Review Document For

Systems Engineering Workflow Use Case:

Evaluate System Safety

Last Updated: 1/4/2016 9:59:00 AM

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# Introduction

## Intent

The intent of this document is to provide the material required to support the review of the use case “Evaluate System Safety". Use the Word “Track Changes” features to suggest changes and add comments as necessary to log questions and comments.

The section called "Items to Review" contains the artifacts that are to be evaluated for this review. The additional material in this document is intended to provide the appropriate context and definitions to support the review.

## Assumptions

1. Initial Activities - The first passes of the activities are based on the foundational material references. The intent is to capture what is described in these foundational artifacts as a starting point and to use a review process to refine and enhance their content based on industry expertise. Therefore this initial passes represents a “stake in the ground” that we can measure from and are a synthesis of the material from this foundational material and other common knowledge. The reviews will provide the mechanism to hone them into the most current practices across the industry.
2. Context Assumptions -
   1. The workflow use cases defined are intended to be used on large complex systems supported by large geographically diverse development teams. With smaller and simpler systems some of the use cases or use case behavior may not be needed.
   2. The workflow use cases are described assuming a model-based approach will ultimately be used to develop a system. However, many of the use cases are not dependent on using model-based techniques, since they are the very same use cases System Engineers have been using before model-based techniques were available.
3. What vs. Who - Activity diagrams are used to capture the Systems Engineering workflow behaviors. The first passes of these activities have a Systems Engineering discipline swimlane and in this model that includes Systems Engineering roles, Specialty Engineering roles, and V&V (Verification and Validation) roles. Therefore, it also includes the Systems Engineering Development System (SEDS) which provides the tools for these roles. The focus on these initial activities will be to discovery "what" actions need to be performed, and not to identify if a human or a tool executes these actions. Later refined revisions may decompose this swimlane and identify who or what executes these actions.
4. Sequence of Actions - On each activity a default flow of the activity is shown. Often this ordering helps understand the basic flow and it keeps the diagrams readable. However in reality many of these actions actually are occurring in parallel, iterating as needed, and stopping and re-starting as other events occur, more information becomes available and as issues surface. The real value of these activities is capturing what tasks are being done and not necessarily the order they are done. Therefore please keep this in mind as the activities are being examined.

# Context

The diagram below defines a typical Product Domain structure. Within this domain is the context block called Systems Engineering.

Systems Engineering is the context for the Systems Engineering Workflow Use Cases. It includes the roles associated with applying system wide activities including the Systems Engineering roles, Specialty Engineering roles, V&V (Verification and Validation) roles and it includes the Systems Engineering Development System (SEDS) providing the tools for these roles. [Created for model]

Systems Engineering (SE) is an interdisciplinary approach and means to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, and then proceeding with design synthesis and system validation while considering the complete problem: operations, cost and schedule, performance, training and support, test, manufacturing, and disposal. SE considers both the business and the technical needs of all customers with the goal of providing a quality product that meets the user needs. [10, INCOSE Handbook, Appendix C]

(1) Interdisciplinary approach governing the total technical and managerial effort required to transform a set of customer needs, expectations, and constraints into a solution and to support that solution throughout its life. (ISO/IEC/IEEE 2010)

(2) An interdisciplinary approach and means to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, then proceeding with design synthesis and system validation while considering the complete problem:

* Operations
* Performance
* Test
* Manufacturing
* Cost & Schedule
* Training & Support
* Disposal

Systems engineering integrates all the disciplines and specialty groups into a team effort forming a structured development process that proceeds from concept to production to operation. Systems engineering considers both the business and the technical needs of all customers with the goal of providing a quality product that meets the user needs. (INCOSE 2012) [3, SEBoK Glossary]



Figure 1: Systems Engineering Workflow Use Case Context

# Items to Review

## "Evaluate System Safety" Use Case

### Use Case Attributes

1. The location of this use case in the model browser is; "Evaluate System Safety", in the model browser is "SE Life Cycle Workflow Use Cases::System Development Stage::SE Domain Workflow Use Cases::Evaluate System Safety".
2. The Maturity Level is listed as "Evolving Activity".
3. The Priority assigned for completing this use case is listed as "Medium".

### Use Case Description

**Goal -** The goal of this workflow use case is to evaluate the system for safety related hazards and derive a plan to mitigate these risks.

**Primary Actor -** Safety SysEng

**Secondary Actors -**

**Preconditions -**

1. The following Use Cases have been initiated and are at least at a reasonable level of maturity;

* Analyze Stakeholders Needs
* Derive System Requirements

**Activity -**

1. Identify applicable safety standards
2. Identify Safety Hazards undesired events and their causes
3. Determine Risk level of each hazard
4. Analyze Hazard’s faults and failures
5. Define the Safety Measures
6. Create Safety Requirements
7. Provide traceability from Safety measures to faults and to hazards
8. Conduct analysis to determine the severity level, the probability of occurrence and assess the level of risk.
9. Determine if the analysis results are acceptable for use.
   1. If it is acceptable, capture these results and show tractability to identified Hazard.
   2. If not, determine best corrective solution to eliminate or minimize the level of risk. This could be by design and/or by procedure/process
   3. Update Model and other information
      1. Derive Safety related requirements that address Hazards.
      2. Show how these requirements are satisfied
      3. Show traceability from Hazards to Risk mitigation requirements to system elements satisfying those requirements.
10. Verify solution to determine if Hazard has been appropriately addressed.

**Post Conditions -**

**References and Citations:**

[2] References: INCOSE Systems Engineering Handbook

[3] SEBok - Concept Definition

[7] Douglas, Bruce: Safety Analysis of UML Models

### Use Case Related Diagrams

#### Use Case Diagram



Figure 2: Specialty Engineering

#### Activity Diagrams

##### Evaluate System Safety



Figure 3: Evaluate System Safety

##### Analyze System Hazards



Figure 4: Analyze System Hazards

##### Design S0I with Safety Measures



Figure 5: Design S0I with Safety Measures

#### Block Definition Diagrams



Figure 6: Safety Related Terms

### Other Called Activities

The following Call Operations are located on the above activities.

1. Import Reference Material
2. Measure Change Impact
3. Conduct a Review

# Supporting Information

The items in this section are intended to provide information that will assist the reviewer in reviewing the material in section 3, “Items to be reviewed”. This material is not part of the review, however comments for this material will also be considered.

## Called Activities

### Conduct a Review



Figure 7: Conduct a Review

### Measure a Change Impact



Figure 8: Measure a Change Impact

### Import Reference Material



Figure 9: Import Reference Material

### Analyze Requirements



Figure 10: Analyze Requirements

### Categorize Requirements



Figure 11: Categorize Requirements

### Add Requirement



Figure 12: Add Requirement

## Table of Concept Terms

Table 1: Concept Terms Table

| Name | Definition | Acronym |
| --- | --- | --- |
| Acquirer | The stakeholder that acquires or procures a product or service from a supplier. [2]  SEBoK Definition [3] |  |
| Analyze Needs Controls and Enablers | A collection of artifacts that control and enable the Stakeholder Requirements Definition Process.  This includes: Applicable Laws and Regulations Industry Standards - relevant industry specifications and standards Agreements - terms and conditions of the agreements Project Procedures and Standards - including project plans Project Directives Organization/Enterprise Policies, Procedures, and Standards - including guidelines and reporting mechanisms Organization/Enterprise Infrastructure Project Infrastructure [2, section 4.1] |  |
| Analyze Needs Inputs | A collection input artifacts required for the Stakeholder Requirements Definition Process. . [2, section 4.1] |  |
| Analyze Needs Outputs | A collection of output artifacts for the Stakeholder Requirements Definition Process establish the initial set of stakeholder requirements for project scope and associated agreements. . [2, section 4.1] |  |
| Baseline | The gate-controlled step-by-step elaboration of business, budget, functional, performance, and physical characteristics, mutually agreed to by buyer and seller, and under formal change control. Baselines can be modified between formal decision gates by mutual consent through the change control process. [2, INCOSE Handbook Appendix C]  A specification or product that has been formally reviewed and agreed upon, that thereafter serves as the basis for further development, and that can be changed only through formal change control procedures. (ISO/IEEE 2008) [3, SEBoK Glossary] |  |
| Change Impact Analysis Summary | The change impact analysis summary provides the results after performing a “Measure Change Impact Assessment” task. .  This task allows the user to select one or more elements that could theoretically change and provides to the user a list of all impacted elements. Elements can be any type of artifact including documents, models, requirements or configuration items and an element’s properties including behavior, attributes and interfaces. The results also provide the inter-relationships between each of the items presented.   The search can be adjusted by depth of change, the types of elements included and by the types of relationships included. The presentation is ideally graphical. |  |
| Change Impact Assessment | This includes an impact assessment of proposed changes, including the impact on project plans, costs, benefits, risks, quality, and schedule. [4, 15288 section 6.3.5.3 c]  This artifact could be associated with a single change request, a major release or an initial development.   This artifact captures an estimate that should include a schedule, technical feasibility and all costs associated with the engineering development, validation and verification efforts. It includes items such as:  - The Change Impact Analysis Summary providing of the extent of changes including the impacted CIs.  - Human resource costs and Man-hours  - Other life cycle costs that may be impacted during operations, manufacturing, support or retirement  - Equipment resource costs for development, validation and verification such as test equipment, facilities, tools, etc.  - A preliminary plan estimating the expected duration for development, field upgrades, manufacturing upgrades. The plan should consider availability of people and equipment.   - An estimate when these capabilities could be made available for validation, verification and customer release  - Any perceived risks and possible mitigation plans |  |
| Change Management System | A set of functionality that provides capabilities to support a change management process such as managing change requests (opening, grouping, assigning responsibility, managing state, archiving), managing versions of files, defining and managing branches and defining and managing baselines. | CM |
| Change Request | Requests to update any formal baselines that have been established. In many cases, the need for change requests is identified during the project assessment and control process, Can originate from any life cycle process. [10, INCOSE Handbook, Appendix E]  The INCOSE Handbook called this a Project Change Request. The term Change Request seems to cover a broader originating scope other than just when a project is active. |  |
| Commercial off-the-shelf | Commercial items that require no unique acquirer modifications or maintenance over the life cycle of the product to meet the needs of the procuring agency. [2] | COTS |
| Component | A system element comprised of multiple parts; a cleanly identified item. [2]  SEBoK Definition [3] |  |
| Concept of Deployment | Describes the way the system will be delivered and installed. [2, section 4.1] |  |
| Concept of Operations | Also known as “ConOps” - Describes the way the system works from the operator’s perspective. The ConOps includes the user description and summarizes the needs, goals, and characteristics of the system’s user community. This includes operation, maintenance, and support personnel. [2, section 4.1] | ConOps |
| Concept of Production | Describes the way the system will be manufactured, including any hazardous materials used in the process. [2, section 4.1] |  |
| Concept of Support | Describes the desired support infrastructure and manpower considerations for maintaining the system after it is deployed. This includes specifying equipment, procedures, facilities, and operator training requirements. [2, section 4.1] |  |
| Conceptual System Architecture | The Conceptual System Architecture (CSA) is an early view of the finalized system architecture and is typically captures in the proposal stage.  The CSA describes the basic concepts and approach of the actual system architecture. Typically more detail is captured in this early stage of development in aspects of the system that are perceived to contain more risk. In a model-based environment the CSA is captured in the form of a SysML model. A document may also be generated from the CSA model to assist in the review and to help communicate to people without access to the model. | CSA |
| Configuration item | A hardware, software, or composite item at any level in the system hierarchy designated for configuration management. (The system and each of its elements are individual CIs.) CIs have four common characteristics: 1. Defined functionality, 2. Replaceable as an entity, 3. Unique specification, 4. Formal control of form, fit, and function   [2, INCOSE SE Handbook] | CI |
| Customer | The organization or person that receives a product or service. (ISO/IEC/IEEE 2015) [3, SEBoK Glossary] |  |
| Design Constraints | The boundary conditions, externally or internally imposed, for the system-of-interest within which the organization must remain when executing the processes during the concept and Development Stage. [2] |  |
| Electrical Engineering | The application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of electrical and electronic elements; that is, the application of engineering to electrical and electronic elements. [Adapted from SEBoK SW Engineering definition]  Electrical Engineering organization consists of the Electrical Engineers and an environment of integrated tools and capabilities used to perform Electrical Engineering development activities and tasks. |  |
| Element | See System element [2} |  |
| EMI SysEnging | This specialty engineering entity is responsible to ensure all requirements associated with electronic emissions meet the overall stakeholder’s needs and meet associated regulatory agency requirements. |  |
| Engineer | Engineering is the discipline, art, and profession that applies scientific theory to design, develop, and analyze technological solutions. In the contemporary era, it is generally considered to consist of the major basic branches of chemical engineering, civil engineering, electrical engineering, and mechanical engineering. There are numerous other engineering sub-disciplines and interdisciplinary subjects that are derived from concentrations, combinations, or extensions of the major engineering branches.  [8, Wikipedia, List of engineering branches] |  |
| Engineering Analysis | This specialty engineering entity is responsible for executing a defined analytical study focused on mitigating risk |  |
| Engineering Artifact | This term is used to represent any type of Engineering artifact, including a document, spreadsheet, analysis or test data and any type of model, etc.  This term is useful when a generalized behavior requires input or output data without specifying this data for a specific specialty area. |  |
| Engineering Discipline | Engineering is the discipline, art, and profession that applies scientific theory to design, develop, and analyze technological solutions. In the contemporary era, it is generally considered to consist of the major basic branches of chemical engineering, civil engineering, electrical engineering, and mechanical engineering. There are numerous other engineering sub-disciplines and interdisciplinary subjects that are derived from concentrations, combinations, or extensions of the major engineering branches.  [8, Wikipedia, List of engineering branches]  In this model the Engineering discipline consists of the engineers and the environment of integrated tools and capabilities used to perform engineering development activities and tasks. |  |
| Environment | The surroundings (natural or man-made) in which the system-of interest is utilized and supported; or in which the system is being developed, produced and retired.[2] |  |
| Environmental SysEnging | This specialty engineering entity is responsible to ensure all requirements associated with environmental factors including temperature, humidity, UV exposure, radiation, magnetic forces, vibration, and others, meet the overall stakeholder’s needs and all appropriate regulatory requirements. |  |
| Fault | A safety fault is a non-conformance of a system that leads to a hazard [7]. |  |
| FMEA | Failure mode and effects analysis (FMEA) is an inductive reasoning (forward logic) single point of failure analysis and is a core task in reliability engineering, safety engineering and quality engineering. A successful FMEA activity helps to identify potential failure modes based on experience with similar products and processes - or based on common physics of failure logic. [8, Topic: Failure mode and effects analysis] | FMEA |
| Hardware Engineering | The application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of hardware; that is, the application of engineering to hardware elements. [Adapted from SW Engineering definition]  Hardware Engineering organization consists of the Mechanical Engineers and the environment of integrated tools and capabilities used to perform Hardware Engineering development activities and tasks. |  |
| Hazard | A hazard is system state that when combined with other environmental conditions inevitably leads to an accident [7]. |  |
| Human Factors SysEnging | This role of System Engineering is responsible to ensure all requirements associated with the interaction of the systems and humans. |  |
| Infrastructure SysEnging | This specialty engineering entity is responsible to ensure all requirements meet the overall stakeholder’s needs associated with areas of engineering including systems communications, network hardware and design, enclosures, computing hardware, system management, system time keeping and other, meet the overall stakeholder’s needs. |  |
| Initial RVTM | Initial Requirements Verification and Traceability Matrix - A list of requirements, their verification attributes, and traceability. [2, section 4.1] | I-RVTM |
| Interface | In computing, an interface is a shared boundary across which two separate components of a computer system exchange information. The exchange can be between software, computer hardware, peripheral devices, humans and combinations of these. ([8] Wikipedia) |  |
| Key Performance Parameter | A critical subset of the performance parameters representing those capabilities and characteristics so significant that failure to meet the threshold value of performance can be cause for the concept or system selected to be re-evaluated or the project to be reassessed or terminated. (Adapted from Glossary of Defense Acquisition Acronyms and Terms, Defense Acquisition University Press, January 2001). [9] | KPP |
| Manufacturing | The manufacturing organization disciplines consists of the people, facilities, tools and resources to support the manufacturing of products. |  |
| Measure of Effectiveness | The “operational” measures of success that are closely related to the achievement of the mission or operational objective being evaluated, in the intended operational environment under a specified set of conditions; i.e. how well the solution achieves the intended purpose. (Adapted from DOD 5000.2, DAU, INCOSE) [9]  A measure used to quantify the performance of a system, product or process in terms that describe a measure to what degree the real objective is achieved. [2] | MOE |
| Measure of Performance | The measures that characterize physical or functional attributes relating to the system operation, measured or estimated under specified testing and/or operational environment conditions. (Adapted from DOD 5000.2, DAU, INCOSE, and EPI 280-04, LM Integrated Measurement Guidebook) [9] | MOP |
| Measures of Effectiveness Needs | Measures of Effectiveness (MOEs) are the “operational” measures of success that are closely related to the achievement of the mission or operational objective being evaluated, in the intended operational environment under a specified set of conditions (i.e., how well the solution achieves the intended purpose). [2, section 4.1] | MOEs |
| Model-based Systems Development | Model-based Systems Development (MBSD) is the formalized application of modeling to support all aspects of product engineering and support system requirements, design, implementation, analysis, verification, validation, manufacturing, support and management activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases. Therefore MBSD includes domains such as MBSE, software design and implementation and mechanical design and implementation, and electrical design and implementation. | MBSD |
| Model-based Systems Engineering | “Model-based systems engineering (MBSE) is the formalized application of modeling to support system requirements, design, analysis, verification, and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases”. Ref - International Council on Systems Engineering (INCOSE), Systems Engineering Vision 2020, Version 2.03, TP-2004-004-02, September 2007. | MBSE |
| MOE Data | Data provided to measure the MOEs. [2, section 4.1] |  |
| Other Eng Tools and Sources | A tool used to provide some type of defined computations for a particular type of analysis. This computational tool could be implemented with a common spreadsheet or a very specialized tool. | CT |
| Preliminary Change Package | This information highlights what has been changed against an identified baseline. This can include:  - A list of features added to the system  - A list of change requests resolved in this release   - A list of configuration items (CI) that are required to be updated or replaced  - Any special installation instructions, upgrade instructions or notes.   - The cost to develop and upgrade the systems in the field and in manufacturing   - Effectivity of the change on existing systems in the field and in manufacturing  - Project schedule including milestones, activities and deliverables with start and end dates |  |
| Preliminary Project Plan | A preliminary project plan reflects the plan changes resulting from a proposed change to the existing plan. This includes changes in cost and schedules. The schedule changes typically include the tasks needed to update the hardware and software design and implementation, updates to verification plans, manufacturing plans changes, and supplier plans. | SCN |
| Product Development Domain | The Product Development Domain provides the systems context for Systems Engineering. Included in this domain are all the entities that influence or interact with the system of interest, i.e. Systems Engineering. |  |
| Program Management | The organization that is responsible for managing several related projects, often with the intention of improving an organization’s performance. It is often closely related to systems engineering and industrial engineering. From Wikipedia at http://en.wikipedia.org/wiki/Program\_management. This can also be referred to as Project Management. |  |
| Project Constraints | Includes all other constraints from the stakeholder including cost, schedule, and solution constraints. [2, section 4.1] |  |
| Project Management System | An environment of tools and capabilities used to assist in the process of managing a projects tasks and activities. This can include identify development tasks, assigning responsibility, scheduling, measuring progress, measuring quality, measuring resources actually used, etc. |  |
| RAM SysEnging | This specialty engineering entity is responsible to ensure all requirements associated with reliability, availability and maintainability meet the overall stakeholder’s needs. |  |
| Regulatory Documents | Regulatory compliance documents establish a set of rules, principles or usages that describe the goals that an organization, a system or equipment should implement to ensure the awareness of and take steps to comply with relevant laws and regulations. |  |
| Review Comments | The Review Comments artifact is produced as a result of reviewing a Review Package. Comments may add, delete or update items in the Review Package. Comments can be captured in many different forms, i.e. document change bars, red lines, text color changes, annotation, etc.. Each comment should identify the reviewer and the time of change.  The set of comments in the Review Comments artifact can be of multiple forms, e.g. an annotated version of the review package, a separate report, etc. |  |
| Review Package | The review package describes what is the proposed change being reviewed. Typically this is measured against the previous baseline. The review package contains all the changed items and any additional needed information to complete the context of those changed items.  The review package should highlight what items have been added, deleted or updated, e.g. document change bars, red lines, text color changes, annotation, etc.  The review package can consist of any type of artifact, including models, documents, code, parts of the system, prototypes, etc. |  |
| Review Results | Review Results are archived after a review.  The review results contains:  1. The list of reviewers  2. A list all the changed items referenced in the Review Package.   3. All comments from reviews  4. The adjudication results for each comment  5. A list of open action Items resulting from the review and a plan for closing each of them |  |
| Safety Measure | Safety measures are activities and precautions taken to improve safety, i.e. reduce risk related to human health [6].  A safety measure could be used to detect or mitigate a fault [7]. |  |
| Safety Report | The result of a safety analysis and evaluation. |  |
| Safety SysEnging | This specialty engineering entity is responsible to ensure all requirements associated with the operational safety of the system meet the overall stakeholder’s needs. |  |
| SE Development System | The Systems Engineering Development System (SEDS) is the system used to provide an integrated environment of tools and capabilities required to perform Systems Engineering activities and tasks. This includes the environment to support system requirements flowdown, design, analysis, verification, validation activities. The SEDS provides interfaces to external domains such as the software, mechanical, electrical engineering domains and interfaces to manufacturing, support and product management domains. | SEDS |
| SE Repository | The Systems Engineering Repository provides persistent storage for any Systems Engineering work product artifact. This can include items such as models, specifications, documents, work instructions, analysis data, requirements, etc. |  |
| Security SysEnging | This specialty engineering entity is responsible to ensure all requirements associated with data security and system security meets the overall stakeholder’s needs. |  |
| Software Engineering | (1) The application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software; that is, the application of engineering to software. (IEEE 1990)  (2) The study of approaches as in (1). (IEEE 1990) [3, SEBoK Glossary]  Software Engineering organization consists of the software engineers and the environment of integrated tools and capabilities used to perform Software Engineering development activities and tasks. |  |
| Source Documents | Extract, clarify, and prioritize all of the written directives embodied in the source documents relevant to the particular stage of procurement activity. [2, section 4.1] |  |
| Specialty Engineer | Specialty Engineer applies Specialty Engineering discipline principles in areas of cost analysis, safety, security, RAM, performance analysis, etc. |  |
| Specialty Engineering | Specialty Engineering is the collection of those narrow disciplines that are needed to engineer a complete system. (Elowitz, 2006) [3, SEBoK Glossary] |  |
| Stakeholder | A stakeholder is any entity (individual or organization) with a legitimate interest in the system. Typical stakeholders include users, operators, organization decision-makers, parties to the agreement, regulatory bodies, developing agencies, support organizations, and society-at-large. [2, INCOSE Handbook Sec 4.1.1.2] |  |
| Stakeholder Needs | Description of users’ and other stakeholders’ needs or services that the system of interest will provide. [2, section 4.1)  The benefits That the Stakeholders wish to be satisfied by or delivered by the system when it is implemented and functioning. |  |
| Stakeholder Requirements | Formally documented and approved stakeholder requirements that will govern the project, including: required system capabilities, functions, and/or services; quality standards; and cost and schedule constraints. [2, section 4.1] |  |
| Stakeholder Requirements Traceability | All stakeholder requirements should have bidirectional traceability, including to their source, such as the source document or the stakeholder need. [2, section 4.1] |  |
| Subsystem | A system element comprising an integrated set of assemblies, which performs a cleanly and clearly separated function, involving similar technical skills, or a separate supplier. [2] |  |
| Supplier | An organization or an individual that enters into an agreement with the acquirer for the supply of a product or service. [2] |  |
| Support | The discipline is contracted to provide technical support to the customer for the system-of-interest. This can include installation of the systems, answering technical questions, investigating customer issues, planned maintenance, training and removal at the end of the life cycle. |  |
| SWaP SysEnging | This specialty engineering entity is responsible to ensure all requirements associated with size weight and power meets the overall stakeholder’s needs. |  |
| System | A combination of interacting elements organized to achieve one or more stated purposes [2} An integrated set of elements, subsystems, or assemblies that accomplish a defined objective. These elements include products (hardware, software, and firmware), processes, people, information, techniques, facilities, services, and other support elements. An example would be an air transportation system. [2] |  |
| System Architect | Looks across all aspects of the system to ensure the overall system meets the stakeholders’ needs. |  |
| System Element | A member of a set of elements that constitutes a system a major product, service, or facility of the system (the term subsystem is sometimes used instead of element) [2] |  |
| System of Interest | The system whose life cycle is under consideration. [2]   (1) The system whose life cycle is under consideration. (ISO/IEC/IEEE 2015)  (2) The system of interest to an observer. (Bertalanffy 1968)  [3, SEBoK Glossary] | SoI |
| Systems Engineer | A systems engineer is “a person who practices systems engineering” and whose systems engineering capabilities and experience include sustained practice, specialization, leadership or authority over systems engineering activities. Systems engineering activities may be conducted by any competent person regardless of job title or professional affiliation. (Created for SEBoK) [3, SEBoK Glossary] |  |
| Systems Engineering | Systems Engineering is the context for the Systems Engineering Workflow Use Cases. It includes the roles associated with applying system wide activities including the Systems Engineering roles, Specialty Engineering roles, V&V (Verification and Validation) roles and it includes the Systems Engineering Development System (SEDS) providing the tools for these roles. [Created for model] Systems Engineering (SE) is an interdisciplinary approach and means to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, and then proceeding with design synthesis and system validation while considering the complete problem: operations, cost and schedule, performance, training and support, test, manufacturing, and disposal. SE considers both the business and the technical needs of all customers with the goal of providing a quality product that meets the user needs. [10, INCOSE Handbook, Appendix C] (1) Interdisciplinary approach governing the total technical and managerial effort required to transform a set of customer needs, expectations, and constraints into a solution and to support that solution throughout its life. (ISO/IEC/IEEE 2010)   (2) An interdisciplinary approach and means to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, then proceeding with design synthesis and system validation while considering the complete problem:  Operations  Performance  Test  Manufacturing  Cost & Schedule  Training & Support  Disposal Systems engineering integrates all the disciplines and specialty groups into a team effort forming a structured development process that proceeds from concept to production to operation. Systems engineering considers both the business and the technical needs of all customers with the goal of providing a quality product that meets the user needs. (INCOSE 2012) [3, SEBoK Glossary] | SE |
| Technical Measures | Technical measurements is the set of measurement activities used to provide the supplier and/or acquirer insight into progress in the definition and development of the technical solution and the associated risks and issues. This insight helps project management make better decisions throughout the life-cycle to increase the probability of delivering a technical solution that meets both the specified requirements and the mission needs. This insight is also used in trade-off decisions when performance exceeds the threshold. [9] |  |
| Technical Performance Measure | TPMs measure attributes of a system element to determine how well a system or system element is satisfying or expected to satisfy a technical requirement or goal. [9] | TPM |
| V&V Engineer | Verification and Validation Engineer  Responsibilities are to produce a Test Plan, Test Procedures, Test Integration Plan, execute the tests, produce a V&V test report, Requirements Verification Matrix |  |
| V&V Engineering | Validation and Verification (V&V) Engineering consists of the V&V engineers and the environment of integrated tools and capabilities used to create and manage information associated with verification and validation activities and tasks. |  |
| Validation | A confirmation, through the provision of objective evidence, that the requirements for a specific intended use or application have been fulfilled [ISO 9000: 2000] [2] |  |
| Validation Criteria | May specify who will perform validation activities, and the environments of the system-of-interest. [2, section 4.1] |  |
| Verification | Confirmation, through the provision of objective evidence, that specified requirements have been fulfilled [ISO 9000: 2000] [2] |  |

## Table of Use Case List

Table 2: List of Use Cases

| Owner | Name |
| --- | --- |
| Exploratory and Concept Stage | Response to a Customer Request |
| Exploratory and Concept Stage | Analyze Stakeholders Needs |
| Exploratory and Concept Stage | Derive System Requirements |
| Exploratory and Concept Stage | Analyze System Life-cycle Costs |
| Management Workflow Use Cases | Plan a Development Cycle |
| Management Workflow Use Cases | Manage SE Development Progress |
| Management Workflow Use Cases | Manage SE Development Environment |
| Management Workflow Use Cases | Create a Baseline |
| SE Domain Workflow Use Cases | Derive Product Architecture |
| SE Domain Workflow Use Cases | Evaluate System Safety |
| SE Domain Workflow Use Cases | Perform System RMA Engineering |
| SE Domain Workflow Use Cases | Apply System Security Engineering |
| SE Domain Workflow Use Cases | Analyze System Performance |
| SE Domain Workflow Use Cases | Allocate and Manage SWaP |
| SE Domain Workflow Use Cases | Perform a Trade Study |
| SE Domain Workflow Use Cases | Analyze Behavior Correctness |
| SE Domain Workflow Use Cases | Manage Product Lines |
| SE Domain Workflow Use Cases | Integrate Human Domain Constraints |
| SE Domain Workflow Use Cases | Perform Environmental Engineering |
| SE Domain Workflow Use Cases | Collaborate with Implementation Domain Team |
| SE Domain Workflow Use Cases | Perform EMI Engineering |
| Validation and Verification Workflow Use Cases | Develop Verification Plan and Procedures |
| Validation and Verification Workflow Use Cases | Develop a System Integration Plan |
| Validation and Verification Workflow Use Cases | Execute a Verification Test Procedure |
| Validation and Verification Workflow Use Cases | Provide V&V Status |
| Production Stage | Support Produceability Engineering |
| Product and Service Life Management Stage | Support Initial Installation |
| Product and Service Life Management Stage | Architect Sustainability System |
| Product and Service Life Management Stage | Process Change Request |
| Product and Service Life Management Stage | Support System Modernization Plan |
| Product and Service Life Management Stage | Support System Disposal and Retirement |

## Table of Actors

Table 3: List of Actors

| Name | Description |
| --- | --- |
| Change Control Board | “A Change Control Board (CCB) with representatives from appropriate areas of the project is set up to effectively analyze, control and manage changes being proposed to the project.” “CCBs may be comprised of members from both the customer and the supplier.” “The board includes representation from project management since the CCB decisions will have an impact on schedule, budget, and resources.” [3, SEBoK, The Influence of Project Structure and Governance on Systems Engineering and Project Management Relationships] |
| Configuration Control Board | Configuration Control Board (CCB) provides a central a central point to coordinate, review, evaluate, and approve all proposed changes to baselined documentation and configurations and configuration, including hardware, software and firmware. The review board is composed of members from the various disciplines, including SE, software and hardware engineering, project management, product assurance, and configuration management. [10, INCOSE Handbook, section 5.5.2.2]  The CCB can contain members from all relevant stakeholders. Some additional members can also be from all engineering disciplines, Manufacturing and Support, |
| Customer | A customer (sometimes known as a client, buyer, or purchaser) is the recipient of a good, service, product, or idea, obtained from a seller, vendor, or supplier for a monetary or other valuable consideration. [8] |
| Electrical Engineering | Electrical engineers apply the principles of electrical engineering to the design, development, maintenance and testing of electrical equipment. Electrical engineering includes the study and application of electricity, electronics, and electromagnetism. [8] |
| Engineering Management | Engineering Management is a specialized form of management that is concerned with the application of engineering principles to business practice. Engineering management is a career that brings together the technological problem-solving savvy of engineering and the organizational, administrative, and planning abilities of management in order to oversee complex enterprises from conception to completion. [8] |
| Manufacturing | Manufacturing engineering is a discipline of engineering dealing with different manufacturing practices and includes the research, design and development of systems, processes, machines, tools and equipment. The manufacturing engineer’s primary focus is to turn raw materials into a new or updated product in the most economic, efficient and effective way possible [8]. |
| Mechanical Engineering | Mechanical engineering is the discipline that applies the principles of engineering, physics, and materials science for the design, analysis, manufacturing, and maintenance of mechanical systems. It is the branch of engineering that involves the design, production, and operation of machinery [8]. |
| Project Management | (1) The application of knowledge, skills, tools, and techniques to project activities to meet the project requirements. (PMI 2013)  (2) The collection of work activities concerned with planning and estimating, measuring and controlling, leading and coordinating, and managing risk factors for a project. (Fairley 2009) [3, SEBoK Glossary] |
| SE Collaborators | SE Collaborators can include all disciplines that are external to systems engineering (SE), participate in the product life cycle and need to collaborate with SE in resolving product technical questions. This collaboration can be initiated by SE or by an SE collaborator. The SE collaborators can include any engineering disciplines, manufacturing, support and training. |
| Software Engineering | Software engineers apply the principles of software engineering to the design, development, maintenance, testing, and evaluation of the software and systems that make computers or anything containing software work.[8] |
| Stakeholder | A person, group or organization with an interest in a project. [8]  A party having a right, share or claim in a system or in its possession of characteristics that meet that party’s needs and expectations.[2] |
| Support | The discipline is contracted to provide technical support to the customer for the system-of-interest. This can include installation of the systems, answering technical questions, investigating customer issues, planned maintenance, training and removal at the end of the life cycle. |

## References and Citations List

The reference numbers in this list must be kept in-sync with the references and citations in the Systems Engineering Concept Model (SECM)

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