LPR 7123.1

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Langley Research Center

LaRC Systems Engineering Processes and Requirements

National Aeronautics and Space Administration

DOCUMENT HISTORY LOG

Document Revision	Effective Date	Description
A	July 20, 2010	Baseline

Contents

PREFACE

P.1 PURPOSE

P.1.1 This Langley Procedural Requirements (LPR) document implements the Agency Systems Engineering Management requirements documented in NASA Procedural Requirements (NPR) 7123.1A Appendix C. These processes focus on defining stakeholder expectations and implementing a systematic approach for satisfying those expectations. The processes are extracted from industry, national, international, and Agency standards. These processes provide the best typical practices currently available.

P.2 APPLICABILITY

P.2.1 This LPR applies to the personnel, programs, projects, and tasks at LaRC, including contractors to the extent specified in their respective contracts or agreements. ("Contractors," for purposes of this paragraph, include contractors, grantees, Cooperative Agreement recipients, Space Act Agreement partners, or other agreement parties.)

P.2.2 This LPR applies to all Programs, Projects and Tasks conducted by LaRC that are governed by NPR 7120.5, *NASA Spaceflight Program and Project Management Requirements*. This LPR also applies to all Institutional Infrastructure Programs, Projects, and Tasks conducted by LaRC (with the exception of environmental compliance and restoration activities), that are governed by NPR 7120.7, *NASA Information Technology and Institutional Infrastructure Program and Project Management Requirements*. In addition, this LPR applies to Technology Development Programs, Projects, and Tasks conducted by LaRC that are governed by NPR 7120.8, *NASA Research and Technology Program and Project Management Requirements*.

P.3 AUTHORITY

42 U.S.C. 2473(c) (1), Section 203(c) (1) of the National Aeronautics and Space Act of 1958, as amended.

P.4 APPLICABLE DOCUMENTS

a. NPR 7120.5, NASA Space Flight Program and Projects Management Requirements

b. NPR 7120.7, NASA Information Technology and Institutional Infrastructure Program and Project Management Requirements

c. NPR 7120.8, NASA Research and Technology Program and Project Management Requirements

d. NPR 7123.1, NASA Systems Engineering Processes and Requirements

e. NPR 7150.2, NASA Software Engineering Requirements

f. LAPD 7000.2, Review Program for Langley Research Center (LaRC) Facility Projects

g. LPR 1440.7, LaRC Records Management Procedural Requirements

h. LPR 5000.2, Procurement Initiator's Guide

i. LPR 5300.1, Product Assurance Plan

j. LPR 7120.5, Space Flight Project Practices Handbook

k. LPR 7130, Project and Task Review Procedural Requirements

l. LPR 7120.7, Space Flight Independent Life Cycle Review Procedural Requirements

m. LPR 8040.1, Flight Projects Directorate Space Flight Configuration Management Requirements

n. LMS-CP-1725, Export Control

o. LMS-CP-2310, Electronic Storage and Archival Systems (Document and Data Management)

p. LMS-CP-4756, Handling, Preservation, Storage, and Shipping of Space Flight Hardware

q. LMS-CP-5526, Product Requirements Development and Management Procedures

P.5 MEASUREMENT/VERIFICATION

Verification will be accomplished by inspection as part of the LaRC Internal Audit process.

P.6 CANCELLATION

None

Original signed on file
Cynthia C. Lee
Associate Director

Approved for public release via the Langley Management System. Distribution is unlimited.

1. RESPONSIBILITIES

1.1 The LaRC Center Director, or designee, is responsible for the implementation of the SE policies, processes, and procedures at LaRC.

1.2 The Chair of the LaRC Center Management Council (CMC), or designee, serves as the LaRC Designated Governing Authority (DGA) to approve systems engineering implementation for LaRC Class 1 Programs/Projects/Tasks (see Appendix D for Program/Project/Task Class descriptions).

1.3 The LaRC Chief Engineer, or designee:

1.3.1 Serves as the LaRC DGA to approve systems engineering implementation of LaRC Class 2 and 3 Programs/Projects/Tasks;

1.3.2 Reviews Class 1 Programs/Projects/Tasks systems engineering implementation prior to DGA review/approval; and

1.3.3 Ensures the appropriate Engineering Directorates review the Systems Engineering Management Plan (SEMP) (for a Class 1 or Class 2 Program/Project/Task) or other appropriate documentation of systems engineering implementation plans (for a Class 3 Program/Project/Task).

1.4 The Program/Project/Task Manager (PM), or designee:

1.4.1 Ensures a SEMP (for a Class 1 or Class 2 Program/Project/Task) or other appropriate documentation (for a Class 3 or Class 4 Program/Project/Task) is written to define Program/Project/Task implementation of SE requirements and processes;

1.4.2 Ensures review and approval of the SEMP or other appropriate documentation by the appropriate SE DGA;

1.4.3 Controls the SEMP or other appropriate documentation under Program/Project/Task control processes;

1.4.4 Provides the design team with statutory, regulatory, and Agency mandatory requirements, relevant information from previous similar designs, and any other requirements for product design and development.

1.4.5 Ensures that software developed within NASA or acquired complies with NPR 7150.2, for systems that contain software (see NPR 7123.1, Section 6.2.6).

1.5 The Program/Project/Task Systems Engineering Team (SET):

1.5.1 Prepares the SEMP;

1.5.2 Executes or oversees the execution of the Program/Project/Task systems engineering tasks.

1.6 The Director of the engineering organization providing the Program/Project/Task Chief Engineer (or Lead Systems Engineer if no Chief Engineer), or designee:

1.6.1 Ensures the Chief Engineer (or Lead Systems Engineer or other appropriate person) for the Program/Project/Task prepares the SEMP (for a Class 1 or Class 2 Program/Project/Task) or other appropriate documentation (for a Class 3 or Class 4 Program/Project/Task) in accordance with this LPR.

1.6.2 Ensures all engineering directorates involved in the engineering work of the Program/Project/Task concur on the SEMP or other appropriate documentation.

1.6.3 Ensures compliance with the approved SEMP or other appropriate documentation.

1.6.4 Approves the plans for systems engineering implementation for Class 4 Programs/Projects/Tasks.

1.7 For Programs/Projects/Tasks involving more than one Center, the lead organization develops documentation to describe the hierarchy and reconciliation of plans for implementing system engineering processes and requirements that are applicable to all Centers involved. However, the LaRC Center Director, Engineering Director and Chief Engineer are responsible to ensure all LaRC work in support of these efforts is in compliance with this LPR and NPR 7123.1.

1.8 Responsibilities for various activities associated with the SEMP or other appropriate documentation of the systems engineering implementation are summarized in Table 1-1.

	Class 1	**Class 2**	**Class 3**	**Class 4**
CMC Chair	Approves			
Chief Engineer	Reviews	Approves	Approves	
Program/Project/Task Manager	Concurs	Concurs	Concurs	Concurs
Engineering Director	Reviews	Reviews	Reviews	Approves
Systems Engineering Team	Prepares	Prepares	Prepares	Prepares

Table 1-1 Responsibilities for the SEMP or alternative documentation of systems engineering implementation

2. PROCEDURE

2.1 Program/Project/Task Systems Engineering

2.1.1 The Program/Project/Task Systems Engineering Life-cycle is defined as a set of activities, processes and reviews that enables the smooth, incremental development of products essential to successfully achieving the Program/Project/Task goals.

2.2 The Systems Engineering Management Plan (SEMP)

2.2.1 The purpose of a SEMP is to provide a single, integrated technical planning document which addresses the systems engineering management and implementation for systems and subsystems for in-house and contracted Programs/Projects/Tasks.

Req. 001: Each Class 1, and 2 Program/Project/Task (refer to Appendix D) SET shall provide to the DGA a SEMP as described in Appendix D.4 “SEMP Annotated Outline” of NPR 7123.1, NASA Systems Engineering Processes and Requirements.”

Rationale: [The SEMP is required by NPR 7123.1. The SEMP provides the specifics of the technical effort and describes what technical processes will be used, how the processes will be applied, how the project will be organized to accomplish its activities, and the cost and schedule associated with accomplishing the activities. At LaRC, a stand-alone SEMP is required for any Class 1 and 2 Program/Project/Task because of their size and/or visibility.]

Trace: [NPR 7123.1 Sections 3.13, 6.2.1, 6.2.2]

Allocation: [LPR 7120.5, LPR 7120.7]

Verification Method: [Inspection]

Req. 002: Each Class 3 and Class 4 Program/Project/Task SET shall provide to the DGA the documentation of the material typically found in a SEMP (see Appendix D.4 “SEMP Annotated Outline” of NPR 7123.1) in the manner and form agreed to with the DGA.

Rationale: [Smaller projects do not have the resources to develop a full SEMP, so the DGA decides what needs to be documented and the form that documentation will take. For example, the material may be documented in the project plan, as an appendix to the project plan, or in some other appropriate form as determined by the DGA.]

Trace: [NPR 7123.1 Sections 3.1.3, 6.2.1, 6.2.2]

Allocation: [LPR 7120.5, LPR 7120.7]

Verification Method: [Inspection]

2.2.2 The SEMP and the project plan are coordinated to ensure compatibility with the allocated resources/enabling products (cost, schedule, personnel, and facilities), milestones and deliverables. The SEMP is used to identify and evaluate the required technical teams' performances. The SEMP is also used in the technical risk assessment and deriving the progress measurement criteria.

2.2.3 For projects with significant portions of the engineering work contracted out, the LaRC SEMP scopes and plans the NASA portion of the project implementation of the systems engineering common technical processes before, during and at the completion of the contracted effort. This includes planning the technical team's involvement in the Request for Proposal (RFP) preparation, in source selection activities, acceptance of deliverables, and storage and disposal of residual hardware.

2.2.3.1 Depending upon the scope and content of the contracted effort, a contractor may be required to develop and maintain a SEMP or other appropriate documentation for their contracted effort.

2.2.4 SEMP Maintenance

Req. 003: Each Program/Project/Task SET shall update the SEMP (or alternate documentation as required in Req. 002), prior to each Program/Project/Task lifecycle review.

Rationale: [The SEMP (or alternate documentation) is not as useful if it is outdated. The update is necessary for DGA approval at the review (see Req. 004).]

Trace: [NPR 7123.1 section 6.2.4]

Allocation: []

Verification Method: [Inspection]

Req. 004: The DGA shall review and approve or disapprove the SEMP (or alternate documentation as required in Req. 002) at each Program/Project/Task lifecycle review.

Rationale: [The SEMP (or alternate documentation) is not as useful if it is outdated. Approval at this frequency is required by NPR 7123.1.]

Trace: [NPR 7123.1 section 6.2.3]

Allocation: []

Verification Method: [Inspection]

2.3 Systems Engineering Common Technical Processes

2.3.1 The implementation of the 17 Common Technical Processes are described in the SEMP (or alternate documentation) as discussed in NPR 7123.1, Appendix D.4.6. The LaRC tailoring of the best practices described in NPR 7123.1, Appendix C, are enumerated in Appendix E of this LPR. Additional information about these 17 processes is provided in NASA/SP-2007-6105 (which can be found on the NASA Technical Reports Server at: http://ntrs.nasa.gov/search.jsp?R=140111&id=5&as=false&or=false&qs=Ntt%3DSystems%2BEngineering%2BHandbook%26Ntk%3DTitle%26Ntx%3Dmode%2Bmatchall%26Ns%3DHarvestDate%257c1%26N%3D0).

Req. 005: Each Class 1, and 2 Program/Project/Task SET shall follow the best practices enumerated in Appendix E.2 of this document for each of the 17 Common Technical Processes unless the SEMP documents reason(s) for not following particular practice(s).

Rationale: [These best practices are extracted from industry, national, international, and agency standards. In general, they should be used on Class 1 and 2 Programs/Projects/Tasks. However, the individuality of each Program/Project/Task is appreciated and some practices that work for some Programs/Projects/Tasks do not work well for others, hence the intent of this requirement to give the Program/Project/Task sufficient flexibility to define the practices that they will follow subject to documenting reasons why any of the practices in Appendix E.2 will not be followed. For instance, the SET may conclude that the overhead associated with particular practices, or perhaps even entire processes exceed the benefit derived from particular practices, or they may conclude that alternative practices are better suited to the Program/Project/Task.]

Trace: [NPR 7123.1 Sections 3.1.3, 3.2.1.1, 3.2.2.1, 3.2.3.1, 3.2.4.1, 3.2.5.1, 3.2.6.1, 3.2.7.1, 3.2.8.1, 3.2.9.1, 3.2.10.1, 3.2.11.1, 3.2.12.1, 3.2.13.1, 3.2.14.1, 3.2.15.1, 3.2.16.1, 3.2.17.1]

Allocation: [LPR 7120.5, CP-5526, LPR 5000.2, LPR 5300.1, CP-4756, LPR 1440.7, LPR 8040.1, CP-1725, CP-2310, LPR 7120.7, LPR 7130, LAPD 7000.2, CP-5621]

Verification Method: [Inspection]

2.3.2 Because Class 3 and 4 Programs/Projects/Tasks are typically more resource-constrained then Class 1 and 2 Programs/Projects/Tasks, their SETs are not

required to document reasons for departing from the practices of Appendix E.2. However, Req. 002 still requires that they document the practices they will follow for the 17 Common Technical Processes.

2.3.3 Approval of the SEMP by the DGA constitutes approval of the systems engineering technical processes described in the SEMP. However, the SEMP cannot be used to grant relief from requirements outside of this LPR. Waivers and/or tailoring of requirements specified in other documents are required to follow the waiver and/or tailoring requirements of those other documents.

3. RECORDS

The following records are required by this LPR:

Record	Custodian
SEMP or other equivalent documentation	PM or designee

Additional records may be required, depending upon the detailed contents of the SEMP (or equivalent documentation).

4. TAILORING AND WAIVERS

4.1 Waivers to requirements specific to this LPR can be granted by the LaRC Center Director or his/her designee.

Req. 006: The PM of the Program/Project/Task shall provide any waiver requests to the LaRC Center Director (or designee) in writing, signed by the PM, and accompanied by evidence of concurrence by the relevant Project Chief Engineer or the Project Lead Systems Engineer and the Program/Project/Task sponsor (the Principal Investigator or other appropriate person).

Rationale: [The request is in writing to ensure a document trail. The signature of the PM ensures his/her awareness and support of the waiver request. The concurrence of the Project Chief Engineer or the Project Lead Systems Engineer ensures that the engineering aspects have been reviewed. The concurrence of the sponsor ensures that the sponsor is aware of the request – i.e., there is an informed customer.]

Trace: []

Allocation: []

Verification Method: [Inspection]

4.2 In cases where the identity of the Project Chief Engineer or Project Lead Systems Engineer and/or the Project sponsor are unclear, the LaRC Chief Engineer or his/her designee may assign individuals to act in those roles or may waive the requirement for concurrence.

Req. 007: The PM of the Program/Project/Task shall maintain all waiver documentation.

Rationale: [The Program/Project/Task is the responsible party for maintaining project documentation.]

Trace: []

Allocation: []

Verification Method: [Inspection]

4.3 Any tailoring or waivers to requirements of this LPR involving other LMS documents will be approved in accordance with the tailoring or waiver processes applicable to those LMS documents.

APPENDIX A. DEFINITIONS

A.1 Customer – The organization or individual that has requested a product and will receive the product to be delivered. The customer may be an end user of the product, the acquiring agent for the end user, or the requestor of the work products from a technical effort. Each product within the system hierarchy has a customer.

A.2 Designated Governing Authority – The management entity above the program, project, or task level with technical oversight responsibility.

A.3 Measure of Effectiveness (MOE) – A measure by which a stakeholder's expectations are judged in assessing satisfaction with products and systems produced and delivered in accordance with the associated technical effort. The MOE is deemed to be critical to not only the acceptability of the product by the stakeholder, but also critical to the operational / mission usage. An MOE is typically qualitative in nature or not able to be used directly as a "design-to" requirement.

A.4 Measure of Performance (MOP) – A quantitative measure that, when met by the design solution, will help ensure that an MOE for a product or system will be satisfied. These MOPs are given special attention during design to ensure that the MOEs to which they are associated are met. There are generally two or more measures of performance for each MOE.

A.5 Stakeholder – A group or individual who is affected by or in some way accountable for the outcome of an undertaking. Stakeholders include all who are involved in the Program/Project/Task – end-users, designers, manufacturing, test, and quality personnel, including those who may not be directly involved with doing the processing work.

A.6 Technical Requirements – Statements defining necessary performance characteristics of a product. Technical requirements are stated in a verifiable manner such that pass/fail or quantitative assessment criteria are specified.

A.7 Validation – Testing, possibly under simulated conditions, to ensure that a finished product works as required.

A.8 Validation (of a product) – Proof that the product accomplishes the intended purpose. Validation may be determined by a combination of test, analysis, and demonstration.

A.9 Verification – The process of proving or demonstrating that a finished product meets design specifications and requirements.

A.10 Verification (of a product) – Proof of compliance with specifications. Verification may be determined by test, analysis, demonstration, and inspection.

APPENDIX B. ACRONYMS

CMC	Center Management Council
CP	Center Procedure
DGA	Designated Governing Authority
LAPD	Langley Policy Directive
LaRC	Langley Research Center
LCC	Life-Cycle Cost
LMS	Langley Management System
LPR	Langley Procedural Requirements
MOE	Measure of Effectiveness
MOP	Measure of Performance
NASA	National Aeronautics and Space Administration
NPR	NASA Procedural Requirements
PM	Program, Project or Task Manager
SE	Systems Engineering
SEMP	Systems Engineering Management Plan
SET	Systems Engineering Team
WBS	Work Breakdown Structure

APPENDIX C. REQUIREMENTS LIST FOR THIS LPR

Requirement Number	Prior Paragraph Number	Description (these are abbreviated, the full text of the LPR paragraph apply)
001	2.2.1	Each Class 1, and 2 Program/Project/Task (refer to Appendix D) SET shall provide to the DGA a Systems Engineering Management Plan (SEMP) as described in Appendix D.4 “SEMP Annotated Outline” of NPR 7123.1, NASA Systems Engineering Processes and Requirements.”
002	2.2.1	Each Class 3 and Class 4 Program/Project/Task SET shall provide to the DGA the documentation of the material typically found in a SEMP (see Appendix D.4 “SEMP Annotated Outline” of NPR 7123.1) in the manner and form agreed to with the DGA.
003	2.2.4	Each Program/Project/Task SET shall update the SEMP (or alternate documentation as required in Req. 002), prior to each Program/Project/Task lifecycle review.
004	2.2.4	The DGA shall review and approve or disapprove the SEMP (or alternate documentation as required in Req. 002) at each Program/Project/Task lifecycle review.
005	2.3.1	Each Class 1, and 2 Program/Project/Task SET shall follow the best practices enumerated in Appendix E.2 for each of the 17 Common Technical Processes unless the SEMP documents reason(s) for not following particular practice(s).
006	4.1	The PM of the Program/Project/Task shall provide any waiver requests to the LaRC Center Director (or designee) in writing, signed by the PM, and accompanied by evidence of concurrence by the relevant Project Chief Engineer or the Project Lead Systems Engineer and the Program/Project/Task sponsor (the Principal Investigator or other appropriate person).
007	4.2	The PM of the Program/Project/Task shall maintain all waiver documentation.

APPENDIX D. CLASS OF PROGRAM/PROJECT/TASK

D.1 LaRC has established four classes of programs, projects, and tasks, where Class 1 is considered the highest class and Class 4 is considered the lowest class. The classification is done at program/project/task initiation and is reassessed at least annually to determine if the classification should be modified.

D.2 Agency-level Programs and Projects (those identified in the NASA Meta Data Manager database at: https://nsminfo.nasa.gov/nsminfo/home/Disclaimer.aspx) are Class 1. Other Programs/Projects/Tasks are initially classified at the highest level corresponding to planned annual and life-cycle costs (LCC) as indicated in Table D-1. For instance, a Program/Project/Task that is expected to have a LCC of $3M, with annual costs of $1M in the first year and $2M in the second year, would be initially considered as Class 2. Similarly, a Program/Project/Task with an expected annual cost of $1M per year for each of 5 years would also initially be considered as Class 2. For each program/project/task, the DGA according to the initial classification communicates the initial classification to the DGA of the next higher level of classification. The DGA of the higher level (or the Class 1 DGA where there is no higher level) decides whether other factors warrant a change in the initial classification.

D.3 The DGA for Class 1 Programs/Projects/Tasks is the Chair of the LaRC Center Management Council (CMC), or designee. The DGA for Class 2 and Class 3 Programs/Projects/Tasks is the LaRC Chief Engineer or designee. The DGA for Class 4 Programs/Projects/Tasks is the Engineering Director or designee of the organization leading the technical effort of the LaRC portion of the Program/Project/Task.

Class	Annual Cost	And/Or	Life-cycle Cost
1	≥$10M	OR	≥$25M
2	≥$2M and <$10M	OR	≥$5M and <$25M
3	≥$250K and <$2M	OR	≥$1 and <$5M
4	<$250K	AND	<$1M

Table D-1

D.4 Occasionally, LaRC will be responsible for multiple separate systems, subsystems, or elements that are part of a larger final project. For instance, in Figure D-1, the total LaRC portion of the work for the NASA project comprises Element A and Element B. In such cases, the Program/Project/Task class is determined by the total LaRC portion. At the option of the person who would be the DGA of the total LaRC portion, the requirements of this LPR (e.g., SEMP, technical processes) may be met at the level of the total LaRC portion, at the Element A and Element B levels, or both.

D.5 In the example given in Figure D-1, the total LaRC portion has a LCC of $26M, making it a Class 1 Program/Project/Task. At the discretion of the Class 1 DGA, the requirements of this LPR may be met by the PM and SET of the total LaRC portion satisfying the requirements of a Class 1 Program/Project/Task. Alternatively, the Class 1 DGA may decide that the requirements of this LPR are to be met by the PM and SET

of Element A satisfying the requirements of a Class 3 Program/Project/Task and the PM and SET of Element B satisfying the requirements of a Class 2 Program/Project/Task. The Class 1 DGA may also decide that the requirements of this LPR are to be satisfied by both alternatives.

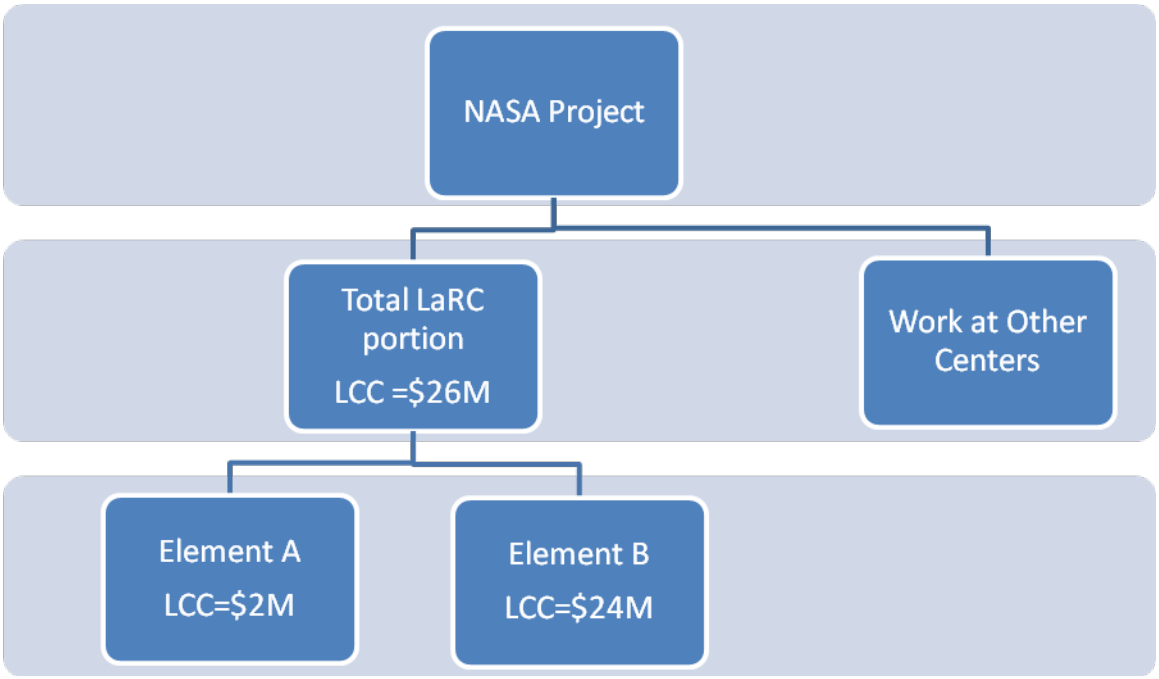

Figure D- 1

APPENDIX E. COMMON TECHNICAL PROCESSES BEST PRACTICES

E.1 Overview

E.1.1 There are one hundred five (105) “Expected Process Activities” presented as the third column of NPR 7123.1 Table 3-1 entitled “Process Activity Traceability Matrix” (pp.H2-2). These activities are considered “Best Practices.” These best practices are extracted from industry, national, international, and agency standards. They provide the best typical practices currently available. These best practices are reformatted and restated in Section E.2 of this appendix to include the addition of a number of LaRC practices that are appropriate to some of the processes. Therefore, while the process numbering is consistent with NPR 7123.1, the numbering of the separate practices is changed to accommodate the LaRC practices.

E.1.2 The 17 common technical processes are enumerated according to their description in this document and their interactions shown in Figure E-1. This SE common technical processes model illustrates the use of: (1) the system design processes for “top down” design of each product in the system structure, (2) the product realization processes for “bottom up” realization of each product in the system structure, and (3) the technical management processes for planning, assessing, and controlling the implementation of the system design and product realization processes and to guide technical decision making (decision analysis). The SE common technical processes model is referred to as an “SE engine” to stress that these common technical processes are used to drive the development of the system products and associated work products required by management to satisfy the applicable product-line life-cycle phase exit criteria while meeting stakeholder expectations within cost, schedule, and risk constraints.

E.1.3 The common technical processes are applied to a product-based Work Breakdown Structure (WBS) model. The processes are used to develop both the products that will satisfy the operational or mission functions of the system (end products) and those that will satisfy the life-cycle support functions of the system (enabling products). The enabling products facilitate the activities of system design, product realization, operations and mission support, sustainment, and end-of-product-life disposal or recycling by having the products and services available when needed.

E.1.4 Langley Form LF-464 can be used as a checklist to track compliance of the practices enumerated in section E.2. The practice description is significantly abbreviated in the form. The full text in section E.2 should be used for a more complete description of each practice.

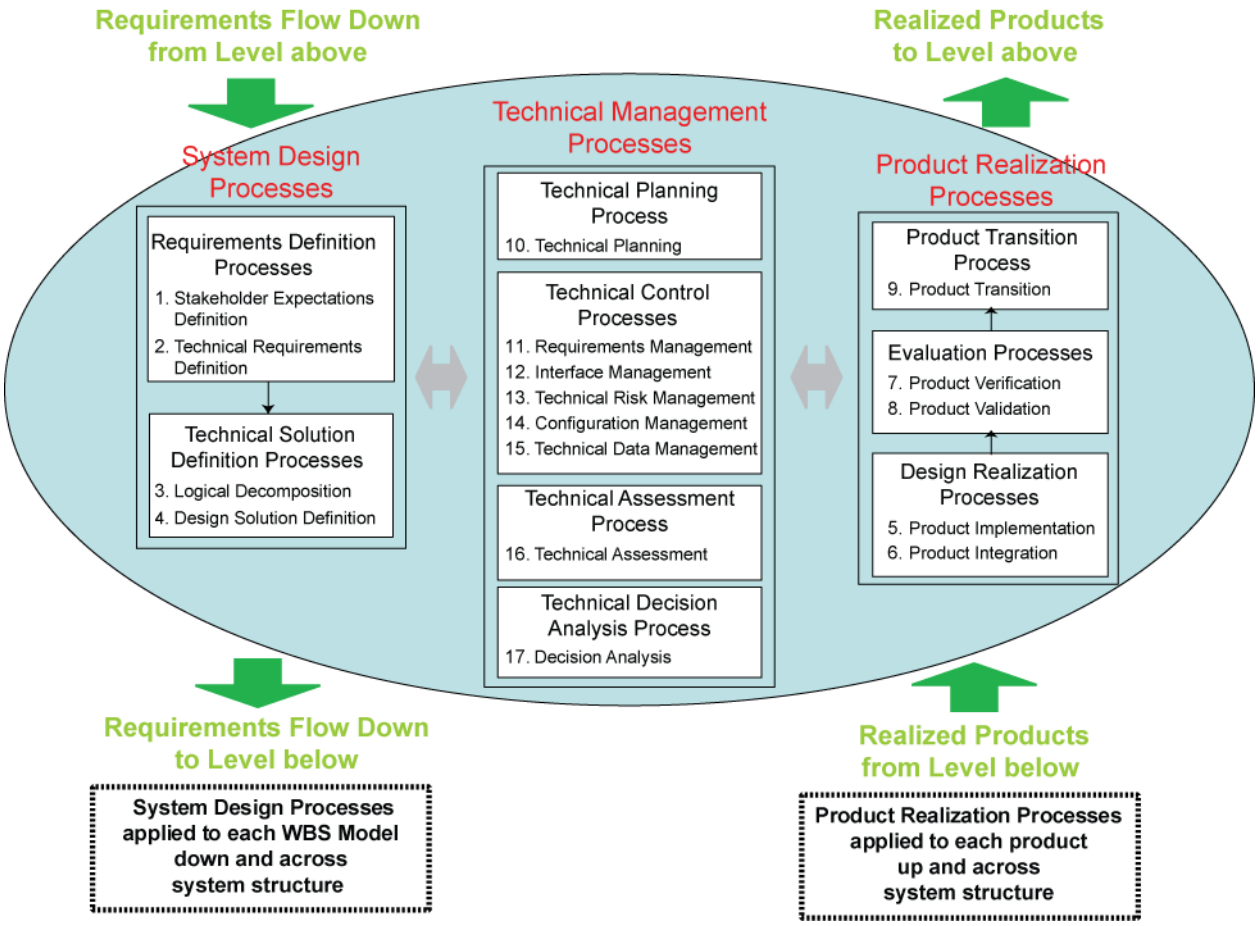

Figure E-1 Systems Engineering Engine

E.2 Systems Engineering Common Technical Processes

E.2.1 Stakeholder Expectations Definition Process Best Practices

E.2.1.1 Establish a list that identifies customers and other stakeholders that have an interest in the system and its products (**NOTE:** *This list should include personnel from the Langley organizations that will be supporting the project, industry partners, Customer engineering and program personnel. The Systems Engineer is advised to include a broad range of technical, program and customer personnel in the discovery of the stakeholders and their needs.*).

E.2.1.2 Elicit customer and other stakeholder expectations (needs, wants, desires, capabilities, external interfaces, and constraints) from the identified stakeholders (*the format in which these inputs are captured conforms to LMS-CP-5526)*.

E.2.1.3 Identify and document all external interfaces (e.g., hardware, software, other systems) for the product. The external interfaces form the boundaries between the system of interest and other systems. If helpful, create, use, and maintain interface diagrams to depict all of the external interfaces. *(This is a LaRC additional practice.)*

E.2.1.4 Validate the customer(s) and other stakeholder expectations and identified external interfaces to ensure all expectations and interfaces are identified and agreed upon. *(This is a LaRC additional practice.)*

E.2.1.5 Establish and then validate operational concepts and support strategies based on stakeholder's expected use of the system products over the system's life, including Assembly, Integration, Test, Transportation, Operations, and Disposal. *(This practice includes LaRC supplementary provisions.)*

E.2.1.6 Define Stakeholder expectations in acceptable statements that are complete sentences and have the following characteristics: (1) individually clear, correct, and feasible to satisfy; implementable; only one interpretation of meaning; one actor-verb-object expectation; and can be validated at the level of the system structure at which it is stated; and (2) in pairs or as a set there is an absence of redundancy, there is consistency with respect to terms used, they are not in conflict with one another, and they do not contain stakeholder expectation of questionable utility or which have an unacceptable risk of satisfaction (**NOTE:** The output of this definition conforms to LMS-CP-5526).

E.2.1.7 Analyze stakeholder expectation statements to establish a set of MOEs by which overall system or product effectiveness will be judged, and customer satisfaction will be determined.

E.2.1.8 Validate that the resulting set of stakeholder expectation statements are upward and downward traceable to reflect the elicited set of stakeholder expectations and that any anomalies identified are resolved.

E.2.1.9 Obtain commitments from customer and other stakeholders that the resultant set of stakeholder expectation statements is acceptable.

E.2.1.10 Baseline the agreed to set of stakeholder expectation statements.

E.2.2 Technical Requirements Definition Process Best Practices

E.2.2.1 Analyze the scope of the technical problem to be solved to identify and resolve the design boundary that identifies: (1) which system functions are under design control and which are not; (2) expected interaction among system functions (data flows, human responses, and behaviors); (3) external physical and functional interfaces (mechanical, electrical, thermal, data, procedural) with other systems; (4) required capacities of system products; (5) timing of events, states, modes, and functions related to operational scenarios; and (6) emerging or maturing technologies necessary to make requirements.

E.2.2.2 Define constraints affecting the design of the system or products or how the system or products will be able to be used.

E.2.2.3 Define functional and behavioral expectations for the system or product in technical terms for the range of anticipated uses of system products as identified in the concept of operations; this permits separating defined stakeholder expectation functions and behaviors that belong to a lower level in the system structure and allocating them to the appropriate level.

E.2.2.4 Define the performance requirements associated with each defined functional and behavioral expectation.

E.2.2.5 Define technical requirements in "shall" statements that are complete sentences with a single "shall" per numbered statement and have the following characteristics: (1) individually clear, correct, and feasible; not stated as to how it is to be satisfied; implementable; only one interpretation of meaning; one actor-verb-object requirement; and can be validated at the level of the system structure at which it is stated; and (2) in pairs or as a set, there is an absence of redundancy, consistency with terms used, no conflict with one another, and form a set of "design-to" requirements.

E2.2.6 Document the rationale (e.g., why requirement exists, assumptions, expected operations, trade study results) for each requirement established. *(This is a LaRC additional practice.)*

E.2.2.7 Validate that the resulting technical requirement statements: (1) have bidirectional traceability to the baselined stakeholder expectations; (2) were formed using valid assumptions; and (3) are essential to and consistent with designing and realizing the appropriate product solution form that will satisfy the applicable product-line life-cycle phase exit criteria.

E.2.2.8 Define MOPs for each identified measure of effectiveness (MOE) that cannot be directly used as a design-to technical requirement.

E.2.2.9 Document the verification method(s), e.g., test, analysis, inspection, demonstration, for each requirement established. *(This is a LaRC additional practice.)*

E.2.2.10 Define appropriate TPMs by which technical progress will be assessed.

E.2.2.11 Establish the technical requirements baseline.

E.2.3 Logical Decomposition Process Best Practices

E.2.3.1 Define one or more logical decomposition models based on the defined technical requirements to gain a more detailed understanding and definition of the design problem to be solved.

E.2.3.2 Allocate the technical requirements to the logical decomposition models to form a set of derived technical requirement statements that have the following

characteristics: (1) describe functional and performance requirements, service and attribute requirements, timing requirements, data flow requirements, and other requirements as appropriate for the selected set of logical decomposition models; (2) individually are complete sentences and are clear, correct, and feasible; not stated as to how to be satisfied; implementable; only have one interpretation of meaning, one actor-verb-object expectation; and can be validated at the level of the system structure at which it is stated; (3) in pairs or as a set, have an absence of redundancy, are adequately related with respect to terms used, and are not in conflict with one another; and (4) form a set of detailed "design-to" requirements.

E.2.3.3 Resolve derived technical requirement conflicts.

E.2.3.4 Validate that the resulting set of derived technical requirements have: (1) bidirectional traceability with the set of validated technical requirements and (2) assumptions and decision rationales consistent with the source set of technical requirements.

E.2.3.5 Validate the resultant set of requirements to ensure stakeholders agree that the requirements have been identified and allocated to the appropriate models (e.g., elements and subsystems) and baseline this set of requirements. *(This is a LaRC additional practice.)*

E.2.3.6 Establish the derived technical requirements baseline.

E.2.4 Design Solution Definition Process Best Practices

E.2.4.1 Define alternative solutions for the system end product being developed or improved that are consistent with derived technical requirements and non-allocated technical requirements, if any.

E.2.4.2 Analyze each alternative solution against defined criteria, such as satisfaction of external interface requirements; technology requirements; off-the-shelf availability of products; physical failure modes, effects, and criticality; life-cycle cost and support considerations; capacity to evolve; make vs. buy; standardization of products; integration concerns; and context of use issues of operators considering tasks, location, workplace equipment, and ambient conditions.

E.2.4.3 Select the best solution alternative based on the analysis results of each alternative solution and technical decision analysis recommendations.

E.2.4.4 Generate the full design description of the selected alternative solution in a form appropriate to the product-line life-cycle phase, location of the WBS model in the system structure, and phase exit criteria to include: (1) system specification and external interface specifications; (2) end product specifications, configuration description documents, and interface specifications; (3) end product subsystem initial specifications, if subsystems are required; (4) requirements for associated supporting

enabling products; (5) end product verification plan; (6) end product validation plan; and (7) applicable logistics and operate-to procedures.

E.2.4.5 Verify that the design solution definition: (1) is realizable within constraints imposed on the technical effort; (2) has specified requirements that are stated in acceptable statements and have bidirectional traceability with the derived technical requirements, technical requirements, and stakeholder expectations; and (3) has decisions and assumptions made in forming the solution consistent with its set of derived technical requirements, separately allocated technical requirements, and identified system product and service constraints.

E.2.4.6 Baseline the design solution definition specified requirements including the specifications and configuration descriptions.

E.2.4.7 Initiate development or acquisition of the life-cycle supporting enabling products needed, as applicable, for research, development, fabrication, integration, test, deployment, operations, sustainment, and disposal.

E.2.4.8 Initiate development of the system products of the next lower level WBS model, if any.

E.2.5 Product Implementation Process Best Practices

E.2.5.1 Prepare to conduct product implementation including: (1) prepare a product implementation strategy and detailed planning and procedures and (2) determine whether the product configuration documentation is adequately complete to conduct the type of product implementation as applicable for the product-line life-cycle phase, location of the product in the system structure, and phase exit criteria.

E.2.5.2 If the strategy is for buying an existing product, participate in the buy of the product including: (1) review the technical information made available by vendors; (2) assist the preparation of requests for acquiring the product from a vendor; (3) assist the inspection of the delivered product and the accompanying documentation; (4) determine whether the vendor conducted product validation or if it will need to be done by a project technical team; and (5) determine the availability of enabling products to provide test, operations, and maintenance support and disposal services for the product.

E.2.5.3 If the strategy is to reuse a product that exists in the Government inventory, participate in acquiring the reused product including: (1) review the technical information made available for the specified product to be reused; (2) determine supporting documentation and user manuals availability; (3) determine the availability of enabling products to provide test, operations, and maintenance support and disposal services for the product; (4) assist the requests for acquiring the product from Government sources; and (5) assist the inspection of the delivered product and the accompanying documentation.

E.2.5.4 If the strategy is to make the product: (1) evaluate the readiness of the product implementation enabling products to make the product, (2) make the specified product in accordance with the specified requirements, configuration documentation, and applicable standards, and (3) prepare appropriate product support documentation, such as integration constraints and/or special procedures for performing product verification and product validation.

E.2.5.5 Capture work products and related information generated while performing the product implementation process activities.

E.2.5.6 Abide by any relevant requirements identified in the *Procurement Initiator's Guide* (LPR 5000.2). *(This is a LaRC additional practice.)*

E.2.6 Product Integration Process Best Practices

E.2.6.1 Prepare to conduct product integration to include: (1) preparing a product integration strategy, detailed planning for the integration, and integration sequences and procedures; and (2) determining whether the product configuration documentation is adequately complete to conduct the type of product integration applicable for the product-line life-cycle phase, location of the product in the system structure, and management phase exit criteria.

E.2.6.2 Document and approve integration procedures and sequences including a "completion timeline" that supports the "need date". *(This is a LaRC additional practice.)*

E.2.6.3 Obtain lower level products required to assemble and integrate into the desired product.

E.2.6.4 Confirm received products being integrated have been verified to their own specific set of requirements. *(This is a LaRC additional practice.)*

E.2.6.5 Confirm that the received products that are to be assembled and integrated have been validated to demonstrate that the individual products satisfy the agreed upon set of stakeholder expectations, including interface requirements.

E.2.6.6 Prepare the integration environment in which assembly and integration will take place to include evaluating the readiness of the product-integration enabling products and the assigned workforce.

E.2.6.7 Assemble and integrate the received products into the desired end product in accordance with the specified requirements, configuration documentation, interface requirements, applicable standards, and integration sequencing and procedures.

E.2.6.8 Document results/modifications/changes generated during integration. *(This is a LaRC additional practice.)*

E.2.6.9 Prepare appropriate product support documentation, such as special procedures for performing product verification and product validation.

E.2.6.10 Document delivery of the end product for higher level processing. *(This is a LaRC additional practice.)*

E.2.6.11 Capture work products and related information generated while performing the product integration process activities.

E.2.7 Product Verification Process Best Practices

E.2.7.1 Prepare to conduct product verification to include as applicable to the product-line life-cycle phase and WBS model location in the system structure: (1) reviewing the product verification plan for specific procedures, constraints, conditions under which verification will take place, pre- and post-verification actions, and criteria for determining the success or failure of verification methods and procedures; (2) arranging the needed product-verification enabling products and support resources; (3) obtaining the end product to be verified; (4) obtaining the specification and configuration baseline against which the verification is to be made; and (5) establishing and checking the verification environment to ensure readiness for performing the verification.

E.2.7.2 Perform the product verification in accordance with the product verification plan and defined procedures to collect data on each specified requirement with specific attention given to MOPs.

E.2.7.3 Analyze the outcomes of the product verification, including identifying verification anomalies, establishing recommended corrective actions, and establishing conformance to each specified requirement under controlled conditions.

E.2.7.4 Prepare a product verification report providing the evidence of product conformance with the applicable design solution definition specified requirements baseline to which the product was generated, including bidirectional requirements traceability and actions taken to correct anomalies of verification results.

E.2.7.5 Capture the work products from the product verification.

E.2.8 Product Validation Process Best Practices

E.2.8.1 Prepare to conduct product validation to include as applicable to the product-line life-cycle phase and product location in the system structure: (1) reviewing the product validation plan for specific procedures, constraints, conditions under which validation will take place, pre- and post-validation actions, and criteria for determining the success or failure of validation methods and procedures; (2) arranging the needed product-validation enabling products and support resources; (3) obtaining the end product to be validated; (4) obtaining the stakeholder expectations baseline against which the validation is to be made; and (5) establishing and evaluating the validation environment to ensure readiness for performing the validation.

E.2.8.2 Perform the product validation in accordance with the product validation plan and defined procedures to collect data on performance of the product against stakeholder expectations with specific attention given to MOEs.

E.2.8.3 Analyze the outcomes of the product validation to include identification of validation anomalies, establishing recommended corrective actions, and establishing conformance to stakeholder expectations under operational conditions (actual, analyzed, or simulated).

E.2.8.4 Prepare a product validation report providing the evidence of product conformance with the stakeholder expectations baseline, including corrective actions taken to correct anomalies of validation results.

E.2.8.5 Capture the work products from the product validation.

E.2.9 Product Transition Process Best Practices

E.2.9.1 Prepare to conduct product transition to include: (1) preparing a product implementation strategy to establish the type of product transition to be made (to the next higher level customer for product integration or to an end user); and (2) reviewing related end product stakeholder expectations and design solution definition specified requirements to identify special transition procedures and enabling product needs for the type of product transition, if any, for packaging, storage, handling, shipping/transporting, site preparation, installation, or sustainment.

E.2.9.2 Evaluate the end product, personnel, and enabling product readiness for product transition including: (1) availability and appropriateness of the documentation that will be packaged and shipped with the end product; (2) adequacy of procedures for conducting product transition; (3) availability and skills of personnel to conduct product transition; and (4) availability of packaging materials/containers, handling equipment, storage facilities, and shipping/transporter services.

E.2.9.3 Prepare the end product for transition to include the packaging and moving the product to the shipping/transporting location and any intermediate storage.

E.2.9.4 Transition the end product with required documentation to the customer, based on the type of transition required, e.g., to the next higher level WBS model for product integration or to the end user.

E.2.9.5 Prepare sites, as required, where the end product will be stored, assembled, integrated, installed, used, or maintained, as appropriate for the life-cycle phase, position of the end product in the system structure, and customer agreement.

E.2.9.6 Abide by any relevant requirements identified in *Product Assurance Plan* (LPR 5300.1) and *Handling, Preservation, Storage, and Shipping of Space Flight Hardware* (LMS-CP-4756). *(This is a LaRC additional practice.)*

E.2.9.7 Capture work products from product transition process activities.

E.2.10 Technical Planning Management Process Best Practices

E.2.10.1 Prepare to conduct technical planning to include: (1) preparing or updating a planning strategy for each of the common technical processes and (2) determining:

a. deliverable work products from technical efforts,
b. technical reporting requirements,
c. other technical information needs for reviews or satisfying product-line life-cycle management phase entry or exit criteria,
d. product and process measures to be used in measuring technical performance, cost, and schedule progress,
e. key or critical technical events with entry and success criteria,
f. data management approach for data collection and storage and how measurement data will be analyzed, reported, and dispositioned as Federal records,
g. technical risks that need to be addressed in the planning effort,
h. tools and engineering methods to be employed in the technical effort, and
i. approach to acquiring and maintaining the technical expertise needed (training and skills development plan).

E.2.10.2 Identify and plan for data archiving of LaRC-delivered data products. *(This is a LaRC additional practice.)*

E.2.10.3 Identify and plan for preservation of records in accordance with *Langley Research Center Records Management Procedural* Requirements (LPR 1440.7). *(This is a LaRC additional practice.)*

E.2.10.4 Identify and plan for hardware to be retained and stored, including storage location and requirements (e.g., environmentally controlled storage). *(This is a LaRC additional practice.)*

E.2.10.5 Define the technical work to be done to include associated technical, support, and management tasks needed to generate the deliverable products and satisfy entry and success criteria of key technical events and the applicable product-line life-cycle management phase.

E.2.10.6 Schedule, organize, and determine the cost of the technical effort.

E.2.10.7 Prepare the SEMP and other technical plans needed to support the technical effort and perform the technical processes.

E.2.10.8 Obtain stakeholder commitments to the technical plans.

E.2.10.9 Issue authorized technical work directives to implement the technical work.

E.2.10.10 Capture work products from technical planning activities.

E.2.11 Technical Requirements Management Process Best Practices

E.2.11.1 Prepare to conduct requirements management to include: (1) preparing or updating a strategy and procedures for: (a) establishing that expectation and requirement statements, singularly and as a whole, are prepared in accordance with established formats and rules; (b) identifying expectations and requirements to be managed, expectation and requirement sources, and allocation and traceability of requirements and linking product expectations and requirements with costs, weight, and power allocations, as applicable; and (c) formal initiation, assessment, review, approval, and disposition of engineering change proposals and changes to expectation and requirements baseline; (2) selecting or updating an appropriate requirements management tool; and (3) training technical team members in the established requirements management procedures and in the use of the selected/updated requirements management tool.

E.2.11.2 Conduct requirements management to include: (1) capturing, storing, and documenting the expectations and requirements; (2) establishing that expectation and requirement statements are compliant with format and other established rules (e.g., LMS-CP-5526); (3) confirming each established requirements baseline has been validated; and (4) identifying and analyzing out-of-tolerance system-critical technical parameters and unacceptable validation and verification results and proposing requirement-appropriate changes to correct out-of-tolerance requirements. *(This practice has been modified with supplementary LaRC material.)*

E.2.11.3 Conduct expectation and requirements traceability to include: (1) tracking expectations and requirements between baselines, especially MOEs, MOPs, and TPMs and (2) establishing and maintaining appropriate requirements compliance matrixes that contain the requirements, bidirectional traceability, compliance status, and any actions to complete compliance.

E.2.11.4 Manage expectation and requirement changes to include: (1) reviewing engineering change proposals (ECPs) to determine any changes to established requirement baselines; (2) documenting requested requirement(s) change (e.g., modification, addition, or deletion) with justification for change; (3) communicating the requested requirement(s) change to all stakeholders who are impacted; (4) ensuring that each requested requirement(s) change includes an evaluation of the impact (e.g., cost, schedule, technical, higher/derived/lower/interface requirements, effect on constituent parts, components and products already delivered) of the requested requirement(s) change; (5) implementing formal change procedures for proposed and identified expectation or requirement changes; and (6) disseminating the approved change information. *(This practice has been modified with supplementary LaRC material.)*

E.2.11.5 Capture work products from requirements management process activities to include maintaining and reporting information on the rationale for and disposition and implementation of change actions, current requirement compliance status, and expectation and requirement baselines.

E.2.12 Technical Interface Management Process Best Practices

E.2.12.1 Prepare or update interface management procedures for: (1) establishing interface management responsibilities for those interfaces that are part of agreement boundaries; (2) maintaining and controlling identified internal and external physical and functional interfaces; (3) preparing and maintaining appropriate physical and functional interface specifications or interface control documents and drawings to describe and control interfaces external to the system end product; (4) identifying interfaces between system products (including humans) and among configuration management items; (5) establishing and implementing formal change procedures for interface evolution; (6) disseminating the needed interface information for integration into technical effort activities and for external interface control; and (7) training technical teams and other applicable support and management personnel in the established interface management procedures.

E.2.12.2 Conduct interface management during system design activities for each WBS model in the system structure to include: (1) integrating the interface management activities with requirements management activities; (2) analyzing the concept of operations to identify critical interfaces not included in the stakeholder set of expectations; (3) documenting interfaces both external and internal to each WBS model as the development of the system structure emerges and interfaces are added and existing interfaces are changed; (4) documenting origin, destination, stimulus, and special characteristics of interfaces; (5) maintaining the design solution definition for internal horizontal and vertical interfaces between WBS models in the system structure; (6) maintaining horizontal traceability of interface requirements across interfaces and capturing status in the established requirements compliance matrix; and (7) confirming that each interface control document or drawing that is established has been validated with parties on both sides of the interface.

E.2.12.3 Conduct interface management during product integration activities to include: (1) reviewing product integration procedures to ensure that interfaces are marked to ensure easy and correct assembly/connection with other products; (2) identifying product integration planning to identify interface discrepancies, if any, and report to the proper technical team or technical manager; (3) confirming that a check is completed on all physical interfaces before connecting products; (4) evaluating assembled products for interface compatibility; (5) confirming that product verification and product validation plans/procedures include confirming internal and external interfaces; and (6) preparing an interface evaluation report upon completion of integration, product verification, and product validation.

E.2.12.4 Conduct interface control to include: (1) managing interface changes within the system structure; (2) identifying and tracking proposed and directed changes to

interface specifications and interface control documents and drawings; (3) confirming that the vertical and horizontal interface issues are analyzed and resolved when a change affects products on both sides of the interface; (4) controlling traceability of interface changes including source of the change, processing methods, and approvals; and (5) disseminating the approved interface change information for integration into technical efforts at every level of the project.

E.2.12.5 Capture work products from interface management activities.

E.2.13 Technical Risk Management Process Best Practices

E.2.13.1 Prepare a strategy to conduct technical risk management to include: (1) documenting how the project risk management plan will be implemented in the technical effort; (2) planning identification of technical risk sources and categories; (3) identification of potential technical risks; (4) characterizing and prioritizing technical risks; (5) planning informed technical management (mitigation) actions should the risk event occur; (6) tracking technical risk status against established triggers; (7) resolving technical risk by taking planned action if established triggers are tripped; and (8) communicating technical risk status and mitigation actions taken, when appropriate.

E.2.13.2 Identify technical risks to include: (1) identifying sources of risk issues related to the technical effort; (2) anticipate what could go wrong in each of the source areas to create technical risk issues; (3) analyzing identified technical risks for cause and importance; (4) preparing clear, understandable, and standard form risk statements; and (5) coordinating with relevant stakeholders associated with each identified technical risk.

E.2.13.3 Conduct technical risk assessment to include: (1) categorize the severity of consequences for each identified technical risk in terms of performance, cost, and schedule impacts to the technical effort and project; (2) analyze the likelihood and uncertainties of events associated with each technical risk and quantify (for example, by probabilities) or qualify (for example, by high, moderate, or low) the probability of occurrence in accordance with project risk management plan rules; and (3) prioritize risks for mitigation.

E.2.13.4 Prepare for technical risk mitigation to include: (1) selecting risks for mitigation and monitoring; (2) selecting an appropriate risk-handling approach; (3) establishing the risk level or threshold when risk occurrence becomes unacceptable and triggers execution of a risk mitigation action plan; (4) selecting contingency actions and triggers should risk mitigation not work to prevent a problem occurrence; (5) preparing risk mitigation and contingency action plans identifying responsibilities and authorities.

E.2.13.5 Monitor the status of each technical risk periodically to include: (1) tracking risk status to determine whether conditions or situations have changed so that risk monitoring is no longer needed or new risks have been discovered; (2) comparing risk status and risk thresholds; (3) reporting risk status to decision authorities when a threshold has been triggered and an action plan implemented; (4) preparing technical

risk status reports as required by the project risk management plan; (5) communicating risk status during technical reviews in the form specified by the project risk management plan.

E.2.13.6 Implement technical risk mitigation and contingency action plans when the applicable thresholds have been triggered to include: (1) monitoring the results of the action plan implemented; (2) modifying the action plan as appropriate to the results of the actions; (3) continuing actions until the residual risk and/or consequences impacts are acceptable or become a problem to be solved; (4) communicate to the project when risks are beyond the scope of the technical effort to control, will affect a product higher in the system structure, or represent a significant threat to the technical effort or project success; (5) preparing action plan effectiveness reports as required by the project risk management plan; (6) communicating action plan effectiveness during technical reviews in the form specified by the project risk management plan.

E.2.13.7 Abide by the appropriate additional requirements identified in *Product Assurance Plan* (LPR 5300.1) Section 4.1.2, Risk Management Requirements. *(This is a LaRC additional practice.)*

E.2.13.8 Capture work products from technical risk management activities.

E.2.14 Technical Configuration Management Process Best Practices

E.2.14.1 Prepare a strategy to conduct configuration management for the system products and designated work products to include: (1) documenting how the project configuration management plan, if any, will be implemented; (2) identifying items to be put under configuration control; (3) identifying schema of identifiers to accurately describe a configuration item and its revisions or versions; (4) controlling changes to configuration items; (5) maintaining and reporting disposition and implementation of change actions to appropriate stakeholders including technical teams within the project; (6) ensuring that products are in compliance with specifications and configuration documentation during reviews and audits; (7) providing the appropriate reference configuration at the start of each product-line life-cycle phase; (8) obtaining appropriate tools for configuration management; and (9) training appropriate technical team members and other technical support and management personnel in the established configuration management strategy and any configuration management procedures and tools.

E.2.14.2 Identify baselines to be under configuration control to include: (1) listing of the configuration items to control; (2) providing each configuration item with a unique identifier; (3) identifying acceptance requirements for each baseline identified for control; (4) identifying the owner of each configuration item; and (5) establishing a baseline configuration for each configuration item.

E.2.14.3 Manage configuration change control to include: (1) establishing change criteria, procedures, and responsibilities; (2) receiving, recording, and evaluating change requests; (3) tracking change requests to closure; (4) obtaining appropriate

approvals before implementing a change; (5) incorporating approved changes in appropriate configuration items; (6) releasing changed configuration items for use; and (7) monitoring implementation to determine whether changes resulted in unintended effects (e.g., have compromised safety or security of baseline product).

E.2.14.4 Maintain the status of configuration documentation to include: (1) maintaining configuration item description records and records that verify readiness of configuration items for testing, delivery, or other related technical efforts; (2) maintaining change requests, disposition action taken, and history of change status; (3) maintaining differences between successive baselines; and (4) controlling access to and release of configuration baselines.

E.2.14.5 Conduct configuration audits to include: (1) auditing baselines under control to confirm that the actual work product configuration matches the documented configuration, the configuration is in conformance with product requirements, and records of all change actions are complete and up to date; (2) identifying risks to the technical effort based on incorrect documentation, implementation, or tracking of changes; (3) assessing the integrity of the baselines; (4) confirming the completeness and correctness of the content of configuration items with applicable requirements; (5) confirming compliance of configuration items with applicable configuration management standards and procedures; and (6) tracking action items to correct anomalies from audit to closure.

E.2.14.6 Abide by the appropriate additional requirements identified in *Flight Projects Directorate Space Flight Configuration Management Requirements* (LPR 8040.1). *(This is a LaRC additional practice.)*

E.2.14.7 Capture work products from configuration management activities to include: (1) a list of identified configuration items; (2) description of configuration items placed under control; (3) change requests, disposition of the requests, and rationale for the dispositions; (4) documented changes with reason for changes and change actions; (5) archive of old baselines; and (6) required reports on configuration management outcomes.

E.2.15 Technical Data Management Process Best Practices

E.2.15.1 Prepare a strategy for the conduct of technical data management to include: (1) determining required data content and form and electronic data exchange interfaces in accordance with international standards or agreements; (2) establishing a framework for technical data flow within the project technical processes and to/from contractors; (3) designating technical data management responsibilities and authorities regarding origination, generation, capture, archiving, security, privacy, and disposal of technical data work products; (4) establishing the rights, obligations and commitments regarding the retention of, transmission of, and access to technical data items; (5) establishing relevant data storage, transformation, transmission and presentation standards and conventions to be used; (6) establishing project or program policy and agreements or legislative constraints; (7) describing the methods, tools, and metrics used during the

technical effort and for technical data management; and (8) training appropriate technical team members and support and management personnel in the established technical data management strategy and related procedures and tools.

E.2.15.2 Collect and store required technical data to include: (1) identifying existing sources of technical data that are designated as outputs of the common technical processes; (2) collecting and storing technical data in accordance with the technical data management strategy and procedures; (3) recording and distributing lessons learned; (4) performing technical data integrity checks on collected data to confirm compliance with content and format requirements and identifying errors in specifying or recording data; and (5) prioritizing, reviewing, and updating technical data collection and storage procedures.

E.2.15.3 Maintain stored technical data to include: (1) managing the databases to maintain proper quality and integrity of the collected and stored technical data and to confirm that the technical data is secure and is available to those with authority to have access; (2) performing technical data maintenance as required; (3) preventing the stored data from being used or accessed inappropriately; (4) maintaining the stored technical data in a manner that protects it against foreseeable hazards, such as fire, flood, earthquake, and riots; and (5) maintaining periodic backups of each technical database.

E.2.15.4 Provide technical data to authorized parties to include: (1) maintaining an information library or reference index to provide data available and access instructions; (2) receiving and evaluating requests for technical data and delivery instructions; (3) confirming that required and requested technical data is appropriately distributed to satisfy the needs of the requesting party and in accordance with established procedures, directives, and agreements; (4) confirming that electronic access rules are followed before allowing access to the database and before any data is electronically released/transferred to the requester; and (5) providing proof of correctness, reliability, and security of technical data provided to internal and external recipients.

E.2.15.5 Abide by the appropriate additional requirements identified in *Space Flight Project Practices Handbook* (LPR 7120.5), *Langley Research Center Records Management Procedural Requirements* (LPR 1440.7), *Export Control* (LMS-CP-1725), and *Electronic Storage and Archival System* (LMS-CP-2310). *(This is a LaRC additional practice.)*

E.2.16 Technical Assessment Process Best Practices

E.2.16.1 Prepare a strategy for conducting technical assessments to include: (1) identifying the plans against which progress and achievement of the technical effort are to be assessed; (2) establishing procedures for obtaining cost expenditures against work planned and task completions against schedule; (3) identifying and obtaining technical requirements against which product development progress and achievement will be assessed and establishing the procedures for conducting the assessments; (4) establishing events when TPMs, estimation or measurement techniques, and rules for taking action when out-of-tolerance conditions exist will be assessed; (5) identifying and planning for phase-to-phase technical reviews and WBS model-to-model vertical progress reviews, as well as establishing review entry and success criteria, review board members, and close out procedures; (6) establishing which technical effort work products will undergo peer review, the team members who will perform the peer reviews, and reporting requirements; and (7) training team members, support staff, and managers involved in conducting technical assessment activities.

E.2.16.2 Assess technical work productivity (progress and achievement against plans) to include: (1) identifying, collecting, and analyzing process measures (e.g., earned value measurements for measuring progress against planned cost, schedule, resource use, and technical effort tasks) and identifying and reporting cost-effective changes to correct variances; (2) monitoring stakeholder involvement according to the SEMP; and (3) monitoring technical data management against plans.

E.2.16.3 Assess product quality (progress and achievements against technical requirements) to include: (1) identifying, collecting, and analyzing the degree of technical requirement and TPM satisfaction; (2) assessing the maturity of the WBS-model products and services as applicable to the product-line life-cycle phases; (3) determining any variances from expected values of product performance and identifying and defining cost-effective changes to correct variances.

E.2.16.4 Conduct technical reviews to include: (1) identifying the type of technical reviews and each review's purpose and objectives; (2) determining progress toward satisfying entry criteria; (3) establishing the makeup of the review team; (4) preparing the review presentation materials; and (5) identifying and resolving action items resulting from the review.

E.2.16.5 Abide by the appropriate additional requirements identified in *Project and Task Review Procedural Requirements* (LPR 7130), *Space Flight Independent Life Cycle Review Procedural Requirements* (LPR 7120.7), *Review Program for Langley Research Center Facility Projects* (LAPD 7000.2). *(This is a LaRC additional practice.)*

E.2.16.6 Capture work products from the conduct of technical assessment activities to include: (1) identifying variances resulting from technical assessments; (2) identifying and reporting changes to correct variances; (3) recording methods used in doing assessment activities; (4) documenting assumptions made in arriving at the process and product measure outcomes; and (5) reporting corrective action recommendations.

E.2.17 Technical Decision Analysis Process Best Practices

E.2.17.1 Establish guidelines to determine which technical issues are subject to a formal analysis/evaluation process to include: (1) when to use a formal decision-making procedure, for example, as a result of an effectiveness assessment, a technical tradeoff, a problem needing to be solved, action needed as a response to risk exceeding the acceptable threshold, verification or validation failure, make-buy choice, evaluating a solution alternative, or resolving a requirements conflict; (2) what needs to be documented; (3) who will be the decision makers and their responsibilities and decision authorities; and (4) how decisions will be handled that do not require a formal evaluation procedure.

E.2.17.2 Define the criteria for evaluating alternative solutions to include: (1) the types of criteria to consider include the following: technology limitations, environmental impact, safety, risks, total ownership and life-cycle costs, and schedule impact; (2) the acceptable range and scale of the criteria; and (3) the rank of each criterion by its importance.

E.2.17.3 Identify alternative solutions to address decision issues to include alternatives for consideration in addition to those that may be provided with the issue.

E.2.17.4 Select evaluation methods and tools/techniques based on the purpose for analyzing a decision and on the availability of the information used to support the method and/or tool.

E.2.17.5 Evaluate alternative solutions with the established criteria and selected methods to include: (1) evaluation of assumptions related to evaluation criteria and of the evidence that supports the assumptions; and (2) evaluation of whether uncertainty in the values for alternative solutions affects the evaluation.

E.2.17.6 Select recommended solutions from the alternatives based on the evaluation criteria to include documenting the information that justifies the recommendations and gives the impacts of taking the recommended course of action.

E.2.17.7 Report the analysis/evaluation results/findings with recommendations, impacts, and corrective actions.

E.2.17.8 Capture work products from decision analysis activities to include: (1) decision analysis guidelines generated and strategy and procedures used; (2) analysis/evaluation approach, criteria, and methods and tools used; (3) analysis/evaluation results, assumptions made in arriving at recommendations, uncertainties and sensitivities of the recommended actions or corrective actions; and (4) lessons learned and recommendations for improving future decision analyses.

APPENDIX F. REFERENCES

The following documents may be useful to individuals in addressing the requirements of this LPR.

a. NPR 1441.1, NASA Records Retention Schedules

b. NASA/SP-2007-6105, NASA Systems Engineering Handbook

c. NPR 8000.4A, Agency Risk Management Procedural Requirements

d. CMMI® Guidelines for Process Integration and Product Improvement – Addison-Wesley

e. LPR 7120.4, LaRC Technical Authority Implementation Plan