select and provide qualified Team Leads and Team members.
- Define the Team and Team Leads responsibility, authority and accountability for delivering quality products.
- Document any "required" training needs or On the Job Training (OJT) of employees in accordance with GPG 3410.2.
- Ensures that training received using funds other than GSFC training funds is documented either in the employee's official or unofficial personnel folder.

Team Lead

- Meet with the customer to understand and document the product requested.
- Present to the ISD Management an estimate of the staffing and skill levels, and approximate time commitments required to meet the customer's request.
- Assess the skills and expertise needed. Work with the ISD Management Team to select an appropriate qualified Team to ensure that the individuals are qualified to perform their assigned responsibilities.
- Maintain a list of any "required" training needed and received by team members
- Assign work to Team members.

Location of Employee Qualification Records

- Team Lead and Team members basic qualifications to perform their job derive from their meeting the criteria specified in their Position Description (PD) that are kept in their personnel folders.
- Team Lead and Team members training achievements requested via GSFC training forms are kept in their training records in Office of Human Resources (OHR). All others are kept either in the employee's official (with the Office of Human Resources) or unofficial (with supervisor) personnel folder.
- Team Lead also maintains records of "required" training for Team members.
- For those Team members or Team Leads who are new hires or have been reassigned after 1/4/99, On the Job Training will be documented by the supervisor per GPG 3410.2.
- Specific QMS management and Team Lead requirements related to employee training and qualifications may be found in GPG 3410.2.

Ideal Output of Process Is:

- Clearly defined communication channels
- Full alignment with ISD/GSFC strategic objectives
- Customer satisfaction
- Quick response to request
- Clear, mutual understanding of customer's goals and schedule
- Flexible solution options with clear, unbiased tradeoffs
- Timely, accurate customer profile and needs information for ISD planning purposes

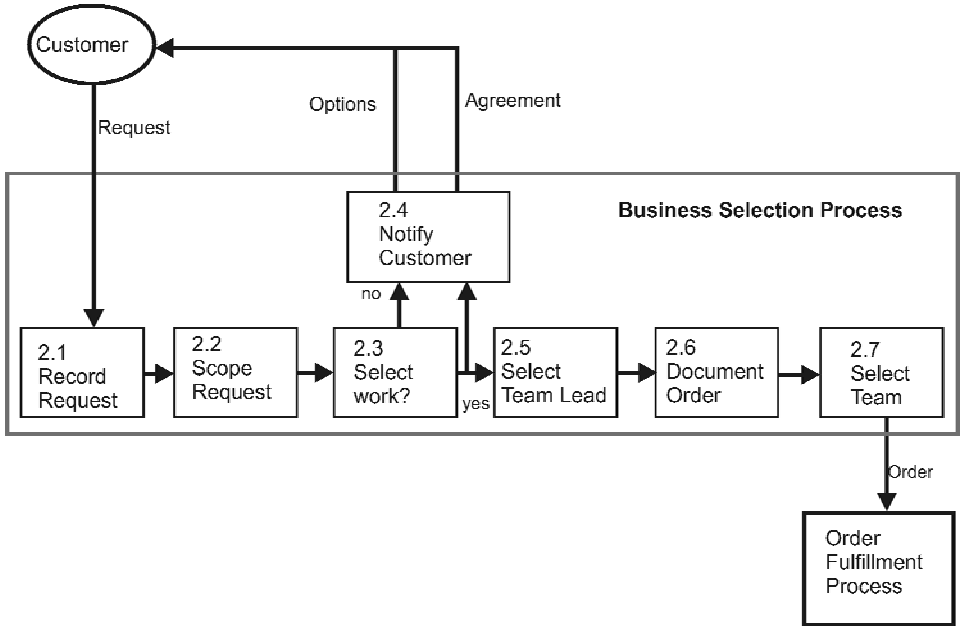

Figure 2.1 Business Selection Process

2.1 Record Request

- Anyone, internal or external to the ISD, may request ISD products. Requests may originate formally, such as through the issuance of Statements Of Work, or informally through conversation and phone calls. Any ISD employee may act as this initial Point of Contact in such requests for products.
- Initial product request documentation and subsequent initial ISD Management notification of such product requests is the responsibility of this initial Point of Contact employee. Documentation may take a range of forms, but generally an e-mail shall be formulated and forwarded to Branch management or higher. Such documentation shall include the name and organization of the individual requesting products, the date of the contact requesting these products, a description of the products requested, any information on schedule, staffing, funding, etc., and any other related information thought useful. In initial discussions the ISD employee shall outline the ISD process and set a target date for ISD follow-up contact back to the product request originator.
- Following Branch/ISD management notification, the ISD Management Team shall select an ISD Point of Contact to iterate and clarify this product request with the originator.

2.2 Scope Request

- The ISD Point of Contact shall further explore the product request with the customer and scope the work being proposed. This may involve the Point of Contact arranging meetings involving other ISD civil servants and/or contractors as appropriate. The Point of Contact shall document customer discussions and agreements in electronic form to serve as a basis for customer review, update, and concurrence.
- The ISD Point of Contact shall work with the customer and the ISD to establish a top-level schedule and to provide a rough estimate of resources (people, money, facilities, etc.) needed to provide the requested products.
- The ISD Point of Contact shall actively involve the ISD Management Team in the resolution of any identified issues, such as questions of feasibility, work appropriateness, resources, etc.

2.3 Select Work

- The ISD Management Team holds the responsibility for agreements to provide customer products.
- The ISD Management Team, supported by the designated ISD Point of Contact, shall decide whether to proceed with the work or reject the work, based on a range of factors, including ISD Strategic Implementation Plan & Yearly Action Plan criteria, request prioritization against other product needs, GSFC mission priorities, available resources, etc. (long sentence)
- The ISD Management Team shall work with the ISD Point of Contact to briefly document the basis for the ISD “Go” or “No Go” decision.

2.4 Notify Customer

- The Point of Contact, and when appropriate, an ISD Management Team representative shall meet with the customer to discuss and affirm the ISD "Go" or "No Go" decision.
- When limitations within the ISD preclude the support desired to develop the requested product, the ISD shall work with the customer at exploring other alternative solutions.

2.5 Select Team Lead

- ISD Management Team shall be responsible for selecting the Team Lead to provide the product requested.
- Depending upon the nature of the support needed, selection may be made through a variety of processes, including Branch level assignment, ISD wide e-mail interest solicitations, or formal personnel actions.
- Customer participation shall be encouraged in the Team Lead selection process.

2.6 Document Order

- The Team Lead shall be responsible for documenting the details of the product request and the general plan for meeting this request in the framework of the Product Plan. Specific Product Plan sections required are: 1.3, 1.4, 1.5, 1.6, 1.11 and 1.12 listed in Appendix C. (The remaining sections of the Product Plan are completed and the plan signed in the Order Fulfillment Process.)
- The order must be a signed Customer Agreement, which should either specify the requirements directly or refer to where the requirements are documented. This agreement could be accomplished by having the customer sign the Product Plan. In formulating this documentation, the Team Lead shall make maximum use of the ISD Point of Contact documentation and knowledge. Efforts in this Order agreement elaboration and negotiation shall involve other ISD employees and contractors as appropriate.

2.7 Select Team

- The Team Lead and ISD Management Team share responsibility in Team staffing.
- Team staffing, as for the Team Lead selection, may be made through a variety of processes, including Branch assignment, ISD-wide e-mail interest solicitations, or formal personnel actions.
- Customer involvement in Team selection is generally more a matter of concurrence than active participation.

3.0 Order Fulfillment Process

Overview

The Team now has the responsibility for completing the Order Fulfillment Process. This process begins with the continuation of detailed communication with the customer to further refine the customer's needs and expectations. These refinements are documented in the Product Plan. This process is followed when the customer desires a tangible product. The quality of the product and the effectiveness of the process is dependent upon the iteration between assembling, building, fielding the product and customer feedback. If the product is a software product or the maintenance of a software product, use the processes for software development or software maintenance in Appendices A and B, respectively. This iterative process is illustrated in Figure 3.0.

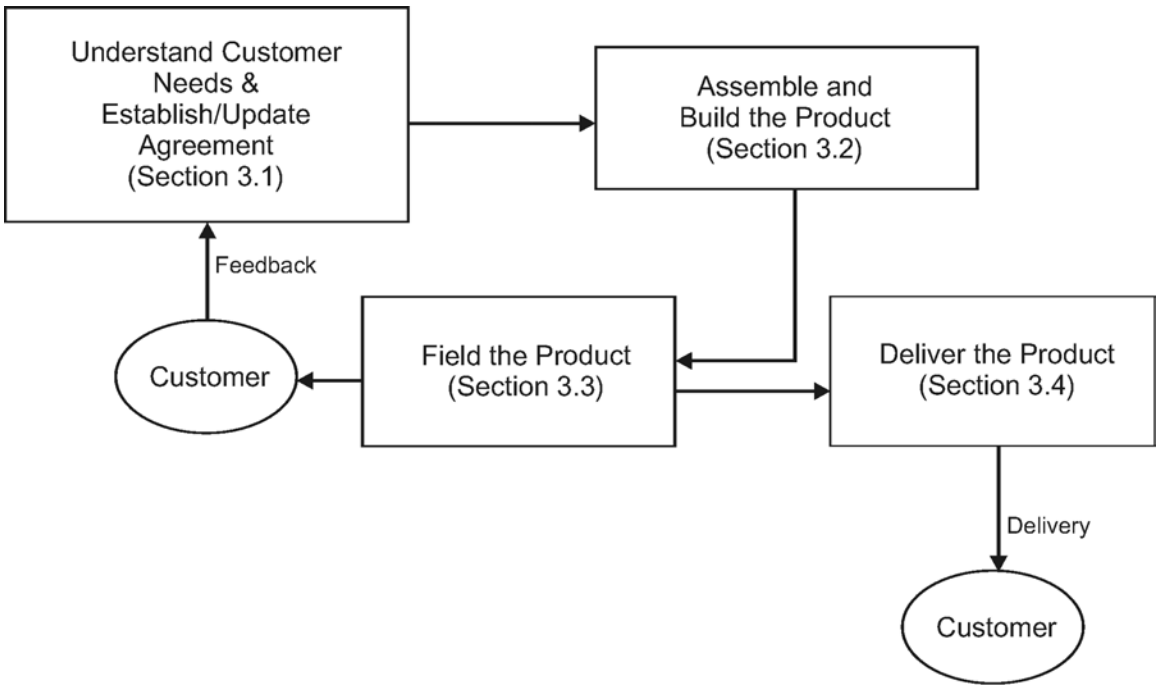

Figure 3.0 The Iterative Process for ISD Product Development

Roles and Responsibilities

Below are listed the roles and responsibilities associated with this process. Team and Team Lead roles have been expanded upon in Appendix E.

ISD Chief

- Designates the ISD Management Team Member responsible for the approval of any Product Plan covered by this handbook. Unless specified otherwise in the Product Plan, this will be the supervisor of the Team Lead.

ISD Management Team

- Ensure that approaches taken by the Team stay aligned with the ISD Strategic Implementation Plan
- Ensure that the Team obtains necessary resources in a timely and effective manner
- Reviews and approves the Team's Product Plan
- Effectively remove barriers which impede a Team's progress
- Ensure and defend the Team's empowerment rights throughout the process
- Document the process for reviewing and changing Product Plans (customer agreements)
- Facilitate support that the Team cannot provide themselves
- Ensure customer inputs for the Team Lead's performance plans and evaluations are made and maintained (appropriate supervisor)
- Ensure Team Lead's inputs for the Team performance plans and evaluations are made and maintained (appropriate supervisor)
- Provide training to Team members as requested by the Team lead
- Document any identified training needs of employees on Performance Plan
- Document any required OJT and "required" training per GPG 3410.2
- Allocate resources as requested by the Team and approved

Available Contracts Data Base Administrator

- Maintain a data base of current contracting mechanisms (hardware, software, manpower) that have demonstrated acceptable performance
- Details of the information and format for this database may be found in the Supplier Performance Records, GPG 5100.2

Team Lead

- Manage the entire customer order fulfillment process from receipt of the initial customer objectives to the final fielding of quality products to the customer
- Document each Team members roles and responsibilities for inclusion in the Product Plan
- Provide performance assessment on Team members as requested by the ISD Management Team
- Report appropriate information to customers and the designated ISD Management Team member in a timely and accessible manner
- Determine and document any training required for Team members and work with the ISD Management Team to ensure that training needs are met and that only qualified people work in producing the product
- Maintain a list of "required" training received by Team members

- Work with the customer and the ISD Management Team to resolve issues and conflicts that are beyond control of the Team
- Identify any internal or external consultants that may be needed
- Identify and request resources that are not directly under the Team's control
- Ensure that the Team maintains a customer focus throughout the process and aligns the Teams goals with the customer's objectives
- Ensure the Team works with the customer to define project guidelines and reflects these guidelines in the Product Plan
- Ensures the success of the Team in meeting customer requirements according to cost and schedule goals
- Provide leadership in developing a cohesive, focused, motivated Team
- Ensure Team personnel are implementing and following through on their responsibilities
- Maintain documentation of key issues and decisions, and, optionally, supporting rationale or information
- Produce and maintain a master list of documentation/information for the project and ensure it remains under Configuration Control. This is to include a:
  - ◊ Product Plan (see Appendix C)
  - ◊ List Of All Processes Used
  - ◊ List Of All Quality Record Types (in format listed in GPG 1440.7, see App. B)
- Identify a Quality Records Custodian whose name will be recorded in the Product Plan and who has responsibility for control of the quality records associated with the Product Plan
- Ensure Team personnel are implementing and following all of their responsibilities
- In addition to the work processes and processes identified above, documents that appear on the master list must be controlled
- Have a design plan and process management plan for your product development. Include these plans in the Product Development Plan.
  - ◊ Identify design verification and validation activities and assure that they are executed and documented
  - ◊ Establish a Team review plan and ensure that all planned reviews are conducted
  - ◊ Document action items as Requests for Action (RFAs) and document responses to RFAs
- Ensure that the Team evaluates the need for statistical techniques required for developing or testing the product as well as the need for any statistical techniques required to analyze the product development process
  - ◊ Document any processes used to implement or control the application of any statistical techniques identified above
- Identify and use a corrective action process
  - ◊ The project corrective action process must address the following: customer complaints, actions resulting from audit findings, and major nonconformances (see GPG 1710.1)

- ◊ Ensure that non-conformances meeting the criteria listed in GPG 1710.1 are documented in the Center on-line NCR/CA database. This shall occur after an initial acceptance tested version release of a system or subsystem to the customer or representative has occurred (accompanied by a release letter). For flight software, this is after initial acceptance testing completion on the flight software test bed.
- ◊ The process must be written and controlled. It must be referenced or detailed in the Product Plan.

- Identify and use a preventive action process
  - ◊ Maintain a Preventive Action List

- Define and use a Configuration Management process
  - ◊ The project must have an explicit, written Configuration Management process. It may be by reference, but it must be explicit and define what items will be controlled, who has authority to make changes, how the status of changes will be handled, and what configuration checking (audit) processes will be used.
- Have a process for reviewing and approving documents
  - ◊ All controlled documents and deliverables must be reviewed and approved. Projects must have a written process for completing this activity for documents controlled by the project.
  - ◊ All controlled documents and data must have evidence that they were reviewed and approved by authorized personnel. Further, changes to these must be reviewed and approved by the same functions/organizations that initially performed the activities.
- Have a written process for uniquely identifying and controlling all products
  - ◊ Develop a system to identify product and track status of work being performed on product and provide a method for s/w that tracks the status of tests planned/test results/and test status by unique s/w version number or build identification and date.
  - ◊ All products must have a unique product identification name or number so that erroneous products or versions are not used by project personnel in work performance
  - ◊ Ensure that tests and inspections to be conducted are documented in test plans
  - ◊ Ensure that status of tests and inspections are documented in test database
- Ensure that test results are documented and that testing does not proceed past a planned test/inspection point until non-conformances have been documented
- Every formal release shall be documented in a written release notice containing the version/release changes, including database changes, the requirements and the nonconformance information
- Have a process for controlling incoming products
  - ◊ Ensure that Receiving Inspection Instructions are prepared for incoming products where applicable and document on Work Order Authorization (WOA) (see GPG 4520.2) using GSFC Receiving Inspection & Test System (RITS)

- ◊ Ensure that Receiving Inspection Instructions are executed and that any non-conformances are documented on WOA and on the appropriate non-conformance form (see GPG 5100.1)

- Provide input for evaluation for Supplier Performance Records (see GPG 5100.1)
- Ensure that test equipment and test software is working properly and maintain records of this verification
- Have a process for controlling and safeguarding any customer-supplied product
  - ◊ Inform the customer and obtain authorization if repair or rework is required of the customer supplied product
  - ◊ Document any damage or malfunction of customer supplied product and report to the customer for disposition of the product
- Ensure that any product requiring handling, storage or shipping is processed according to the GPG 6400.1. Retain shipping records on Form 20-4.

Team

- Defines their mission, vision and objectives based on their customer's objectives and ISD strategic implementation goals
- Identify customer expectations and develop metrics to ensure that those expectations are met quantitatively and qualitatively
- Establish effective communications mechanisms to facilitate the change process and to avoid misunderstandings
- Identify customer supplied resources and information that will be needed for the successful completion of the project
- Record effort and progress in the form of project metrics. Specific metrics are listed in Appendix G.
- Know the GSFC Quality Policy and how it affects products and processes, including Team efficiency
- Know where to find a master document list identifying the acceptable processes for performing the job
- Have an immediate access to all current process required for the job. Relevant process for the job must be written, reviewed, approved (signed by an authorized person), available (you must have access), current (up to date), and followed
- Know how processes used are improved or changed
- Discard or appropriately mark all outdated controlled documents
- Know where project schedules are maintained and what they are
- Know where Team quality records are maintained and be able to produce them
- Know how each unique version of a system or product is identified and controlled
- Know how you are qualified to do your work, how training is offered, and how work assignments are made
- Follow the processes that pertain to your job and maintain appropriate records

3.1 Understand Customer Needs and Establish Agreement

To deliver a quality product the Team must understand the needs and requirements of the customer. To do this, the Team communicates and builds consensus and agrees to the requirements. This agreement must be established, written and updated in the Product Plan. In QMS terminology, the Product Plan *IS THE QUALITY PLANNING DOCUMENT* for producing the product. The table of contents for a Product Plan and salient points are in Appendix C and include the customer agreement, the management approach, the technical approach, and product assurance. The length and level of detail of the Product Plan should be commensurate with the scope and complexity of the project. Updates to the Product Plan follow the same approval cycle as for the original agreement. For software development and maintenance, the Product Plan is the Software Management Plan. See Appendix A, Section 1.1.1.1 and Appendix B, Section 2.1.1.1.

There must be a signed Customer Agreement, which should either specify the requirements directly or refer to where the requirements are documented. This agreement could be accomplished by having the customer sign the Product Plan. The Product Plan should also specify the elements and extent to which the customer's processes are to be used, especially in the areas such as reviews, non-conformance reporting, configuration management, inspection and testing, etc.

3.2 Assemble/Build Product

After producing the Product Plan, the Team begins the process of producing the product according to the Product Plan. The process begins with the Team to determine what organizational assets and information are available to be utilized on the Project. This might include technology assessments, Off-the-Shelf capabilities, lessons learned, etc. The process ends with the release of a product to the customer, whether it is a final delivery or an agreed-upon interim delivery with partial capabilities. For software and software maintenance products, refer to the processes in Appendix A and Appendix B, beginning with Sections 1.2 and 2.2, respectively. The steps for assembling/building a product are illustrated in Figure 3.1.

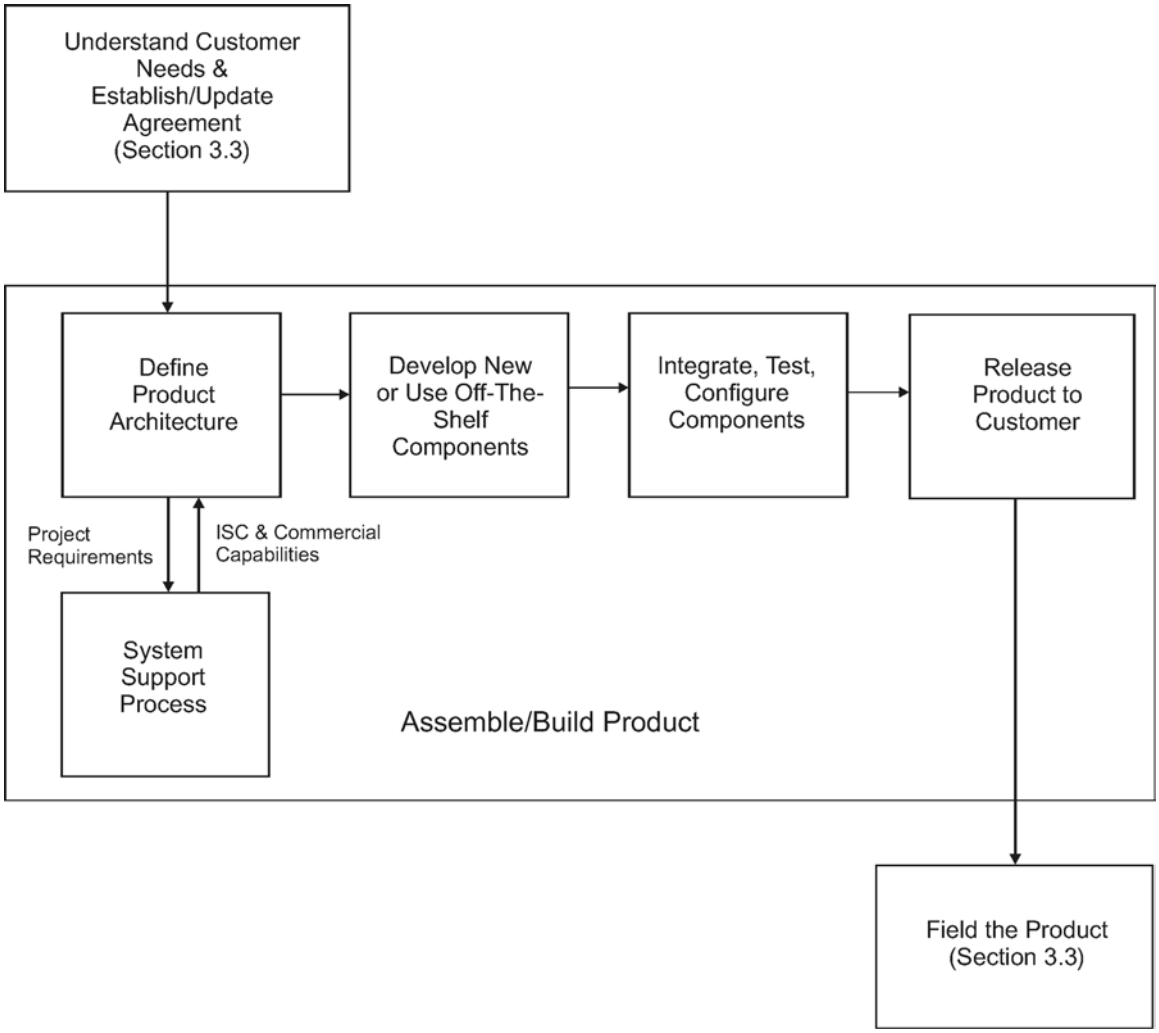

Figure 3.1 The Assemble/Build Process

3.3 Field Product

After building/assembling a release of the product the Team delivers the product according to the Product Plan. Test support is provided, as requested by customer, and might include such things as operational scenarios, special test cases, end-to-end testing, spacecraft integration and test, concurrent release testing, mission readiness testing. After fielding, customer feedback is evaluated. This includes both product and process assessments and metrics collection to be used in improving Team performance. Following this assessment, new agreements are reached as needed, and the process repeats again, beginning with the Understand Customer Needs and Establish Agreement step. The steps for fielding a product are illustrated in Figure 3.2.

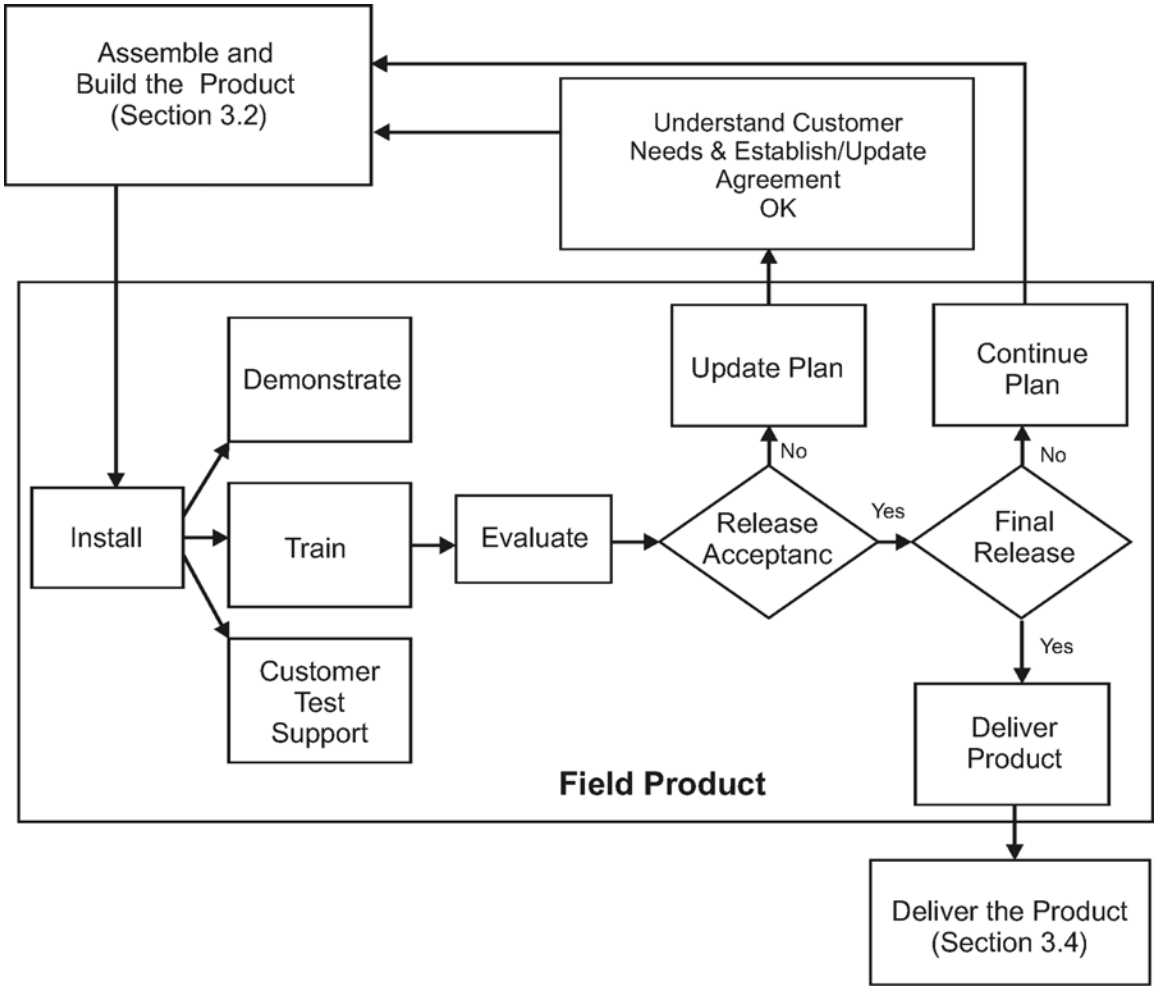

Figure 3.2 Fielding the Product

3.4 Deliver the Product

Once the customer has accepted the final product, any ancillary products specified in the Product Plan are to be delivered to the customer. This also triggers an orderly shut down of the project. Typical elements of the Deliver the Product Process include:

- Delivering final source code, users guide, test materials, and documentation, etc., to the customer
- Packaging appropriate information, quality records, and lessons learned, as available, and moving them to a central storage site
- Closing out contracts
- Closing out resources (money, facilities, and people)
- Transitioning the system to maintenance, as specified in the Product Plan
- Transferring licenses and agreements, as required
- Closing out Team Performance appraisal evaluations
- Celebrating Team success

For software products, see Appendix A, Sections 1.1.1.4-1.1.1.6 and Sections 1.6.1-1.6.2.3.
For maintenance products, see Appendix B, Sections 2.1.1.4 and Sections 2.6.1-2.6.2.3.
The steps for delivering the product are illustrated in Figure 3.3.

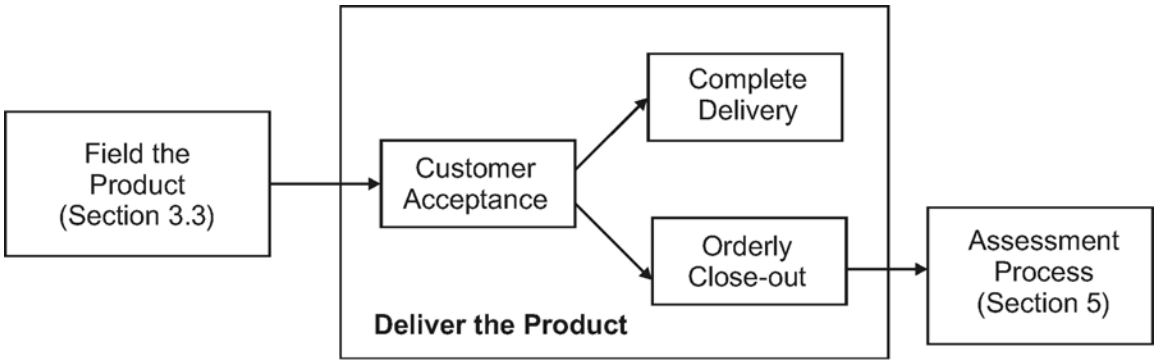

Figure 3.3 Deliver the Product Process

4.0 Assessment Process

Assessments are done continuously throughout the lifecycle of the project, from initial request to closeout. Assessments are made of the Business Process, software process and products, and the product line. These assessments are also used to update the ISD Product Development Handbook as required, and to provide inputs to the Strategic Implementation Planning Process.

Roles and Responsibilities

Below are listed the roles and responsibilities associated with this process.

ISD Chief

- Establish a continuous improvement process for improving the Business Development Process and the Product Development Handbook

ISD Management Team

- Ensure the ISD Quality Manual (i.e., the Product Development Handbook) remains aligned with the GSFC Quality Manual
- Review GSFC Quality Management System for recommended improvements
- Ensure alignment of organization to the ISD Quality Manual
- Define responsibilities and authority for delivering quality products

4.1 Business Process Assessment

ISD Management Team is responsible for assembling a team consisting of selected ISD management and Team Leads, the ISD/Quality Management System Representative, a Software Engineering Laboratory representative. This team:

- Collects feedback routinely from
  - ◊ Teams
  - ◊ Customers
  - ◊ ISD Management Team
  - ◊ ISD/QMS Representative
- Assesses the feedback
- Makes recommendations for improvement
- Solicits comments from all ISD personnel and supporting contractors
  - ◊ via the Web
  - ◊ via e-mail
- Finalizes recommendations to ISD Management Team

- Incorporates approved recommendations into Product Development Handbook and Strategic Implementation Process

4.2 Software Methodology Assessment

The Goddard Space Flight Center Engineering Process Group (EPG), using Team assessments and metrics collected during the project, provides recommendations for improvements to the software development process. The Software Methodology Process uses the following approach:

- Understand, characterize, and document ISD's software processes and products
- Identify candidate process changes, design studies based on ISD's business goals, and understand impacts and changes to the baselined process resulting from the proposed study
- Identify appropriate metrics required for s/w process improvement activities
- Collect, store, quality assure, summarize, and export the ISD's project data
- Analyze the project data to develop and maintain organizational models (e.g., cost estimation models, effort profiles, error profiles)
- Develop and update software engineering standards based on the experiences of the ISD Teams
- Package results and provide derived information in useful forms such as guidebooks, tools, and training courses
- Maintain the ISD's projects database, which contains historical data from the organization's various projects
- Maintain the ISD's library of experience packages, including guidebooks, standards, handbooks, and reports

4.3 Product Line Assessment

The ISD Management Team is responsible for assessing the product line:

- With respect to:
  - ◊ What customers want
  - ◊ The ISD strategic plan
  - ◊ The commercial market
- With respect to the minimum requirements of:
  - ◊ Customer satisfaction
  - ◊ Cost
  - ◊ Schedule
  - ◊ Burden of maintenance
  - ◊ Commercial product availability

4.4 Product Development Handbook Assessment

- Update handbook as required using ISD Configuration Management process

5.0 ISD Crosscutting Processes

This section provides information on three additional processes which are used and controlled at the ISD level (versus Team level). They are not part of the six basic ISD Business Processes, but are used in support of them in a crosscutting manner.

5.1 Configuration Control Process (Items include Quality Records, Documentation, and Data)

Roles and Responsibilities

ISD/QMS Representative

- Represent ISD at the Directorate level in all matters concerning the GSFC Quality Management System and ISO 9001 certification, implementation, and maintenance
- Direct all activities pertaining to the Quality Management System or ISO 9001 within ISD
- Overall responsibility for maintaining the ISD Product Development Handbook
- Review newly developed Team Processes specified in the Product Plan for ISO 9001 compliance
- Overall responsibility for adding/deleting/maintaining the ISD Library of Approved Team Processes

ISD Document Configuration Manager

- Maintains a list of ISD level quality records and configuration controlled items, date or identification number/letter, their locations and their owners
- Obtains approval for deletion of items from controlled list from the ISD Management Team

Process Description

- Quality record, documents, and data which are held and controlled at the ISD Center level are managed by the Document Configuration Manager
- When an individual desires to place a new document under CM that individual request permission via email from the ISD Chief
- Once approved, the ISD Management Team assigns an owner who is responsible for maintaining the history and current version of the item
- A list of all controlled items, their owners, their latest version date and their locations is maintained by the Document Configuration Manager
- The owner is responsible for ensuring that all information under his control is current, legible, readily retrievable and safe from damage/loss

- Deletion of items from the ISD level of control can be made by anyone through the owner to the Document Configuration Manager. The Document Configuration Manager will then request permission from the ISD Management Team and will proceed accordingly.
- The Configuration Control Board for a document is determined by the ISD Management Team, and consists of those people identified on the document signature page and stated accordingly in the document under change control procedures
- Change control authority is determined by the ISD Management Team and is indicated by those people/positions on the signature page of each document
- For items under configuration control requiring updates, the following change control process will be used:
  - ◊ Changes to any item may be submitted by anyone to the owner of the configured item. This shall include an assessment of the cost and schedule impact, and changes required to other configuration controlled items.
  - ◊ The owner shall log the change request and prepare the appropriate document updates
  - ◊ The owner will communicate with other owners affected by the item and any other personnel deemed appropriate in order to negotiate the acceptability of the change
  - ◊ The owner will document the negotiated changes required by any other owners and distribute them to the owners and Document Configuration Manager
  - ◊ Individual owners affected by this change are responsible for updating their respective configuration controlled items to reflect negotiated changes
  - ◊ The owner shall make the appropriate changes in the configuration controlled copy of the document and update the document date
  - ◊ Notification of items that have been updated are to be sent via email to the Document Configuration Manager and to all affected personnel by each owner. The Document Configuration Manager shall retain the email notifications of the document updates.

5.2 Process for Adding, Deleting or Modifying Approved Team Processes in the Library for Use in Product Plans

The Library of Approved Team Processes is maintained on the web at http://isc.gsfc.nasa.gov/ISO9k/ISO9001.htm by the ISD/QMS representative, and is under ISD configuration control.

Roles and Responsibilities

ISD/QMS Representative

- Review newly developed Team Processes specified in the Product Plan
- Overall responsibility for maintaining the ISD Library of Approved Team Processes

Library Modification

- Anyone can make a recommendation for adding, deleting or modifying a reference
- The recommendation should be written up and should include the process to be added, deleted or modified, the name of the process for which it is an alternate (relative to the Product Plan Table of Contents), and a short description of the merits of the approach
- The recommendation should be submitted to the ISD/QMS Representative for an assessment of compliance with QMS (ISO 9001)
- Once approved, the ISD/QMS Representative is responsible for ensuring that the new process is included in the reference library for approved use
- The ISD/QMS Representative shall notify the ISD Document Configuration Manager to update the documentation in the ISD Configuration Controlled Items database
- The ISD/QMS Representative shall notify all of Code 580 and its support contractors of the update via e-mail

Appendix A: Software Development Process

This process description is intended to be used as a starting point in defining the project's technical approach. The activities are not intended to be strictly time sequenced. This allows them to be used to define activities in a variety of project lifecycles. For example, a project that uses an incremental build lifecycle may use the Implementation and Integration activities many times, while a small project with well-known requirements may use the waterfall lifecycle and execute each applicable activity only once. There may be activities that are unique to the project to mitigate special risks or to handle special requirements. These may be added to meet the project's unique needs.

For administrative or institutional software, the responsible Director of may grant waivers to these requirements, using the process described in GPG 8730.3. Note that any software used in any flight or ground system is not considered institutional.

1.1 Cross-Cutting Activities

1.1.1 Team Management

1.1.1.1 Develop a Software Management Plan

The Product Development Lead (PDL) shall develop a Software Management Plan (SMP) using the Software Management Plan Guide in the Attachment to this GPG. GSFC Form 19-21 provides a template for the recommended SMP outline. (Note: When using GSFC Form 19-21, information can be rearranged or supplemented as long as required information is included.) The completed SMP describes the customer requirements and the resources (e.g., budget, schedule, and staffing) allocated to execute the Plan. The Plan defines the approach that will be used to track project status, for configuration management, product assurance, risk management, and independent verification and validation. It also summarizes the technical approach including the review plan, documentation to be produced and the criteria used to tailor this Process for Software Development. Tailoring is determined by the PDL with the concurrence of line management and the customer (typically a project manager or principal investigator).

Tailoring factors include project characteristics such as the criticality of the application, the size of the PDT and user community, the degree of reuse, and other project specific factors. Required activities are designated as "shall" and may not be deleted. Best practices from past experience are designated as “recommended” and should be thoughtfully considered for adoption by the PDL.

GPG 8700.4 and GPG 8700.6 define the procedures and guidelines for required mission-level reviews and their applicability. The software PDT participates in, or contributes material to, required mission-level Project or Program reviews (e.g. EPR's or IIR's), as required.

The PDL shall define, with the participation of line management, Product Manager, and the customer, an appropriate set of reviews as a resource to increase the probability of

success. Reviews may be combined to improve value or efficiency. However, when reviews are combined, review objectives from each shall be addressed to the level of detail required for the individual reviews. The following reviews for software development projects should be considered:

- Software System Concept Review (SCR)
- Software System Requirements Review (SRR)
- Software Specification Review (SSR)*
- Preliminary Design Review (PDR)*
- Critical Design Review (CDR)
- Acceptance Test Readiness Review (ATRR)
- Operational Readiness Review (ORR)*

* **Required for all projects**

All software PDT reviews, above, shall:

- Be scheduled with published agendas.
- Have a review team chair and other members with appropriate expertise that are independent of the PDT, project and immediate line management
- Include customer representatives
- Record meeting notes
- Collect Requests for Action (RFA's)
- Record and track RFA's to resolution with the independent review team.
- Report results to the Project Manager and the Code 301 Integrated Review (System Review) Team Chair in the case of an activity that is part of a larger system.

1.1.1.2 Manage the Task

The PDL negotiates project-staffing assignments, assigns technical work to staff members, and helps assure that all PDT members are qualified to perform their assigned duties. The PDL is also responsible for the day-to-day management of the task according to the SMP. The PDL shall periodically review, record and report the status of system design, development, implementation, and testing using the methods defined in the SMP. It is recommended that project status be an objective measure of work products accomplished against planned resource allocation (e.g., schedule, cost and effort).

1.1.1.3 Collect Metrics

Project metrics, at a minimum, shall include schedule planned vs. actual dates, budget (effort and cost), product size, and product error information, such as open/closed nonconformances (i.e., discrepancy reports), and shall be collected periodically (e.g., monthly or quarterly) as defined in the SMP. Project metrics are analyzed and the results used to initiate process improvement activities.

1.1.1.4 Document Lessons Learned

The PDL shall query the NASA Lessons Learned Information System (which is maintained at http://llis.nasa.gov) and other knowledge resources, as appropriate, to access relevant past experiences and knowledge that can be leveraged to reduce risk, improve quality and efficiency. These queries shall be conducted at the beginning of, and then periodically throughout, the software development lifecycle. The PDL shall also submit significant lessons learned to the web-based LLIS throughout the product lifecycle, as appropriate.

It is recommended that lessons learned be documented at the end of each phase in a Software Development History. The Software Development History is updated to include lists of the products produced, milestones and key events, phase duration, key decisions, problems encountered, and summaries of the metrics collected during the phase. It describes the specific lessons and recommendations that pinpoint the major strengths and weaknesses of the process used and the product itself, with particular attention to planning, requirements, development, testing, CM, QA, and new technology.

1.1.1.5 Prepare and Maintain Project Documentation

The PDT shall design, prepare, and maintain the documents as specified in the SMP and consistent with higher-level Project requirements. The PDT ensures that each document is reviewed, that the changes identified during the review are properly implemented and that appropriate approval signatures are obtained. Well in advance of delivery, the PDT shall complete GSFC Form 1679, "New Technology Report;" this form allows the commercialization office to make an assessment of the software before delivery. It is important not to wait until delivery to complete this form, so that the software may be released in a timely fashion.

1.1.1.6 Transition to Maintenance Organization

At the conclusion of the project the completed system may be transitioned to the internal or external customer, or another organization, for ongoing operations and maintenance. To protect Government-owned intellectual property, this transition should take place in accordance with the provisions of NPD/NPG 2210.1 where applicable (see section 1.6 below). If such a transition occurs, the PDT shall perform training and maintenance activities as defined in the SMP and shall prepare the system and documentation for final delivery. Configuration management, quality assurance and delivery activities are performed as for delivery of a build/release. Project records are to be stored, transferred or disposed of according to the SMP and NPG 1441.1C.

1.1.2 Training

1.1.2.1 Identify and Document Required Training Needs

The PDL shall identify and document the QMS-required training needed by PDT members. Required training includes familiarizing PDT members with the SMP, the methodology, standards, and design process used, maintenance of PDT records, and use of a nonconformance recording system. It also includes training required when working

in proximity to instruments or spacecraft, such as Electrostatic Discharge Awareness Training, Range or Launch Safety, Laser Safety, etc. The PDL works with the appropriate supervisors to assure that the identified training is provided. It is recommended that the PDL identify any special developmental training such as language and tool training, and identify on-the-job-training to build an adequate level of understanding in all PDT members

1.1.2.2 Record Training Received

As PDT members obtain training, the PDL shall maintain records of the training that has been received and by whom (see GPG 3410.2).

1.1.3 Configuration Management (See GPG 1410.2)

1.1.3.1 Perform Configuration Identification

The PDT shall identify, in the SMP, the types of items to be placed under configuration control and shall identify when they will be placed under configuration control. Items that are to be controlled at the higher-level Project shall be identified. The PDT defines baselines for major stages in system development, e.g., requirements baseline, design baseline. The PDT identifies the products comprising each baseline, down to the level of the smallest controllable unit. The PDT shall develop a unique identification for each planned system build/release and delivery. The PDT defines naming and labeling conventions as appropriate. It is recommended that the PDT clearly identify reused software components and that the identification scheme distinguish software components that have been modified from those that are being reused without modification.

1.1.3.2 Maintain Configuration Control

The PDT shall preserve the integrity of all system baselines, components, and products that are not under higher-level Project control. The PDT shall track changes to controlled products to assure that the configuration of all identified items is known at all times. Controlled products include system baselines, project documents (requirements, design, test plans, etc.), source code, object code, released and developmental versions of the target system, critical test software and any customer-provided product (e.g., government off the shelf [GOTS]) used in the development of the software system. The use of a commercial configuration management tool is recommended for configuration control of the project's permanent source code libraries. The PDT shall maintain records of all software configuration management activities performed, including all changes made to software and documents under configuration control.

1.1.3.3 Monitor and Report Configuration Status

It is recommended that the PDT periodically produce configuration status reports. These reports typically include such information as the number of changes made to date, the reason for each change, the number of system releases to date, the functionality provided with each release, and the latest version and revision identifiers. It is recommended that

the first configuration status report list configuration items for any components that are to be reused. This report is reviewed against design documentation and configuration records from the system that is the source of the software to be reused to ensure that all components are accounted for and of the proper version.

1.1.4 Quality Assurance

1.1.4.1 Support Project Reviews, Walkthroughs, and Inspections

Quality reviews address completeness, readability, traceability, and conformance to PDT standards. They assess both the quality of the product (the deliverable under review) and the quality of the process (the way the review is conducted, including planning, announcement, preparation, conduct, and follow-up). Problem areas are identified and appropriate corrections suggested. Although quality is a shared responsibility, it is recommended that the responsibility for advocating and assessing the quality assurance process be centralized in a single individual. It is recommended that product quality be addressed during all major reviews (requirements reviews, design reviews, etc.). It is recommended that quality also be addressed during in-process reviews (walkthroughs, inspections, test reviews, etc.). It is recommended that inspection criteria for any customer-provided product (e.g., GOTS) used by the PDT be established in conjunction with the customer. Results of all reviews and inspections, including those of incoming customer-supplied products, shall be documented.

1.1.4.2 Review Project Deliverables

It is recommended that all major project deliverables (documents, software releases, presentations, etc.) be reviewed for quality. It is recommended that a sample of minor deliverables (unit designs, unit code, test plans and results, etc.) be reviewed for quality.

1.1.4.3 Monitor and Manage Risk

The Risk Management process is identified in the SMP. Risks shall be continuously identified, analyzed, planned, tracked, controlled, communicated and documented. A detailed discussion of the NASA process and resources for Continuous Risk Management is found in NPG 7120.5 “NASA Program and Project Management Processes and Requirements.”

1.1.4.4 Monitor and Support Problem Identification and Corrective Action

The PDT shall employ and follow a problem identification and corrective action process consistent with the Goddard requirements. If a minor Nonconformance Reporting /Corrective Action (NCR/CA) system is used it should include the version or release number where the problem was found and, ideally, the version number that includes the corrections. The PDT shall record the number and severity of defects and nonconformances and the corresponding corrective and preventive actions; this information is used for process improvement. The PDT shall identify and segregate any

nonconforming builds/releases, or deliveries. When, with customer concurrence, software is delivered with known nonconformances, the release letter clearly identifies the nonconformances. Software with nonconformances that has not been approved for delivery is identified and maintained separately so that it is not inadvertently included in a delivered product. The PDT shall document any nonconformances for customer-supplied products (e.g., GOTS). After product delivery major nonconformances which meet the criteria specified in GPG 1710.1 shall be recorded in the in the Center NCR/CA system.

1.1.4.5 Control Documents and Records

The PDT shall control all of the records identified in the SMP. The PDT shall document and implement a process for the identification, review, approval, distribution, retention, and disposition of documents and records.

1.1.4.6 Perform Configuration Audits

Prior to each release or delivery, it is recommended that an audit of the software be performed. The audit verifies that every delivery item (e.g., program, input file, test software, or document) is as reported in the delivery documentation and release letter. Each item on the delivery list is checked to ensure that the item is present, is complete, is the correct version, is in the specified delivery format, and is correctly identified. (Additional requirements apply for external releases or deliveries; refer to 1.6.1 for additional information.)

1.1.4.7 Support IV&V Activities as Required

The PDL shall provide support to the Project for the submission of the IV&V criteria information listed at http://swmetrics.nasa.gov/ivvcrit/. If it is determined that the project requires IV&V support, the PDT shall provide the required support to the IV&V facility for these activities throughout the life of the project.

1.1.4.8 Comply with Specific Electrical Engineering Division and Project Requirements for Connecting to Flight Hardware

The ISD PDL shall insure that any ISD non-flight device connecting to flight hardware shall be developed and maintained in compliance with the Electrical Engineering Division (EED) and any specific Project policies and practices (MASIS for HST, for example). The PDL shall also insure that all civil servants and support contract staff equipment interfacing with flight elements for purposes of software/firmware debug and update comply with EED and specific Project direction.

1.2 Requirements Activities

1.2.1 Software/System Concept Definition

1.2.1.1 Develop a System, Software and Operations Concept

It is recommended that the PDT develop system, software and operation concepts if they do not already exist. In performing this activity the PDT formulates overall concepts for the system and the software by examining customer needs, looking for similarities in previous missions or systems, and identifying existing software, including commercial off the shelf (COTS) or GOTS that could be used or reused. The system and software concepts take the form of a high-level conceptual architecture. Operations concepts take the form of scenarios that show how users operate the system for each major operational mode.

Where software is to be reused this activity makes use of existing documentation. Where the architecture is reused and a significant portion of the code is planned for reuse, a goal of this activity is to understand the similarities and differences between the system to be reused and the new system. The PDT validates the software concept of the system selected for reuse against customer needs. COTS/GOTS in the existing system are reviewed for continued suitability. Where gaps, unneeded elements, and areas requiring significant modification are identified the PDT looks for additional compatible existing software from other sources, including COTS/GOTS that could be used or reused. Effort is concentrated on functionality that is not met by the system to be reused and areas where significant changes are anticipated.

1.2.1.2 Hold a Software System Concept Review

It is recommended that the PDT hold a SCR, or participate in a higher-level Project SCR. The purpose of the SCR is to bring together experts independent of the PDT, project and immediate line management, customers and other interested parties to examine and influence the proposed system and operations concept before detailed requirements are written. If the SCR is held, the PDL shall collect RFA's and shall track RFA responses and resolutions.

SCR Topics:

- Top level requirements (e.g., customer needs, problem description, higher-level Project requirements, anticipated software safety requirements)
- High level, "ideal," architecture, identification of components to be reused
- Identification of major external interfaces
- Operations concepts for major modes of operation

For a system with significant reuse, and where both the PDT and the customers have experience with the system to be reused, it is recommended that the focus of the review be on similarities and differences between the system planned for reuse and the target system. The review helps to determine if the gaps have been properly identified and addressed.

1.2.2 Requirements Definition

1.2.2.1 Define and Document High-Level Requirements

If the customer has not provided high-level functional/operational requirements, the PDT shall define and document the high-level requirements based on the system concept. The PDT works with the customer to define the system and high-level requirements and to derive requirements down to the subsystem (or equivalent) level. The PDT defines internal and external software interfaces, and determines performance and reliability requirements.

1.2.2.2 Conduct a Software System Requirements Review

It is recommended that the PDT hold a SRR or participate in or contribute to a higher-level Project SRR**.** At the SRR the high-level requirements and specifications are presented (subject to appropriate non-disclosure agreements) to experts independent of the PDT, project and immediate line management, customers, users, and other interested parties (e.g., managers and subject area experts). If the SRR is held, the PDL shall collect RFA's that result from the SRR and track RFA responses and resolutions. The PDT incorporates feedback from the review into the requirements document(s) and places the documents under configuration management. If the high-level requirements have been provided, the SRR serves as a forum for the PDT to demonstrate its understanding of the requirements and to identify any TBD's.

SRR Topics

- Detailed review of requirements, concentrating on critical requirements, including software safety requirements
- Traceability of requirements to customer source documents
- Performance, interface and derived requirements.
- Identify risks, TBD's and required resolution dates

1.2.2.3 Analyze Requirements for Omissions, Contradictions and Clarifications

The PDT shall analyze the high-level requirements. Conflicting, ambiguous and infeasible requirements are identified. The PDT classifies each requirement into one or more categories such as, "mandatory", "needs clarification," "information only," etc. Use of the Automated Requirements Measurement (ARM) Tool developed by the Software Assurance Technology Center is recommended. More information about the tool can be found at http://satc.gsfc.nasa.gov/tools/arm/index.html.

1.2.2.4 Derive and Document Detailed Requirements and Specifications

The PDT uses appropriate requirements analysis techniques (e.g., object-oriented or functional decomposition techniques) to analyze the requirements. At this stage, the PDT focuses on what the software needs to do rather than how to do it. Software operations concepts are refined to a more detailed level and reports, displays, etc. are defined. The

PDT shall identify and document detailed requirements and specifications by identifying the primary input types and formats, and output products needed to satisfy the requirements. The PDT shall produce a detailed specification of the technical requirements for the software product. The form and media for the specification are at the discretion of the PDL. Good requirements are clear, complete, consistent, testable, and traceable to customer requirements. The PDT shall document software/hardware interfaces and interfaces among subsystems developed by different teams in interface control documents (ICD's) as needed (e.g., telemetry formats).

1.2.2.5 Conduct a Software Specifications Review (a.k.a. Software Requirements Review)

The PDT shall conduct a SSR to present the detailed software requirements, specifications and operations concepts presented (subject to appropriate non-disclosure agreements) to experts independent of the PDT, project and immediate line management, customers, users, and other interested parties. The PDL shall collect the RFA's that result from the SSR and track RFA responses and resolutions. The PDT incorporates feedback from the review into the requirements, interface and related documents.

SSR Topics:

- Detailed software requirements
- Software operations concepts
- Selection of COTS components
- Allocation of requirements to components to be reused and/or COTS or GOTS components
- Hardware that may need to be built
- Traceability of detailed requirements to high-level requirements
- Definition of data in external interfaces
- Definition of data transformations
- Initial allocation of requirements to builds (i.e., build plan)
- Risks and prototype plans or results
- Safety critical issues
- External Dependencies
- Identification of TBD's and required resolution dates

For projects where there is extensive reuse, the SSR concentrates on the new and modified components. Details of requirements for the components to be reused without modification are presented in enough detail to provide context.

1.2.2.6 Obtain Customer Concurrence on Requirements

The PDT shall obtain customer concurrence on the requirements. This is often achieved through a formal review, such as an SSR, and includes resolution of RFA's generated by the review. Alternative means of achieving concurrence include a document review and approval cycle or a series of requirements walkthroughs where comments are recorded

and incorporated as appropriate. When customer concurrence is achieved the resulting requirements shall be placed under configuration control.

1.2.3 COTS/GOTS Evaluation and Selection (where applicable)

1.2.3.1 Validate Existing COTS/GOTS Selections

For projects with extensive reuse, it is recommended that COTS or GOTS components be validated to determine if they adequately meet the requirements of the new system. In some cases only upgrades or new versions are needed.

1.2.3.2 Determine the Selection Criteria for COTS/GOTS

The PDT shall identify and document, as a matrix or checklist, the attributes that will be used to evaluate potential COTS/GOTS for use in the system. Appropriate criteria include: the degree to which the COTS/GOTS provides required functionality; the estimated total cost of using and maintaining the product vs. the cost of developing and maintaining the same functionality over the full life cycle; the familiarity of the PDT with the product and the cost of the learning curve; and vendor considerations such as stability and customer support.

1.2.3.3 Identify Potential COTS/GOTS Candidates

It is recommended that the PDT select a small number of COTS/GOTS candidates for in-depth evaluation. Identification is accomplished using vendor documentation, industry review and ratings, and previous experience. (Note that in most cases, open competitive procurement of COTS products is required. See GPG 5100.1 for additional information on procurements.)

1.2.3.4 Obtain Demo Versions and Evaluate the Candidate COTS/GOTS

It is recommended that the PDT obtain evaluation versions of candidate COTS/GOTS**.** The PDT works with vendors to obtain demo versions of candidate products. If demo versions are not available, the PDT works with the vendor to understand how the product meets the project needs. The PDT uses the selection criteria to evaluate the candidates.

1.2.3.5 Document the Selection Criteria and Evaluation Results

For each product that is evaluated, the PDT shall document the results of the evaluation against the selection criteria. The results of the evaluation and selection are reported at the SSR. The report provides a record that shows the key factors in the evaluation and provides insight into the decision-making.

1.2.3.6 Document the Risks Associated With the Use of the Selected COTS/GOTS

It is recommended that the COTS evaluation identify potential risks (cost, schedule, reliability, etc.) posed by the selected COTS/GOTS components. Acceptable risk thresholds and mitigation strategies are identified.

1.3 Design Activities

1.3.1 Procurement

1.3.1.1 Procure and Install Hardware, Software, and Firmware in the Development Environment

The PDT procures and installs hardware and COTS/GOTS in the development environment. It is recommended that any software that will be reused be obtained and installed in the development environment. Software to be reused shall be placed under configuration management when it is installed in the development environment. These efforts often extend into implementation.

1.3.2 Prototyping

1.3.2.1 Perform Prototyping to Reduce Risks

It is recommended that the PDT develop prototypes to mitigate risks such as requirements uncertainty, new hardware, a new development language or environment, or stringent performance requirements. Prototypes to resolve requirements uncertainty often take the form of functional user interface mockups and occur in parallel with requirements definition through to implementation. Prototypes involving COTS/GOTS to evaluate their ability to meet functional requirements may occur in parallel with requirements analysis. Prototypes to investigate performance risks or to evaluate new technology often occur in parallel with design activities.

1.3.2.2 Document the Prototyping Effort

If the prototype is large or lengthy or if the risks under investigation are significant it is recommended that planning, development, and management of the prototype be documented in a prototype plan. A prototype plan describes the purpose and goals of the prototype, the resources allocated to the prototype, and the prototyping method and procedures. It is recommended that the results of the prototype be documented in an update to the prototype plan.

1.3.3 Preliminary Design

1.3.3.1 Refine Operational Scenarios

Operations concepts or operational scenarios are received from a higher-level Project or are developed as part of system concept definition. It is recommended that operational scenarios be refined or developed from operations concepts. Additional detail and clarifications are added. Scenarios are decomposed into lower levels of detail. Screen layouts and report formats are defined, as are preliminary interface dialogs for both human-computer interfaces (HCI) and systems interfaces.

1.3.3.2 Perform Performance Modeling

If the system has performance requirements that are anticipated to be difficult to meet, it is recommended that performance sizing/modeling/measurement be performed.

1.3.3.3 Prepare High-level Architecture Diagrams

The purpose of preliminary design is to define the high-level architecture that best satisfies the requirements and specifications. The PDT uses appropriate analysis techniques (e.g., object-oriented techniques or functional decomposition) to analyze the requirements. The PDT evaluates design options, weighing choices according to system priorities, such as performance, usability, reliability, or maintainability. The PDT shall generate high-level diagrams of the selected architecture, including any COTS/GOTS and glue-ware. The PDT pays special attention to interfaces among COTS/GOTS and custom software elements.

For high-reuse projects the PDT starts with the high-level architecture of the system to be reused. If there is not adequate high-level design documentation for the system to be reused it is recommended that the PDT create this documentation.

1.3.3.4 Design and Document High-level Functions and Specifications

The PDT shall design and document the principal, or critical, modules in the system. The PDT selects an appropriate analysis and documentation approach to accomplish this (e.g., use cases and package specifications, or prologs and program design language). The PDT prepares specifications for the principal components in the system. For projects with extensive reuse the PDT starts with high-level functions and specifications of the system to be reused, reviewing them to ensure that the requirements of the new system are adequately met. Modifications are made as required and new functions and specifications are developed to meet new requirements.

1.3.3.5 Verify the High-level Design

The PDT shall verify the high-level design. The PDT shall document the procedures it uses for this purpose. Appropriate verification activities include walkthroughs and/or PDT level inspections of the high-level design documentation (e.g., design diagrams, use cases, package specifications, etc.). Follow up actions shall be documented and tracked to closure.

1.3.3.6 Conduct a Preliminary Design Review

The PDT shall hold a PDR to present the system design (subject to appropriate non-disclosure agreements) to experts independent of the PDT, project and immediate line management, customers, users and other interested parties (e.g., managers and experts). The PDL shall collect RFAs that result from the PDR and track RFA responses and resolutions. The PDT incorporates feedback from the review into the preliminary design documentation.

PDR Topics:

- Design
- Design alternatives and identified "ideal" design (hardware & software)
- Design drivers
- Safety critical issues
- Software hazard reduction features
- Risks and prototype results
- Lessons learned (previous lessons applied and new ones learned)
- Reuse/COTS tradeoffs
- Testing strategy
- Traceability of requirements to design elements
- Size estimates and schedule
- Staffing plans
- Updated build plan
- Issues and TBD's, along with resolution dates

For projects where the architecture of another system is being reused, the PDR concentrates on new functions and modifications to the existing architecture.

1.3.4 Detailed Design

1.3.4.1 Develop and Document the Low-level Design

The purpose of low-level design is to complete the design so that it satisfies all the requirements and can be directly implemented in code. It is recommended that the PDT prepare design documentation to the lowest level of detail of the system to produce "code-to" specifications for each module. The PDT selects an appropriate analysis and documentation approach to accomplish this (e.g., use cases and package specifications, or prologs and program design language). The PDT refines the operations scenarios for the system and completes the design of input and output formats, such as displays, reports, and databases.

For projects where there is extensive reuse it is recommended that the PDT use the same analysis and documentation approach as was used for the system that is being reused. This facilitates understanding of the design of the new system as a whole. If there is not adequate low-level design documentation for the system to be reused it is recommended that the PDT create it to the level needed to understand the new system. It is recommended that code-to specifications for modules to be modified be produced. Code-to specifications for modules to be reused without modification need not be produced.

1.3.4.2 Verify the Low-level Design

It is recommended that the PDT verify the low-level design. If PDT level verification of the low-level design is performed, the PDT shall document the procedures it uses for this purpose. Walkthroughs and/or PDT level inspections of the emerging designs are appropriate verification activities. Follow up actions shall be documented and tracked to resolution. The low-level design of modules to be reused without modification need not be verified.

1.3.4.3 Conduct a Critical Design Review

It is strongly recommended that the PDT hold a CDR and participate in or contribute to a higher-level Project CDR**.** The PDT presents the completed design (subject to appropriate non-disclosure agreements) to experts independent of the PDT, project and immediate line management, customers, users, and other interested parties (e.g., managers and experts). Participants evaluate the design to ensure that it satisfies requirements and is correct, complete, robust, and testable. If the CDR is held, the PDL shall collect the RFA's that result from the CDR and shall track RFA responses and resolutions. The PDT incorporates feedback from the review into the design documentation.

CDR Topics:

- Final design (hardware & software)
- Final Reuse/COTS decisions
- Interface definitions and ICD status
- Prototype results
- Build/development dependencies
- Final build plans
- Updates to Test strategies
- Updates to requirements and design traceabilty, including traceability to test plans
- Updates to size estimates and schedule
- Staffing plans
- Issues, including software safety issues, risks and TBD's

For projects with extensive reuse and where the review is held at the PDT level, the CDR concentrates on the new or changed functions and modifications to the existing design.

1.4 Implementation Activities

1.4.1 Code New Modules and Modify Reused Modules

PDT members shall code new modules and/or modify reused modules according to the design, using the coding standards or conventions specified in the SMP. This activity also includes implementing tailoring and configuration of COTS/GOTS components.

1.4.2 Verify New and Revised Modules

The PDT shall verify new and revised modules. Code reading, walkthroughs, inspections and unit tests are appropriate verification activities. Records appropriate to the verification techniques shall be kept. Errors are corrected and the module is certified as having been verified. The PDT shall document the procedures it uses for verification and certification.

1.4.3 Integrate Modules

The purpose of integration is to ensure that modules function correctly together. It is recommended that the PDT plan and document the integration process and integration testing activities. The PDT integrates the modules (COTS/GOTS, glue-ware, and/or new modules), and tests the integrated modules to ensure that they function together correctly. The PDT reports and corrects defects and then delivers the integrated system for build/release testing.

1.4.4 Draft System and User Documentation

It is recommended that the PDT produce a draft of the system description and user's guide. At a minimum, the draft user's guide could consist of an outline of material to be incorporated into the operations manual. The system description document is an "as-built" design document.

1.5 Test Activities

1.5.1 Build Testing

1.5.1.1. Prepare a Build/Release Test Plan

The purpose of build/release testing is to verify that the software provides the functionality required of the build/release and is a correct implementation of the design; the emphasis is on functional and performance requirements. A test team, consisting of PDT members or a team independent of the PDT but supported by the PDT, shall prepare a build/release test plan. The test plan documents the procedures to be followed in testing each build/release to ensure that it satisfies requirements. The test plan includes traceability between tests and requirements. It includes regression tests to ensure that previously tested functions are not adversely affected in each new build.

1.5.1.2 Verify the Build/Release Test Plan

The test team shall perform a team level verification of the build or release test plan. The verification inspection ensures (1) that the test procedures completely test the requirements to be satisfied in the build/release and (2) that they are written to maximize reuse in system and/or acceptance testing.

1.5.1.3 Prepare or Procure Test Software

If required for adequate test, the PDT shall build, or procure, special software to generate data sets or simulate missing hardware or software components. The PDT determines the degree to which test software must follow PDT standards.

1.5.1.4 Verify Critical Test Equipment or Software

If test software or test equipment is critical to ensuring the success and validity of software, the equipment or software shall be verified to ensure that it functions correctly. The PDT shall document procedures and tests used to verify test equipment and test software to ensure that the tests can be easily and efficiently repeated.

1.5.1.5 Conduct Build/Release Tests

The test team executes the tests specified in the plan. The results of build/release tests shall be recorded. The PDT analyzes and corrects discrepancies found in build testing. It is recommended that the test team produce a test report after the completion of testing for the build/release.

1.5.2 System Testing

System testing is designed to verify the functionality of the software product against the requirements and specifications in a more realistic operational environment, for example as a "string test" including multiple systems. The test team shall develop a system test plan to verify the end-to-end functionality of the system in satisfying the requirements and specifications. The plan includes traceability of test cases to requirements and specifies the environment for the system tests. It is recommended that the tests be executed on the integrated spacecraft/hardware system where this is feasible.

For a project with significant reuse the end-to-end system tests often include system tests defined for the system that is being reused. It is recommended that the end-to-end system tests include regression testing of components that are being reused.

1.5.2.1 Verify the System Test Plan

The test team will verify the system test plan in order to ensure that all requirements are adequately tested and that test data can reasonably be made available.

1.5.2.2 Develop Detailed Test Procedures

It is recommended that detailed, step-by-step test procedures be prepared. The test procedures identify each test step, the data to be used, and expected results from each step. It is recommended that the test team use draft system and user documentation in preparing test procedures.

1.5.2.3 Conduct System-Level or End-to-End Tests

The test team executes the test procedures specified in the system test plan. Test results shall be recorded. The test team issues documentation of product and test problems that are identified. The PDT, according to CM procedures, will correct these identified problems.

1.5.2.4 Verify System and User Documentation

During conduct of the system test, the draft of the users' guide is verified, noting such flaws as missing or unclear instructions, contradictions, etc. The PDT shall analyze and correct any problems encountered in the document and shall complete the documentation.

1.5.2.5 Report System-Level or End-to-End Test Results

The test team shall produce a test report after the completion of system testing. The test report identifies the tests that were executed and their results, includes a summary of nonconformances found during testing, and identifies remaining nonconformances.

1.5.3 Acceptance Testing

1.5.3.1 Conduct an Acceptance Test Readiness Review

It is recommended that an ATRR be held. The acceptance test team, which is usually independent of the PDT, meets with the PDT, project and immediate line management, customers, testers, users, and other interested parties to review the results of the testing completed to date, and to evaluate preparedness for acceptance testing. If any external individuals (not Civil Servants) participate in this review, appropriate non-disclosure agreements must be signed in advance of the review. Outstanding problems that affect acceptance testing are discussed. If an ATRR is held, the RFA's that result from the ATRR shall be collected and tracked to resolution.

ATRR Topics:

- Status of system readiness
- Summary of test results; tests performed, successful tests, known problems, waivers and issues
- Discussion of support to be provided for Acceptance Testing.
- Acceptance test approach including ground rules, tools and reporting (input provided by the Acceptance Test Team)
- Test schedule (input provided by the Acceptance Test Team)

1.5.3.2 Support Acceptance Testing

It is recommended that members of the PDT be available to support Acceptance Testing as conducted by the customer or an independent test organization. This support consists of consulting activities, analysis of test results, and correction of nonconformances as requested.

1.6 Delivery and Support Activities

1.6.1 Delivery

When software is released or delivered to an external organization, it is important that Government-owned intellectual property be protected. Refer to NPD/NPG 2210.1, "External Release of NASA Software," for further information concerning the domestic or foreign release of software created by or for NASA.

1.6.1.1 Prepare the Release Letter

The PDL shall document the delivery of the accepted system release in a release letter to the customer that details the release identification, release contents, release capabilities, and any remaining nonconformances.

1.6.1.2 Prepare Shipping Records

The PDT shall prepare shipping records that accompany any hardware or other items transported. The records identify each item being delivered, its delivery medium, and its destination.

1.6.1.3 Deliver the Completed System or Release

The PDT shall deliver the software and all documentation using the media and methods identified in the SMP. (See NPD/NPG 2210.1 regarding external releases or deliveries.)

1.6.2 Operations Support

1.6.2.1 Support the Operational Readiness Review

The PDT shall support the ORR held by the Acceptance Test Team, or shall participate in, or contribute to, a higher-level Project ORR**.** The ORR serves as an opportunity to review the ability of the system to support operations. The status of the remaining nonconformances and the status of system documentation are presented. If an ORR is held, the PDL shall collect the RFA's that result from the ORR and shall track RFA responses and resolutions.

ORR Topics:

- Summary of test results including Acceptance Testing with nonconformances and their impact on operations
- Status of system documentation including user and operations manuals.
- Status of external interface agreements
- Readiness of operational environment for installation
- Operational support and maintenance support plans
- Configuration control procedures

1.6.2.2 Provide Customer Training

The PDT shall provide training in the installation and execution of the software to operations staff (or other users) to the extent specified in the SMP. The PDT shall train maintenance personnel as specified in the SMP.

1.6.2.3 Provide Technical Assistance

The PDT shall provide technical support and maintenance during the agreed-upon support period as defined in the SMP. The PDT responds to questions raised by operations staff and other users and assists in identifying and analyzing defects or

anomalies in the behavior or performance of the system. Records of maintenance requests shall be kept.

Appendix B: Software Maintenance Process

This process description is intended to be used as a starting point in defining the project's technical approach. The activities are not intended to be strictly time sequenced. This allows them to be used to define activities in a variety of maintenance situations. There may be activities that are unique to the project to mitigate special risks or to handle special requirements. These may be added to meet the project's unique needs.

2.1 Cross-Cutting Activities

2.1.1 Team Management

2.1.1.1 Develop a Software Management Plan

The Product Maintenance Lead (PML) shall develop a SMP using the Software Management Plan Guide in the Attachment of this GPG. GSFC Form 19-21 provides a template for the recommended SMP outline. (Note: When using GSFC Form 19-21, information can be rearranged or supplemented as long as required information is included.) The completed SMP describes the customer requirements and resources (e.g., budget and staffing) allocated to execute the Plan. It documents release planning and the strategy for prioritizing maintenance requests including criteria for identifying emergency changes. It identifies a nominal maintenance release schedule, reviews for nominal releases and their formality, and internal Product Maintenance Team (PMT) level verification. It identifies exceptional circumstances that may result in fewer or more reviews or more formal reviews (e.g., response to a critical spacecraft failure).

For external releases or deliveries, additional requirements may apply. See NPD/NPG 2210.1, “External Release of NASA Software,” for further information on the domestic or foreign release of software created by or for NASA.

The SMP defines the approach that will be used to track project status, for configuration management, product assurance, risk management, and independent verification and validation. It also summarizes the technical approach including the review plan, documentation to be maintained and the criteria used to tailor this Process for Software Maintenance.

Tailoring is determined by the PML in consultation with management and the customer. Tailoring factors include project characteristics such as the criticality of the application, the size of the Product Maintenance Team (PMT) and user community, the degree of reuse, and other project specific factors. Required activities (i.e., those designated as "shall") may not be deleted.

The PML defines the review plan for nominal releases based on the criticality, complexity, and the number of users affected by the maintenance changes. For high

priority or emergency patches the PML has the authority to accomplish the goals of a review - to achieve customer concurrence - through other means (e.g., telecon or email), followed by more formal documentation of concurrence after the emergency is resolved. The following reviews should be considered:

- Maintenance Release Planning Review
- Maintenance Release Design Review*
- Acceptance Test Readiness Review
- Operations Readiness Review

*Required Reviews

Software project reviews shall:

- Be scheduled with published agendas
- Include customers or customer representatives
- Record meeting notes
- Collect RFA's
- Record and track RFA's to resolution.

2.1.1.2 Manage the Task

The PML negotiates project-staffing assignments, assigns technical work to staff members, and helps assure that all PMT members are qualified to perform their assigned duties. The PML is also responsible for the day-to-day management of the task according to the SMP. The PML shall periodically review and record the status of maintenance activities using the methods defined in the SMP. It is recommended that project status be an objective measure of work products accomplished against planned resource allocation (e.g., schedule, cost and effort).

2.1.1.3 Collect Metrics

Project metrics, at a minimum, shall include schedule planned vs. actual dates, budget (effort and cost), actual release content vs. planned release content, change in product size, and product error information, such as open/closed nonconformances (i.e., discrepancy reports), and shall be collected periodically (e.g., monthly or quarterly). Project metrics are analyzed and the results used to initiate process improvement activities.

2.1.1.4 Document Lessons Learned

The PML shall review, at the beginning of, and then periodically throughout the maintenance effort, the LLIS (which is maintained at http://llis.nasa.gov) for relevant experiences and knowledge that can be leveraged to reduce risk, improve quality, an/or apply Best Practices. The PML shall also submit significant lessons learned to the web-based LLIS system as appropriate.

It is recommended that lessons learned be documented in a Software Development History at each maintenance release. The Software Development History is updated to

include lists of the products in the delivery, milestones and key events, release duration, key decisions, problems encountered, and summaries of the metrics collected during the phase. It describes the specific lessons and recommendations that pinpoint the major strengths and weaknesses of the process used and the product itself, with particular attention to planning, requirements, development, testing, CM, QA, and changes in technology.

2.1.1.5 Prepare and Maintain Project Documentation

The PMT shall maintain the project documents as specified in the SMP. The PMT ensures that each change to project documentation is reviewed, and that the changes identified during the review are properly implemented and that appropriate approval signatures are obtained.

2.1.2 Training

2.1.2.1 Identify and Document Required Training Needs

The PML shall identify and document the training for PMT members that are required by the QMS. Required training includes familiarizing PMT members with the SMP, the methodology, standards, and design process used, maintenance of PMT records, and use of a nonconformance recording system. It also includes training required when working in proximity to instruments or spacecraft, such as Electrostatic Discharge Awareness Training, Range or Launch Safety, Laser Safety, etc. The PML works with the appropriate supervisors to assure that the identified training is provided. It is recommended that the PML identify any special developmental training such as language and tool training, and identify on-the-job-training to build an adequate level of understanding in all PMT members of software that will be maintained.

2.1.2.2 Record Training Received

As PMT members obtain training, the PML shall maintain records of the training that has been received and by whom (see GPG 3410.2).

2.1.3 Configuration Management (See GPG 1410.2)

2.1.3.1 Perform Configuration Identification

The PMT shall identify, in the SMP, the types of items to be placed under configuration control and shall identify when they will be placed under configuration control. Items, if any, that are to be controlled at the higher-level Project, shall be identified. For maintenance projects each release constitutes a baseline. The PMT identifies the products comprising each baseline, down to the level of the smallest controllable unit. The PMT shall develop a unique identification for each planned system release/version and delivery. The PMT defines naming and labeling conventions as appropriate. It is recommended that the PMT follow naming and labeling conventions (e.g., release/version, file and module naming conventions) consistent with those established during the system development.

2.1.3.2 Maintain Configuration Control

The PMT shall preserve the integrity of all system baselines, components, and products. The PMT shall track changes to controlled products to assure that the configuration of all identified items is known at all times. Controlled products include system baselines, project documents (requirements, design, test plans, etc.), source code, object code, released and developmental versions of the target system, critical test software and any customer-provided product (e.g., GOTS) used in the development of the software system. The use of a commercial configuration management tool is recommended for configuration control of the project's permanent source code libraries. This also includes maintaining change control over any critical test software. The PMT shall maintain records of all software configuration management activities performed, including all changes made to software and documents under configuration control.

2.1.3.3 Monitor and Report Configuration Status

It is recommended that the PMT periodically produce configuration status reports. These reports typically include such information as the number of changes made to date, the reason for each change, the number of system releases to date, the functionality provided with each release/version, and the latest version and revision identifiers. It is recommended that the first configuration status report list configuration items for the system at the start of the maintenance project and include identification of any known nonconformances that exist at the time. This report is reviewed against design documentation and configuration records received with the software at the start of the project.

2.1.4 Quality Assurance

2.1.4.1 Support Project Reviews, Walkthroughs, and Inspections

Quality reviews address completeness, readability, traceability, and conformance to PMT standards. They assess both the quality of the product (the deliverable under review) and the quality of the process (the way the review is conducted, including planning, announcement, preparation, conduct, and follow-up). Problem areas are identified and appropriate corrections suggested. Although quality is a shared responsibility, it is recommended that the responsibility for advocating and assessing the quality assurance process be centralized in a single individual. It is recommended that product quality be addressed at each major review. It is recommended that quality also be addressed during in-process reviews (walkthroughs, inspections, test results etc.). It is recommended that inspection criteria for any customer-provided product (e.g., GOTS) used by the PMT be established in conjunction with the customer. Results of all reviews and inspections, including those of incoming customer-supplied products, shall be documented.

2.1.4.2 Review Project Deliverables

It is recommended that all major project deliverables (documents, software releases, presentations, etc.) be reviewed for quality. It is recommended that a sample of minor deliverables (unit designs, unit code, test plans and results, etc.) be reviewed for quality.

2.1.4.3 Monitor and Manage Risk

The Risk Management approach is identified in the SMP. Risks shall be continuously identified, analyzed, monitored, tracked, mitigated and status reported at each review. A detailed discussion of risk management is found in NPG 7120.5 "NASA Program and Project Management Processes and Requirements."

2.1.4.4 Monitor and Support Problem Identification and Corrective Action

The PMT shall employ and follow a problem identification and corrective action process consistent with the Goddard Center requirements. If a minor NCR/CA system is used it should include the version or release number where the problem was found and, ideally, the version number that includes the corrections. The PMT shall record the number and severity of defects and nonconformances and the corresponding corrective and preventive actions; this information is used for process improvement. The PMT shall identify and segregate any nonconforming builds/releases or deliveries. When, with customer concurrence, software is delivered with known nonconformances, the release letter clearly identifies the nonconformances. Software with nonconformances that has not been approved for delivery is identified and maintained separately so that it is not inadvertently included in a delivered product. The PMT shall document any nonconformances for customer-supplied products (e.g., GOTS). Major nonconformances that meet the criteria specified in GPG 1710.1 shall be recorded in the in the Center NCR/CA system.

2.1.4.5 Control Documents and Records

The PMT shall control all its own records as identified in the SMP. The PMT shall document and implement a process for the identification, review, approval, distribution, retention, and disposition of documents and records.

2.1.4.6 Perform Configuration Audits

At the beginning of the maintenance project and prior to each release or delivery, it is recommended that an audit of the software be performed. The audit at the start of the project ensures that all the required system elements and documentation are present. Audits performed prior to a release or delivery verify that every delivery item (e.g., program, input file, test software, or document) is as reported in the delivery documentation and delivery letter. Each item on the delivery list is checked to ensure that the item is present, is complete, is the correct version, is in the specified delivery format, and is correctly identified. (Additional requirements apply for external releases or deliveries; refer to 2.6.1 for additional information.)

2.1.4.7 Support IV&V Activities as Required

The PML shall provide support to the Project for the submission of the IV&V criteria information listed at http://swmetrics.nasa.gov/ivvcrit/. If it is determined that the project

requires IV&V support, the PMT shall provide the required support to the IV&V facility for these activities throughout the life of the project.

2.1.4.8 Comply with Specific Electrical Engineering Division and Project Requirements for Connecting to Flight Hardware

The ISD PML shall insure that any ISD non-flight device connecting to flight hardware shall be developed and maintained in compliance with the Electrical Engineering Division (EED) and any specific Project policies and practices (MASIS for HST, for example). The PML shall also insure that all civil servants and support contract staff equipment interfacing with flight elements for purposes of software/firmware debug and update comply with EED and specific Project direction.

2.2 Requirements Activities

2.2.1 Maintenance Request Evaluation

2.2.1.1 Document Each Maintenance Request and Assign a Unique Identifier for Tracking Purposes

Each maintenance request shall be assigned a tracking number and logged. The PML assigns PMT members to evaluate the request. It is recommended that the PML assign lead responsibility for investigating each maintenance request to a specific PMT member.

2.2.1.2 Perform Preliminary Assessment of Resources Required to Implement Each Maintenance Request

It is recommended that a preliminary assessment of the resources required to implement a solution to the maintenance request be performed and documented. It is recommended that the PMT document procedures for performing this assessment in the SMP.

2.2.1.3 Classify the Maintenance Request

The SMP identifies recommended classification categories for maintenance requests, such as severity level and type (e.g., by subsystem, by error type). It is recommended that the maintenance request be classified and that classification metrics be collected.

2.2.1.4 Prioritize the Maintenance Requests

The PML shall periodically meet with the customer to establish and accept or reject recommendations for all new change requests. Notification of the rejected changes shall be sent to the originator along with a brief rationale. Accepted maintenance requests shall be assigned a resolution priority based on the user's priority, the PMT's assessment of the impact on operations, and the effort to implement a solution. It is recommended that the SMP include guidelines and procedures for prioritization, including criteria for designating a nonconformance as serious enough to require following emergency patch procedures.

2.2.2 Maintenance Release Definition

2.2.2.1 Derive New or Modified Requirements from the Maintenance Request

If the request is for minor modifications to existing requirements, the PMT identifies the required changes. If the request is for new functionality or for complex changes, the analysis method specified in the SMP is used to derive detailed requirements to fully define the change. The focus of requirements definition and analysis activities is on what the changed software needs to do rather than how to do it. Modifications that affect operations, for example changes to system parameters, reports, displays, etc. are defined. New reports and displays are identified. Test requirements are also derived. If the change is driven from needs external to the user community (e.g., a change to an institutional or other interfacing system that requires a corresponding change to the system being maintained), walkthroughs with users and representatives of interfacing systems are recommended**.** Draft updates to the requirements document are prepared using mark-ups to show where text is to be inserted or deleted to make clear what is being changed.

2.2.2.2 Refine the Estimated Resources (e.g., Staff and Effort) Required to Implement the Requested Maintenance Change

It is recommended that the assigned PMT member reevaluate the preliminary impact assessment to make a detailed estimate of the resources and schedule required to implement the change. The resource estimate includes the effort to generate additional or changed test data and to modify test software as required. It is recommended that the PMT identify dependencies among components and determine if a phased implementation is desirable and/or feasible.

2.2.2.3 Plan Release Contents Using Request Priorities and Resource Estimates

The PML shall work with customers to plan the content of maintenance releases. The PML uses knowledge about the areas of the system that will be affected by a change and about upcoming work, along with the customer's priority input, to identify planned release contents. If a change is identified as critical to continued operations, one or several maintenance requests may be designated as an emergency patch and implemented on an expedited schedule.

2.2.2.4 Conduct a Maintenance Release Planning Review

It is recommended that a Maintenance Release Planning Review be conducted for each Maintenance Release. The purpose of the review is to gain customer concurrence on the release contents, the proposed changes to requirements and the planned release schedule. Review participants include customers, users or their representatives. If the Maintenance Release Planning Review is held, meeting minutes shall be taken and RFA’s tracked to closure.

Maintenance Release Planning Review Topics:

- Summary of maintenance requests in the release, including priority and resource estimates

- New and modified requirements
- Operational impacts
- Release schedule

In most cases the review is an informal technical meeting. However, it is recommended that the review be formal for major upgrade releases, where there are multiple user organizations, if the changes are complex or have a significant impact on operations, or if the changes impact interfacing systems.

2.3 Design Activities

2.3.1 Update the Maintenance Request Documentation

For each maintenance change in the planned release, it is recommended that information describing the alternatives considered and the selected solution be added to the maintenance request tracking documentation. This information serves as documentation of the proposed change to the system and provides traceability for changes to software and documentation that result from the maintenance request.

2.3.2 Identify all Affected Elements of the Software Design

Identify all software elements, including COTS/GOTS components and documentation that are affected by the maintenance change(s). If a Requirements Traceability Matrix exists, use it as a guide to help identify the components that implement the impacted requirements.

2.3.3 Modify the Design

Using the design approach and techniques specified in the SMP, design modifications to existing components and design new components. The PMT shall document the design modifications. Where possible, use mark-ups of existing design material to highlight changes. If the changes are too extensive to be shown as markups, generate replacement diagrams and other design material, and make both the new material and the old material available for review.

2.3.4 Identify Tailoring/Configuration Changes (where applicable)

If the maintenance change calls for changes to the tailoring or configuration of a COTS/GOTS component, identify and document those changes. If the maintenance request calls for changes to existing system configuration parameters, identify and document those changes.

2.3.5 Procure and Install Replacement COTS/GOTS Components in the Development Environment (where applicable*)*

If approved by the customer, initiate procurement activities to obtain the new version(s) of COTS/GOTS components and install the product for testing when it arrives. (Note that

in most cases, open competitive procurement of COTS products is required. See GPG 5100.1 for additional information on procurements.)

2.3.6 Verify Design Modifications

It is recommended that a PMT-level review of the resulting modified design be conducted. Follow-up actions shall be documented and tracked to resolution.

2.3.7 Conduct a Maintenance Design Review

For each maintenance release, the PMT shall hold a Maintenance Design Review that includes customers and users. If the release includes changes to a critical system, if the changes are complex, or if there are extensive changes to the system design (e.g., architectural changes or replacement, not upgrade, of COTS/GOTS components), then it is recommended that the review be formal. Meeting minutes shall be taken and RFA's tracked to closure.

Design Review Topics:

- Summary of maintenance requests in the release, including priority and resource estimates
- Summary of requirements changes
- Interface changes
- Summary of operational impacts
- Identification of system architectural changes (if any)
- Description of significant design changes
- Changes to COTS/GOTS
- Release test plan overview
- Updated release schedule

2.4 Implementation Activities

2.4.1 Code New Modules and Modify Existing Modules

PMT members shall code new modules and modify existing modules according to the design, using the coding standards or conventions specified in the Software Development Plan. This activity includes implementing changes to COTS/GOTS tailoring and configuration parameters.

2.4.2 Verify New and Revised Modules

The PMT shall verify new and revised modules. Code reading, walkthroughs, inspections and unit tests are appropriate verification activities. Records appropriate to the verification techniques shall be kept. Errors are corrected and the module is certified as having been verified. The PMT shall document the procedures it uses for verification and certification.

2.4.3 Integrate the Release/Patch

The PMT plans the integration activities, integrates the modules (COTS/GOTS, glue-ware, and/or new modules), and tests the integrated modules to ensure that they function together correctly. The PMT documents the procedures it uses for integration. Problems are identified and corrected in preparation for release/patch testing.

2.4.4 Update System and User Documentation if Required

The PMT produces draft updates to the appropriate documentation (e.g., system description, operations manuals, user's guide and training material). At a minimum, the draft updates are mark-ups to the existing documents.

2.5 Test Activities

2.5.1 Release Testing

2.5.1.1 Develop a Release/Patch Test Plan Based on the Existing Test Plans and Regression Tests

The purpose of release/patch testing is to verify that the software provides the functionality required of the release and is a correct implementation of the design; the emphasis is on functional and performance requirements. A test team, consisting of PMT members or a team independent of the PMT but supported by the PDT, shall develop a release/patch test plan using existing system test documentation as the basis for the new and modified tests. Maintenance release tests are at the level of build and functional scenario tests. They demonstrate that the system functions as designed and that changed and new requirements are satisfied. The plan documents the procedures to be followed in testing the release to ensure that it satisfies the new or changed requirements. When testing fixes for defects it is often useful to follow the scenario that was used to recreate the problem as one of the test cases. For critical systems the release test plan shall include regression tests to ensure that unmodified functions are not adversely affected. The plan defines build test completion criteria. The completed test plan shall be placed under configuration management.

2.5.1.2 Review the Test Plan

It is recommended that the test plan be reviewed at the PMT level. If the change is critical or affects interfacing systems a more formal review that includes customer or user representation is recommended**.** Review meeting notes shall be documented.

2.5.1.3 Prepare Detailed Test Procedures for New Test Cases

Detailed step-by-step test procedures shall be prepared. The test procedures identify each test step, the data to be used and results expected from each step. The detailed test procedures reference and build on existing system test procedures.

2.5.1.4 Modify Test Data and Software as Needed

Prepare changes to test data. If necessary, modify existing test drivers and/or test data generation software and verify the changes.

2.5.1.5 Conduct Patch/Release Tests

The test team executes the tests specified in the plan. The results of patch/release tests shall be recorded. The PMT analyzes and corrects discrepancies found in build testing. It is recommended that the test team produce a test report after the completion of testing for the patch/release.

2.5.1.6 Prepare Final Updates to System and User Documentation

The SMP identifies user and system documentation that is to be maintained. At the conclusion of release testing these documents are updated according to project standards and placed under the specified level of configuration control.

2.5.2 Acceptance Testing

2.5.2.1 Conduct a Review of the Test Results

It is recommended that an informal ATRR be held for each release. The test team produces a test report after the completion of testing for the release and reviews the results with customer and user representatives. In most cases a PMT-level review of the release/patch test results is either informal or optional. For large PMT's or critical changes a formal review is recommended. Minutes of the meeting shall be taken and RFA's tracked to closure.

If any external individuals (not Civil Servants) participate in the ATRR, appropriate non-disclosure agreements must be signed in advance of the review.

ATRR:

- List of maintenance requests in the release, including priority and test status (pass/fail)
- Summary of tests conducted and tests passed or failed.
- List of nonconformances remaining in the release and operational impact of the nonconformances on operations.

2.5.2.2 Support Acceptance Testing Performed by the Customer or by an Independent Organization

It is recommended that members of the PMT be available to support Acceptance Testing as conducted by the customer or an independent test organization. This support consists of consulting activities and analysis of test results as requested.

2.6 Delivery and Support Activities

2.6.1 Delivery

For external releases or deliveries, additional requirements may apply. See NPD/NPG 2210.1, "External Release of NASA Software," for further information on the domestic or foreign release of software created by or for NASA.

2.6.1.1 Prepare the Release Letter

The PML shall document the delivery of the accepted system release in a release letter to the customer that details the release identification, release contents, release capabilities, and any remaining nonconformances. The release letter identifies any changes that affect operations or require user training. All software and documentation that are part of the delivery are promoted to the configuration-controlled delivery library at the time of delivery and constitute a system baseline.

2.6.1.2 Prepare Shipping Records for Delivery

The PMT shall prepare shipping records that accompany any items transported. The records identify each item being delivered, its delivery medium, and its destination.

2.6.1.3 Deliver the Completed System or Release

The PMT shall deliver the software and all documentation using the media and methods identified in the
Software Management Plan. Release documentation includes installation and back-out instructions. (See NPD/NPG 2210.1 regarding external releases or deliveries.)

2.6.2 Operations Support

2.6.2.1 Support Review of the Acceptance Test Results

It is recommended that the PMT support the ORR if one is held. The ORR serves as an opportunity to review the ability of the system to support operations. The status of remaining nonconformances is presented.

ORR Topics:

- Summary of Acceptance Testing including nonconformances and their impact on operations
- Summary of tests conducted, tests passed and tests failed
- Identification of nonconformances and suitability of workarounds in the operational environment

2.6.2.2 Provide User Training

To the extent specified in the SMP, the PMT shall provide user training and installation instructions, and user documentation specific to new or modified user and operations capabilities.

2.6.2.3 Provide Technical Assistance

The PMT shall provide technical support to the extent specified in the SMP. The PMT responds to questions raised by operations staff and other users and assists in identifying and analyzing defects or anomalies in the behavior or performance of the system.

Appendix C: Product Plan Instructions

Product Plan—A description of the work to be performed and the resources needed to accomplish the goals and objectives established in the customer agreement. In QMS terminology, the Product Plan is the *QUALITY PLANNING DOCUMENT* for producing the product. The Product plan includes the *design planning information* and the *process management information*.

Figure 1 is the table of contents to be followed by all Teams in generating their Product Plan. All components shall be addressed, but the level of detail is left to the Team based on product complexity and customer needs/expectations.

ISO 9001 standards require certain quality control processes to be documented. Those processes that are required and the criteria that they must meet are described in Appendix F. Samples of these required processes that meet these criteria are in the Library of Approved Team Processes (see http://isc.gsfc.nasa.gov/ISO9k/ISO9001.htm). Each team in their product plan may either refer to one or more specific approved processes, or develop and document their own processes. Any new processes must meet the criteria specified in Appendix F and be approved by the ISD QMS representative. The effective date of the Product Development Handbook being used is to be placed directly under the Product Plan "Table of Contents" label on the "Table of Contents" page and should be labeled as "Version Date xx/xx/xx". This effectively freezes the version of the Product Plan Table of Contents for the duration of the Product Plan.

The following disclaimer should be placed in the footnote section of every page:

> "Printed copies of this document are for **REFERENCE PURPOSES ONLY**! The only controlled copy of this document is located on-line at http://xxxxxxxx."

Optionally for Product Plans originally signed prior to ***8/1/99***, this disclaimer may appear directly after the signature page:

> "References to documents and data (hard copy or electronic) in the Product Plan ***not*** directly under the Team's control shall contain the version identification in the Product Plan."

The Work Order Authorization (WOA) equivalent for software development referred to in the GSFC QMS is defined by the contents of Sections 3.1 and 4.2.1 of the ISD Product Plan, including all associated documentation and references.

Section 1 of the Product Plan (Customer Agreement) may be under either Project or ISD control. It follows the configuration management process outlined in Section 1.15. A customer signature for the Section 1 of the Product Plan is highly recommended (see Figure 2).

The remaining sections of the Product Plan are under ISD Configuration Management and follow the configuration management process defined in Section 4.2.1. At a minimum, these portions of the Product Plan require a Team Lead signature and an appropriate ISD Management Team signature for approval (see Figure 3).

The remainder of this appendix lists the product plan subsections with a description of the contents following each subsection heading. Quality records and controlled

documents are identified in tables in the appropriate subsections. Tables labeled as objective evidence indicate other records that should be maintained by the Team, but are not included on either the quality records list or the controlled documents list.

Certain subsections may be included by reference if documented elsewhere. These subsections are identified with an asterisk (*). It is recommended that subsections containing frequently changing information be included by reference.

Table of Contents for Product Plan

Table of Contents—Product Development Handbook -Version Date: xx/xx/xx

Document Change History—Include version identifier and description of change

Customer Agreement Signature Page

Product Development Signature Page

1. Customer Agreement
2. Management Approach
3. Technical Approach
4. Product Assurance
5. Plan Update History

Appendix A—Acronyms and Abbreviations

Appendix B—References

Figure 1. Template for Table of Contents

NOTE: See following pages for detailed information on contents of each section.

Customer Agreement

for the

(project name)

(system type[1]) Development

Release Date

Month/Year

Prepared by: _____

XXXXXXX

Team Lead

Approved by: _____

XXXXXXX

Customer/Designee

Approved by: _____

XXXXXXX

Information Systems Division Management Representative [2]

The Team Lead, the Customer/Designee, and the Information Systems Division Management Representative constitute the Configuration Control Board for the Customer Agreement portion (Section 1) of this document.

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FIGURE 2. Template for Customer Agreement

Notes: (1) System types—This would be ground data system, flight software, command and data handling system, etc.

(2) Information Systems Division Management Representative—Title listed here should be the specific title of the ISD manager responsible for the development, for example, "Code 5xx Branch Head"

Product Development

for the

(project name)

(system type[1]) Development

Release Date

Month/Year

Prepared by: _____

XXXXXXX

Team Lead

Approved by: _____

XXXXXXX

Information Systems Division Management Representative [2]

The Team Lead and the Information Systems Division Management Representative constitute the Configuration Control Board for this document, with the exclusion of the Customer Agreement (section 1).

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FIGURE 3. Template for Product Development

Notes: (1) System for types—This would be ground data system, flight software, command and data Handling system, etc.

(2) Information Systems Division Management Representative—Title listed here should be the specific title of the ISD manager responsible for the development, for example, "Code 5xx Branch Head"

1.0 Customer Agreement (GPG 1310.1)

1.1 Background

A brief (maximum of one paragraph) description of what larger effort/activity this Team is supporting and how this product fits into the larger picture.

1.2 Team Charter

A brief one-paragraph description of what this Team is being asked to accomplish, including any time constraints or interface boundaries within which this Team is expected to operate.

1.3 Customer(s) Identification

The customer is usually a Flight Project or the person who pays the bill. Otherwise, it should be the person who will define the requirements and accept the products.

1.4 Customer Goals and Objectives

Any special things that the customer wants to accomplish (e.g., rapid turn around, new architecture, special COTS requirements, special experiments, etc.) through this Team's activities.

1.5 Requirements*

This section should list or reference (preferred) any functional/operational requirements as specified by the customer. Include any specific standards to be met and list the interface control documents needed. Include any policies and practices of Electrical Engineering Division (EED) or specific Projects for devices connecting to flight hardware. References must include revision date/number for documents not under direct control of Team Lead. Do not include technical interface documents or databases here. Reference them in Section 2.4

Controlled Document	Comment	Record Held By
Functional Requirements	Signed and dated by Customer	Project or Team Lead

1.6 Deliverables

List products to be delivered for each phase, including software, hardware, licenses, documentation, etc., as directed by customer.

1.7 Schedules*

List *customer—specified* schedule requirements, including such items as documentation, releases and reviews.

1.8 Necessary Customer Training

Specify who is to be trained how many are to be trained, location and nature of training.

1.9 Medium/Method for Product Delivery (GPG 6400.1)

List any required delivery medium and method of delivery for all products listed in Section 1.6

Quality Record	Comment	Record Held By
Shipping Records		Team Lead

1.10 Product Destination

List product delivery destination for all products listed in Section 1.6.

1.11 Post Delivery

Describe who will do maintenance after and how it will be requested/approved. Describe process that will be used for maintenance activities for all products in Section 1.6

1.12 Customer-supplied elements, both technical, and resources (schedule, medium, and interfaces)

List any technical elements supplied by the customer that will be used in the production, testing or packaging/delivery of the product. Do not include funding. Include delivery schedule and medium of supplied items.

1.13 Customer involvement (roles, responsibilities, authority, accountability)

Provide details on the extent of direct customer involvement with the Team (Attends Team meetings? Reviews results? Provides direction? Etc.)

1.14 Acceptance Criteria*

Describe the customer's criteria for determining when the product is completed, (i.e., when will the customer accept the product?) This is usually demonstrated by having a satisfactorily completed test matrix/set of test plans. Customer verbal acceptance is not sufficient.

1.15 Customer Agreement Review and Update Process

Describe the process used to evaluate and approve changes to the customer agreement. Be sure to note that the Team will be evaluating the changes to assure that they have the capability of providing the requested changes. Approval authorities (those listed on the signature page) must be listed specifically by name and title. It must be stated that they consist of the Change Control Board (CCB) or the CCB process/membership must be described or referenced. The original approval authority must approve changes.

2.0 Design Planning and Interface Management (GPG 8700.1)

Controlled Document	Comment	Record Held By
Product Plan	Signed and dated by the CCB which is listed in Plan—usually Team Lead, Branch Head, Customer.	Team Lead
Design Planning Materials • Review Plan • Development Phases	May be in product plan.	Team Lead

Objective Evidence	Comment	Record Held By
Design Planning Materials • Team Work Assignments • Team Organization • Schedules • Budgets	May be included in product plan by reference.	Team Lead

2.1 General development approach

Describe in a sentence or two the general philosophy that will be used to build the product, discussing such aspects as use of commercial-off-the-shelf (COTS), contractor involvement, schedule constraint, use of a particular development methodology or new technology, etc.

2.2 Resources needed (budget, people/skills, and facilities)*

Indicate where the *official* budget is kept. In most cases, the budget will probably reside with the Project. Budget information should be kept by fiscal year, and include both civil servant manpower and any contractor support. Address any specific facilities or any facility modifications required for use in development or testing and their expected required dates.

2.3 Team Organization

2.3.1 Team Organization

Include an explanation or diagram illustrating the organization of the Team personnel and its activities. Note: Any Team organization chart not included in the product plan must be signed and dated. Include the relationship of the Team Lead to the higher level Project organization, if applicable.

2.3.2 Roles, Responsibilities, Authority, Accountability of Team Members*

Describe the method used to assign work to Team members and document the work assignments. Assignments can be made by subsystem (e.g. Command & Data Handling, Planning & Scheduling) or by work function (e.g. testing)

2.3.3 Decision making and conflict resolution process

Describe the method used to resolve conflicts within the Team. If group decisions are used, identify the tiebreaker or ultimate decision authority.

2.4 Team interfaces to other teams, organizations, or groups

Describe any interfaces to other organizations, teams, or groups necessary in developing the product, and a *brief* description of the purpose of each interface. This may include things such as the interface of the ISD flight software team to the flight hardware group for working compatibility issues, or the interface of the Ground Data System to the Flight Operations Team for acceptance of the system.

2.5 Procurement* (GPG 5100.1)

Describe all hardware and software purchase requirements in detail (i.e., What are you going to buy?) Include any purchases necessary for facility modification. If you are using contractor support, list the contractor name and contract number. If special or usual contracting arrangements are required, describe them. Reference the procurement process used to make purchases. Be sure to use RITS for all items within scope.

Quality Record	Comment	Record Held By
Purchase Requests		Team Lead or Team procurement person

2.6 Team training plan* (GPG 3410.2)

Identify any QMS Required Task Specific training need for each Team member. When training is complete, document it by keeping a list of name, course, and date completed. (QMS Required Task Specific training is defined as training that must be taken to acquire new skills or enhance current skills required to perform tasks of that position that affect quality. Examples are Hand Soldering Certification, Electrostatic Discharge Awareness Training, Laser Safety, Cleanroom Procedures, Range or Launch Safety Training, Flight Operations Team Certification, or any required Project-specific training)

Quality Record	Comment	Record Held By
Records of Required Training Needed		Team Lead or Project
Records of Required Training Completed		Team Lead or Project

2.7 Risk mitigation

Describe any areas where there is a special risk to the delivery of the product (if any) and describe how it will be addressed. If there is none, state that.

2.8 Security

Describe the plans for addressing security considerations, both physically for the facilities involved and electronically for any computer systems being used either for development and testing or as a part of the final product.

2.9 Detailed Schedules*

This should be the detailed schedule used to manage the Team's activities. It should contain the Team life cycle schedule including facility preparations, procurements, system development by phase and release, product delivery, and maintenance (if applicable). Make sure to include review dates, documentation, interface control document's (ICD's) delivery dates; test dates, software release dates, procurements, and external deliveries to the customer. It should include and be consistent with customer schedules defined in Section 1.7.

2.10 Technology and commercialization plan

This should describe any technology advancement, technology infusion, and commercialization initiatives that are drivers for any aspect of this product plan. Especially describe any initiative for which the corresponding product plan activities would not be performed if the technology or commercialization initiative was not considered. If there is none, state that.

3.0 Technical Approach

3.1 Design Development (GPG 8700.2)

3.1.1 Product Requirements*

Describe (or reference) the derived requirements/specifications developed by the Team and approved by the Customer. These should include assumptions, interfaces, and performance information. Ensure that requirements are testable. These requirements can be the customer's original requirements (if so, just reference Section 2.3) or can be those derived by the Team itself.

Controlled Document	Comment	Record Held By
Derived Requirements	Signed and dated by Customer and Team Lead	Project or Team Lead
Interface Control Documents	Signed and dated by Representatives of Interfacing Organizations	Project or Team Lead

3.1.2 Product Design*

Describe the design of the product that the Team is planning to produce. Describe how changes in design are updated and traced to changes in the requirements.

Quality Record	Comment	Record Held By
Completed Design Documentation	May include: • High-level architecture description • Design Review Materials • Design Documents	Team Lead

3.1.3 Development Strategy

Describe at a HIGH LEVEL the software components you will build, the commercial off-the-shelf/Government off-the-shelf (COTS/GOTS) or customer supplied items you will use, the prototyping plans, and the integration requirements.

3.1.3.1 Buy Approach* (GPG 5100.1)

Describe any special purchasing strategies for items specified in Section 2.5.

3.1.3.2 Build Approach*

Include the development phases, the sequence of builds, the high level inputs and outputs per build, vendor/customer/prototype elements to be integrated, and the high level functional requirements satisfied in each build.

Quality Record	Comment	Record Held By
Completed Build Plan	Part of software work order authorization (WOA)	Team Lead

3.1.3.3 Prototyping Approach*

Describe any prototyping activities required to develop the product and the purpose for the prototype (i.e., what specific questions are to be answered by the prototype?)

3.1.3.4 Customer Supplied Products Approach

List and briefly describe any software that will be received from the customer for integration into the final product, and any assumptions concerning them.

3.1.4 Product Testing

3.1.4.1 Product inspection and test * (GPG 5330.1)

Describe the testing approach from unit through product delivery (including in-process and final inspection). Reference your test plans and discuss your testing approach for unit, build, and acceptance testing, test team (developers, independent, customer), test data (simulator, supplied data, flight hardware, real data), and any acceptance criteria (particularly any from the customer for final acceptance—Section 2.11). Describe how changes in design are mapped to changes in test plans.

Controlled Document	Comment	Record Held By
Documentation of Verification Activities	Include one or more: • Unit Test Plans • Code Reading Checklist • Design Baseline • Integration Test Plans • Build Test Plans	Team Lead

Quality Record	Comment	Record Held By
Documentation of Verification Activities	Include one or more: • Unit Test Results • Code Reading Signoffs • Design Walkthrough Documentation (including issues and resolutions) • Integration Test Results • Build Test Results	Team Lead

Controlled Document	Comment	Record Held By
Documentation of (End-to-End) System Validation Activities	**Include one or more:** • High Level Description of Test To Be Run (Can be in Test Procedures) • Test Validation Matrices • Detailed Description of Tests with Inputs, Expected Outputs, and Step by Step Procedures for Running the Tests • Acceptance Criteria	**Team Lead**

Quality Record	Comment	Record Held By
Documentation of (End-to-End) System Validation Activities	Include one or more: • Validation Matrices • Validation Test Results	Team Lead

3.1.4.2 Incoming inspection and test (GPG 4520.2)

For purchased items, including hardware, document the Receiving Inspection Instructions to describe special receiving instructions and tests if other than kind, count and condition. Be sure that all in-scope products received after May 1, 1999, are identified and entered into the RITS system.

Quality Record	Comment	Record Held By
Receiving Inspection Instruction (RITS entry)	RITS entry made by Team Lead or Team purchase person	Team Lead or Team purchase person
RITS Work Order Authorization (WOA)		Team Lead

Incoming Inspection Nonconformance Report	See GPG 5340.2	Center Nonconformance Reporting/Corrective Action (NCR/CA) System

3.1.4.3 Statistical Techniques* (GPG 8070.2)

Unless the Team determines a need for statistical testing of the product or other statistical methods, include the following paragraph in this section of your Product Plan.

"The Team has evaluated the need for statistical testing of the products developed under this Product Plan and has determined that statistical techniques are not required."

Examples of statistical techniques being used are (1) techniques to obtain reliability of hardware systems and (2) comparisons of output results after a platform language conversion. If statistical techniques are being used, then the procedure for their use must be documented.

3.1.5 Development Status*

3.1.5.1 Design/Implementation Status

Describe the method(s) that will be used to track the status through this phase of the product.

Objective Evidence	Comment	Record Held By
Status Information	May include: • Schedule Charts with Status Indicated • Module-by-Module Checklist • Configuration Management Records • Documentation of Weekly Status Meetings	Team Lead or designee

3.1.5.2 Testing Status

Describe the method used to track testing status of the product throughout its life cycle.

Objective Evidence	Comment	Record Held By
Test Status Information	May include: • Test Status Chart • Weekly Test Meeting Status • Signoffs of Completed Tests in Test Plan or Procedures	Team Lead or designee

3.1.6 Development Environment

Describe the development and test hardware and locations, and all Team development standards, as appropriate.

3.1.7 Technical Review Program (GPG 8700.4)

Describe the types of reviews you plan to have and the membership of the review boards. This should include a discussion of any code or design walkthroughs you plan to use as verification of the design. You must have at least a requirements review, a design review, and a product acceptance review with the customer where requests for action (RFAs) and responses are kept. Peer reviews as defined by GPG 8700.6 may include team reviews where one team member reviews another team member's work and should be included on the Team review plan. Project related reviews and other higher level reviews may be supported as requested and they should be listed in the Project Plan.

Quality Record	Comment	Record Held By
• Requests for Action (RFAs) and Responses from Review Meetings • Review Meeting Notes with Action Item List and Resolutions	Include One	Team Lead or CCB Chair

3.2 Process for handling, storage, packing, marking, preservation and transportation (GPG 6400.1)

List the medium for the various products to be delivered if different from Section 1.6 and state how they will be delivered to the customer. Describe any plans (such as back-ups) to prevent loss or damage to the product in all phases of development, including software, documentation and hardware.

3.3 Servicing

Describe the process for post delivery product maintenance (i.e., How do you plan to meet the requirements specified in Section 2.8?) Address responsibility for the maintenance, request process, process for doing work, and product redelivery for custom, government off-the-shelf (GOTS) and COTS software and hardware.

Quality Record	Comment	Record Held By
Maintenance requests		Team Lead
Redelivery letters		Team Lead

4.0 Product Assurance

4.1 Product Quality Assurance

4.1.1 Control of Nonconforming Products and Corrective Action* (GPG 5340.2/ GPG 1710.1)

Describe the process for recording and correcting problems in a "minor" Nonconformance Reporting (NCR)/Corrective Action system. Include a description of the process used to evaluate the cause of the problem and to assess whether any changes need to be implemented to prevent future recurrences. The minor NCR system should include the version or release number where the problem was found and ideally, the version number that includes the corrections. Nonconforming products are both identified by their associated NCRs and the associated release numbers. Any products released to the customer will include a ***release letter*** listing the release number, the included capabilities of the release, and a description of any remaining nonconformance in the release. Products with remaining nonconformance may only be released to the customer with proper approval. (See Library of Approved Team Processes or Criteria 7 in Appendix F.) The Center nonconformance reporting/corrective action (NCR/CA) system shall be used if no minor nonconformance system exists or if the nonconformance meets the Center wide criteria listed in the GPG.)

Quality Record	Comment	Record Held By
Nonconformance records from minor NCR system		Team Lead or Nonconformance Lead
Nonconformance records from Center NCR system		Center NCR system
Corrective Action Plans	May be in NCR system	Team Lead or Nonconformance Lead
Product Release Letters		Team Lead

4.2 Configuration Management (GPG 1410.2)

4.2.1 Control of Team software, hardware, documentation, and data*

Describe how your Team does configuration management for your software, hardware and documentation and who has the change authority for each. If you use the Project's process for any of those,

reference where their procedures can be found. Describe the signature and change authority for the development sections of the Product plan. Describe the method used to uniquely identify versions of the software and the elements from which it is built. The use of a commercial configuration management tool is strongly recommended for environments where one is available. If on-line copies of documentation or software are considered the controlled copy, then the approval authority must control on-line access. A list of documents and data under configuration management by the team is to be referenced in the Product Plan in this section. The list is to include the document or database name, the date or version identification of the current version, the location of the documents or database, and the person responsible for the item. Note: Any data bases or web sites containing controlled information directly under the Team's control shall contain a header identifying what is being viewed, as well as the date of the last change and person responsible for its control. (See Library of Approved Team Processes or Criteria 2B and 2B in Appendix F.)

Quality Record	Comment	Record Held By
Software CM records		Team Lead (or Configuration Manager)
List of items under configuration management		Team Lead (or Configuration Manager)
Copy of signature page of configuration management item		Team Lead (or Configuration Manager)
Records of CCB approval		Team Lead (or Configuration Manager)

4.2.2 Control of test software and hardware (GPG 8730.1)

Describe anything used to test the product, which may be both hardware and software. Describe how this software will be validated (i.e., how do you convince yourself that the simulator is working properly?) If the software used for testing is not the final validation, but is only used as part of a self-check, where neither the test software or the product being tested is considered correct until the final results are correct, then describe that test scenario. Describe or reference the configuration management process used to ensure the appropriate version of the simulator is used. See Library of Approved Team Processes or Criteria 4 in Appendix F. Also, discuss any inspection, measuring and test equipment (IMTE) being used and any calibration requirements.

Controlled Document	Comment	Record Held By
Documentation of Test Software Verification Activities	Include one or more: • Test Plans • Acceptance Criteria	Team Lead

Quality Record	Comment	Record Held By
Calibration records and calibration due dates for IMTE Team is using		Team Lead
Test software test results		Team Lead
Records of Verification from Contractor		Team Lead

4.2.3 Quality Records* (GPG 1440.7)

Identify the Team's Quality Records Coordinator (person who keeps the Quality Records List) and the location of the Quality Records List. Describe the process by which an element is added to the Quality Record List by the Coordinator and filed with the Custodian.

Controlled Document	Comment	Record Held By
Quality Records List		Team Lead

4.2.4 Control of customer supplied products* (GPG 5900.1)

Describe the method that will be used to check out or test the software or hardware supplied to you by the customer for inclusion into the product or for testing or packaging of the product. If a customer provides items for use by the Team in the development/testing of the product, describe the process used to report any problems with the item(s) back to the customer. Describe the configuration management process for customer supplied elements listed in Section 1.12 for changes initiated by the Team or by the customer. Include any other processes used to safeguard customer supplied products. (See Library of Approved Team Processes or Criteria 3 in Appendix F.) This section should address simulators, test data, software algorithms, software and/or hardware received from the customer.

Quality Record	Comment	Record Held By
Problem Reports on Customer-Supplied Products		Team Lead

4.3 Process and product metric analysis*

It is a requirement to collect the metrics described in Appendix G, at a minimum. Additionally, product metrics, Team process metrics, and ISD metrics may be collected. Describe how you will use these metrics for process improvement (see Library of Approved Team Processes or Criteria 10 in Appendix F).

Quality Record	Comment	Record Held By
Data and Completed Forms Representing the Required Metrics		Team Lead

5.0 Product Development Journals

5.1 Team Lessons Learned

Maintain a log of lessons learned throughout the life cycle of the team activities. The final lessons learned report is intended to be a brief (about one-half page) summary of the key recommendations for changes or inclusion in future similar projects.

Objective Evidence	Comment	Record Held By
Lessons Learned Log or document		Team Lead

5.2 Key Issues, Decisions, and Rationale

Maintain a log of key issues, decisions, and rationale through the life cycle of the Team.

Objective Evidence	Comment	Record Held By
Log of Key Issues, Decisions, rationale		Team Lead

*Items may be included by reference

Appendix A: Acronyms and Abbreviations

Appendix B: References

Include a list of any references used in the Product Plan.

Appendix D: List of Quality Record Types

This appendix contains examples of typical ISD ("Center") level and Team level Quality Record types which must be maintained for ISO 9001 compliance.

General information on quality records:

- Quality records demonstrate implementation or completion of the activity or function or the actual as-built or as-tested configuration. They are *not* revised once completed.
- Each Branch and each Product Team must have a Quality Records List and a Quality Records Coordinator. For the Quality Records List use the template in GSFC form 2266 which can be found on the GSFC Quality Management System (ISO 9001) web site.
- Unless otherwise documented in a QMS document, the Quality Records Coordinator is the Product Team lead for Teams and the Branch Head for Branches.
- Product Team Quality Records List shall only contain those quality records controlled by the Team (Other quality records associated with the Team, but controlled by another group, shall be listed on the other group's quality record list.
- In preparation for an ISO 9001 audit, copies of these types of records would need to be provided to the Lead Auditor for inspection, upon request within one hour.
- All Team members must know the location of these Quality Records.
- Quality records for internal (to ISD) teams shall be maintained in the appropriate Branch for one year following delivery of the product. For the flight projects, the quality records transition to the flight project at the time of the termination of the Team activities.
- Those quality records listed under the Team need not be separate documents, but could be combined into the number of documents that the Team feels is appropriate.

Examples of ISD Quality Management System Documents

- ISD Product Development Handbook

Examples of Typical ISD Quality Record Types

- Team Lessons Learned
- ISD Metrics Collected
- Employee Training Records (formal, other) (see GPG 3410.2- Official records should be in OHR)
- Required On the Job Training Records (Form GSFC 17-112, see GPG 3410.2)

Team Quality Record Types are described in Appendix D.

Appendix E: ISD Roles and Responsibilities

Below are the aggregate list of the roles and responsibilities of ISD members in the total Business Development Process components defined throughout the Product Development Handbook. It is collected here for convenience. Team and Team Lead roles have been elaborated on from an ISO 9001 perspective.

Roles and Responsibilities of the Team Lead

From Section 2:

- Meet with the customer to understand and document the product requested
- Present to the ISD Management a estimate of the staffing and skill levels, and approximate time commitments required to meet the customer's request
- Assess the skills and expertise needed. Work with the ISD Management Team to select an appropriate qualified Team to ensure that the individuals are qualified to perform their assigned responsibilities.
- Maintain a list of any "required" training needed and received by Team members
- Assign work to Team members

From Section 3:

- Manage the entire customer order fulfillment process from receipt of the initial customer order to the final fielding of quality products to the customer
- Document each Team member's roles and responsibilities for inclusion in the Product Plan.
- Provide performance assessment on Team member as requested by the ISD Management Team
- Report appropriate information to customers, and the designated ISD Management Team member in a timely and accessible manner
- Determine and document any training required for Team members and work with the ISD Management Team to ensure that training needs are met and that only qualified people work in producing the product
- Maintain a list of "required" training received by Team members
- Work with the customer and the ISD Management Team to resolve issues and conflicts that are beyond control of the Team
- Identify any internal or external consultants that may be needed
- Identify and request resources that are not directly under the Team's control
- Ensure that the Team maintains a customer focus throughout the process and aligns the Teams goals with the customer's objectives
- Ensure the Team works with the customer to define project guidelines and reflects these guidelines in the Product Plan

- Ensures the success of the Team in meeting customer requirements according to cost and schedule goals
- Provide leadership in developing a cohesive, focused, motivated Team
- Ensure Team personnel are implementing and following through on their responsibilities
- Maintain documentation of key issues and decisions, and, optionally, supporting rationale or information

With respect to QMS (ISO 9001) compliance, the Team Lead specifically needs to:

- Produce and maintain a master list of documentation/information for the project and ensure that it remains under configuration control. This is to include a:
  - ◊ **Product Plan** (see Appendix C)
  - ◊ **List of all processes used**
  - ◊ **List of all quality records** (on Form in GPG 1440.7) (see Appendix D)
- Identify a Quality Records Custodian whose name will be recorded in the Product Plan and who has responsibility for control of the quality records associated with the Product Plan
- Ensure Team personnel are implementing and following all of their responsibilities
  - ◊ In addition to the work processes and processes identified above, documents that appear on the master list must be controlled
- Have a design plan and process management plan for your product development. Include these plans in the Product Development Plan.
  - ◊ Identify design verification and validation activities and assure that they are executed and documented
  - ◊ Establish a Team review plan and ensure that all planned reviews are conducted.
  - ◊ Document action items as RFAs and document responses of RFAs
- Ensure that the Team evaluates the need for statistical techniques required for developing or testing the product as well as the need for any statistical techniques required to analyze the product development process
  - ◊ Document any processes used to implement or control the application of any statistical techniques identified above
- Identify and use a corrective action process
  - ◊ The project corrective action process must address the following: customer complaints, actions resulting from audit findings, and major nonconformances (see GPG 1710.1)
  - ◊ Ensure that non-conformances meeting the criteria listed in GPG 1710.1 are documented in the Center on-line NCR/CA database. This shall occur after an initial acceptance tested version release of a system or subsystem to the customer or representative has occurred (accompanied by a release letter). For flight software, this is after initial acceptance testing completion on the flight software test bed.

- ◊ The process must be written and controlled. It must be referenced or detailed in the Product Plan.

- Identify and use a preventive action process
  - ◊ Maintain a Preventive Action Action List
- Define and use a Configuration Management process
  - ◊ The project must have an explicit, written Configuration Management process. It may be by reference, but it must be explicit and define what items will be controlled, who has authority to make changes, how the status of changes will be handled, and what configuration checking (audit) processes will be used.
- Have a process for reviewing and approving documents
  - ◊ All controlled documents and deliverables must be reviewed and approved. Projects must have a written process for completing this activity for documents controlled by the project.
  - ◊ All controlled documents and data must have evidence that they were reviewed and approved by authorized personnel. Further, changes to these must be reviewed and approved by the same functions/organizations that initially performed the activities.
- Have a written process for uniquely identifying and controlling all products
  - ◊ Provide a system to identify the product and track status of work being performed on product and provide a method for software that tracks the status of tests planned/ test results/ and test status by unique software version number or build identification and date
  - ◊ All products must have a unique product identification name or number so that erroneous products or versions are not used by project personnel in work performance
  - ◊ Ensure that status of tests and inspection s are documented a form which tracks the status of planned tests/ test results and test status by unique software version or build identification and date
  - ◊ Ensure that test results are documented and that testing does not proceed past a planned test/inspection point until non-conformances have been documented

- Every formal release shall be documented in a written release notice containing the version/release changes, including database changes, the requirements and the nonconformance information (see GPG 5330.1 Section 2.1.5)
- Have a process for controlling incoming products
  - ◊ Ensure that Receiving Inspection Instructions are prepared for incoming products where applicable and document on WOA (see GPG 4520.2) using GSFC RITS
  - ◊ Ensure that Receiving Inspection Instructions are executed and that any non-conformances are documented on WOA and on the appropriate non-conformance form (see GPG 5100.1)
- Provide input for evaluation for Supplier Performance Records (see GPG 5100.1)
- Ensure that test equipment and test software is working properly and maintain records of this verification

- Have a process for controlling and safe-guarding any customer-supplied product
  - ◊ Inform the customer and obtain authorization if repair or rework is required of the customer supplied product
  - ◊ Document any damage or malfunction of customer supplied product and report to the customer for disposition of the product
- Ensure that any products requiring handling, storage or shipping are processed according to the GPG 6400.1. Retain shipping records on Form 20-4.

Roles and Responsibilities of the Team

- Defines their mission, vision, and objectives based on their customer's objectives and ISD strategic implementation goals
- Identify customer expectations and develop metrics to ensure that those expectations are met quantitatively and qualitatively
- Establish effective communications mechanisms to facilitate the change process and to avoid misunderstandings
- Identify customer supplied resources and information that will be needed for the successful completion of the project
- Record effort and progress in the form of project metrics. Specific metrics are listed in Appendix G.

With respect to QMS (ISO 9001) compliance, the Team specifically needs to:

- Know the GSFC Quality Policy and how it affects products and processes
- Have an easy access to all processes required for the job
  - ◊ All ISD projects must have written processes for performing their work functions that typically include development, testing, configuration Management, systems engineering, analysis, quality assurance, maintenance, and operations. The primary duties that you perform must have written processes describing how they are done.
  - ◊ Relevant processes for your job must be written, reviewed, approved (signed by an authorized person), available (you must have access), current (up to date), and followed
  - ◊ Know how processes you use are improved or changed. The use of defect analysis, customer feedback, internal reviews, and results from the overall measurement program help guide changes to all ISD and project processes
  - ◊ Know that a master document list identifying the acceptable processes for performing your job exists and must be used
- Discard or appropriately mark all outdated controlled documents
  - ◊ Documents that fall into this category are those contained in Product Plan master list or on the ISD master list. Each project must establish a related process.
  - ◊ Old versions of controlled documents must be marked as obsolete or outdated. A simple handwritten identifier suffices.
- Know where project schedules for reviews and tests are identified

- ◊ Tests (such as system tests or regression tests) and reviews (such as design reviews) must be identified and scheduled in the Product Plan

- Know how defects found in project products are recorded, tracked, corrected
  - ◊ As problems such as "bugs" are found in testing or in the inspection or review process, you must be aware of how such problems are handled for products you are working on. You must be able to refer to some written process that describes how that problem is handled.

- Be aware of and use inspection and test processes for products during development and before delivery
  - ◊ Almost all individuals on the Team participate in the generation of some intermediate or end product such as software, included data bases, data products, documents, or full systems. Each individual must be aware of what inspections take place and where that inspection is defined in a written process.

- Be able to produce records of all inspections, tests and reviews
  - ◊ There must be evidence that activities in your processes have been completed and recorded
  - ◊ Know where quality records are maintained

- Know how each unique version of a system or product is identified and controlled
  - ◊ Different versions of products such as software systems and documents under development or data files to be delivered must have some unique identifier to ensure that erroneous or incorrect versions are not used

- Know how you are qualified to do your work, how training is offered, and how work assignments are made
  - ◊ You are qualified to do your job because of your education and experience, which must meet GSFC job descriptions, and identifies any needed training to meet your work assignment. Each year the performance appraisal review reassesses your capabilities, including both formal and relevant OJT experiences.
  - ◊ A training handbook is provided each year listing available courses. Formal training records are kept in your personnel folder.
  - ◊ Be aware of how work is assigned to you and who assigns you work. Your work is assigned by your immediate supervisor.

- Follow the processes that pertain to your job and maintain appropriate records
  - ◊ The most important responsibility to ensure QMS compliance is for you to adhere to the processes that pertain to your job. Those processes designated for your use must be applied, and appropriate records must be kept as defined by the processes.

ISD Chief

From Section 2:

- Ensure a Team Lead is identified

- Ensure the Team Lead and Team consist of qualified individuals

From Section 3:

- Designates the ISD Management Team member responsible for the approval of any Product Plan covered by this handbook.

From Section 4:

- Establish a continuous improvement process for improving the Business Development Process and the Product Development Handbook

ISD Management Team

From Section 2:

- Develop individual skills, Team skills and centers of expertise
- Select and provide qualified Team Leads and Team members
- Define the Team and Team Leads responsibility, authority and accountability for delivering quality products
- Document any "required" training needs or OJT of employees in accordance with GPG 3410.2
- Ensure that training received using funds other than GSFC training funds is documented either in the employee's official or unofficial personnel folder

From Section 3:

- Ensure that the approaches taken by the Team stay aligned with ISD Strategic Implementation Plan
- Ensure that the Team obtains necessary resources in a timely and effective manner
- Reviews and approves the Team's Product Plan
- Effectively remove barriers which impede a Team's progress
- Ensure and defend the Team's empowerment rights throughout the process
- Document the process for reviewing and changing Product Plans (customer agreements)
- Facilitate support that the Team cannot provide themselves
- Ensure customer inputs for the Team Lead's performance plans and evaluations are made and maintained (appropriate supervisor)
- Ensure Team Lead's inputs for the Team performance plans and evaluations are made and maintained (appropriate supervisor)
- Provide training to Team members as requested by the Team Lead
- Document any identified training needs of employees on Performance Plan
- Ensures that training received using funds other than training funds is documented on the OHR Employee Training Records
- Document any required OJT on GSFC form 17-112 (see GPG 3410.2)
- Identify any specific processes requiring qualification (see GPG 3410.2)

- Allocate resources as requested by the Team and approved

From Section 4:

- Ensure the ISD Quality Manual (i.e., the Product Development Handbook) remains aligned with the GSFC Quality Manual
- Review GSFC Quality Management System as requested for recommended improvements
- Ensure alignment of organization to the ISD Quality Manual
- Define responsibilities and authority for delivering quality products

ISD/QMS Representative

From Section 5:

- Represent ISD at the Directorate level in all matters concerning QMS (ISO 9001) certification implementation and maintenance
- Direct all activities pertaining to QMS (ISO 9001) within ISD
- Overall responsibility for maintaining the ISD Quality Manual (Product Development Handbook)
- Review newly developed Team Processes specified in the Product Plan
- Overall responsibility for adding/deleting/maintaining the ISD Library of Approved Team Processes
- Review newly developed Team Processes specified in the Product Plan
- Overall responsibility for adding/deleting/maintaining the ISD Library of Approved Team Processes

ISD Document Configuration Manager

From Section 5.1:

- Assign identification numbers for quality records, documentation and data
- Maintains a list of ISD level quality records and configuration controlled items, date or identification number/letter, their locations and their owners
- Obtains approval for deletion of items from controlled list from the ISD Management Team

Available Contracts Data Base Administrator

From Section 3:

- Maintain a data base of current contracting mechanisms (hardware, software, manpower) that have demonstrated acceptable performance
- Details of the information and format for this database may be found in the Supplier Performance Records, GPG 5100.2

Appendix F: Required Team Processes & Functions

Below are listed the criteria for Team processes required to be defined in the Product Plan. This definition of processes may be done by reference acceptable existing Team processes located at http://isc.gsfc.nasa.gov/ISO9k/ISO9001.htm or by direct inclusion in the Product Plan itself. Below each process name in this section are listed the criteria required for QMS 9001 compliance that must be performed in the process. The Team may develop their own process as long as the criteria listed here are satisfied. The ISD/QMS Representative has the responsibility for independently reviewing the Team Product Plans to ensure that the processes defined are ISO 9001 compliant. New processes documented by Teams and found to be QMS compliant, will be added to the acceptable Team Processes database by the ISD/QMS Representative for use by reference by subsequent Teams (see process in Section 5.2).

Criteria 1 - Development Methodology (GPG 8072.1)

1. Are requirements documented and agreed upon between customer and Team?

2. Are changes to requirements and software documented according to Team configuration management process?

3. Is Team collecting and documenting an agreed upon set of metrics in order to manage the development?

4. Is Team developing a proposal for method of satisfying customer requirements, determining use of Off-the-Shelf or new development, and considering customer's cost, schedule and quality? Is proposal reviewed with and approved by customer?

5. Have organizational and technical interfaces between different groups which input into the design process been defined?

6. Does the design output identify those characteristics in the design that are crucial to the safe and proper functioning of the product?

7. Are records of design reviews maintained as quality records?

8. Are design verification measures recorded? (quality records)

9. Are design changes and modifications identified, documented, reviewed and approved by authorized personnel prior to their implementation?

10. Is Team verifying design against customer requirements and documenting the results?

The following are methods of performing such reviews: a) reviews such as preliminary or critical design reviews, b) Team reviews, c) design walkthroughs, d) prototyping

11. Has Team selected a development methodology to control the quality of the software being developed? A methodology addresses design, development, testing and delivery of a system.

Methodology may also address the following:

- Programming rules
- Programming language

- Naming conventions
- Standards for commentary (program design language, comments).
- Code reading

12. Are software deliveries tested against customer requirements and results documented?

13. Are delivery schedules and contents of software deliveries agreed upon with the customer and the Team and documented? Is test status of the delivery discussed with the customer prior to delivery and documented?

Criteria 2A - Control of Documents and Data (GPG 1410.1)

These questions shall be addressed for this process:

1. Is there a documented process for control of all documents and data that relate to the quality system?

2. Does the document control process include documents of external origin such as standards and customer requirements?

3. Are documents and data reviewed and approved by authorized personnel prior to use?

4. Is there a master list or equivalent document control process that identifies the current revision status of documents and is it readily available?

5. Do controls ensure that:

   a) Pertinent issues of appropriate documents are available at all locations where operations essential to the effective functioning of the quality system are performed?

   b) Invalid and/or obsolete documents are promptly removed from all points of issue or use, or otherwise assured against unintended use?

   c) Any obsolete documents retained for legal and/or knowledge-preservation purposes are suitably identified?

6. Are changes to documents and data reviewed and approved by the same function/organization that performed the original review and approval?

7. If specified otherwise, do the designated functions/organizations have access to pertinent background information upon which to base their review and approval?

8. Is the nature of the change identified in the document or appropriate attachment where practicable?

Criteria 2B - Control of Quality Records (GPG 1440.7)

1. Has the supplier established documented processes for control of quality records and does this process include: a) Identification? b) Collection? c) Indexing? d) Access? e) Filing? f) Storage? g) Maintenance? h) Disposition?

2. Are quality records maintained to demonstrate conformance to specified requirements and the effective operation of the quality system?

3. Are pertinent quality records from subcontractors an element of this data?

4. Are all quality records legible?

5. Are all quality records stored and retained in such a way that they are readily retrievable?

6. Are all quality records stored in facilities that provide suitable environment to prevent damage or deterioration and to prevent loss?

7. Are quality records made available for evaluation by the customer or customer's representative for an agreed period, where agreed contractually?

Criteria 3 - Control of Customer Supplied Elements (GPG 5900.1)

1. Have documented processes been established for control of verification, identification, storage and maintenance of customer supplied product?

2. Do the processes for customer supplied product include provisions for recording and reporting to the customer a product that is lost, damaged or otherwise unsuitable for use? (For projects, use the NCR/CA system)

Criteria 4 - Identification and Traceability of Products (GPG 5310.4)

Traceability should include how builds and releases are identified including identification of components that comprise the build or release.

1. Are documented processes established for identified items and products by suitable means from receipt and during all stages of production, delivery and installation?

2. Are documented processes available for traceability where appropriate?

3. When traceability is a specified requirement is the product thereof uniquely identified?

4. Is this identification recorded?

Criteria 5 - Product Inspection and Test Approach (GPG 5330.1)

1. Has the supplier established documented processes for inspection and testing activities in order to verify that the specified requirements are met?

2. Does the quality plan or documented process state the required inspection or tests and the records to be established?

3. Does the supplier ensure that incoming product is not used or processed until it has been inspected and determined to be conforming? (Except in circumstances as noted below in question 6)

4. Is verification of conformance to the specified requirement in accordance with the quality plan and/or documented processes? All inspection of Commercial-Off-the-Shelf products should be based on kind, count, and condition unless specified otherwise in the procurement. See GPG 4520.2. All problems with incoming products should use processes defined in Criteria 6. Results of all inspections are quality records.

5. Is consideration given to the amount of control exercised at the subcontractor's premises and recorded evidence of conformance when determining the amount and nature of receiving inspection?

6. If incoming product is released for urgent production is it positively identified and recorded in order to permit recall and replacement in the event it is later determined to be nonconforming?

7. Is the product inspected and tested as required by the quality plan or documented processes?

8. Is product held until the required inspections and tests have been completed or necessary reports have been received and verified? (Except as noted in question 6 above)

9. Are all final inspections and test carried out in accordance with the quality plan and/or documented processes?

10. Do quality plans or documented processes require that all specified inspections and tests (including receiving and in-process inspections and tests) have been carried out and the results meet specified requirements?

11. Do the suppliers processes ensure that no product is dispatched until all activities specified in the quality plan or documented processes have been satisfactorily completed and the associated data and documentation is available and authorized?

12. Are records established and maintained which provide evidence that the product has been inspected and/or tested?

13. Do the records clearly show whether the product has passed or failed the inspection and/or tests according to defined acceptance criteria?

14. Do records identify the inspection authority responsible for release of the product?

Criteria 6 - Control of Test Equipment and Software (GPG 8730.1)

1. Are documented processes established to control, calibrate and maintain inspection, measuring and test equipment (including test software) that is used to demonstrate the conformance of the product to the specified requirements?

2. Is inspection, measuring and test equipment used in a manner which ensures that the measurement uncertainty is known and is consistent with the required capability?

3. Is test software or comparative references such as test hardware checked to prove that they are capable of verifying the acceptability of product prior to release for production, installation or servicing?

4. Is test software of comparative references such as test hardware rechecked at prescribed intervals?

5. Has the supplier established the extent of such checks and are records of these checks maintained?

6. Is technical data pertaining to inspection, measuring and test equipment made available to the customer or customer's representative when this is a specified requirement?

7. Has the supplier determined the measurements to be made and the accuracy required?

8. Are the appropriate inspection, measuring, and test equipment selected that are capable of the necessary accuracy and precision?

9. Is all inspection, measuring, and test equipment that can affect product quality identified, calibrated and adjusted at prescribed intervals, or prior to use, against verified equipment having a known valid relationship to internationally or nationally recognized standards?

10. Where no such standards exist is the basis for calibration documented?

11. Has the process to be employed for calibration of inspection, measuring, and test equipment been defined? Including details of: a) Equipment type? b) Unique identification? c) Location? d) Frequency of checks? e) Check method? f) Acceptance criteria? g) Action to be taken when results are unsatisfactory?

12. Is inspection, measuring and test equipment identified with a suitable indicator or approved identification record to show the calibration status?

13. Are calibration records maintained for inspection, measuring and test equipment?

14. Is the validity of previous inspections and test results assessed and documented when inspection, measuring and test equipment is found to be out of calibration?

15. Does the supplier ensure that the environmental conditions are suitable for the calibration, inspections, measurements and test to be carried out?

16. Does the supplier ensure that the handling, preservation and storage of inspection, measuring and test equipment is such that the accuracy and fitness for use is maintained?

17. Are inspection, measuring and test facilities, including both test hardware and test software, safeguarded from adjustments which would invalidate the calibration testing?

Criteria 7 - Control of Nonconforming Product (GPG 5340.2)

1. Has the supplier established a documented process to ensure that product that does not conform to specific requirements is prevented from unintended use or installation?

2. Does the control provide for: a) Identification? b) Documentation? c) Evaluation? d) Segregation (when practical)? e) Dispositioning?

3. Does the control provide for notification of the functions concerned?

4. Is the responsibility for review and authority for the disposition of nonconforming product defined?

5. Is nonconformance documented in the on-line Nonconformance Form and information on the use of the form is found in the GSFC GPG 5340.2 located at http://arioch.gsfc.nasa.gov/ISO9000? This form should be used only for those nonconformities specified in the GPG 5340.2. All nonconformities shall be retained in the Product Team's database. Nonconformities at the Project level should begin when a new release has been delivered to the customer. All nonconformances shall be cross-referenced to the software product work authorization form.

6. Is nonconforming product reviewed in accordance with documented processes? Are the following options considered? a) Rework to meet the specified requirements? b) Accept with or without repair by concession? c) Regrade for alternative standards? d) Reject or scrap?

7. When required by the contract, is the proposed use or repair of the product, which does not conform to specified requirements, reported for concession to the customer or the customer's representative?

8. Is the description of the nonconformity that has been accepted, and of repairs, recorded to denote the actual conditions?

9. Is repaired and/or reworked product reinspected in accordance with the quality plan and/or documented processes?

Criteria 8 - Preventive and Corrective Action (GPG 1710.1)

Product Teams are expected to have their own documented corrective and preventive action process with attributes described below. However, any nonconformance which meets the criteria specified in the Control of Nonconforming Products (GPG1710.1) and has been entered into the Project Nonconformance Report database will be tracked and closed out by the Project, using the processes described in GPG 1710.1.

1. Does the supplier have documented processes for implementing corrective and preventive action?

2. Is the magnitude of the problem and the risks encountered taken into account when corrective and preventive action is taken to eliminate the causes of actual or potential nonconformities?

3. Are changes to the documented processes resulting form corrective and preventive action implemented and recorded?

4. Do the processes for corrective action include: a) The effective handling of customer complaints and reports of product nonconformities? b) Investigation of the cause of nonconformities relating to product, process and quality system, and recording the results of the investigation? c) Determination of the correction action needed to eliminate the cause of nonconformities? d) Application of controls to ensure that corrective action is taken and that it is effective?

5. Do the processes for preventive action include: a) The use of appropriate sources of information such as: i) Processes and work operations which affect product quality, ii) Concessions, iii) Audit results, iv) Quality records, v) Service records, vi) Customer complaints to detect, analyze and eliminate potential causes of nonconformities? b) Determination of the steps needed to deal with any problems requiring preventive action? c) Initiation of preventive action and application of controls to ensure that is effective? d) Ensuring that relevant information on actions taken is submitted for management review?

Criteria 9 – Process for Product Maintenance

1. Where servicing (maintenance) is a specified requirement, has the Team established documented processes for: a) Performing, b) Verifying, c) Reporting that servicing meets the specified requirements?

Criteria 10 - Process for Process and Product Metrics Analysis (GPG 1710.1)

1. Has the Team identified the need for statistical techniques required for a) Establishing b) Controlling c) Verifying process capability and product characteristics?

2. Has the Team established documented processes to implement and control the application of the statistical techniques identified above?

3. Has the Team identified the method to used to analyze the collected metrics from the product production and the method by which such analysis information will be fed back into the improvement of the process for the next production process?

Appendix G: Mandatory Team Metrics

Table 1 lists the required(1) metrics which all Product Teams are expected to collect, record, and periodically analyze for process improvement potential. The intent is to reduce the number of parameters to a set that is meaningful to the team in managing, assessing, and improving their own internal performance. Since many teams have not previously been required to collect metrics in any specific format or units and are in mid-development, the Team Lead may specify in the product plan the format and units of the metrics collected and the frequency at which they are collected. Table 2 provides a recommendation for the units of the metrics and the frequency of their collection. The information will be analyzed across similar and dissimilar activities to assess best practices and help identify potential for process improvements.

Metric Group	Metric
Project	Name
Schedules	Major milestones (including reviews, test dates, release and build delivery dates) (2) Quantification of progress (3)
Cost	Budget in dollars, under the responsibility of the Team Civil service effort (4) Contractor effort (4)
Quality	Open problem reports (5)

Table 1 - Required Metrics

Notes:

(1) If it is determined that this set of metrics is not meaningful an exception for the collection of some or all of these metrics may be granted by the appropriate Branch Head. Metrics are not meaningful if the Team or ISD cannot use them for managing, assessing, or improving the team's internal performance; or for comparison with similar Teams to assess the effectiveness of ISD processes. This exception will be specifically documented in Section 4.3 of the Team's Product Plan.

(2) Expected project milestones should be recorded as part of the design planning activities.

(3) Quantification of progress may be kept in one of the following ways:

a) By using an earned value system, with each activity assigned a relative weight (or number of points)

b) As a checklist of activities to be completed versus those completed

c) As a collection of regular periodic progress reports

(4) Civil service (or contractor) effort may be recorded in staff months or as a percentage of the total time a person is assigned to the Team. Civil Service effort may be based on requested support instead of actual accumulated manpower if not readily accessible, but should reflect actual personnel assignments when the two significantly deviate.

(5) Open problem reports should be the number of unresolved problems or discrepancies listed in the minor NCR/CA system or the Goddard NCR/CA system.

Metric Group	**Metric**	**Units**	**When Recorded (1)**
Project	Name	Names	At project start
Schedules	-Planned major milestones. Should include the following: Reviews Documentation (including ICDs) Tests Releases/builds Procurements External Deliveries to Team -Actual major milestones. See above -Quantification of progress	 Milestone Dates Start/Stop Dates Start/Stop Dates Start/Stop/Delivery Dates Start/Key/Delivery Dates Milestone Dates Same as above Earned value point system	-During project planning activities -Schedules should be updated for changes in plan -At completion of milestone -On a continuing basis
Cost	-Budget for: COTS hardware COTS software COTS software maintenance COTS hardware maintenance -Civil service manpower estimated(2) -Civil service actual(3) -Contractor manpower estimated -Contractor manpower actual -Training (4) -Travel	 Dollars by fiscal year Dollars by fiscal year Dollars by fiscal year Dollars by fiscal year Staff months Staff months Staff months Staff months Number of classes Number of trips	-Initial planned budget numbers should be recorded during the project planning activities. Budget expenditures should be monitored on a periodic basis and compared with the planned budget
Non Conform-ances (5)	-Open nonconformances -Number of nonconformances due to: >requirements misinterpretation >missed requirements > improper implementation > poor performance >Cosmetic	Numbers and severity Numbers and severity Numbers and severity Numbers and severity Numbers and severity Numbers and severity	-On a continuing basis -On a continuing basis
System Changes (6)	-Number of changes due to: >New requirements >Modified requirements >Deleted requirements	Number	-On a continuing basis

Table 2: Recommended Metrics

Notes:

1) Unless otherwise noted, metrics are collected at the project start, at key reviews and releases. Maintain a log of reasons for changes.

2) Estimated Civil Service effort may be based on requested support.

3) Actual Civil Service manpower should reflect actual personnel assignments if actual accumulated manpower is not readily available.

4) Training should represent the number of classes that Team members plan to and/or have taken (if two people take the same class, that counts as 2 classes).

Travel should represent the number trips that Team members plan to and/or have taken (if two people go on the same trip, that counts as two trips).

5) This is to include errors only, not Customer requested changes to the system (see System Changes). For each type of error, include the cumulative number that have been identified and the cumulative number that have been recorded in the GSFC NCR system. Also for each non-conformance, record the level of severity, where "High" implies that the software problem(s) are serious and cannot/should not be used, where "Medium" implies that the problem is serious but that the software is usable (possibly with work-around), and where "Low" implies the problems are not serious.

6) These are Customer directed changes that may result in a change to cost, schedule and/or size, and should be logged as required. Only the number of times this has occurred is to be recorded, NOT actual number of requirement changes. There is no attempt to normalize changes, but to just record the number of times redirection has occurred, even if proposed by the Team and accepted by the Customer.

Appendix H: References

1. Product Development Handbook

   http://isc.gsfc.nasa.gov/ISO9k/pdh/PDH.pdf

2. Strategic Implementation Planning Process

   TBD

3. Yearly Action Planning Process

   TBD

4. Library of Approved Team Processes

   http://isc.gsfc.nasa.gov/ISO9k/ISO9001.htm

5. GSFC Quality Management System Manual (ISO 9001)

   http://arioch.gsfc.nasa.gov/ISO9000/index.htm

Appendix I: Acronym List

AETD	Applied Engineering and Technology Directorate
CA	Corrective Action
COTS	commercial off-the-shelf
EPG	Engineering Process Group
GOTS	government off-the-shelf
GPG	Goddard Procedure and Guidelines
GSFC	Goddard Space Flight Center
ICD	interface control document
ISD	Information Systems Division
ISO	International Organization of Standardization
NASA	National Aeronautics and Space Administration
NCR	Non-Conformance Report
OBE	on-board equivalent
OHR	Office of Human Resources
OJT	on the job training
PD	position description
PG	Procedures and Guidelines
QM	Quality Manual
QMS	Quality Management System
RFA	Requests for Action
RITS	Receiving Inspection and Test System
S/W	software
TBD	to be determined
URL	uniform resource locator
WOA	Work Order Authorization