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Record of Revisions

Rev	Date	Description	POC	RM
0	9/20/2017	Initial issue based in large part on parent company procedures and subject matter expertise. Completes PIAT 2015-1228 Action 3 and TLW POFMR-2016-22 Action 7.2.4 to execute a formal SE requirements development and verification program through requiring specific deliverables.	Tobin Oruch, *ES-DO*	Larry Goen, *ES-DO*

1.0 GENERAL (SE-GEN)

1.1 Purpose

This chapter describes the "how, when, and who" for implementing the Systems Engineering (SE)[1] requirements and concepts of:

A. DOE O 413.3, *Program and Project Management for the Acquisition of Capital Assets*[2];
B. DOE G 413.3-1, *Managing Design and Construction Using Systems Engineering for Use with DOE O 413.3A*;
C. DOE-STD-1073, *Configuration Management*; and
D. DOE-STD-1189, *Integration of Safety into the Design Process*.[3]

1.2 Applicability

A. The full chapter is required for capital projects over $20M[4] total project cost (TPC) modifying or building hazard category 1–3 nuclear facilities.[5] For projects below those thresholds subject to DOE O 413.3, implement in a tailored fashion to meet the Order.[6] Projects not subject to the order may adapt chapter as desired.

1.3 Chapter Organization

The chapter is currently composed of two documents, with contents as follows:

A. The SE Requirements document (this document). Sections:
   1. SE-GEN (General)
   2. SE-GR (Graded Approach)
   3. SE-PL (Planning)
   4. SE-RM (Requirements Management)
   5. SE-V&V (Verification and Validation)
   6. Appendices with definitions, references, and selected deliverable contents requirements
B. The SE Guide document (non-mandatory companion document). Sections:
   1. SE-PLG (Planning Guidance)
   2. SE-RMG (Requirements Management Guidance)
   3. SE-V&VG (Verification and Validation Guidance)

[1] SE is "a proven, disciplined approach that supports management in clearly defining the mission or problem; managing system functions and requirements; identifying and managing risk; establishing bases for informed decision-making; and, verifying that products and services meet customer needs. The goal of the [systems] engineering approach is to transform mission operational requirements into system architecture, performance parameters and design details." [413.3B Chg. 3, Att. 2, Definitions]
[2] Ref. DOE O 413.3B Chg. 3, App B, 4.b.
[3] Some of projects following this chapter will be "Major Modifications" to (or new) HC 2 or 3 nuclear facilities and thus subject to DOE-STD-1189. Chapter is consistent with but does not unnecessarily impose requirements of 1189.
[4] Lesser cost/complexity projects were judged inappropriate for initial chapter rollout.
[5] For in-scope projects, it is assumed that an external design agency (AE) will be subcontracted by LANL for the preliminary and final design, and many of the systems engineering (SE) expectations for that phase will be executed by the AE. Projects underway with preliminary design at the time Chapter 20 is initially issued are not required to follow it by ESM practice (ESM Chapter 1 Z10 allows projects already in progress to continue using the standards of record when they started the current project phase without changing to updated standards). But adopting concepts to extent practical will benefit it during later phases, since many aspects are required by NQA-1 or to support testing and commissioning. Finally, for the sake of simplicity, this chapter is written assuming that a project is starting with conceptual design and including all subsequent design phases.
[6] When tailoring this standard for other project scenarios, refer to the SE Planning (SE-PL) section and obtain LANL Site Chief Engineer concurrence.

1.3.1 Future Development (Guidance)

Chapter 20 may expand in the future to more fully address the following SE topics[7]:

1. *Technical Baseline Control and Integration: Identification of technical baselines to be developed, selection of baseline review and approval milestones and methods, control of approved baselines, identification and control of system interfaces, identification of items selected for external review, and balancing of requirements across systems.*
2. *Systems Analysis and Development: Types of analyses that convert customer needs and requirements into discrete final product requirements and a system architecture that will be used to drive design. Systems analysis and development processes are multi-disciplinary by necessity.*
3. *Configuration Management: Configuration management (CM) establishes consistency among design documentation, physical configuration, and facility documentation, and maintains this consistency throughout the life cycle of the system. This material would address the five functions of CM and the associated implementation details.*
4. *Technical Risk Management: Technical risk management activities evaluate stakeholder, facility and system requirements, and evaluate selected technologies to identify program risks. Identified risks are tracked and analyzed, and mitigations are developed and implemented when needed.*

1.4 Roles, Responsibilities, Authorities, and Accountabilities (R2A2)

A. The LANL Engineering Services Division (ES or ESD) is delegated responsibility to define and implement the Facility Systems Engineering (FSE) program within LANL. ES Division will establish a Facility Systems Engineering (FSE) capability to influence policy and processes through the Conduct of Engineering (CoE) program, and to oversee and provide support to projects implementing FSE processes. FSE is implemented by the Project Engineers with the assistance of an SE SME. The ES Engineering Project Delivery Group Leader is responsible for the project assignments for those assigned to the SE discipline.

B. The key goal of the FSE Program is to provide excellence in project execution through the application of Systems Engineering principles and methods. This document provides the framework to achieve this goal. The primary members of this framework include organizational and process elements and how they relate to other elements of LANL. It is ES Division's intent to develop SE as a core competency and distinct discipline within Engineering to ensure LANL's capabilities for the long term.

C. Systems engineering processes provide a lifecycle approach to the development of systems and are multi-functional in their nature. Systems processes influence how work is performed and integrated among engineering, procurement, construction, startup, operations, and quality organizations within LANL. Thus, the policies and processes established by CoE will influence policies and processes of these other organizations. All LANL organizations will need to work together to achieve an effective systems engineering implementation.

D. The FSE function and project organizations will define the SE roles they need according to the work scope and organizational design. Responsibility for the systems acquisition and engineering activities required to acquire new and to modify existing facilities and systems are distributed across LANL Organizations and project personnel. Each role has defined responsibilities, accountabilities and authorities. As a minimum, the roles identified in the following table are required.

[7] These areas are identified in the document, "*Architecture for a Systems Engineering Program: Building a Systems Engineering Framework for LANL Operations & Business Directorate*" (draft).

E. External Design Agency (AE) Role in SE: The default requirement is that the Design Agency for preliminary and final design perform all SE-related functions described herein, including maintenance of the SE tool, unless otherwise is specifically indicated in their statement of work. Guidance: *If an outside AE is used for conceptual design, LANL should choose to include SE in their scope.*

Table SE-GEN-1 Roles, Responsibilities, Authorities, and Accountabilities (SE-focused)

POSITION	ROLE	RESPONSIBILITY	ACCOUNTABILITY	AUTHORITY
KEY ORGANIZATIONS				
Principal Associate Director for Operations & Business (PADOPS)	Champion for systems engineering approach by ADNHHO	• Ensure successful implementation of the systems engineering program through the ES Division	• Accountable to the LANL Director for the quality of engineering	• Approve documents supporting an SE program (e.g., PD340)
Principal Associate Director for Capital Projects (PADCAP)	Champion for systems engineering approach within PADCAP	• Ensure projects identify, document and manage requirements • Ensure projects verify and document successful implementation of requirements	• Accountable to the LANL Director for the quality of projects	• Approve project approaches
Associate Director for Nuclear & High Hazards Operations (ADNHHO)	CoE Program Responsible Manager	• Responsible for Engineering execution of projects • Issue systems engineering standards and guides through the ES Division	• Accountable to PADOPS for SE Program implementation	• Approve documents specifying the SE program (e.g., P341, P342) • FSE Program Architecture approval
Associate Director for Project Management (ADPM)	Capital Project Responsible Manager	• Direct systems acquisition activities • Work with project sponsors to establish mission need • Issuing authority for capital project work processes	• Accountable to PADCAP for the quality of SE program implementation	• Manage projects
Design Authority/ Site Chief Engineer[8]	Establish and Oversee the FSE Program	• Owner of the FSE Program • Develop policy, procedures and guides for use by projects • Provide direction and support for SE program rollout and implementation on projects • Manage FSE personnel and project assignments • Provide SE personnel training and development opportunities • Coordinate the FSE program	• Accountable to the Associate Director for Nuclear & High Hazards Operations for the definition and development of the FSE program	• Direct implementation of the FSE Program • Approve SEP • Approve final selection of Design Agency • Approve RCD for projects subject to this chapter (along with FDAR).

[8] Also ES Division Leader at time of writing

POSITION	ROLE	RESPONSIBILITY	ACCOUNTABILITY	AUTHORITY
FDAR	Represent the Design Authority for a project	• Approve the project-specific SEP • Approving design requirements • Identifying and maintaining technical baseline documents and changes thereto	• To the ES Division DL for SE program implementation	• Project SE Program role assignments • Project-specific SEP, RM, and CM plans approval • Project requirement approvals and any interpretations
Acquisition Services Management Division Leader (ASM)	Procure project design and execution services	• Implement procurement procedures • Support SE-based acquisition strategy	• Accountable to the Associate Director for Business Integration for the quality of project acquisition	• Manage procurement process
Quality and Performance Assurance Division Leader (QPA)	Ensure processes and standards are developed to meet QA requirements, and are followed	• Together with ASM, integrate SE practices into the system acquisition processes • Assess FSE program effectiveness and compliance	• Accountable to the Associate Director for Mission Assurance, Security, and Emergency Response for institutional quality	• Manage institutional quality
KEY PROJECT PERSONNEL (ON IPT)				
Project Manager (PM)	Oversee project definition and execution	• Ensure sound SE practices are scheduled and correctly integrated with other projects activities. • Ensure SE activities have sufficient budget to ensure successful execution	• To ADPM for project success including SE implementation	• Management of the project • SEP approval
Lead Project Engineer (LPE)	• Oversee the design process implementing design control • Oversee the FSE Program for a project	Assist project and Facility Design Authority Representative (FDAR) with: • Assign FSE Program roles • Own the SEP and implement the SE processes per the SEP • Ensure the integrity of the SE processes and alignment with ES Division standards and processes • Integration of all systems • Ensure establishment of SE tool and Management of facility requirements (programmatic and technical) • Confirm design compliance with requirements • Supervise and manage the project SE function	• To Engineering Project Delivery functional manager and Project Manager for Engineering performance	• Ensure the SEP is implemented

POSITION	ROLE	RESPONSIBILITY	ACCOUNTABILITY	AUTHORITY
Lead Systems Engineer (LSE) *(Typically LANL project engineering organization during Conceptual, external design agency(AE) during Preliminary/Final)*	Perform as the requirements owner for the Functional Specification	• Establish the SE tool • Ensure complete allocation of the initial Requirements Baseline • Validate requirements • Generate systems specifications, ICDs, FDDs and SDDs • Specify verification requirements for the Functional baseline • • Balance and integrate requirements across facilities and systems	• Accountable to the LPE for implementation of assigned requirements	• Functional Specification approval
Systems Engineer (SE)	Perform as the requirements owner for the systems and facilities assigned to them	• Develop the System Requirements Baseline • Maintain the SE tool with current information Ensure the completeness and quality of the System Requirements Baseline • Ensure consistency of interface requirements across system boundaries • Validate requirements • Specify verification requirements • Review designs for compliance with the baseline • Maintain the databases tool with current information • Integrate system interface requirements	• Accountable to the LSE for implementation of assigned requirements	• System Specification development for assigned systems
Design Lead	Perform as the system designer for those systems assigned to them	• Support System Specification development • Develop a system design that meets the requirements in the system specification • Integrate requirements and designs from all engineering disciplines for assigned systems • Ensure design integration with interfacing systems • Specify system component requirements and verifications • Conduct design reviews with the SE • Review and verify vendor designs for their system	• To LPE for design performance • To SE for implementation of assigned requirements	• System design document approval
Procurement Engineering Lead	Facilitate high risk procurements	• Guide SE-based acquisition strategies.	• To LPE for promoting FSE implementation	• Procurement package development
Commissioning Agent	Test and commission	• Develop tests to satisfy Test Acceptance Criteria Table and ESM Chapter 15, Commissioning • Compile test results package	• To LPE for performance of required testing	• Test development and performance

POSITION	ROLE	RESPONSIBILITY	ACCOUNTABILITY	AUTHORITY
Quality Representative on IPT	Ensure processes are documented and followed	• Review project quality documents, approve as required • Assess project including FSE program effectiveness and compliance	• To QPA Division Leader for quality affecting activities	• Quality deliverables and actions

1.5 SE Software Tools (SE tool)[9]

A. At the start of Conceptual Design Phase, the project shall:
   1. Use SE software tools approved by the chapter POC to support requirements management, systems analysis of various kinds (e.g., functional analysis, discrete simulation), system architecture/design, and risk management.
   2. Obtain sufficient licenses/access to SE software tools for use on the project.
   3. *See Graded Approach Table SE-GR-1 which follows for when commercial tool is required.*

2.0 SE GRADED APPROACH (SE-GR)

A. The project shall apply a graded approach to the application of the requirements of this Chapter based on project size according to the requirements of the following table. This table grades certain aspects of systems engineering. Those items not contained on the table are not graded, except as stated within those sections.

Table SE-GR-1 Graded Approach

Acronyms and other terms are explained in Appendix A and the corresponding chapter sections.

	Project Size (TPC)		
	<$100M	**$100M - $300M[10]**	**>$300M**
SE-GEN -- General			
Use of commercial requirements management software	Recommended	Required	Required
SE-PL -- Planning			
No grading; implement section as written			
SE-RM -- Required Depth of Requirements Traceability (Trace to all implementing SSCs except as noted)			
Nuclear Safety Requirements	Yes	Yes	Yes
Regulatory Requirements	Yes	Yes	Yes
External Interface Rqmts	Yes	Yes	Yes
All Requirements in IRB	No	Yes	Yes
All Requirements in CDB	No	Yes	Yes

[9] In industry, the SE tool may also be known as the Technical Requirements Management System (TRMS). SE tools that do not provide calculational output that is utilized may be excluded from ESM Chapter 21 Software (see SOFT-GEN). If calc features are used, subject to Ch 21 but may not be safety software if content is exported and formally reviewed/accepted (software not relied upon).
[10] $100-700M TPC is the DOE O 413.3B range for Under Secretary approval.

Requirements in Preliminary Design Baseline (PDB)	No	No	Yes
SE-V&V			
Scope of RVM and TAC Tables	• Nuclear Safety Rqmts • Regulatory Rqmts	• All IRB Rqmts • All CDB Rqmts	• All IRB Rqmts • All CDB Rqmts • All PDB Rqmts

3.0 SYSTEMS ENGINEERING PLANNING (SE-PL)

Synopsis: The objective of SE planning is to ensure SE methods are implemented in project planning in a manner appropriately for the project scope, size, and complexity.

A. The project shall:

1. Develop and implement a structured approach to SE as prescribed in this section.

2. Plan SE activities and integrate them with the other project activities in the appropriate life cycle stages. The SE planning shall address the following topics in accordance with the requirements of this chapter.

   a. Project life cycle stages and design reviews

   b. Technical baseline development and control

   c. Acquisition planning

   d. Requirements management

   e. Systems analysis and development

   f. Interface management

   g. Verification and validation

   h. Technical risk management

   i. Configuration management

3. Perform SE planning and incorporate results into a Systems Engineering Plan (SEP)[11]. Complete this planning during the initial stages of the project, concurrently with the Project Execution Plan (PEP). Coordinate SE planning with other project planning to ensure consistency. *The SEP should be a standalone document incorporated by reference from (or by attachment to) the PEP. For SEP content, refer to the "Systems Engineering Plan (SEP)" article in the SE Guide's Section SE-PLG.*

3.1 Project Life Cycle Stages and Reviews

Synopsis: The SE activities needed for a project depend on the project life cycle stages and associated milestones supported by the project scope.

[11] Alternatively, the SEP material may be incorporated into another engineering-specific plan such as a Project Engineering Execution Plan (PEEP).

A. The project shall:

1. Determine the project life cycle stages and customer milestones that are within project scope in accordance with client directives. Refer to the following graphic for typical stages of a DOE program. *The project lifecycle typically includes the stages listed below, but may differ by project.*

   a. Mission need

   b. Pre-Conceptual

   c. Technology development

   d. Conceptual design

   e. Preliminary design

   f. Final design

   g. Procurement

   h. Construction

   i. Startup and commissioning

2. Determine the client milestones to be supported by the project. For DOE projects the Critical Decision (CD) milestones are defined in DOE O 413.3 and are associated with lifecycle stages. For instance, CD-3 is the Critical Decision before the start of the construction phase.

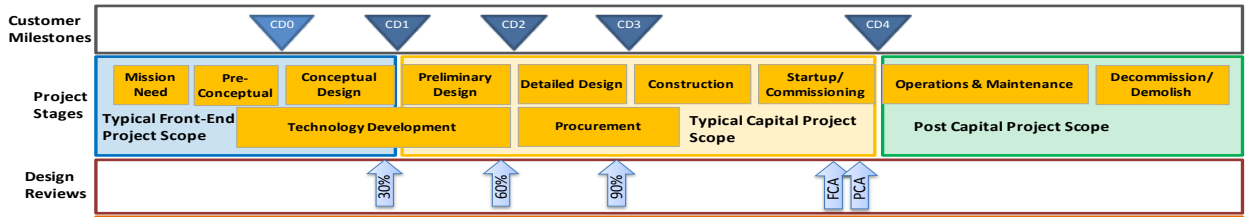

Figure SE-GEN-1, DOE Critical Decisions and Reviews by Project Phase[12]

B. The PE shall:

1. Tailor the activities of this chapter to address the specific phases, acquisition strategy, and SSCs within project scope with the concurrence of the Design Authority (Site Chief Engineer).

2. Include the plans resulting from these activities in the SEP.

3.2 Technical Baseline Development

Synopsis: Identification of technical baselines to be developed, selection of baseline review and approval milestones and methods, control of approved baselines, identification of items selected for external review.

[12] This is a generalized representation of phases based on DOE Order 413.3, related guides, and a typical construction project life cycle. The actual life cycle events will be determined during project planning.

A. The project shall:

1. Provide the budget, tools, and other resources required to conduct technical baseline development activities in accordance with the SE-RM section of this document.

2. Include technical baseline development activities in the project Work Breakdown Structure (WBS).

3. Include technical baseline development activities in the project schedule.

B. The PE shall:

1. Select the technical baselines to be developed by the project, regardless of the organization performing the work (e.g., LANL, Design Agency, supplier). Refer to "Technical Baselines" in the Section 4.0 Requirements Management (SE-RM) for the specific technical baselines.

2. Determine the technical design reviews (e.g., 30%, 60%, 90%) to be conducted by the project and establish the associated processes and success criteria. Include reviews according to the project phases and the acquisition strategy that determined how the development activities would be executed among various organizations (e.g., LANL, design agencies, suppliers).

3. Determine technical baseline approval events. *Guidance: It is recommended that technical baseline documents remain as preliminary (alpha) revisions until the design review at the end of each project stage. The documents should be approved as "baselined" (i.e., numeric revision under strict change control – refer to the "Configuration Management" article) no later than successful completion of the associated design review. For the associated design reviews, refer to "Technical Baselines" within the "Requirements Management (SE-RM)" Section.*

4. Identify the SSC requirement and design documentation that shall be evaluated by external resources prior to approval, and document in SEP or another document referenced by it. *The items requiring external review might be stipulated by contract, LANL subcontractor practice, or by LANL edict (e.g., structural design per ESM Chapter 5). See also SE Guide.*

5. Submittals: Identify to the project the processes to be used to review, accept, and control Design Agency design, procurement, fabrication, and verification submittals. *These are described in a number of PM and CoE APs, LANL Master Spec Section 01 3300 Submittal Procedures, and DRS instructions; augment as necessary.*

6. Include the plans resulting from these activities in the SEP.

3.3 Acquisition Planning

Synopsis: Acquiring a suitable Design Agency that is skilled in both systems engineering and nuclear facility design is critical to project success. It is a systems engineering function to document the required systems engineering work scope, and to establish the documents needed to support Design Agency selection. SE activities are tailored according to the scope, scale, and complexity of the project scope per Section 2, Graded Approach.

A. The PE shall:

1. Selection Criteria for Award

   a. Develop a statement of design agency experience and capability required for successful execution of the contract scope without the need for LANL to supplement their abilities. *Refer to the SE Guide, SE-PLG section, "Design Agency Selection Criteria for Award" subsection.*

   b. Provide the criteria to ASM for incorporation into the solicitation and the design agency evaluation documents. A best-value procurement approach shall be used.

2. Develop a Design Agency statement of work[13] that includes the following:

   a. Identification of the facilities and systems to be developed.

   b. Identification of previously completed engineering documentation that shall be used by the design agency as basis for their work.

   c. Identification of interfaces with existing facilities and SSCs, and SSCs being developed in parallel with the design agency's scope. List *interface control documents* (ICDs) by name where they exist (*ICDs developed by LANL must follow AP-341-626, Design Interface Control).*

   d. Mandatory participation in interface development processes with the organizations responsible for the other side of the interface.

   e. Mandatory product development, verification activities, and associated processes, by project phase, based on the current level of development. Require the design agency to comply with the requirements of this chapter and the rest of the LANL Standards (*this would include ESM Chapter 1 deliverables in Z10 and its Att. C, 30-60-90 Deliverables Schedule).*

   f. Mandatory participation in activities that LANL will use to review and accept design (e.g., design reviews) and the delivered products.

   g. Deliverables resulting from Design Agency involvement in engineering, procurement, fabrication/construction, and verification activities. As a minimum, require:

      1) All documentation and data forming each technical baseline that was modified, updated, or developed by the design agency.

      2) Completed Design Verification Matrix and Design Verification Report including design review documentation, qualification test plans and results, and alternate calculations.

   h. A requirement for addressing known technical development risks and for establishing processes and mitigations for additional technical risks identified during the course of development.

   i. A requirement addressing known hazards and for establishing or participating in processes and mitigations for additional hazards identified during the course of development.

[13] Ref. AP-341-702, *Statements of Work*

j. A requirement for the design agency to execute a systems engineering program in accordance with this chapter. Also invoke DOE-STD-1073, DOE-STD-1189 (as appropriate), ANSI/EIA-649, and other applicable mandates imposed by DOE. *Quality Program requirements should be addressed in Exhibit H. When the design agency is not LANL, their SE program will be described in a document entitled Systems Engineering Management Plan (SEMP), a different term from LANL's plan (SEP).*[14]

k. Other requirements to be imposed on the design agency that are necessary to complete the project scope, and to operate and maintain design agency-provided data and products.

3. Provide input to the solicitation instructions to the offeror with the following requirements:

a. Require each offeror, as part of their proposal, to provide a SEMP that details their SE activities for the project and relates these activities to the project WBS and schedule.

b. Require each offeror, as part of their proposal, to provide the information needed to assess their capabilities and experiences against the Design Agency Selection Criteria for Award.

4. Provide estimates for the expected cost and schedule of Design Agency work. Provide this information for use in the PEP, and for evaluating schedules and costs proposed by offerors.

5. Evaluate adequacy of the bidding Design Agencies. The LANL Design Authority[15] shall approve final selection of Design Agency. *Refer to "Design Agency Selection Criteria for Award" in the SE Guide, SE-PLG section.*

3.4 Requirements Management Planning

A. The project shall:

1. Provide the budget, tools and other resources required to conduct requirements management activities in accordance with the RM requirements of this Chapter. Refer to the "Requirements Management (SE-RM)" section for the specific RM requirements.

2. Include RM activities in the project Work Breakdown Structure (WBS).

3. Include RM activities in the project schedule.

B. The PE shall:

1. Tailor the RM requirements based on the scope, size, and complexity of the project in accordance with Section 2 Graded Approach and document these tailoring decisions in the SEP. Refer to the "Requirements Management (SE-RM)" section for the specific RM requirements.

2. Develop the planning to conduct RM activities and include the planning results in the SEP.

[14] SEP/SEMP distinction is DoD practice.

[15] This is the Site Chief Engineer and ES Div Leader at time of writing.

3.5 Systems Analysis and Development

Synopsis: Systems Engineering planning identifies the types of analyses that convert customer needs and requirements into discrete final product requirements and a system architecture that will be used to drive design. Types of analyses can include functional analysis, trade studies for alternate technologies and architectures, sizing calculations, discrete process simulations, throughput analysis, reliability and availability analysis, failure modes analysis, safety analysis, security analysis and many other types. This subsection addresses planning for systems analyses, rather than how to do systems analyses.

A. The project shall:

1. Provide the budget, tools and other resources required to conduct systems analysis activities.

2. Include systems analysis activities in the project work breakdown structure (WBS)

3. Include systems analysis activities in the project schedule.

B. The PE shall determine the systems analysis activities necessary to:

1. Derive a complete set of facility, system, structure and component requirements that, if implemented, will provide mission success and compliance with the Initial Requirements Baseline (IRB). These analyses shall be traceable to the IRB, and to the implementing SSCs. The requirements will be documented in the FRD, RCD, facility specifications, system specifications, equipment specifications and other forms of requirements documents. The document type will depend on the project phase and the SSC being defined. Include the needed analyses in the SEP.

2. Establish required behaviors for facilities, systems, and major subsystems. The results of functional analysis shall be used to specify functional requirements for the facilities, systems, and major subsystems to which the functions are allocated. Identify the functional analysis activities that will be performed by the project and include these activities in the SEP. A Functional Analysis (FA) report or FRD is the expected deliverable. *Guidance: The PE should plan at least one FA to address the systems within scope. Multiple FAs can be planned, depending on system groupings and development timeframes. For example, one FA might cover all process systems, and a separate FA can cover all utility systems.*

3. Select among alternate technologies and system architectures. Identify the specific trade studies that will be performed and include these activities in the SEP.

4. Establish final product requirements and architectures, such as throughput rates, system sizing, redundant trains, reliability and availability, and other factors influencing the ability of the final product to achieve mission objectives. Identify the specific analyses that will be performed and include these activities in the SEP.

5. Establish requirements for specialty areas, as needed for the project. Refer to the SE Guide, Section SE-RMG, “Requirement Categories” subsection for a list of

potential areas for analysis and requirements development. Identify the specific analyses that will be performed and include these activities in the SEP.

3.6 Interface Management

Synopsis: It is necessary to plan for control of interfaces with facilities and systems that are external to the project. Establishing clear boundaries and operational protocols will set project scope, establish physical locations for joining systems, establish interconnection details and reduce risks caused by uncertainties in this information.

A. The project shall:

1. Provide the budget, tools and other resources required to conduct interface management activities
2. Include interface management activities in the project Work Breakdown Structure (WBS)
3. Include interface management activities in the project schedule.

B. The PE shall:

1. Identify the physical interfaces between the project's final product and the SSCs and those belonging to external organizations. For example, these interfaces could include connections to the electric grid, the LANL water systems, central fire alarm systems, and other pre-existing external systems. Determine the number and scope of Interface Control Documents (ICDs) that will be generated and maintained throughout the project.
2. Plan formalized means to document and control the external interfaces using ICDs. Document this process in the SEP. LANL-produced ICDs follow *AP-341-626, Design Interface Control.*
3. Include activities for the development and control of each ICD in the SEP.

3.7 Verification and Validation Planning

A. Projects shall:

1. Provide the budget, tools and other resources required to conduct requirements management activities in accordance with the V&V requirements of this Chapter. Refer to the "Verification and Validation (SE-V&V)" section for the specific V&V requirements.
2. Include V&V activities in the project Work Breakdown Structure (WBS).
3. Include V&V activities in the project schedule.

B. The PE shall:

1. Tailor the V&V requirements based on the scope, size and complexity of the project based on Section 2 Graded Approach and document these tailoring decisions in the SEP. *Refer to the "Verification and Validation (SE-V&V)" section for the specific V&V requirements, including the material on SSC V&V planning.*
2. Develop the planning to conduct V&V activities, and include the planning results in the SEP.

3.8 Technical Risk Management

Synopsis: Technical risk management activities evaluate stakeholder, facility and system requirements, and evaluate selected technologies to identify program risks.

A. During development of the PEP and SEP, the project shall:

1. Identify and analyze risks addressing the project's ability to comply with technical requirements, and risks addressing the lack of maturity of the technologies that will be developed or deployed for or by the project.
2. Include the risks on a risk register, and incorporate that list into the SEP.
3. Establish risk handling strategies for each risk, and include this information in the risk register.
4. Plan for implementing risk mitigations according to the selected risk handling strategies, and include these plans in the SEP.
5. Provide the budget, tools and other resources required to conduct risk management activities.
6. Include significant risk mitigations in the PEP project schedule and WBS.
7. Plan for continued risk assessment and management throughout the project duration, and include the planning results in the SEP.

3.9 Configuration Management

Synopsis: Configuration management (CM) establishes consistency among design documentation, physical configuration, and facility documentation, and maintains this consistency throughout the life cycle of the system.

A. The project shall:

1. Plan to implement configuration management activities in accordance with LANL procedures, DOE-STD-1073, and ANSI/EIA-649.
2. Establish a process to recommend Class I design changes to the FDAR for approval based on AP-341-616, *Technical Baseline Change During Design*, or LANL-approved equivalent. Class I changes are those technical changes requiring customer or PADCAP Change Control Board (CCB) approval per AP-350-161, such as those:
    a. changing a Government approved document containing technical requirements, designs or constraints,
    b. changing contract or stakeholder level technical requirements, and/or
    c. causing threshold cost or schedule impacts, as defined in AP-350-161.
3. Establish a process to approve/disapprove Class II design changes based on AP-341-616, *Technical Baseline Change During Design*, or LANL-approved equivalent. Class II changes are any changes to previously baselined requirements (imposed or derived) and design documents that are not Class I changes.

4. Review and approve Design Agency technical baseline documents at events prescribed in the SEP, and Class I changes to approved Design Agency technical baseline documents.
5. Periodically assess and audit Design Agency CM processes for effectiveness and compliance.
6. Provide the budget, tools and other resources required to conduct configuration management activities.
7. Include the plans resulting from these activities in the SEP.

3.10 Systems Engineering Deliverables Summary

Table SE-PL-1 below lists the major deliverables required by this Chapter. It provides a quick reference to aid in planning. It is a summary only and does not include all requirement details. See chapter text for details.

Table SE-PL-1 Summary for Chapter 20 Systems Engineering Deliverables (Note, does not include all requirement details; see text for that)					
No.	Deliverable	Implementation Detail			Reference
		How	When	Who[1,2]	ESM Ch. 20 Ref.[3]
During Pre-Conceptual Phase, update before Preliminary Design Phase					
1	Systems Engineering Plan (SEP)	▪ Content per SE Guide SE-PLG, 1.3 ▪ Complete the activities specified in the SE-PL section of this Chapter	▪ Concurrently with the Project Execution Plan (PEP)	▪ PE (D) ▪ LPE (A) ▪ DA (Chief Engineer) (A)	SE-PL, 3.0
2	Budget, schedule, resources, and tools	▪ Include in the PEP ▪ Based on SEP content	▪ Concurrently with the Project Execution Plan (PEP)	▪ PE (D) ▪ LPE (A) ▪ PM (A)	SE-PL, 3
For every Design Agency (AE) Solicitation					
3	Design Agency Selection Criteria for Award	▪ Content per SE Guide SE-PLG, 1.2.A ▪ Include additional criteria for Design Agency selection per project determination	▪ Concurrently with the Project Execution Plan (PEP) ▪ Concurrently with development of the solicitation to hire a Design Agency	▪ PE (D) ▪ LPE (A)	SE-PL, 3.3, A.1.
4	Design Agency Statement of Work	▪ Content per SE-PL	▪ Concurrently with development of the solicitation to hire a Design Agency	▪ PE (D) ▪ LPE (A) ▪ PM (A)	SE-PL, 3.3.A.2
5	Instructions to the Offeror	▪ Content per SE-PL	▪ Concurrently with development of the solicitation to hire a Design Agency	▪ PE (D) ▪ LPE (A) ▪ PM (A)	SE-PL, 3.3.A.3
Conceptual Design Phase					
6	Initial Requirements Baseline (List) (IRB)	▪ Content per SE-RM	▪ At the beginning of Conceptual Design Phase ▪ Prior to developing the documents in the Conceptual Design Baseline	▪ PE (D) ▪ LPE (A)	SE-RM, 4
7	Functions and Requirements Document (FRD)	▪ Develop per AP-341-601 ▪ Add V&V information	▪ During Conceptual Design	▪ PE (D) ▪ LPE (A) ▪ FDAR (A)	SE-RM, 4
8	Requirements & Criteria Document (RCD)	▪ Develop per AP-341-602 ▪ Add V&V information	▪ During Conceptual Design	▪ PE (D) ▪ QA (R) ▪ LPE (A)	SE-RM, 4

Table SE-PL-1 Summary for Chapter 20 Systems Engineering Deliverables (Note, does not include all requirement details; see text for that)					
No.	**Deliverable**	**Implementation Detail**			**Reference**
		How	**When**	**Who[1,2]**	**ESM Ch. 20 Ref.[3]**
				▪ FDAR (A) ▪ DA (Chief Engineer) (A) ▪ PM (A) ▪ Client (facility or program)	
9	Conceptual Design Baseline	▪ Develop the FRD and RCD as listed above ▪ Develop facility-level drawings identified in Table SE-RM-1 Project Technical Baselines	▪ During Conceptual Design	▪ PE (D) ▪ PE (A) for individual alpha revision documents ▪ LPE (A) for individual numeric revision documents	SE-RM, 4
Preliminary Design Phase					
10	System/Facility Baseline	▪ Develop system/subsystem specifications per Appendix C, Major Element Specification Contents ▪ Develop system-level drawings identified in Table SE-RM-1 Project Technical Baselines and Associated Deliverables per ESM (summary in Chapter 1 Section Z10, Attachment C.)	▪ During Preliminary Design	▪ PE (D) ▪ DAg (A) for individual alpha revision documents ▪ FDAR (A) for individual numeric revision documents	SE-RM, 4
Final Design					
11	Final Design Baseline	▪ Develop final design documentation per ESM Chapter 1 Section Z10, Attachment C.	▪ During Detailed/Final Design	▪ PE (D) ▪ DAg (A) for individual alpha revision documents ▪ FDAR (A) for individual numeric revision documents	SE-RM, 4
14	Test Acceptance Criteria (TAC) Table	▪ See Appendix E	▪ Concurrent with Final Design Baseline development during Detailed/Final Design phase	▪ DAg (D) ▪ LPE (A)	SE-V&V, 5.2.1.B.3.a
Multiple Phases					
12	Design Verification Matrix (DVM)	▪ See Appendix D	▪ At the beginning of the project and maintained until all verification is complete	▪ DAg (D) ▪ LPE (A)	SE-V&V, 5.1.1.A.4
13	Design Verification Report (DVR)	▪ DVR format and content will vary by method of verification.	▪ As each design verification activity is completed	▪ DAg (D) ▪ LPE (A)	SE-V&V, 5.1.5, 5.1.6

Table SE-PL-1 Summary for Chapter 20 Systems Engineering Deliverables (Note, does not include all requirement details; see text for that)					
No.	**Deliverable**	**Implementation Detail**			**Reference**
		How	**When**	**Who[1,2]**	**ESM Ch. 20 Ref.[3]**
15	Requirements Verification Matrix (RVM)	▪ See Appendix F	▪ Concurrent with technical baseline development during each project phase	▪ DAg (D) ▪ LCxA (R) ▪ QA (R) ▪ System engineers and/or FDAR (R) ▪ LPE (A)	SE-V&V, 5.2.2.A

Notes:

[1] D = Develop; R = Review; A = Approve.

[2] DA = Design Authority; DAg = Design Agency; FDAR = Facility Design Authority Representative; LPE = Lead Project Engineer; PE = Project Engineer; PM = Project Manager

[3] Ref. = ESM Chapter 20 section name and paragraph number (e.g., SE-RM, 4.1).

4.0 REQUIREMENTS MANAGEMENT (SE-RM)

4.1 Technical Baselines

Synopsis: The primary objective of Requirements Management (RM) is to establish and maintain a requirements baseline for a project or program.

4.1.1 Projects shall:

1. Implement a structured approach to RM as prescribed in this section. Implement the following basic requirements management functions in accordance with the requirements of this Chapter:
   a. Identify and Document the requirements
   b. Analyze, Validate, Allocate, and Trace the requirements
   c. Control Change to the requirements
   d. Verify and Validate requirements are satisfied by the SSCs
   e. Organize, balance and integrate the requirements.
2. Develop the following technical baselines in Table SE-RM-1 in the sequence listed, starting with the Initial Requirements Baseline and continuing with the baselines for phases within the project scope. For the purpose of this chapter, the technical baseline deliverables include only requirements specifications and design documents. Basis documents such as studies, calculations, and other project deliverables, although important, are not considered part of the technical baselines.

Table SE-RM-1: Project Technical Baselines and Associated Deliverables

Project Phase: Pre-Conceptual	**Baseline Name:** Initial Requirements Baseline (IRB)
Baseline Contents: This baseline states objectives and requirements from the client (project owner), Operations, regulators, external interface partners, site and other contractually recognized stakeholders. It typically consists of the following documents: • contract • mission needs statement • customer specifications • regulations • permits • interface control documents • site-specific standards • operations requirements document • documents containing site-specific considerations for geo-technical conditions, environmental conditions and Natural Phenomenon Hazards (NPH) Note: The above list is generally comprehensive. However, other criteria documents may be included by contract, or by mutual agreement between client and the project. All sources shall be managed under configuration control. These documents provide the starting point for analysis and design of the final product (project result).	

Project Phase: Conceptual Design	**Baseline Name:** Conceptual Design Baseline (CDB)

Baseline Contents: This baseline states functional, performance and other types of requirements defining the top configuration item required by contract, such as a facility, or an integrated facility. It provides the requirements used to define the facility (and sometimes system) processes and flows, the systems architecture and the verification requirements. It represents completion of approximately 30% of the overall design effort. Documents include:

- Functions and Requirements Document (FRD) (Refer to AP-341-601)
- Conceptual Design Report (requirements and design portions only) or Requirements and Criteria Document (Refer to AP-341-602 for the RCD)
- discipline-specific criteria
- interface control documents (ICDs)
- plot plan
- process flow diagrams (PFDs)
- mechanical flow diagrams (MFDs)

Note: The above list is generally comprehensive. The FRD contains requirements resulting from analyses such as nuclear safety, fire, security, human factors, and others. The analysis documents are not part of the baseline, but provide the basis for the requirements in the FRD. Traceability from the analysis documents to the FRD shall be provided.

Project Phase: Preliminary Design	**Baseline Name:** Preliminary Design Baseline

Baseline Contents: This baseline states functional, performance, and other types of requirements defining the facility systems and structures. It provides the necessary and sufficient requirements to design a system, structure, or item and to verify that item design is satisfactory for its purpose. It represents completion of approximately 60% of the overall design effort. This baseline consists of:

- specifications for systems and structures (refer to Appendix C, Major Element Specification Contents)
- system-level drawing types (e.g., piping and instrumentation diagrams, ventilation and instrumentation diagrams, mechanical handling diagrams, electrical single lines)
- general arrangement drawings
- system and facility design descriptions alpha-rev drafts (when required by ESM Ch 1 Z10 Att B and considered technical baseline by FDAR, with TBDs where content is not final).

Note 1: In addition to the above, refer to Engineering Standards Manual Chapter 1 Section Z10, Attachment C (30-60-90 Deliverable Schedule).

Note 2: The specifications for systems and structures contain requirements resulting from analyses such as nuclear safety, fire, security, human factors, and others. The analysis documents are not part of the baseline, but provide the basis for the requirements. Traceability from the analysis documents to the specifications shall be provided.

Project Phase: Final Design (Detailed Design)	**Baseline Name:** Final Design Baseline

Baseline Contents: This baseline consists of design documents used to identify, specify, construct, and purchase components. It represents completion of approximately 90% of the overall design effort. It is comprised of:

- Specifications and designs completed by the prime contractor, design agency, and suppliers.
- Design documents include piping isometrics, concrete neatlines, structural steel drawings, hanger details, equipment specifications, equipment data sheets, logic diagrams, and many other types as needed by each engineering discipline.
- system and facility design descriptions numeric revisions (when required by ESM Ch 1 Z10 Att B and considered technical baseline by FDAR, with TBDs where content is not final).

Note 1: There are dozens of design document types used by the various Engineering disciplines and required by the Engineering Standards Manual (some are listed by Chapter 1 Section Z10, Attachment C).

Note 2: The specifications for equipment/components contain requirements resulting from analyses such as nuclear

safety, fire, security, human factors, and others. The analysis documents are not part of the baseline, but provide the basis for the requirements. Traceability from the analysis documents to the specifications shall be provided.

For the sake of simplicity, this chapter emphasizes the conceptual, preliminary, and final design phase elements assuming the award for design was made. When tailoring this standard for other project scenarios, refer to Section SE-PL and obtain LANL Site Chief Engineer concurrence.

4.2 Identify and document the technical requirements

4.2.1 Identify Requirements

The following activities are required to identify requirements.

A. At the start of Conceptual Design, the project shall:

1. Identify the applicable authorized requirements sources to be included in the Initial Requirements Baseline (IRB). Refer to the SE Guide, SE-RMG, “Client and Regulatory Source Documents” Subsection, for the expected IRB sources.

2. Identify additional sources by conducting an exhaustive search for the client and regulatory source documents that are either cited by the contract, relevant due to scope or relevant due to governmental jurisdictions. Confirm source applicability with the client and project management and add these sources to Project IRB list.

3. Generate a Project IRB List identifying the documents identified as a result of the previous two steps. The listed sources will be referred to as the IRB throughout this procedure. The list shall have one entry for each document that includes:

   a. the document title,

   b. the document number (or other unique identification designation),

   c. the document revision,

   d. the organization that owns and approves the document

4. Maintain each document on the IRB List under formal configuration control and keep the Project IRB List current throughout the project duration. Regularly monitor each document owned by an external agency for changes.

5. Document any additional, clarified or previously undocumented requirements elicited from the client, regulators or stakeholders. These new requirements shall be added to existing or new document(s) according to the nature and source of the requirement. After authorization by the client contracting officer of the resulting new or updated documents, these additional documents shall be added to the Project IRB list.

6. Substantially complete the Project IRB list before proceeding with developing the Conceptual Design Baseline.

7. Organize the requirements per this Section’s “Organize Requirements” article (*4.6).*

B. During Conceptual Design, the PE shall:

1. Develop design criteria to state required design codes and standards, to establish required design methods and margins, and to provide generally

applicable project-wide requirements. This could be part of the RCD or stand-alone design criteria documents.

2. Identify, within the IRB, statements of goals and objectives, and unclear statements, that imply or infer technical requirements.[16] Work with client, regulators, and senior LANL management to resolve requirements ambiguity and incompleteness.

4.2.2 Assign Technical Requirements

During Conceptual Design, the PE shall assign responsibility for further development and implementation of each requirement to a responsible organization or person.

4.2.3 Analyze, validate, allocate, and trace the requirements

Note: See Graded Approach in Section 2 (SE-GR) for traceability depth based on project size.

Analyze Requirements

A. During Conceptual Design, the PE shall:

1. Analyze requirements in the IRB to establish a complete set of requirements for the final product to be delivered by the project and organize them into the FRD and RCD. This includes functional, performance, nuclear safety and other technical requirements. The content of the FRD and RCD shall be per AP-341-601 and AP-341-602 respectively. In instances when the FRD and RCD are not applicable, follow Appendix C, Major Element Specification.

2. Capture results of the analysis in the SE tool.

3. Develop and capture more detailed preliminary requirements that specify the systems and structures needed to achieve the final product. Ensure results of nuclear safety analyses and resulting requirements (e.g., functions and control strategies) are identified and captured.

4. Identify documents and other sources providing the basis information that was used to develop and justify each requirement, according to the level of detail required by the project plans. Represent the basis sources in the SE tool to enable linking for traceability. Refer to the “4.2.6 Trace Requirements” for linking to ensure traceability.

5. Identify the Key Performance Parameters (KPPs) for the overall final product delivered by the project. Label them in the SE tool as Key Performance Parameters. KPPs are generally expressed as system effectiveness (e.g., throughput, design utilization rate, system output quality) and system quality (e.g., availability, usability).

6. Assemble the Functional Baseline documents, and have them reviewed and approved per the project plan. Documents may be approved individually in the order necessary to enable subsequent work, or as a group at the end of Conceptual Design. Documents may be initially approved as preliminary (indicated by an alpha revision). Conceptual Design Baseline documents shall be issued as a baselined document (indicated by a numeric revision) no later than the end of Conceptual Design.

[16] The PE may need to elicit information from the client, regulators, and senior LANL management to resolve requirements ambiguity and incompleteness. In addition, the PE should be aware of biases that might inappropriately constrain the technical solution, and work to alleviate the requirements of these biases.

7. Control documents that are issued with a numeric revision using formal configuration control procedures, with the FDAR as the approval authority. Thus, it is important not to issue a document with a numeric revision until the content has reasonable surety for the stage of development. Note that Class I changes, although approved by the FDAR, may not be approved without prior consent of the customer or implemented prior to resolution of budget and schedule impacts with the project manager.

B. During Preliminary Design, the PE shall:

1. Analyze requirements in the IRB and Conceptual Design Baseline to establish a complete set of requirements for the systems and structures to be delivered by the project, based on the acquisition strategy for each SSC. *Guidance: As noted in R2A2 subsection above, the default is that the project will subcontract this work*.

2. If some of the requirements development work was subcontracted, review the requirements developed by the Design Agency to confirm their completeness and validity. Ensure nuclear safety requirements were developed and implemented in the design.

3. Finalize requirements for each system and structure.

4. Capture the requirements in the SE tool, to the extent indicated in the Systems Engineering Plan. Ensure results of nuclear safety analyses and resulting requirements (e.g., functions and control strategies) are identified and captured.

5. For those components that are not subcontracted, develop and capture more detailed preliminary requirements that specify the components.

6. Identify documents and other sources providing the basis information that was used to develop and justify each requirement, according to the level of detail required by the project plans. Represent the basis sources in the SE tool to enable linking for traceability. *Refer to* “4.2.6 Trace Requirements” *below for linking to ensure traceability.*

7. Assemble the System/Facility Baseline documents, and have them reviewed and approved per the project plan. *Documents may be approved individually in the order necessary to enable subsequent work, or as a group at the end of Preliminary Design. Documents may be initially approved as preliminary (indicated by an alpha revision).* When: System/Facility Baseline documents shall be issued as a baselined document (indicated by a numeric revision) no later than the end of Preliminary Design.

8. Control documents that are issued with a numeric revision using formal configuration control procedures, with the FDAR as the approval authority. *Thus, it is important not to issue a document with a numeric revision until the content has reasonable surety for the stage of development. Note that Class I changes, although approved by the FDAR, may not be approved without prior consent of the customer or implemented prior to resolution of budget and schedule impacts with the project manager.*

C. During Final Design, the PE shall:

1. Analyze requirements in the IRB, Conceptual Design and System/Facility baselines to establish a complete set of requirements for the components to be developed by the project, based on the acquisition strategy for each SSC.

Guidance: As noted in R2A2 subsection above, the default is that the project will subcontract this work.

2. If some of the requirements development work was subcontracted, review the requirements developed by the Design Agency to confirm their completeness and validity. Ensure nuclear safety requirements were developed and implemented in the design.

3. Finalize requirements for each component.

4. Capture the requirements in the SE tool, to the extent indicated in the Systems Engineering Plan.

5. For those components that are not subcontracted, develop and capture more detailed preliminary requirements that specify the components. Ensure results of nuclear safety analyses and resulting requirements (e.g., functions and control strategies) are identified and captured.

6. Identify documents and other sources providing the basis information that was used to develop and justify each requirement, according to the level of detail required by the project plans. Represent the basis sources in the SE tool to enable linking for traceability. Refer to "4.2.6 Trace Requirements" below for linking to ensure traceability.

7. Assemble the Final Design Baseline documents, and have them reviewed and approved per the project plan. *Documents may be approved individually in the order necessary to enable subsequent work, or as a group at the end of Final Design. Documents may be initially approved as preliminary (indicated by an alpha revision).* Final Design Baseline documents shall be issued as a baselined document (indicated by a numeric revision) no later than the end of Final Design.

8. Control documents that are issued with a numeric revision using formal configuration control procedures, with the Project Engineering Manager as the approval authority. *Thus, it is important not to issue a document with a numeric revision until the content has reasonable surety for the stage of development. Note that Class I changes, although approved by the Project Engineering Manager, may not be approved without prior consent of the customer or implemented prior to resolution of budget and schedule impacts with the project manager.*

4.2.4 Validate Requirements

A. As requirements are developed during each design stage, the project shall:

1. Validate the requirements developed during each project phase prior to acceptance and further processing.

2. Validate by confirming the requirements have the following characteristics:

   a. Necessary: Has to be met or possessed by a system to solve a stakeholder problem or to achieve a stakeholder objective, such as mission, availability, safety, security, or quality.

   b. Clear: Conveys what must be achieved in a manner that can be understood by those who are expected to implement and verify the requirement, without having to ask the author what was meant.

c. Traceable: Can be traced to an approved client, stakeholder, regulatory or other binding document. Tracing can be direct to these documents or derived through project analytical documents used to derive them.

d. Verifiable: Is quantified by measurable conditions and bounded by constraints. Satisfaction of the requirement can be objectively measured or demonstrated.

e. Feasible: The requirement can be achieved using current technology, or technology that can be successfully developed by the project.

f. Defensible: The requirement is justified using technically sound scientific and engineering analysis. The requirement shall not impose unwarranted constraints.

g. Implementation Free: States *what* is required and *how well* it should be done, without bias for *how* it will be done. It should not specify the use of specific new or historical solutions. The design team should be allowed to choose the best means of accomplishing the requirements.

h. Affordable: The requirement can be achieved within the cost and schedule bounds established for the system development and operations.

3. Ensure requirements are stated clearly and simply, and describe what is needed rather than how it should be provided. *Refer to the SE Guide, SE-RMG Section, "Requirement Validation Guidance".*

4.2.5 Allocate Requirements

A. Throughout the project duration, the PE shall:

1. Assign requirements to the appropriate engineering discipline for implementation.

2. Allocate each requirement in the IRB and Functional Specification to each system, structure or component that is required to achieve that requirement.

3. Allocate all further decomposed or derived requirements to each system, structure or component that is required to achieve that requirement.

4. Allocate requirements prior to completion of Preliminary Design.

4.2.6 Trace Requirements

A. At the start of Conceptual Design Phase, the project shall:

1. Determine the extent to which traceability is required to meet client and reviewer expectations (e.g., Operational Readiness Review [ORR] expectations). Refer to the table in Section 2 Graded Approach of this document. At a minimum:

a. each requirement in each IRB document shall be traceable downward to one or more requirement or design document contained in the Conceptual Design, Preliminary Design, and Final Design baselines, and vice versa;

b. safety basis and regulatory requirements will be traceable to a requirement statement or design document for the implementing SSC, and vice versa; and

c. allocation of requirements to SSCs is complete.

2. Develop a definition of traceability links required to record developmental relationships among requirements, basis information (e.g., analysis, study, calculation), design documents (e.g., drawing, data sheet), and other implementing documents (e.g., material requisition) in a manner that demonstrates flow down and justification for system development decisions. *Examples of traceability link definitions are provided in the SE Guide, SE-RMG Section, "Requirements Database Object Relationships".*

B. Throughout the project duration, the PE shall:

1. What

a. Establish the traceability links among requirements within the SE tool. These traces shall also show decomposition where it occurred.

b. Establish the traceability links between requirement and the supporting documents.

c. Establish the traceability links between SSCs and the supporting documents.

2. Completion Timing

a. Traceability links associated with systems and facilities shall be complete before the end of preliminary design.

b. Traceability links associated with components shall be complete before the end of final design.

4.3 Control changes to the requirements

A. As new requirements or changes to baselined requirements are proposed or directed, the PE shall:

1. Ensure compliance with configuration management requirements in SE-RM, "Configuration Management" (3.9).

2. Evaluate the technical validity of the new requirements and proposed changes to requirements. *Refer to SE-RM "Validate Requirements" article*.

3. Query the SE tool and the traceability information to identify the requirements, documents and SSCs affected by the new or changed requirements.

4. Analyze impacts to the current design, procured and constructed material, technical risk and project cost and schedule, and enter them onto a change tracking list.

5. Develop the change documentation for the requirements document affected by the new requirements or proposed changed requirements. Refer to the applicable ESM Chapter or LANL AP addressing development of the affected document for the correct change documentation to be used.

6. Present the change documents and associated change impacts to the Project Engineering Manager to seek approval. Link this process with the project change process for scope, cost and schedule. The FDAR is the ultimate approval authority for design changes. The Project Manager is the approval authority for cost and schedule changes. Note that the technical content of Class I changes, although initially approved by the Project Engineering Manager, may not be

approved without final consent of the Requirements Owner and FDAR or implemented prior to resolution of budget and schedule impacts with the Project Manager.

7. If the change is approved, implement the change document and cascade the change to the subsequently affected documents, update analytical and design documents starting from the top of the document hierarchy and working downward. Refer to the Chapter addressing development of each affected document type for the correct change documentation to be used.

8. Update change tracking list as changes are approved and implemented to ensure all impacts are tracked to completion.

4.4 Verify Compliance with the Requirements

A. Throughout the project duration, the PE shall:

1. Specify one or more verification method for each requirement that will be used to confirm the capability of the actual SSC to which the requirement is allocated. The verification methods are addressed by the SE Guide, Section SE-RMG, under ”Verification Methods”.

2. Specify the methods of verification required for each SSC based on the associated key functional, performance, or physical requirements. Key requirements will be selected by the project based on importance to project mission, safety, contractual or regulatory compliance, integration with other SSCs or technical risk.

3. Record the method of verification in the specification containing the requirement.

4. Capture the method of verification in the SE tool.

5. Specify the project timeframe that the verification is expected to be completed. These timeframes shall align with milestones on the project schedule. If verification is by demonstration or test, then the timeframe shall relate to the project test event schedule (e.g., FAT, Startup, Commissioning).

6. Capture verification completion results and current status in the SE tool, according to the detail required by the Systems Engineering Plan.

Note: Conducting verification activities and tracking of same shall be in accordance with Section 5.0 “Verification and Validation (SE-V&V)”.

4.5 Organize, Balance, and Integrate the Requirements

4.5.1 Organize Requirements

A. During Conceptual Design, the project shall:

1. Import and parse verbatim the text from each IRB document into the SE tool in a manner that efficiently enables requirements management functions.

Note: *See SE-GEN for the SE tool requirements; using an SE tool will simplify execution of this chapter.*

2. Import and parse verbatim the text from each design criteria document into an SE tool in a manner that efficiently enables requirements management functions.

3. Maintain traceability of all parsed items to the source document.

4. Categorize each of the parsed verbatim text items as either 'Heading,' 'Information,' or 'Requirement' as follows:

    a. Heading: Document Section heading.

    b. Information: Text that provides context, explanation or that does not state a requirement.

    c. Requirement: Test that states something that the project-provided final product is required to provide, to have, or to do.

5. Categorize requirements as 'Applicable Now' or 'Future.' The concept of "future" requirements could apply if a project is expected to provide capability on an incremental or phased basis. Some requirements are communicated in current documentation, but are clearly identified as applying to future phases.

6. Provide each requirement with a unique identification number to enable configuration management (i.e., identification, tracking, control, status accounting).

B. During Conceptual Design, the PE shall:

1. Review each requirement extracted from IRB documents to identify:

    a. The technical requirements that specify or bound the capability of the physical final product(s) (e.g., system, structure, component, software) to be provided or modified by the project.

    b. The requirements specifying Engineering activities, processes, methods, analysis factors and other constraints to be incorporated into the project execution.

2. Categorize the technical requirements by type (e.g., functional, performance, interface, execution, verification), and apply the category label in the SE tool.

3. Organize Documents

C. During Conceptual Design, the project shall:

1. Establish a requirements hierarchy, similar to that shown in the SE Guide Section SE-RMG, "Design Document Hierarchy" subsection. The hierarchy shall:

    a. describe the order of precedence of project technical requirements sources,

    b. document ownership/change authority, and

    c. preclude circular references.

2. Balance and Integrate Requirements.

D. The project shall:

1. Integrate requirements across systems and facilities to ensure consistency. Resolve design issues among design groups and disciplines to arrive at a balanced set of requirements. *(An acceptable attribute in the design of one SSC may adversely affect the design of another SSC to the detriment of overall facility performance. The project must resolve such issues.)*

2. Correct imbalances in the system design caused by Customer priorities, team design solutions, or technical requirement complications.

3. Monitor RM performance.

E. The project shall monitor the requirements baselines and quality of data in the SE tool by doing the following:

1. Develop metrics, including:

a. the number of unallocated [or unimplemented] requirements

b. the number of requirements that do not trace back to a IRB source

c. the number of requirements changes approved

d. the number of requirements not linked to a verification method or activity

e. consider other metrics that can expose issues with RM implementation

2. Track performance against each metric on a periodic basis (e.g., monthly).

3. Conduct assessments, sampling:

a. the correctness of information in the SE tool against the latest revisions of the IRB documents,

b. the correctness of requirements allocation, and

c. the adequacy of requirements bases.

4. Provide periodic assessments of the project compliance with the requirements of this chapter.

5.0 VERIFICATION AND VALIDATION (SE-V&V)

Synopsis: The primary objectives of V&V are to confirm the adequacy of:

- nuclear safety design,
- the as-installed and/or as-built SSCs, and
- the final product to serve the mission.

This section excludes design verification activities such as normal design checking, review, and approval processes that are part of the normal design processes.

A. Projects shall:

1. Implement a structured approach to V&V as prescribed in this section.

2. Implement the following V&V functions in accordance with the requirements of this section:

a. Design Verification per ASME NQA-1, Requirement 3, Section 500,

b. SSC Verification, and

c. Final Product Validation.

This SE-V&V section is structured to reflect these three objectives.

This section assumes a working knowledge of the Requirements Management section of this document. For an understanding of V&V principles, refer to the SE Guide, SE-V&VG section.

5.1 Design Verification per ASME NQA-1, Requirement 3, Section 500

This subsection is applicable for projects in all hazard category 1–3 nuclear facilities; outside of these, perform checking and verification activities as required by the project QAP.

5.1.1 Design Verification (DV) Planning and Control

A. For all SSCs identified as implementing nuclear safety requirements, the responsible design agency shall:

1. Select DV methods, to include any one or a combination of the following:
    a. Design review
        1) multi-disciplinary design review
        2) individual critical design review
    b. Alternate calculations
    c. Qualification testing.
2. Select the type and depth of the verification based upon the nature of the item, considering:
    a. the importance of the specific attribute to safety,
    b. the complexity of design,
    c. the degree of standardization,
    d. the state of the art,
    e. the similarity with previously proven designs, and
    f. the effects of known problems for the design.
3. Document the selected design verification method decisions and current verification status in a Design Verification Matrix (DVM), for applicable SSCs for which they are responsible. The minimum DVM content shall include:
    a. SSC Unique Identifier and name,
    b. selected DV method(s),
    c. the portion of the SSC to be verified when performing the method, and
    d. current design verification status.

    Note: See Appendix D for more detail on the **Design Verification Matrix.**
4. Provide a current copy of the DVM to the project as required by contract, when updated, and upon request.
5. Ensure that the planned DVs are appropriately addressed in design agency planning.

6. Ensure DV is performed prior to releasing the design for procurement, manufacture, construction, or use by another design organization, except where this timing cannot be met, such as when insufficient data exist.

7. Track the completion status for each SSC requiring DV.

8. Ensure in all cases that DV is completed prior to relying upon the SSC or computer program to perform its function.

B. The project shall:

1. Require the responsible design agency to conduct DV per ASME NQA-1, Requirement 3, Section 500, and per the requirements of this chapter.

2. Check adequacy of design agency DV method and depth decisions. If inadequate, identify the deficiencies to the responsible design agency and require them to correct deficiencies.

3. Ensure that the planned DVs are appropriately addressed in the Project Execution Plan.

4. Oversee the design agency implementation and execution of DV to confirm compliance with ASME NQA-1 and the requirements of this chapter.

5.1.2 Design Review

A. Design reviews shall provide assurance that the final design is correct and satisfactory by addressing the following questions:

1. Were the design inputs correctly selected?

2. Are assumptions necessary to perform the design activity adequately described and reasonable? Where necessary, are the assumptions identified for subsequent reverifications when the detailed design activities are completed?

3. Were appropriate design methods and computer programs used?

4. Were the design inputs correctly incorporated into the design?

5. Is the design output reasonable compared to design inputs?

6. Are the necessary design inputs for interfacing organizations specified in the design documents or in supporting procedures or instructions?

7. Have suitable materials, parts, processes, and inspection and testing criteria been specified?

5.1.2.1 Multi-Disciplinary Design Review

A. Multi-disciplinary design reviews are used as a means of DV when systems or major subsystems are evaluated in whole and as a collection of integrated components. When DV is accomplished by multi-disciplinary/group review, the responsible design agency shall:

1. Establish the scope of the review, including identifying:
   a. which SSCs will have their designs verified by the review, and
   b. associated key design documents that will be used to verify the design, including:

1) system descriptions,
2) flow diagrams,
3) piping and instrument diagrams,
4) electrical single-line diagrams,
5) site arrangement drawings,
6) equipment location drawings,
7) structural drawings,
8) detailed engineering drawings,
9) engineering specifications, and
10) calculations supporting the key design documents for safety related SSCs.

2. Establish the review team. The team composition:

a. Shall include competent individual(s) or group(s) other than those who performed the original design but who may be from the same organization.

b. May include the originator's supervisor, provided:

1) the supervisor did not specify a singular design approach or rule out certain design considerations and

2) did not establish the design inputs used in the design; or

3) the supervisor is the only individual in the organization competent to perform the verification.

c. May include members from off-project.

B. The review team leader shall:

1. Distribute to the team members a design review package comprised of the key design documents used to represent the design and the design input requirements.

2. Conduct the review either in a meeting or separately by the individual team members as long as the review is conducted concurrently.

3. Distribute all team comments among the team members.

4. Resolve disagreements among the team members.

5. Provide a consolidated list of comments as agreed upon by the members to the responsible contractor and the PE.

5.1.2.2 Individual Critical Design Review

A. Individual Critical Design Reviews are usually conducted around a single component, and can be achieved by checking component design documents as they are generated. Design checking may be used when all the questions under "Design Review" above are evaluated and documented for each document at the time of checking. When DV is accomplished by individual critical design review, the PE shall:

1. If selected, this design review method may be satisfied by the independent check of the document, performed in accordance with the appropriate procedure (e.g., Calculations, Drawings, or Specifications). It must be confirmed, however, that all

the requirements of an Design Review are satisfied—i.e., that the independent checking:

a. includes all applicable questions per the “Design Review” article above,

b. is performed by an individual who has adequate competence to have originated the document, and is sufficiently independent such that they are not verifying their own work, and

c. has access to the necessary design information.

5.1.3 Alternate Calculation

A. When DV is accomplished by performing alternate calculations, the responsible design agency shall:

1. Ensure the appropriateness of the assumptions and input data.
2. Use an alternate method to that used in the original calculation or analysis.
3. Verify correctness of the alternate method used.
4. Evaluate the appropriateness of any computer program, its associated computer hardware and system software used per Requirement 3, 501.2..
5. Compare the results to the original calculations or analysis to verify their correctness. *Note: alternate calculations are not required to go through the checking process.*

5.1.4 Qualification testing

A. DV for some designs or specific design features can be achieved by suitable qualification testing of a prototype or initial production unit. When DV is accomplished by qualification testing, the responsible design agency shall comply with the requirements of NQA-1 Requirement 11 and shall:

1. Identify the qualification tests.
2. Identify the specific design features that will be verified by the tests when other features of the design will be verified using other means.
3. Clearly define and document the test configuration.
4. Demonstrate adequacy of performance under conditions that simulate the most adverse design conditions. Definition of the most adverse condition shall consider:
   a. operating modes
   b. environmental conditions
5. Establish and verify scaling laws when tests are being performed on models or mockups. Subject results of model test work to error analysis, where applicable, prior to use in final design work.
6. Document and evaluate test results by the responsible design agency to assure that test requirements have been met.
7. Resolve test failures. If qualification testing indicates that modifications to the item are necessary to obtain acceptable performance, the modification shall be documented and the item modified and retested or otherwise verified to assure satisfactory performance.

5.1.5 DV Documentation

A. The responsible design agency shall:

1. Document results of DV efforts for each SSC in a DV Report (DVR).

2. Provide the DVR to the project for review.

5.1.6 Acceptance of Design Verification Results

A. For all methods of design verification, the PE shall:
   1. Review the design verification method selection for appropriateness.
   2. Review each DVR to confirm adequacy of process and results.
   3. Ensure all comments are objectively dispositioned and implemented in the key design documents and associated calculations.

B. The responsible design agency shall:
   1. Resolve substantive comments and issues[17] raised through project review of the documentation.
   2. Update and re-submit the DVR according to comment resolutions.
   3. Verify the modified design prior to release or use when the design is modified to resolve verification findings.

5.1.7 Effects of Change on DV

The tasks of this subsection apply when the design inputs (e.g., requirements) or design of an SSC, whose design was previously design verified, were subsequently changed.

A. The responsible Design Agency shall:
   1. Control change to design inputs and design using design control methods commensurate with those applied to the original design.
   2. Evaluate the effect of the change(s) on the overall design, the supporting analyses and the previous DV results. Consider the effects for the following life cycle activities:
      a. operations,
      b. maintenance,
      c. test,
      d. surveillance, and
      e. inspection.
   3. If some part or all of the DV was invalidated by the change and needs to be repeated or updated, then:
      a. change the DV status of the previously verified SSC design to “reverify” on the DVM,
      b. repeat the steps required by the “
      c. Design Verification (DV) Planning” Subsection,
      d. perform the DV method,
      e. update and re-submit the DVR,
      f. resolve substantive comments and issues raised through project review of the documentation, and
      g. update the status on the DVM.

B. The PE shall:
   1. Review appropriateness the DV repeat/update decision made by the responsible design agency, and advise that agency as needed.
   2. Review DV method selection for appropriateness.
   3. Review DV documentation to confirm adequacy of process and results.
   4. Ensure all comments are objectively dispositioned and implemented in the key design documents and associated calculations.

[17] The PE determines which comments and issues are substantive, with any disagreements arbitrated by the FDAR.

5.2 SSC Verification

Note: See Section 2 Graded Approach (SE-GR) for V&V expectations based on project size.

Synopsis: SSC verification activities provide objective evidence that the as-delivered/as-built SSCs conform to the requirements they were designed to meet. The relationship between technical requirements and verification requirements is illustrated in the V-diagram (see Figure SE-V&V-1). The principle is that the functional/operational specification and drawings that define a final product will be used to determine that product's acceptability. Thus, compliance with the functional specification (RCD/FRD) defining the entire final product as a single "black box" will be used to accept (validate) that facility. Compliance with the major element specification defining a system as a single "black box" will be used to accept (verify) the system. Compliance with equipment specifications, data sheets and detailed drawings will be used to accept (verify) components.

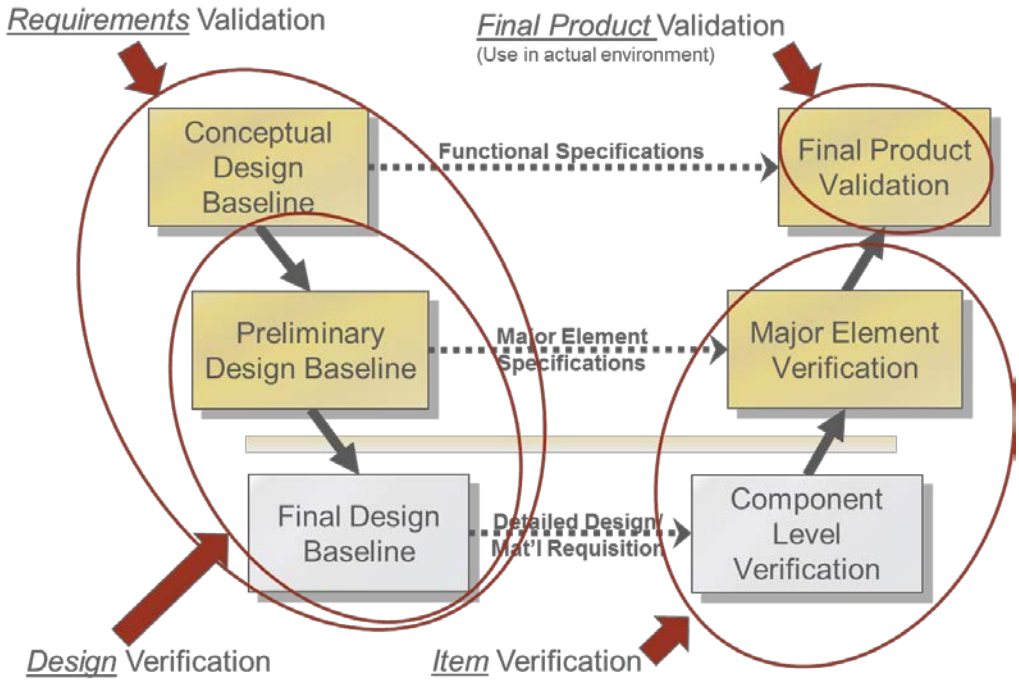

Figure SE-V&V-1, V-Diagram (Annotated)

SSC verification begins on the bottom, right-hand side of the V-diagram with component-level verification. This indicates that the components are measured against the specific requirements in their specification and drawing before they are integrated into their larger system. Subsequently the systems are measured against the requirements included in *their* specifications. After the systems are verified and integrated into a complete facility, that final product (result) can be *validated* as indicated above and in the "Final Product Validation" subsection (*5.3*).

5.2.1 SSC V&V Planning

A. The Project shall:

1. Establish a V&V strategy that accounts for both the system development lifecycle and the system acquisition strategy (i.e., what type organizations will perform the design, fabrication/ construction, and verification work). The V&V strategy shall address:

a. The sequence of test phases that will be used during the project and used for planning the specific test and demonstration activities for each SSC. *For example, the following test phases might be included:*

1) Factory Acceptance Test (FAT): Testing performed on a component (e.g., pump, filter) or subsystem (e.g., glovebox, equipment skid) prior to shipment to LANL for acceptance. FAT confirms the component or subsystem meets requirements of an equipment specification, data sheet, or other requirement and design documents.

2) Startup Test: Testing performed on site for an installed system to confirm the system meets the requirements stated in the system specification. These tests are generally performed after confirmation that the system was correctly built according to design.

3) Cold Commissioning Test: Testing performed on a system, or on an integrated set of systems after completion of Startup tests. These tests would include the use of simulants and/or hazardous chemicals to prove adequate function and performance prior to introducing radioactive constituents.

Note: Certain projects may require use of PD115, LANL Readiness Program, prior to some testing, especially introduction of radioactive material.

4) Hot Commissioning: Testing performed on a system, or on an integrated set of systems, after completion of Cold Commissioning tests. These tests would include the introduction of radioactive constituents.

5) Facility Validation: Testing performed on the fully constructed facility to confirm the facility meets the requirements stated in the FRD, and adequately fulfills the intended mission.

b. The expected completion of V&V activities with respect to project activity type, including:

1) analysis: typically completed prior to acceptance of the design;

2) inspection: typically completed prior to acceptance from a supplier, or prior to acceptance of construction work package closeout;

3) demonstration or test: completion based on the level of the SSC, according to the sequence of test phases discussed above.

2. Determine the organization responsible to perform each type of V&V activity.

3. Incorporate V&V strategy into the SEP, and activities into the SEP and PEP based on input from the PE and FDAR.

B. The PE shall:

1. Review appropriateness of the verification method(s) entered into the SE tool for each requirement. The methods were entered per the “Verify Compliance with the Requirements” article in the “Requirements Management (SE-RM)” section.

Required functional characteristics shall be verified by demonstration or test to the extent practicable. Where total verification by test is not feasible, testing is used to verify key characteristics and assumptions used in the analysis or simulation.

2. Specify the timeframe that the specific verification activities are expected to be completed, based on the V&V strategy. These timeframes shall be incorporated into the project schedule.

3. Specify test conditions and associated acceptance criteria for each requirement using test as the required method of verification, before completion of the Final Design project phase. (Tests are performed by organizations other than Engineering). Capture this information in the SE tool and link the information to the associated test requirement.

   a. A **Test Acceptance Criteria (TAC) Table**, per Appendix E of this document, shall be provided to the test organization as a final design deliverable

5.2.2 SSC V&V Activities

A. The Project shall:

1. Contractually require equipment suppliers and Design Agencies to conduct SSC verification activities for the SSCs within their scope.

2. Require equipment suppliers and Design Agencies firms to provide verification results and supporting documentation that are appropriate to the method of verification used. If the SSC is safety-related, refer to the Design Verification article (*5.1*) of this section for additional requirements.

3. Capture verification completion results and current status in the SE tool, throughout the project duration, according to the level of detail required by the Systems Engineering Plan.

4. Generate, maintain, and provide a **Requirements Verification Matrix (RVM)** report, as requested throughout the project duration. See Appendix F for RVM content requirements.

5. Complete verification by analysis for each requirement to be verified in this manner, prior to the completion of the Final Design phase.

6. Complete verification by inspection of the SSCs against their requirements to be verified in this manner, prior to final acceptance of a received or constructed item. *Verification-by-inspection information is captured in receipt inspection records and in construction work packages. The volume of this information is too great to input into the SE tool. The project record system already captures these records and links them to the SSCs*.

7. Complete verification of the SSCs by demonstrations and tests against their requirements to be verified in this manner, according to the timing indicated in the SE tool or RVM.

B. The PE shall:

1. Review test results, as tests are completed, to confirm adequate satisfaction of the requirements by the SSC, and to resolve issues of inadequate performance.

C. Design Agencies and Equipment suppliers shall:

1. Perform verifications of SSCs within their scope, prior to acceptance by the project. Verification methods shall be as established by the project.

5.3 Final Product Validation

Synopsis: Final product validation proves that realized SSCs, as manufactured and installed into an integrated facility or system, conform to stakeholder expectations and mission objectives, as stated in the FRD.

The objectives of the final product validation process are to:

- Confirm that the final product fulfills its intended use when operated in its intended environment.
- Confirm that the final product can be used by the intended operators.
- Ensure that any problems discovered are appropriately resolved.

The organization responsible for validation can vary with the project. For example, the facility owner might require final product validation be performed by its trained operators for a modification to an existing operational facility. In other cases, the project or its Design Agencies might be responsible.

A. The project shall determine the organization responsible to conduct final product validation and **incorporate this decision into project planning**.

B. If final product validation is within the scope of the project, then the Project shall:

1. Develop a validation plan for the integrated facilities/final product whose performance is to be validated.

2. Determine validation methods for the final product to demonstrate that it meets mission functional and performance requirements and stakeholder expectations. Validation is to be performed on the final installed system as it is ready to go into operations.

3. Validate required functional characteristics by demonstration or test to the extent practicable.

4. Carry out validation in the intended operational environment under simulated or actual operational conditions.

5. Document results of final product validation in a report that describes the test conditions and contains test data, data analyses, and conclusions regarding the acceptability of the completed system.

6. Document deficiencies, discrepancies or other issues that require correction.

7. Update or close related technical risk items.

C. The PE shall:

1. For an integrated facility, specify required validation methods in the FRD and the SE tool.

2. Specify test conditions and acceptance criteria in the FRD and the SE tool.

3. Confirm final product meets mission objectives, client and stakeholder expectations, and is suitable for use in the actual operational environment.

6.0 APPENDICES

APPENDIX A: Acronyms and Definitions

APPENDIX B: References

APPENDIX C: Major Element Specification Contents

APPENDIX D: Design Verification Matrix (DVM)

APPENDIX E: Test Acceptance Criteria (TAC) Table

APPENDIX F: Requirements Verification Matrix (RVM)

Appendix A: Acronyms and Definitions

Only key terms are listed. See PD340, *Conduct of Engineering and Configuration Management for Facility Work* and other CoE documents for additional terms (*these may be consolidated in a future Engineering Standards document*).

Table SE-A1 Acronyms

Acroynm[1]	Definition
A	Approve
AE	Architect-Engineer
AP	Administrative Procedure
ASM	Acquisition Services Management
ASME	American Society of Mechanical Engineers
CM	Configuration Management
CoE	Conduct of Engineering
Cx	Commissioning
D	Develop
DA	Design Authority (e.g., Site Chief Engineer)
DOE	(United States) Department of Energy
DVM	Design Verification Matrix
DVR	Design Verification Report
ES	Engineering Services
ESD	Engineering Services Division
ESM	Engineering Standards Manual
FA	Functional Analysis
FAT	Factory Acceptance Test
FDAR	Facility Design Authority Representative
FDD	Facility Design Description
CDB	Conceptual Design Baseline
FRD	Functions and Requirements Document
FSE	Facility Systems Engineering
GTC	General Test Criteria
ICD	Interface control document
LANL	Los Alamos National Laboratory
LCxA	LANL Commissioning Authority
LPE	Lead Project Engineer
LSE	Lead Systems Engineer
NA	Not Applicable
NQA-1	ASME NQA-1-2008/NQA-1A-2009, Quality Assurance Requirements for Nuclear Facility Applications, Part I and Part II
OHC	Other hazard control
ORR	Operational Readiness Review
PE	Project Engineer
PEP	Project Execution Plan
PFD	Process Flow Diagram
P&ID	Process and Instrumentation Diagram
POC	Point of Contact
R	Review
RCD	Requirements and Criteria Document
RVM	Requirements Verification Matrix
SDD	System Design Description
SE	Systems Engineering
SEP	Systems Engineering Plan
SME	Subject Matter Expert
SSC	Structure, System, or Component
TAC	Test Acceptance Criteria
CIRB	Initial Requirements Baseline
V&V	Verification and Validation
WBS	Work Breakdown Structure

[1] Only key acronyms are listed, see note preceding the definitions table regarding others.

Table SE-A2 Definitions

Item	Definition
Allocation	The process of assigning requirements to appropriate SSCs that will fulfill the requirement. This may include functional analysis to simplify the allocation process.
Asset	A general term used to refer to a system, facility, structure or component. This term is commonly used in the SE tool to refer to the block object type used to represent SSCs.
Basis of Design	A controlled set of validated requirements that define the envelope of functional, performance, safety, and interface requirements with which a completed design must comply. This may also be called the Functional Specification.
Class I changes	Those technical changes requiring customer or PADCAP Change Control Board (CCB) approval per AP-350-161, such as those: changing a Government approved document containing technical requirements, designs or constraints, changing contract or stakeholder level technical requirements, and/or causing threshold cost or schedule impacts, as defined in AP-350-161. [concept from MIL-HNBK-61]
Class II changes	Any changes to previously baselined requirements (imposed or derived) and design documents that are not Class I changes.
Conceptual Design Baseline (CDB)	The CDB is composed of requirements and design documents that define the final product to be delivered by a project. The associated requirements documents, including the RCD and FRD, specify the final product and its associated processes and constraints. The associated design documents identify the system and facilities that comprise the project. They also identify the plot layout. The CDB is developed during a project Conceptual Design phase. Refer to the Table SE-RM-1 for identification of contents.
Conceptual Design Phase	The phase of system/facility acquisition that develops a conceptual design package that fully specifies the final product to be developed and provides concept-level designs for facility and process. During this phase, the number and type of facilities and systems are identified for further development, with preliminary requirements being developed for each. (Begins when Critical Decision 0 [CD-0] is received, ref. DOE O 413.3]
Constraint	A limitation on the possible design solutions available to perform the required functions. Constraints typically result from laws, regulations, DOE Orders, national consensus codes and standards, or LANL ESM. Other sources of constraints include operating / maintenance experience, previous design, and customer needs and objectives.
Decomposition	The process of refining a requirement in further detail through the use of analysis.
Derived Requirement	A lower level function or performance metric that is deduced or inferred to fill in detail, gaps, or to subdivide an upper level requirement amongst multiple SSCs. Derived requirements are generally determined through functional analysis, trade studies, or calculations. These can be changed by a project through additional analysis.
Design Authority	The entity that has overall responsibility for the adequacy, safety, functional capability, and completeness of engineering work and design product.
Design Criteria	A requirement established through the authority of a contract, a regulatory document, or by a LANL Engineering authority (e.g., the ESM). Design criteria are valid on the authority of the issuing agency or organization and does not need additional justification.

Design Verification Matrix (DVM)	A document identifying the SSCs requiring design verification per ASME NQA-1, specifying the design verification methods, and that is used for tracking status of the design verification.
Design Verification Report (DVR)	A document that is used to record results of design verification activities.
Final Design Baseline	The Final Design Baseline is composed of requirements and design documents that specify the components to be procured, constructed and delivered by a project. It is developed during a project Final Design phase. Refer to Table SE-RM-1 for identification of contents
Final Design Phase	The phase of system/facility acquisition that develops component-level detailed designs that can be procured, manufactured, and constructed. (Begins when Critical Decision 2 [CD-2] is received, ref. DOE O 413.3]
Final product validation	The process of confirming that a completed final product meets stakeholder and/or mission requirements and is suitable for its intended use in the actual operational environment – the right final product was built.
Functional Analysis	A systematic process for determining the capabilities necessary to achieve the desired operational objectives and contract requirements. This process is iterative in nature, generating a hierarchy of functions that can be allocated to implementing SSCs. Also included is a process for decomposing [parsing or separating] a requirement into distinct parts that the project can satisfy through engineering of facilities physical systems and technological elements.
Functional Requirement	A capability needed to satisfy all or part of a Customer's operational needs and objectives. A function is normally an action verb.
Functional Specification	A document that specifies the final product to be delivered by a project. The definition identifies, in quantifiable terms, the final product boundaries, interfaces, functionality, performance, constraints and other specific requirements. At LANL, the functional specification need is met by the FRD and RCD.
General Test Criteria (GTC)	A set of parameters that are observed or measured during a test: 1) to determine if functional or performance requirements are met for a non-safety or non-permitted component, system, or integrated set of systems; or 2) to confirm an assumption used as a basis for design of such items. GTC can be either qualitative or quantitative. They are established only for those parameters that need verification through test and have a set of limits that are established by design. GTC specify the location of measurement or the conditions for a test, if it is necessary to provide a context for validation of the parameter. GTC can be expressed as an upper limit, lower limit, or a range (e.g., not to exceed 40 ft per minute, not less than 40 feet per min, or 40 feet per min ±10%). GTC is the term applied to test criteria used to confirm compliance with requirements other than nuclear safety and regulatory permit requirements. (See related definition for Test Acceptance Criteria).
High-level Requirement	Functional and performance requirements and mission objectives that are normally defined by the customer in their technical requirements documents. Also included are technical requirements from regulations, directives, policies, and other customer and corporate documents.
Identification	The process of eliciting, searching for, and collecting requirements/constraints applicable to a design to ensure that the requirement set is comprehensive and complete.
Initial Requirements Baseline (IRB)	The IRB is the first baseline, and is developed by LANL for a facility or system. The IRB is typically developed from activities completed prior to Conceptual Design phase. Refer to the Table SE-RM-1 for identification of contents.
Implementing Document	A document (e.g., procedure, specification, drawing, etc.) that satisfies a requirement.

Interface Requirement	A functional or performance requirement, or a constraint, imposed on the boundary between two SSCs. An interface requirement can address boundary design details, location, connections, input/output characteristics, controls (engineered and administrative), physical interactions (e.g., vibration) or functional interactions. Interface requirements are typically imposed by joint decisions between two organizations, by pre-existing conditions or decisions, or imposed by the Customer or Stakeholder (e.g., existing external facility). A project may not change interface requirements unilaterally.
Key Performance Parameters	Required facility or system characteristics for the final product to be delivered to the client (e.g., integrated facility or system), relating to the ability to achieve the operational mission when used by trained operators in the intended operational environment under specified conditions. KPPs are used to focus development and associated decisions in a manner that ensures these parameters are met by the final product. They are used as part of the performance baseline at CD-2.
Other hazard controls	The hazard evaluation process may identify preventive or mitigative controls that do not rise to the level of SC or SS but still enhance the safety of the facility. These controls are identified in the hazard evaluation table, but not explicitly credited with a SC/SS designation as identified in the DSA. Such controls are maintained in accordance with safety management programs and the Unreviewed Safety Question process. Other hazard controls may also include specific controls required by DOE in its Safety Evaluation Report (see DOE-STD-1104-2009 for further guidance). [from DOE-STD-3009-2014]
Performance Baseline	The cost and schedule baseline established for a project.
Performance Requirement	A measure of how well a functional requirement must be performed by an SSC to be acceptable.
Preconceptual Design Phase	The phase of system/facility acquisition that examines alternate approaches to satisfying a mission need, establishes high-level requirements, confirms feasible alternatives exist, and selects the preferred alternative approach. Results are used to make a decision to pursue conceptual design.
Preliminary Design Phase	The phase of system/facility acquisition that advances the conceptual design by fully specifying the facilities and systems that will be design, and constructed to meet the mission need. It details the system and facility-level design by identifying the required components and structures. This phase provides sufficient detail to enable procurement of long-lead items. (Begins when Critical Decision 1 [CD-1] is received, ref. DOE O 413.3]
Requirement	A quantified [or quantifiable] stipulated function or performance metric that defines adequate capability or acceptable accomplishment of a task. These are normally mandated by an external entity as a basis for acceptability of a structure, system or component. In general, requirements may not be unilaterally changed by a project.
Requirements Verification Matrix (RVM)	A document that is used to identify, plan and track completion of V&V activities, by requirement. The RVM is typically developed for each system using the requirements in the system specification.
SE tool	The Technical Requirements Management System. Per the graded approach section, the TRMS may be either simple or a commercially available SE automation tool. See subsection 1.5.
Sub-allocation	Reassignment of a portion of a requirement to another discipline or department.

Preliminary Design Baseline	The Preliminary Design Baseline is composed of requirements and design documents that define the systems and facilities to be developed by a project. The associated requirements documents specify the systems and facilities. The associated design documents identify the components and structures that comprise the systems and facilities. These components will be further detailed during the Final Design activities. The Preliminary Design Baseline is developed during a project Preliminary Design phase. Refer to Table SE-RM-1 for identification of contents.
Systems Engineering Plan (SEP)	A LANL-produced planning document that describes the engineering effort to produce the deliverables required by this chapter.
Systems Engineering Management Plan (SEMP)	A document that addresses a subcontractor AE's overall systems engineering management approach. It provides unique insight into the application of their standards, capability models, configuration management, and toolsets to their organization. This is different from a Systems Engineering Plan (SEP) which should address SE aspects on a particular program or project. The SEMP is usually written in response to LANL's SEP and describes the AEs proposed efforts for planning, controlling and conducting a fully integrated engineering effort. (adapted from INCOSE)
System Verification	The process of confirming that systems and structures fulfill specified design requirements – the requirements were properly rolled into the design
Technical Requirements Management System (TRMS)	An automation tool used to collect, sort, allocate, trace, and maintain requirements, AKA SE tool.
Test Acceptance Criteria (TAC)	A set of parameters that observed or measured during a test: 1) to determine if nuclear safety and regulatory permit functional or performance requirements are met for a component or system, or an integrated set of systems; or 2) to confirm an assumption used as a basis for design of such items. TAC can be either qualitative or quantitative. They are established only for those parameters that need verification through test and have a set of limits that are established by design. TAC specify the location of measurement or the conditions for a test, if it is necessary to provide a context for validation of the parameter. TAC can be expressed as an upper limit, lower limit, or a range (e.g., not to exceed 40 ft per minute, not less than 40 feet per min, or 40 feet per min ±10%). TAC is the term applied to test criteria used to confirm compliance with nuclear safety and regulatory permit requirements. (See related definition for General Test Criteria). Refer to Appendix E, TAC Table.
Tracing	A process to relate the source of requirements with implementing documents in a manner that is transparent, stable, and auditable. Tracing is bi-directional, meaning that a requirement can be traced to all implementing documents, and each requirement of an implementing document can be traced back to its source.
Validation (Final Product)	The process of confirming that a requirement meets high level functional and performance requirements and is necessary, consistent, unambiguous, feasible, and measurable.
Verification (of SSCs)	The process of confirming that SSCs and the facility meet all requirements imposed on the design.

Appendix B: References

The following are cited as either a mandate or guidance in the chapter. *Most national standards are available to LANL personnel via links; other users must purchase.*

DOE

10 CFR 830, *Nuclear Safety Management*

DOE O 413.3, Program and Project Management for the Acquisition of Capital Assets

DOE G 413.3-1, Guide for Managing Design and Construction Using Systems Engineering for Use with DOE O 413.3A

DOE G 413.3-9, Project Review Guide for Capital Asset Projects

DOE-STD-1073, Configuration Management

DOE-STD-1189, Integration of Safety into the Design Process.

IEEE and ISO/IEC/IEEE

IEEE 1220, *Standard for Application and Management of the Systems Engineering Process*

ISO/IEC/IEEE 15288, Systems and Software Engineering Life Cycle Processes

ISO/IEC/IEEE 29148, Systems and software engineering -- Life cycle processes -- Requirements engineering

INCOSE

INCOSE-TP-2003-002-04, (2015) *Systems Engineering Handbook: A Guide for System Life Cycle Process and Activities*

INCOSE-TP-2010-006-02, (2015) *Guide for Writing Requirements*

LANL (internal-only unless noted). Contact the chapter POC for assistance in obtaining LANL documents.

Conduct of Engineering

AP-341-402, *Engineering Document Management in Operating Facilities*

AP-341-605, *Calculations*

AP-341-601, *Functions and Requirements Document*

AP-341-602, *Requirements and Criteria Document (RCD)*

AP-341-611, *System Design Descriptions*

AP-341-616, *Technical Baseline Change During Design*

AP-341-620, *Review of LANL Produced Design Documents*

AP-341-621, *Design Authority Technical Review*

AP-341-622, *LANL Review of Designs Produced by External Agencies*

AP-341-702, *Statements of Work*

Project Management (*access via EDMS*)

AP-350-161, *PADCAP Change Control Board*

AP-350-406, *Startup and Commissioning*

ASM Website

ES Division Office (ES-Div) Website

P330-8, *Inspection and Test*

P341, *Facility Engineering Processes Manual*

P342, *Engineering Standards*

P1020-2, *Laboratory Document Control*

STD-342-100, *Engineering Standards Manual* (available externally)

ESM Chapter 15, Commissioning

Military (*http://quicksearch.dla.mil/*)

MIL-STD-499B, Systems Engineering

MIL-HNBK-61, Configuration Management Guidance

Various Sources

ANSI/EIA-632, *Processes for Engineering a System*

ANSI/EIA-649, *National Consensus Standard for Configuration Management*

ASME NQA-1-2008/NQA-1A-2009, *Quality Assurance Requirements for Nuclear Facility Applications*, Parts I and II

Appendix C: Major Element Specification Contents

The following content specifies required content for major element specifications (typically systems, but may be subsystems). Uses of these specifications are defined in the SE-RM section of this Chapter. Replace "Major Element" with "System" or "Subsystem" based on the specification usage.

A. General

1. Purpose

   Defines the reasons the Major Element exists/is being developed

2. Scope

   a. Identifies Major Element name, including three-letter acronym

   b. Expresses the needs that drive Major Element development

   c. Explains how the Major Element satisfies the expressed needs

   d. Describes the application of the Major Element, including benefits, objectives, and goals

3. Overview

   a. Context

      1) Describe the final product context: Major elements of the Major Element, and how they interact

      2) Include appropriate diagrams and narrative to provide the context

      3) Define significant interfaces crossing Major Element boundaries

   b. Functions

      Describe key Major Element capabilities, conditions, and constraints

   c. User Characteristics

      1) Identify each type of user/operator/maintainer of the Major Element (by function, location, type of device)

      2) Identify the number of users in each group and the nature of their use of the Major Element

4. Definitions

   Use appropriately.

B. Facility Requirements

1. Functional Requirements

   Define functional requirements applicable to Major Element operation.

2. Usability Requirements

   a. Define usability (quality in use) requirements

   b. Define measureable effectiveness, efficiency, and satisfaction criteria

3. Performance Requirements

   Define critical performance conditions and their associated capabilities.

4. Major Element Interfaces

   a. Specify requirements for interfaces among Major Element elements and with external entities.

b. Define any interdependencies or constraints associated with the interfaces.

5. Major Element operations

a. Human factors

1) Specify any special or unique human system integration requirements

2) Define any areas, stations, or SSCs that would require concentrated human engineering attention due to the sensitivity or importance of the operation or task.

b. Maintainability

Specify the quantitative maintainability requirements that apply to maintenance in the planned maintenance and support environment.

6. Major Element modes and states

Identify the various modes and states. If the Major Element can exist in more than one, or if the Major Element requires specific states and modes with varying requirements.

7. Physical characteristics

a. Physical requirements

1) Include constraints on weight, volume, and dimension.

2) Include the construction characteristics of where the Major Element will be constructed.

3) Include requirements for materials to be used in the item or service covered by this Major Element specification.

4) Include requirements covering nameplates and system markings, interchangeability of equipment, and workmanship.

b. Adaptability requirements

Define requirements for growth, expansion, capability, and contraction.

8. Environmental conditions

a. Include environmental conditions to be encountered/impacted by the Major Element.

b. Include seismic and other special natural hazard criteria.

9. Facility security

Define the security requirements pertaining to the Major Element.

10. Information management

Define the requirements for the facility's management of information that it receives, generates, or exports.

11. Policies and regulations

a. Detail any relevant organizational policies that will affect the operation or performance of the Major Element.

b. Detail any relevant external regulatory requirements or constraints imposed by normal business practices.

c. Describe management expectations, external commitments, and other "soft" requirements.

12. Major Element life cycle sustainment

    a. Describe quality activities to help realize and maintain a quality Major Element.

    b. Include provisions of facilities needed to ensure operational and depot-level support, spares, sourcing & supply, etc.

13. Packaging, handling, shipping, and transportation

    Define requirements imposed on the Major Element to ensure that the outputs meet packaging, handling, shipping, and transportation criteria (DOT, waste acceptance, etc.)

14. Fire protection

    Describe constraints on the Major Element design imposed by fire protection system requirements and limitations.

15. Personnel Safety

    Describe applicable requirements that are specifically established to protect individuals.

16. Personnel-related requirements

    Specify the Major Element requirements, if any, to accommodate the number, skill levels, duty cycles, or other information about the personnel who will use or support the Major Element.

17. Precedence of requirements

    Specify, if applicable, the order of precedence or assigned weights of requirements in this Major Element specification.

C. References

1. Reference documents used in the body of document listed (for codes and standards, identify specific editions and dates).

2. A statement is made requiring that the use of any other edition, revision, or issue require originator's approval.

3. Approved Requirement Interpretations are included as references.

APPENDIX D: Design Verification Matrix (DVM)

LANL Project Design Verification Matrix

Document No: ______________________________
Rev:

	SSC			Classification of SSC			Method(s) of Verification							Tracking of Partial Design Verification
Description/Scope of SSC(s)	System	Structure	Component	ML-1	ML-2	OHC ML-3	Multidiscipline/Group Review*	Individual Critical Review*	Qualification Testing	Alternate Calculation	Method Detail	Status of Verification -Forecast -Partial -Complete -Reverify	DVR Number	Justification, Including - Information Required to Complete DV - Anticipated source of data or information

Reviewer: ____________ ____________ ____________
Print name *Signature* *Date*

Approver: ____________ ____________ ____________
Print name *Signature* *Date*

Figure SE-D1, Design Verification Matrix (DVM) (Sample)

This figure provides an example of a matrix used to plan and track design verification. This format is not required, but the content is. *An xls file of the above is available as a reference on the Ch. 20 webpage.*

The DVM is intended to be updated periodically throughout the project. The instructions and minimum content are as follows:

1. Description/ Scope of SSC(s): This column will list all SSCs requiring design verification and include the SSC name and the tag numbers that uniquely identify the SSCs represented in the row.
2. SSC: This set of columns is check boxes to indicate whether the SSC is a system, structure of component.
3. Classification of SSC: This set of columns is check boxes used to indicate the safety level of the SSCs and should be checked as indicated in the Safety Basis documentation.
4. Method(s) of Verification: This set of columns is check boxes used to indicate the method or methods of verification that will be used to qualify the SSC. It is important to remember that these activities are intended to prove the adequacy of the design rather than the actual article. These verifications should take place prior to buying or building items to be installed in the system or facility, unless it cannot be done due to infeasibility. Schedule difficulties are not a reason to delay verification.

5. Method Detail: This column will contain information providing the justification and expectations for each method selected. Justifications should indicate why the method was selected, such as the ability to reasonably confirm the SSC's ability to meet a requirement. Expectations should identify the portion of the SSC and/or the requirement that will be confirmed by the method.

   Note: Qualification tests are used to prove a design by testing a prototype to the extremes of the operational conditions. The test articles will not be used in the finished facility/system due to the risk of it being damaged. Subsequent to this test, production of items to be delivered to the project will be authorized.

   An entry shall be made for each method checked, and for each verification required, to ensure the SSC's ability to meet all safety functions. For example, an entire component may be confirmed to operate through a seismic environment using a qualification test performed by the supplier. Another entry will be made to confirm the same component's design to confine gas and airborne contaminants, using individual critical review.

6. Status of Verification: Indicate the current status of the design verification activities. Choices include:
   a. Forecast: planned
   b. Partial: The DV activities are partially completed
   c. Complete: The DV activities are completed for the SSC
   d. Reverify: A previously completed DV should be checked and possibly redone due to a change in requirements or design
7. DVR Number: Identify the DVR number documenting the design verification activities completed, partially completed, or re-verified for the SSC.
8. Tracking of Partial Design Verification: Discuss why the DV activities were only partially completed at the time the DVM was updated. For the unfinished portion, identify the information that is required to complete the design verification, and who will provide that information.
9. Reviewer Signature: This signature is used to confirm that the document was checked and confirmed to be accurate.
10. Approver Signature: This signature authorizes issuance of the document as a project record.

Note: Signatures are needed only when issuing a project record. However, interim publication of the document might not be necessary if the DVM is maintained in the SE tool. In this case, the SE tool provides the working copy that is maintained current and only printed for convenience, or when the final version is ready to be issued as a record.

APPENDIX E: Test Acceptance Criteria (TAC) Table

Synopsis: When an SSC will be verified by test, additional information regarding test conditions and acceptance criteria is required. A Test Acceptance Criteria (TAC) Table, shown below, shall be provided to the test organization. The form below provides an example. *The SE tool should be implemented in a manner, and maintained with current information, to enable the TAC Table to be generated automatically from the SE tool. Doing so will enable the TAC Table to be generated at the touch of a button rather than having to be maintained using a document or spreadsheet.*

Function/Requirement	Source Reference	Type	Acceptance Criteria	Notes/Comments	Test Conditions

Figure SE-E1 Test Acceptance Criteria (TAC) Table (Sample)

This format is not required, but the content is. The TAC is intended to be updated periodically throughout the project. The TAC instructions and minimum content are as follows:

1. Function/Requirement: This column provides a verbatim statement of the function/requirement to be verified by test. The function/requirement resides in the system/facility specification. The SE tool can be used to automatically keep the specifications, RVMs and TAC Tables aligned, such that an up-to-date version can be printed instantly.
2. Source Reference: This column provides a reference to the source document containing the requirement. Examples include a concatenation of the document name, document number and the heading number for the requirement. This number should relate to the number used in the RVM “Unique ID” column.
3. Type: This column is used to identify if the acceptance criteria is a General Test Criteria (GTC) or a Test Acceptance Criteria (TAC). Refer to the SE-V&V Section and Definitions.
4. Acceptance Criteria: This column states the quantitative measures or qualitative results that must be achieved to confirm that the requirement has been met.
5. Notes/Comments: This column will contain notes and other comments relevant to the test, criteria or conditions that need to be communicated to the test organization.
6. Test Conditions: This column will state the specific test conditions and measurement locations required for the test. For example, an interlock for radiation might be tested using a simulated signal from the sensor rather than stimulating the sensor using a radioactive source. A water system requirement for flow to a facility might be tested under conditions with water being transferred to other facilities simultaneously.

APPENDIX F: Requirements Verification Matrix

Synopsis: The project is required to develop a system verification plan that includes a Requirements Verification Matrix (RVM). Typically, an RVM is generated for each Facility and System. They are not typically

Unique ID	Requirement	A	I	D	T	Plan	Results

generated for components due to the quantity of them that would be required. An example of acceptable RVM content is shown below. *The SE tool should be implemented in a manner, and maintained with current information, to enable the RVM to be generated automatically from the SE tool. Doing so will enable the RVM to be generated at the touch of a button rather than having to be maintained using a document or spreadsheet.*

Figure SE-F1, Requirements Verification Matrix (RVM) (Sample)

This format is not required, but the content is. The RVM is intended to be updated periodically throughout the project. This information should be captured in the SE tool such that this matrix can be viewed or printed at any time using the most current data. The RVM instructions and minimum content are as follows:

1. Unique ID: This column provides a reference number that uniquely identifies the requirement. Examples include a unique number automatically assigned by the database (e.g., object ID), or a concatenation of the document name, document number and the heading number for the requirement. The numbering system applied by the project shall be applied consistently for all RVMs and captured within the SE tool to enable finding the requirement when the tool is searched. This number should be provided to enable traceability and correct linking of a requirement to the associated verification information.
2. Requirement: The matrix shall include a verbatim statement of each requirement in the system/facility specification. The SE tool can be used to automatically keep the specifications and RVMs aligned, such that an up-to-date version can be printed instantly.
3. AIDT: This set of columns is check boxes used to indicate the required method(s) of verification for that requirement. A, I, D, and T refer to the verification methods of Analysis, Inspection, Demonstration, and Test, respectively. The box for each selected method should be checked. Multiple methods may be necessary to ensure the ability to meet all aspects of the requirement is confirmed.
4. Plan: This column provides a brief description of the verification method to be used. For example, if verification by analysis was chosen, then the type of analysis should be specified here (e.g., calculation, simulation). In addition, the project event or period the verification method should be accomplished should be stated. For example, verification by test that occurs during factory test, startup test or other test phase. Verification by analysis should be completed before the end of the Final Design phase. Inspections should be completed at time of equipment receipt or prior to the end of construction, depending on the nature or relationships among the items being inspected. If more than one type of verification is required, make one entry in the column for each method and indicate the portion of the requirement to be verified by each method. In the SE tool relate the method of verification to the plan.
5. Results: This column will contain information providing verification status, and referencing the documentation showing the results of the verification activity. Indicate the verification status by including a brief description, such as “not completed”, “passed”, “failed”. This should be followed by a document reference if a status of passed or failed is entered. The type of document referenced depends on the method. The document could be a calculation, a simulation output report, a test report, an inspection record, or some other appropriate documentation. If more than one type of verification is required, make one entry in the column for each method. In the SE tool relate the method of verification to the result.