	DRYDEN PROCEDURAL REQUIREMENT	**Directive:**	**DPR-7123.1**
		Effective Date:	November 5, 2007
		Expiration Date:	November 5, 2012

This document is uncontrolled when printed.
Before use, check the Master List to verify that this is the current version.
Compliance is mandatory.

RESPONSIBLE OFFICE: X/Office of the Chief Engineer

SUBJECT: Systems Engineering Requirements Document

Kevin Petersen

Kevin Petersen
Director

11/9/07
Date

CONTENTS

PREFACE

P.1 Purpose

The purpose of this document is to establish the Center's requirements for the implementation of systems engineering practices in accordance with NPR 7123.1. Systems engineering is a logical systems approach performed by multidisciplinary teams to engineer and integrate the Center's systems to ensure products meet customers' needs. This systems approach is applied to all elements of a system and all hierarchical levels of a system over the complete project life cycle. In addition, the Center's interpretation of specific elements of AS9100 is defined to ensure that the Center's implementation incorporates the fulfillment of these requirements.

P.2 Applicability

This document and the requirements identified within it apply to all flight projects and major ground support system development projects managed by the Center. It applies to products that are intended to be flown as well as (to the greatest extent practical) products used in direct support of flight, including experiments, simulation, and software used for verification or validation of flight products. To the extent practical, it also applies to Center products affecting flight, such as office software tools. This includes products designed for flight research, such as analysis tools, corrective action systems, and configuration management systems, etc.

Through partnerships with industry, academia, other NASA Centers, and other government agencies, the Center enters into projects at various stages of their lifecycles, often just prior to the operations phase. The applicability of this DPR and other Center requirements will be identified during the negotiation of the partnership agreements. In cases where these requirements are not invoked, a suitable alternate systems engineering approach will be identified.

Many other discipline areas such as safety, medical, reliability, maintainability, quality assurance, information technology, security, logistics, and environmental, etc., perform functions during project life-cycle phases that influence or are influenced by the engineering organizations, and the requirements of those functions need to be fully integrated with the engineering functions. The interactions of the engineering processes with these enabling processes are described in the Dryden Management Systems Manual.

P.3 Authority

NPR 7120.5D	NASA Space Flight Program and Project Management Requirements
NPR 7123.1A	NASA Systems Engineering Processes and Requirements
NPR 1280.1	NASA Management System Policy
NPR 7150.2	NASA Software Engineering Requirements

P.4 Applicable Documents

DCP-P-005	Project Formulation and Approval
DCP-P-006	Objectives and Requirements Documents (ORD)
DCP-R-603	Flight Loads Laboratory Operations Requirements Document
DCP-R-604	Flight Load Laboratory Thermal-Structural Ground Test Hazard Analysis
DCP-S-007	Software Assurance
DCP-X-008	Tech Brief (T/B) & Mini Tech Brief (Mini T/B)
DCP-X-009	Airworthiness and Flight Safety Review Process
DCP-X-020	Flight Operational Readiness Review (ORR) and Operational Readiness Review Panel (ORRP)
DCP-X-044	Processing of Agreements from Review to Signature
DHB-O-001	Operations Engineer's Handbook
DHB-P-002	Project Managers' Handbook
DHB-R-002	Objectives and Requirements Document Handbook
DHB-R-007	Project Chief Engineer's Handbook
DHB-X-001	Airworthiness and Flight Safety Review, Independent Review, Mission Success Review, Technical Brief and Mini-Tech Brief Guidelines
DOP-M-106	Western Aeronautical Test Range (WATR) Mission Control Center (MCC) Systems Software Acceptance Testing
DOP-P-003	Mission Development and Implementation
SAE AS9100	Aerospace Quality Management Systems Standard

P.5 Measurement/Verification

The methods to ensure compliance with this DPR and NPR 7123.1 will be documented in the SE implementation procedures and through internal and external assessments and audits.

P.6 Cancellation

None

CHAPTER 1: INTRODUCTION

1.1 Project Lifecycle

A. The Dryden system engineering requirements are defined to establish a standard, disciplined engineering approach to systems development throughout the lifecycle of a project. In alignment with NPR 7120.5D and NPR 7123.1, the project lifecycle shown in Figure 1 has been defined for projects performed by the Center.

B. The lifecycle is intended to be a standard for the Center's projects, but it is common for the Center to enter into partnerships with external entities on existing projects at various stages of their lifecycles. The requirements of this DPR should be followed to ensure consistency between all projects being conducted at the Center.

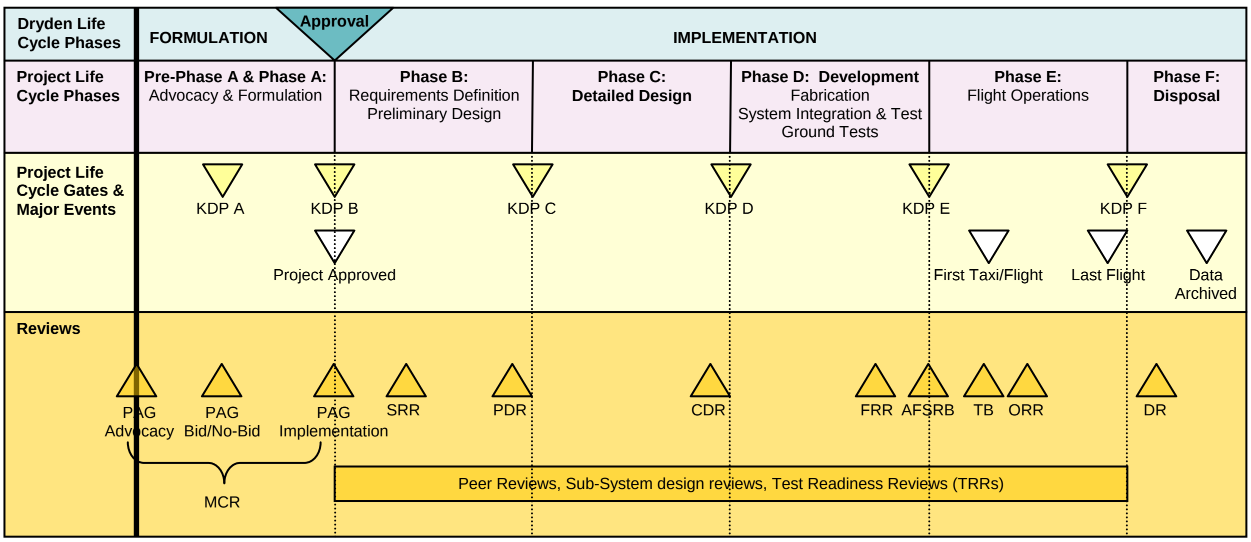

Figure 1. Dryden Project

Acronyms:

KDP – Key Decision Point
PAG – Project Approval Group
SRR – Systems Requirement Review
PDR – Preliminary Design Review
CDR – Critical Design Review
MCR – Mission Concept Review
FRR – Flight Readiness Review
AFSRB – Airworthiness and Flight Safety Review Board
TB – Tech Brief
ORR – Operational Readiness Review
DR – Data Review
TRR – Test Readiness Review

1.2 DPR Scope

This DPR:

A. Establishes a set of systems engineering activities to be performed during each phase of the lifecycle. These activities include, but are not necessarily limited to:

- Planning and Documentation
- Reviews/Briefs

- Products
- Milestones/Activities

B. Defines the entry and exit criteria for the lifecycle reviews

C. Identifies how the required activities can be supplemented and tailored to achieve specific project requirements

D. Identifies SAE AS9100, Aerospace Quality Management Systems Standard, requirements related to systems engineering functions

1.3 Roles and Responsibilities

Per NPR 7123.1, Section 2.3, the Designated Governing Authority (DGA) for the technical effort described in this DPR begins with the Dryden Center Director. From there, authority is delegated to the Associate Director of Operations. Authority for issues that relate to the application of aircraft airworthiness standards for modification, operation, or maintenance of aircraft are further delegated through the Director of Operations to a project's Lead Operations Engineer. Authority for issues related to the application of technical requirements and standards, including the approval of waivers, are delegated to the Project's Chief Engineer through the Director for Research Engineering. See Figure 2 for a graphical representation of this process.

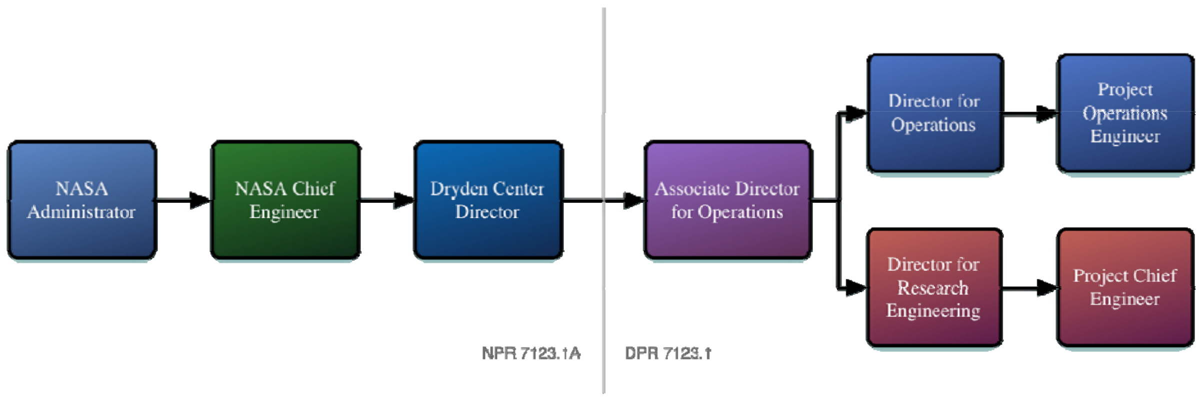

Figure 2. Flow of Technical Designated Governing Authority at Dryden

1.4 Systems Engineering Management Plan

A Systems Engineering Management Plan (SEMP) is used to document the technical content of each project and is a "living" document, updated throughout the project's lifecycle. Guidance for the creation of a SEMP and a template are found in DHB-R-007, Project Chief Engineer's Handbook.

1.5 Risk Management

Risk Management at all program levels must be an inherent part of all systems management program planning and lifecycle activities. The project's overall approach to managing technical risk should be described in the SEMP. In addition, a project Risk Management Plan should be developed that describes:

- The project's overall risk policy and objectives

- The programmatic aspects of the risk management activities (roles and responsibilities, resources, and schedules, etc.)
- A description of the methodologies, processes, and tools to be used for risk identification, characterization, tracking, and mitigation
- Documentation requirements for each risk management product and action

CHAPTER 2: ENGINEERING LIFE CYCLE REQUIREMENTS

2.1 Pre-Phase A & Phase A: Advocacy and Formulation

As stated in Chapter 1, Dryden enters into projects at various stages of their development lifecycle. Regardless of their maturity, all Dryden projects are required to follow a standard advocacy and formulation process as described in DCP-P-005, Project Formulation and Approval. While many of the activities and products of the advocacy and formulation process are programmatic in nature, there are systems engineering activities (i.e., planning) that occur during this phase that are critical to ultimate success of a project

2.1.1 Required Documentation

A. The following items shall be documented in the formulation process by the project team. The format for the documentation of these items may vary depending on the scope and complexity of the project and the formulation timeline. The following items should be identified in a draft Project Plan (see DHB-P-002, Project Managers' Handbook, for a description) prior to project implementation approval:
   - Project technical objectives – Determined by negotiation with the stakeholders / customers. Includes project success and failure criteria.
   - Preliminary technical approach – Initial identification of the technical work required to meet the project objectives.
   - Preliminary technical risk assessment – Identification of the risk associated with the preliminary technical approach
   - Preliminary Ops Concept

B. The following items should be identified in the draft SEMP:
   - Draft top-level Work Breakdown Structure (WBS) – An organized identification of top-level project technical elements aligned with the preliminary technical approach.
   - Preliminary review plan – A plan for technical reviews will be negotiated with the Dryden Chief Engineer during the formulation process.

2.2.2 Configuration Control

The draft SEMP should define a project configuration control process for the project that will manage, document, and communicate changes to objectives, requirements, design, and plans, as well as all hardware and software elements of the system. Participation by entities outside of Dryden, including interfaces with other configuration control processes, must be clearly stated.

2.2 Phase B: Requirements Development and Preliminary Design

2.2.1 Requirements Development

Following project approval, the technical team is responsible for identification of technical requirements to accomplish the project objectives and comply with Center and Agency process and product standards. While simple in concept, the process of requirements development is different for every project. Regardless of the scope and complexity of the project, the process of system requirements development will:

- Identify customer need, stakeholder requirements, and mission objectives. (Includes Program Commitment Agreements (PCAs))
- Ensure there is a common understanding of the operational concept of the system, including nominal and off-nominal mission scenarios. This is usually documented in a Concept of Operations Document (ConOps).
- Use a top-down approach, flowing from the mission objectives.
- Identify required functional and physical characteristics that are measurable and verifiable.
- Identify requirements that must be considered for compliance with Agency and Center process standards. Requirements should address institutional disciplines including, but not limited to, hardware and software quality assurance, reliability, manufacturing, maintenance, operational safety, environmental safety, range and public safety.
- Fully define the requirements at the system level, including user requirements (What is the concept of operation?), functional requirements (What must the system do?), performance requirements (How well must the system perform?) and constraints (How is the design, development, or operation limited?).
- Identify those requirements that describe key characteristics, as defined later in this document.
- Ensure each requirement is correct, clear, consistent, complete, unambiguous, verifiable, independent, and traceable.
- Include the appropriate rationale for each requirement.
- Perform requirements management, an iterative process of defining, allocating, tracking, collecting metric, controlling, and verifying technical requirements, that meet all the customer’s expectations.

- Culminate with a review of the requirements at a System Requirements Review (SRR). Criteria for the SRR will be defined later in this document.

2.2.2 Requirements Documentation

A. The process used to collect and document the various requirements will vary depending on system size and complexity. A common practice at Dryden is the utilization of an Objectives and Requirements Document (ORD) to collect system requirements, flight test requirements, and research requirements from the various technical disciplines. The ORD process is defined in DHB-R-002, Objectives and Requirements Document Handbook, and DCP-P-006, Objectives and Requirements Documents (ORD). Use of the ORD is accepted practice, but other methods of collecting multidisciplinary requirements may be acceptable.

B. For more complex systems, the collected set of requirements should be documented in a single “living”, configuration-controlled System Requirements Document (SRD).

C. The Requirements Document will include information on requirement traceability and identify those requirements that reflect key characteristics.

D. The Project Chief Engineer, the Project Operations Engineer, and the Project Manager shall approve the SRD.

2.2.3 Preliminary Design

A. During the Preliminary Design phase, the decomposition of subsystem requirements continues and design concept trade studies are performed. A preliminary design is defined and evaluated against all defined system requirements. The preliminary design is utilized to determine top-level verification and validation plans for each of the system requirements.

B. The following systems engineering activities will occur during the preliminary design phase:

- Perform design trade studies to identify a candidate architecture that best satisfies the defined requirements within the defined constraints, while at the same time carrying an acceptable level of risk.
- Perform modeling and simulation as required for risk reduction activities.
- Create a top-level physical system architecture baseline depiction of the system.
- Assign configuration items to the major hardware and software elements as appropriate based on the design concept.

- Allocate system requirements to the hardware and software configuration items based on the chosen architecture.
- Continue the definition and decomposition of requirements for each of the defined subsystems until a level of definition is reached where each element can either be procured or fabricated. Ensure that traceability between parent and child requirements is maintained and key characteristics are identified.
- Produce draft versions of hardware and software development and integration plans.
- Produce draft versions of system verification and validation plans describing how the system will be tested and evaluated against the requirements.
- Identify those requirements that will be verified by analysis, and determine the type and scope of analyses to be performed.
- Conduct preliminary hazard analysis and risk reduction activities.
- Conduct a Preliminary Design Review (PDR). Criteria for the PDR will be defined later in this document. For complex systems, multiple PDRs may be required to cover all subsystems.

2.3 Phase C: Detailed (or Critical) Design Phase

A. During the detailed design phase (also known as Critical Design phase), the system and subsystem design continues in preparation for the release of procurement or fabrication orders in accordance with the appropriate software or hardware design processes defined in the Dryden Management System.

B. The following systems engineering activities will occur during the detailed design phase:

- Finalize and approve architecture (physical and functional).
- Finalize and approve all hardware and software development and integration plans.
- Finalize and approve system verification and validation plans.
- Finalize hazard and technical risk analysis.
- Maintain configuration control of all approved documents.
- Perform requirements management, update requirements documentation as required if new or changed requirements are identified, and provide traceability to the top WBS model requirements.
- Coordinate design configurations to integrated schedule.
- Maintain configuration control over the system design to verify continued compliance with approved requirements.
- Conduct the Critical Design Review (CDR), the culmination of the engineering activity in this phase. The criteria for the CDR are defined later in this document.

- Finalize design drawings, part list, materials, and engineering instructions that enable fabrication and builds.

2.4 Phase D: Fabrication, System Integration, and Test

A. Systems engineering diligence is key to the success of this critical phase, during which the system is produced and qualified for flight through analysis and test. Close coordination between the system designers, fabricators, and testers is vitally important during this phase.

B. Systems engineering tasks during this phase will:

- Ensure that design documents are properly approved and submitted to the fabricators, coders, and/or suppliers in accordance with Center procedures.
- Maintain active configuration control of the interfaces for external and internal interfaces of the system, subsystem, and components.
- Ensure that key characteristics of the design are monitored and checked appropriately.
- Maintain active configuration control during the production effort, ensuring that discrepancies noted during production are properly identified and dispositioned.
- Ensure that components, subsystems, and systems are tested in accordance with the approved testing and verification/validation plans.
- Ensure the planned analyses are performed, documented, and reviewed.
- Maintain active configuration control during the testing efforts, ensuring that discrepancies noted during tests are properly identified and dispositioned.
- Ensure that requirements changes, test plan changes, or waiver requests are properly documented and approved.
- Ensure that test results are properly documented and controlled.
- Prepare for the Airworthiness and Flight Safety Review process as defined by the Dryden Chief Engineer and the guidelines described in DHB-X-001, Airworthiness and Flight Safety Review, Independent Review, Mission Success Review, Technical Brief and Mini-Tech Brief Guidelines

2.5 Phase E: Operations

A. During the operations phase, systems engineering efforts are focused largely on configuration control, compliance with test plans, and coordination of data reviews and independent reviews.

B. Phase E systems engineering efforts will:

- Ensure that configuration control is maintained, with discrepancies and configuration changes properly identified and documented.
- Perform Tech Briefs as required.

- Ensure that ground and/or flight test plans are followed and results analyzed.
- Ensure that ground and/or flight data is properly reviewed and stored.
- Ensure that ground and/or flight test results are properly documented.

2.6 Phase F: Disposal

The primary systems engineering tasks during this phase are to properly archive project technical data, hardware, and software. Specific tasks will:

- Ensure that all design data, qualification test data, and flight test data is properly archived in the appropriate manner.
- Ensure that all hardware is stored or disposed of in the proper manner in accordance with Center processes.

CHAPTER 3: LIFECYCLE REVIEW CRITERIA

3.1 Program Approval Group (PAG) or Mission Concept Review (MCR)

The PAG affirms the mission need and examines the proposed mission's objectives and the concept for meeting those objectives. Guidelines for the Mission Concept Review can be found in DHB-R-007. The MCR at Dryden is the Dryden Project Approval Group or PAG Process. Details on the PAG Process can be found in DCP-X-044, Processing of Agreements from Review to Signature.

3.2 System Requirements Review (SRR)

The SRR is used to ensure that the program requirements are properly formulated and correlated with the Agency and mission directives and strategic objectives. Guidelines for the System Requirements Review, including entrance and exit criteria, and documented in DHB-R-007, Appendix D, "System Requirements Review."

3.3 Preliminary Design Review (PDR)

The PDR demonstrates that the preliminary design meets all the system requirements with acceptable risk and within the cost and schedule constraints. The PDR also establishes the basis for proceeding with the detailed design. It will show that the correct design options have been selected, interfaces have been properly allocated, and verification methods have been described. Guidelines for the Preliminary Design Review, including entrance and exit criteria, are documented in DHB-R-007, Appendix D, "Preliminary Design Review."

3.4 Critical Design Review (CDR)

CDR demonstrates that the maturity of the design is appropriate to support proceeding with full-scale fabrication, assembly, integration, and test. CDR determines that the technical effort is on track to complete the flight and ground system development and that mission operations will meet mission performance requirements within the identified cost and schedule constraints. Guidelines for the Critical Design Review, including entrance and exit criteria, are documented in DHB-R-007, Appendix D, "Critical Design Review."

3.5 Test Readiness Review (TRR)

TRR ensures that the test article (hardware/software), test facilities, support personnel, and test procedures are ready for testing and data acquisition, reduction, and control. A TRR is held prior to commencement of the verification testing. TRR Guidelines are called out in the following Dryden documents: DCP-R-603, Flight Loads Laboratory Operations Requirements; DCP-R-604, Flight Load Laboratory Thermal-Structural Ground Test Hazard Analysis; DOP-M-106, Western Aeronautical Test Range (WATR) Mission Control Center (MCC) Systems Software Acceptance Testing; and DCP-S-007 Software Assurance

3.6 Flight Readiness Review (FRR)

An FRR is held to ensure that a vehicle is ready for flight and the hardware is deemed acceptably safe for flight (i.e., meeting the established acceptable risk criteria or documented as being accepted by the PM and DGA). The FRR also is used to establish that the flight and ground software elements are ready to support flight and flight operations and interfaces are checked and found to be functional. Additionally, the FRR will review and establish that open items and waivers have been examined and found to be acceptable and all open safety and mission risk items have been addressed. FRR guidelines are described in DHB-X-001; DHB-R-007, Appendix D; DCP-X-009, Airworthiness and Flight Safety Review Process; and DHB-O-001, Operations Engineer's Handbook.

3.7 Airworthiness and Flight Safety Review Board (AFSRB)

At Dryden, the AFSRB process is part of the FRR processes. AFSRB guidelines are called out in DHB-X-001 and DCP-X-009, Airworthiness and Flight Safety Review Process and also discussed in DOP-P-003, Mission Development and Implementation.

3.8 Tech Briefs

At Dryden, the Tech Brief process is part of the overall Flight Readiness Review process. The Tech Brief process is an on-going review of the FRR and AFSRB process and should be treated with the same gravity and due process. Guidance on the Tech Brief process can be found in DHB-X-001; DHB-R-007; and DCP-X-008, Tech Brief (T/B) and Mini Tech Brief (Mini T/B). Tech Briefs are also discussed in DOP-P-003, Mission Development and Implementation.

3.9 Operational Readiness Review (ORR)

The ORR is held prior to deployed flights and includes a review of FRR activities and information and also includes a review of deployed location information, activities, and routes, no go procedures, and mission rules. ORR guidelines are shown in DCP-X-020, Flight Operational Readiness Review (ORR) and Operational Readiness Review Panel (ORRP).

3.10 Decommissioning Review (DR)

A DR confirms the decision to terminate or decommission the system and assesses the readiness of the system for the safe decommissioning and disposal of system assets. It is also known as a disposal review.

CHAPTER 4: AS9100 (AEROSPACE QUALITY MANAGEMENT SYSTEMS STANDARD) REQUIREMENTS

4.1 First Article (AS9100)

SAE AS9100, Aerospace Quality Management Systems Standard, has two unique additional requirements that must be addressed in the implementation of DPR-7123.1. The first requirement has to do with independent verification and validation of the first unit produced prior to handover to manufacturing.

A. Dryden's definition of "first article" is:

> "First unit produced for full compliance to requirements meeting final intended purposes of the customer. At Dryden, this is defined as the output from a research design and development environment."

B. Dryden does not process products in volume production runs, and therefore does not perform independent first article inspections. The intent of first article inspection will be accomplished through the verification and validation activities of the design and development lifecycle.

4.2 Key Characteristics (AS9100)

A. The second unique SAE AS9100 requirement has to do with the identification of key characteristics during the design and development process and the flowdown of key characteristics to the in-house manufacturing organizations and/or suppliers through the purchasing processes.

B. Dryden's definition of key characteristics is:

> "Key characteristics are defined as the features of a material, process, or part whose variation has a significant influence on product fit, performance, service life, manufacturability, or with a clear and imminent safety impact if it is not complied with (e.g., output voltage, shields/covers, warning markings, etc.)."

C. Key characteristics will be identified and evolved throughout the DFRC project lifecycle

D. Functional key characteristics are the features of a system, subsystem, or assembly whose attributes are more suitably verified through analysis and/or test.

E. A customer is more likely to define the objectives and goals of what they desire in terms of function, features, performance, and data. The prioritization of customer requirements and objectives by the project manager defines the customer's key characteristics. The Project Manager shall document these requirements in an appropriate project agreement document (e.g., Objectives and Requirements Document, System Requirements Document, etc.).

F. The design organization shall specify and document physical key characteristics for material, hardware, and systems. Appropriate testing will be formulated and documented to verify that the key characteristics have been achieved.

G. For parts that are designed and fabricated by an off-site vendor, the vendor shall be provided by the purchasing organization with sufficient documentation, including identification of key characteristics, to ensure that the vendor provides the desired product.

H. Design and development organizations shall transmit key characteristics to the internal fabrication function(s) via drawings, associated inspection plans, or other applicable documents. A Quality Engineering (QE) function shall perform a risk-based review of the drawings and specification documents and, in conjunction with the design organization, may identify additional key characteristics that would be added to drawings or other applicable documents as appropriate.

I. The Quality Assurance organization shall verify adherence to key characteristics for all on-site and off-site fabricated parts prior to release for delivery.

Appendix A: Definitions

First Article: First unit produced for full compliance to requirements meeting final intended purposes of the customer. At Dryden, this is defined as the output from a research design and development environment.

Formulation Phase: See NPR 7120.5D for definitions of program phases.

Key Characteristics: Key characteristics are defined as the features of a material, process, or part whose variation has a significant influence on product form, fit, function, performance, service life, manufacturability, or with a clear and imminent safety impact if it is not complied with (e.g., output voltage, shields/covers, warning markings, etc.).

Verification: Proof by examination of objective evidence that the product complies with specifications. Verification is performed to ensure the product complies with requirements and may be determined by test, analysis, demonstration, inspection, or a combination of these.

Validation: Proof by examination of objective evidence that the product accomplishes the intended purpose. Validation is performed to ensure that the product is ready for a particular use, function, or mission, and may be determined by test, analysis, demonstration, or a combination of these.

Document History Log

Peer Review Date: November 01, 2007

This page is for informational purposes and does not have to be retained with the document.

Status Change	Document Revision	Effective Date	Page	Description of Change
Baseline		11-09-07		