33rd Annual INCOSE international symposium

hybrid event

Honolulu, HI, USA
July 15 - 20, 2023

Ms. Lori Zipes

Tea, Pie, and Other Ingredients

to Build Competency and Have a Successful Systems Engineering Career

What is a System Engineer?

- How many Systems Engineers do you know?
- What do they do?

What is Systems Engineering?

Systems Engineering is a **transdisciplinary** and integrative approach to enable the successful realization, use, and retirement of engineered systems, using systems principles and concepts, and scientific, technological, and management methods.

INCOSE Systems Engineering Handbook V5. p 1

Core engineering competencies

- Calculus
- Physics
- Statics
- Dynamics
- Fluids
- Thermodynamics
- Circuits
- Digital Logic
- Signal Analysis
- Algorithms
- Operating Systems
- Programming Languages
- …

Core engineering competencies

- Calculus
- Physics
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- Operating Systems
- Programming Languages
- …

If you have these competencies…

All images courtesy of AdobeStock

Important Definitions

Pause for some definitions

Important Definitions

- Competence: demonstrable performance and behaviors
- Competency: the ability to do some**thing** well

INCOSE Systems Engineering
Competency Assessment Guide 2023, p 5

"The sum of an individual's competencies will make up their competence."

INCOSE Systems Engineering Handbook
V5. p 261

Important Definitions

- Job: something you get paid to do
- Position: related to an organizational structure
- Role: one or more duties to accomplish with some level of skill (**competency**)

INCOSE Systems Engineering
Competency Assessment Guide 2023, p 17

Important Definitions

- Example job: selling hot dogs
- Position: hot dog vendor
- Relevant roles: driver, cook, salesperson, server, cashier, (possibly also) accountant, marketer, purchaser, lawyer…

Context matters:
School fair?
Street corner?
Fenway Park?

INCOSE Systems Engineering Competency Assessment Guide 2023, p 17

Engineering Competencies

- Calculus
- Physics
- Statics
- Dynamics
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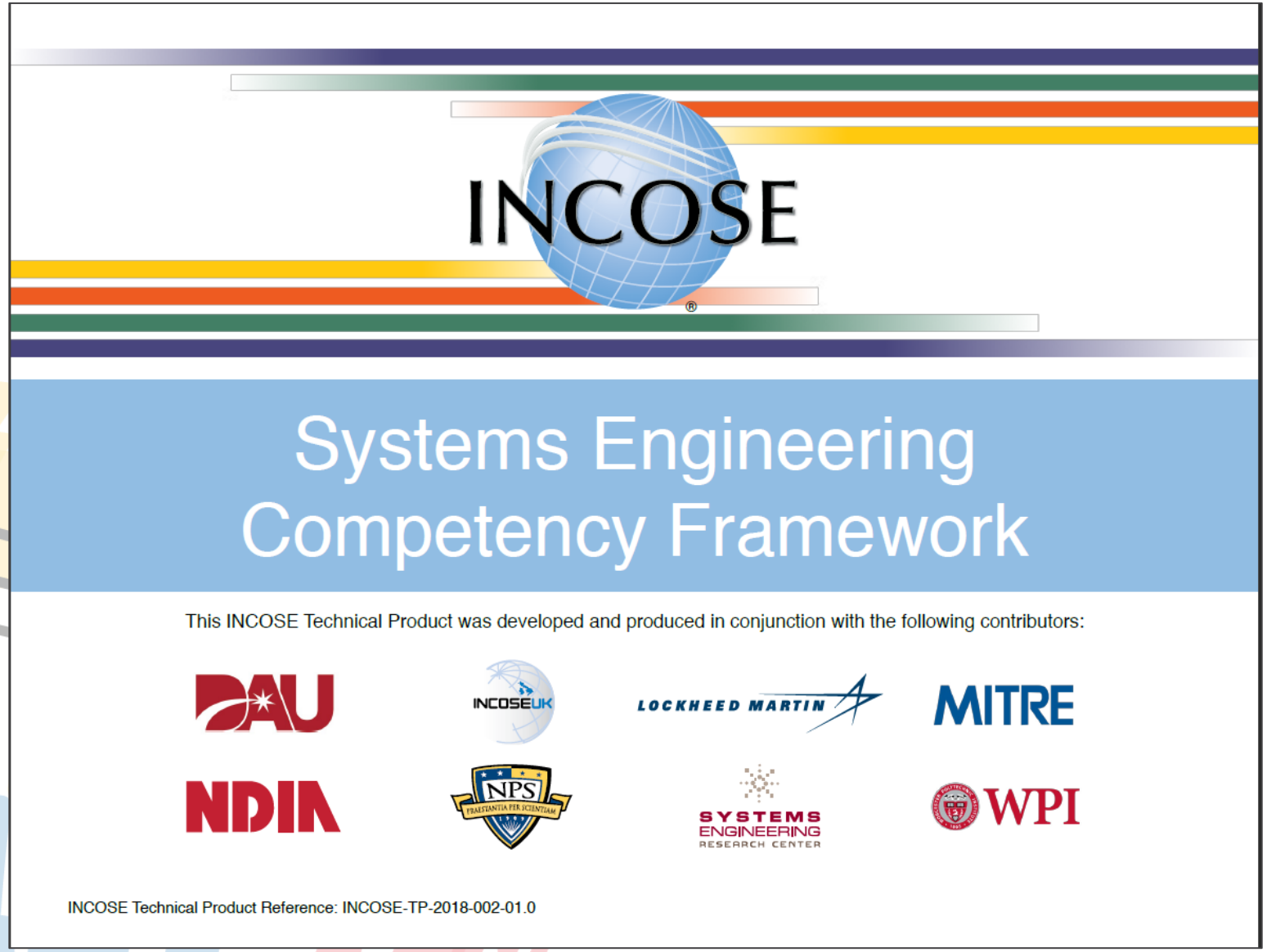
Systems Engineering Competencies



Systems Engineering Competencies

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.

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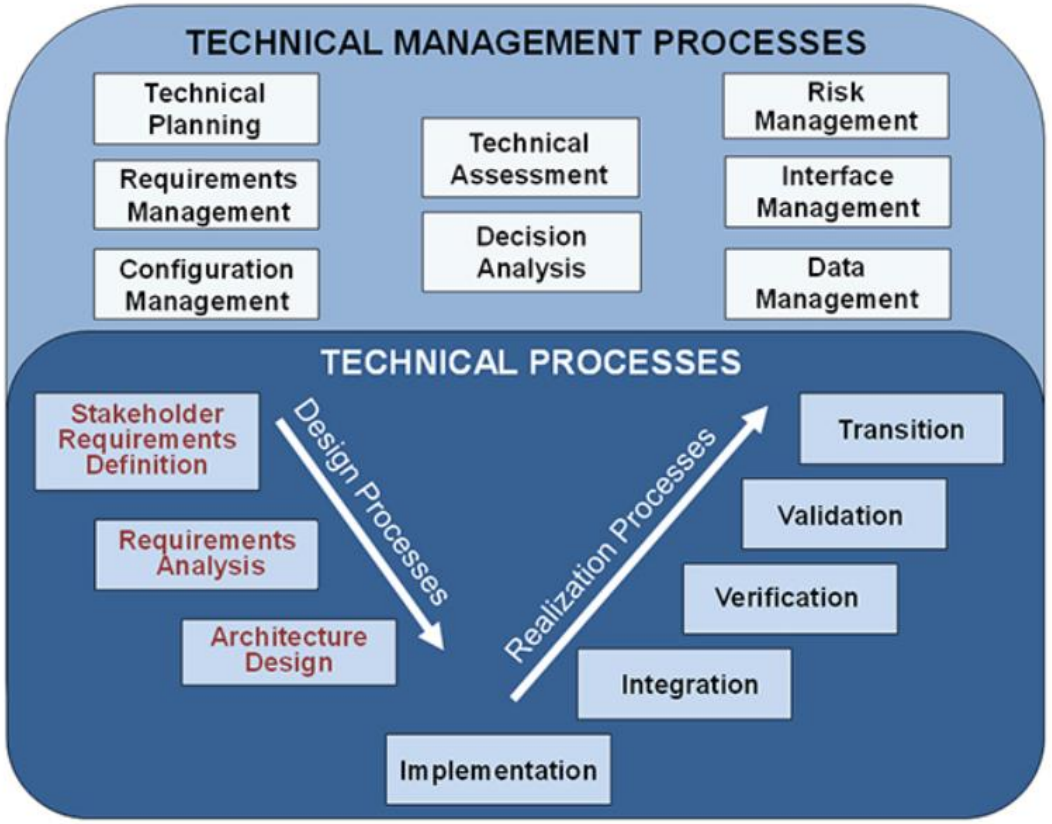
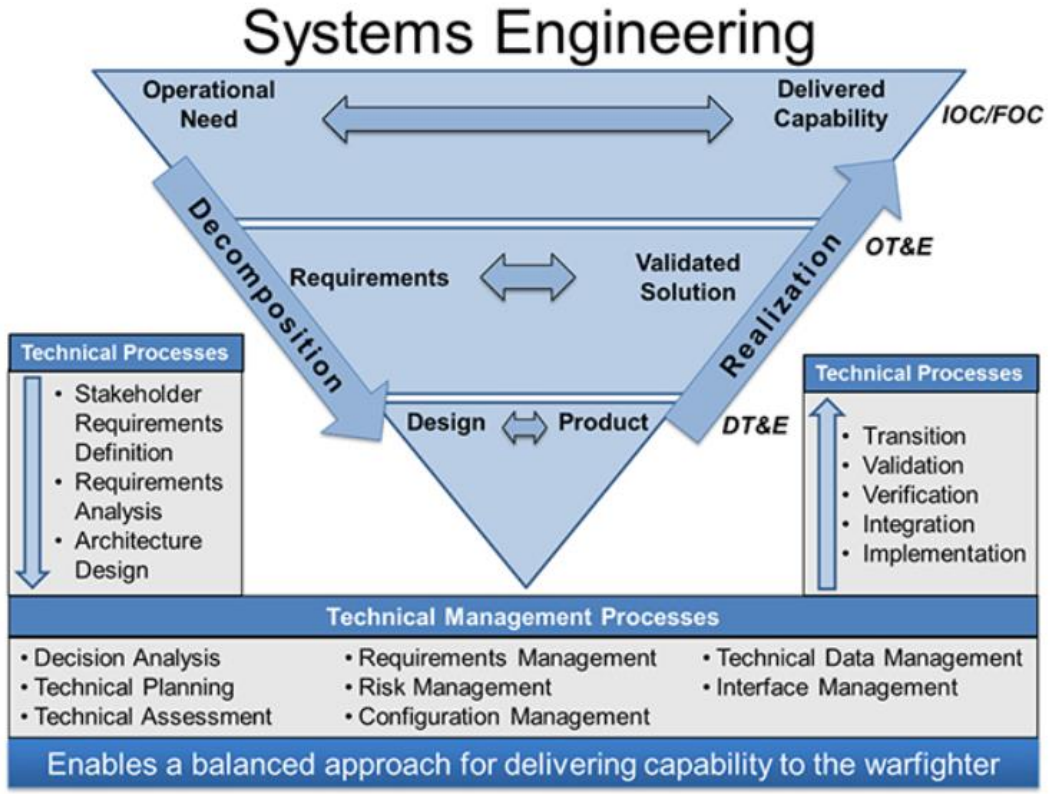
Systems Engineering Competencies





Defense Acquisition University
Systems Engineering process models
~2003 and 2015

Systems Engineering competencies

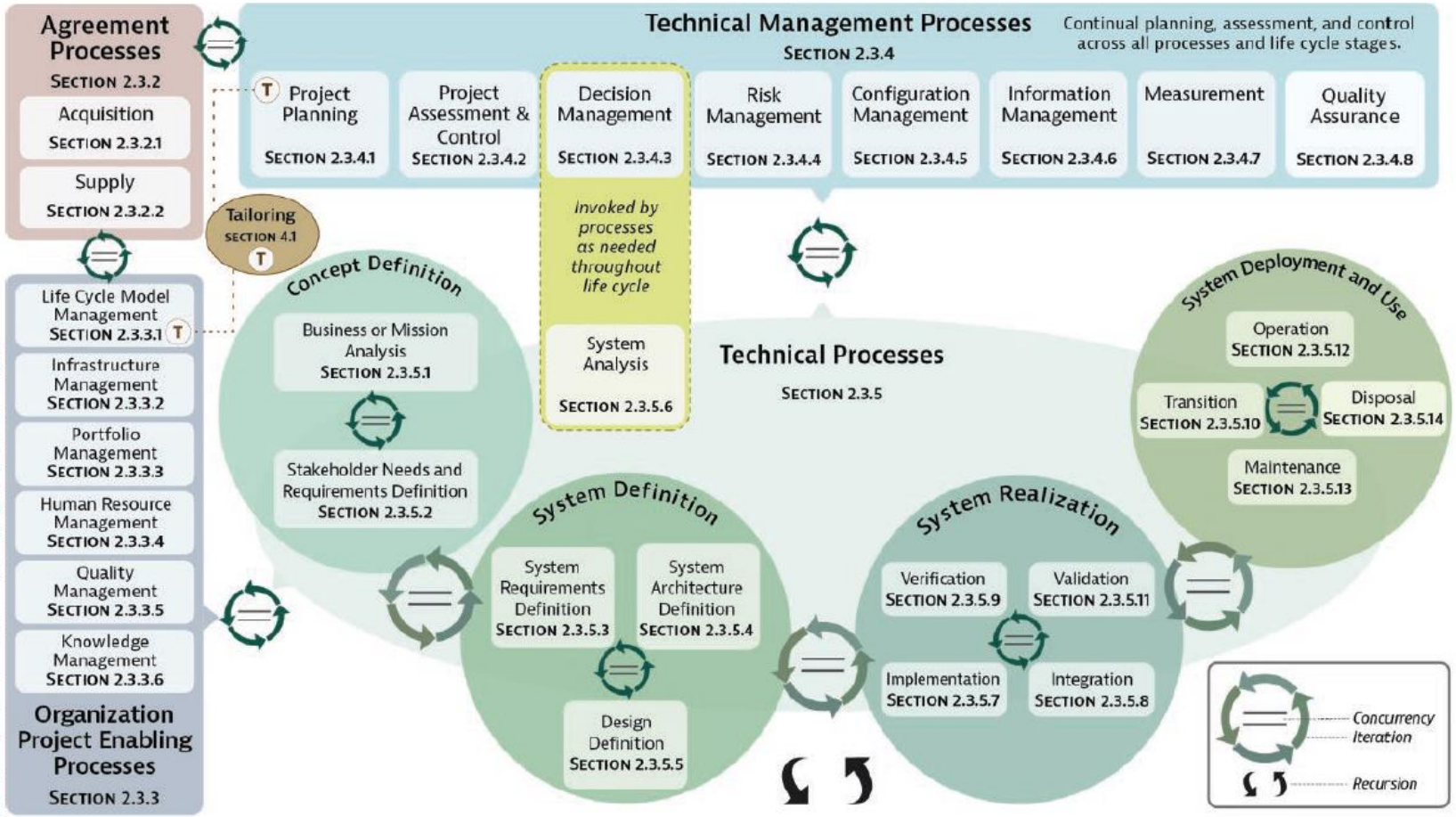


FIGURE 2.10 System life cycle processes per ISO/IEC/IEEE 15288. INCOSE SEH original figure created by Roedler and Walden. Usage per the INCOSE Notices page. All other rights reserved.

Bloom's Taxonomy

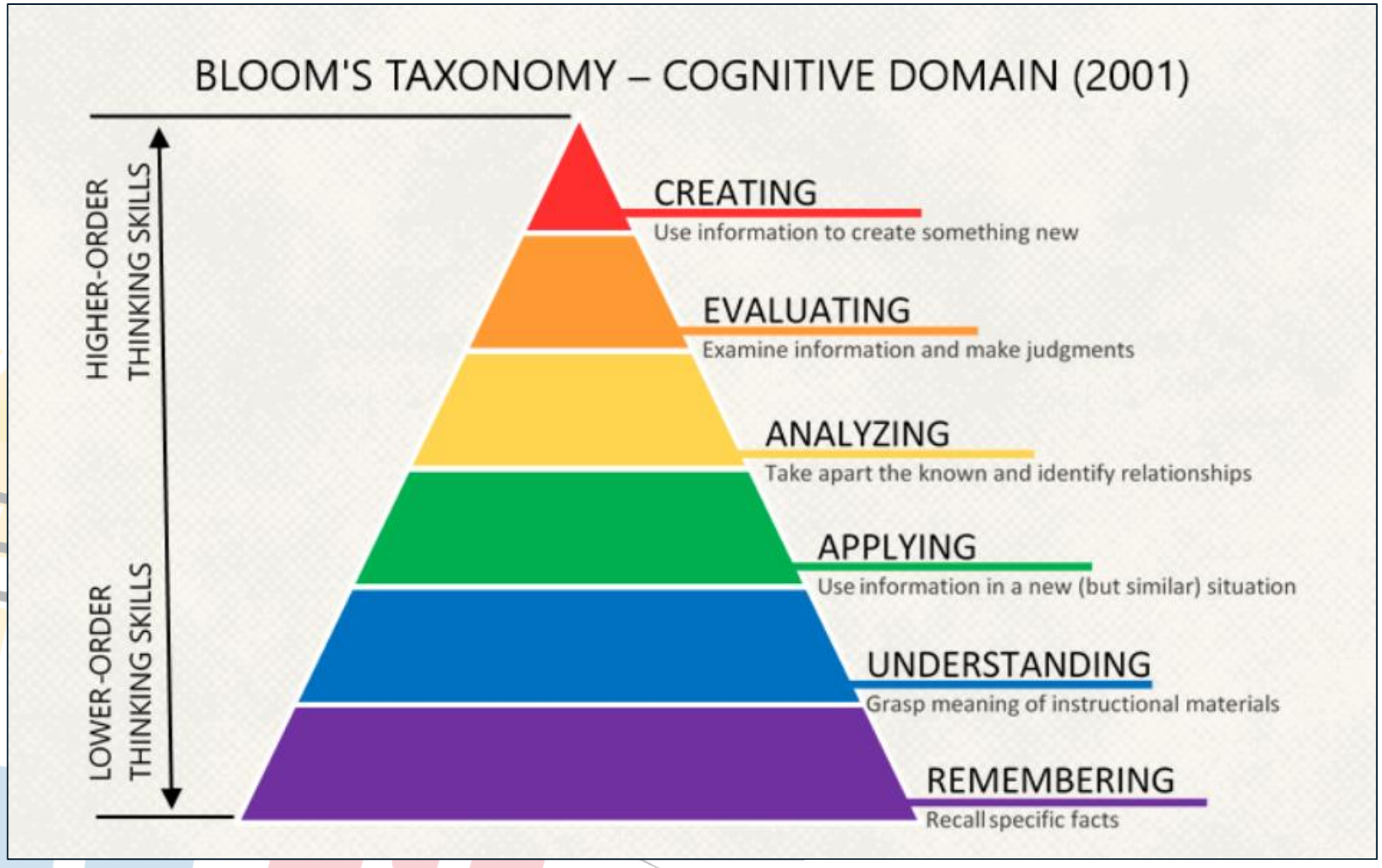


Image source: https://citt.ufl.edu/resources/the-learning-process/designing-the-learning-experience/blooms-taxonomy/

Tea …

T

Having “T” shaped knowledge

Breadth across all areas, depth in (at least) one

Requirements	Architecture	Design	Implementation	Integration	Verification	Validation	Operation
Requirements	Architecture	Design			Verification		Operation
	Architecture				Verification		
	Architecture						
	Architecture						
	Architecture						
	Architecture						
	Architecture						
	Architecture						
	Architecture						
	Architecture						
	Architecture						
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	Architecture						

Having “T” shaped knowledge

Breadth across all areas, depth in (at least) one

Work in Months by Position and SE Area	P1	P2	P3	P4	P5	P6	P7	Total Months of Effort in Each SE Area
SE Functional Areas								
Requirements Engineering	0	0	0	0	0	0	0	0
System and Decision Analysis	0	0	0	0	0	0	0	0
Architecture/ Design Development	0	0	0	0	0	0	0	0
Systems Integration	0	0	0	0	0	0	0	0
Verification and Validation	0	0	0	0	0	0	0	0
System Operation and Maintenance	0	0	0	0	0	0	0	0
Technical Planning	0	0	0	0	0	0	0	0
Technical Monitoring and Control	0	0	0	0	0	0	0	0

Pie …

π

Having π shaped knowledge

Requirements	Architecture	Design	Implementation	Integration	Verification	Validation	Operation
Requirements	Architecture	Design			Verification	Validation	
Requirements					Verification	Validation	
Requirements					Verification	Validation	
Requirements					Verification		
Requirements					Verification		
Requirements					Verification		
Requirements					Verification		
Requirements					Verification		
Requirements					Verification		
Requirements					Verification		
					Verification		

Example careers

Engineer, small system design-prototype-test-deliver, large system requirements development, system architecting, test and evaluation.

Requirements	Architecture	Design	Implementation	Integration	Verification	Validation	Operation
Requirements	Architecture	Design			Verification	Validation	
Requirements	Architecture				Verification	Validation	
Requirements	Architecture				Verification	Validation	
Requirements	Architecture						
Requirements							
Requirements							
Requirements							

Example careers

Engineer, small system design and implementation, large system design engineer, design team lead.

Requirements	Architecture	Design	Implementation	Integration	Verification	Validation	Operation
Requirements	Architecture	Design	Implementation	Integration			
	Architecture	Design	Implementation	Integration			
		Design	Implementation	Integration			
		Design	Implementation	Integration			
		Design		Integration			
		Design		Integration			

Levels of Competency

Requirements Definition

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 stakeholde needs. Explains why managing rec throughout the lifecycle is i Explains why there is a nee all types of requirements. Describes the relationship requirements and acceptar	Identifies all stakeholders and their sphere of influence. Assists with the elicitation of requirements from stakeholders. Describes the characteristics of good 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. 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.

Describes different types of requirements (e.g. functional, non-functional, business etc.).

Explains why there is a need for good quality requirements.

ISECF 2018, p 53

Requirements Definition

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 requirement examples. Describes different gather requirement Explains why there traceability in the r Assists with establi acceptance criteria Identifies potential within the requirem Explains how requi and vice versa and Assists with the es maintenance of rec information.	Defines governing requirements elicitation and management plans, processes and appropriate tools and uses these to control and monitor requirements elicitation and management activities. 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 rements elicitation t, including associated ges the tailoring of equirements elicitation t processes to meet the t. opriateness of rational way. ges the suitability and the requirements set. akeholders to address ise-level requirements nagement issues. d 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.

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.

ISECF 2018, p 53

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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.

ISECF 2018, p 53

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Influences key stakeholders beyond the enterprise boundary in support of requirements elicitation and management.

Example position: Medical Devices Chief Engineer

Level 1	Level 2	Level 3	Level 4	Level 5
	Finance	Quality	Project mgmt	Systems thinking
	Logistics	Requirements	Planning	Risk Opportunity mgmt
	Coaching	Architecting	Decision mgmt	Monitoring and control
	Concurrent eng	Design	Ethics	Communications
	Enterprise integration	Integration	Leadership	Critical Thinking
	Acquisition & supply	Interfaces	Negotiation	
	Information mgmt	Verification	Team Dynamics	
	Configuration mgmt	Validation		
		Operation		
		Lifecycles		
		Capability Engineering		
		General Engineering		
		Systems Modeling and Analysis		
		Facilitation		
		Emotional intelligence		

Domain, Size, Complexity…

Depth of knowledge enables proper tailoring

Revisiting the Competency Groups

SE Management

- Information Management
- Planning
- Monitoring and Control
- Risk and Opportunity Management
- Business & Enterprise Integration
- Decision Management
- Concurrent Engineering
- Configuration Management
- Acquisition and Supply

Professional

- Communications
- Facilitation
- Ethics and Professionalism
- Coaching & Mentoring
- Technical Leadership
- Emotional Intelligence
- Negotiation
- Team Dynamics

Core SE Principles

- General Engineering
- Systems Thinking
- Capability Engineering
- Critical Thinking
- Systems Modelling and Analysis
- Lifecycles

Integrating

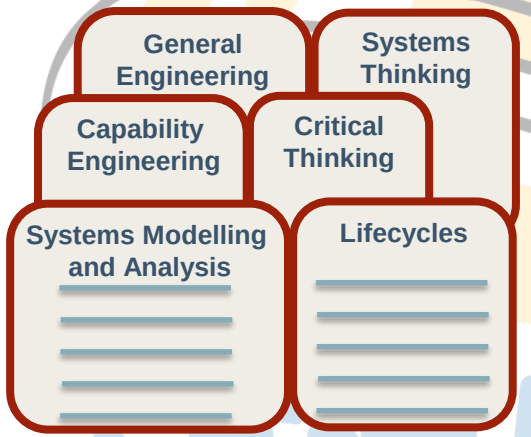
- Quality
- Finance
- Project Management
- Logistics

Technical

- Requirements Definition
- Systems Architecting
- Transition
- Operations and Support
- Design For …
- Integration
- Interfaces
- Verification
- Validation

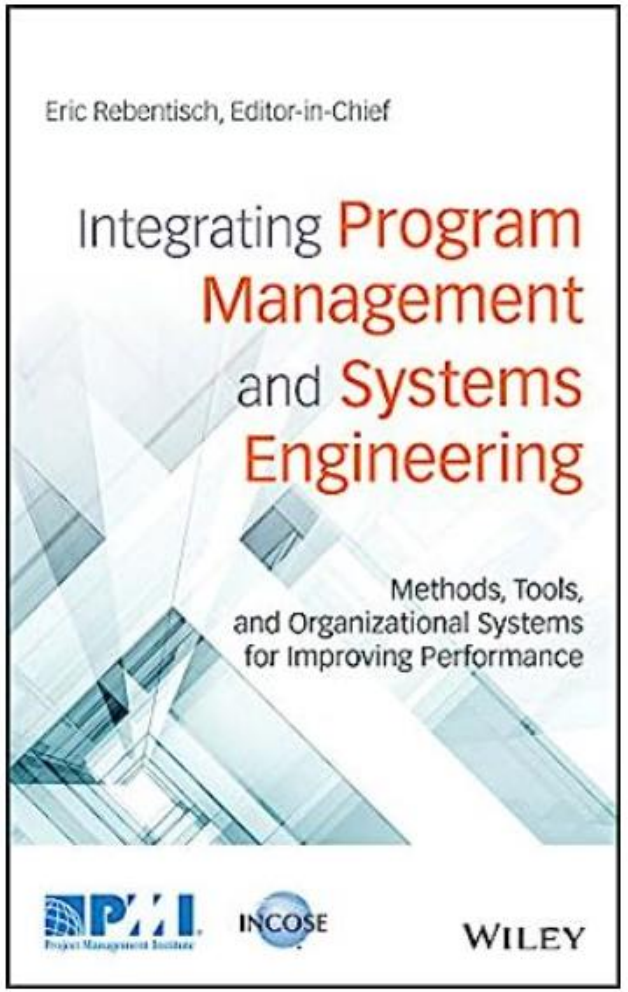
Revisiting the Competency Groups

Core SE Principles



Revisiting the Competency Groups

Revisiting the Competency Groups



Revisiting the Competency Groups

Professional

- Communications
- Facilitation
- Ethics and Professionalism
- Coaching & Mentoring
- Technical Leadership
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- Negotiation
- Team Dynamics

Core SE Principles

- General Engineering
- Systems Thinking
- Capability Engineering
- Critical Thinking
- Systems Modelling and Analysis
- Lifecycles

Integrating

- Quality
- Finance
- Project Management
- Logistics

Other thoughts

Paradoxical mindset

- Holding contradictory thoughts in your mind, embracing the inherent tension

Telescoping (zoom in, zoom out)

- Keep track of the entire picture, but be able to dive down deep into the details when necessary.
- This is where the technical background is important

Other thoughts

The BEST System Engineers are:

- PROACTIVE
- Inherent LEADERS
- CURIOUS & courageous
- LIFELONG learners

Lori's thoughts for young SEs:

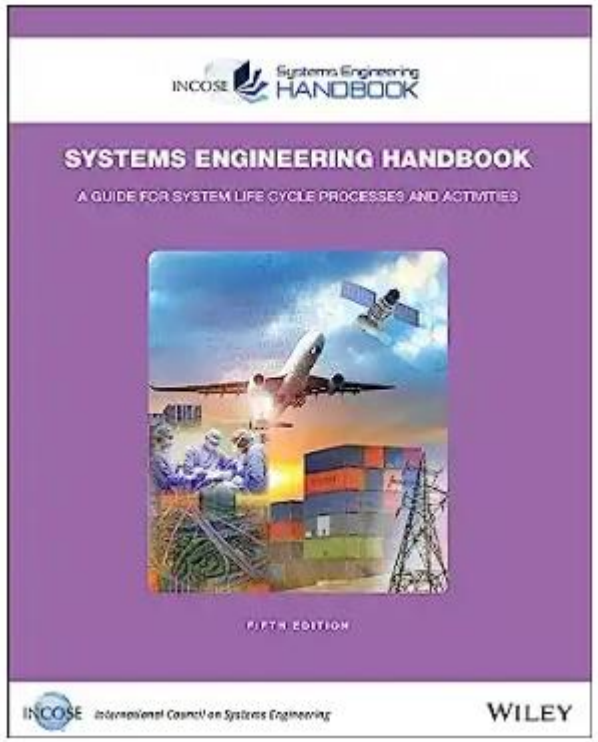
Cybersecurity

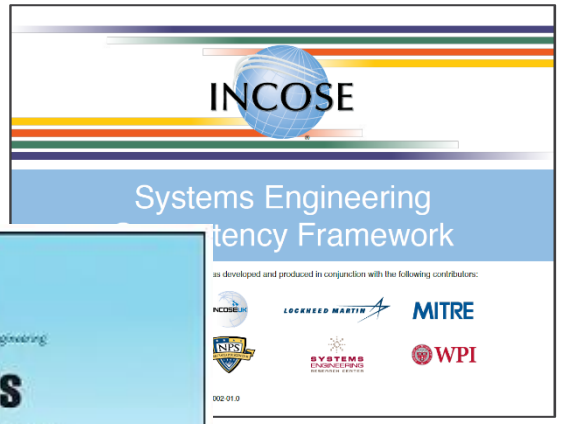
AI/ML & data science

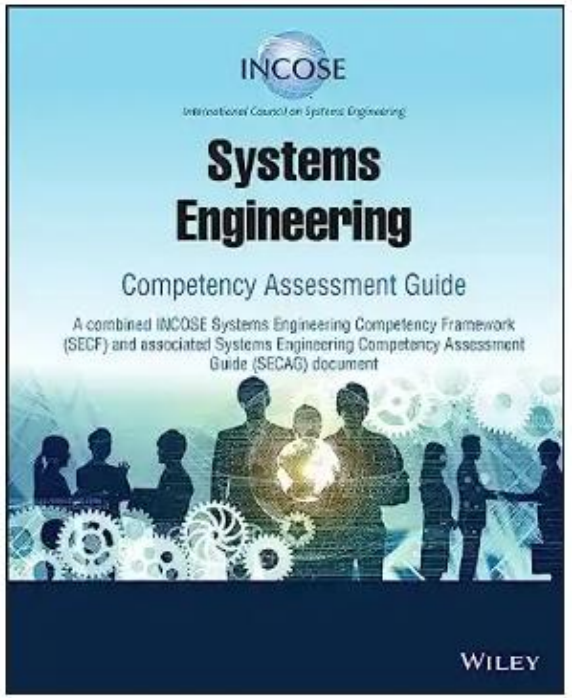
The human as an element of (almost) all systems

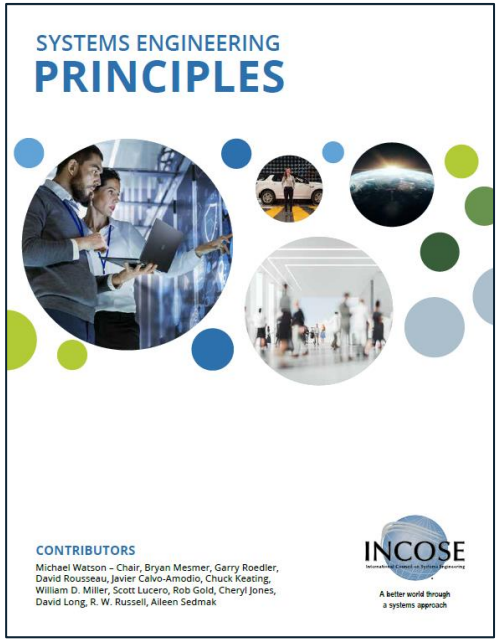
Human behavior (Colonial oil pipeline, stock market & e-currency…)

Additional Resources









Questions?