Enterprise Systems Engineering Management Plan

Release Date:

Approved by:

Document Change Record

TABLE OF CONTENTS

1.0 Introduction

This System Engineering Management Plan (SEMP) establishes the overall plan for the system engineering management within Enterprise and identifies and describes the organization, roles and responsibilities, overall tasks, and engineering management planning required to control the design, development, fabrication, and tests associated with Enterprise projects. This SEMP is an operating plan for how Enterprise will execute its systems engineering function. The boundaries of the Enterprise Systems engineering function is as shown in Figure 1. This SEMP can be tailored for each specific Project; however, how one project executes its systems engineering shall not differ greatly from how another project shall execute its systems engineering regardless of the project's scope, acquisition strategy, risk, life cycle phase, etc. This SEMP shall also be used in determining the adequacy of subcontractors and vendors systems engineering processes and requirements. If necessary, it shall be tailored and flowed down as a contractual requirement.

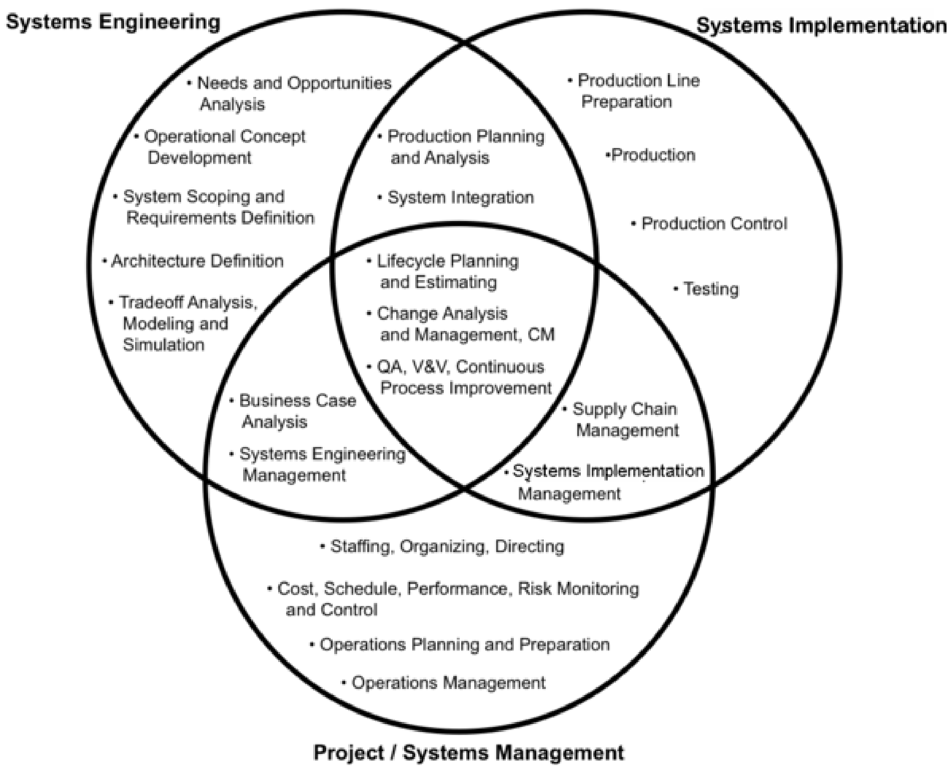


Figure 1: Systems Engineering Function Boundaries

1.1 Purpose

The purpose of this document is to identify and describe the overall systems engineering processes and methods to be used during all phases of all Enterprise projects.

1.2 Scope

This SEMP establishes the overall plan for the systems engineering management of all Enterprise projects. The SEMP describes technical planning and control, systems engineering processes, and engineering specialty integration. It represents the application of systems engineering techniques tailored to Enterprise projects. Operational aspects of Enterprise projects are not covered in this plan. This document shall apply to all Enterprise personnel, contractor personnel and potentially to all supply chain contractors. The SEMP is a living document and shall be modified as needed and maintained under configuration control. Enterprise Systems Engineering uses the sequential Vee model as our Life Cycle model and all Systems Engineering (SE) processes are configured per that model. (Figure 2)

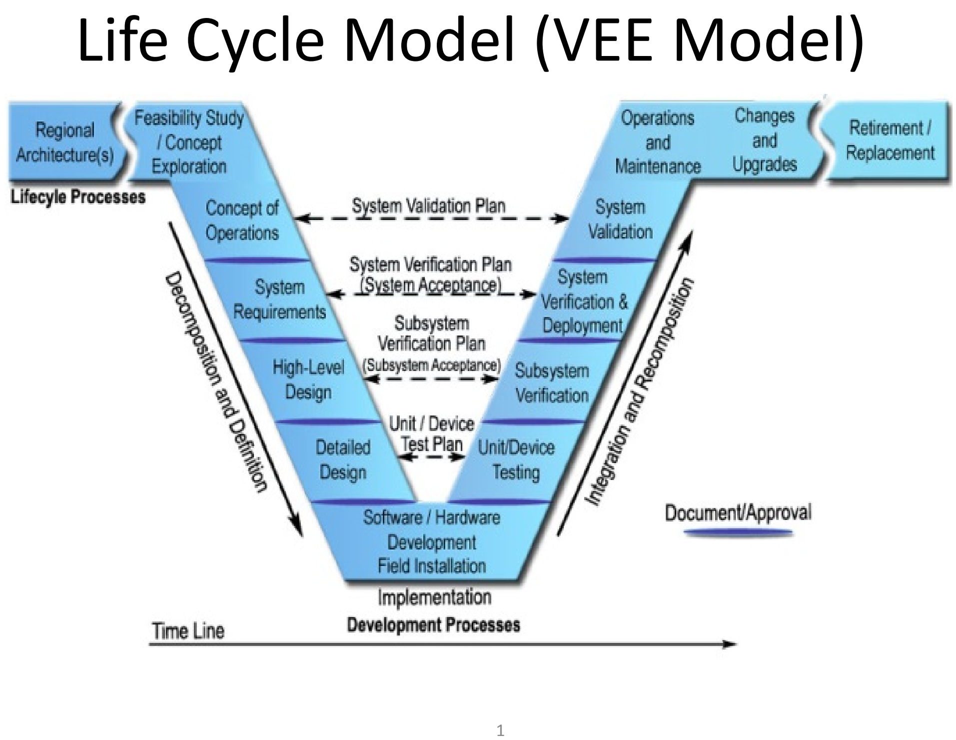


Figure 2: Enterprise Sequential Vee Life Cycle Model

2.0 Enterprise Documents

The following Enterprise documents are developed and updated by the Enterprise Systems Engineering Center:

1. Systems Engineering Management Plan
2. Systems Engineering Metrics Document
3. Systems Engineering Training Plan
4. Risk Management Plan and Process
5. Requirements Management Plan and Process
6. Configuration Management Plan and Process
7. Systems Process and Product Assurance Plan

8. Environmental, Safety and Occupational Health (ESOH) Management Plan
9. Diminishing Manufacturing and Material Sources (DMSMS) Management Plan (Includes Counterfeit and Non-Conforming Parts) and Process
10. Modeling and Simulation Plan
11. Baseline Control Plan and Process
12. Systems Engineering Continuous Process Improvement Plan
13. RAMT Plan and Process
14. EMI/EMC Plan
15. Human Factors Plan
16. Network Architecture Plan
17. Lessons Learned Plan
18. Software Development/Control (Surveillance) Plan
19. Software Requirements Specification
20. Systems Engineering and SEIT Charters
21. Risk Review Board, Configuration Control Board, Engineering Review Board, Failure Prevention and Review Board, Integrated Test Team Charters
22. Systems Engineering Training Plan and Course Materials
23. System Validation and Verification Plan
24. Integration and Test Plan
25. Use Case Development Procedure
26. Customer Support Transition Procedure
27. Integrated Baseline Review Procedure
28. Data Management Plan and Process
29. Interface Management Process
30. Technical Assessment Process
31. Architecture Design Process

2.1 Parent Documents

The documents in this paragraph establish the criteria and technical basis for the existence of this document.

Document Number	Parent Document Title
Version 1.0	Enterprise Program/Project Plan
Version 4, 2015	INCOSE Systems Engineering Handbook
Version 1.0 Published August 27, 2010	Joint Software Systems Safety Engineering Handbook
1998	US Army Systems Engineering Fundamentals
DEFENSE ACQUISITION UNIVERSITY PRESS January 2001	SYSTEMS ENGINEERING FUNDAMENTALS
NASA/SP-2007-6105 Rev1, 2007	NASA Systems Engineering Handbook

2.2 Applicable Documents

Applicable documents are those documents that form a part of this document. These documents carry the same weight as if they were stated within the body of this document.

Document Number	Applicable Document Title
AS-6500	Manufacturing Management Program, issued 11-2014
IEEE 1220 - 2005	Standard for Application and Management of the Systems Engineering Process
ISO/IEC 15288 - 2008	Systems and Software Engineering System Life Cycle Processes
ISO 12207	Software Engineering and Development
ANSI/EIA 632	Processes for Engineering a System
November 1994	GOVERNMENT-INDUSTRY DATA EXCHANGE PROGRAM Operations Manual
SD – 22, August 2012	Diminishing Manufacturing Sources and Material Shortages (DMSMS): A Guidebook of Best Practices and Tools for Implementing a Robust DMSMS Management Program (August 2012)

2.3 Reference Documents

Reference documents are those documents that, though not a part of this document, serve to clarify the intent and contents of this document.

Document Number	Reference Document Title
MIL-STD-499A	Engineering Management
DI-E-7144 and DI-MGMT-81024	System Engineering Management Plan
MIL-STDs and MIL-HDBKs	As Required
N/A	Risk Management Guide for DOD Acquisition, Fifth Edition, Version 2.0, 2003
MIL-STD-882E	DoD Standard Practice for System Safety, 2012

3.0 Technical Project Planning and Control

3.1 Project Organization

Each Enterprise Project will be managed in accordance with the Enterprise SEMP. There will be a single Enterprise Project Manager who will lead the Project and a single Project

Systems Engineer assigned as support for the Project Manager. A Systems Engineering Integration Team (SEIT) will be developed for each Project and led by the Project Systems Engineer.

The Enterprise Systems Engineering Center (SEC) organizational structure (Figure 3) is arranged to accommodate Project Work Breakdown Structures (WBS) as well as the necessary project management functions. Specific individual Systems Engineers will be assigned to each Enterprise Project and systems engineering support team members will be assigned in a matrix fashion. The SEC will administratively own all SE personnel and they will be matrixed out as necessary to each Project SEIT.

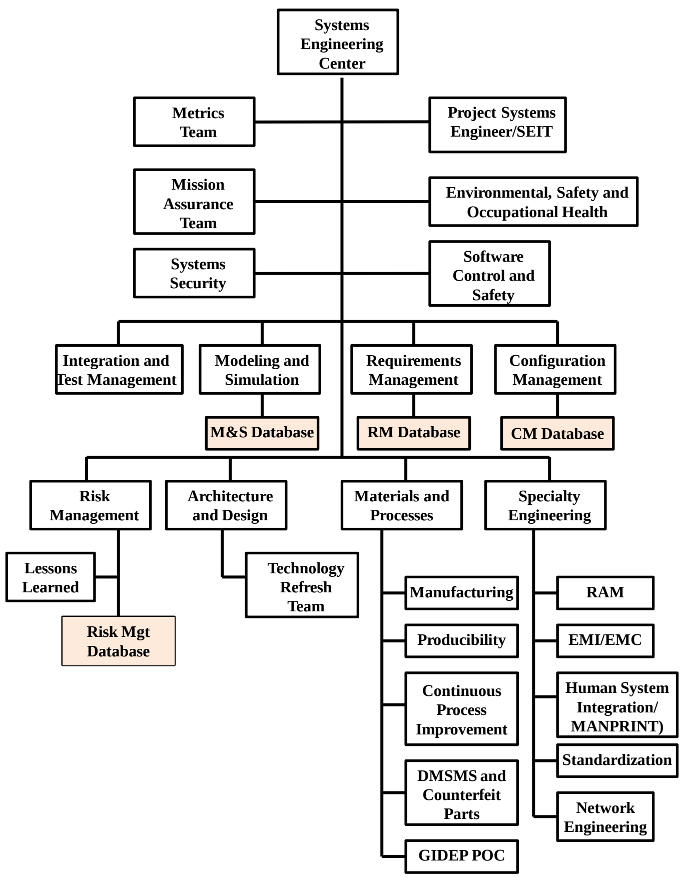


Figure 3: Enterprise Systems Engineering Center Organization

3.2 Responsibility and Authority

While the Project Manager has full responsibility and accountability for the execution of the project, meeting all requirements will necessitate support from Systems Engineering. This section will delineate the responsibilities of systems engineering to effectively plan, support, control, and deliver products to meet the requirements of an Enterprise Project.

A Responsibility Assignment Matrix (RAM) is developed for each project by using the WBS, the Integrated Master Schedule (IMS), the Enterprise organizational structure and the contract requirements to link deliverables and/or activities to resources. The RAM provides a realistic picture of the resources needed and identifies if you have enough resources for the each deliverable, activity and overall project. Additionally, it clearly shows who is responsible for what and if they are actually accomplishing the work assigned, it keeps everybody on the same page on who is accountable for a particular task and keeps all the necessary people in the loop and reduces miscommunications. By creating a RAM; deliverables are assigned a responsible party, who will review or add input and the appropriate approval authority is identified. It is especially useful in clarifying roles and responsibilities in cross-functional/ departmental projects and processes. The key responsibility roles[1] are as follows:

1. Responsible - Those who do the work to achieve the task. There is at least one role with a participation type of responsible, although others can be delegated to assist in the work required.
2. Accountable (also approver or final approving authority) - The one ultimately answerable for the correct and thorough completion of the deliverable or task, and the one who delegates the work to those responsible. In other words, an accountable must sign off (approve) work that responsible provides. There must be only one accountable specified for each task or deliverable.
3. Consulted - Those whose opinions are sought, typically subject matter experts; and with whom there is two-way communication.
4. Informed - Those who are kept up-to-date on progress, often only on completion of the task or deliverable; and with whom there is just one-way communication.

The assigned Project Systems Engineer has the responsibility for managing the technical aspects of the project. The Project Systems Engineer is responsible for technical oversight of the project and for coordinating the technical aspects of the project, particularly internal and external project interfaces. While one individual is assigned as the lead Project Systems Engineer, it must be recognized that systems engineering is a team effort, in which the entire Systems Engineering Team must participate, in order to achieve project success within the allotted constraints. The lead Project Systems Engineer's role is to work with the Project Manager and the Enterprise Systems Engineering Team to satisfy the customer's needs.

The Project Systems Engineering team shall assist the Project Staff in developing and maintaining the Project IMS, Integrated Master Plan (IMP) and all baselines. The Project systems engineering team has the responsibility for the following Enterprise Project documents, matrices, and plans:

[1] Role distinction - There is a distinction between a role and individually identified people: a role is a descriptor of an associated set of tasks; may be performed by many people; and one person can perform many roles. For example, an organization may have ten people who can perform the role of project manager, although traditionally each project only has one project manager at any one time; and a person who is able to perform the role of project manager may also be able to perform the role of business analyst and tester.

1. Project Systems Engineering Management Plan
2. Project Software Control Plan
3. Project Requirements Document and Flowdown
4. Project Requirements Traceability Matrix
5. Project Design Requirements Verification Matrix
6. Project Configuration Management Plan
7. Project Verification and Validation Plan
8. Project Test Plans
9. Project Risk Management Plan
10. Project Operations Concept Plan
11. Project Product Assurance Plan
12. Project Information Technology Security Plan
13. Task Orders

Some of the teams and Boards that the Project Systems Engineer will coordinate and chair are:

1. Project Design Team
2. Integrated Test Team
3. Project Configuration Control Board
4. Risk Management Board
5. Engineering Review Board

3.3 Standards, Procedures, and Training

Where appropriate, the standards and procedures established by Enterprise and our industry shall be utilized. All standards and specifications used will be documented in the appropriate design documentation. Systems Engineering training requirements for a project will be determined by the Project Systems Engineer and submitted to the Enterprise Systems Engineering Director for approval.

3.4 Work Breakdown Structures

The WBS for an Enterprise Project is defined in the appropriate Project Plan and Project Development Schedule. Figure 4 provides an example.

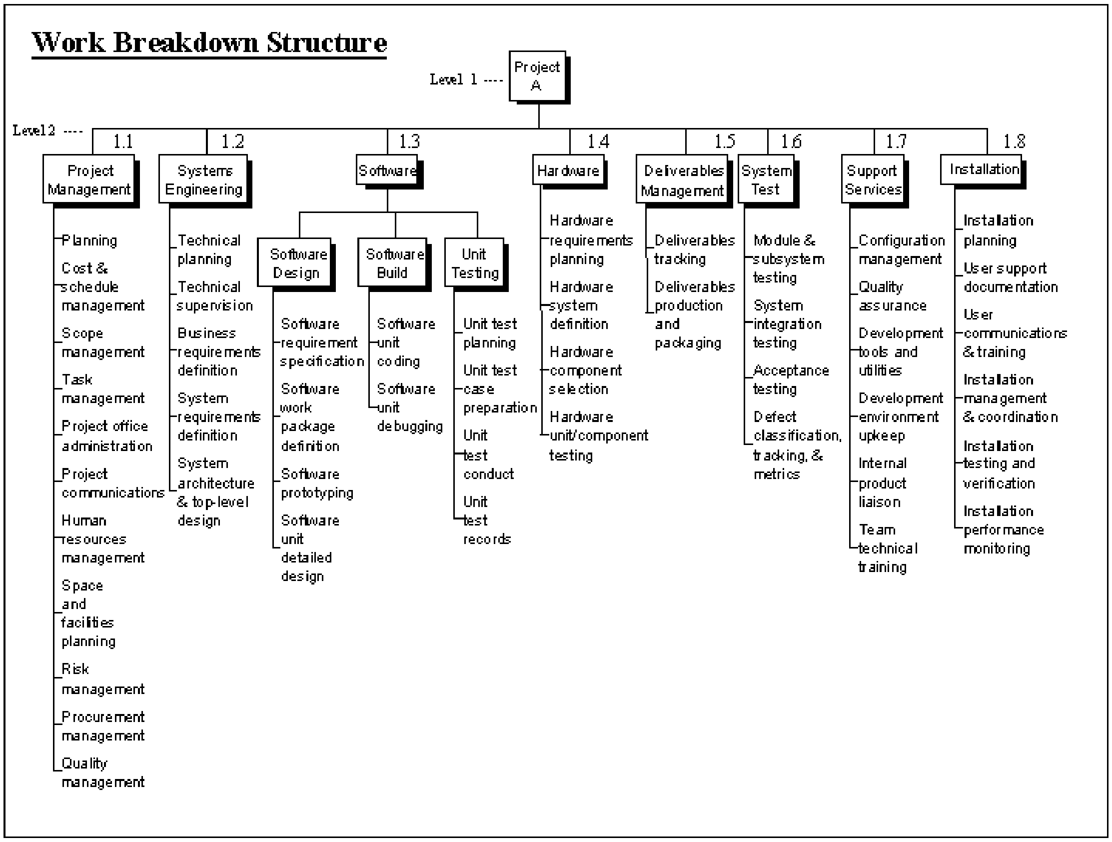


Figure 4: Example Project Work Breakdown Structure

3.5 Systems Integration

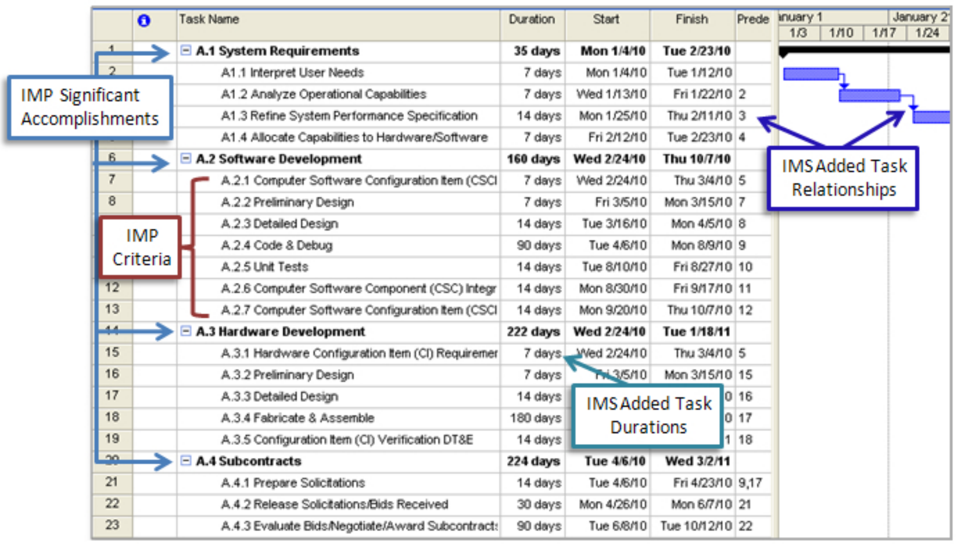
The systems integration effort will be controlled by the technical review process. The procedures, facilities, and scheduling of the integration effort shall be addressed during the reviews. The Enterprise Project Manager, Chief Engineer, lead design engineers, Project Systems Engineer, and ESOH, MANPRINT, HSI, risk and mission assurance representatives will review and provide approval to proceed in regard to subsystem and system integration.

3.6 Project Interface Control

The design team, along with the Project Manager, shall determine when formal interface control documents are required. Initially a Standard Interface Document (SID) will be prepared and expanded with each phase of the project. When an outside customer or a subcontractor/supplier is bringing a test article, a formal interface control document (ICD) will be required and will be provided by the customer/subcontractor/supplier.

3.7 Project Schedule and Milestones

An example top-level Enterprise Project schedule is provided in Figure 5. The milestones must be related to completion of major WBS elements. The schedule will be tracked according to the Project WBS. The WBS element leads will have responsibility for reporting to the project schedule analyst on a monthly basis. The schedule will be baselined after the implementation of the Project PDR (or its equivalent) and accordingly come under the configuration control process at that time. All project engineers should be cognizant of all schedule inputs. A description of the process used for managing the schedule changes is included in the Enterprise project schedule control document and change approvals via the project configuration control process as outlined in the Enterprise Systems Engineering Configuration Management Procedure.



	Task Name	Duration	Start	Finish	Prede
1	A.1 System Requirements	35 days	Mon 1/4/10	Tue 2/23/10	
2	A1.1 Interpret User Needs	7 days	Mon 1/4/10	Tue 1/12/10	
3	A1.2 Analyze Operational Capabilities	7 days	Wed 1/13/10	Fri 1/22/10	2
4	A1.3 Refine System Performance Specification	14 days	Mon 1/25/10	Thu 2/11/10	3
5	A1.4 Allocate Capabilities to Hardware/Software	7 days	Fri 2/12/10	Tue 2/23/10	4
6	A.2 Software Development	160 days	Wed 2/24/10	Thu 10/7/10	
7	A.2.1 Computer Software Configuration Item (CSCI	7 days	Wed 2/24/10	Thu 3/4/10	5
8	A.2.2 Preliminary Design	7 days	Fri 3/5/10	Mon 3/15/10	7
9	A.2.3 Detailed Design	14 days	Tue 3/16/10	Mon 4/5/10	8
10	A.2.4 Code & Debug	90 days	Tue 4/6/10	Mon 8/9/10	9
11	A.2.5 Unit Tests	14 days	Tue 8/10/10	Fri 8/27/10	10
12	A.2.6 Computer Software Component (CSC) Integr	14 days	Mon 8/30/10	Fri 9/17/10	11
13	A.2.7 Computer Software Configuration Item (CSCI	14 days	Mon 9/20/10	Thu 10/7/10	12
14	A.3 Hardware Development	222 days	Wed 2/24/10	Tue 1/18/11	
15	A.3.1 Hardware Configuration Item (CI) Requiremer	7 days	Wed 2/24/10	Thu 3/4/10	5
16	A.3.2 Preliminary Design	7 days	[illegible]	Mon 3/15/10	15
17	A.3.3 Detailed Design	14 days	[illegible]	[illegible] 0	16
18	A.3.4 Fabricate & Assemble	180 days	[illegible]	[illegible] 0	17
19	A.3.5 Configuration Item (CI) Verification DT&E	14 days	[illegible]	[illegible] 1	18
20	A.4 Subcontracts	224 days	Tue 4/6/10	Wed 3/2/11	
21	A.4.1 Prepare Solicitations	14 days	Tue 4/6/10	Fri 4/23/10	9,17
22	A.4.2 Release Solicitations/Bids Received	30 days	Mon 4/26/10	Mon 6/7/10	21
23	A.4.3 Evaluate Bids/Negotiate/Award Subcontracts	90 days	Tue 6/8/10	Tue 10/12/10	22

Figure 5: Example Integrated Master Schedule

3.8 Project Reviews

The Project Plan shall define the project reviews that will be held in accordance with the Project. Each Systems Engineering team member shall support the Project Manager and Project Systems Engineer in this activity by providing the appropriate details and status as required.

3.8.1 Technical Design Review

The technical review process, which shall be used during each Project, shall follow the design review process and informal design review process as outlined in Enterprise Document SE-PLA-0022.

3.8.2 Technical Interchange Meeting (TIM)

Other technical reviews shall be held on an as-needed basis to address issues as they arise. Besides technical design issues, each TIM may address any, or all, of the engineering specialties described in **Section 4.0** of this document. Prior to each TIM, the agenda shall be distributed to the project team members. At the completion of each TIM, minutes will be documented and filed with all other project documentation.

3.9 Project Technical Performance Management (TPM)

The specific TPM effort will be tailored to meet the project needs and shall be planned by the Project Manager and the Project Systems Engineer and executed as required.

3.9.1 Parameters

The technical performance parameters selected for tracking shall be key indicators of project success. Each parameter identified shall be correlated within specific WBS elements.

Potential Parameters: (Note: Parameters should be added or deleted as necessary)

1. Software performance
2. Software tool(s) performance
3. Human performance
4. System test performance
5. Reliability performance
6. Environmental performance
7. Quality evaluation performance
8. Project management performance
9. Safety compliance

3.9.2 Planning

The following data shall be established during the planning stage for each parameter to be tracked:

1. Specification requirement
2. Time-phased planned value profile with tolerance band
3. Project events significantly related to the achievement of the planned value profile (reviews, audits, etc.)
4. Conditions of measurement (type of test, simulation, analysis, etc.)

Metrics shall be developed to report on the parameters status during the Project system life cycle. Metrics data can be acquired from audit reports (internal and external), review reports (internal and in-process), test reports, minutes of meetings, quality evaluation records, and configuration status accounts, etc. When contractually specified, the specific method and technique will be established, documented in a detailed procedures document, and implemented. If not contractually specified, a metrics method and technique shall be chosen and implemented. Possible metrics and representations of them should be chosen from the examples provided in Appendix B. Metrics shall be collected and presented to Enterprise Senior Management for ALL projects.

3.9.3 Implementation

As the design progresses, the achievement-to-date shall be tracked continually for each of the selected technical performance parameters. In case the achievement-to-date value falls outside the tolerance band, a new profile or "current estimate" will be developed. The current estimate shall be determined from the achievement to date and the remaining schedule and budget. For specific tasks to be accomplished under a Project, the Project

Systems Engineer will assign a Task Lead and, in conjunction with the Task Lead, develop and distribute Task Orders describing the overall task, necessary inputs, work flow and specific exit criteria.

3.9.4 Cost and Schedule Performance Measurement

Technical performance measures shall be related to cost and schedule performance measurement. Cost, schedule, and technical performance measures will be made against elements of the WBS. Too often, systems engineering is viewed as not having a defined "product." This results in systems engineering being reflected as Level Of Effort (LOE) in many Earned Value Management (EVM) plans and cost accounts. Good systems engineering planning, including the identification and management of the technical baselines (functional baseline, allocated baseline, and product baseline) should call out specific systems engineering products in the form of these baselines. When aligned to the system WBS, the technical baselines should be the basis for earned value cost accounts and provide a product-driven view of managing systems engineering costs (and value). Additionally, when the maturity of these technical baselines are entry criteria for event-based technical reviews, earned value can provide critical insight to technical progress against accumulated cost and schedule measures.

3.9.5 Status Reporting

Parameters selected for tracking shall be identified and their status reported at regular intervals by the WBS subelement leads. The format and content of these reports shall be in accordance with the status accounting reports used by configuration management. They shall identify the parameters selected and identify their status together with a summary and any recommendations.

3.9.6 Other Plans and Controls

Other required Project Plans, including the Test and Evaluation Master Plan (TEMP), the Risk Management Plan (RMP), the Systems Safety Program Plan (SSPP) and Project Network Security Plan (NSP) (not to be confused with Enterprise IT system) are to be developed by the Project Systems Engineering team.

The Enterprise Project Manager, with support from the Project Systems Engineer, is responsible for any contracted technical engineering support and contract oversight. Surveillance of contracted technical requirements is accomplished through design reviews, technical interchange meetings, Quality Assurance (QA), Configuration Management (CM) audits and/or reviews, approval of required plans, tracking of schedule and cost performance, discrepancy reports on materials and manufacturing processes, and continuous oversight by technical and procurement management.

3.10 Project Technical Communication

The Enterprise Project Systems Engineering Team should make every effort to utilize available communications technology and tools to facilitate the exchange of information throughout the entire Project team. The available technology and tools at Enterprise are XXX. The Project Manager and Project Systems Engineer shall develop required Project mailing lists at the start of the Project and ensure that all necessary personnel are included. Separate mailing lists for specific areas are recommended as well as an overall Project personnel mailing list. The Outlook calendar function shall be used to schedule Project meetings. The Systems Engineering Team Security Representative along with Enterprise IT personnel will play a role in ensuring the confidentially, availability and integrity of these Project communications versus security risks.

3.10.1 Documentation

Design documentation shall be in accordance with the Project Document Management Plan which is developed from the contractual CDRLs. The following documentation shall be produced for the entire Enterprise Project or for each Project system/subsystem, as appropriate.

3.10.2 Project Documentation

The Project documentation shall have document numbers. The configuration manager will be responsible for assigning document numbers. The project systems engineering documentation list will include the Project Plan, specifications, drawings, procedures, schedules, and reports.

3.10.3 Product Documentation/Configuration Management System

The Project shall use the existing Enterprise Document Release Authorization (DRA) process for all interim and final documentation release. Release approval will be by the appropriate IPT lead, Project Systems Engineer and Project Manager. All electronic documentation for release and revision management shall be controlled by the Project Plan and the Enterprise Systems Engineering Configuration Management procedure. Project team members shall submit interim release documentation to the Project Systems Engineer. The Project Systems Engineer will then control the document and follow the Project Plan and the Enterprise Systems Engineering Configuration Management procedure.

3.11 Project Systems Engineering Configuration Management

The Project Configuration Manager shall be assigned by the Enterprise Systems Engineering Manager and shall implement an internal configuration management system (based on the Enterprise Systems Engineering Configuration Management Plan and Process documents) for the control of all configuration documentation, physical media, and physical parts representing or comprising the product. For software, the system shall address the evolving developmental configuration and support environments (engineering, implementation and test) used to generate and test the product.
The Project and all subcontractors' configuration management systems shall consist of the following elements:

1. Configuration identification
2. Configuration control
3. Configuration accounting
4. Configuration audits

And clearly define

1. the set of artifacts (configuration items) under the jurisdiction of CM
2. how artifacts are named
3. how artifacts enter and leave the controlled set
4. how an artifact under CM is allowed to change
5. how different versions of an artifact under CM are made available and under what conditions each one can be used
6. how CM tools are used to enable and enforce CM

Responsibilities include

1. Baseline (functional, allocated, developmental and product) management
2. Preparation of change control status reports
3. Member of the configuration control board (secretariat)
4. Participation in formal design reviews
5. Management of the configuration library and database(s)

Configuration Baselines Description (DoD)

(Reference: http://acqnotes.com/acqnote/careerfields/configuration-baselines)

A Configuration Baseline is established for specific events in a program's life-cycle and contributes to the performance portion of a program's Acquisition Program Baseline (APB). The overall Technical Baseline rolls up into the APB and consists of the following configuration baselines:

1. Functional Baseline: Definition of the required system functionality describing functional and interface characteristics of the overall system, and the verification required to demonstrate the achievement of those specified functional characteristics. This baseline is derived from the Capability Development Document (CDD) and normally includes a detailed functional performance specification for the overall system and the tests necessary to verify and validate overall system performance. The functional baseline is normally established and put under configuration control at the System Functional Review (SFR). It is usually verified with a System Verification Review (SVR) and/or a Functional Configuration Audit (FCA).
2. Allocated Baseline: Definition of the configuration items making up a system, and then how system function and performance requirements are allocated across lower level configuration items (hence the term allocated baseline). It includes all functional and interface characteristics that are allocated from the top level system or higher-level configuration items, derived requirements, interface requirements with other configuration items, design constraints, and the verification required to demonstrate the traceability and achievement of specified functional, performance, and interface characteristics. The performance of each configuration item in the allocated baseline is described in its preliminary design specification as are the tests necessary to verify and validate configuration item performance. The allocated baseline is usually established and put under configuration control at each configuration item's (hardware and software) Preliminary Design Review

(PDR), culminating in a system allocated baseline established at the system-level PDR.

3. Product Baseline: Documentation describing all of the necessary functional and physical characteristics of a configuration item; the selected functional and physical characteristics designated for production acceptance testing; and tests necessary for deployment/installation, operation, support, training, and disposal of the configuration item. The initial product baseline includes “build-to” specifications for hardware (product, process, material specifications, engineering drawings, and other related data) and software (software module design - “code-to” specifications). The Initial product baseline is usually established and put under configuration control at each configuration item’s Critical Design Review (CDR), culminating in an initial system product baseline established at the system-level CDR. By DoD policy, the PM shall assume control over this initial product baseline after the system-level CDR and control all Class 1 changes. Until completion of the System Verification Review (SVR) and/or FCA, Class 1 changes shall be those changes that affect the government performance specification. Following the SVR/FCA, the government will further define contractually what constitutes a Class 1 change. The system product baseline is finalized and validated at the Physical Configuration Audit (PCA).
4. Developmental Baseline: the contractor's design and associated technical documentation that defines the contractor’s evolving design solution during development of a CI. The developmental configuration for a CI consists of that contractor internally released technical documentation for hardware and software design that is under the developing contractor's configuration control.

Based on the definition of the functional, allocated and product baselines as Government baselines, there has always been considerable confusion as to what to call the baseline established between a contractor and a subcontractor. From the contractor’s point of view, it is an allocated baseline. From the subcontractor’s view, it is a functional baseline since it constitutes the top-level requirement that the subcontractor must meet, and which the subcontractor may need to allocate further down the CI tree. Whether this baseline is considered a functional baseline, an allocated baseline, or a functional/allocated baseline, is immaterial so long as the configuration control requirements for the related configuration documentation are clearly established.

3.11.1 Software Configuration Management

The Systems Engineering Configuration Management will include Software Configuration Management (SCM) capabilities. The goals of Enterprise SCM are as follows:

1. Configuration identification - Identifying configurations, configuration items and baselines
2. Configuration control - Implementing a controlled change process. This is usually achieved by setting up a change control board whose primary function is to approve or reject all change requests that are sent against any baseline

3. Configuration status accounting - Recording and reporting all the necessary information on the status of the development process
4. Configuration auditing - Ensuring that configurations contain all their intended parts and are sound with respect to their specifying documents, including requirements, architectural specifications and user manuals
5. Build management - Managing the process and tools used for builds
6. Process management - Ensuring adherence to the organization's development process
7. Environment management - Managing the software and hardware that host the system
8. Teamwork - Facilitate team interactions related to the process
9. Defect tracking - Making sure every defect has traceability back to the source(s)

3.11.2 Project Configuration Control Procedures

A Project Configuration Control Board (CCB) will be established with the intent of controlling changes to baselined Project technical requirements and documentation. Once system/subsystem requirements have been baselined, all new requirements will be submitted to the CCB for assessment and approval. Upon approval, the baseline will be changed to reflect new requirements. Lower level boards can be established to address lower level requirements and documentation.

3.11.3 Project Configuration Control Board

The CCB is chaired by the Project Systems Engineer, and consists of the Chief Engineer, lead engineers, ESOH and HSI, risk and mission assurance representatives. Operation and maintenance representatives, customers, external agency representatives and other project team members may participate as subject matter dictates. The CCB is the controlling authority for establishing all Project configuration baselines. The CCB shall meet at least monthly, or as items are pending. Documents controlled by the CCB can be found in the project plan.

3.11.4 Project Change Approval Procedure

The cognizant team member(s) who holds principal responsibility for the component, unit, subsystem or system will submit the appropriate change documentation to the CCB. These change requests must come through the Engineering Review Board of the Failure Prevention and Review Board. On receipt of the change documentation, the CCB shall consider the proposed changes, taking into consideration the economic impact upon the project, as well as the technical merits of the proposed changes. Approval of the proposed change documentation shall require the signature of the CCB chair. Final approved documents shall be disseminated to the project team members and retained in the project archives**.** The CCB shall have an action tracking log for ensuring completion.

3.12 Project Mission Assurance

The Systems Engineering Manager shall appoint a Lead for Project Mission Assurance (MA). This person shall work under the Project Systems Engineer and be a participant in the Project FPRB. He/she will be responsible for oversight of quality assurance and the development of the Project Product Assurance Plan, Project System Safety Plan, and Risk Management Plan. The MA lead will be responsible for reviewing all Project documentation, results, etc., to assess the safety posture of the system design. The MA lead is also responsible for developing and performing the overall system reliability analysis and maintaining it as the project progresses. The MA lead reports directly to the Project Manager; however, the role of the MA lead is to ensure the appropriate level of ESOH, reliability, risk, and quality assurance is maintained on the Enterprise project.

If there are multiple interfaces, requirements, customers, and/or project phases, the Enterprise Project shall have a separate Product Assurance Plan that describes all the MA activities and documentation in an integrated fashion. Various MA activities shall be performed during all project phases from concept to disposal. During the concept and design phase, MA requirements and best practices will be identified and incorporated into the design as part of the normal design review process. Sources for these requirements and best practices include contractual requirements, Enterprise documents, the lessons learned system, and federal and state regulations such as OSHA. The primary analyses that shall be accomplished during Enterprise Project design are called System Assurance Analyses (SAA's). These analyses shall be performed for each major Enterprise Project subsystem and include the following as a minimum:

System description
End-to-end analysis
Criticality assessment
Hazard analysis
Reliability analysis (FMEA/CIL(Critical Items List)) on critical subsystems
Fault tree analysis
Security risk assessment
Sneak circuit, quantitative reliability, maintainability, EEE parts selection, human factors, or special analyses as required by the PCCB
Recommendations for improvement

The primary goal of the SAA is to enhance design iteratively to eliminate hazards and single failure points that have loss of life, loss of or damage to critical systems and equipment, and personnel (including operators and maintainers) injury potential. Where single failure points (critical items) cannot be eliminated, CIL sheets shall be generated and approved by the PCCB. Each designer shall be responsible for incorporating ESOH, reliability, maintainability, and quality considerations into their design. S&MA design issues shall be addressed and resolved during design reviews. Where resolution is not achieved, S&MA issues will be brought to the Enterprise Project PCCB for resolution.

The Quality Program shall be tailored for the various missions of the Enterprise Project using the Enterprise Safety, Reliability, Maintainability, and Quality Assurance Programs directive. As a minimum, the Quality Program shall consist of inspections, testing, and analysis of systems and equipment designed, fabricated, operated, and/or tested at Enterprise to ensure the desired level of quality is maintained.

3.13 Project Risk Management

The Enterprise Systems Engineering Manager shall appoint a Project Risk Manager from the SE Team. Technical, operational, management, organizational, enterprise and external risks shall be addressed by the Project by following the Enterprise Risk Management Process or Guide. The objective of the Project Risk Management Process is to document the process in which the project team will identify, assess, control and monitor the risks in achieving project success. This person will work under the Project Mission Assurance Lead and assist in addressing all risk areas necessary for the Project. The Project Risk Manager and the Enterprise Risk Manager shall facilitate the Risk Management meetings. The risks identified shall be documented, statused, assigned owners and monitored by the Project Risk Manager. Risk assessment and approved mitigation plan actions shall be accomplished by assigned Project risk owners.

3.13.1 Lessons Learned

The Systems Engineering Team Risk Manager will maintain the Enterprise Lessons Learned database. Lessons learned during each phase of an Enterprise Project shall be documented by all project team members and submitted to the Project Systems Engineer. The Project Systems Engineer will consolidate and input identified and approved lessons learned into the overall Enterprise Lessons Learned database. Prior to the formal start of any Enterprise Project, a Lessons Learned review meeting will take place discussing how any lessons learned can affect/impact the overall Project. Also prior to the beginning of each Project phase, a Lessons Learned review meeting will take place discussing how the lessons learned can affect the next phase of the Project.

3.13.2 Counterfeit Parts Procedure

The Systems Engineering Team Risk Manager will control and maintain the Enterprise Counterfeit Parts process. This process is designed to eliminate the receipt and unintentional delivery of counterfeit parts and Project systems containing counterfeit parts. It is designed to assist purchasing in procuring parts from reliable sources, assure authenticity and conformance of procured parts, control parts identified as counterfeit and report counterfeit parts to other potential users and Government Investigative authorities. The Enterprise Systems Engineering Team shall determine and maintain a Counterfeit Parts Plan and process. This will be applied to each specific project as required.

4.0 Part II: Systems Engineering Process

4.1 Requirements Management

Enterprise requirements management is the process of documenting, analyzing, tracing, prioritizing and agreeing on requirements and then controlling change and communicating to relevant stakeholders. It is a continuous process throughout all projects, controlled and coordinated by the Enterprise Systems Engineering Team. The purpose of the requirements management process is to ensure that all Enterprise Projects documents, verifies and meets the needs and expectations of its customers and internal or external stakeholders. Requirements management begins with the analysis and elicitation of the objectives and constraints of the organization, includes supporting planning for requirements, integrating requirements and attributes for requirements, as well as relationships with other information delivering against requirements, and changes for these. Enterprise requirements management addresses functional requirements, performance requirements, constraints, interface requirements, environmental requirements and other requirements as defined in the INCOSE Systems Engineering handbook.

A System Requirements Document (SRD) will be generated to address each phase of an Enterprise Project as per the Enterprise Requirements Management Plan. The Project Team shall develop the Project requirements. An Enterprise independent review team (chaired by the Enterprise Systems Engineering Manager) will review the requirements and provide comments at the Project Systems Requirements Review (SRR). The SRD will be baselined upon resolution of the SRR comments.

4.1.1 Functional Analysis

A functional analysis shall be performed at the formulation phase of the project. This analysis will form the basis of the generation of project requirements. The functional analysis shall be an informal iterative process stemming from the top-level functional requirements flow down to the SRD. The functional analysis shall also provide an avenue to verify that all requirements have been identified.

4.1.2 Requirement Allocation

The allocation of requirements shall be phased and mapped to the functional requirements. A Requirements Traceability Matrix shall be developed to document the performance requirements and their associated functional requirement. The matrix will verify that all requirements are related to the Project. This will begin the formulation of the Design Requirements Verification Matrix that must be completed to assure that every requirement has been considered in the Project system's design and build phases.

4.1.3 Requirements Traceability

Requirements traceability is concerned with documenting the life of a requirement. It should be possible to trace back to the origin of each requirement and every change made to the requirement should therefore be documented in order to achieve traceability. Even the use of the requirement after the implemented features have been deployed and used should be traceable.

4.2 System Design

System design is the process of defining the architecture, components, modules, interfaces, and data for a system to satisfy specified requirements. System design is the application of systems theory to product development. The system design process can incorporate linear thinking, parallel thinking, or both, depending on the nature of the anticipated system, subsystem, or element of a subsystem. The structure, composition, scale, or focal point of a new/incremental system design is in either a top-down or bottom-up design style. Each phase of the system design will be done with the previous and future phases taken into consideration. The overall Systems V model used by

Enterprise is shown in Figure 6. The assigned Project Systems Engineer and the matrixed Systems Engineering Team members shall support all design aspects of the specific Project.

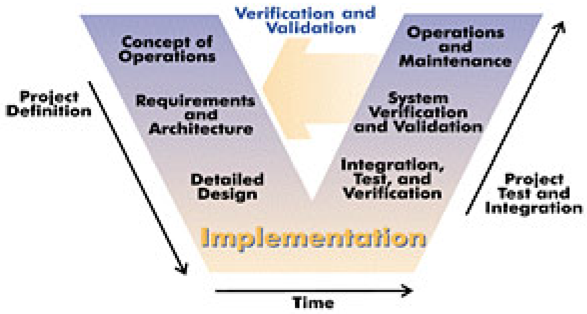


Figure 6: Systems V Model

4.2.1 System Synthesis

Synthesis in design shall be accomplished through regular Project team meetings at which the full range of design products, problems, and interfaces shall be addressed. If possible, appropriate industry Research and Development work should also be addressed and reviewed. This process is facilitated by the systems engineering products, especially the requirements matrix, schedule, and package preparation for the major formal reviews. Accountability is the key to synthesis. Progress reporting and production of high-quality well-considered design products that are able to stand up to review are essential. End-to-end implementation of this project shall be in accordance with Enterprise Project Implementation Documents. The Project Manager will track action items during team meetings, and minutes will be published.

4.3 Materials and Process Engineering

The Enterprise Systems Engineering Team Materials and Process Engineering is a multidisciplinary field that focuses on the manufacture of high-quality, cost-effective parts and systems. The Enterprise Systems Engineering Manager shall assign Materials and Process Engineering personnel to each Project as required. Materials and process engineering will ensure that the Enterprise project system design will use Material Readiness Level 7 (see Document SE-PLA-0009) and above materials and processes unless specifically directed to examine lower MRL level materials and processes. Materials and process engineering assessments may be used to optimize the Enterprise Project hardware design capabilities and limitations. The intent of these assessments is to optimize productivity. Materials and process engineering will address materials and processes issues associated with Enterprise project hardware, and assist in implementing new technologies when and where appropriate.

Materials and Processes personnel will also address development of maintenance and repair materials (documentation) and analyses and will assist in determining new maintenance and repair technologies and processes where appropriate. This includes both Depot-Level and Field-Level maintenance. Level of Repair Analysis (LORA) is used as an analytical methodology to determine when an item will be replaced, repaired, or discarded based on cost considerations and operational readiness requirements. For a complex engineering system containing thousands of assemblies, sub-assemblies, components, organized into several levels of indenture and with a number of possible repair decisions, LORA seeks to determine an optimal provision of repair and maintenance facilities to minimize overall system life-cycle costs. Logistics personnel examine not only the cost of the part to be replaced or repaired but all of the elements required to make sure the job is done correctly. This includes the skill level of personnel, support equipment required to perform the task, test equipment required to test the repaired product, and the facilities required to house the entire operation.

4.4 Modeling and Simulation (M&S)

The responsibility for planning and coordinating program modeling and simulation efforts belongs to the Enterprise Project Manager and may be delegated to the Project Systems Engineer and other program staff as appropriate. Modeling and simulation efforts are included in the systems engineering effort as part of project risk management and cost and schedule planning. Modeling and simulation efforts include identifying metrics that relate the use of modeling and simulation to cost savings and risk reduction. The Systems Engineering Manager shall assign a Systems Engineering Team M&S engineer to each Project. The Enterprise Systems Engineering M&S Engineering will also maintain a model and database of all legacy components, parts, subsystems and systems capable of being used in future Enterprise projects.

4.4.1 Modeling and Simulation Uses

Enterprise Systems Engineers use models to define, understand, communicate, assess, interpret, and accept the project scope; to produce technical documentation and other artifacts; and to maintain “ground truth” about the system(s). Projects should identify and maintain a system model, representing all necessary viewpoints on the design and capturing all relevant system interactions. Unless impractical, the Project should develop the system model using standard model representations, methods, and underlying data structures. The system model is a product of both Systems Engineering and Design Engineering efforts. The Project should construct the model by integrating data consumed and produced by the modeling and simulation activities across and related to the Project as well as appropriate existing Enterprise models and simulations. The Project should confirm the model baseline at appropriate technical milestones. The Project should construct depictions of system concepts developed in support of technical reviews using the system model as source data.

4.4.2 Models and Simulations

The system model should include, but not be limited to, parametric descriptions, definitions of behaviors, internal and external Interfaces, cost inputs, and traces from operational capabilities to requirements and design constructs. The system model should be a part of, and evolve with, the project baseline. The system model should be integrated throughout the project life cycle and across domains within a project’s various phases. The system model can provide source data for the project to use to construct instantiated models to support system trades; optimizations; design evaluations; system, subsystem, component, and subcomponent integration; cost estimations; etc.

The project should update the system model throughout the project life cycle. Capturing these updates in the system model will provide continuity among the project modeling and simulation users and activities. Unless impractical, during the development and construction of models and simulations, the project should ensure the models will be applicable to other project areas such as training and testing.

4.4.3 Project Use of Models and Simulations

The development of models, construction of simulations, and use of these assets to perform project definition and development activities requires collaboration among all Project stakeholders. Proper use of modeling and simulation throughout the project's life cycle is critical for program success. The Systems Engineering Team M&S staff will provide sufficient training to other Project personnel to support the appropriate use of modeling and simulation. The Project should identify metrics and track the metrics to support the linkage between the training and increased support to the Project. Modeling and simulation provides critical capabilities to effectively deal with issues including but not limited to interoperability, joint operations, and systems of systems across the entire life cycle. Models employed in Project activities should be credible, and the Project should use the models while acknowledging a level of risk appropriate to the application.

4.5 Integration and Test

Technical design verification and validation will be accomplished for each phase through the use of one of the following methods: test, analysis, demonstration, similarity, inspection, simulation, validation of records, certification or not applicable, as described in the Enterprise Design Requirements Verification Matrix document.

The Project Design Requirements Verification Matrix will list all requirements as stated in the Project System Requirements Document. In addition, requirements imposed by other applicable documents shall be listed in the matrix. The Project Design Requirements Verification Matrix will identify each requirement, verification method, responsible organization, completion date, and document or test case that will ensure that the system/subsystem/unit/component complies with (satisfies) the requirement.

A preliminary version of the Project Design Requirements Verification Matrix will be required as part of the Project Preliminary Design Review (PDR) and updated at the Project Critical Design Review (CDR).

4.5.1 Verification and Validation Testing

Each phase of the project will culminate in the performance of validation testing. Each procedure used for verification and validation Testing will be shown in the Project Design Requirements Verification Matrix. The tests will also be scheduled and resource loaded on the project planning schedule. The design verification testing will be conducted as a part of the validation testing wherever possible. When this cannot be accomplished, a separate test procedure will be prepared and executed. The tests proposed for each phase of the project will be optimized in the Integrated Validation Plan which is explained in **section 4.5.3** of this document.

4.5.2 Discrepancy Reporting and Disposition

All discrepancies identified during the verification and validation testing shall be handled as issues per SE-GUIDE-0039. Such issues shall be identified as coming from the Validation/Verification testing process and shall be corrected as part of the validation process with all dispositions being documented in the appropriate documentation. During verification and validation discrepancies of all kinds need to be noted and documented. Those that have no impact to utilization or operations can be waived. Rework or retest may be required. In the extreme case, redesign may be required. The type of discrepancy will the drive the required project documentation.

The Issues Tracking System shall fully document the problem description and track it to closure. The Enterprise Systems Engineering Team will manage the entire issues tracking system. These issues (from the Validation/Verification process) shall be routed through the Project Systems Engineer to the appropriate design lead. The design lead will report the status of the Validation/Verification issue to the Project Manager and the Project Systems Engineer on a regular basis. Any uncorrected issues will be documented in a waiver and approved by the Project Configuration Control Board (CCB).

4.5.3 Integrated Validation Plan

An Integrated Validation Plan shall detail the process through which each of the Enterprise Project subsystems and components are integrated and tested as a system. This plan will describe the processes used to integrate Enterprise project system/subsystem installation, testing, and turnover. A list of all systems to be installed, tested, and turned over, the time frames in which these systems will be installed, tested, and turned over, and how the interfaces between subsystems will be tested will be included in this plan. All schedules will be coordinated with the Enterprise project schedule to ensure the project goals and commitments are met.

4.6 Specialty Engineering

The need for specialty engineering expertise in Enterprise Projects is related to technical risks and projected use of the technology(ies) being selected. Specialty Engineering efforts will be centered on system development for technology experimentation and the need for specialty assurance engineering will be assessed on a case-by-case basis. The resources to perform these analyses will be provided to the Enterprise Project Manager by assigned, trained Systems Engineering Team members or through contracted Subject Matter Experts.

Specialty engineering ensures that Enterprise Project technology development and systems designs are compatible with the interface needs and expected operating environment, and utilizes resident expertise and specialty engineering knowledge from past and current Enterprise projects and programs.

4.6.1 Reliability Engineering

Enterprise Systems Engineering Team RAM engineers will evaluate Enterprise Project system technology developments utilizing analytical techniques such as fault tree analyses (FTA), functional failure modes and effects analyses (FMEA), and other analytical methods. The Systems engineering Manager will assign a RAM engineer to each Project based on the expected specific type of product. When specific equipment design is identified, the equipment performance will be evaluated by applying statistical data and probabilistic analyses.

For Enterprise the term "reliability" is used as an overarching concept that includes availability and maintainability (RAM). Reliability is concerned with the probability of a failure occurring over a specified time interval, availability is a measure of something being in a state (mission capable) ready to be tasked (i.e., available) and maintainability is the parameter concerned with how the system in use can be restored after a failure, while also considering concepts like preventive maintenance and Built-In-Test (BIT), required maintainer skill level, and support equipment. When dealing with the availability requirement, the maintainability requirement must also be invoked as some level of repair and restoration to a mission-capable state must be included.

Note that the complex systems now being developed by Enterprise are integrated solutions consisting of hardware and software. Because software performance affects the system RAM performance requirements, software must be addressed in the overall RAM requirements for the system. The wear or accumulated stress mechanisms that characterize hardware failures do not cause software failures. Instead, software exhibits behaviors that operators perceive as a failure. User perception of what constitutes a software failure will surely be influenced by both the need to reboot and the frequency of “glitches” in the operating software.

4.6.1.1 Effective Root Cause Analysis

Root cause analysis (RCA) is a method of problem solving that tries to identify the root causes of faults or problems. A root cause is a cause that once removed from the problem fault sequence, prevents the final undesirable event from recurring. A causal factor is a factor that affects an event's outcome, but is not a root cause. Though removing a causal factor can benefit an outcome, it does not prevent its recurrence for certain. Root cause analysis is not a single, sharply defined methodology; there are many different tools, processes, and philosophies for performing RCA.

The primary aim of root cause analysis is to identify the factors that resulted in the nature, the magnitude, the location, and the timing of the harmful outcomes (consequences) of one or more past events in order to identify what behaviors, actions, inactions, or conditions need to be changed to prevent recurrence of similar harmful outcomes and to identify the lessons to be learned to promote the achievement of better consequences. ("Success" is defined as the near-certain prevention of recurrence.). To be effective, root cause analysis must be performed systematically, usually as part of an investigation, with conclusions and root causes that are identified backed up by documented evidence. Usually a team effort is required. Note that there may be more than one root cause for an event or a problem. The purpose of identifying all solutions to a problem is to prevent recurrence at lowest cost in the simplest way. If there are alternatives that are equally effective, then the simplest or lowest cost approach is preferred. To be effective, the analysis should establish a sequence of events or timeline to understand the relationships between contributory (causal) factors, root cause(s) and the defined problem or event to prevent in the future. Note that root cause analysis can help transform a reactive culture (that reacts to problems) into a forward-looking culture that solves problems before they occur or escalate. More importantly, it reduces the frequency of problems occurring over time within the environment where the root cause analysis process is used. Root cause analysis is a threat to many cultures and environments, therefore a "non-punitive" policy toward problem identifiers is be required.

RCA (in steps 3, 4 and 5) forms the most critical part of successful corrective action, because it directs the corrective action at the true root cause of the problem. Knowing the root cause is secondary to the goal of prevention, but without knowing the root cause, it is not possible to determine what an effective corrective action for the defined problem would be.

1. Define the problem or describe the event to prevent in the future. Include the qualitative and quantitative attributes (properties) of the harmful outcomes. This usually includes specifying the natures, the magnitudes, the locations, and the timing of events. In some cases, "lowering the risks of reoccurrences" may be a reasonable target. For example, "lowering the risks" of future automobile accidents maybe more reasonable target than "preventing all" future automobile accidents.
2. Gather data and evidence, classifying it along a timeline of events to the final failure or crisis. For every behavior, condition, action, and inaction specify in the "timeline" what should have been done when it differs from what was done.
3. Use the Fishbone and/or the 5 Whys techniques (see figures 7 and 8 below) and identify the causes associated with each step in the sequence towards the defined problem or event. "Why" is taken to mean "What were the factors that directly resulted in the effect?" Use all three 5 Whys techniques – Specific, Detection and Systemic.
4. Classify causes into causal factors that relate to an event in the sequence and root causes, which if eliminated, can be agreed to have interrupted that step of the sequence chain.
5. Identify all other harmful factors that have equal or better claim to be called "root causes." If there are multiple root causes, which is often the case, reveal those clearly for later optimum selection.
6. Identify corrective action(s) that will with certainty prevent recurrence of each harmful effect, including outcomes and factors. Check that each corrective action

would, if pre-implemented before the event, have reduced or prevented specific harmful effects.

7. Identify solutions that, when effective, and with consensus agreement of the group, prevent recurrence with reasonable certainty, are within the institution's control, meet its goals and objectives and do not cause or introduce other new, unforeseen problems.
8. Implement the recommended root cause correction(s).
9. Ensure effectiveness by observing the implemented recommendation solutions.
10. Identify other methodologies for problem solving and problem avoidance that may be useful.
11. Identify and address the other instances of each harmful outcome and harmful factor.

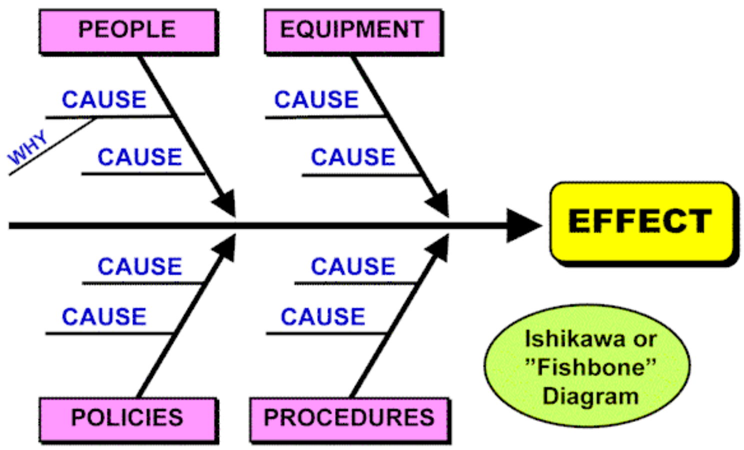


Figure 7: Fishbone Diagram

Figure 8: Root Cause Analysis

4.6.2 Systems Safety Engineering

Systems Engineering Team Safety Engineering (SSE) will analyze the effects of Enterprise Project technology(ies) for hazards and safety issues through use of MIL-STD-882E (and other contractual requirements, if any). The Systems Engineering Manager will assign an SSE to each project. The assigned SSE is responsible for preparing a System Safety Project Plan (SSPP). The SSPP purpose is to establish the organization and define activities to identify possible hazards and to analyze and reduce the risk of their occurrence relevant to the project. Note that safety is a property of a system, not a property of the components (including software) that comprise the system. When the context of the system changes, the safety properties also change, including those attributes, interlocks, and checks and balances designed to mitigate the risks associated with the system. It is essential to perform system safety engineering tasks on safety-critical systems to reduce safety risk in all aspects of a program. These tasks include software system safety activities involving the design, code, test, independent verification and validation (IV&V), operation and maintenance, and change control functions within the software engineering development and deployment processes.

The main objective of Enterprise systems safety engineering, which includes software system safety, is the application of engineering and management principles, criteria, and techniques to optimize all aspects of safety within the constraints of operational effectiveness, time, and cost throughout all phases of the system lifecycle. Within the domain of systems engineering, systems safety engineering identifies and analyzes behavioral and interface requirements, the design architecture, and the human interface within the context of both systems and systems of systems (SoS). In addition, system safety engineering defines requirements for design and systems engineering, taking into account the potential risks, verification and validation (V&V) of effective mitigation, and residual risk acceptance by certification or approval authorities.

4.6.2.1 Environmental and Occupational Safety and Health

While considered during design, the primary safety concerns associated with an Enterprise Project during construction, activation, operations, and maintenance will include those that pertain to compliance with OSHA, EPA, or other federal or state regulations. Use of appropriate safety practices and adherence to generic industrial safety requirements will be followed on all Enterprise Projects. For the product, a Preliminary Hazard Analysis (PHA) will be performed early in the system design to determine the potential hazards that may occur as a result of the system. Hazards analysis is part of the design process and used in every phase of the design.

4.6.2.2 Environmental Engineering

If required, SSE will accomplish an environmental assessment in accordance to the guidelines of the Enterprise Project Plan. Any environmental assessment is intended to define environmental stress sequences, durations, and levels of equipment life cycles; be used to develop analysis and test criteria tailored to the equipment and its environmental life cycle; evaluate equipment's performance when exposed to a life cycle of environmental stresses; identify deficiencies, shortcomings, and defects in equipment design, materials, manufacturing processes, packaging techniques, and maintenance methods; and demonstrate compliance with contractual requirements.

4.6.3 Human Factors Engineering

Enterprise Human Factors Engineering (HFE) shall be integrated to all other systems engineering processes and disciplines to ensure the Enterprise project system design is compatible with human operational interface needs. The Systems Engineering Manager will assign a Human Factors Engineer to each specific Enterprise Project. The engineer will provide HFE assessments that shall be used to optimize the Enterprise Project design given current human capabilities and limitations as well as contractual requirements. The intent of these assessments is to optimize usability, decrease potential for human error (operator and maintainer) while ensuring safety during operations.

HFE (in the DoD, this is Human Systems Integration and MANPRINT) is the discipline of applying what is known about human capabilities and limitations to the design of products, processes, systems, and work environments. It can be applied to the design of all systems having a human interface, including hardware and software. Its application to system design improves ease of use, system performance and reliability, and user satisfaction, while reducing operational errors, operator stress, training requirements, user fatigue, and product liability. Human factors engineering includes a wide range of major design considerations including but not limited to: Ergonomics, Anatomy, Demographics, Psychology, organizational dynamics, the effects of physical environments on the operator, human reliability and human information processing, the human as a sensor, training, workplace design, work organization design and the allocation of tasks between humans and other parts of a system. Human factors engineering as a result should interface directly with a wide range of other design disciplines activities and processes over the complete life cycle of any development program. These different activities include but are not limited to: training, maintenance, safety, reliability, usability, staffing, security, test and evaluation, manufacturing design, and risk management.

4.6.4 Electromagnetic Engineering

Enterprise Project electromagnetic engineering will address Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC) issues associated with Enterprise project systems. The Systems Engineering Manager will assign an Electromagnetic Engineer to each specific Enterprise Project. Electrical and electronic facilities, systems, subsystems, and equipment shall be designed with all contractual and reference regulatory EMC/EMI requirements in mind. Consideration shall be given to both the conducted and the radiated emissions and susceptibility. The method of verification for these requirements shall be documented as part of the Design Requirements Verification Matrix. Project facilities, systems/ subsystems, and equipment selected for EMC/EMI testing shall be done in accordance with the contractual requirements and the Enterprise Project Plan. Note that inadvertent electromagnetic radiation can cause unacceptable degradation of instrumentation or communication equipment (interference to electronic equipment within range). EMC will be achieved within Enterprise project hardware by elimination or control of unintentional radiation or by shielding equipment from its effects.

Enterprise electromagnetic engineering is concerned with proper design and engineering to minimize the impact of the Electromagnetic (EM) environment on equipment, systems, and platforms. EM control applies to the EM spectrum interactions of both spectrum-dependent and non- spectrum-dependent objects within the system and in the operational environment. Examples of non-spectrum-dependent objects that could be affected by the EM environment include all other electrical/electronic systems, ordnance, personnel, fuels, sensors, networks, communications and overall systems. Note that Electromagnetic Environmental Effects (E3) are defined in DoD Joint Publication 1-02 as: The impact of the electromagnetic environment upon the operational capability of military forces, equipment, systems, and platforms. It encompasses all electromagnetic disciplines, including electromagnetic compatibility and electromagnetic interference; electromagnetic vulnerability; electromagnetic pulse; electronic protection, hazards of electromagnetic radiation to personnel, ordnance, and volatile materials; and natural phenomena effects of lightning and precipitation static.

4.6.5 Systems Security Engineering

Systems Security Engineering (SSE) is the vehicle for interfacing research and technology protection into the Systems Engineering (SE) acquisition process. Enterprise SSE is the element of system engineering that applies scientific and engineering principles to identify security vulnerabilities and minimize or contain risks associated with these vulnerabilities. The Systems Engineering Team SSE will provide each Enterprise Project with a System Security Management Plan (SSMP). The format and contents for the SSMP are outlined in the appropriate Data Item Descriptions listed in MIL-HDBK-1785.

SSE uses mathematical, physical and related scientific disciplines, and the principles and methods of engineering design and analysis to specify, predict, and evaluate the vulnerability of the system to security threats. Key SSE criteria shall be specified across the full lifecycle in order to build security into a system. In order to be cost-efficient and technically effective, SSE at Enterprise is integrated into Systems Engineering (SE) as a key sub-discipline.

Systems security engineering will investigate and advocate systems requirements imposed by various contractual security architectures, existing and future threats and reference regulations. Following the assumption that all new projects will need to be integrated into an existing network information infrastructure, SSE will gather and analyze requirements that affect the confidentiality, integrity, and availability of the system. As part of the requirements phase of a project, they will gather security requirements that may affect the decision to implement specific technologies in the project. System security engineering will identify and track risks to the system based on security threats. They necessarily need to coordinate these risks with the Project Risk Manager and Project Manager, and evaluate and propose solutions to these risks that are balanced with the overall requirements. For projects that span multiple organizations, SSE will need to coordinate security control requirements between the multiple organizations and ensure the risks undertaken by the project do not impose unacceptable risks.

4.6.6 Standardization

Design teams, to the maximum extent practical, shall make use of common and legacy parts and equipment throughout all phases of the Enterprise Project. Considerations for standardization include, but are not limited to

1. Reducing the number of different models and makes of equipment in use
2. Maximizing the use of common parts in different equipment
3. Minimizing the number of different types of parts, assemblies, etc.
4. Using only a few basic types and varieties of parts, etc., to ensure that those parts are readily distinguishable, compatible with existing practices and used consistently for given applications
5. Controlling, simplifying and reducing part coding, numbering practices, and storage problems
6. Maximizing the use of Commercial Off-The-Shelf (COTS) items and components
7. Maximizing the use of interchangeable parts
8. Maximizing the use of applicable industry and Government standards

4.6.7 Network Engineering

Some Enterprise projects will rely heavily on computer hardware, firmware and software products. Rapid advances in information technology cause today's equipment to become obsolete tomorrow. In recognition of this shift, the Systems Engineering Team will provide all necessary Information Technology expertise to all applicable Enterprise projects. Such support will follow the requirements of the Enterprise Information Technology Management Plan.

4.6.7.1 Information Technology Hardware

The Enterprise Project will follow the applicable Enterprise Information Technology Management Plan for purchased and developed computer/embedded computer/peripheral hardware.

4.6.7.2 Information Technology Software

The Systems Engineering Configuration Management team will aid all Projects’ CCBs in maintaining a consistent configuration of all software products and versions. With each subsequent phase of development/testing/production, an analysis will be performed to identify software products/versions that need to be upgraded/replaced/modified. The upgrades/replacements/modifications are to be planned, scheduled and tested as part of the development of the phase with sufficient regression testing being performed as appropriate.

4.7 Materials and Processes

The Enterprise Systems Engineering Team Materials and Processes area addresses materials and processes research, development, and support for all Enterprise current and future Projects. The impact of materials and processes is pervasive to all systems Enterprise works on and provides. More importantly, Materials and Processes often represent the limiting factors in system cost, performance, and risk. The Systems Engineering Materials and Processes engineers will provide each Project with producibility analyses, manufacturing analyses, Diminishing Manufacturing Sources and Materiel Shortages (DMSMS) analyses, logistics support and coordinates the Enterprise Continuous Process Improvement activities.

4.7.1 Manufacturing Engineering

The Systems Engineering Team will maintain current knowledge of manufacturing engineering capabilities and potential improvements that can be used to make Enterprise manufacturing processes and product designs more efficient and producible. The Systems Engineering Manager will assign a Manufacturing Engineer to each Project to support the design, development, production and sustainment of products.

4.7.2 Manufacturing Readiness Levels

Manufacturing Readiness Levels (MRLs) are used with design and production assessments and are designed to assess the maturity of a given technology, system, subsystem, or component from a manufacturing prospective. MRLs provide decision makers (at all levels) with a common understanding of the relative maturity (and attendant risks) associated with manufacturing technologies, products, and processes being considered to meet customer requirements

Manufacturing readiness and technology readiness go hand-in-hand. MRLs, in conjunction with Technology Readiness Levels (TRL), are key measures that define risk when a technology or process is matured and transitioned to a system. It is quite common for manufacturing readiness to be paced by technology readiness or design stability. Manufacturing processes will not be able to mature until the product technology and product design are stable.

Level	Definition	DoD MRL Description
1	Basic Manufacturing Implications Identified	Basic research expands scientific principles that may have manufacturing implications. The focus is on a high level assessment of manufacturing opportunities. The research is unfettered.
2	Manufacturing Concepts Identified	This level is characterized by describing the application of new manufacturing concepts. Applied research translates basic research into solutions for broadly defined military needs.
3	Manufacturing Proof of Concept Developed	This level begins the validation of the manufacturing concepts through analytical or laboratory experiments. Experimental hardware models have been developed in a laboratory environment that may possess limited functionality.
4	Capability to produce the technology in a laboratory environment	This level of readiness acts as an exit criterion for the MSA Phase approaching a Milestone A decision. Technologies should have matured to at least TRL 4. This level indicates that the technologies are ready for the Technology Development Phase of acquisition. Producibility assessments of design concepts have been completed. Key design performance parameters have been identified as well as any special tooling, facilities, material handling and skills required.

5	Capability to produce prototype components in a production relevant environment	Mfg. strategy refined and integrated with Risk Management Plan. Identification of enabling/critical technologies and components is complete. Prototype materials, tooling and test equipment, as well as personnel skills have been demonstrated on components in a production relevant environment, but many manufacturing processes and procedures are still in development.
6	Capability to produce a prototype system or subsystem in a production relevant environment	This MRL is associated with readiness for a Milestone B decision to initiate an acquisition program by entering into the EMD Phase of acquisition. Technologies should have matured to at least TRL 6. The majority of manufacturing processes have been defined and characterized, but there are still significant engineering and/or design changes in the system itself.
7	Capability to produce systems, subsystems, or components in a production representative environment	System detailed design activity is nearing completion. Material specifications have been approved and materials are available to meet the planned pilot line build schedule. Manufacturing processes and procedures have been demonstrated in a production representative environment. Detailed producibility trade studies are completed and producibility enhancements and risk assessments are underway. Technologies should be on a path to achieve TRL 7.
8	Pilot line capability demonstrated; Ready to begin Low Rate Initial Production	The system, component or item has been previously produced, is in production, or has successfully achieved low rate initial production. Technologies should have matured to TRL 9. This level of readiness is normally associated with readiness for entry into Full Rate Production (FRP). All systems engineering/design requirements should have been met such that there are minimal system changes. Major system design features are stable and have been proven in test and evaluation.
9	Low rate production demonstrated; Capability in place to begin Full Rate Production	The system, component or item has been previously produced, is in production, or has successfully achieved low rate initial production. Technologies should have matured to TRL 9. This level of readiness is normally associated with readiness for entry into Full Rate Production (FRP). All systems engineering/design requirements should have been met such that there are minimal system changes.
10	Full Rate Production demonstrated and lean production practices in place	Technologies should have matured to TRL 9. This level of manufacturing is normally associated with the Production or Sustainment phases of the acquisition life cycle. Engineering/design changes are few and generally limited to quality and cost improvements. System, components or items are in full rate production and meet all engineering, performance, quality and reliability requirements. Manufacturing process capability is at the appropriate quality level.

4.7.3 Parts Management

Systems Engineering Team parts management provides for the implementation of an effective Parts Management Program (PMP) on Enterprise Projects and acquisitions. They provide performance-based parts management processes and practices which are intended to be adapted to individual Project needs and which provide appropriate latitude for innovative approaches and design solutions by the contractors. The objectives of the Enterprise PMP are to reduce logistics footprint and total life-cycle cost, and to increase logistics readiness of all M General products.

Systems Engineering Team Parts Engineers provide requirements for the application of the PMP to contracts for new design, modifications of existing products and equipment acquisition. Applicability of individual aspects of the requirements contained in the PMP is dependent upon Project business and support strategies, technologies used, expected service life, etc.. The components of the Off-The-Shelf (OTS) and Non-Developmental Item (NDI) equipment are not subject to parts management procedures unless the equipment is modified. When OTS and NDI equipment requires modification, only the parts proposed for the modified portion of the equipment shall be subject to the appropriate parts selection procedures of our PMP.

4.7.4 Diminishing Manufacturing Sources and Material Shortages (DMSMS)

DMSMS is “the loss or impending loss of manufacturers of items or suppliers of items or raw materials may cause material shortages that endanger a weapon system or equipment development, production, or post-production support capability.” The Defense Acquisition Guide establishes a Diminishing Manufacturing Sources and Materiel Shortages (DMSMS) Plan as a key program document. The Enterprise Systems Engineering Team will determine and maintain a DMSMS Plan to actively address DMSMS concerns throughout the entire Enterprise enterprise to help ensure effective life-cycle support and reduce adverse impacts on development, production, readiness or mission capability.

The primary objectives of this Plan are to define a proactive Enterprise DMSMS management process that can be used by each Project Manager to build an effective DMSMS Program tailored to each Project, to define DMSMS support metrics to measure the effectiveness of their DMSMS Program, and to promote cost-effective supply chain management integrity through DMSMS problem resolution at the lowest (cost, time, functional) level. This overall Plan outlines an effective DMSMS process as one which:

1. Ensures that all parts and material to develop, produce or repair the system are available
2. Reduces, or controls, Total Ownership Cost (TOC)
3. Minimizes Total Life Cycle Systems Management (TLCSM) cost
4. Eliminates, or at least minimizes, reactive DMSMS actions
5. Evaluates design alternatives
6. Provides for risk mitigation as it applies to DMSMS
7. Evaluates more than one approach to resolve DMSMS issues
8. Collects metrics to monitor process effectiveness

4.7.5 Producibility

The Project system/subsystem engineers shall identify all producibility issues, which might affect the feasibility of meeting the project requirements. The Enterprise Systems Engineering Manager will assign Producibility personnel to aid in each Project. Producibility issues include, but are not limited to, technical performance goals, current state of technology, economic and schedule issues, current skills mix, and facilities availability. Systems Engineering Producibility shall develop a Producibility Analysis Report that identifies potentially high cost, high risk, and long lead-time items. The report shall be used to determine whether the item can be produced economically to drawing and specification requirements and within the design to unit production cost goals. All producibility analysis shall be performed as a formal review and may lead to make or buy decisions. All final decisions, and the rationale for the decisions, will be documented. All hardware fabricated by Enterprise shall comply with all appropriate fabrication standards.

4.7.6 Continuous Process Improvement

Enterprise’s Continuous Process Improvement is coordinated by the Enterprise Systems Engineering Team but individual process improvement analyses/projects can be performed by any Department or individual person within Enterprise. The Enterprise

Systems Engineering Manager will review and approve all CI requests before they are implemented.

The Enterprise continuous improvement process features a systems approach to improving the work flow in an existing organization or process. Phases of the model used include an analysis phase to identify specific problems, a design phase, an implementation phase and an evaluation phase as noted in Figure 9.

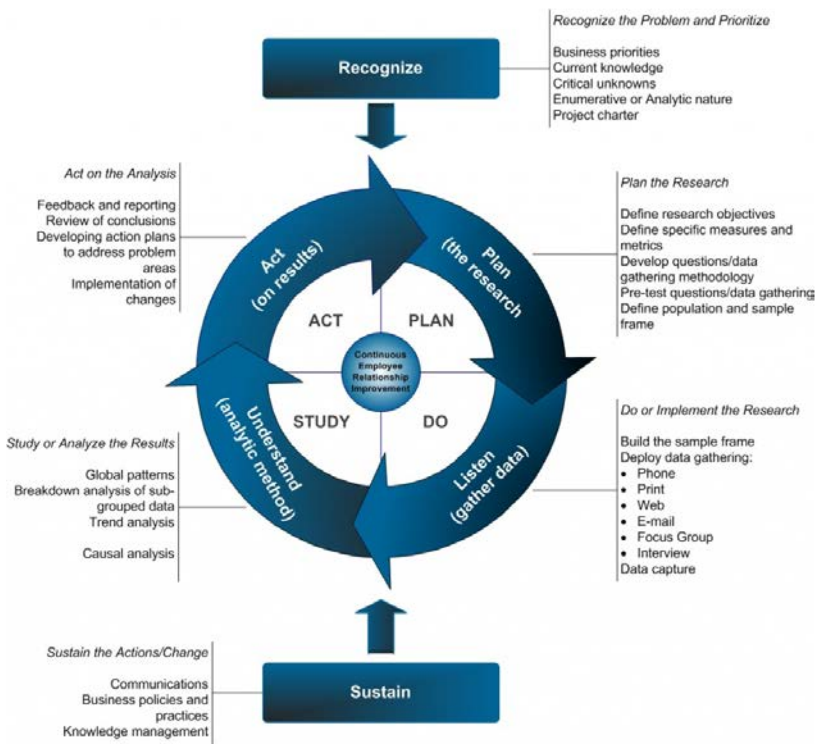


Figure 9: Enterprise's CI Process Model

4.7.7 Logistics Support
If required by the Enterprise Project Plan, a Project Integrated Logistics Support Plan (LSP) will be developed addressing the spares philosophy, operational requirements, logistic support analysis candidate list, training, maintenance concept, operations and maintenance instructions (OMI), and parts storage area. A logistics specialist will be identified to support the design process and preparation of the plan. Long lead and limited life items lists will be collected as part of the design and will not be included as part of the LSP.

4.7.8 Technology Baseline and Commonality
The responsibility for maintaining knowledge of the state-of-the-art in appropriate technology and in research and development throughout our industry and in other areas belongs to the Enterprise System Engineer and may be delegated to the Enterprise Design Engineer and other program staff as appropriate. The general areas of technology useful for Enterprise projects are:

1. Armor
2. Human Factors
3. MANPRINT
4. Structural
5. Materials
6. Electromagnetic interference control and blocking
7. Electronics
8. Nanotechnology
9. Power Systems

4.8 Tradeoff Studies
Opportunities for tradeoff studies throughout each phase of the Project shall be identified and performed by the designated design teams with appropriate Systems Engineering Team support. These studies shall take into account all relevant issues including technical, economic, and scheduling feasibility. All final decisions and the rationale for the decisions will be documented. If some tradeoff studies require specific knowledge and/or training, the Systems Engineering Manager will determine if such knowledge/training is available within Enterprise or a consultant is required.

4.9 Information Technology Systems Security
The Enterprise Project Plan will define any systems or IT security requirements for the Project. These include administration and operational risks to the Project and any products. The extent of security measures to counter risk will depend upon the overall sensitivity of the information produced by the project. Section 9 of the IT Security Plan will state how the project will implement information security throughout the project life cycle in concert with the SEMP.

4.10 Systems Engineering Tools
During the course of the Project, various types of analyses will be performed. Due to the large market of tools available to aid in analysis efforts, Enterprise Senior Management

has defined the types of tools to be used. This uniformity will ensure compatibility between the files that would be shared among Projects and Project team members, thereby minimizing loss of productivity. Other tools shall be added as needed. Software configuration management shall be addressed in computer software. Current tools to be applied to all Enterprise Projects are as follows:

Product	Tool
Schedule	Microsoft Project
Spending Plan	Microsoft Excel
Requirements Tracking/Flowdown	Requirements Management
Requirements Document	Microsoft Word
Requirements Verification Matrix	Microsoft Excel
Drawings/Models	TBD
Decision Making	TBD
Engineering Analysis	Microsoft Excel
Risk Management	Risk Management
Configuration Management	Configuration Management
Software Configuration Management	TBD
Presentations	Microsoft PowerPoint
Plans and Procedures	Microsoft Word
PDM/CM	TBD
RAM Analysis	TBD

5.0 Notes

6.0 APPENDIXES

A: ACRONYMS LIST

CDR	Critical Design Review
CIL	Critical Items List
COTS	Commercial Off The Shelf
CWBS	Contract Work Breakdown Structure
DRA	Document Release Authorization
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EPA	Environmental Protection Agency
FEMA	Functional Failure Modes and Effects Analyses
FTA	Fault Tree Analyses
HFE	Human Factors Engineering
ICD	Interface Control Document
IT	Information Technology
ITSP	Information Technology Security Plan
LSP	Logistics Support Plan
MA	Mission Assurance
OSHA	Operational Safety and Hazard Analyses
PCCB	Project Change Control Board
PDR	Preliminary Design Review
PHA	Preliminary Hazard Analyses
QA	Quality Assurance
RFA	Request for Action
RID	Review Item Discrepancies
RMP	Risk Management Plan
S&MA	Safety and Mission Assurance
SEDS	Systems Engineering Detailed Schedule
SEMP	Systems Engineering Management Plan
SEMS	Systems Engineering Master Schedule
SID	Standard Interface Document
SMO	Systems Management Office
SRD	Systems Requirements Document
SRR	Systems Requirements Review
SSA	Systems Assurance Analyses
SSE	System Safety Engineer
SSP	Systems Safety Plan
SSPP	Systems Safety Project Plan
TBD	To Be Determined
TDR	Technical Design Review
TEMP	Test and Evaluation Master Plan
TIM	Technical Interchange Meeting
TPM	Technical Performance Management
WBS	Work Breakdown Structure

B: TECHNICAL REVIEWS

Reference: Defense Manufacturing Management Guide for Program Managers, Chapter 12 - Technical Reviews and Audits

Technical Reviews and Audits

Technical reviews and audits are a systems engineering tool that provide a way to assess progress and maturity of the product as it moves through the various phases of the acquisition life cycle. These reviews and audits are consistent with existing DoD and commercial best practices and form the backbone for effective systems engineering planning. All reviews are or should be multi-disciplined that ensure all of the members of the IPT have an opportunity to review the product and documentation in order to assess progress in their functional area towards achievement of phase goals. These reviews provide a systematic process for assessing risk and easing the transition from development to production and beyond by:

1. Assessing the maturity of the design/development effort;
2. Clarifying design requirements;
3. Challenging the design and related processes;
4. Checking proposed design configuration against technical requirements, customer needs, and system requirement;
5. Evaluating the system configuration at different stages;
6. Providing a forum for communication, coordination, and integration across all disciplines and IPTs;
7. Establishing a common configuration baseline from which to proceed to the next level of design and production; and
8. Recording technical decisions and rationale in the decision database.

Reviews are an important oversight tool that the program manager can use to review and evaluate the state of the system and the program, re-directing activity if necessary. Figure 10 shows the relative timing of each of the technical reviews, technically oriented program reviews, and technology readiness assessments.

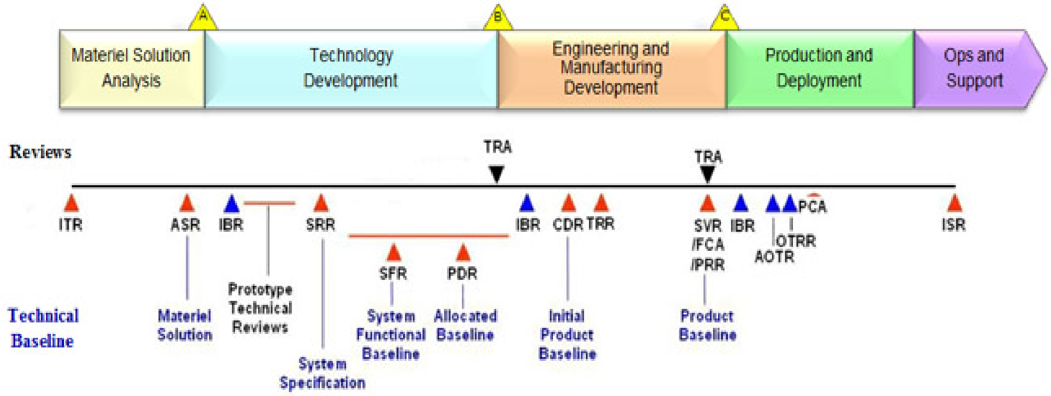


Figure 10: Systems Engineering Technical Review Timing

The following business and technical reviews are held for most programs:

1. Initial Technical Review (ITR),
2. Alternative Systems Review (ASR),
3. System Requirements Review (SRR),
4. Technology Readiness Assessment (TRA),
5. Integrated Baseline Review (IBR),
6. System Functional Review (SFR),
7. Preliminary Design Review (PDR),
8. Critical Design Review (CDR),
9. Test Readiness Review (TRR),
10. System Verification Review (SVR),
11. Functional Configuration Audit (FCA),
12. Production Readiness Review (PRR),
13. Operational Test Readiness Review (OTRR),
14. Physical Configuration Audit (PCA), and
15. In-Service Review (ISR).

OSD has developed a checklist for each of technical reviews. The checklist structure for many of the reviews is in Figure 11 and includes twelve focus areas to include the PQM community. Questions can be segregated by focus area by enabling the macros and selecting PQM. This will provide only those questions that have been identified as an interest area for that focus area. These checklists are available on the Systems Engineering Community of Practice (CoP) at the Defense Acquisition University (DAU).

Figure 11 Typical Format for a Technical Review

Initial Technical Review (ITR)
The ITR is a multi-disciplined technical review to support a program's initial Program Objective Memorandum submission. This review ensures a program's technical baseline is sufficiently rigorous to support a valid cost estimate (with acceptable cost risk) and enable an independent assessment of that estimate by cost, technical, and program management Subject Matter Experts (SMEs). The ITR assesses the capability needs and Materiel Solution approach of a proposed program and verifies that the requisite research, development, test and evaluation, engineering, manufacturing, logistics, and programmatic bases for the program reflect the complete spectrum of technical challenges and risks. Additionally, the ITR ensures the historical and prospective drivers of system life-cycle cost have been quantified to the maximum extent and that the range of uncertainty in these parameters has been captured and reflected in the program cost estimates.

Alternative System Review (ASR)
The ASR is a multi-disciplined technical review to ensure the resulting set of requirements agrees with the customers' needs and expectations and then the system under review can proceed into the Technology Development phase. The ASR should be completed prior to, and provide information for, Milestone A. Generally, this review assesses the preliminary materiel solutions that have been evaluated during the Materiel Solution Analysis phase, and ensures that the one or more proposed materiel solution(s) have the best potential to be cost effective, affordable, operationally effective and suitable, and can be developed to provide a timely solution to a need at an acceptable level of risk. Of critical importance to this review is the understanding of available system concepts to meet the capabilities described in the Initial Capabilities Document (ICD) and to meet the affordability, operational effectiveness, technology risk, and suitability goals inherent in each alternative concept.

System Requirements Review (SRR)
The SRR is a multi-disciplined technical review to ensure that the system under review can proceed into initial systems development, and that all system requirements and performance requirements derived from the Initial Capabilities Document or draft Capability Development Document are defined and testable, and are consistent with cost, schedule, risk, technology readiness, and other system constraints. Generally this review assesses the system requirements as captured in the system specification, and ensures that the system requirements are consistent with the approved materiel solution (including its support concept) as well as available technologies resulting from the prototyping effort.

System Functional Review (SFR)
The SFR is a multi-disciplined technical review to ensure that the system's functional baseline is established and has a reasonable expectation of satisfying the requirements of the Initial Capabilities Document or draft Capability Development Document within the currently allocated budget and schedule. It completes the process of defining the items or

elements below system level. This review assesses the decomposition of the system specification to system functional specifications, ideally derived from use case analysis. A critical component of this review is the development of representative operational use cases for the system. System performance and the anticipated functional requirements for operations maintenance, and sustainment are assigned to sub-systems, hardware, software, or support after detailed analysis of the architecture and the environment in which it will be employed. The SFR determines whether the system's functional definition is fully decomposed to its lower level, and that IPTs are prepared to start preliminary design.

Preliminary Design Review (PDR)
The PDR is a technical assessment establishing the physically allocated baseline to ensure that the system under review has a reasonable expectation of being judged operationally effective and suitable. This review assesses the allocated design documented in subsystem product specifications for each configuration item in the system and ensures that each function, in the functional baseline, has been allocated to one or more system configuration items. The PDR establishes the allocated baseline (hardware, software, human/support systems) and underlying architectures to ensure that the system under review has a reasonable expectation of satisfying the requirements within the currently allocated budget and schedule.

Technology Readiness Assessment (TRA)
The TRA is a regulatory information requirement for all acquisition programs. The TRA is a systematic, metrics-based process that assesses the maturity of Critical Technology Elements (CTEs), including sustainment drivers. The TRA should be conducted concurrently with other Technical Reviews, specifically the Alternative Systems Review (ASR), System Requirements Review (SRR), or the Production Readiness Review (PRR). If a platform or system depends on specific technologies to meet system operational threshold requirements in development, production, or operation, and if the technology or its application is either new or novel, then that technology is considered a CTE.

Critical Design Review (CDR)
The CDR is a key point within the Engineering and Manufacturing Development (EMD) phase. The CDR is a multi-disciplined technical review establishing the initial product baseline to ensure that the system under review has a reasonable expectation of satisfying the requirements of the Capability Development Document within the currently allocated budget and schedule. Incremental CDRs are held for each Configuration Item culminating with a system level CDR. This review assesses the final design as captured in product specifications for each Configuration Item in the system and ensures that each product specification has been captured in detailed design documentation. Configuration Items may consist of hardware and software elements, and include items such as airframe/hull, avionics, weapons, crew systems, engines, trainers/training, support equipment, etc. Product specifications for hardware enable the fabrication of configuration items, and include production drawings. Product specifications for software

enable coding of the Computer Software Configuration Item. The CDR evaluates the proposed Baseline ("Build To" documentation) to determine if the system design documentation (Initial Product Baseline, including Item Detail Specs, Material Specs, Process Specs) is satisfactory to start initial manufacturing.

Test Readiness Review (TRR)
The TRR is a multi-disciplined technical review designed to ensure that the subsystem or system under review is ready to proceed into formal test. The TRR assesses test objectives, test methods and procedures, scope of tests, and safety and confirms that required test resources have been properly identified and coordinated to support planned tests. The TRR verifies the traceability of planned tests to program requirements and user needs. It determines the completeness of test procedures and their compliance with test plans and descriptions. The TRR also assesses the system under review for development maturity, cost/ schedule effectiveness, and risk to determine readiness to proceed to formal testing.

System Verification Review (SVR)
The SVR is a multi-disciplined product and process assessment to ensure the system under review can proceed into Low-Rate Initial Production and full-rate production within cost (program budget), schedule (program schedule), risk, and other system constraints. Generally this review is an audit trail from the System Functional Review. It assesses the system functionality, and determines if it meets the functional requirements (derived from the Capability Development Document and draft Capability Production Document) documented in the functional baseline. The SVR establishes and verifies final product performance. It provides inputs to the Capability Production Document. In some organizations the SVR is conducted concurrently with the Production Readiness Review.

Functional Configuration Audit (FCA)
The FCA is the formal examination of the as tested characteristics of a configuration item (hardware and software) with the objective of verifying that actual performance complies with design and interface requirements in the functional baseline. It is essentially a review of the configuration item's test/analysis data, including software unit test results, to validate the intended function or performance stated in its specification is met. For the overall system, this would be the system performance specification. For large systems, audits may be conducted on lower level configuration items for specific functional areas and address non-adjudicated discrepancies as part of the FCA for the entire system. A successful FCA typically demonstrates that Engineering and Manufacturing Development product is sufficiently mature for entrance into Low-Rate Initial Production.

Production Readiness Review (PRR)
The PRR examines a program to determine if the design is ready for production and if the prime contractor and major subcontractors have accomplished adequate production planning without incurring unacceptable risks that will breach thresholds of schedule, performance, cost, or other established criteria. The review examines risk; it determines if production or production preparations identify unacceptable risks that might breach

thresholds of schedule, performance, cost, or other established criteria. The review evaluates the full, production-configured system to determine if it correctly and completely implements all system requirements. The review determines whether the traceability of final system requirements to the final production system is maintained.

At this review, the Integrated Product Team (IPT) should examine the readiness of the manufacturing processes, the quality management system, and the production planning (i.e., facilities, tooling and test equipment capacity, personnel development and certification, process documentation, inventory management, supplier management, etc.). A successful review is predicated on the IPT's determination that the system requirements are fully met in the final production configuration, and that production capability forms a satisfactory basis for proceeding into Low-Rate Initial Production (LRIP) and Full-rate production.

Typically performed incrementally, PRRs determine if production preparation for the system, subsystems, and configuration items is complete, comprehensive, and coordinated. A PRR formally examines producibility of the design, the control over the projected production processes, and adequacy of resources necessary to execute production.

Operational Test Readiness Review (OTRR)
The OTRR is a multi-disciplined product and process assessment to ensure that the system can proceed into Initial Operational Test and Evaluation with a high probability of success, and that the system is effective and suitable for service introduction. The Full-Rate Production Decision may hinge on this successful determination. The understanding of available system performance in the operational environment to meet the Capability Production Document is important to the OTRR. Consequently, it is important the test addresses and verifies system reliability, maintainability, and supportability performance and determines if the hazards and ESOH residual risks are manageable within the planned testing operations. The OTRR is complete when the Service Acquisition Executive evaluates and determines materiel system readiness for Initial Operational Test and Evaluation.

Physical Configuration Audit (PCA)
The PCA is conducted around the time of the Full-Rate Production Decision. The PCA examines the actual configuration of an item being produced. It verifies that the related design documentation matches the item as specified in the contract. In addition to the standard practice of assuring product verification, the PCA confirms that the manufacturing processes, quality control system, measurement and test equipment, and training are adequately planned, tracked, and controlled. The PCA validates many of the supporting processes used by the contractor in the production of the item and verifies other elements of the item that may have been impacted/redesigned after completion of the System Verification Review. A PCA is normally conducted when the government plans to control the detail design of the item it is acquiring via the Technical Data Package. When the government does not plan to exercise such control or purchase the

item's Technical Data Package (e.g., performance based procurement), the contractor should conduct an internal PCA to define the starting point for controlling the detail design of the item and establishing a product baseline. The PCA is complete when the design and manufacturing documentation match the item as specified in the contract. If the PCA was not conducted before the Full-Rate Production Decision, it should be performed as soon as production systems are available.

In-Service Review (ISR)

The ISR is a multi-disciplined product and process assessment to ensure that the system under review is operationally employed with well-understood and managed risk. This review is intended to characterize the in-service health of the deployed system. It provides an assessment of risk, readiness, technical status, and trends in a measurable form. These assessments substantiate in-service support budget priorities. The consistent application of sound programmatic, systems engineering, and logistics management plans, processes, and sub-tier in-service stakeholder reviews will help achieve the ISR objectives. Example support groups include the System Safety Working Group and the Integrated Logistics Management Team. A good supporting method is the effective use of available government and commercial data sources. In-service safety and readiness issues are grouped by priority to form an integrated picture of in-service health, operational system risk, system readiness, and future in-service support requirements