INCOSE®

Systems Engineering Competency Framework

This INCOSE Technical Product was developed and produced in conjunction with the following contributors:

DAU · INCOSE UK · LOCKHEED MARTIN · MITRE · NDIA · NPS · SYSTEMS ENGINEERING RESEARCH CENTER · WPI

INCOSE Technical Product Reference: INCOSE-TP-2018-002-01.0

INCOSE SYSTEMS ENGINEERING COMPETENCY FRAMEWORK

The INCOSE Systems Engineering Competency Framework is a collaborative product from a series of meetings of the INCOSE International Competency Working Group, held at INCOSE International Workshops and on conference calls between January 2011 and January 2018. The Competency Working Group is Chaired by Don Gelosh and Co-Chaired by Mimi Heisey.

Compiled and Edited by:

Ian Presland, ESEP

Primary Contributing Authors (alphabetical order):

Richard Beasley, ESEP
Don Gelosh, CSEP-Acq
Mimi Heisey
Ian Presland, ESEP
Lori Zipes, ESEP

Acknowledgements

This INCOSE Systems Engineering Competency Framework is a new collaborative product based on several sources.
We would like to acknowledge and thank the following organizations for their contributions of competency models, competency frameworks, and other resources, without which the development and production of this framework would have been impossible:

Defense Acquisition University	National Defense Industrial Association
INCOSE UK Ltd.	Naval Postgraduate School
Lockheed Martin Corporation	Systems Engineering Research Center
MITRE Corporation	Worcester Polytechnic Institute

We would like to acknowledge the contributions of the following people in the development and review of this framework:

Juan P. Amenabar	Heidi Hahn	Everett Lewis	Bill Stone
Eileen Arnold	Charles Home	Ken Nidiffer	Lucio Tirone
Lilian Boichon	Nicole Hutchison	Pascal Paper	Steve Untz
Heidi Davidz	Suja Joseph-Malherbe	Garry Roedler	Cliff Whitcomb
Bernardo Delicado	James Johnson	Udit Sahoo	Jan Ziarko
Emmanuelle Garcia	Subash Kafle	John Snoderly	

We would like to acknowledge the INCOSE UK Advisory Board, including the following list of individuals who participated in the UK Working group which created the Competency Framework Issue 3:

Stuart Arnold	Samantha Brown	Sue Goodlass	Alan Smith
Keith Barnwell	Dez Cas	David Hawken	Jocelyn Stoves
Matthew Bromley Barratt	Dave Chelsom	Simon Hinsley	Les Oliver
Roger Barrett	Doug Cowper	John Hooper	Simon Perry
Richard Beasley	Allen Fairbairn	Sandra Hudson	David Venn
Shane Bennison	Ayman El Fatatry	Ady James	Simon Wilson
Andy Bond	Jeremy Gill	Richard Allen-Shalless	

We would like to thank all members of the INCOSE International Competency Working Group for their contribution and support to the ideas and concepts within this framework.

Disclaimer

Reasonable endeavors have been used throughout its preparation to ensure that the Systems Engineering Competency Framework is as complete and correct as is practical. INCOSE, its officers and members shall not be held liable for the consequences of decisions based on any information contained in or excluded from this framework. Inclusion or exclusion of references to any organization, individual or service shall not be construed as endorsement or the converse. Where value judgements are expressed these are the consensus view of expert and experienced members of INCOSE.

Copyright

TABLE OF CONTENTS

FIGURES

TABLES

INTRODUCTION

The goal of the INCOSE International Competency Working Group is to define a global standard for those competencies regarded as central to the practice and profession of Systems Engineering, together with a set of indicators which can be used to verify attainment of those competencies.

This document is an output from that working group.

PURPOSE

The purpose of this document is to provide a set of competencies for Systems Engineering within a framework that provides guidance for both beneficiaries and practitioners to identify knowledge, skills, abilities and behaviors important to Systems Engineering effectiveness in the domain for which the competency model is applied.

SCOPE

The main body of this document is a generic framework. This can be applied in the context of any application, project, organization or enterprise for both individual and/or organizational assessment and/or development. The framework is expected to be tailored to suit the application and domain in which it is applied, combining competencies identified herein with others taken from complimentary frameworks (e.g. Program Management, Human Resources, Aerospace, Medical), or generated organizationally, to define the required knowledge, skills and behaviors appropriate to an area or role.

CONTEXT

The context of this document is well represented in the definition of Systems Engineering as published by the International Council of Systems Engineering (INCOSE) and reflected in standards used across industry today. This competency framework specifically aligns with these standards in the areas of terminology and concepts to ensure using organizations have the ability to use these as complementary resources and to ensure the framework is consistent with industry standards.

In developing the Systems Engineering competencies in this document, the working group considered the following sources:

- Atlas 1.1: An Update to the Theory of Effective Systems Engineers (Hutchison, et al. 2018)
- ISO/IEC/IEEE 15288:2015 Systems and Software engineering – System life cycle processes (ISO/IEC JTC 1/SC 7 Software and Systems Engineering Technical Committee 2015);
- Capability Maturity Model Integration V1.3 (CMMI® Institute 2010);
- EIA731 (Electronic Industries Alliance 2002);
- INCOSE Systems Engineering Body of Knowledge (INCOSE 2017);
- INCOSE Systems Engineering Handbook, Fourth Edition (INCOSE 2015);
- NASA Systems Engineering Handbook, Rev 2 (National Aeronautics and Space Administration (NASA) 2016);
- EE/BCS Safety Competency Guidelines (Institution of Engineering and Technology 2013);
- US DoD's Better Buying Power 3.0 Implementation Plan (Kendall, F 2014);
- Defense Acquisition University Competency Model (Defense Acquisition University 2013);
- US Navy's Systems Engineering Competency Career Model (SECCM) (Whitcomb, Khan, and White 2014);
- INCOSE Systems Engineering Professional Certification Program (INCOSE 2018).

OBJECTIVE

The objective of this new competency framework is to leverage existing competency frameworks and competency models in order to:

- Capitalize on feedback received on existing frameworks and models from a decade of practical use globally;
- Improve alignment with other INCOSE initiatives;
- Address content and language to widen its appeal, recognizing the growth of a systems approach within several new domains;
- Reflect the latest collective intelligence of industry as reflected in the data, descriptions and standards available as learning benchmarks globally.

DOCUMENT OVERVIEW

Part 2 of the document summarizes the framework architecture, the format of the competency area definitions and each of the levels of competence recognized within the framework.

Part 3 of the document provides high-level guidance on how to use the framework. It includes:

- A section defining a series of "use cases". These cover the many ways the framework has been envisioned as being used by both organizations and individuals;
- An overview of "Competence-based assessment". It is important to realize that this is a specific measurement technique and this section includes an outline of the technique, the skills expected from those thinking of performing assessment or selecting assessors and methods for training assessors;
- Tailoring. As stated in the introduction, the framework needs to be tailored to reflect organizational needs.

It also provides an overview of how the framework can be tailored and mapped to organizational roles. This is further elaborated in Annex C.

Part 4 is a list of acronyms and abbreviations used in the framework.

Part 5 is a Glossary of terminology used in the framework.

Part 6 is a list of documents referenced from the framework.

Annex A contains a formal mapping from the last formal release of the Issue 3 framework to this new framework. This mapping is intended to help support migration of any organizations using Issue 3 to the new framework.

Annex B contains background information as to how the framework aligns with INCOSE and other initiatives.

As stated above, Annex C provides further information on deployment of the framework. It includes a step-by-step guide to using the competencies to define organizational roles and job descriptions.

Annexes D and E form the main technical body of this document. Annex D contains the formal competency framework definition, while Annex E contains guidelines for assessing the competencies defined in Annex D. For this new framework, Annex E is blank.

The authors welcome feedback on this document. Annex F is a comment form provided for this purpose.

INCOSE SE COMPETENCY FRAMEWORK DEFINITION

COMPETENCY OVERVIEW

The terms 'competency' and 'competencies' focus on the personal attributes or inputs of an individual. They can be defined as the technical attributes and behaviors that individuals must have, or must acquire, to perform effectively at work.

'Competence' and 'competences' are broader concepts that encompass demonstrable performance outputs as well as behavior inputs, and may relate to a system or set of minimum standards required for effective performance at work. (Chartered Institute of Personnel Development (CIPD) 2018).

Competency is "a measure of an individual's ability in terms of their knowledge, skills, and behavior to perform a given role (p. xvi)." (Holt and Perry 2011). *Competency* is distinct from *competence*, defined by Merriam-Webster as the ability to do something well (Merriam Webster 2018). Competence, then, reflects the total characteristics of the individual, while "competency" reflects a single area; the sum of an individual's competencies makes up their competence (Holt and Perry 2011).

Although these terms are now regularly used interchangeably. In this document, the term 'competency' is used to define the need ("requirement") and "competence" is used to characterize the "outcome" ("validation").

A 'Competency Framework' is a structure that sets out and defines each individual competency required by individuals working in an organization or part of an organization. (Chartered Institute of Personnel Development (CIPD) 2018). This document defines a framework of competencies for the Systems Engineering discipline.

Note that "competence" differs from "capability". Capability is an organizational or organizational team attribute that refers to the ability to execute the organization's mission (i.e. deliver a product or service). Engineering capabilities are defined in terms of people (competencies), processes, facilities and equipment, the integration of which leads to the ability to produce an engineered product or service.

Indeed, to be effective in any Systems Engineering task an individual will normally require in addition:

- Supporting Skills and Techniques;
- Domain Knowledge.

Supporting skills and techniques help an individual perform a task effectively within a context. Skills and techniques may be organization, project or role specific. For instance, the ability to use a company-standard “Requirements Management” tool may be central to performing a given role effectively within one organization, but this tool-specific skill will not help in another organization if it uses a different tool. However, possessing the knowledge, understanding and experience (i.e. possessing competence) to perform Requirements Management effectively as a task goes beyond the specifics of using any one tool or technique. Indeed, competence may be gained through using a variety of tools. However, an individual organization is likely to require additional “tool-specific skills” for any practitioner to operate effectively within it. The definition of such required skills will form part of the organization-specific tailoring (i.e. the contextualization of the framework).

In a similar way, “domain knowledge” exists within an industrial context (e.g. automotive, healthcare, space). This requires specialization appropriate to the domain addressing areas such as the commercial or organizational environment, the supply chain and domain-specific technical standards/protocols.

Competence supports the ability to carry out a process, but it is not just about executing a defined process. Competence includes capitalizing on a wider understanding of the relationship between processes, understanding an individual’s specific role in supporting their execution within the wider organizational structure, and the behavioral skills required to ensure that process activities are executed effectively. This document includes a mapping of competencies to INCOSE Systems Engineering Handbook processes (see Figure 3) which clearly demonstrates the relationship is not one-to-one. This document also includes a detailed discussion on how roles can be defined in terms of competence and deployed so that they work together to ensure the effective delivery of Systems Engineering within an organization (Annex C).

This new framework excludes competencies associated with domain knowledge. Users of this framework can use the ideas defined herein, together with resources available within their domain to extend the scope of this framework by adding domain-specific competencies applicable to their project, business, organization or domain area.

FRAMEWORK STRUCTURE

Competencies predominately associated with Systems Engineering have been identified and grouped into five themes which are summarized in Figure 1 below. All competence areas are fully defined in a series of tables forming Annex D of this document.

CORE COMPETENCIES

Core competencies underpin engineering as well as systems engineering.

Systems Thinking	The application of the fundamental concepts of systems thinking to systems engineering;
Lifecycles	Selection of the appropriate lifecycles in the realization of a system;
Capability Engineering	An appreciation of the role the system of interest plays in the system of which it is a part;
General Engineering	Foundational concepts in mathematics, science and engineering and their application;
Critical Thinking	The objective analysis and evaluation of a topic in order to form a judgement;
Systems Modeling and Analysis	Provision of rigorous data and information including the use of modeling to support technical understanding and decision making.

PROFESSIONAL COMPETENCIES

Behavioral competencies well-established within the Human Resources (HR) domain. To facilitate alignment with existing HR frameworks, where practicable, competency definitions have been taken from well-established, internationally-recognized definitions rather than partial or complete re-invention by INCOSE.

Communications	The dynamic process of transmitting or exchanging information;
Ethics and Professionalism	The personal, organizational, and corporate standards of behavior expected of systems engineers;
Technical Leadership	The application of technical knowledge and experience in systems engineering together with appropriate professional competencies;
Negotiation	Dialogue between two or more parties intended to reach a beneficial outcome where difference exist between them;
Team Dynamics	The unconscious, psychological forces that influence the direction of a team's behavior and performance;
Facilitation	The act of helping others to deal with a process, solve a problem, or reach a goal without getting directly getting involved;
Emotional Intelligence	The ability to monitor one's own and others' feelings and use this information to guide thinking and action;
Coaching and Mentoring	Development approaches based on the use of one-to-one conversations to enhance an individual's skills, knowledge or work performance.

MANAGEMENT COMPETENCIES

The ability to perform tasks associated with controlling and managing Systems Engineering activities. This includes tasks associated with the Management Processes identified in the INCOSE SE Handbook.

Planning	Producing, coordinating and maintaining effective and workable plans across multiple disciplines;
Monitoring and Control	Assessment of an ongoing project to see if the current plans are aligned and feasible;
Decision Management	The structured, analytical framework for objectively identifying, characterizing and evaluating a set of alternatives;
Concurrent Engineering	A work methodology based on the parallelization of tasks;
Business and Enterprise Integration	The consideration of needs and requirements of other internal stakeholders as part of the system development;
Acquisition and Supply	Obtaining or providing a product or service in accordance with requirements;
Information Management	Addresses activities associated with all aspects of information, to provide designated stakeholders with appropriate levels of timeliness, accuracy and security;
Configuration management	Ensuring the overall coherence of system functional, performance and physical characteristics throughout its lifecycle;
Risk and Opportunity Management	The identification and reduction in the probability of uncertain events, or maximizing the potential of opportunities provided by them,

TECHNICAL COMPETENCIES

The ability to perform tasks associated primarily with the suite of Technical Processes identified in the INCOSE SE Handbook.

Requirements Definition	To analyze the stakeholder needs and expectations to establish the requirements for a system;
System Architecting	The definition of the system structure, interfaces and associated derived requirements to produce a solution that can be implemented;
Design for…	Ensuring that the requirements of all lifecycle stages are addressed at the correct point in the system design;
Integration	The logical process for assembling a set of system elements and aggregates into the realized system, product or service;
Interfaces	The identification, definition and control of interactions across system or system element boundaries;
Verification	A formal process of obtaining objective evidence that a system fulfils its specified requirements and characteristics;
Validation	A formal process of obtaining objective evidence that the system achieves its intended use in its intended operational environment;
Transition	Integration of a verified system into its operational environment including the wider system of which it forms a part;
Operation and Support	When the system is used to deliver its capabilities, and is sustained over its lifetime.

INTEGRATING COMPETENCIES

This competency group recognizes Systems Engineering as an integrating discipline, joining activities and thinking from specialists in other disciplines to create a coherent whole.

Project Management	Identification, planning and coordinating activities to deliver a satisfactory system, product, service of appropriate quality;
Finance	Estimating and tracking costs associated with the project;
Logistics	The support and sustainment of a product once it is transitioned to the end user;
Quality	Achieving customer satisfaction through the control of key product characteristics.

Figure 1 Complete Listing of Competencies in the Systems Engineering Competency Framework

COMPETENCY AREA TABLE FORMAT

Annex D contains the formal definition of all competencies within the framework. Each competency has associated with it a single competency table, which provides:

- **Description** explains what the competency is and provides meaning behind the title. Each title can mean different things to different individuals and enterprises;
- **Why it matters** indicates the importance of the competency and the problems that may be encountered in the absence of that competency;
- **Effective indicators of knowledge and experience** table contains a list of evidence-based indicators for five defined levels of competence, which are themselves defined below. Indicators provide a definition of what is expected to be demonstrated in order that competence can be assumed at the level indicated. Note that the indicators defined are "entry level" requirements for each level. The timing of when experience was gained should be taken into consideration when assessing current competence: individuals may have had competence at a defined level historically, but this may have reduced over time.

Whilst Annex D is the "requirement" for expressing competence at a level, Annex E contains guidance for assessing individual competence against the indicators listed in Annex D. Annex E can be interpreted as "verification and validation" evidence required for confirming competence at levels characterized in Annex D.

Although the specific nature of evidence provided will differ from organization and individual, each defined indicator has at least one possible element of potential evidence associated with it.

Competence Levels

Five "levels" of increasing competence have been defined in terms of levels of knowledge and experience for each competency area:

- **Awareness**

  The person displays knowledge of key ideas associated with the competency area and understands key issues and their implications. They ask relevant and constructive questions on the subject. This level characterizes engineers new to the competency area. It could also characterize an individual outside Systems Engineering who requires an understanding of the competency area to perform their role.

- **Supervised Practitioner**

  The person displays an understanding of the competency area and has some limited experience. They require regular guidance and supervision. This level defines those engineers who are "in-training" or are inexperienced in that competency area.

- **Practitioner**

  The person displays both knowledge and practical experience of the competency area and can function without supervision on a day-to-day basis. They are also capable of providing guidance and advice to less experienced practitioners.

- **Lead Practitioner**

  The person displays extensive and substantial practical knowledge and experience of the competency area and provides guidance to others including practitioners encountering unusual situations. Typically, this level is associated with an individual who is the "go-to" person for advice and to determine best practice within the competency area within an organization or business unit.

- **Expert**

  In addition to extensive and substantial practical experience and applied knowledge of the competency area, this individual contributes to and is recognized beyond the organizational or business boundary. Typically, this level is associated with an individual contributing to and defining regional or international best practices within the competency area.

During a formal assessment of competence, in addition, there may be a need to record a level of

- "Unaware" meaning that the criteria for "awareness" has not been reached;
- "Not Applicable" which would be appropriate if the competence area is tailored out and not applicable to the business; and
- "Not Assessed" meaning that for whatever reason, the competency area was not covered as part of the assessment activity.

USING THE COMPETENCY FRAMEWORK

TYPICAL USAGE SCENARIOS

Organizations and individuals have numerous ways in which they can use the INCOSE Competency Framework to their advantage.

Organizations use competency frameworks for human resource management, as described in the INCOSE Systems Engineering Handbook Fourth Edition (INCOSE 2015). This may include using competence assessment in recruiting and selecting candidates for employment; for appraisals, promotions, and compensation decisions; for aligning organizational structures to maximize organizational capability; and to identify workforce training requirements that can be communicated to internal or external training providers who can develop and tailor content that will deliver the required competencies (Holt and Perry 2011) (SFIA Foundation 2014).

Individuals may use self-assessment of their competence levels for career planning and identifying needs for personal and professional development; comparing self-assessed competence against competency-based vacancy announcements also helps individuals to identify opportunities which match their skills and experience (Holt and Perry 2011); (SFIA Foundation 2014). SFIA notes that use of competency frameworks in job postings reduces risks both to the individual and the organization, reducing churn induced when individuals feel ‘the job is not what they thought it would be’ and minimizing situations in which the organization discovers they do not have the right set of skills for effective mission execution.

Educational institutions and training providers use industry- and discipline-specific competency frameworks to align their offerings to provide graduates the knowledge they need to develop their skills at the right level (SFIA Foundation 2014).

Several “standard” usage scenarios were developed in the Universal Competency Assessment Model (UCAM) (Holt and Perry 2011). These scenarios are not described in detail here. A detailed analysis can be found in the paper “Use Cases for the INCOSE Competency Frameworks” (Hahn and Whitcomb 2017). However, in summary, the framework can be used to support any of the usage scenarios defined in Table 1.

Table 1 Typical Usage Scenarios for the INCOSE Competency Framework

USAGE	USERS	DESCRIPTION
To define required competence outcomes from educational courses	Educators, Employers	A company recruiter or capability manager interacts with a representative of an educational institution to define the competencies expected from those leaving the educational institution. This helps align program content to better prepare graduates for company employment.
To assure employers that students completing a course will have acquired specific knowledge and skills	Educators, Employers	A company recruiter or capability manager interacts with a representative of an educational institution to assess and recruit pre-qualified students against a set of competency needs for a company pipeline programs.
To align course curricula for external accreditation purposes	Educators, Accreditors	An educational curriculum provider interacts with curriculum sponsors and/or accreditation agencies to assess the effectiveness of an educational course/module in delivering stated outcomes against pre-defined accreditation objectives. This might be through assessment of learning objectives against competency needs, and outcomes against competence acquired or those attending the course
To create (or maintain) role descriptions	Employers	An employer defines the needs for an organizational role in terms of competencies and their minimum required levels. This use case is elaborated further in the section on role definitions elsewhere in this document. A competency-driven job definition can also help ensure that the requirements for a role are based upon ability rather than age and thus aligns with age-discrimination legislation in areas such as the European Union (GOV.UK 2017).
To create job vacancies	Employers	An employer publishes the requirements for an organizational role in terms of competencies and their minimum required levels – as defined above. Candidates and recruiting agencies can compare this against their own (or their candidates') competences to determine their suitability for the position. It also supports candidate preparation as it provides an insight into the evidence they may be asked to provide during their application and/or interview.
To support candidate recruitment	Employers	Having defined the requirements for a role in terms of competencies, an employer can assess candidate competence against the required competencies using the Competency Framework assessment guide. This helps to provide an objective (and repeatable) assessment of candidates at interview.
To support employee performance assessments and rating	Employers, Employees	An employer sets targets for individual competence attainment in one or more competencies, and provides opportunities for competency development to occur. The competence assessment activity can be used to formally gauge competence level attainment against the targets set, as an input to their overall performance rating.
To define career path models	Employers, Employees	An employer can link career paths within the organization to differing expected combinations of competencies and associated minimum competence levels. This can be used to provide insight to employees as to the competence needs for differing career development paths. This indicates the competencies and levels necessary to progress a selected career path – informing employee career development choices along the way.
To self-assess supporting personal career development planning	Employees	An employee can "self-assess" their skills against the competency framework, using the assessment guidance provided. This helps inform their career development choices – whether as part of a job application or more generally as part of a personal career path development.
To perform workforce risk analyses or mission/ business case analysis	Organizations, Acquirers	An organization can use information gathered through individual employee competency assessment against the framework to analyze organizational capability within a specific domain of Systems Engineering, or more generally. This could be driven by current or future business aspirations. Acquirers (i.e. organizations placing contracts) could mandate minimum organizational capability requirements for those supporting a contract/task as a risk reduction strategy – requesting capability data based upon competency assessments using the framework rather than traditional more generalized experiential statements from a business.
To target training investment	Organizations	An organization gathers enterprise-wide data through individual employee competence assessment against the framework and uses this to assess organizational-level strengths and weaknesses. This enables training investment to be focused on areas deemed organizationally (and individually) in areas where it is needed most.

TAILORING THE FRAMEWORK

The INCOSE Competency Framework is expected to be tailored as part of its deployment.

The framework has been structured so that organizations can tailor it to develop competency models ideally suited to their organizational needs and workforce. The framework contains the fundamental Systems Engineering competencies that can support almost any Systems Engineering role. Using organizations can tailor this competency framework to derive a bespoke competency model by:

- Adding or deleting competencies as needed;
- Revising or only using a subset of the competencies;
- Adding, deleting, or revising the proficiency level indicators for any of the five levels for any of the competencies;
- Developing a bespoke set of Systems Engineering roles associated with the necessary supporting competencies;
- Developing their own unique set of use cases for the competency models they derive from the competency framework (Gelosh, D., M. Heisey, J. Snoderly and K. Nidiffer 2017).

Systems Engineering is a broad discipline that interacts with all other engineering disciplines and as such can be deployed in a variety of ways. To support this, the INCOSE Competency Framework can be tailored to make it relevant and appropriate to a specific use. The terminology used in this document for different levels of competence may be relabeled as needed (e.g. to remove any reference to specific roles). The range of competencies encompassed by the Systems Engineering framework is very large and it is not expected that an individual will be operating at "Expert" or even "Lead Practitioner" level in more than a few of these competencies.

It is important therefore that this framework be used as the common starting point or baseline for tailoring the description of Systems Engineering relevant to an organization and individual. It is expected that an organization will have a set of roles, each with a profile against these competencies (or a tailored sub-set), with different levels of competence needed. These roles may well include requirements for expertise in other engineering skills and domain specific knowledge / experience. An important check for the enterprise will be to ensure that the roles are balanced (expertise not diluted and all key competencies covered) and the means of communication and integration of the roles understood – so that the "team" is appropriately competent in Systems Engineering (Beasley 2013).

Individual Professional Development

Individuals should tailor the framework as indicated above based on their specific or proposed future roles, and their current level of competence. This allows them to identify career progression exploiting their identified strengths and identification of personal development plans.

Enterprise Ability Development

To use the competency framework, an enterprise will need to review their requirements for the different competencies and competence levels and generate a scope for the skills required across the enterprise, in generic roles, within teams and at an individual level. These role specifications can then be mapped to existing and potential employees. These competencies provide a framework for career development and recruitment processes by describing the Systems Engineering skill requirements for a role.

This may require some specific tailoring of competencies to suit the needs of the enterprise. This tailoring can include:

- Combining competencies into definitions relevant / appropriate to the enterprise;
- Utilizing a subset of competencies depending on the specific activities of the organization.

An organization may wish to trace the tailoring back to this original framework, to enable benchmarking against other organizations, and to update in-line with changes to this source framework.

This framework can be adapted and integrated with other frameworks to describe specific roles in the organization. It is important that roles are profiled to define requirements, and then individuals assessed against / matched to the role, rather than starting with the individual.

A general test for completeness of role definitions is to check whether the full scope of Systems Engineering competencies defined within this framework is covered somewhere within the set of enterprise role definitions.

Other Tailoring Approaches

The INCOSE Systems Engineering Handbook Fourth Edition (INCOSE 2015), Chapter 8, "Tailoring Process and Application of Systems Engineering", describes several methods whereby organizations can tailor SE processes. These methods and approaches can also be used to help analyze and tailor this competency framework.

The technical report entitled *Atlas 1.1: An Update to the Theory of Effective*

Systems Engineers (Hutchison, et al. 2018), Section 5.2 Tailoring the Proficiency Framework, provides a general description and two examples of how a using organization can tailor the Atlas Proficiency Framework. These same tailoring approaches could be applied to this competency framework to derive a unique competency model to satisfy user needs.

THE RELATIONSHIP BETWEEN ROLES, JOB DESCRIPTIONS AND COMPETENCIES

A Competency Framework can be used to define Roles and Job descriptions. This section summarizes how this can be achieved.

Roles and Job descriptions are not the same thing. Merriam-Webster online (Merriam Webster 2018) defines each as follows:

- “Job”
  - A regular remunerative position;
  - A specific duty.
- “Role”
  - A function or part performed, especially in a particular operation or process.

One way to understand this distinction is through analogy. Imagine a hot dog vendor at a ballgame. Their “job” is to sell hot dogs. To do this, they are required to fulfil several distinct roles: driver, cook, server, cashier, salesperson (as well as accountant, business developer, marketing, legal representative, procurement etc.). To be effective in their job, individuals need to be competent in each of the many roles which make up their overall job scope.

It is often the case that some specific competencies required to discharge one role may be similar to those required by another role. Equally, some roles may demand a higher level of competence than others. For instance, the “cashier” and “salesperson” roles in the example above are likely to both require good “communications” skills, whilst the “accountant” and cashier roles both need some form of “math” competence, although the level expected from the accountant role is likely to be considerably higher than the cashier role.

Job descriptions also reflect the nature and scope of the enterprise and the way that it is set-up and operated. In a small enterprise, such as that of the hot dog vendor, many roles will be performed by a single individual. In large enterprises, roles may be performed by different people within the organization.

The situation is the same when defining job descriptions for Systems Engineers in an enterprise, project or team.

A competency based role statement defines a role not only in terms of what the person performing the role does (e.g. the processes followed) but the competencies required to execute those tasks. Looking at the level of involvement in each of the processes allows definition of the level of each competence needed.

Considerations when Defining Competency Based Role Statements

Every organization is different and will have different - and possibly incomplete - definitions of processes and competency as well as different organizational structures in which these are deployed. In addition, organizations evolve over time, requiring competencies and processes to evolve to match. The specifics of an individual role statement and which roles are appropriate (or not) within an organization is context dependent.

Annex C discusses this topic in more detail. It lists several important considerations when defining role statements. In summary, these are:

- Take account of the way the organization is structured;
- Consider the visibility of Systems Engineering within an organization and its relationship with other disciplines;
- Add any applicable domain specific competencies to ensure requirements reflect the domain;
- Adjust language and terminology to reflect organizational norms;
- Take account of the purpose of the role statement (e.g. role definition, career development).

COMPETENCE ASSESSMENT APPROACHES

Competence assessment can be implemented with one of three approaches (or combinations of these). These are analyzed in Table 2. The pros and cons of each basic approach need to be considered when determining the deployment approach for an organization.

Table 2 Comparison between Competency Assessment Régimes

METHOD	DESCRIPTION	BENEFITS	DISADVANTAGES
SELF-ASSESSMENT	Individuals are provided with a formal description of each competence area and competence level indicator by the organization, and independently determine what they believe their competence levels to be.	Reasonably cost-effective. Effort of assessment is split across the organization. Requires little support from the organization. Individuals can include experience which may not be well-known within their current organization. Can be used by individuals in organizations for career planning where Systems Engineering is not well-established.	Individuals may not understand the full scope of the competence, leading to potential overstating of their own competence. Equally individuals may also understate their competence, due to lack of awareness of self-confidence in competency areas. Organizational consistency is hard as individuals may self-assess to different standards. Individuals reluctant to accept Systems Engineering may over-score themselves to demonstrate they do not need development in this area.
MANAGER ASSESSMENT	Managers are provided with a formal description of each competence area and competence level indicator, and independently determine the individual competence levels of staff members for the purpose of training or job assignments. This could be with or without interview of the individual concerned.	Cost-effective. If managers understand the competencies and know their staff well, assessment can be a quick process. If managers use an interview-based technique this can be very accurate. The consistency of organizational assessment can be good, if managers are prepared well. Can be aligned well to organizational strategies – implemented through managers.	May be a burden to managers with large numbers of staff, or if the manager formally interviews individuals. If managers do not understand the full scope of the competencies, errors in ratings can occur (e.g. if a manager is not an expert in Systems Engineering). If managers do not know their staff well, assessment can be erroneous. Individuals may feel uncomfortable admitting a lack of competence to their manager or may feel stressed at the idea of assessment, which may influence accuracy. Managers may exhibit bias for/against an individual influencing outcome. Managers may not be aware of experience gained by individuals before they worked for the manager.
INDEPENDENT ASSESSMENT	Independent trained assessors (from inside or outside the organization) formally interview individual staff members to assess their competence. This is commonly deployed with two assessors to provide consistency and results analysis but can be achieved with just one or indeed three.	The use of trained assessors ensures candidates are put at ease, helping to ensure complete and honest responses. The use of trained assessors ensures an accurate reflection of the scope of competence areas and indicators in the framework. There is unlikely to be any subjective bias from knowing the history or circumstances of a candidate. The assessment is fact-based. Two or more assessors can further ensure consistency against the defined standards than one alone.	Can be quite expensive, especially if assessors are formally trained internally as part of the initiative to ensure their full understanding of the framework. Administration required to set-up interviews can be time consuming. Individuals may feel uncomfortable admitting a lack of competence if they feel they are being “judged” or may feel stressed at the idea of independent assessment, both of which may influence accuracy.

ATLAS 1.1 PROFICIENCY ASSESSMENTS

The Atlas 1.1 technical report (Hutchison, et al. 2018), Section 5.3 Proficiency Assessments, describes yet another method to assess proficiency. In a manner similar to this competency framework, the Atlas model assesses proficiency across five levels: Fundamental Awareness, Novice, Intermediate, Advanced, and Expert. The Atlas model uses radar maps to illustrate the evolving proficiency level profiles of individuals against the six proficiency areas. Using organizations could also use radar maps to assess the proficiency levels of individuals against the five competency areas or against a subset of the 36 competencies described in this competency framework.

Assessing the Assessors

Clearly, successful competence assessment relies upon those carrying out the assessment ("assessors") being competent themselves. How can this be achieved within an organization "new" to the discipline of Systems Engineering? Here are some general points to consider.

- Assessors should be trained in how to perform a competency-based interview. Competency-based assessment is not the same as merely asking questions about statements made in a résumé provided by the interviewee. Competency-based interviews search for evidence, not just for affirmations by the candidate. Put simply, one of the key skills of this form of assessment is to examine evidence of competency by asking "open" questions. (An open question is one which does not immediately elicit the response (" Yes" or "No"). Follow-up questions can probe further detail as necessary.
- Assessors should be selected for their ability to conduct the assessment in an open and constructive manner. This helps candidates to relax and should help ensure their responses are open and honest as well.
- Lack of a full understanding of the full scope and meaning of the competence and its associated competence indicators will undermine the assessment approach. Even a well-written competence framework can only help so far; it is necessary to understand, interpret and contextualize the framework for an organizational need.
  - Assessors may be highly-regarded experts within the organization's business domain but this does not guarantee they are experts in Systems Engineering.
  - There may be merit in seeking out training in the scope of the competency framework from Systems Engineering experts, to ensure that each competence area is properly understood by both assessors.
  - There may be merit in selecting assessors based upon formal Systems Engineering credentials. For example, INCOSE offers Certification at three levels. Ensuring that assessors have attained "Practitioner" or "Expert" level accreditation (i.e. "CSEP", "ESEP" levels) within the INCOSE Systems Engineering Professional (SEP) program (INCOSE, Certification 2018) would help ensure their knowledge and understanding of the full scope of Systems Engineering as defined within the framework was adequate to interpret the framework correctly.

ACRONYMS AND ABBREVIATIONS

ACRONYM	MEANING
ARCIFE	Accountable, Responsible, Consulted, Informed, Facilitator, Expert
BCS	British Computer Society
BKCASE	Body of Knowledge and Curriculum to Advance Systems Engineering project
CIO	Chief Information Officer [United Kingdom]
CIPD	Chartered Institute of Personnel Development [United Kingdom]
CMMI®	Capability Maturity Model® Integration [CMMI Institute]
CPD	Continued Professional Development
CSEP	Certified Systems Engineering Professional
CSEP-Acq	Certified Systems Engineering Professional (with Acquisition extension)
DAU	Defense Acquisition University [United States]
DoD	Department of Defense [United States]
DoDAF	Department of Defense Architecture Framework
EIA	Electronic Industries Alliance
ESEP	Expert Systems Engineering Professional
IEC	International Electrotechnical Commission
IEE	Institution of Electronics Engineering [now renamed Institution of Engineering and Technology (IET)]
IEEE	Institute of Electrical and Electronics Engineers

ACRONYM	MEANING
INCOSE	International Council on Systems Engineering
INCOSE UK Ltd.	UK Chapter of the International Council on Systems Engineering
ISO	International Standards Organization
JTC	Joint Technical Committee
KSA	Knowledge, Skills and Abilities
MOD	Ministry of Defence [United Kingdom]
NASA	National Aeronautics and Space Administration [United States]
NPS	Naval Postgraduate School
OPM	Office of Personnel Management [United States]
RACI	Responsible, Accountable, Consulted and Informed
SE	Systems Engineering
SEBoK	Guide to the Systems Engineering Body of Knowledge
SECCM	Systems Engineering Competency Career Model (US Navy)
SEP	(INCOSE) Systems Engineering Professional certification program
SFIA	Skills Framework for the Information Age
UCAM	Universal Competency Assessment Model
UK	United Kingdom
US	United States

GLOSSARY

This glossary defines words/phrases in the context of use within the 'Systems Engineering Competency Framework' and 'Guide to Competency Evaluation'. Several sources have been provided in some cases to aid explanation.

Where multiple potential definitions exist, the glossary definition is based upon definitions from the following sources, in the priority listed below:

1. INCOSE Systems Engineering Handbook (Fourth Edition) (INCOSE 2015);
2. INCOSE Systems Engineering Body of Knowledge (SEBoK) (BKCASE Project 2017);
3. INCOSE UK Ltd. Systems Engineering Competencies Framework (Issue 3) (INCOSE UK 2010);
4. Other well-established internationally-recognized sources;
5. INCOSE Competency Working Group.

GLOSSARY TERM	DEFINITION
Ability	A term used in human resource management denoting an acquired or natural capacity or talent that enables an individual to perform a particular task successfully (BusinessDictionary.Com 2018).
Architecture	(System) fundamental concepts or properties of a system in its environment embodied in its elements, relationships, and in the principles of its design and evolution (INCOSE 2015).
Architecting	Process of conceiving, defining, expressing, documenting, communicating, certifying proper implementation of, maintaining and improving an architecture throughout a system's life cycle (ISO/IEC/IEEE 2011). The architecting process sometime involves the use of heuristics to establish the form of architectural options before quantitative analyses can be applied. Heuristics are design principles learned from experience. (Rechtin, E 1990).
Authored	Wrote the document or work product (i.e. did not just sign the front page) (INCOSE UK 2010).
Behavior	The way in which one acts or conducts oneself, especially towards others. (Oxford Dictionaries 2018).
Best Practice	A procedure that has been shown by research and experience to produce optimal results and that is established or proposed as a standard suitable for widespread adoption (Merriam Webster 2018).
Capability	An expression of a system, product, function, or process ability to achieve a specific objective under stated conditions (INCOSE 2015). The ability to achieve a desired effect under specified (performance) standards and conditions through combinations of ways and means (activities and resources) to perform a set of activities. (DoD 2009).
Coaching	Helping, supporting, advising, explaining, demonstrating, instructing and directing others resulting in transfer of knowledge and skills (INCOSE 2015).
Competence	The measure of specified ability (INCOSE 2015).
Competence-based assessment	An evidence-based activity, where an individual is independently assessed (or self-assesses) in one or more defined areas, to determine whether they are able to demonstrate that their knowledge, skills and experience meet a defined or required level of proficiency ("competence level").

GLOSSARY TERM	DEFINITION
Competency	An observable, measurable set of skills, knowledge, abilities, behaviors, and other characteristics an individual needs to successfully perform work roles or occupational functions. Competencies are typically required at different levels of proficiency depending on the specific work role or occupational function. Competencies can help ensure individual and team performance aligns with the organization's mission and strategic direction. (U.S. Office of Personnel Management (OPM) 2015). A measure of an individual's ability in terms of their knowledge, skills, and behavior to perform a given role (Holt and Perry 2011).
Competent	Having a specified level of competence. (INCOSE UK 2010).
Complexity (of a Project)	A measure of how difficult it is to understand how a system will behave or to predict the consequences of changing it (Sheard and Mostashari 2009). The degree to which a system's design or code is difficult to understand because of numerous components or relationships among components (ISO/IEC 2009).
Configuration Management	Configuration Management is the discipline of identifying and formalizing the functional and physical characteristics of a configuration item at discrete points in the product evolution for the purpose of maintaining the integrity of the product system and controlling changes to the baseline (INCOSE 2017).
Discipline	Area of expertise e.g. systems, software, hardware, program management, quality assurance etc. (INCOSE UK 2010).
Domain	A problem space. (IEEE 2010).
Element	See system element.
Enterprise	One or more organizations sharing a definite mission, goals, and objectives to offer an output such as a product or service. (ISO 2000). An organization (or cross organizational entity) supporting a defined business scope and mission that includes interdependent resources (people, organizations and technologies) that must coordinate their functions and share information in support of a common mission (or set of related missions). (CIO Council 1999). The term enterprise can be defined in one of two ways. The first is when the entity being considered is tightly bounded and directed by a single executive function. The second is when organizational boundaries are less well defined and where there may be multiple owners in terms of direction of the resources being employed. The common factor is that both entities exist to achieve specified outcomes. (MOD 2004). A complex, (adaptive) socio-technical system that comprises interdependent resources of people, processes, information, and technology that must interact with each other and their environment in support of a common mission. (Giachetti, R. E 2010).
Enterprise Asset	(As applied to a person) known by reputation to be a leader in the field, highly valued, highly regarded. Recognized by the community outside employer organization (e.g. asked to be on conference panel, government advisory board etc.) (INCOSE UK 2010).
Framework	A basic conceptional structure (as of ideas). (Merriam Webster 2018). Broad overview, outline, or skeleton of interlinked items which supports a particular approach to a specific objective, and serves as a guide that can be modified as required by adding or deleting items. (BusinessDictionary.Com 2018).
Information	Information is an item of data concerning something or someone. Information includes technical, project, organizational, agreement and user information.
Interface	A point where two or more entities interact. Interactions may involve systems, system elements including their environment, organizations, disciplines, humans (users, operators, maintainers, developers etc.) or some combination thereof.
Job	A job is a recognized organizational position, usually performed in exchange for payment. Historically the terms "job" and "role" have been used interchangeably, more recently a distinction has appeared. A job comprises all, or parts, of one or more defined "roles" which govern organizational processes and activities. An individual may remain in the same "job" for a long period, but during this time will usually perform multiple roles. This topic is discussed in further detail in Annex C of this document.

GLOSSARY TERM	DEFINITION
Knowledge	(In the context of KSA) A body of information applied directly to the performance of a function. US Office of Personnel Management (Wikipedia 2017).
Mentoring	Mentoring is a relationship where a more experienced colleague shares their greater knowledge to support development of a less experienced member of staff. It uses many of the techniques associated with coaching. One key distinction is that mentoring relationships tend to be longer term than coaching arrangements.
Organization	A group of people and facilities with an arrangement of responsibilities, authorities and relationships (INCOSE 2015).
Professional Development	A structured approach to learning to help ensure competence to practice, taking in knowledge, skills and practical experience. Continued Professional Development (CPD) can involve any relevant learning activity, whether formal and structured or informal and self-directed (INCOSE UK Chapter 2017)
Project	An endeavor with defined start and finish criteria undertaken to create a product or service in accordance with specified resources and requirements (INCOSE 2015).
Program	A group of related projects managed in a coordinated way to obtain benefits and control not available from managing them individually. Programs may include elements of related work outside of the scope of the discrete projects in the program. (PMI 2008).
Recent	(In the context of competency assessment) Within the last five years (INCOSE UK 2010).
Role	A role is a recognized organizational position, usually performed in exchange for payment. Historically the terms “job” and “role” have been used interchangeably, more recently a distinction has appeared. A job comprises all, or parts, of one or more defined “roles” which govern organizational processes and activities. An individual may remain in the same “job” for a long period, but during this time will usually perform multiple roles. This topic is discussed in further detail in Annex C of this document.
Skills	(In the context of KSA) An observable competence to perform a learned psychomotor act. US Office of Personnel Management (Wikipedia 2017).
Specialty Engineering	(Verb) Analysis of specific features of a system that requires special skills to identify requirements and assess their impact on the system life cycle (INCOSE 2015). (Noun) Specialty Engineering is the collection of those narrow disciplines that are needed to engineer a complete system. (Elowitz, M 2006).
Stakeholder	A party having a right, share, claim, or vested interest in a system or in its possession of characteristics that meet that party’s needs and expectations (INCOSE 2015).
Stage (Lifecycle Stage)	A period within the life cycle of an entity that relates to the state of its description or realization. (ISO/IEC/IEEE 2015).
System	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. (INCOSE 2015).
Systems Engineering	Systems Engineering 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 lifecycle, 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. 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 user needs. (INCOSE 2004).
System Element	A member of a set of elements that constitutes a system. A system element is a discrete part of a system that can be implemented to fulfil specified requirements. A system element can be hardware, software, data, humans, processes (e.g., processes for providing service to users), procedures (e.g., operator instructions), facilities, materials, and naturally occurring entities (e.g., water, organisms, minerals), or any combination. (ISO/IEC/IEEE 2015).

GLOSSARY TERM	DEFINITION
Sub System	The level below the system of interest (INCOSE 2015). A system that is part of a larger system (Merriam Webster 2018).
Super System	The level above the system of interest (INCOSE 2015). A system that is made up of systems (Merriam Webster 2018).
System of Interest	The system whose life cycle is under consideration. (INCOSE 2015).
System of Systems	A System of Interest whose system elements are themselves systems; typically, these entail large□scale interdisciplinary problems with multiple, heterogeneous, distributed systems (INCOSE 2015).
Tailoring	Tailoring a process adapts the process description for a particular end. For example, a project creates its defined process by tailoring the organization's set of standard processes to meet the objectives, constraints, and environment of the project. (Adapted from notes/discussion of "tailoring guide") (ISO/IEC/IEEE 2009).
Team	A group of individuals who work together to achieve a common goal.
Verification	Provision of objective evidence that the system or system element fulfils its specified requirements and characteristics (INCOSE 2015).
Validation	Provision of objective evidence that the system, when in use, fulfils its business or mission objectives and stakeholder requirements, achieving its intended use in its intended operational environment. (INCOSE 2015).

BIBLIOGRAPHY

Beasley, R. 2013. *The need to tailor competency models – with a use case from Rolls-Royce.* INCOSE International Symposium IS2013.

BKCASE Project. 2017. *SEBoK v1.9 Section 5: Enabling Systems Engineering.* November 30. Accessed 2018. http://sebokwiki.org/wiki/Enabling_Systems_Engineering.

Brackett, Rivers, and Salovey. 2011. "Emotional Intelligence: Implications for Personal, Social, Academic, and Workplace Success." *Social and Personality Psychology Compass, Vol 5: Pages 88–103.* Accessed 2018. https://doi.org/10.1111/j.1751-9004.2010.00334.

BusinessDictionary.Com. 2018. *Framework definition.* Accessed April 2018. http://www.businessdictionary.com/definition/framework.html.

Chartered Institute of Personnel Development (CIPD) [UK]. 2018. "What are Coaching and Mentoring?" *Coaching and Mentoring Factsheet.* Accessed 2018. https://www.cipd.co.uk/knowledge/fundamentals/people/development/coaching-mentoring-factsheet#6995.

Chartered Institute of Personnel Development (CIPD). 2018. *Competence or competency?* https://www.cipd.co.uk/knowledge/fundamentals/people/performance/competency-factsheet#6374.

CIO Council. 1999. *Federal Enterprise Architecture Framework (FEAF).* Washington, DC, USA: Chief Information Officer (CIO) Council.

CMMI® Institute. 2010. *Capability Maturity Model Integration (CMMI®) V1.3.* CMMI® Institute.

Defense Acquisition University. 2013. *SPRDE Competency Model.* Defense Acquisition University (DAU)/U.S. Department of Defense, June 12.

DoD. 2009. *DoD Architecture Framework (DoDAF), version 2.0.* Washington, DC, USA: U.S. Department of Defense (DoD).

Electronic Industries Alliance. 2002. *Systems Engineering Capability Model EIA731_1:2002.* EIA.

Elowitz, M. 2006. *Specialty Engineering as an Element of Systems Engineering.* Albequerque, NM, USA: Presentation to Enchantment Chapter, INCOSE. Albequerque, NM, USA, August 9.

Gelosh, D., M. Heisey, J. Snoderly and K. Nidiffer. 2017. *Version 0.75 of the Proposed INCOSE Systems Engineering Competency Framework.* Proceedings of the International Symposium 2017 of the International Council on Systems Engineering (INCOSE).

Giachetti, R. E. 2010. *Design of Enterprise Systems: Theory, Architecture, and Methods.* Boca Raton, FL, USA: CRC Press, Taylor and Francis Group.

GOV.UK. 2017. *Equality Act 2010: guidance.* https://www.gov.uk/guidance/equality-act-2010-guidance#age-discrimination.

Hahn and Whitcomb. 2017. *Use Cases for the INCOSE Competencies Framework.* Unpublished.

Holt and Perry. 2011. *A Pragmatic Guide to Competency Tools, Frameworks and Assessment.* BCS.

Hutchison, N., D. Verma, P. Burke, M. Clifford, R. Giffin, and S. Luna. 2018. *Atlas 1.1: An Update to the Theory of Effective Systems Engineers (Technical Report SERC-2018-TR-101A).* Report, Hoboken, NJ: Systems Engineering Research Center, Stevens Institute of Technology. Accessed 2018. http://www.dtic.mil/dtic/tr/fulltext/u2/1046509.pdf.

IEEE. 2010. *IEEE 1570-2010 Standards for Information Technology.* Standard, New York, NY, USA: Institute of Electrical and Electronics Engineers.

INCOSE. 2014. *A World in Motion - Systems Engineering Vision 2025.* San Diego: INCOSE.

—. 2018. *Certification.* Accessed 2018. https://www.incose.org/certification.

—. 2017. *SEBoK v1.9 Systems Engineering Body of Knowledge.* November 30. http://www.sebokwiki.org/wiki/Guide_to_the_Systems_Engineering_Body_of_Knowledge_(SEBoK).

—. 2015. *Systems Engineering Handbook - A Guide for System Life Cycle Processes and Activities Fourth Edition.* San Diego: Wiley.

INCOSE UK Chapter. 2017. "U3: What is Continuing Professional Development (CPD)." Feburary. Accessed 2018. https://incoseonline.org.uk/Documents/uGuides/dot107_U-guide_U3_WEB.pdf.

INCOSE UK. 2010. *INCOSE UK SE Competency Framework/Guide.* INCOSE UK.

INCOSE. 2004. *What is Systems Engineering?* Accessed April 2018. http://www.incose.org/practice/whatissystemseng.aspx.

INCOSE, OMG. 2018. *MBSE Wiki.* Accessed April 2018. http://www.omgwiki.org/MBSE/doku.php.

Institution of Engineering and Technology. 2013. *Competency Framework for Independent Safety Assessors (ISAs).* November 17. Accessed February 19, 2018. https://www.theiet.org/factfiles/isa/index.cfm.

ISO. 2000. *ISO 15704. 2000. Industrial Automation Systems -- Requirements for Enterprise-Reference Architectures and Methodologies.* Standard, Geneva, Switzerland:: International Organization for Standardization (ISO).

ISO/IEC. 2009. *ISO/IEC 24765. Systems and Software Engineering Vocabulary (SEVocab).* Standard, Geneva, Switzerland: International Organization for Standardization (ISO)/International Electrotechnical Commission (IEC) [database online].

ISO/IEC JTC 1/SC 7 Software and Systems Engineering Technical Committee. 2015. *ISO/IEC/IEEE 15288:2015 Systems and software engineering -- System life cycle processes.* ISO/IEC.

ISO/IEC/IEEE. 2009. *ISO/IEC/IEEE 24765:2009 Systems and Software Engineering - System and Software Engineering Vocabulary.* Geneva: International Organization for Standardization (ISO)/ International Electrotechnical Commission (IEC)/ Institute of Electrical and Electronics Engineers (IEEE).

—. 2011. *ISO/IEC/IEEE 42010 Systems and software engineering - Architecture Description.* Geneva, Switzerland: International Organization for Standardization (ISO)/International Electrotechnical Commission (IEC)/Institute of Electrical and Electronics Engineers (IEEE).

—. 2015. *ISO15288 : Systems and Software Engineering -- System Life Cycle Processes.* Geneva, Switzerland: International Organisation for Standardisation / International Electrotechnical Commissions / Institute of Electrical and Electronics Engineers. ISO/IEC/IEEE.

Kendall, F. 2014. *US DoD's Better Buying Power 3.0 Implementation Plan.* White Paper, Office of the Under Secretary of Defense Acquisition, Technology and Logistics .

Mayer, John D., and Peter Salovey. 1997. ""What is Emotional intelligence?"." In *Emotional Development and Emotional Intelligence: Educational implications*, by Edited by Peter Salovey and David J. Sluyter, 3-31. New York: Harper Collins.

Merriam Webster. 2018. *Dictionary by Merriam Webster.* Accessed 2018. https://www.merriam-webster.com/.

MOD. 2004. *Ministry of Defence Architecture Framework (MODAF), Version 2. .* London, UK: : U.K. Ministry of Defence.

National Aeronautics and Space Administration (NASA). 2016. *NASA Systems Engineering Handbook (SP-2016-6105, Rev 2).* NASA.

Oxford Dictionaries. 2018. *Definition: behaviour (US: behavior).* Accessed April 2018. https://en.oxforddictionaries.com/definition/behaviour.

PMI. 2008. *A Guide to the Project Management Body of Knowledge (PMBOK® Guide), 4th Edition.* Newtown Square, PA, USA: Project Management Institute (PMI).

Prati, Melita, Douglas, Ferris, Ammeter, Buckley. 2003. "Emotional Intelligence, Leadership Effectiveness, and Team Outcomes." *The International Journal of Organizational Analysis Vol 11, No. 9* 21-40.

Presland, I. 2017. *Comparison of SEP Technical Areas with Version 4 Framework Competencies performed for Certification Advisory Group.* Unpublished - Internal INCOSE Document, June.

Rechtin, E. 1990. *Systems Architecting: Creating & Building Complex Systems.* Upper Saddle River, NJ, USA: Prentice-Hall.

Rumsfeld, D. 2012. *There are known knowns.* Briefing at United States Defence Department, 12 February 2002, Wikipedia. Accessed 2018.

Salovey, Peter and John D. Mayer. 1990. "Emotional Intelligence." *Imagination, Cognition and Personality 9, No. 3* 185-211.

SFIA Foundation. 2014. *Skills Framework for the Information Age (V6).* https://www.sfia-online.org/en/sfia-6.

Sheard and Mostashari. 2009. "Principles of Complex Systems for Systems Engineering." *Systems Engineering, 12(4)* 295-311.

Sheard, S. 1996. "12 Systems Engineering Roles." *INCOSE International Symposium .* Boston MA, USA: INCOSE.

U.S. Office of Personnel Management (OPM). 2015. *Human Capital Assessment and Accountability Framework (HCAAF) Resource Center, "Glossary".* Accessed June ., 2015. http://www.opm.gov/hcaaf_resource_center/glossary.asp.

Whitcomb, Khan, and White. 2014. *Development of a System Engineering Competency Career Model: An Analytical Approach Using Bloom's Taxonomy.* Technical Report, US Naval Postgraduate School.

Wikipedia. 2017. *Knowledge, Skills and Abilities.* https://en.m.wikipedia.org/wiki/Knowledge,_Skills,_and_Abilities.

Williams and Reyes. 2012. *Technical Leadership in Systems Engineering.* Accessed 2018. SEBoKwiki.org/wiki/Technical_Leadership_in_Systems_Engineering.

ANNEX A: MAPPING OF THE NEW FRAMEWORK TO ISSUE 3 FRAMEWORK

The INCOSE Systems Engineering Competency Framework is a new development based in part on the 'Systems Engineering Competencies Framework' and 'Guide to Competency Evaluation' originally created by INCOSE UK Ltd. and published as "Issue 3" in 2010 (INCOSE UK 2010).

Figure 2 represents a mapping of new framework competencies to Issue 3 competencies. The mapping is not intended to be a full traceability statement, but is designed primarily to provide guidance to those currently using Issue 3 who would like to understand the implications and changes necessary to migrate/upgrade to this new framework.

The following points should be noted:

- Whilst the "scope" of Systems Engineering has not been redefined between Issue 3 and this new framework, some areas deliberately omitted in Issue 3 have been addressed for the first time in this new framework.
- In some areas, the mapping between the two frameworks is subjective; some Issue 3 competence areas have been divided into multiple competencies in the new framework whilst the scope of other competence areas has been redefined.

In this figure:

✓✓✓ The Issue 3 competency area definition is broadly encompassed within the new competence area framework definition.

✓ The Issue 3 competency area has a limited, or implicit relationship to the new framework area or is split across multiple areas.

- Shaded columns reflect competence areas which did not form part of the scope of Issue 3 (e.g. behaviors).

New Framework Competency Areas		CORE COMPETENCIES						PROFESSIONAL COMPETENCIES								TECHNICAL COMPETENCIES									MANAGEMENT COMPETENCIES									INTEGRATING COMPETENCIES			
Framework (issue 3) Competency Areas		Systems Thinking	Lifecycles	Capability Engineering	General Engineering	Critical Thinking	Systems Modelling and Analysis	Communications	Ethics and Professionalism	Technical Leadership	Negotiation	Team Dynamics	Facilitation	Emotional Intelligence	Coaching and Mentoring	Requirements Definition	System Architecting	Design for…	Integration	Interfaces	Verification	Validation	Transition	Operation and Support	Planning	Monitoring and Control	Decision Management	Concurrent Engineering	Business & Enterprise Integration	Acquisition and Supply	Information Management	Configuration Management	Risk and Opportunity Management	Project Management	Finance	Logistics	Quality
SYSTEMS THINKING	System Concepts	✓✓✓																																			
	Super-System Capability Issues			✓✓✓																										✓							
	Enterprise and Technology Environment																												✓✓✓								
SE HOLISTIC LIFECYCLE	Determining and Managing Stakeholder Requirements															✓✓✓														✓							
	System Design - Architectural Design																✓✓✓																				
	System Design - Concept Generation																✓✓✓																				
	System Design - Design for …																	✓✓✓																			
	System Design - Functional Analysis																✓✓✓																				
	System Design - Interface Management																			✓✓✓										✓	✓	✓					
	System Design - Maintain Design Integrity																		✓	✓				✓							✓	✓					
	System Design - Modelling and Simulation						✓✓✓																														
	System Design - Select Preferred Solution																✓										✓										
	System Design - System Robustness																		✓	✓	✓	✓		✓													
	Systems Integration & Verification																		✓		✓																
	Validation																					✓✓✓															✓
	Transition to Operation																						✓	✓						✓							
SE MANAGEMENT	Concurrent Engineering																											✓✓✓		✓				✓		✓	
	Enterprise Integration																												✓✓✓					✓	✓	✓	✓
	Integration of Specialisms																	✓✓✓	✓	✓									✓✓✓					✓	✓	✓	✓
	Lifecycle Process Definition		✓✓✓																											✓				✓			✓
	Planning, Monitoring and Controlling																								✓	✓				✓			✓	✓	✓	✓	✓

Figure 2 Mapping of New Framework Competencies to "Issue 3" Framework Competencies

ANNEX B: ALIGNMENT WITH INCOSE AND OTHER INITIATIVES

INCOSE SYSTEMS ENGINEERING HANDBOOK FOURTH EDITION

The INCOSE Systems Engineering Handbook, Fourth Edition (INCOSE 2015) describes the discipline, the practice and the processes that need to be carried out when doing Systems Engineering. Competencies are the specific abilities needed by individuals to perform the processes and conduct “good” Systems Engineering. Competency is the specific ability needed by an individual to support / contribute to the execution of Systems Engineering processes.

Competency provides a different perspective to Systems Engineering to the process view. Combining process and competency gives a more complete view of what is needed by both organizations and individuals to achieve the benefits of Systems Engineering.

There are many Systems Engineering processes and they are performed by teams of individuals. Understanding the relationships among the processes and competencies helps to assign process activities and the aligned supporting competencies to the individuals in those teams.

The general relationships between competencies defined in this framework and processes defined in the handbook are shown in Figure 3. This figure is primarily intended for those seeking guidance in this area as the mappings is somewhat subjective: many of the relationships are not one-to-one; competencies may underpin more than one process and their linkage is complex.

In this figure, the following key applies:

✓✓✓ The framework competency definition has a significant relationship with the reference handbook process.

✓ The framework competency definition has a relationship to the reference handbook process, but this is somewhat limited.

Note that Figure 3 does not attempt to map professional competencies. These are only briefly addressed in handbook (Chapter 2), which is primarily a technical document.

INCOSE SE Handbook Processes / New Framework Competency Areas		TECHNICAL PROCESSES														TECHNICAL MANAGEMENT PROCESSES								AGREEMENT PROCESSES		ORGANIZATIONAL PROJECT-ENABLING PROCESSES					
		Business or mission analysis	Stakeholder needs and requirements definition	System requirements definition	Architecture definition	Design definition	System analysis	Implementation	Integration	Verification	Transition	Validation	Operation	Maintenance	Disposal	Project planning	Project assessment and control	Decision management	Risk management	Configuration management	Information management	Measurement	Quality assurance	Acquisition	Supply	Life cycle model management	Infrastructure management	Portfolio management	Human resource management	Quality management	Knowledge management
Core SE principles	Systems Thinking	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓	✓	✓✓✓	✓✓✓	✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓	✓	✓		✓	✓	✓	✓	✓	✓✓✓	✓	✓	✓	✓	✓
	Lifecycles	✓	✓	✓	✓		✓	✓✓✓	✓	✓✓✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓			✓	✓	✓✓✓		✓			
	Capability Engineering	✓	✓✓✓	✓	✓	✓	✓		✓✓✓	✓	✓	✓✓✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓✓✓	✓	✓	✓
	General Engineering	✓	✓✓✓	✓	✓✓✓	✓✓✓	✓✓✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓✓✓		✓										✓
	Critical Thinking	✓	✓✓✓	✓	✓✓✓	✓✓✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓✓✓	✓✓✓	✓✓✓		✓	✓	✓✓✓							✓✓✓	✓
	Systems Modelling and Analysis	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓✓✓	✓	✓					✓	✓		✓	✓	✓
Professional Competencies	Communications																														
	Ethics and Professionalism																														
	Technical Leadership																														
	Negotiation																														
	Team Dynamics																														
	Facilitation																														
	Emotional Intelligence																														
	Coaching and Mentoring																														
Technical Competencies	Requirements Definition	✓✓✓	✓✓✓	✓✓✓	✓					✓		✓	✓	✓	✓				✓		✓		✓✓✓	✓	✓					✓✓✓	
	System Architecting		✓		✓✓✓	✓✓✓																									
	Design for…					✓✓✓	✓✓✓																✓			✓				✓✓✓	
	Integration				✓	✓	✓	✓✓✓	✓✓✓																						
	Interfaces		✓		✓	✓			✓																						
	Verification									✓✓✓																					
	Validation	✓	✓									✓✓✓																			
	Transition										✓✓✓															✓✓✓					
	Operation and Support			✓	✓✓✓	✓✓✓	✓✓✓											✓													
SE Management Competencies	Planning		✓	✓		✓	✓	✓	✓✓✓	✓	✓✓✓	✓✓✓				✓✓✓			✓							✓		✓			
	Monitoring and Control							✓	✓	✓	✓	✓		✓			✓✓✓	✓	✓			✓✓✓									
	Decision Management				✓✓✓	✓✓✓		✓										✓✓✓			✓		✓								
	Concurrent Engineering			✓	✓	✓	✓	✓	✓	✓						✓	✓				✓✓✓										
	Business & Enterprise Integration	✓✓✓	✓					✓			✓		✓	✓	✓						✓						✓✓✓	✓	✓✓✓	✓✓✓	✓✓✓
	Acquisition and Supply			✓✓✓				✓✓✓	✓									✓	✓	✓				✓✓✓	✓✓✓						
	Information Management	✓	✓	✓	✓	✓	✓		✓	✓✓✓		✓	✓	✓	✓						✓✓✓										✓
	Configuration Management				✓	✓	✓		✓	✓✓✓	✓	✓	✓	✓						✓✓✓											
	Risk and Opportunity Management		✓													✓✓✓	✓✓✓	✓	✓✓✓	✓	✓							✓✓✓			
Integrating Competencies	Project Management		✓													✓✓✓	✓✓✓		✓					✓	✓	✓	✓	✓✓✓	✓		
	Finance	✓																													
	Logistics																			✓	✓			✓	✓✓✓		✓				
	Quality	✓	✓	✓																			✓✓✓	✓✓✓	✓✓✓					✓✓✓	

Figure 3 Mapping of SE Handbook Processes to Framework Competencies

INCOSE

INCOSE SYSTEMS ENGINEERING PROFESSIONAL (SEP) CERTIFICATION PROGRAM

The INCOSE Systems Engineering Professional (SEP) Certification program (INCOSE 2018) is another important initiative for alignment.

At "Practitioner" level status, to acquire Certified Systems Engineering Professional or CSEP designation, this program requires applicants to demonstrate knowledge and experience in 14 Systems Engineering "Technical Areas" . This is supplemented by a "knowledge examination" based upon the INCOSE Systems Engineering handbook (INCOSE 2015)

To acquire Expert Systems Engineering Professional (ESEP) designation, the requirements for demonstrable experience are made significantly broader and are supplemented with an additional requirement to demonstrate technical leadership within the Systems Engineering profession. (NOTE: There is currently no "knowledge" examination at this level, however).

Clearly, these concepts of demonstrating "knowledge and experience" bear a resemblance to demonstrating competence, although the SEP program does not currently employ the assessment-based approach to validating competence identified in this framework.

As part of a Certification Advisory Group (CAG) initiative to improve alignment of the SEP program to other INCOSE products, in June 2017 the SEP Technical Areas were compared against the proposed 36 competencies contained within the New framework (Presland, I 2017). The results of this comparison are shown in Figure 4.

In this figure, the following key applies:

✓✓✓ The SEP technical area has an extensive or significant overlap with the framework competency area.

✓ The SEP technical area has a more limited, or implicit relationship to the framework competency area or is encompassed by multiple areas.

Greyed-out cells indicate professional competencies covered formally only as part of Expert-level INCOSE designation. These competencies are not expected to be demonstrated at "Practitioner" (i.e. Certified Systems Engineering Professional or CSEP) level.

Figure 4 is a primarily intended a subjective mapping provided for those seeking guidance in this area. However, it suggests all SEP Technical Areas are covered by at least one of the competencies within the Competency Framework.

NOTE: The SEP Technical Area "Other" is designed primarily to capture experience not classifiable by an applicant into one of the other 13 technical areas. Such experience (if deemed to be "Systems Engineering") will normally be re-classified by application reviewers into one or more of the other 13 Technical Areas, meaning that coverage of "other" as a technical area is not required.

New Framework Competency Areas / **SEP Program Technical Areas**

SEP Program Technical Areas	CORE SE PRINCIPLES: Systems Thinking	Lifecycles	Capability Engineering	General Engineering	Critical Thinking	Systems Modelling and Analysis	PROFESSIONAL COMPETENCIES: Communications	Ethics and Professionalism	Technical Leadership	Negotiation	Team Dynamics	Facilitation	Emotional Intelligence	Coaching and Mentoring
Requirements Engineering	✓✓✓	✓	✓✓✓	✓	✓	✓✓✓	✓	✓		✓✓✓				
Systems and Decision Analysis	✓✓✓		✓	✓	✓	✓✓✓	✓	✓						
Architecture/Design Development	✓✓✓		✓✓✓	✓	✓	✓✓✓	✓	✓		✓				
Systems Integration	✓		✓✓✓	✓	✓	✓✓✓	✓	✓						
Verification and Validation	✓		✓	✓	✓	✓✓✓	✓	✓		✓✓✓				
System Operation and Maintenance	✓	✓	✓	✓	✓	✓	✓	✓						
Technical Planning	✓✓✓		✓	✓	✓		✓	✓		✓				
Technical Monitoring and Control	✓✓✓		✓	✓	✓	✓	✓	✓		✓				
Acquisition and Supply	✓	✓	✓✓✓	✓	✓		✓	✓		✓✓✓				
Information and Configuration Management	✓	✓	✓	✓	✓		✓	✓						
Risk and Opportunity Management	✓✓✓		✓✓✓	✓	✓	✓✓✓	✓	✓						
Lifecycle Process Definition and Management	✓	✓✓✓	✓	✓	✓		✓	✓						
Specialty Engineering	✓✓✓		✓	✓	✓	✓✓✓	✓	✓						
Organizational Project Enabling Activities	✓✓✓		✓	✓	✓		✓	✓		✓				
Other														

SEP Program Technical Areas	TECHNICAL COMPETENCIES: Requirements Definition	System Architecting	Design for…	Integration	Interfaces	Verification	Validation	Transition	Operation and Support
Requirements Engineering	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓	✓✓✓
Systems and Decision Analysis	✓✓✓	✓	✓						
Architecture/Design Development	✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓	✓		✓
Systems Integration	✓	✓✓✓	✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓	
Verification and Validation	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓
System Operation and Maintenance			✓		✓			✓✓✓	✓✓✓
Technical Planning	✓	✓		✓✓✓	✓	✓	✓	✓	✓✓✓
Technical Monitoring and Control			✓						✓✓✓
Acquisition and Supply	✓✓✓	✓✓✓	✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓		✓
Information and Configuration Management	✓	✓		✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓
Risk and Opportunity Management	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓
Lifecycle Process Definition and Management			✓✓✓	✓		✓	✓	✓	
Specialty Engineering	✓	✓	✓✓✓	✓	✓	✓✓✓	✓✓✓	✓	✓
Organizational Project Enabling Activities	✓			✓	✓				✓
Other									

SEP Program Technical Areas	SE MANAGEMENT COMPETENCIES: Planning	Monitoring and Control	Decision Management	Concurrent Engineering	Business & Enterprise Integration	Acquisition and Supply	Information Management	Configuration Management	Risk and Opportunity Management	INTEGRATING COMPETENCIES: Project Management	Finance	Logistics	Quality
Requirements Engineering	✓✓✓	✓	✓		✓	✓✓✓	✓	✓	✓✓✓	✓		✓	✓
Systems and Decision Analysis	✓	✓	✓✓✓						✓	✓	✓	✓	✓
Architecture/Design Development			✓	✓	✓	✓✓✓	✓	✓	✓✓✓				
Systems Integration			✓	✓	✓	✓✓✓	✓	✓	✓✓✓				✓
Verification and Validation	✓	✓	✓	✓	✓	✓✓✓	✓	✓	✓✓✓	✓		✓✓✓	✓✓✓
System Operation and Maintenance	✓✓✓	✓✓✓	✓	✓✓✓	✓	✓	✓✓✓	✓✓✓	✓	✓		✓✓✓	✓✓✓
Technical Planning	✓✓✓	✓	✓	✓✓✓	✓	✓✓✓	✓	✓	✓✓✓	✓✓✓	✓✓✓	✓	✓
Technical Monitoring and Control	✓✓✓	✓✓✓	✓	✓	✓	✓			✓	✓✓✓	✓✓✓	✓	✓
Acquisition and Supply	✓✓✓	✓✓✓	✓	✓✓✓		✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓	✓	✓	✓✓✓
Information and Configuration Management		✓✓✓	✓		✓	✓✓✓	✓✓✓	✓✓✓	✓	✓✓✓		✓	✓
Risk and Opportunity Management	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓	✓✓✓			✓✓✓	✓✓✓	✓✓✓	✓	✓
Lifecycle Process Definition and Management	✓✓✓	✓	✓	✓✓✓	✓	✓	✓	✓	✓	✓✓✓		✓	✓
Specialty Engineering	✓	✓	✓	✓	✓	✓✓✓	✓	✓	✓			✓✓✓	✓✓✓
Organizational Project Enabling Activities	✓✓✓	✓✓✓	✓	✓	✓✓✓		✓	✓	✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓
Other													

Figure 4 Comparison of SEP Technical Areas to New Framework Competencies

INCOSE VISION 2025 ROLES AND COMPETENCIES

The INCOSE publication "A World in Motion Systems Engineering Vision 2025" (INCOSE 2014) contains a section devoted to "Roles and Competencies." This section highlights that to be successful, all leaders should be systems thinkers and all systems engineers need to possess a broad set of socio-technical and technical leadership skills. The section goes on to suggest that an additional set of competencies is necessary to support the expanded roles of the future systems engineer: software-based tools, systems and specialty engineering methods, Systems Engineering foundations, full system life cycle experience, and domain specific application and technical knowledge. This INCOSE Competency Framework update aligns well with the intent of the Vision 2025 document and covers most of the suggested competencies. The Competency Framework is especially well-aligned in the areas of technical leadership and other professional competence areas.

INCOSE MODEL-BASED SYSTEMS ENGINEERING INITIATIVE

The INCOSE Model-Based Systems Engineering (MBSE) initiative is an important direction for Systems Engineering and is a key plank of the INCOSE strategic direction. An overview of this initiative can be found at (INCOSE, OMG 2018). This competency framework fully supports this initiative in two key ways.

Firstly, Systems Modeling and Analysis has been added as a core competency in this new framework, recognizing its importance to both current and future direction of Systems Engineering. Within the competence definition it is recognized that modeling is more than just the skills to run modelling software; it includes the "modeling mindset" and the ability not only to produce appropriate models, but also to understand their purpose and to use their output effectively.

Secondly, INCOSE recognizes that models will be used increasingly to support all aspects of Systems Engineering: concept generation; requirements elicitation; use cases; architecture; detailed analysis; integration; verification; validation; and in support of operation and maintenance. Systems Engineers will be required to couple modeling skills with the relevant technical competencies, in order to ensure that the model they produce is useful. Furthermore, Systems Engineering Management competencies will be required to control the scope and production of models through planned activities, and Professional Competencies will assist in the creation of effective models and communication of results to all parties.

ATLAS PROFICIENCY MODEL

The technical report entitled: Atlas 1.1: An Update to the Theory of Effective Systems Engineers (Hutchison, et al. 2018), describes the Atlas Proficiency Model developed by the Systems Engineering Research Center. Section 5.4 of the technical report compares the Atlas Proficiency Model with the draft INCOSE Competency Framework Version 0.75. The set of competencies in this final Competency Framework are the same as in Version 0.75 so the comparison remains valid. Section 5.4 also states that: “Overall, the Helix team found that though the different approaches taken led to different grouping of knowledge, skills, and abilities, the INCOSE 0.75 Competency Model and the Atlas proficiency model aligned well.”

ANNEX C: DEFINING ROLES USING THE FRAMEWORK

INTRODUCTION

The purpose of this Annex is to describe the typical structure of a generic role statement within an organization.

It uses a competency based approach, utilizing the Systems Engineering competencies defined in this framework, and their relationship to the Systems Engineering processes defined in the INCOSE Systems Engineering Handbook (INCOSE 2015).

The resulting role statements can be used for recruitment, promotion, planned and /or individual development as described earlier. The Annex is generic to help deployment within a wide range of organizations.

A competency based role statement can be considered as a set of "requirements" for individuals (components) who make up the enterprise (the system). It defines the role not only in terms of what the person in the role does (e.g. the processes followed) but also the competencies required to follow those processes. Looking at the level of involvement in the processes allows definition of the level of each competence needed. Further information on the topic is available from Section 5 of BKCASE "Enabling Systems Engineering" (BKCASE Project 2017).

The structure of the rest of this section is as follows:

- A list of key considerations. Major points, issues, assumptions to address when defining competency based role statements.
- The recommended structure for a role statement. This is built from the competency framework and defined Systems Engineering processes.
- Guidance on defining competence levels within a role statement. Competence levels depend upon the level of engagement with the generic Systems Engineering processes needed for the role.
- Guidance on the tailoring of generic role statements to real organizations. This extends the generic approach to real-world organizations, where competencies and processes may not be those included in the INCOSE Competency Framework and the INCOSE Systems Engineering Handbook.

CONSIDERATIONS WHEN DEFINING ROLE STATEMENTS

Every organization is different, and will have different - and possibly incomplete - definitions of processes and competencies as well as different organizational structures in which these are deployed. In addition, organizations evolve over time, requiring competencies and processes to evolve to match. Development of generic role descriptions should bear these points in mind. We are after all dealing with the most variable element in an organization – its people.

Role statements can be used for a variety of purposes. There is no right or wrong purpose and no right or wrong roles within an organization. Both are context dependent.

Whatever the purpose, the following should be noted:

A job description is different from a role statement. A role statement is part of an organization design, whereas a job description may comprise a combination of roles adapted to the specific needs of the organization and the strengths of any individual. An individual's job may require them to perform several different roles.

- Ideally roles defined within an organization need to form an integrated whole. However, whilst organizational structures vary: some organizations will have a Systems Engineering department; others make Systems Engineering competency core to all roles. Organizational structure will affect the way roles interact with each other.
- As Systems Engineering is an "integrating" discipline any role statement covering Systems Engineering is likely to contain domain specific competencies.
- Tailoring of the INCOSE competency framework and of the terminology within it needs to reflect the needs, language, approaches and priorities appropriate to an organization is to be expected. A good example of such tailoring is to be found in the paper "The need to tailor competency models – with a use case from Rolls-Royce" (Beasley 2013) which was produced for the INCOSE Competency Working Group.
- Role statements can be used to support many different purposes; the purpose of creating a role statement must be clear when it is created. In some organizations, role statements are "entry level" (i.e. competencies are required to be, mostly, "met" to get the job), or they can define "stretch targets" challenging an individual to perform the role beyond expectations (i.e. they are used as guidance supporting ongoing professional development).
- The relationship between role, reward and position within the organization needs to be carefully considered. Linking competence directly to reward can be dangerous (make honest self-assessment hard). Different roles may be undertaken during the development of a career (e.g. some may provide essential breadth of experience to enable an individual to take on a more senior role). Some valuable additional information on this topic can be obtained from the Helix (Hutchison, et al. 2018) research program.

In summary, when defining role statement, we need to ensure

- their purpose is understood;
- the way the organization integrates Systems Engineering with other disciplines (e.g. Program Management, Sales, etc.) is understood;
- the role definition aligns with organizational HR policies and terminology

ROLE STATEMENT STRUCTURE

It is recommended that a typical generic role statement should include the following elements:

- **Role name** – The title of the role, which should describe the role succinctly.
- **Role purpose** – This should provide the primary aim of the role, ideally in just one or two sentences.
- **Activities performed** – This should be an accountability statement for the role.
  - List the process activities that the role does. Any role may do a range of activities, or focus (specialize) on just one. Other, non-Systems Engineering processes used in the organization should be included as needed.
  - The level of accountability should be defined by applying (or consulting) a responsibility and accountability matrix (e.g. a RACI or similar)
  - Generic activities that can be defined external to the process or specific applications or instances of the process can be included.
- **Competencies required (highest level)**
  - These should be divided into the groups defined in this framework.
  - The overall level should be built by assessing the competencies needed for each activity, taking the highest level from all activities within each competence area

- **Other constraints or preferences for role**
  - e.g. licenses, qualifications, specific experiences or domain knowledge needed.
  - The contents of this section will be specific to the organization.

ASSIGNING COMPETENCIES TO A ROLE STATEMENT

This section provides generic guidance in the definition of competencies, and associated competence levels for a role statement. Any real-world implementation will also have to address organizational concerns. This is addressed later.

Figure 3 in Annex A provides a mapping of framework competencies to INCOSE Systems Engineering processes. Any role will require its holder to be competent in several processes. The competencies associated with each process can be derived from this figure. The level of competence expected within a role will be determined by considering the nature of the involvement in the process using Figure 3 in combination with Figure 5, the ARCIFE model.

ARCIFE (Accountable, Responsible, Consulted, Informed, Facilitator, Expert) analysis is a refinement on the standard RACI (Responsible, Accountable, Consulted, Informed) analysis for engagement in an activity. This considers some of the specifics of the nature of aspects of Systems Engineering (notably the integration of specialist glue role referred to by Sheard in12 Systems Engineering Roles (Sheard, S 1996). It is not uncommon for some Systems Engineering roles to be heavily involved with helping other Engineers do Systems Engineering activities.

The ARCIFE terms are defined below:

- **A – Accountable** Leadership, making sure the activity is done, and done right. Often the accountable person delegates the actual doing. There should only be one accountable person for a specific activity / issue.
- **R – Responsible** People (maybe different roles) that do the activity (so if the output of the activity is a report, these are the authors). Responsibility can be shared in a team.
- **C – Consulted** Engaged in the work; may provide input, or (more likely) either apply specific technical / domain knowledge to assist with the activity, or they use / act on the outcome of the process and influence it
- **I – Informed** Needs to know either that the work product is produced, or the outcome (or part of outcome and decision from process activity.

The next two terms are in a different dimension to the level of descending importance above. To embed Systems Engineering individuals may have to help the team apply specific SE techniques, or define and develop best practice.

- **F – Facilitator / Coach** – Lead workshops or discussions applying Systems Approach (with people from other skills) and build consolidated and agreed models. This aspect includes sufficient expertise and knowledge in Systems Approach (process and techniques) to select the most appropriate for the situation, considering both the nature of the system of interest, and for the “systems” competence and experience of the team they are working with.
- **E – Expert** – Develops / explains or teaches methods and process in this area, and advances the state of the art. Considered a specialist in the competency.

Once the level of ARCIFE involvement is determined then the competency level can be determined using Figure 5 as a starting point.

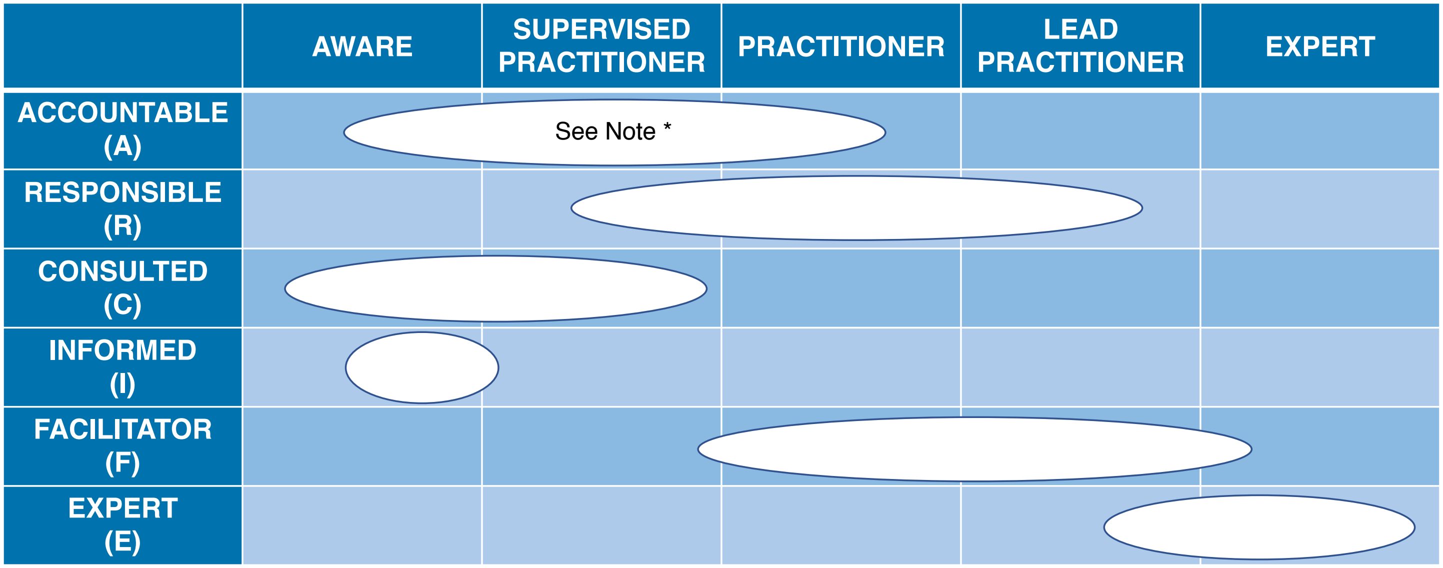

Figure 5 ARCIFE Levels Mapped to Competency Levels

*** Note**

Those accountable for a process may not necessarily have the highest competency level. Whilst they may, in the past, have operated at a higher level of competency – and will draw on this experience - as a leader, their role has moved beyond "doing" to "leadership" such as setting the culture and environment for the activity to be done correctly. Of course, if a role involves both accountability and responsibility, a higher level of competency will normally be required.

Figure 5 gives a range for the required competence level. Judgement based on the level of difficulty and criticality of the activities the role undertakes is needed to finalize the level required.

Since several processes may call for the same competencies, a role statement is completed by taking the highest required competency level defined when all the processes the role is involved with have been analyzed.

TAILORING SHOULD TAKE ACCOUNT OF SPECIFIC ORGANIZATION ISSUES

This INCOSE competency framework is generic, and care needs to be taken during its application to ensure the specific purpose and scope of a role definition, and the level to which Systems Engineering is integrated into the wider organization. Systems Engineering is both implemented and described differently in every organization (e.g. some competencies or processes may be grouped together, or specific terminology applied). It is common for each organization to have specific additional processes and competencies that will need to be included in role descriptions. This sub-section expands the simple generic mapping described earlier to allow this tailoring and adjustment.

Figure 6 shows nine steps that are needed to integrate organization roles, any existing competency processes and competency definition, the processes defined in the INCOSE Systems Engineering Handbook Fourth Edition (INCOSE 2015) and the contents of this framework. The individual steps are described and explained below.

The overall intent of the steps in Figure 6 is to map organization roles to the processes they support; to map organization definitions and terminology (for process and competency) to INCOSE definitions; to allow use of the INCOSE definition of how competencies support process; and to finalize with organization specific role definitions. The outputs produced in Steps 2 and 4 should be retained and used to help map INCOSE terminology for process and competency to any organization-specific language. Each step is explained in more detail below.

- **STEP 1** Perform ARCIFE analysis for the complete matrix for existing organization processes and roles. This allows determination (in Step 9) of elements of the process to include in the "activities performed" part of the role statement (Note: This should be prioritized to keep role statement brief). Depending on the scope of the roles being defined, this activity may allow some processes to be ignored hereafter.
- **STEP 2** Map organization processes onto INCOSE Systems Engineering Handbook processes. If there are additional processes that cannot be mapped, these should be handled separately by extending Figure 3 (see Step 5). One benefit of this activity is that it may highlight overall "gaps" in local process definitions, in terms of INCOSE recommended processes.
- **STEP 3** Combine the outputs of Steps 1 and 2 to produce a mapping of organization roles to INCOSE Systems Engineering Handbook processes. This step should retain any additional organization processes defined. Note this mapping is still in terms of the ARCIFE level of engagement by roles to support the process.
- **STEP 4** Map INCOSE competency area definitions to organization competency definitions. This may include tailoring of INCOSE competencies, and inclusion of additional competencies required by the organization for its roles.
- **STEP 5** Expand the mapping between INCOSE Systems Engineering Handbook processes and INCOSE competency area definitions in Figure 3 to include any organization processes identified in Step 2 and organization competencies identified in Step 4.
- **STEP 6** Use the mapping between processes and competencies produced in Step 5 and the mapping of organization roles to INCOSE Systems Engineering Handbook processes (output of Step 3) to determine the INCOSE defined competencies relevant to each organization role. Judgement will be needed to map the impact of competency on process and the ARCIFE analysis (i.e. engagement of role in performance of role).
- **STEP 7** Use the mapping of INCOSE organization to organization competencies (produced in Step 4) to translate each organization role to the equivalent INCOSE Competency output (produced in Step 6). This produces a set of roles mapped to competency in organization terms
- **STEP 8** Translate the definition of competencies needed by each role (in terms of ARCIFE and competency impact on process to the level of competency needed using Figure 5 as a guide. During this analysis, it will be recognized that some competencies are needed to support many processes at different levels. These should be merged together taking the highest level of competency needed from the range defined for the role as the output.
- **STEP 9** Complete the generic role profile for each organization role, taking the output from Step 1 as "activities performed" and the output from Step 8 as required competency.

The above analysis activity is not straightforward and the individual or team performing the mapping will need to use their judgement, an extensive knowledge of applicable INCOSE products and knowledge of their own organization's definitions and terminologies to complete the analysis successfully.

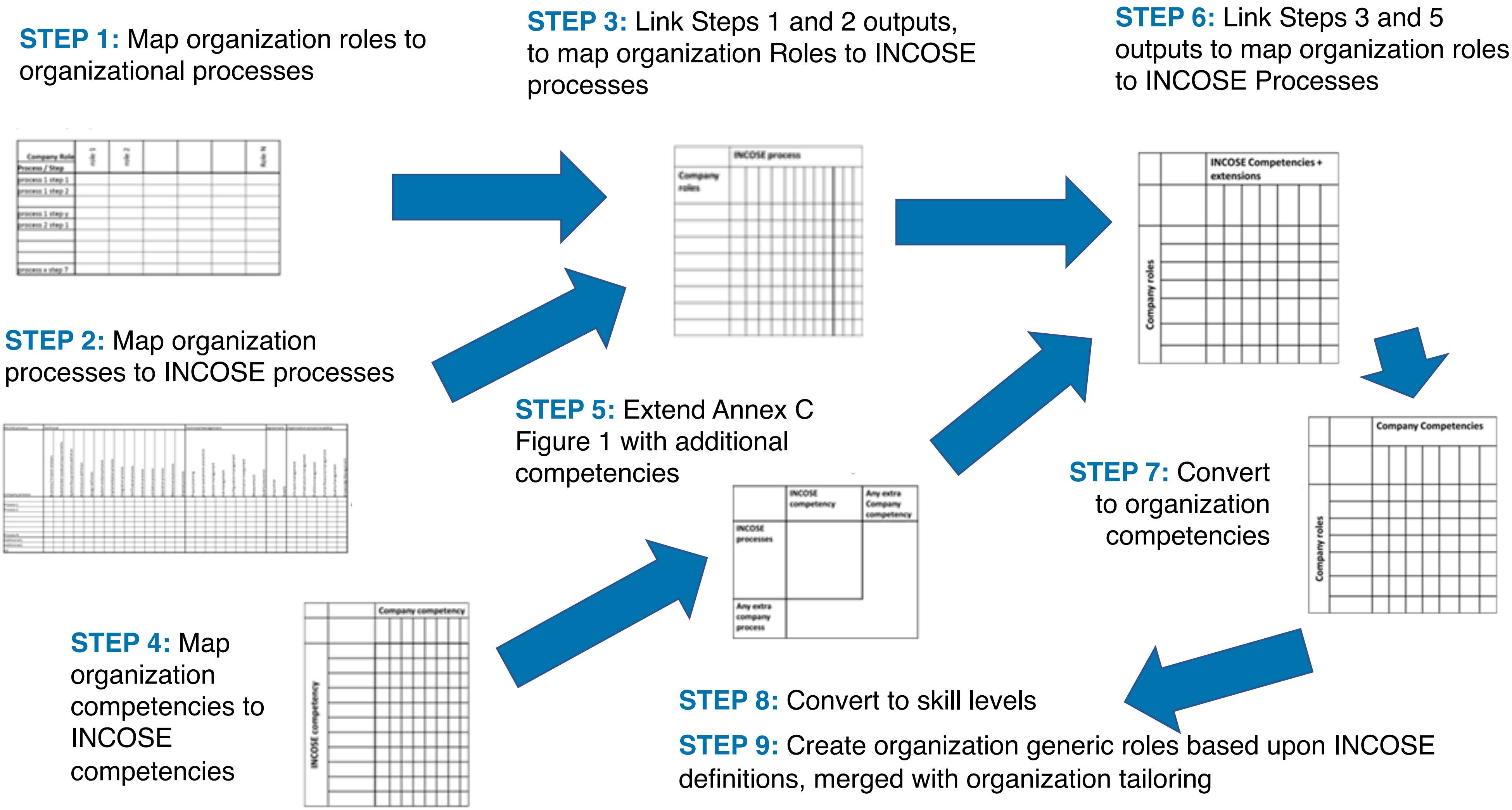

Figure 6 Steps Required to Create Organization Generic Role Profile Using INCOSE Competency Framework

ANNEX D: INCOSE SYSTEMS ENGINEERING COMPETENCY FRAMEWORK

This annex defines each of the competencies identified as forming the new INCOSE Systems Engineering Competency Framework.

It should be read in conjunction with Annex E, which provides the assessment guide for each area.

In summary, this Annex represents the "requirements" for proficiency in 36 competencies at five levels of competence, whilst Annex E defines the evidence expected in order to verify that proficiency at a particular level has been achieved.

COMPETENCY AREA – CORE: SYSTEMS THINKING

Description:

The application of the fundamental concepts of systems thinking to Systems Engineering. These concepts include understanding what a system is, its context within its environment, its boundaries and interfaces, and that it has a lifecycle. System thinking applies to the definition, development and production of systems within an enterprise and technological environment and is a framework for curiosity about any system of interest.

Why it matters:

Systems thinking is a way of dealing with increasing complexity. The fundamental concepts of systems thinking involve understanding how actions and decisions in one area affect another, and that the optimization of a system within its environment does not necessarily come from optimizing the individual system components. Systems Thinking is conducted within an enterprise and technological context. These contexts impact the lifecycle of the system and place requirements and constraints on the systems thinking being conducted. Failing to meet such constraints can have a serious effect on the enterprise and the value of the system.

EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	LEAD PRACTITIONER	EXPERT
Explains what “systems thinking” is and explains why it is important. Explains what “emergence” is, why it is important, and how it can be “positive” or negative” in its effect upon the system as a whole. Explains what a “system hierarchy” is and why it is important. Explains what “system context” is for a given system of interest and describes why it is important. Explains why it is important to be able to identify and understand what interfaces are. Explains why it is important to recognize interactions amongst systems and their elements. Explains why it is important to understand purpose and functionality of a system of interest. Explains how business, enterprise and technology can each influence the definition and development of the system and vice versa. Explains why it may be necessary to approach systems thinking in different ways, depending on the situation, and provides examples.	Identifies and gives examples of the properties of a system. Explains how system behavior produces emergent properties, with examples from own project. Describes the principles of system partitioning within system hierarchy on own project. Assists with definition and understanding of system functionality. Identifies system boundaries on own project, describing external interfaces, explaining why they need to be managed. Explains how humans and systems interact and how humans can be elements of systems. Identifies, with guidance, the influence of enterprise on own system design. Uses systems thinking to contribute to enterprise technology development activities. Contributes and supports, with their own insights, team systems thinking activities.	Identifies and manages complexity with appropriate techniques. Predicts resultant system behavior from its functions and parts. Defines context of a system from a range of viewpoints including system boundaries and external interfaces. Assesses the interaction between humans and systems, and systems and systems. Identifies enterprise and technology issues affecting the design of a system and addresses them using a systems thinking approach. Selects and applies appropriate systems thinking approaches to a range of situations, integrating the outcomes to get a full understanding of the whole. Contributes to delivery of enterprise improvements enabling better system development Leads team systems thinking activities, aligned to purpose of current activities. Reuses and adapts case studies and previous examples of the application of systems thinking in new situations. Guides supervised practitioners in systems thinking techniques.	Recognized, within the enterprise, as an authority in systems thinking techniques, contributing to best practice. Defines and documents enterprise-level policies, procedures, guidance and best practice for systems thinking activities, including associated tools. Reviews and judges the suitability of systems solutions and the planned approach, from a systems thinking perspective. Influences key stakeholders within the enterprise to support and maintain the technical capability and strategy of the enterprise. Adapts systems thinking practices to accommodate novel, complex or difficult system situations or problems. Influences and maintains the local technical strategy in this area Influences key stakeholders to address enterprise-level issues identified through systems thinking. Coaches new and experienced practitioners in systems thinking techniques.	Recognized, beyond the enterprise boundary, as an authority in systems thinking techniques. Contributes to systems thinking best practice. Influences key stakeholders beyond the enterprise boundary to support and maintain the technical capability and strategy of the enterprise. Advises on the suitability of systems solutions and planned approaches. Advises on the suitability of systems thinking approach used across or beyond the enterprise. Advises and arbitrates on complex or sensitive systems capability and strategy issues. Champions the introduction of novel techniques and ideas in systems thinking, producing measurable improvements. Coaches lead practitioners in systems thinking techniques.

COMPETENCY AREA – CORE: LIFECYCLES

Description:

The selection of appropriate lifecycles in the realization of a system. Systems and their constituent elements have individual lifecycles, characterizing the nature of their evolution. Each lifecycle is itself divided into a series of stages, marking key transition points during the evolution of that element. As different system elements may have different lifecycles, the relationship between lifecycle stages on differing elements is complex, varying depending on the scope of the project, characteristics of the wider system of which it forms a part, the stakeholder requirements and perceived risk.

Why it matters:

Lifecycles form the basis for project planning and estimating. Selection of the appropriate lifecycles and their alignment has a large impact on and may be crucial to project success. Ensuring co-ordination between related lifecycles at all levels is critical to the realization of a successful system.

EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	LEAD PRACTITIONER	EXPERT
Identifies different lifecycle types (e.g. waterfall, Vee, incremental, iterative, spiral) and summarizes the key characteristics of each. Explains why selection of lifecycle is important when developing a system solution. Explains why it is necessary to define an appropriate lifecycle process model and the key steps involved. Explains why differing engineering approaches are required in different lifecycle phases and provides examples. Describes the key characteristics of differing lifecycles and how these relate to the system lifecycle.	Describes Systems Engineering lifecycle processes. Explains why it is important to consider future lifecycle stages in the current stage, with examples. Assists in lifecycle definition activities at system or system element level. Describes the system lifecycle in which they are working on their project. Identifies the Systems Engineering lifecycle processes in place on their project. Identifies the advantages and disadvantages of different types of systems lifecycle and where each might be used advantageously.	Identifies the project, enterprise and technology needs affecting the definition of the appropriate lifecycle model, taking these into account in decision making. Uses enterprise-level policies, procedures, guidance and best practice to select lifecycles governing the project. Identifies dependencies aligning lifecycles and lifecycle stages of different system elements accordingly. Influences the lifecycle of system elements beyond boundary of the system of interest, to improve the development strategy. Prepares for future lifecycle phases by taking into consideration their impact on the current phase and improving current activities accordingly. Identifies, and prepares for, transitions between lifecycle stages. Guides supervised practitioners in lifecycle techniques.	Recognized, within the enterprise, as an authority in lifecycle definition, contributing to best practice. Defines and documents enterprise-level policies, procedures, guidance and best practice for lifecycle definition activities, including associated tools. Reviews and judges lifecycle selections designed to meet the needs of the project. Adapts standard lifecycle models, to address specific situations or resolve conflicts between lifecycles where required. Determines the actions required to address variations in the lifecycle stages for the different levels and elements of the system Defines work or issues relevant to the current lifecycle phase by applying knowledge of lifecycles. Influences key stakeholders within the enterprise to support activities required now in order to address future lifecycle stages. Coaches new and experienced practitioners in lifecycle techniques.	Recognized, beyond the enterprise boundary, as an authority in lifecycle definition. Contributes to lifecycle definition best practice. Advises on issues relating to lifecycle definition and their implications on the project. Advises and arbitrates on complex or sensitive lifecycle issues. Advises on the suitability on lifecycles or their adaptation for complex, concurrent projects. Champions the introduction of novel techniques and ideas in lifecycle techniques, producing measurable improvements. Coaches lead practitioners in lifecycle techniques.

COMPETENCY AREA – CORE: CAPABILITY ENGINEERING

Description:

A system or enterprise "capability" relates to the delivery of a desired effect (outcome) rather than delivery of a desired performance level (output). Capability is achieved by combining differing systems, products and services, using a combination of people, processes, information as well as equipment. Capability-based systems are enduring systems, adapting to changing situations rather than remaining static against a fixed performance baseline.

Why it matters:

Understanding the difference between capability and product is important in order to be able to separate the desired effect from any preconceived expectations as to its delivery mechanism. Even if the system of interest only delivers part of a wider capability, obtaining a good understanding of the wider intent helps keep options option, facilitating innovation and creativity in solutions. Failure to do this will generally result in sub-optimization and lost opportunities.

EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	LEAD PRACTITIONER	EXPERT
Explains the concept of capability and how the use of capabilities to characterize systems can prove beneficial. Explains how capability requirements can be satisfied by integrating several systems. Explains how super system capability needs impact on the development of each system that contributes to the capability. Describes and illustrates the difficulties of translating capability needs of the wider system into system requirements.	Describes the environment and the capability outcome required in own project. Identifies, with guidance, capability issues from the wider system which will affect the design of a system of interest. Assists in technology planning required to provide capability. Assists in improving the enterprise to embed or improve utilization of capability. Describes different elements that make up capability within own project, with examples.	Identifies capability issues of the wider (super) system which will affect the design of own system and translates these into system requirements. Assesses the extent to which the proposed system solutions meet capability of the wider system and makes trade-offs to improve delivery of capability. Implements technology planning that includes technology innovation, risk, maturity, readiness levels and insertion points into existing capability. Assesses existing capability to identify gaps relative to desired capability identifying approaches to reduce or eliminate this deficit. Contributes to delivery of enterprise capability improvements. Creates an operational concept for a capability (what it does, why, how, where, when and who) Guides supervised practitioners in capability engineering.	Recognized, within the enterprise, as an authority in capability engineering, contributing to best practice. Defines and documents enterprise-level policies, procedures, guidance and best practice for capability engineering activities, including associated tools. Reviews and judges the suitability of capability solutions and the planned approach. Able to identify key "pinch points" in the development and implementation of specific capability Identifies impact and changes needed in super system environment as a result of the capability development Able to ensure alignment, balance and trade-offs in and between the different elements (in a level) ensuring that capability performance is not traded out Able to integrate views / focus on value, purpose and solution for capability (rather than any one of these) Coaches new and experienced practitioners in capability engineering.	Recognized, beyond the enterprise boundary, as an authority in capability engineering. Contributes to capability engineering best practice. Influences key stakeholders beyond the enterprise boundary to support and develop the capabilities of the enterprise. Advises on the suitability of capability solutions, and the derived needs for the systems that make up the capability Advises and arbitrates on complex or sensitive capability strategy issues. Advises on differences and relationships between capability and product-based systems. Researches and analyzes similarities and differences between capability systems across different domains and uses this to develop or improve capability solutions in own domain. Champions the introduction of novel techniques and ideas in capability engineering, producing measurable improvements. Coaches lead practitioners in capability engineering.

COMPETENCY AREA – CORE: GENERAL ENGINEERING

Description:

Foundational concepts in mathematics, science and engineering and their application.

Why it matters:

Systems Engineering is performed in a technical scientific environment and as a result, a good understanding of mathematics, science coupled with a sound appreciation of core engineering principles is a critical foundation for effective Systems Engineering. Without this, systems engineers cannot communicate effectively and efficiently with engineers from other domains.

EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	LEAD PRACTITIONER	EXPERT
Demonstrates knowledge of core principles of science and mathematics. Demonstrates knowledge of fundamentals of engineering as a discipline. Explains why probability and statistics are both relevant to engineering, with examples. Explains why analytical methods and sound judgement are central to engineering decisions. Explains what an engineered system is and recognizes examples of engineered systems which are physical, software and socio-technical systems or combinations thereof. Explains why uncertainty is an important factor in engineering and explains how it might arise from many sources.	Applies scientific and mathematical knowledge when performing engineering tasks. Uses appropriate engineering approaches when performing engineering tasks. Considers the nature and effect of variation in engineering tasks. Uses proven analytical methods when performing engineering tasks, whilst appreciating the limitations of their applicability. Uses software-based tools, together with the products they create, to facilitate and progress engineering tasks. Explains why the value of a mathematical approach can be limited in a human-centric or human-originated system, with examples.	Selects appropriate software-based tools from those available to the project and uses them, together with the products they create to facilitate and progress engineering tasks. Determines scientific and mathematical methods to be used in support of tasks and justifies their selection. Selects relevant engineering approaches and methods to be used in support of engineering tasks and justifies their selection. Applies probability and statistics in engineering tasks recognizing benefits and limitations on results obtained. Defines level of variation or probability appropriate to the current task and justifies this decision. Structures tasks around practical and proven engineering principles. Assesses situations using well-established engineering principles and uses these assessments to make sound engineering judgements. Adapts approaches to take account of human-centric aspects of systems development. Guides supervised practitioners in selecting appropriate scientific, engineering or mathematical principles.	Recognized, within the enterprise, as an authority in general engineering principles, contributing to best practice. Advises across the enterprise, on the suitability of general engineering approaches selected. Adapts mathematics and engineering principles so that they can be applied to specific engineering situations. Explains the difference between scientific and engineering approaches in order to engage with pure scientific advances Assesses the appropriate level of understanding of the impact of variation and uncertainty on engineering outcomes. Advises on issues requiring the application of engineering judgement. Advises stakeholders on issues affecting the "broader" engineering approach to engineering activities. Reviews and judges the quality of engineering judgements made by others across the enterprise. Coaches new and experienced practitioners basic engineering approaches in their work.	Recognized, beyond the enterprise boundary, as an authority in general engineering principles and their application to Systems Engineering. Contributes to best practice in the application of general engineering principles to Systems Engineering. Influences key stakeholders beyond the enterprise boundary to support general engineering and mathematical research and development. Develops new applications of mathematical methods to engineering practices. Advises and arbitrates on issues which relate to complex engineering principles. Reflects and develops ideas of engineering approach based on experience and learning Maintains awareness of developments in sciences, technologies and related engineering disciplines, recognizing areas where new developments might be applicable within their own discipline or enterprise. Champions the introduction of novel general engineering practices and techniques, producing measurable improvements. Coaches lead practitioners in applying engineering approaches to their work.

COMPETENCY AREA – CORE: CRITICAL THINKING

Description:

The objective analysis and evaluation of a topic in order to form a judgement.

Why it matters:

Artifacts produced during the conduct of Systems Engineering need to be defendable. Critical thinking helps improve the quality of input information, assumptions and decisions. A failure to apply critical thinking may lead to invalid outputs including decisions and the solutions from which they are derived.

EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	LEAD PRACTITIONER	EXPERT
Explains why conclusions and arguments made by others may be based upon incomplete, potentially erroneous or inadequate information, with examples. Identifies logical steps in an argument or proposition and the information needed to justify each. Explains why assumptions are important and why there is a need to ensure that they are based upon sound information. Explains the relationship between assumptions and risk and why assumptions need to be validated. Explains why ideas, arguments and solutions need to be critically evaluated. Lists common techniques and approaches used to propose or define arguments. Explains how own perception of arguments from others may be biased and how this can be recognized. Explains how the experiences of others may influence the specific issue being worked.	Prepares clear description of evidence and arguments needed in order to make informed decisions. Recognizes logical relationships and dependencies between propositions. Critically reviews own work to test logic, assumptions, arguments, approach and conclusions. Works as part of a team to construct robust arguments responding to critical thinking. Open to suggestion as to how to improve the quality of chosen approach, decisions or conclusions of their work. Reconsiders and identifies weaknesses and assumptions in their own arguments Uses common techniques to proposing, defining or challenging arguments and conclusions, with guidance. Identifies potential limitations in others' which may impact arguments made regarding proposals or ideas. Analyzes own perspective for potential cognitive bias for or against arguments made by others.	Develops a logical critique of work, including assumptions, approaches, arguments, conclusions and decisions. Examines the impact of assumptions or weak logic and looks for substantive arguments. Assists others in a team to construct robust arguments responding to critical thinking. Applies a range of different approaches to identify and challenge conclusions. Relates the experiences of others to the specific issue being worked. Recognizes how others' limitations in assessing arguments made regarding proposals or ideas Guides supervised practitioners in the application of critical thinking in their work.	Recognized, within the enterprise, as an authority in critical thinking and its application to Systems Engineering, contributing to best practice. Defines and documents enterprise-level policies, procedures, guidance and best practice for critical thinking, including associated tools. Advises across the enterprise, on the application of critical thinking approaches to assumptions, approaches, arguments, conclusions and decisions. Applies a range of techniques and viewpoints to critically evaluate assumptions, approaches, arguments, conclusions and decisions. Reviews and judges impact of weak, incomplete or flawed arguments, conclusions and decisions made across the enterprise. Composes logical and clear explanations in support of the resolution of intricate or difficult situations across the enterprise. Recognizes uncertainty in assessing situations, and recommends approaches to address this. Applies own experiences to inform the critical examination of novel scenarios or domains. Exercises balanced judgement in determining which part needs deeper critical review Identifies individuals who can bring independence or different perspective to assessments. Coaches new and experienced practitioners in the application of critical thinking in their work.	Recognized, beyond the enterprise boundary, as an authority in critical thinking and its application to Systems Engineering. Contributes to best practice in the application of critical thinking to Systems Engineering. Influences key stakeholders within and beyond the enterprise boundary to improve and support thinking assumptions, approaches, arguments, conclusions and decisions. Advises and arbitrates on issues which relate to complex or sensitive assumptions, approaches, arguments, conclusions and decisions. Advises on resolution of weak, incomplete or flawed approaches impacting arguments, conclusions and decisions made across the enterprise. Advises in the identification of alternative approaches to address flawed thinking and its results. Develops personal and vicarious experiences to improve critical thinking in self and others. Champions the introduction of novel critical thinking practices and techniques, producing measurable improvements. Coaches lead practitioners in the application of critical thinking in their work.

COMPETENCY AREA – CORE: SYSTEMS MODELING AND ANALYSIS

Description:

Modeling is a physical, mathematical, or logical representation of a system entity, phenomenon, or process. System analysis provides a rigorous set of data and information to aid technical understanding and decision making across the lifecycle. A key part of systems analysis is modeling.

Why it matters:

Modeling, analysis and simulation can provide early, cost effective, indications of function and performance, thereby driving the solution design, enabling risk mitigation and supporting the verification and validation of a solution. Modeling and simulation also allow the exploration of scenarios outside the normal operating parameters of the system.

EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	LEAD PRACTITIONER	EXPERT
Explains why system representations are required and the benefits they can bring to developments. Describes the scope and limitations of models and simulations, including definition, implementation and analysis. Describes different types of modeling and simulation and provides examples. Explains how the purpose of modeling and simulation affect the approach taken. Explains why functional analysis and modeling is important in Systems Engineering. Explains the relevance of outputs from systems modeling and analysis, and how these relate to overall system development. Explains the difference between modeling and simulation. Describes a variety of system analysis techniques which can be used to derive information about a system.	Uses modeling and simulation tools and techniques to represent a system or system element. Interprets and uses outcomes of modeling and analysis, with guidance. Explains why models and simulations have a limit of valid use, and the risks of using models and simulations outside those limits. Uses tools and techniques to conduct analysis of models, with guidance. Contributes to the model development and interpretation activities. Explains why models are developed for a specific purpose or use and provides examples. Uses system analysis techniques to derive information about the real system, with guidance.	Defines governing modeling and analysis plans, processes and appropriate tools for a project, and uses these to monitor and control systems modeling and analysis activities for a system or system element. Implements the strategy and approach to be adopted for the modeling and analysis on a system or system element. Leads and determines appropriate representation or analysis of a system or system element. Selects appropriate tools and techniques for system modeling and analysis. Selects and defines appropriate representations of a system or system element. Uses appropriate representations of a system or system element in order to derive information about the real system. Uses appropriate system analysis techniques to derive information about the real system. Manages models that are produced within a project. Guides supervised practitioners in modeling and systems analysis.	Recognized, within the enterprise, as an authority modeling and analysis, contributing to best practice. Defines and documents enterprise-level policies, procedures, guidance and best practice for systems modeling and analysis, including associated tools. Reviews and judges the adequacy of tailoring of enterprise-level systems modeling and analysis processes for specific projects. Advises across the enterprise, on systems modeling and analysis. Leads and determines appropriate representations or analysis of complex system or system elements. Adapts approach to accommodate the specifics of a given situation or system of interest being modeled or analyzed. Reviews and judges the outputs of systems modeling and analysis, ensuring the results can be used for the intended purpose. Advises on selection of appropriate modeling or analysis approach, based on understanding the strengths and weaknesses of various modeling and analysis techniques. Leads the integration and combination of different models and analyses for a system or system element. Coaches new and experienced practitioners in systems modeling and analysis.	Recognized, beyond the enterprise boundary, as an authority in system modeling and analysis. Contributes to system modeling and analysis best practice. Influences key stakeholders within and beyond the enterprise boundary in systems modeling and analysis. Applies a wide-ranging knowledge of the strengths and weaknesses of available modeling and analysis techniques, to advise on the appropriateness of selected approaches in any given level of complexity and novelty. Defines strategy and approach to be used for modeling and analysis of complex or novel system or system elements. Advises on the suitability and limitations of models and analysis techniques used. Reviews and judges the suitability of systems modeling and analysis approaches and results Advises and arbitrates on complex or sensitive issues relating to systems modeling and analysis. Champions the introduction of novel practices and techniques in systems modeling and analysis, producing measurable improvements. Coaches lead practitioners in systems modeling and analysis.

COMPETENCY AREA - PROFESSIONAL: COMMUNICATIONS

Description:

The dynamic process of transmitting or exchanging information using various principles such as verbal, speech, body-language, signals, behavior, writing, audio, video, graphics, language, etc. Communication includes all interactions between individuals, individuals and groups or between different groups.

Why it matters:

Communication plays a fundamental role in all facets of business within an organization, in order to: transfer information between individuals and groups to develop a common understanding and build and maintain relationships and other intangible benefits. Ineffective communication has been identified as the root cause of problems on projects.

EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	LEAD PRACTITIONER	EXPERT
Explains communications in terms of the sender, the receiver, and the message and why these three parameters are central to the success of any team communication. Explains why there is a need for clear and concise communications. Describes the role communications has in developing positive relationships. Explains why employing the appropriate means for communications is essential. Explains why openness and transparency in communications matters. Explains why systems engineers need to listen to stakeholders' point of view.	Uses a governing communications plan and appropriate tools to control communications, with guidance. Communicates effectively among peers. Develops positive relationships through effective communications, with guidance. Employs appropriate communications mechanisms to interact with others. Develops trust through openness and transparency in communication, with guidance. Actively listens and seeks clarification of stakeholders' points of view.	Uses a governing communications plan and appropriate tools to control communications. Communicates effectively with all stakeholders on project. Develops and maintains positive relationships through effective communications. Expresses alternate points of view in a diplomatic manner using the appropriate means of communication. Creates a communicating culture by finding appropriate language and communication styles, augmenting where necessary to avoid misunderstanding. Expresses thoughts effectively and convincingly to reinforce the content of the message. Performs active listening, asking questions where appropriate. Seeks feedback to communications. Guides supervised practitioners in communications within Systems Engineering.	Recognized, within the enterprise, as an authority on the application of communications within Systems Engineering, contributing to best practice. Defines and documents enterprise level governing communications management processes, tools and guidance. Uses full breadth of available techniques to communicate effectively with stakeholders across the enterprise. Maintains and grows positive relationships through effective communications in challenging situations, adapting to audience as necessary for communication clarity. Uses effective communications to persuade and convince stakeholders to reach consensus in challenging situations Adopts a proactive style, building consensus among stakeholders using techniques supporting the verbal messages (e.g. non-verbal communication). Reformulates stakeholders' points of view or expresses ideas clearly in a concise way or language they can be understood. Provides direct feedback to stakeholders and team. Anticipates and mitigates potential problems in communication. Coaches new and experienced practitioners in communications within Systems Engineering.	Recognized, beyond the enterprise Recognized, beyond the enterprise boundary, as an authority on the application of communications within Systems Engineering. Contributes to best practice in the application of communications techniques to Systems Engineering. Influences key stakeholders beyond the enterprise boundary in support of communications activities affecting Systems Engineering. Contributes to enterprise communications vision. Advises key stakeholders on the suitability of communications strategies, plans, processes and tools. Fosters a collaborative learning, listening atmosphere amongst key stakeholders. Advises and arbitrates on complex or sensitive communications-related matters affecting Systems Engineering. Champions the introduction of novel techniques and ideas for effective communications, producing measurable improvements. Coaches lead practitioners in best practice communications techniques within Systems Engineering.

COMPETENCY AREA - PROFESSIONAL: ETHICS AND PROFESSIONALISM

Description:

Professional ethics encompass the personal, organizational, and corporate standards of behavior expected of systems engineers. Professional ethics also encompasses the use of specialist knowledge and skills by systems engineers when providing a service to the public. Overall, competence in ethics and professionalism can be summarized by a personal commitment to professional standards, recognizing obligations to society, the profession and the environment.

Why it matters:

Systems engineers are routinely trusted to apply their skills, make judgments and to reach unbiased, informed and potentially significant decisions because of their specialized knowledge and skills. It is important that the professional systems engineer always acts ethically, in order to maintain trust, ensure professional standards are upheld, and that their wider obligations to society, and the environment are met.

EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	LEAD PRACTITIONER	EXPERT
Explains why Systems Engineering has a social significance and how this relates to ethics and professionalism. Describes applicable codes of conduct for professional systems engineers including institutional or company codes of conduct Lists typical safety standard and requirements and provides examples. Explains why there is a need to undertake engineering activities in a way that contributes to sustainable development and provides examples. Explains why it is necessary to develop, plan, carry out, and record Continued Professional Development (CPD) in order to maintain and enhance competence in own area of practice. Explains why systems engineers have a responsibility to act in an ethical manner and provides examples.	Complies with applicable codes of professional conduct for own activities within the enterprise. Manages and applies safe systems of work under supervision. Undertakes and takes personal responsibility for ensuring their own activities are performed in a way that contributes to sustainable development. Uses imagination, creativity and innovation to suggest changes to the business which maintain and enhance the quality of the environment and community, and meet financial objectives. Initiates and performs personal continual development planning and record keeping. Performs own activities with integrity. Exercises own responsibilities in an ethical manner, seeking guidance as necessary.	Works within all relevant legislation and regulatory frameworks, including social and employment legislation. Ensures safe systems at work by applying a sound knowledge of health and safety legislation to address health, safety and welfare issues, ensure compliance with health, safety and welfare requirements, perform hazard identification and to perform risk management. Undertakes and takes personal responsibility for ensuring project engineering activities are performed in a way that contributes to sustainable development. Uses imagination, creativity and innovation to select and implement changes to the project which maintain and enhance the quality of the environment and community, and meet financial objectives. Carries out and records the continual professional development necessary to maintain and enhance competence in own area of practice evaluating outcomes against any plans made. Ensures all members of the team operate with integrity and in an ethical manner. Exercises responsibilities in an ethical manner without support of guidance. Guides supervised practitioners in matters relating to ethics and professionalism, including career development planning.	Recognized, within the enterprise, as an authority on the application of ethics and professionalism to Systems Engineering, contributing to best practice. Reviews and judges compliance with all relevant legislation and regulatory frameworks. Applies a sound knowledge of health, safety and welfare legislation to review and judge safe systems at work, including compliance with requirements, hazard identification and risk management systems and safety culture. Leads and takes personal responsibility for ensuring engineering activities across the enterprise are performed in a sustainable way. Leads projects across the enterprise with imagination, creativity and innovation. Reviews and judges enterprise development continual development planning activities to ensure they maintain and enhance organizational and individual competencies, evaluating outcomes against any plans made. Recognized as a role model for ethics and integrity within the enterprise. Coaches new and experienced practitioners in matters relating to ethics and professionalism, including career development planning.	Recognized, beyond the enterprise boundary, as an authority on the application of ethics and professionalism to Systems Engineering, Contributes to best practice in ethics and professionalism within Systems Engineering. Influences the direction of relevant legislative and regulatory frameworks in support of improving professionalism and ethics within Systems Engineering. Influences the direction of health, safety and welfare requirements, hazard identification systems, risk management systems and organizational safety culture. Influences projects beyond the enterprise boundary with imagination, creativity and innovation. Advises key stakeholders beyond the enterprise boundary on the sustainability of engineering activities in order to contribute to sustainable development. Advises on development planning activities beyond the enterprise boundary, to ensure they maintain and enhance organizational and individual competencies, evaluating outcomes against any plans made. Recognized as a role model for ethics and integrity beyond the enterprise boundary. Champions the introduction of novel techniques and ideas in ethics and professionalism, producing measurable improvements. Coaches lead practitioners in matters relating to ethics and professionalism, including career development planning.

COMPETENCY AREA - PROFESSIONAL: TECHNICAL LEADERSHIP

Description:

Systems Engineering technical leadership is the combination of the application of technical knowledge and experience in Systems Engineering with appropriate professional competencies. This encompasses an understanding of customer need, problem solving, creativity and innovation skills, communications, team building, relationship management, operational oversight and accountability skills coupled with core Systems Engineering competency and engineering instinct.

Why it matters:

The complexity of modern system designs, the severity of their constraints and the need to succeed in a high tempo, high-stakes environment where competitive advantage matters, demands the highest levels of technical excellence and integrity throughout the lifecycle. Systems Engineering technical leadership helps teams meet these challenges.

EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	LEAD PRACTITIONER	EXPERT
Explains the role of technical leadership within Systems Engineering. Defines "vision", "strategy" and "goal" terms and why each is important in leadership. Explains why understanding the strategy is central to Systems Engineering leadership. Explains why fostering collaboration is central to Systems Engineering. Explains why the art of communications is central to Systems Engineering. Explains why fostering collaboration is central to Systems Engineering leadership and how poor collaboration impacts on the quality of leadership provided. Describes technical analysis and problem techniques and established best practices which can be used improve the excellence of Systems Engineering solutions. Explains how creativity, ingenuity, experimentation and accidents or errors, often lead to technological and engineering successes and advances and provides examples. Explains how different sciences impact the technology domain and the engineering discipline.	Performs Systems Engineering activities with integrity, earning trust from others by applying both professional and technical competencies successfully. States the vision and describes how it impacts both the project and the wider enterprise. States team and project goals and works towards these, thinking strategically, holistically and systemically when performing own tasks. Accepts constructive criticism and uses this to self-improve, whilst remaining willing to challenge or offer constructive criticism to others on the team. Listens to viewpoints from others and takes these into account when developing solutions. Communicates ideas clearly and effectively to peers, selecting techniques and technical vocabulary. Applies creativity, innovation and problem solving techniques in own work. Identifies concepts and ideas in sciences, technologies and engineering disciplines beyond their own discipline, which could benefit the project solution.	Leads Systems Engineering activities on their team with integrity, earning trust from others. Leads Systems Engineering activities on the team, combining appropriate competencies, with demonstrable success. Interprets vision for project team, influencing and integrating their viewpoints to gain acceptance. Strives for project goals, changing strategies as necessary, to ensure success. Accepts constructive criticism and uses this to self-improve, whilst remaining willing to challenge or offer constructive criticism to others. Leads Systems Engineering activities collaboratively. Enables and empowers team members to be successful, by supporting, facilitating, promoting, giving ownership and supporting them in their endeavors. Communicates ideas clearly and effectively to team, using appropriate techniques and technical vocabulary. Applies creativity, innovation and problem solving techniques to develop strategies or resolve team or project issues. Guides supervised practitioners in technical and leadership issues within Systems Engineering.	Recognized, within the enterprise, as a leader in Systems Engineering, contributing to best practice. Leads Systems Engineering activities across the enterprise with integrity, earning trust from others. Leads Systems Engineering activities across the enterprise, combining professional and technical competencies, with demonstrable success. Accepts criticism with professional demeanor using it to self-improve, whilst remaining open to challenging or offer constructive criticism to others within and beyond the enterprise. Fosters collaboration between stakeholders across the enterprise, sharing ideas and knowledge and establishing mutual trust. Enables and empowers others within the enterprise to be successful. Applies creativity, innovation and problem solving techniques to develop strategies or resolve complex project or enterprise issues. Maintains current technical expertise, through studying new and emerging best practice in own discipline and in sciences, technologies and engineering disciplines beyond their own. Coaches new and experienced practitioners in technical and leadership issues within Systems Engineering.	Recognized, beyond the enterprise boundary, as a leader in Systems Engineering, Contributes to best practice in leadership in Systems Engineering. Influences key Systems Engineering stakeholders in leadership issues beyond the enterprise boundary with integrity, earning trust from others. Leads Systems Engineering activities beyond the enterprise, combining appropriate professional competencies with technical knowledge and experience. Leads activities collaboratively beyond the enterprise boundary, establishing mutual trust. Enables and empowers others beyond the enterprise boundary to be successful. Advises in complex or sensitive problem or issue resolution, applying creativity and innovation to ensure successful delivery. Fully utilizes their extended network and influencing skills to gain collaborative agreement with key stakeholders to progress project or enterprise needs. Champions the introduction of novel techniques and ideas in leadership, producing measurable improvements. Coaches lead practitioners in technical and leadership issues within Systems Engineering.

COMPETENCY AREA - PROFESSIONAL: NEGOTIATION

Description:

Negotiation is a dialogue between two or more parties intended to reach a beneficial outcome over one or more issues where differences exist with respect to at least one of these issues. This beneficial outcome can be for all parties involved, or just for one or some of them. Negotiation aims to resolve points of difference, to gain advantage for an individual or collective, or to craft outcomes to satisfy various interests. It is often conducted by putting forward a position and making small concessions to achieve an agreement.

Why it matters:

Systems Engineers are the "glue" that hold elements of a complex system development together. To achieve success, they need to involve themselves in many aspects of a project, interacting with different types of stakeholders and organizations. This necessitates resolution of many different types of issue in order to gain agreement between differing groups of stakeholders. Good negotiation skills are central to this activity.

EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	LEAD PRACTITIONER	EXPERT
Explains what negotiation is and provides examples of different types, scenarios and styles for negotiation. Describes situations where it may be necessary to negotiate and why. Explains how different stakeholders hold different positions and bargaining power and provides examples.	Determines when and when not to negotiate. Establishes working level relationships with counterparts to resolve routine issues. Assists in negotiations by providing information and being part of the team. Describes key stakeholders' situation and communicates individual requirements and negotiation positions of these stakeholders. Researches and analyzes data from a range of sources to provide useful input to the negotiation team Describes different stakeholders with different positions and bargaining power and provides examples from project. Assists with review of immediate results, broad implications and unintended consequences of a negotiation decision Handles objections without losing confidence.	Follows established best practice strategies for negotiation in terms of preparation, approach, strategy, tactics and style. Performs negotiation with internal and external project stakeholders, recognizing the differing styles of negotiating parties and adapts own style accordingly. Manages buy-in and gains trust with internal stakeholders prior to and during negotiations Manages internal expectations and keep all parties informed of developments. Analyzes data from a range of sources to make robust fact-based statements during negotiations, to make available choices clear and simple to stakeholders. Handles objections and challenges the points of view expressed by others without damaging stakeholder relationships. Reviews the immediate results, broad implications and unintended consequences of a negotiation decision Demonstrates and uses political awareness regarding key decision-makers. Guides supervised practitioners in negotiation techniques.	Recognized, within the enterprise, as an authority on the application of negotiation techniques to Systems Engineering, contributing to best practice. Ensures best practice is used during preparation and execution of negotiations. Reviews and judges the suitability of the planned approach or strategy for negotiations affecting Systems Engineering. Leads negotiation teams, with regular, demonstrable success in closing negotiations, accepting accountability for final negotiation outcomes whether successful or not. Adjusts personal positions and style quickly if circumstances change favorably and unfavorably Negotiates in tough, challenging situations with both external and internal stakeholders Establishes credibility and gains trust and respect of all parties to negotiations. Handles objections professionally, challenging the points of view of others, whilst persuading them to support your position. Influences third-party decision-makers through good political awareness. Coaches new and experienced practitioners in negotiation techniques and their application to Systems Engineering situations.	Recognized, beyond the enterprise boundary, as an authority on the application of negotiation techniques to Systems Engineering, Contributes to best practice in the application of negotiation techniques to Systems Engineering. Influences key stakeholders beyond the enterprise boundary in support of negotiations activities affecting Systems Engineering. Influences key strategic decision-makers to deploy successful negotiation strategies. Leads negotiations beyond the enterprise boundary, on complex or strategic decisions. Challenges appropriateness of negotiating stance or reasoning. Advises negotiators on strategies designed to persuade key or challenging stakeholders to change their views, with demonstrable results. Advises on positions and negotiating styles. Accepts accountability for final negotiation outcomes whether successful or not. Champions the introduction of novel techniques and ideas in negotiation techniques, producing measurable improvements. Coaches lead practitioners in negotiation techniques and their application to Systems Engineering situations.

COMPETENCY AREA - PROFESSIONAL: TEAM DYNAMICS				
Description: Team dynamics are the unconscious, psychological forces that influence the direction of a team's behavior and performance. Team dynamics are created by the nature of the team's work, the personalities within the team, their working relationships with other people, and the environment in which the team works.				
Why it matters: Team dynamics can be good - for example, when they improve overall team performance and/or get the best out of individual team members. They can also be bad - for example, when they cause unproductive conflict, demotivation, and prevent the team from achieving its goals.				
EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE				
AWARENESS	**SUPERVISED PRACTITIONER**	**PRACTITIONER**	**LEAD PRACTITIONER**	**EXPERT**
Lists different types of team and the role of each team within the project or organization. Describes the different stages of team development and how they affect team dynamics and performance Describes the positive and negative features of cooperation and competition within teams, and provides examples. Explains how the effectiveness of team communications is affected by the characteristics of the sender, the receiver, and the message itself, and provides examples. Describes the differing nature of disagreement, conflict and criticism in teams and provides examples of each including core strategies for resolving conflict. Explains why team building can help form effective teams, what it involves and its key challenges. Describes different types of team-building activities, their aims and provides examples.	Determines when and when not to Identifies own positions, roles and responsibilities within different teams within the project or organization. Identifies team goals and works with others to accomplish them. Identifies the stage (e.g. Forming, Storming, Norming etc.) at which each of the teams within which they participate is operating and provides rationale. Describes the building blocks of successful team performance and why they affect performance. Explains how team goals, communication, and interpersonal actions are affected by competitive behaviors. Identifies competitive behaviors within a team and their potential cause (e.g. cultural, personal, and organizational reasons). Describes different potential types of team conflict and the differing techniques available to resolve them. Explains how team dynamics affect decision making.	Works in collaboration with other teams to accomplish interdependent project or organizational goals. Recognizes the dynamic of their team and applies best practice to improve this as necessary. Encourages all team members to have the same understanding of an assignment and that this is in line with organizational intent. Fosters cooperation and pride within the team through strategies focused on group goals, communication, and interpersonal actions. Challenges and addresses negative behaviors within the team. Gives constructive feedback to improve team performance and manages emotions as an important aspect of team's communications. Identifies and resolves conflict in a team. Applies best practice techniques to obtain team consensus when making decisions. Uses team-building activities to improve team dynamics. Guides supervised practitioners in team dynamics.	Recognized, within the enterprise, as an authority on the application of team dynamics to Systems Engineering, contributing to best practice. Reviews and judges the dynamic of the team, advising where improvement is necessary. Applies, or advises on, selection of measurable group goals, communication or interpersonal actions designed to improve team performance. Challenges and addresses negative behaviors of key enterprise stakeholders, with measurable success. Encourages all team members to express their opinions and feelings, combining ideas to create alternative solutions in the team. Applies, or advises on, different best practice techniques depending on the situation and decision required. Encourages communication between team members and builds trust within the team through interpersonal communication Uses different types of team-building activities to improve team dynamics, depending on the team context Coaches new and experienced practitioners in team dynamics.	Recognized, beyond the enterprise boundary, as an authority on the application of team dynamics to Systems Engineering. Contributes to best practice in the application of team dynamics to Systems Engineering. Advises on strategies for improving team dynamics on complex or challenging teams. Advises and arbitrates on selection and interpretation of goals used to challenge, measure and assess team performance. Advises and arbitrates on how team members can be rewarded to act cooperatively. Challenges and addresses negative behaviors of key stakeholders beyond the enterprise boundary, with measurable success. Influences key stakeholders on conflict issues which affect the wider enterprise team. Influences key stakeholders where complex decisions affect the wider enterprise team. Champions the introduction of novel techniques and ideas in team dynamics, producing measurable improvements. Coaches lead practitioners in team dynamics.

COMPETENCY AREA - PROFESSIONAL: FACILITATION

Description:

The act of helping others to deal with a process, solve a problem, or reach a goal without getting directly involved. The goal is set by the individuals or groups, not by the facilitator.

Why it matters:

Modern systems engineers must perform successfully in environments where accountability expectations are increasing, but where the use of direct authority may not achieve the desired results. Numerous sources indicate that an alternative form of leadership can address these seemingly contradictory conditions. This form of leadership has been named "facilitative leadership", and is the ability to lead without controlling, while making it easier for everyone in the organization to achieve agreed-upon goals.

EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	LEAD PRACTITIONER	EXPERT
Explains what facilitation is summarizing its key characteristics and techniques. Explains how facilitation can help individuals and groups to achieve their goals. Describes the different stages of group formation and how they can impact facilitation effectiveness. Describes the different forms of conflict and dissent in a group, how they impact facilitation and techniques available to mitigate their impact. Describes different approaches to problem solving and the patterns of thinking associated with each.	Acts as a neutral servant of a group performing a facilitated task. Able to form a group to perform a facilitated task. Establishes rules of conduct between individuals within a facilitated group, with guidance. Acts as impartial observer focused on facilitated group activities, with guidance. Assists in facilitating a group problem solving session. Leads a facilitated group problem solving session, with guidance.	Establishes rules of conduct between individuals within a facilitated group. Acts as impartial observer focused on facilitated group activities. Facilitates self-improvement of group performance. Protects individuals and their ideas from attack within a facilitated group Ensures the facilitated group is working well together. Leads a facilitated group problem solving session. Guides supervised practitioners in facilitation techniques.	Recognized, within the enterprise, as an authority on the application of facilitation techniques to Systems Engineering, contributing to best practice. Plans methods to be used within the facilitated activity and coordinates logistics of the meeting arrangements. Selects the most appropriate style of facilitation based upon group maturity. Helps the facilitated group clarify goals. Facilitates group towards achieving its objectives. Acts as a referee in times of conflict, disagreement or tension within the facilitated group. Fosters systematic patterns of thinking during the facilitated group problem solving process. Coaches new and experienced practitioners in facilitation techniques.	Recognized, beyond the enterprise boundary, as an authority on the application of facilitation techniques to Systems Engineering. Contributes to best practice in the application of facilitation techniques to Systems Engineering. Advises key stakeholders on plans, methods and logistics to be used for facilitated sessions. Influences key stakeholders to support facilitated group activities. Reviews and judges facilitated group performance. Defines alternative ways of working to reinforce collaboration within the context of the facilitated group. Advises and arbitrates on complex or sensitive matters, conflict disagreement or tension affecting facilitated groups. Anticipates and mitigates potential problems in facilitation. Brings prevailing mental models to the surface and challenges facilitation group participants having the ability to build a shared vision. Champions the introduction of novel techniques and ideas for effective facilitation, producing measurable improvements. Coaches lead practitioners in facilitation techniques.

COMPETENCY AREA - PROFESSIONAL: EMOTIONAL INTELLIGENCE

Description:

Emotional intelligence is the ability to monitor one's own and others' feelings, to discriminate among them, and to use this information to guide thinking and action. This is usually broken down into four distinct but related proposed abilities: perceiving, using, understanding, and managing emotions.

Why it matters:

Emotional intelligence is regularly cited as a critical competency for effective leadership and team performance in organizations. It influences the success with which individuals in organizations interact with colleagues, the approaches they use to manage conflict and stress, and their overall job performance. As Systems Engineering involves interacting with many diverse stakeholders, emotional intelligence is critical to its success.

EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	LEAD PRACTITIONER	EXPERT
Explains why the perception of emotion is important including differentiating one's own emotions from those of others. Explains how emotions can be used to facilitate thinking such as reasoning, problem solving, and interpersonal communication and explains why this is important. Explains why it is important to be able to understand and analyze emotions, and can provide examples of the language and meaning of emotions and relationships between emotions. Explains why managing and regulating emotions in both oneself and in others is important.	Identifies emotions in one's physical states, feelings and thoughts. Perceives the emotions of others via verbal and non-verbal cues. Describes the language used to label emotions and provides examples from own experiences.	Interprets meanings and origins of emotions and acts accordingly. Expresses emotions, and needs related to those feelings. Reflectively monitors emotions in relation to oneself and others. Capitalizes fully upon changing moods in order to best fit the task at hand Stays open to feelings, both those that are pleasant and those that are unpleasant. Guides supervised practitioners in matters relating to emotional intelligence.	Recognized in the enterprise, as an authority on the application of emotional intelligence to Systems Engineering, contributing to best practice. Manages own emotion by preventing, reducing, enhancing, or modifying an emotional response Manages emotion in others by preventing, reducing, enhancing, or modifying an emotional response Applies emotional intelligence techniques in tough, challenging situations with both external and internal stakeholders, with demonstrable results. Able to reflectively engage or detach from an emotion depending on its perceived utility in a situation Uses emotional intelligence to influence key stakeholders within the enterprise. Coaches new and experienced practitioners in matters relating to emotional intelligence.	Recognized, beyond the enterprise boundary, as an authority on the application of emotional intelligence to Systems Engineering. Contributes to best practice in the application of emotional intelligence to Systems Engineering. Uses emotional intelligence to influence key stakeholders beyond the enterprise boundary. Advises and arbitrates on complex or sensitive emotionally-charged issues. Champions the introduction of novel techniques and ideas in the use of emotional intelligence, producing measurable improvements. Coaches lead practitioners in matters relating to emotional intelligence.

COMPETENCY AREA - PROFESSIONAL: COACHING AND MENTORING

Description:

Coaching and mentoring are development approaches based on the use of one-to-one conversations to enhance an individual's skills, knowledge or work performance. Coaching is a non-directive form of development aiming to produce optimal performance and improvement at work. It focuses on specific skills and goals, although may impact an individual's personal attributes. The process typically lasts for a defined period. Mentoring is a relationship where a more experienced colleague shares their greater knowledge to support development of a less experienced member of staff. It uses many of the techniques associated with coaching. One key distinction is that mentoring relationships tend to be longer term than coaching arrangements.

Why it matters:

Coaching and mentoring play an important role in the development of Systems Engineering professionals, providing targeted development and guidance, organizational and cultural insights. They represent learning opportunities for both parties, encouraging sharing and learning across generations and/or between roles. In addition, an organization may benefit through greater retention of staff, improved skills and productivity, improved communication, etc.

EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	LEAD PRACTITIONER	EXPERT
Describes key characteristics and personal attributes of coach and mentor roles, and how both approaches help to develop individual potential. Explains how those undergoing coaching and mentoring need to act in order to benefit from the activity. Explains why listening to an individual's goals and objectives is important. Lists enterprise goals and describes the influence mentoring may have on meeting those goals. Explains why taking a comprehensive approach to assess an individual's challenge is important.	Describes the design and operation of the enterprise's mentoring program. Describes coaching and mentoring opportunities available within the enterprise. Identifies areas of own skill, knowledge or performance requiring development which could benefit from coaching or mentoring, and explains why. Assesses and analyzes personal challenges through various perspectives. Assists with development of others within the team.	Participates as a coach or mentor in an enterprise coaching and mentoring program. Agrees career development goals and objectives with individuals. Develops individual career development paths based on development goals and objectives Uses available coaching and mentoring opportunities to develop individuals within the enterprise. Develops individuals within their team by supporting them in solving their individual challenges. Performs coaching or mentoring of inexperienced systems engineers within the enterprise to improve their skills, knowledge or performance. Guides supervised practitioners in "coaching and mentoring" to improve their competence in this area.	Recognized, within the enterprise, as an authority on the application of coaching and mentoring to Systems Engineering, contributing to best practice. Ensures best practice is used during coaching and mentoring activities. Reviews and judges the suitability of planned coaching and mentoring programs affecting Systems Engineering within the enterprise. Leads development of enterprise coaching and mentoring programs. Oversees the successful execution of a defined enterprise coaching and mentoring program. Continuously assesses and provides feedback on career development path activities for individuals within the enterprise. Advises on individual coaching and mentoring issues with demonstrable success. Performs coaching or mentoring of experienced systems engineers within the enterprise, Coaches new and experienced practitioners in "coaching and mentoring".	Recognized, beyond the enterprise boundary, as an authority on the application of coaching and mentoring to Systems Engineering. Contributes to best practice in the application of coaching and mentoring techniques within Systems Engineering. Influences key stakeholders beyond the enterprise boundary in support of coaching and mentoring activities affecting Systems Engineering. Advises on strategies for coaching and mentoring programs affecting Systems Engineering. Leads or advises on development of coaching and mentoring programs which extend beyond the enterprise boundary. Continuously assesses and provides feedback on the effectiveness of an enterprise mentoring program Advises on complex or challenging coaching and mentoring issues with demonstrable success. Performs coaching or mentoring of experienced systems engineers beyond the enterprise boundary. Champions the introduction of novel techniques and ideas in coaching and mentoring, producing measurable improvements. Coaches lead practitioners in coaching and mentoring to improve their competence in this area.

COMPETENCY AREA – TECHNICAL: REQUIREMENTS DEFINITION

Description:

To analyze the stakeholder needs and expectations to establish the requirements for a system.

Why it matters:

The requirements of a system describe the problem to be solved (its purpose, how it performs, how it is to be used, maintained and disposed of and what the expectations of the stakeholders are).

EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	LEAD PRACTITIONER	EXPERT
Describes different types of requirements (e.g. functional, non-functional, business etc.). Explains why there is a need for good quality requirements. Identifies major stakeholders and their needs. Explains why managing requirements throughout the lifecycle is important. Explains why there is a need to manage all types of requirements. Describes the relationship between requirements and acceptance.	Identifies all stakeholders and their sphere of influence. Assists with the elicitation of requirements from stakeholders. Describes the characteristics of good quality requirements and provides examples. Describes different mechanisms used to gather requirements. Explains why there is a need for traceability in the requirements process. Assists with establishment of acceptance criteria for requirements. Identifies potential requirement conflicts within the requirement set. Explains how requirements affect design and vice versa and provides examples. Assists with the establishment and maintenance of requirements traceability information.	Defines governing requirements elicitation and management plans, processes and appropriate tools and uses these to control and monitor requirements elicitation and management activities. Elicits and validates stakeholder requirements. Writes good quality, consistent requirements. Derives requirements by analyzing beyond the boundary of the system of interest. Establishes acceptance criteria for requirements. Resolves and negotiates requirement conflicts in order to establish a complete and consistent requirement set for the system of interest. Assesses the impact of changes to requirements on the solution and program. Guides supervised practitioners in requirements elicitation and management.	Recognized, within the enterprise, as an authority in requirements elicitation and management techniques, contributing to best practice. Defines and documents enterprise-level policies, procedures, guidance and best practice for requirements elicitation and management, including associated tools. Reviews and judges the tailoring of enterprise-level requirements elicitation and management processes to meet the needs of a project. Challenges appropriateness of requirements in a rational way. Reviews and judges the suitability and completeness of the requirements set. Influences key stakeholders to address identified enterprise-level requirements elicitation and management issues. Coaches new and experienced practitioners in requirements elicitation and management.	Recognized, beyond the enterprise boundary, as an authority in requirements elicitation and management techniques. Contributes to requirements elicitation and management best practice. Influences key stakeholders beyond the enterprise boundary in support of requirements elicitation and management. Advises on the suitability of the approach to elicitation and management of requirements. Advises and arbitrates on complex or sensitive requirements-related issues. Champions the introduction of novel techniques and ideas in requirements elicitation and management, producing measurable improvements. Coaches lead practitioners in requirements elicitation and management.

COMPETENCY AREA – TECHNICAL: SYSTEM ARCHITECTING

Description:

The definition of the system structure, interfaces and associated derived requirements to produce a solution that can be implemented to enable a balanced and optimum result that considers all stakeholder requirements (business, technical….). This includes the early generation of potential system concepts that meet a set of needs and demonstration that one or more credible, feasible options exist.

Why it matters:

Effective architectural design enables systems to be partitioned into realizable system elements which can be brought together to meet the requirements. Failure to explore alternative conceptual options as part of architectural analysis may result in a non-optimal system. There may be no viable option (e.g. technology not available).

EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	LEAD PRACTITIONER	EXPERT
Describes the principles of architectural design and its role within the lifecycle. Describes different types of architecture and provides examples. Explains why architectural decisions can constrain and limit future use and evolution and provides examples. Explains why there is a need to explore alternative and innovative ways of satisfying the requirements. Explains why alternative discipline technologies can be used to satisfy the same requirement and provides examples. Describes the process and key artifacts of functional analysis. Explains why there is a need for functional models of the system. Explains how outputs from functional analysis relate to the overall system design and provides examples.	Uses a governing process and appropriate tools to manage and control their own system architectural design activities. Uses analysis techniques to support architectural design process. Assists with the architectural design trade-offs. Contributes to alternative architectural designs that are traceable to the requirements Interprets an architectural design. Contributes candidate concepts (no matter how radical). Assists with the assessment of the feasibility of concepts. Uses appropriate tools and techniques to conduct functional analysis. Contributes to system architectural design activities.	Defines governing systems architecting plans, processes and appropriate tools and uses these to monitor and control system architectural design activities. Generates alternative architectural designs traceable to the requirements. Assesses a range of architectural designs and justifies the selection of the optimum solution. Chooses appropriate analysis and selection techniques Partitions between discipline technologies and works with specialists to derive discipline specific requirements Uses the results of system analysis activities to inform system architectural design. Describes the strengths and weaknesses of relevant technologies in the context of the requirement and provides examples Creates and is open to several possible alternative options and concepts and demonstrates that credible, feasible options exist Tracks key aspects of the evolving design solution and uses this information to adjust architecture, if appropriate. Guides supervised practitioners in system architectural design.	Recognized, within the enterprise, as an authority in system architectural design techniques, contributing to best practice. Defines and documents enterprise-level policies, procedures, guidance and best practice for system architectural design including associated tools. Reviews and judges the tailoring of enterprise-level system architectural design processes to meet the needs of a project. Demonstrates a full understanding of architectural design and functional analysis techniques and their appropriateness, given the levels of complexity of the system of interest. Reviews and judges the suitability of architecture designs and associated analyses. Realizes systems using a model that comprises a complete, coherent, and consistent architectural design. Influences key stakeholders to address enterprise-level system architectural design issues. Coaches new and experienced practitioners in system architecture design.	Recognized, beyond the enterprise boundary, as an authority in system architectural design. Contributes to system architectural design best practice. Influences key stakeholders beyond the enterprise boundary in support of system architectural design. Advises on the suitability of the approach to system architectural design. Advises and arbitrates on complex or sensitive system architecture-related issues. Advises in techniques for concept generation. Champions the introduction of novel techniques and ideas in system architectural design, producing measurable improvements. Coaches lead practitioners in system architectural design.

COMPETENCY AREA – TECHNICAL: DESIGN FOR…

Description:

Ensuring that the requirements of all lifecycle stages are addressed at the correct point in the system design. During the design process consideration should be given to the design attributes such as manufacturability, testability, reliability, maintainability, affordability, safety, security, human factors, environmental impacts, robustness and resilience, flexibility, interoperability, capability growth, disposal, cost, natural variations etc. Includes the need to design for robustness. A robust system is tolerant of misuse, out of spec scenarios, component failure, environmental stress and evolving needs.

Why it matters:

Failure to design for these attributes at the correct point in the development lifecycle may result in the attributes never being achieved or achieved at escalated cost. In particular, a robust system provides greater availability during operation.

EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	LEAD PRACTITIONER	EXPERT
Explains why there is a need to accommodate the requirements of all lifecycle stages when determining a solution. Identifies design attributes and explains why attributes must be balanced using tradeoff studies Identifies different design specialties and describes their role and key activities. Explains why it is important to integrate design specialties into the solution and how this can be a potential source of conflict with requirements. Explains how design specialties can affect the cost of ownership and provides examples. Explains how the design, throughout the lifecycle, affects the robustness of the solution. Identifies analytical techniques and describes the importance of design integrity, legislation, whole life costs and customer satisfaction. Describes the relationship between reliability, availability, maintainability and safety.	Uses a governing process and appropriate tools to manage and control their own specialty engineering activities. Identifies design attributes and describes how they influence the design. Supports the selection and balancing of design attributes in support of specialty engineering needs. Assists specialists in ensuring that the design attributes are addressed. Assists with trade-off activities involving conflicting demands from design specialisms. Assists with activities characterizing the operational environment in support of specialty engineering activities. Assists with trade studies which determine and characterize specialty characteristics of proposed solutions. Identifies the relationships between the integration of specialisms within their project and provides examples. Assists with the identification of constraints placed on the system because of the needs of design specialisms. Uses techniques and tools to ensure delivery of designs meeting specialty needs.	Defines governing specialty engineering plans, processes and appropriate tools and uses these to monitor and control specialty engineering activities. Selects and balances design attributes throughout the design process in support of specialty engineering needs. Works with appropriate specialists to ensure that the design addresses these attributes effectively and at the correct time. Conducts trade-offs involving conflicting demands from design specialisms. Selects and uses appropriate techniques to characterize the operational environment requires to support specialty engineering activities. Selects and uses appropriate techniques and trade studies to determine and characterize specialty characteristics of proposed solutions. Manages the integration of specialisms within a project. Identifies and addresses constraints placed on the system because of the needs of design specialisms. Guides supervised practitioners in specialty engineering.	Recognized within the enterprise, as an authority in specialty engineering techniques, contributing to best practice. Defines and documents enterprise-level policies, procedures, guidance and best practice relating to specialty engineering including associated tools. Reviews and judges the tailoring of enterprise-level system specialty engineering processes to meet the needs of a project. Reviews and judges the strategy to be adopted to ensure required specialty engineering characteristics are met. Carries out sensitivity analyses on specialty engineering trade-off criteria. Reviews and judges the suitability of plans for the incorporation of all lifecycle design attributes at the correct point within the design process. Reviews and judges selected solutions against key specialty engineering design parameters. Influences key stakeholders to address enterprise-level specialty-related design issues. Coaches new and experienced practitioners in specialty engineering.	Recognized beyond the enterprise boundary, as an authority in Specialty Engineering. Contributes to specialty engineering best practice. Influences key stakeholders beyond the enterprise boundary in support of specialty engineering activities. Advises on the suitability of the approach to specialty engineering activities including their organization and integration across the enterprise. Advises and arbitrates on complex or sensitive specialty engineering-related issues including cost of ownership and allocation of technical margins. Integrates activities across several specialisms. Resolves conflicts involving specialisms. Predicts and advises on evolving system need and its impact over time. Champions the introduction of novel techniques and ideas in specialty engineering producing measurable improvements. Coaches lead practitioners in specialty engineering.

COMPETENCY AREA – TECHNICAL: INTEGRATION

Description:

Systems Integration is the logical process for assembling a set of system elements and aggregates into the realized system, product or service that satisfies system requirements, architecture and design. Systems integration focuses on the testing of interfaces, data flows, and control mechanisms, checking that realized elements and aggregates perform as predicted by their design and architectural solution, since it may not always be practicable or cost-effective to confirm these lower-level aspects at higher levels of system integration.

Why it matters:

Systems Integration should be planned so that system elements are brought together in a logical sequence to avoid wasted effort. Systematic and incremental integration makes it easier to find, isolate, diagnose and correct problems. A system or system element that has not been integrated systematically cannot be relied on to meet its requirements.

EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	LEAD PRACTITIONER	EXPERT
Explains why integration is important and how it confirms the system design, architecture and interfaces. Explains why it is important to integrate the system in a logical sequence. Explains why planning and management of systems integration is necessary. Describes the relationship between integration and verification.	Uses a governing process and appropriate tools to manage and control their own integration activities. Assists with the development of integration plans based upon standards and corporate processes including identification of method and timing for each activity. Writes integration plans for smaller projects. Diagnoses simple faults typically found during integration activities, documents, communicates and follows up with corrective actions. Gathers evidence during integration in support of downstream test and acceptance activities. Assists with the identification of an integration environment.	Defines governing integration plans, processes and appropriate tools and uses these to monitor and control integration activities. Develops integration plans based upon standards and corporate processes including identification of method and timing for each activity. Writes integration plans for larger, more complex systems or projects. Diagnoses complex faults typically found during integration activities, documents, communicates and follows up with corrective actions. Prepares evidence obtained during integration in support of downstream test and acceptance activities. Oversees system, product or service integration activities. Identifies a suitable integration environment. Writes detailed integration procedures. Demonstrates effective management of systems integration activities. Guides supervised practitioners in integration.	Recognized, within the enterprise, as an authority in integration, contributing to best practice. Defines and documents enterprise-level policies, procedures, guidance and best practice for integration, including associated tools. Reviews and judges the tailoring of enterprise-level integration processes to meet the needs of a project. Reviews and judges the suitability of integration plans. Reviews and judges detailed integration procedures. Reviews and judges evidence generated during integration. Leads integration activities on complex systems or projects. Influences key stakeholders to address identified enterprise-level integration issues. Coaches new and experienced practitioners in integration.	Recognized, beyond the enterprise boundary, as an authority in systems integration. Contributes to systems integration best practice. Influences key stakeholders beyond the enterprise boundary in support of integration activities. Advises on the suitability of the approach to integration. Advises on evidence generated during integration. Advises and arbitrates on complex or sensitive integration-related issues. Champions the introduction of novel techniques and ideas in integration, producing measurable improvements. Coaches lead practitioners in integration.

COMPETENCY AREA – TECHNICAL: INTERFACES

Description:

Interfaces occur where system elements interact, for example human, mechanical, electrical, thermal, data, etc. Interface Management comprises the identification, definition and control of interactions across system or system element boundaries.

Why it matters:

Poor interface definition and management can result in incompatible system elements (either internal to the system or between the system and its environment) which may ultimately result in system failure or project overrun.

EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	LEAD PRACTITIONER	EXPERT
Explains why there is a need for interface definition and management and its impact on the integrity of the system solution. Identifies and describes possible sources of complexity in interface definition and management.	Uses a governing process to manage and control their own interface management activities. Identifies and defines simple interfaces.	Defines governing interface management plans, processes and appropriate tools and uses these to monitor and control interface management activities. Identifies, defines and controls system element interfaces. Describes possible sources of complexity for the interface definition and management of a project and provides examples. Identifies consequences of changes to interfaces on the system elements, system and/or system of systems and provides examples. Guides supervised practitioners in interface definition and management.	Recognized, within the enterprise, as an authority in interface definition and management, contributing to best practice. Defines and documents enterprise-level policies, procedures, guidance and best practice for interface definition and management, including associated tools. Reviews and judges the tailoring of enterprise-level interface definition and management processes to meet the needs of a project. Reviews and judges the suitability and completeness of interfaces and associated management practices. Liaises and arbitrates when there are conflicts in the definition of interfaces or their management. Influences key stakeholders to address identified enterprise-level interface definition and management issues. Coaches new and experienced practitioners in interface definition and management.	Recognized, beyond the enterprise boundary, as an authority in interface definition and management. Contributes to interface definition and management best practice. Influences key stakeholders beyond the enterprise boundary in support of interface definition and management. Advises on the suitability of the approach to interface definition and management. Advises and arbitrates on complex or sensitive interface-related issues. Advises on the suitability of the approach to interface definition and management. Champions the introduction of novel techniques and ideas in interface definition and management, producing measurable improvements. Coaches lead practitioners in interface management.

COMPETENCY AREA – TECHNICAL: VERIFICATION

Description:

Verification is the formal process of obtaining objective evidence that a system or system element, product or service fulfils its specified requirements and characteristics. Verification includes formal testing of the system against the system requirements; including qualification against the super system environment (e.g. electro-magnetic compatibility, thermal, vibration, humidity, fungus growth, etc.). Put simply, it answers the question "Did we build the system right?".

Why it matters:

System verification should be planned so that system elements are tested in a logical sequence to avoid wasted effort. Systematic and incremental verification makes it easier to find, isolate, diagnose and correct problems. A system or system element that has not been verified cannot be relied on to meet its requirements. Systems Verification is an essential pre-requisite to customer acceptance and certification.

EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	LEAD PRACTITIONER	EXPERT
Explains what verification is, the purpose of verification and why verification against the system requirements is important. Explains why there is a need to verify the system in a logical sequence. Explains why planning for system verification is necessary. Describes how traceability can be used to establish whether a system meets requirements. Describes the relationship between verification, validation, qualification, certification and acceptance.	Uses a governing process and appropriate tools to plan and control their own verification activities. Assists with the development of verification plans based upon standards and corporate processes including identification of method and timing for each activity. Writes verification plans for smaller projects. Diagnoses simple faults typically found during verification activities and follows up with corrective actions. Gathers evidence in support of verification, qualification, certification and acceptance. Uses verification to establish whether a system meets requirements. Assists with the identification of a verification environment.	Defines governing verification plans, processes and appropriate tools and uses these to monitor and control verification activities. Develops verification plans based upon standards and corporate processes including identification of method and timing for each activity. Writes verification plans for larger, more complex systems or projects. Diagnoses complex faults typically found during verification activities and follows up with corrective actions. Prepares evidence obtained during verification testing to support system verification, qualification, certification and acceptance. Traces verification requirements to system requirements and vice versa. identifies a suitable verification environment. Oversees system, product or service verification activities. Writes detailed verification procedures. Guides supervised practitioners in verification.	Recognized within the enterprise, as an authority in verification, contributing to best practice. Defines and documents enterprise-level policies, procedures, guidance and best practice for verification, including associated tools. Reviews and judges the tailoring of enterprise-level verification processes to meet the needs of a project. Reviews and judges the suitability of verification plans. Reviews and judges detailed verification procedures. Reviews and judges evidence generated during verification. Leads verification activities on complex systems or projects. Influences key stakeholders to address identified enterprise-level verification issues. Coaches new and experienced practitioners in verification.	Recognized beyond the enterprise boundary, as an authority in verification. Contributes to verification best practice. Influences key stakeholders beyond the enterprise boundary in support of verification activities. Advises on the suitability of the approach to verification. Advises on the suitability of verification plans and practices for complex systems or projects. Advises and arbitrates on complex or sensitive verification-related issues. Champions the introduction of novel techniques and ideas in verification, producing measurable improvements. Coaches lead practitioners in verification.

COMPETENCY AREA – TECHNICAL: VALIDATION

Description:

The purpose of validation is to provide objective evidence that the system, product or service when in use, fulfills its business or mission objectives and stakeholder requirements, achieving its intended use in its intended operational environment. Put simply, validation checks that the needs of the customer/end user have been met and answers the question "Did we build the right system?"

Why it matters:

Validation is used to check that the system meets the needs of the customer/end user. Failure to satisfy the customer will impact future business. Validation provides some important inputs to future system development.

EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	LEAD PRACTITIONER	EXPERT
Explains what validation is, the purpose of validation and why validation is important. Explains why there is a need for early planning for validation. Describes the relationship between validation, verification, qualification, certification and acceptance. Describes the relationship between traceability and validation.	Uses a governing process and appropriate tools to plan and control their own validation activities. Assists with the development of validation plans based upon standards and corporate processes including identification of method and timing for each activity. Explains why customer and communications both need to reflect the terminology of the customer or end user. Conducts system validation activities in accordance with defined procedures, recording results, highlighting anomalies and supporting resolution of any failures. Collates validation results in support of downstream qualification, certification and acceptance activities.	Defines governing validation plans, processes and appropriate tools and uses these to monitor and control validation activities. Develops validation plans based upon standards and corporate processes including identification of method and timing for each activity. Focuses on customer needs and communicates using the terminology of the customer and end user. Writes validation plans for larger, more complex systems or projects. Reviews and judges validation results, diagnosing complex faults found during validation activities. Oversees system, product or service validation activities. Writes detailed validation procedures Prepares evidence obtained during validation testing to support Certification and acceptance. Traces validation requirements back to user needs and vice versa Guides supervised practitioners in validation.	Recognized within the enterprise, as an authority in validation, contributing to best practice. Defines and documents enterprise-level policies, procedures, guidance and best practice for validation, including associated tools. Reviews and judges the tailoring of enterprise-level validation processes to meet the needs of a project. Reviews and judges the suitability of validation plans. Reviews and judges detailed validation procedures. Reviews and judges evidence generated during validation. Leads validation activities on complex systems or projects. Influences key stakeholders to address identified enterprise-level validation issues. Coaches new and experienced practitioners in validation.	Recognized beyond the enterprise boundary, as an authority in validation. Contributes to validation best practice. Influences key stakeholders beyond the enterprise boundary in support of validation activities. Advises on the suitability of the approach to validation. Advises on the suitability of validation plans and practices for complex systems or projects. Advises and arbitrates on complex or sensitive validation-related issues using the language of the customer or user where appropriate. Champions the introduction of novel techniques and ideas in validation, producing measurable improvements. Coaches lead practitioners in validation.

COMPETENCY AREA – TECHNICAL: TRANSITION

Description:

Transition is the integration of a verified system, product or service into its operational environment including the wider ("Super") system of which it forms a part. Transition is performed in accordance with stakeholder agreements and includes support activities and provision of relevant enabling systems (e.g. production and volume manufacturing, site preparation, support and logistics systems, operator training). Transition is used at each level in the system structure.

Why it matters:

Incorrectly transitioning the system into operation can lead to misuse, failure to perform, and customer or end user dissatisfaction. Failure to plan for transition to operation may result in a system that is delayed into service or market with a consequential impact on the customer or business. Failure to satisfy the customer will impact future business.

EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	LEAD PRACTITIONER	EXPERT
Explains why there is a need to carry out transition to operation, how it is performed and the benefits a controlled transition to operation brings. Lists the type of activities and work products required for transition to operation and provides examples.	Uses a governing process and appropriate tools to plan and control their own transition activities. Conducts transition to production or operation activities in accordance with the plan. Describes the system, product or service's contribution to the wider system (super-system) of which it forms a part.	Defines governing transition plans, processes and appropriate tools and uses these to monitor and control transition activities. Develops transition plans based upon standards and corporate processes including identification of method and timing for each activity. Performs a system, product or service transition to production and operation taking into consideration its contribution to the wider (super) system. Communicates using the terminology of the user. Oversees transition activities with proven results. Guides supervised practitioners in transition to operation.	Recognized, within the enterprise, as an authority in transition activities, contributing to best practice. Defines and documents enterprise-level policies, procedures, guidance and best practice for transition to operation or production, including associated tools. Reviews and judges the tailoring of enterprise-level transition processes to meet the needs of a project. Reviews and judges the suitability of transition plans. Reviews and judges detailed transition procedures. Influences key stakeholders to address identified enterprise-level transition to operation issues. Leads transition activities on complex systems or projects. Coaches new and experienced practitioners in transition to operation.	Recognized, beyond the enterprise boundary, as an authority in system transition activities. Contributes to system transition best practice. Influences key stakeholders beyond the enterprise boundary in support of transition activities. Advises on the suitability of the approach to transition. Advises and arbitrates on complex or sensitive transition-related issues using the language of the customer or user where appropriate. Champions the introduction of novel techniques and ideas in transition activities, producing measurable improvements. Coaches lead practitioners in transition to operation.

COMPETENCY AREA – TECHNICAL: OPERATION AND SUPPORT

Description:

Operation is when the system, product or service is used to deliver its capabilities over its lifetime. Support encompasses the activities required to sustain operation of the system, product or service over time, especially as the result of failures, performance issues, evolving needs, obsolescence and technology changes and includes disposal of the system and its components when they reach end of life. Support entails monitoring system performance, addressing system failures and performance issues and updating the system to accommodate evolving needs and technology.

Why it matters:

The operations and support stages of a system, product or service typically account for the largest portion of the total life cycle cost. Proactive and systematic responses to operational issues contribute significantly to user satisfaction and operational cost management.

EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	LEAD PRACTITIONER	EXPERT
Explains why a system, product or service needs to be supported during operation and provides examples. Describes the difference between preventive and corrective maintenance Explains why it is necessary to address failures, parts obsolescence and evolving user requirements during system operation. Lists the different levels of repair capability and describes the characteristics of each.	Uses a governing process and appropriate tools to plan and control their own system, product or service operations, maintenance and support-related activities. identifies and supports collection and review of operational data in order to assess system, product or service performance. Assists with the assessment of system failures or performance issues and the preparation of design change to rectify such failures. Assists with the assessment of evolving user need, including activities assessing the feasibility of updates in response to the changed need. Assists with assessments of new technologies and helps conduct studies to identify possible system updates. Assists with assessments of components approaching obsolescence and helps conducts studies to identify suitable replacements. Assists with updates of technical data (e.g. procedures, guidelines, checklists, training and maintenance materials) to ensure they are current. Identifies potential changes to system operational environment or external interfaces.	Defines governing operation and support plans, processes and appropriate tools and uses these to monitor and control system, product or service operation, maintenance and support activities. Develops and implements system, product or service operation, maintenance and support plans based upon standards and corporate processes. Determines data to be collected in order to assess system, product or service operational performance. Assesses system failures or performance issues and initiates design change proposals to rectify failures. Identifies system elements approaching obsolescence and conducts studies to identify suitable replacements. Monitors and addresses changes to system operational environment or external interfaces. Ensures technical support data (e.g. procedures, guidelines, checklists, training and maintenance materials) remain current. Guides supervised practitioners in system, product or service operation, maintenance and support.	Recognized, within the enterprise, as an authority in service operation, maintenance and support, contributing to best practice. Defines and documents enterprise-level policies, procedures, guidance and best practice for operation and support, including associated tools. Reviews and judges the tailoring of enterprise-level operation and support processes. Applies advanced practices to the support of a system, product or service. Assesses potential technology upgrades for a system, product or service and evaluates cost-benefit ratio for upgrading the design solution. Leads support activities for a system, product or service in operation. identifies and executes plans for the disposal of a system, product or service at end-of-life. Influences key stakeholders to address identified enterprise-level system, product or service operation, maintenance and support issues. Coaches new and experienced practitioners in system, product or service operation, maintenance and support.	Recognized, beyond the enterprise boundary, as an authority in service operation, maintenance and support. Contributes to system service operation, maintenance and support best practice. Influences key stakeholders beyond the enterprise boundary in support of operation and support activities. Advises on the suitability of the approach to operation, maintenance and support. Advises and arbitrates on complex or sensitive operations, maintenance and support-related issues. Champions the introduction of novel techniques and ideas in system, product or service operation, maintenance and support producing measurable improvements. Coaches lead practitioners in system, product or service operation, maintenance and support.

COMPETENCY AREA – SYSTEMS ENGINEERING MANAGEMENT: PLANNING

Description:

The purpose of planning is to produce, coordinate and maintain effective and workable plans across multiple disciplines. Systems Engineering planning includes planning the way the engineering of the system will be performed and managed, tailoring generic engineering processes to address specific project context, technical activities and identified risks. This includes estimating the effort, resources and timescales required to complete the project to the required quality level. Planning is performed in association with the Project Manager. Plans and estimates may need updating to reflect changes or to overcome unexpected issues encountered during the development process.

Why it matters:

It is important to identify the full scope and timing of all Systems Engineering activities and their associated resource needs and to link this with task effort and cost estimation through controlled planning. Alignment between Systems Engineering planning and estimation is vital to ensure that assumptions made when developing a plan, such as ways of working and process tailoring are taken into consideration. Failure to plan correctly will mean inadequate visibility of progress and is likely to cause ongoing problems with time, budget and quality.

EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	LEAD PRACTITIONER	EXPERT
Defines key planning and estimating terms and acronyms and describes the relationships between them. Explains why planning Systems Engineering activities is important and how planning interacts across disciplines and organizations. Identifies key areas that need to be addressed in a project Systems Engineering plan. Describes the principles of Systems Engineering process tailoring including its benefits and potential issues. Identifies key potential sources of change on a project and why the impact of such changes needs to be carefully assessed and planned. Describes the relationship between lifecycle reviews and planning.	Uses a governing process and appropriate tools to plan and control their own Systems Engineering planning activities. Describes the role and relationship of Systems Engineering planning to wider overall project planning and management. Assists with the preparation of plans for managing the engineering of a system, product or service. Assists with the preparation of Systems Engineering work packages including effort and resource estimates for Systems Engineering tasks. Assists with the assessment and re-planning of Systems Engineering activities associated with proposed and approved engineering changes. Assists with the identification of key design parameters required to track critical aspects of the design during development.	Defines a governing process and appropriate tools and uses these to plan and control Systems Engineering planning activities. Prepares plans for managing Systems Engineering activities as part of a wider project plan. Prepares effort and resource estimates for Systems Engineering tasks in accordance with governing processes and procedures. Selects key design parameters required in order to track critical aspects of the design during development. Influences project management to secure identified future Systems Engineering needs of a project. Assesses required updates to Systems Engineering plans as the result of potential engineering changes. Updates plans for Systems Engineering activities following approval of engineering changes. Guides supervised practitioners in Systems Engineering planning.	Recognized, within the enterprise, as an authority in Systems Engineering planning, contributing to best practice. Defines and documents enterprise-level policies, procedures, guidance and best practice for Systems Engineering planning, including associated tools. Reviews and judges the tailoring of enterprise-level Systems Engineering planning processes to meet the needs of a project. Coordinates Systems Engineering planning across multiple diverse projects or across a complex system, with proven success. Reviews and judges the suitability of proposed Systems Engineering plans and associated estimates. Reviews and judges on the impact of engineering changes on existing Systems Engineering plans and estimates. Influences key stakeholders to address identified enterprise-level Systems Engineering project planning issues. Coaches new and experienced practitioners in Systems Engineering planning.	Recognized, beyond the enterprise boundary, as an authority in Systems Engineering planning. Contributes to Systems Engineering planning best practice. Influences key Systems Engineering planning stakeholders beyond the enterprise boundary. Advises and arbitrates on complex or sensitive Systems Engineering planning issues. Advises on the suitability of the approach within proposed Systems Engineering plans and associated estimates. Influences strategic Systems Engineering planning activities which link Systems Engineering to other disciplines at enterprise level Champions the introduction of novel techniques and ideas in Systems Engineering planning, producing measurable improvements. Coaches lead practitioners in Systems Engineering planning.

COMPETENCY AREA – SYSTEMS ENGINEERING MANAGEMENT: MONITORING AND CONTROL

Description:

Monitoring and control assesses the project to see if the current plans are aligned and feasible; determines the status of a project, technical and process performance and directs execution to ensure that performance is according to plans and schedule, within project budgets, and satisfies technical objectives.

Why it matters:

Failure to adequately assess and monitor performance against the plan prevents visibility of progress and, in consequence, appropriate corrective actions may not be identified and/or taken when project performance deviates from that required.

EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	LEAD PRACTITIONER	EXPERT
Explains why monitoring and controlling Systems Engineering activities against planning documentation is important. Describes the role of Systems Engineering monitoring and control within the wider execution of the project plan. Explains how project organization and work breakdown documentation is used to control and monitor Systems Engineering work execution. Describes different types of technical and non-technical reviews and decision gates across the Systems Engineering lifecycle and their relationship with monitoring, controlling and potential re-planning of Systems Engineering tasks. Describes typical Systems Engineering metrics and measures and how these contribute to monitoring and controlling Systems Engineering on a project. Explains why maintaining good communications with all stakeholders is an important part of the monitoring and control of Systems Engineering on a project.	Uses a governing process and appropriate tools to plan and control their own monitoring and control of Systems Engineering activities. Assists with the measurement, assessment and reporting of Systems Engineering tasks against plans. Assists with monitoring and control of Systems Engineering activities by producing or acquiring data for use in determining deviations or trends against plans. Identifies potential corrective actions based upon measurement and assessment to control Systems Engineering activities. Assists with monitoring of critical aspects of the design solution during development and identifies potential remedial action as required. Assists with the management of technical margins both horizontally and vertically through the project hierarchy.	Defines a governing process and appropriate tools and uses these to plan and control the monitoring and control of Systems Engineering activities. Monitors and controls Systems Engineering activities in accordance with governing processes and procedures during the full lifecycle of a project. Monitors Systems Engineering activities as part of overall project execution. Measures, assesses and reports Systems Engineering tasks against estimates and plans to key stakeholders on a project. Monitors and controls Systems Engineering activities by processing assessment data in order to determine deviations or trends against plans. Applies necessary remedial corrective actions based upon measurement and assessment to control Systems Engineering activities. Manages and trades technical margins both horizontally and vertically through the project hierarchy. Guides supervised practitioners in Systems Engineering monitoring and control.	Recognized, within the enterprise, as an authority in Systems Engineering monitoring and control, contributing to best practice. Defines and documents enterprise-level policies, procedures, guidance and best practice for Systems Engineering monitoring and control, including associated tools. Reviews and judges the tailoring of enterprise-level Systems Engineering monitoring and control processes and associated work products, to meet the needs of a project. Coordinates Systems Engineering monitoring and control across multiple diverse projects or across a complex system, with proven success. Reviews and judges on the management and trade of technical margins both horizontally and vertically through the project hierarchy. Measures, assesses and reports Systems Engineering tasks against plans to key stakeholders on multiple distinct projects or a complex project. Reviews and judges proposals for preventative or remedial actions when assessment indicates a trend towards deviation on multiple distinct projects or a complex project. Influences key stakeholders to address identified enterprise-level Systems Engineering monitoring and control issues. Coaches new and experienced practitioners in Systems Engineering monitoring and control.	Recognized, beyond the enterprise boundary, as an authority in Systems Engineering monitoring and control. Contributes to Systems Engineering monitoring and control best practice. Influences Systems Engineering monitoring and control activities of key project stakeholders beyond the enterprise boundary. Advises and arbitrates on complex or sensitive Systems Engineering monitoring and control issues. Advises on the suitability of the approach for monitoring and controlling system developments. Champions the introduction of novel techniques and ideas in Systems Engineering monitoring and control, producing measurable improvements. Coaches lead practitioners in Systems Engineering monitoring and control.

COMPETENCY AREA – SYSTEMS ENGINEERING MANAGEMENT: RISK AND OPPORTUNITY MANAGEMENT

Description:

Risk is an uncertain event or condition that, if it occurs, has a positive or negative effect on project or enterprise objectives. The purpose of risk and opportunity management is to reduce potential risks to an acceptable level before they occur, or maximize the potential of any opportunity, throughout the life of the project. Risk and opportunity management is a continuous, forward-looking process that is applied to anticipate and avert risks that may adversely impact the project and can be considered both a project management and a Systems Engineering activity.

Why it matters:

Every new system (or existing system modification) has inherent risk but is also based upon the pursuit of an opportunity. Risk and opportunity are both present throughout the lifecycle of systems and the primary objective of managing these areas as part of Systems Engineering activities is to balance the allocation of resources to achieve greatest risk mitigation (or opportunity benefits).

EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	LEAD PRACTITIONER	EXPERT
Describes the distinction between risk, issue, opportunity and can provide examples of each. Lists key factors associated with good risk management and why these factors are important. Identifies different classes of risk and can provide examples of each. Identifies different types of risk treatment available and can provide examples of each. Identifies different types of opportunity and can provide examples of each. Describes a typical high-level process for risk and opportunity management. Explains how risk is typically assessed and can provide examples.	Uses a governing process and appropriate tools to plan and control their own risk and opportunity management activities. Assists with the preparation of risk and opportunity management processes and work products to meet the needs of a specific project. Assists with the identification, assessment, analysis and treatment of risks and opportunities on a project. Assists with the identification and deployment of mitigation activities designed to address Systems Engineering risks and opportunities. Assists with the monitoring and management of Systems Engineering risks and opportunities during project execution. Assists with the communication of risk and opportunity status to affected stakeholders.	Defines governing risk and opportunity management plans, processes and appropriate tools and uses these to control and monitor risk and opportunity management activities. Establishes a project risk and opportunity profile including context, probability, consequences, thresholds, priority and risk action and status. Identifies, assesses, analyzes and treats risks and opportunities for likelihood and consequence in order to determine magnitude and priority for treatment Monitors and manages Systems Engineering risks and opportunities during project execution. Treats risks and opportunities effectively, considering alternative treatments and generating a plan of action when thresholds exceeds certain levels Communicates risk and opportunity status to affected stakeholders Guides supervised practitioners in Systems Engineering risk and opportunity management.	Recognized, within the enterprise, as an authority in Systems Engineering risk and opportunity management, contributing to best practice. Defines and documents enterprise-level policies, procedures, guidance and best practice for Systems Engineering risk and opportunity management, including associated tools. Reviews and judges the tailoring of enterprise-level risk and opportunity management processes and associated work products to meet the needs of a project. Coordinates Systems Engineering risk and opportunity management across multiple diverse projects or across a complex system, with proven success. Establishes an enterprise risk profile including context, probability, consequences, thresholds, priority and risk action and status. Reviews and judges on the treatment of risks and opportunities across multiple diverse projects or a complex project, with proven success. Influences key stakeholders to address identified enterprise-level project risks and opportunities. Coaches new and experienced practitioners in Systems Engineering risk and opportunity management.	Recognized, beyond the enterprise boundary, as an authority in Systems Engineering risk and opportunity management. Contributes to Systems Engineering risk and opportunity management best practice. Influences key stakeholders beyond the enterprise boundary in support of risk and opportunity management. Advises and arbitrates on complex or sensitive risk and opportunity issues. Advises on the suitability of risk and opportunity strategies. Advises on complex or sensitive Systems Engineering risk and opportunity management issues. Champions the introduction of novel techniques and ideas in Systems Engineering risk and opportunity management, producing measurable improvements. Coaches lead practitioners in Systems Engineering risk and opportunity management.

COMPETENCY AREA – SYSTEMS ENGINEERING MANAGEMENT: DECISION MANAGEMENT

Description:

Decision management provides a structured, analytical framework for objectively identifying, characterizing and evaluating a set of alternatives for a decision at any point in the lifecycle in order to select the most beneficial course of action.

Why it matters:

System development entails an array of interrelated decisions that require the holistic perspective of the Systems Engineering discipline. Decisions include selection of preferred solution at every level of the system, including technology option selection, architecture selection, make-or-buy decisions, strategy selection for maintenance, disposal. Whilst some low value decisions can be made and recorded simply, key decisions which might affect the long-term success and value delivery of the project need to be controlled using a formalized decision management process.

EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	LEAD PRACTITIONER	EXPERT
Identifies the Systems Engineering situations where a structured decision is, and is not, appropriate. Explains why there is a need to select a preferred solution. Describes the relevance of comparative techniques (e.g. trade studies, make/buy, etc.) to assist decision processes. Explains how to frame, tailor and structure a decision including its objectives and measures, and outlines the key characteristics of a structured decision making approach. Explains how uncertainty impacts on decision making. Justifies the need for communication and accurate recording in all aspects of the decision-making process.	Uses a governing process and appropriate tools to plan and control their own decision management activities. Assists with decision management and associated communications planning. Assists with selection of decision criteria and performance parameters. Assists with the selection of tools and techniques for the decision process and provides examples of different tools and techniques. Assists with decision trade studies and records results. Monitors and catalogs the decision process and associated actions.	Defines governing decision management plans, processes and appropriate tools and uses these to control and monitor decision management activities. Develops decision plans and associated communications based upon standards and corporate processes. Defines decision selection criteria, weightings of the criteria and assess alternatives against selection criteria. Chooses appropriate tools and techniques for making different types of decision. Performs trade-off analysis and justifies the result chosen in terms that can be quantified and qualified. Defines selection criteria, weightings of the criteria and assess potential solutions against selection criteria Chooses the appropriate tools and techniques for selecting the preferred solution, e.g. trade analysis, make/buy analysis Performs trade analysis and justify the result chosen in terms that can be quantified and qualified Guides supervised practitioners in decision management.	Recognized, within the enterprise, as an authority in decision management, contributing to best practice. Defines and documents enterprise-level policies, procedures, guidance and best practice for decision management and communication, including associated tools. Reviews and judges the tailoring of enterprise-level decision management processes and associated work products to meet the needs of a project. Coordinates decision management and trade analysis using different techniques, across multiple diverse projects or across a complex system, with proven success. Influences key stakeholders to address identified enterprise-level decision management issues. Supports negotiation of complex trades. Reviews and judges decisions affecting solutions and the criteria for making the solution. Carries out sensitivity analysis on selection criteria. Coaches new and experienced practitioners in decision management.	Recognized, beyond the enterprise boundary, as an authority in decision management. Contributes to best practice in the application of decision management techniques to Systems Engineering. Influences key decision stakeholders beyond the enterprise boundary. Advises and arbitrates on complex or sensitive decision management or trade-off issues. Advises on strategies for diverse decision types or on complex programs. Resolves issues with complex system trade-offs Champions the introduction of novel techniques and ideas in decision management, producing measurable improvements. Coaches lead practitioners in decision management.

COMPETENCY AREA – SYSTEMS ENGINEERING MANAGEMENT: CONCURRENT ENGINEERING

Description:

Concurrent engineering is a work methodology based on the parallelization of tasks (i.e. performing tasks concurrently). It refers to an approach used in Systems Engineering in which functions of design and development engineering, manufacturing engineering and other enterprise functions are integrated to reduce the elapsed time required to bring a new system, product or service to market.

Why it matters:

Systems Engineering lifecycles involve multiple, concurrent processes and activities which must be coordinated to mitigate risk and prevent unnecessary work, paralysis and a lack of convergence to an effective solution. Concurrency may be the only approach capable of meeting the customer schedule or gaining a competitive advantage. Performance can be constrained unnecessarily by allowing individual system elements to progress too quickly.

EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	LEAD PRACTITIONER	EXPERT
Explains how Systems Engineering lifecycle processes and activities and the development of systems elements can be concurrent and provides examples. Describes the advantages and disadvantages of concurrent engineering.	Describes Systems Engineering lifecycle processes in place on their project and how concurrency issues may impact its successful execution. Assists with co-ordination of concurrent engineering activities on a Systems Engineering project. Assists with generation of concurrency-related inputs to management plans for a Systems Engineering project.	Defines governing concurrency management strategies and uses these to perform concurrent engineering on a project. Identifies elements which can be developed concurrently on a Systems Engineering project. Identifies concurrent interactions within a Systems Engineering lifecycle on a project. Co-ordinates concurrent activities and deals with emerging issues on a Systems Engineering project. Contributes concurrency-related aspects to appropriate management plans for a Systems Engineering project. Advises on concurrency issues and risks on a Systems Engineering project. Guides supervised practitioners in concurrent engineering.	Recognized, within the enterprise, as an authority in concurrent engineering, contributing to best practice. Defines and documents enterprise-level policies, procedures, guidance and best practice for concurrent engineering, including associated tools. Reviews and judges on the tailoring of enterprise-level concurrency processes and associated work products to meet the needs of a project. Co-ordinates concurrent activities and deals with emerging issues across multiple diverse projects, or across a complex system, with proven results. Manages the interactions within Systems Engineering lifecycles across multiple diverse projects, or across a complex system. Reviews and judges on concurrency issues and risks across multiple diverse projects, or on a complex system. Reviews and judges the suitability of plans for managing the engineering of the system, product or service. Influences key stakeholders to address identified enterprise-level concurrent engineering issues. Coaches new and experienced practitioners in concurrent engineering.	Recognized, beyond the enterprise boundary, as an authority in concurrent engineering. Contributes to concurrent engineering best practice. Influences key concurrent engineering stakeholders beyond the enterprise boundary. Advises and arbitrates on complex or sensitive concurrency issues. Develops new strategies for concurrent engineering. Advises senior stakeholders on concurrency issues and risks. Champions the introduction of novel techniques and ideas in concurrent engineering, producing measurable improvements. Coaches lead practitioners in concurrent engineering.

COMPETENCY AREA – SYSTEMS ENGINEERING MANAGEMENT: BUSINESS AND ENTERPRISE INTEGRATION

Description:

Businesses and Enterprises are systems in their own right. Systems Engineering is just one of many activities that must occur in order to bring about a successful system development meeting the needs of all its stakeholders. Systems Engineering addresses the needs of all other internal business and enterprise stakeholders, covering areas such as infrastructure, portfolio management, human resources, knowledge management, quality, information technology, production, sales, marketing, commercial, legal, finance, within and beyond the local enterprise.

Why it matters:

As businesses and enterprises become larger, more complex and the functions within the enterprise more insular, the interdependencies between individual enterprise functions should be engineered using a systems approach at an enterprise level in order to meet the demands of increased business effectiveness and efficiency.

EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	LEAD PRACTITIONER	EXPERT
Explains why a business or enterprise is a system in its own right and describes the business or enterprise "system" using Systems Engineering ideas and terminology. Lists other business or enterprise functions and provides examples. Lists work products from business and enterprise functions to the Systems Engineering process and vice versa and can provide examples.	Uses a governing process and appropriate tools to plan and control their own business and enterprise integration activities. Describes Systems Engineering work products that support business and enterprise infrastructure and provides examples of why this is the case. Describes work products produced elsewhere in the enterprise which impact Systems Engineering activities and provides examples of why this is the case. Assists with creation of Systems Engineering work products required by other business and enterprise functions. Assists with review of work products produced by other business and enterprise functions which affect Systems Engineering activities.	Defines governing business and enterprise integration plans, processes and appropriate tools and uses these to monitor and control business and enterprise integration. Creates Systems Engineering work products needed to establish and maintain the project infrastructure over its lifecycle. Creates Systems Engineering work products needed to initiate and sustain, sufficient and suitable projects to meet business or enterprise objectives. Creates Systems Engineering work products needed to provide the necessary human resources for the project and to develop their competencies, consistent with business and enterprise needs. Creates Systems Engineering work products needed to provide the capability and assets that enable the business or enterprise to exploit opportunities to re-apply knowledge. Uses Systems Engineering techniques to contribute to the definition of the business or enterprise. Reviews work products produced by other enterprise functions for their impact on Systems Engineering activities. Identifies constraints placed on the Systems Engineering process by the business or enterprise. Guides supervised practitioners in business and enterprise integration.	Recognized, within the enterprise, as an authority in business and enterprise integration, contributing to best practice. Defines and documents enterprise-level policies, processes and guidance in business and enterprise integration, including associated tools. Reviews and judges the tailoring of enterprise-level business and enterprise processes and associated work products to meet the needs of a project. Coordinates business and enterprise integration across multiple diverse projects or across a complex system, with proven success. Reviews and judges Systems Engineering work products created for use by other parts of the business and enterprise. Advises key infrastructure, portfolio, human resource, quality and knowledge management stakeholders regarding activities and work products affecting Systems Engineering. Advises key organizational stakeholders regarding the use of Systems Engineering techniques to contribute to the definition of the business/enterprise. Influences key stakeholders to address identified enterprise-level business and enterprise integration issues and constraints. Coaches new and experienced practitioners in business and enterprise integration.	Recognized, beyond the enterprise boundary, as an authority in business and enterprise integration. Contributes to business and enterprise integration best practice. Influences business and enterprise stakeholders beyond the local enterprise boundary. Advises and arbitrates on complex or sensitive business and enterprise integration issues. Advises on the effectiveness of the business or enterprise as a system. Advises on Systems Engineering capability within a business/enterprise context. Advises on the impact of inputs from other business/enterprise functions on the Systems Engineering process. Supports the business or enterprise in improving the integration of Systems Engineering with proven success. Champions the introduction of novel techniques and ideas in business and enterprise integration, producing measurable improvements. Coaches lead practitioners in business and enterprise integration.

COMPETENCY AREA – SYSTEMS ENGINEERING MANAGEMENT: ACQUISITION AND SUPPLY

Description:

The purpose of Acquisition is to obtain a product or service in accordance with the Acquirer's requirements. The purpose of Supply is to provide an Acquirer with a product or service that meets agreed needs.

Why it matters:

All system solutions require agreements between different organizations under which one party acquires or supplies products or services from the other. Systems Engineering helps facilitate the successful acquisition and supply of products or services, in order to ensure that the need is defined accurately, to evaluate the supplier against complex criteria; to monitor the ongoing agreement especially when technical circumstances change; and to support formal acceptance of the product or service.

EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	LEAD PRACTITIONER	EXPERT
Describes the key stages in the acquisition of a system, product or service. Describes the key stages in the supply of a system, product or service. Describes legal and ethical obligations associated with acquisition and supply and provides examples.	Uses a governing process and appropriate tools to plan and control their own acquisition and supply activities. Assists with generation of selected work products associated with acquisition of a system, product or service. Identifies potential acquirers of organization systems, products and services on their program. Assists with generation of selected work products associated with supply of a system, product or service.	Defines governing acquisition and supply plans, processes and appropriate tools and uses these to control and monitor acquisition and supply activities. Develops a tender document requesting the supply of a system, product or service. Selects potential suppliers using criteria to judge their suitability. Evaluates supplier responses to a tender document and makes formal recommendations. Evaluates acquirer requests and works with key internal stakeholders to propose a solution that meets acquirer needs. Establishes an agreement with a supplier for a system, product or service including acceptance criteria. Establishes an agreement with an acquirer for a system, product or service, including acceptance criteria. Monitors and maintains an agreement with a supplier. Executes and maintains agreement with an acquirer in accordance with the agreement terms and conditions. Guides supervised practitioners in acquisition and supply.	Recognized, within the enterprise, as an authority in acquisition and supply, contributing to best practice. Defines and documents enterprise-level policies, procedures, guidance and best practice for acquisition and supply, including associated tools. Reviews and judges the tailoring of enterprise-level acquisition and supply processes and associated work products to meet the needs of a project. Coordinates acquisition and supply across multiple diverse projects or across a complex system, with proven success. Identifies opportunities to supply a system, products or services in accordance with organizational goals Influences key stakeholders to address identified enterprise-level acquisition and supply issues. Coaches new and experienced practitioners in acquisition and supply.	Recognized, beyond the enterprise boundary, as an authority in acquisition and supply. Contributes to acquisition and supply best practice. Influences key acquisition and supply stakeholders beyond the enterprise boundary. Advises and arbitrates on complex or sensitive acquisition and supply issues. Advises on the suitability of the approach to acquisition or supply. Champions the introduction of novel techniques and ideas in acquisition and supply, producing measurable improvements. Coaches lead practitioners in acquisition and supply.

COMPETENCY AREA – SYSTEMS ENGINEERING MANAGEMENT: INFORMATION MANAGEMENT

Description:

Information Management addresses activities associated with the generation, obtaining, confirming, transforming, retaining, retrieval, dissemination and disposal of information, to designated stakeholders with appropriate levels of timeliness, accuracy and security. Information Management plans, executes and controls the provision of information to designated stakeholders that is unambiguous, complete, verifiable, consistent, modifiable, traceable and presentable. Information includes technical, project, organizational, agreement and user information.

Why it matters:

System Engineering requires relevant, timely and complete information during and after the system lifecycle to support all aspects of the development; from the analysis of future concepts to the ultimate archiving and potential subsequent retrieval of project data. Information also supports decision making across every aspect of the development including suppliers and agreements. Information security and assurance are crucial parts of Information Management: ensuring only designated individuals are able to access certain data, whilst protecting intellectual property and making sure information is available as required in line with the sender’s intent.

EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	LEAD PRACTITIONER	EXPERT
Describes various types of information required to be managed in support of Systems Engineering activities and provides examples. Describes various types of information assets that may need to be managed within a project or system. Identifies different classes of risk and can provide examples of each. Describes the relationship between information management and configuration change management. Describes how data rights may affect information management on a project. Describes the legal and ethical responsibilities associated with access to and sharing of enterprise and customer information, and summarizes regulations regarding information sharing.	Uses a governing process and appropriate tools to plan and control information management activities. Assists with generation and maintenance of a data dictionary and technical data library. Assists with identification of valid sources of information and associated authorities. Assists with obtaining, transfer, distribution, maintenance or transformation of information in accordance with integrity, security, privacy requirements and data rights. Assists with assessment and re-planning of Systems Engineering activities associated with engineering changes. Assists with identification and archival of designated information in compliance project requirements. Assists with the identification and disposal of unwanted, invalid or unverifiable information in accordance with requirements. Assists with provision of managed information in support of organizational configuration management. Assists with development of plans addressing information management and its communication. Assists with the sharing of lessons learned beyond the project boundary.	Defines governing plans, processes and appropriate tools and uses these to control and monitor information management and associated communications activities. Generates and maintains a data dictionary, technical data library appropriate to the project. Identifies valid sources of information and designated authorities and responsibilities for the information. Obtains, transfers, distributes, maintains, transforms and manages information artifacts in accordance with integrity, security, privacy requirements and data rights. Identifies formats and media for capture, retention, transmission and retrieval of information, and data requirements for the sharing of information. Determines information archival requirements reflecting legal, audit, knowledge retention and project closure obligations. Provides managed information in support of organizational configuration management and knowledge management requirements (e.g. sharing lessons learned). Describes security, data management and privacy standards and regulations applicable to the project. Guides supervised practitioners in information management.	Recognized, within the enterprise, as an authority in information management, contributing to best practice. Defines and documents enterprise-level policies, processes and guidance for information management, including associated tools. Reviews and judges the tailoring of enterprise-level information management processes and associated work products to meet the needs of a project. Coordinates information management across multiple diverse projects or across a complex system, with proven success. Determines and establishes information management solutions consistent with security and privacy requirements, data rights and information management standards. Influences key stakeholders to address identified enterprise-level information management issues. Gathers, documents and shares Systems Engineering lessons learned throughout the enterprise. Coaches new and experienced practitioners in information management.	Recognized, beyond the enterprise boundary, as an authority in information management. Contributes to information management best practice. Influences key information management stakeholders beyond the enterprise boundary. Advises and arbitrates on complex or sensitive information management issues. Advises on applicable security, data management, data rights, privacy standards and regulations. Advises on the suitability of the approach to information management. Influences key information management stakeholders beyond the enterprise boundary. Champions the introduction of novel techniques and ideas in information management, producing measurable improvements. Coaches lead practitioners in information management.

COMPETENCY AREA – SYSTEMS ENGINEERING MANAGEMENT: CONFIGURATION MANAGEMENT

Description:

Configuration Management (CM) manages and controls system elements and configurations over the program lifecycle, ensuring the overall coherence of the "evolving" design of a system is maintained in a verifiable manner, throughout the lifecycle, and retains the original intent. The Configuration Management activity includes: planning; identification; change management and control; reporting; and auditing.

Why it matters:

Configuration Management ensures that the product functional, performance, and physical characteristics are properly identified, documented, validated, and verified to establish product integrity; that changes to these product characteristics are properly identified, reviews, approved, documented and implemented; and that the products produced against a given set of documentation are known. Without Configuration Management, loss of control over the evolving design, development and operation of a product will occur.

EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	LEAD PRACTITIONER	EXPERT
Explains why the integrity of the design needs to be maintained and how configuration management supports this. Describes the key characteristics of a configuration item (CI) including how configuration items are selected and controlled. Identifies and describes key baselines and baseline reviews in a typical development lifecycle. Describes the process for changing baselined information and a typical lifecycle for an engineering change. Lists key activities performed as part of configuration management and can outline the key activities involved in each. Explains why change occurs and why changes need to be carefully managed. Describes the processes and work products used to assist in Change Management. Describes the meaning of key terminology and acronyms used within Change Management and their relationships.	Uses a governing configuration and change management process and appropriate tools to plan and control their own activities relating to maintaining design integrity. Assists with configuration management planning through tailoring of enterprise and best industry standards culminating in the generation of a configuration management Plan. Describes the need to identify configuration items and why this is done. Generates documentation in support of configuration change control activities. Generates material in support of change control decisions and associated review meetings. Supports configuration status accounting and audits and generates management reports in support of status accounting and audits. Lists applicable standards, regulations, and enterprise level processes. Identifies and reports baseline inconsistencies.	Defines governing configuration and change management plans, processes and appropriate tools and uses these to control and monitor design integrity during the full lifecycle of a project, system, product or service. Takes remedial actions in the presence of baseline inconsistencies Anticipates, identifies, assesses, analyses and controls changes understanding the potential scope within the context of the project. Works with design teams to identify and justify selection of configuration items and associated documentation. Leads change control review activities in conjunction with customer representative and directs resolutions and action items Leads configuration status accounting reports and audits Guides supervised practitioners in configuration management.	Recognized, within the enterprise, as an authority in configuration management, contributing to best practice. Defines and documents enterprise-level policies, procedures, guidance and best practice in configuration management, including associated tools. Reviews and judges the tailoring of enterprise-level configuration and change management processes and associated work products to meet the needs of a project. Coordinates configuration management across multiple diverse projects or across a complex system, with proven success. Influences key stakeholders to address identified enterprise-level configuration management issues. Provides advice on remedial actions to address baseline inconsistencies for projects of various size and complexity. Reviews and advises on major changes and influences key stakeholders to reduce impact of such changes. Coaches new and experienced practitioners in configuration management.	Recognized, beyond the enterprise boundary, as an authority in configuration management. Contributes to configuration management best practice. Influences key stakeholders beyond the enterprise boundary regarding configuration and change management issues. Advises on the suitability of the approach to configuration management. Advises and arbitrates on complex or sensitive configuration and change management issues. Champions the introduction of novel techniques and ideas in configuration management, producing measurable improvements. Coaches lead practitioners in configuration management.

COMPETENCY AREA – INTEGRATING COMPETENCIES: PROJECT MANAGEMENT

Description:

Project Management identifies, plans and coordinates activities required in order to deliver a satisfactory system, product, service of appropriate quality, within the constraints of schedule, budget, resources, infrastructure, available staffing and technology. Project Management includes development engineering but covers the complete project (i.e. beyond the engineering boundary), encompassing disciplines such as sales, business development, finance, commercial, legal, human resources, production, procurement and supply chain management and logistics.

Why it matters:

Good project management reduces risk, maximizes opportunity, cut system, product or service costs and improves both the success rate and the return on investment of projects.

EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	LEAD PRACTITIONER	EXPERT
Explains why cost, schedule, quality and performance need to be balanced during project execution. Describes the role and lists typical responsibilities of a project manager on a project team. Compares and contrasts performing project management on the project or within the wider enterprise and project management as part of Systems Engineering management. Describes the key interfaces between project management stakeholders within the enterprise and the project team.	Uses a governing process and appropriate tools to manage and control their own project management activities. Assists with the development of a project plan for a complete project. Assists with tasks associated with initiating a project. Assists with the monitoring and control of the execution of a complete project. Assists with development of a Work Breakdown Structure (WBS) encompassing all project tasks. Assists with the definition of project work packages for a complete project. Participates in project teams or working groups beyond Systems Engineering. Assists with reviews of contract deliverables, adherence to contract obligations and interpretation of agreements. Assists with tasks associated with completing or terminating a project.	Defines governing project management plans, processes and appropriate tools on a project, and uses these to monitor and control project management tasks within Systems Engineering. Plans a complete project, considering appropriate areas requiring project management attention. Identifies work to be performed on a complete project, defining tasks, owners and characterizing individual packages of work for estimation and execution. Identifies appropriate decision points during program execution and performs project status reviews to enable informed decision making. Initiates a project and individual tasks within it, monitoring and controlling their execution using appropriate performance tracking techniques and tools, to determine progress towards goals. Closes a completed or terminated project. Forms working groups with effective charters extending beyond Systems Engineering. Manages contracted activities required for project execution, including defining evaluation criteria and evaluating proposals. Manages relationships with external stakeholders affecting Systems Engineering. Guides supervised practitioners in project management and its relationship with Systems Engineering.	Recognized, within the enterprise, as an authority on the application of project management to Systems Engineering, contributing to best practice. Defines and documents enterprise-level policies, procedures, guidance and best practice for integrating project management activities with Systems Engineering activities, including associated tools. Works with project management stakeholders to review and judge the tailoring of enterprise-level project management processes to meet the Systems Engineering needs of a project. Reviews and judges the tailoring of enterprise-level project management processes to meet the needs of a project. Coordinates project management across multiple diverse projects or across a complex system, with proven success. Reviews, judges and arbitrates conflicts in project plans or activities beyond the Systems Engineering boundary. Manages complex relationships with external stakeholders affecting Systems Engineering. Influences key stakeholders to address identified enterprise-level project management issues affecting Systems Engineering. Coaches new and experienced practitioners in project management and its relationship with Systems Engineering.	Recognized, beyond the enterprise boundary, as an authority on the application of project management to Systems Engineering. Contributes to best practice in the application of project management to Systems Engineering. Influences key stakeholders beyond the enterprise boundary in support of project management activities affecting Systems Engineering. Advises and arbitrates on complex or sensitive project management or negotiation issues affecting Systems Engineering. Advises project management stakeholders on the suitability of the approach to project management within Systems Engineering. Reviews and judges the suitability of project management plans affecting Systems Engineering activities. Advises on complex relationships with external stakeholders affecting Systems Engineering. Influences strategic project management activities which link Systems Engineering to other disciplines at enterprise level. Champions the introduction of novel techniques and ideas in Systems Engineering project management, producing measurable improvements. Coaches lead practitioners in project management and its relationship with Systems Engineering.

COMPETENCY AREA – INTEGRATING COMPETENCIES: FINANCE

Description:

Finance is the area of estimating and tracking costs associated with the project. It also includes understanding of the financial environment in which the project is being executed.

Why it matters:

Appropriate funding is the life blood of any system development project. It is important for systems engineers to recognize the importance of cost estimation, budgeting, and controlling project finances and to support the finance discipline in its activities.

EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	LEAD PRACTITIONER	EXPERT
Explains why there is a need to estimate, budget, and control costs associated with project execution. Explains how project decisions impact the cost of developing, using, maintaining and supporting the product or service and provides examples. Describes the role, activities and key interfaces between financial stakeholders and the project team. Compares and contrasts performing financial management on the project or within the wider enterprise and managing financial resources as part of Systems Engineering activities.	Uses a governing process and appropriate tools to control their own finance-related tasks. Assists financial stakeholders with detailed cost estimating. Assists financial stakeholders with cost aggregation and analysis to develop funding requirements. Assists with analysis and reporting of recommendations on system life-cycle cost issues & decisions for financial stakeholders. Assists in tracking project performance and expenditure against plan, in support of financial stakeholders. Identifies variances and proposes corrective actions to stay within tolerance of budgets in support of financial stakeholders.	Defines governing financial plans, processes and appropriate tools on a project, and uses these to control and monitor finance-related Systems Engineering tasks. Describes the wider financial environment within which the system, product or service is being developed, and the influence each can have on this other. Executes detailed cost estimating for financial stakeholders. Aggregates activity costs and scheduling to develop project funding requirements and a cost management plan for financial stakeholders. Assesses and makes recommendations on system life-cycle cost issues & decisions for financial stakeholders. Reviews project performance and tracks expenditures to assess execution compared to plan, in support of financial stakeholders. Identifies variances and implements corrective actions to stay within tolerance of budgets in support of financial stakeholders. Guides supervised practitioners in Systems Engineering financial management.	Recognized, within the enterprise, as an authority on the application of financial management to Systems Engineering, contributing to best practice. Defines and documents enterprise-level policies, procedures, guidance and best practice for integrating financial activities with Systems Engineering activities, including associated tools. Works with financial stakeholders to review and judge the tailoring of enterprise-level finance processes to meet the needs of a Systems Engineering project. Challenges appropriateness of financial decisions in a rational way. Reviews and judges Systems Engineering estimates using appropriate techniques. Leads efforts to collect and analyze data to improve accuracy of Systems Engineering estimating within the enterprise, in support of financial stakeholders' needs. Influences key stakeholders to address identified enterprise-level financial management issues affecting Systems Engineering. Coaches new and experienced practitioners in Systems Engineering financial management.	Recognized, beyond the enterprise boundary, as an authority on the application of financial management to Systems Engineering. Contributes to best practice in the application of financial management to Systems Engineering. Influences key stakeholders beyond the enterprise boundary in support of financial activities affecting Systems Engineering. Advises financial stakeholders on the suitability of the approach to financial management within Systems Engineering. Reviews and judges the suitability of financial management plans affecting Systems Engineering activities. Advises and arbitrates on complex or sensitive finance-related issues affecting Systems Engineering. Champions the introduction of novel techniques and ideas in Systems Engineering financial management, producing measurable improvements. Coaches lead practitioners in Systems Engineering financial management.

COMPETENCY AREA – INTEGRATING COMPETENCIES: LOGISTICS

Description:

Logistics focuses on the support and sustainment of the product once it is transitioned to the end user. It includes areas such as life cycle cost analysis, supportability analysis, sustainment engineering, maintenance planning and execution, training, spares and inventory control, associated facilities and infrastructure, packaging, handling and shipping and support equipment for the system and its elements.

Why it matters:

Factoring logistics considerations such as availability, storage and transport, and training needs early in the design effort can significantly reduce total life cycle cost for the system.

EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	LEAD PRACTITIONER	EXPERT
Explains the value of factoring logistics support into system development. Explains the concept and value of life cycle cost and how this affects both the system solution and logistics. Lists key logistics support activities and describes what they involve and why they are important to the success of a system. Describes the role, activities and key interfaces between logistics stakeholders and the project team.	Uses a governing process and appropriate tools to control their own logistics-related tasks. Assists in performing supportability analysis on a project. Assists in development of maintenance concepts taking into consideration life cycle cost. Assists with management and control of spares, repairs and supplies for a project. Assists with the analysis of facilities and infrastructure supporting operation and maintenance of a system. Assists with the identification and acquisition of training aids, simulators and simulations for operators or personnel sustaining the system. Assists with the identification and acquisition of support equipment required to sustain the operation and maintenance of a system. Assists with generation and analysis technical data, reports and documentation supporting the installation, operation, maintenance and sustainment of the system. Assists with assessment of packing, handling, shipping and transportations plans and activities for a project.	Defines governing logistics plans, processes and appropriate tools, and uses these to plan and control logistics-related Systems Engineering tasks. Performs supportability analysis on a project, in collaboration with logistics stakeholders. Identifies, develops and implements maintenance concepts in collaboration with logistics stakeholders. Identifies, plans and reviews the acquisition, catalog, receipt, storage, transferring, issuing and disposal of spares, repair of parts and supplies sustaining the system. Identifies, plans and reviews the facilities and infrastructure required to support operation and maintenance of a system across its life cycle. Identifies, develops, acquires and reviews logistics training products maximizing the effectiveness of operators and personnel sustaining the system at lowest lifecycle cost. Identifies, plans, acquires and reviews the support equipment required to sustain the operation and maintenance of a system across its lifecycle. Identifies, plans and reviews packing, handling, shipping and transportations plans and activities for a project. Generates and analyzes technical data, reports and documentation supporting the installation, operation, maintenance and sustainment of the system. Guides supervised practitioners in Systems Engineering logistics.	Recognized, within the enterprise, as an authority on the application of logistics management to Systems Engineering, contributing to best practice. Defines and documents enterprise-level policies, procedures, guidance and best practice for integrating logistics activities with Systems Engineering activities, including associated tools. Reviews and judges the tailoring of enterprise-level logistics processes, in collaboration with logistics stakeholders, to meet the needs of a Systems Engineering project. Challenges appropriateness of logistics decisions in a rational way. Reviews and judges supportability strategies and supportability decisions for their impact on performance, readiness and life cycle cost. Reviews and judges logistics plans and decisions for their impact on performance, readiness and life cycle cost. Reviews and judges logistics technical documentation. Influences key stakeholders to address identified enterprise-level logistics management issues affecting Systems Engineering. Coaches new and experienced practitioners in Systems Engineering logistics.	Recognized, beyond the enterprise boundary, as an authority on the application of logistics management to Systems Engineering. Contributes to best practice in the application of logistics management to Systems Engineering. Influences key stakeholders beyond the enterprise boundary in support of logistics activities affecting Systems Engineering. Advises logistics stakeholders on the suitability of the approach to logistics management within Systems Engineering. Reviews and judges the suitability of logistics management plans affecting Systems Engineering activities. Advises and arbitrates on complex or sensitive logistics-related issues affecting Systems Engineering. Champions the introduction of novel techniques and ideas in Systems Engineering logistics management, producing measurable improvements. Coaches lead practitioners in Systems Engineering logistics.

COMPETENCY AREA – INTEGRATING COMPETENCIES: QUALITY

Description:

Quality focuses on customer satisfaction via the control of key product characteristics and corresponding key manufacturing process characteristics.

Why it matters:

Proactive quality management improves both the quality of the system, product or service provided, as well as the quality of the project's management processes.

EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	LEAD PRACTITIONER	EXPERT
Describes the role quality plays in developing a successful system product or service. Lists applicable quality standards and summarizes the aims of each. Describes the role, activities and key interfaces between quality stakeholders and the project team. Describes the purpose of quality assurance and quality control and key differences between them. Explains how project decisions impact the quality of a system, product or service and provides examples.	Uses a governing process and appropriate tools to control their own quality-related tasks. Assists with identification of quality measures. Assists with measurement of quality characteristics. Assists with monitoring, measurement and analysis of processes designed to improve project quality. Assists with verification of product conformity to standards. Assists with root-cause analysis of failures and identifies potential corrective actions. Assists with auditing of projects against quality standards (e.g. ISO 9000 or similar).	Defines governing quality plans, processes and appropriate tools on a project, and uses these to control and monitor quality-related Systems Engineering tasks. Identifies appropriate quality measures. Establishes mechanisms for measuring quality. Monitors, measures, analyzes, controls and improves processes. Verifies product conformity to standards. Performs root-cause analysis of failures and determine appropriate corrective actions. Audits project practices against quality standards (e.g. ISO 9000 or similar). Guides supervised practitioners in quality management.	Recognized, within the enterprise, as an authority on the application of quality management to Systems Engineering, contributing to best practice. Defines and documents enterprise-level policies, procedures, guidance and best practice for integrating quality management with Systems Engineering activities, including associated tools. Reviews and judges the tailoring of enterprise-level quality management processes, in collaboration with quality system stakeholders, to meet the needs of a Systems Engineering project. Contributes to best practice in Systems Engineering quality management within the enterprise. Challenges appropriateness of quality stakeholders' decisions in a rational way. Influences key stakeholders to address identified enterprise-level quality management issues. Reviews and judges quality management strategies and decisions. Leads quality audits, including investigations into the cause of quality escapes and defects. Leads efforts regarding continuous improvement of quality on a project. Coaches new and experienced practitioners in quality management.	Recognized, beyond the enterprise boundary, as an authority on the application of quality management to Systems Engineering. Contributes to best practice in the application of quality management to Systems Engineering. Influences key stakeholders beyond the enterprise boundary in support of quality management activities affecting Systems Engineering. Contributes to best practice in Systems Engineering quality management, beyond the enterprise boundary. Advises quality system stakeholders on the suitability of the approach to quality management within Systems Engineering. Reviews and judges the results of quality management plans affecting Systems Engineering. Leads efforts regarding continuous improvement at the enterprise level. Advises on the suitability of the approach to quality management. Advises and arbitrates on complex or sensitive quality management issues affecting the system. Champions the introduction of novel techniques and ideas in quality management within Systems Engineering, producing measurable improvements. Coaches lead practitioners in quality management within Systems Engineering.

ANNEX E: GUIDE TO COMPETENCY EVALUATION

This annex is a companion to the System Engineering Competency Framework defined in Annex D and provides guidance on how to evaluate people against the competency framework.

In summary, the competency framework defined in Annex D represents a set of “requirements” for proficiency in 36 competencies at five levels of competence, whilst this Annex provides expectations for evidence to be produced in order to verify that proficiency at the assessed level has been achieved.

This Annex will be published separately.

ANNEX F: COMMENT FORM

If you wish to submit a comment on this document, please provide the information below and send to **info@incose.org**.

REVIEWED DOCUMENT:	INCOSE Systems Engineering Competency Framework
NAME OF SUBMITTER:	Given name, family name (e.g. Jo DOE)
DATE OF SUBMISSION:	YYYY-MM-DD (e.g. 2018-04-09)
CONTACT INFO:	Email address (e.g. jo.DOE@anywhere.com)
TYPE OF SUBMISSION:	Group, Individual
GROUP NAME AND NUMBER OF CONTRIBUTORS	Group name if applicable (e.g. INCOSE XYZ Working group)
COMMENTS	Please provide comment details including precise reference to the document section, paragraph or line item requiring change. Ideally, comments should be formatted as shown in the table below.

COMMENT ID	CATEGORY	SECTION NUMBER	SPECIFIC REFERENCE	ISSUE, COMMENT AND RATIONALE	PROPOSED CHANGE OR NEW TEXT (MANDATORY)
Unique Identifier	G, E, TH, TL As follows: • G = General • E = Editorial • TH = Technical comment, high priority • TL = Technical comment, low priority	e.g. Section n, Table m	e.g. paragraph, line	Please provide rationale so that comment is clear and supportable.	Good quality new or revised text will increase odds of acceptance.

Systems Engineering Competency Framework

INCOSE Technical Product Reference: INCOSE-TP-2018-002-01.0