Modeling System Life Cycle Concepts

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Presenters Bio

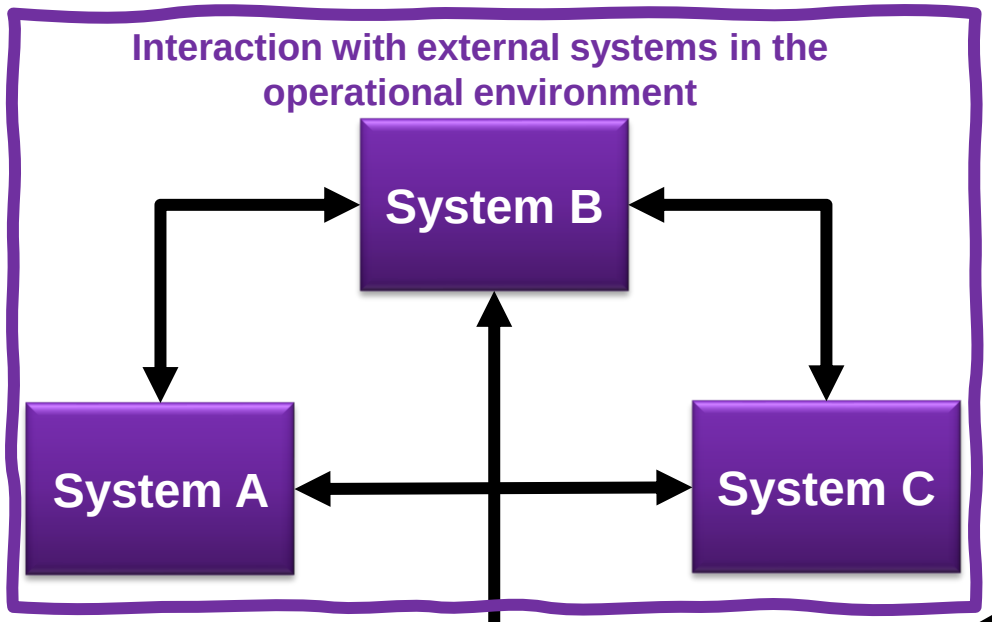
Flavius Galiber is a **Fellow** at **Northrop Grumman** with over 35 years of experience in systems engineering, software development, business development, project management and strategy. He currently trains and coaches organizations and programs in how to practically adopt **Digital Engineering** and **Lean-Agile** principles, practices and tools to help them improve their ways of working. Flavius is passionate about upskilling the workforce worldwide so that everyone, everywhere understands how to efficiently deliver complex solutions that customers and users love. When he isn't working with Northrop Grumman's U.S. and international government customers, Flavius is traveling, art collecting, swimming, playing tennis & golf, and binge-watching his favorite horror, fantasy and science fiction TV shows and movies.

Topics

- **Enabling Systems**
- **System Life Cycle Concepts**
- **Recommended Modeling Approaches for System Life Cycle Concepts**
- **In Summary**

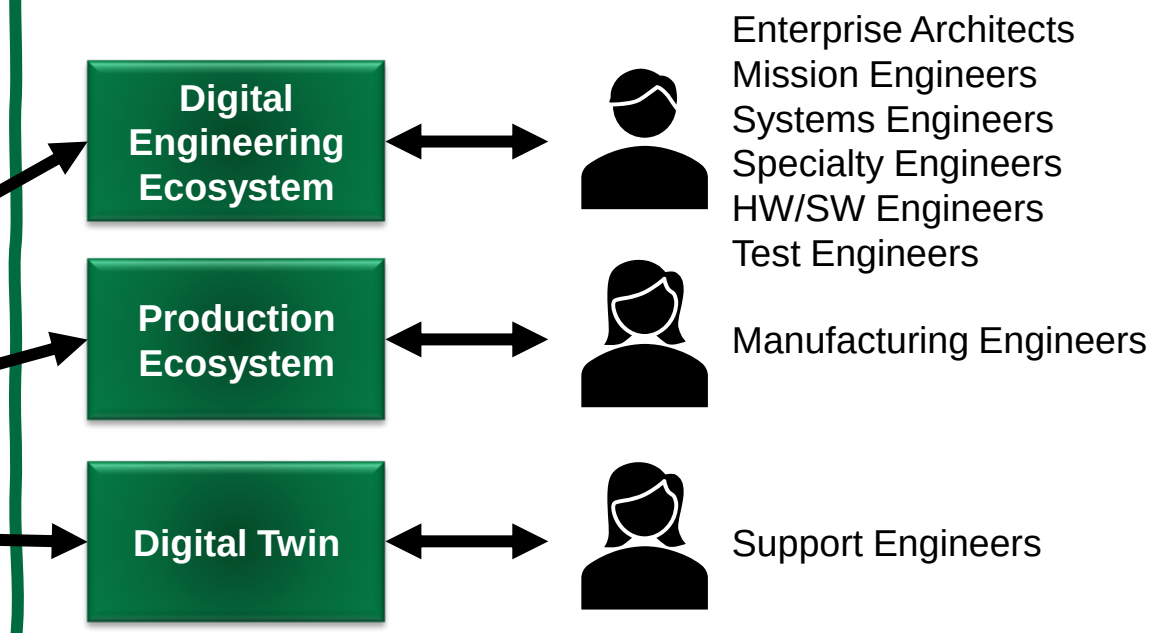
ENABLING SYSTEMS

Enabling Systems



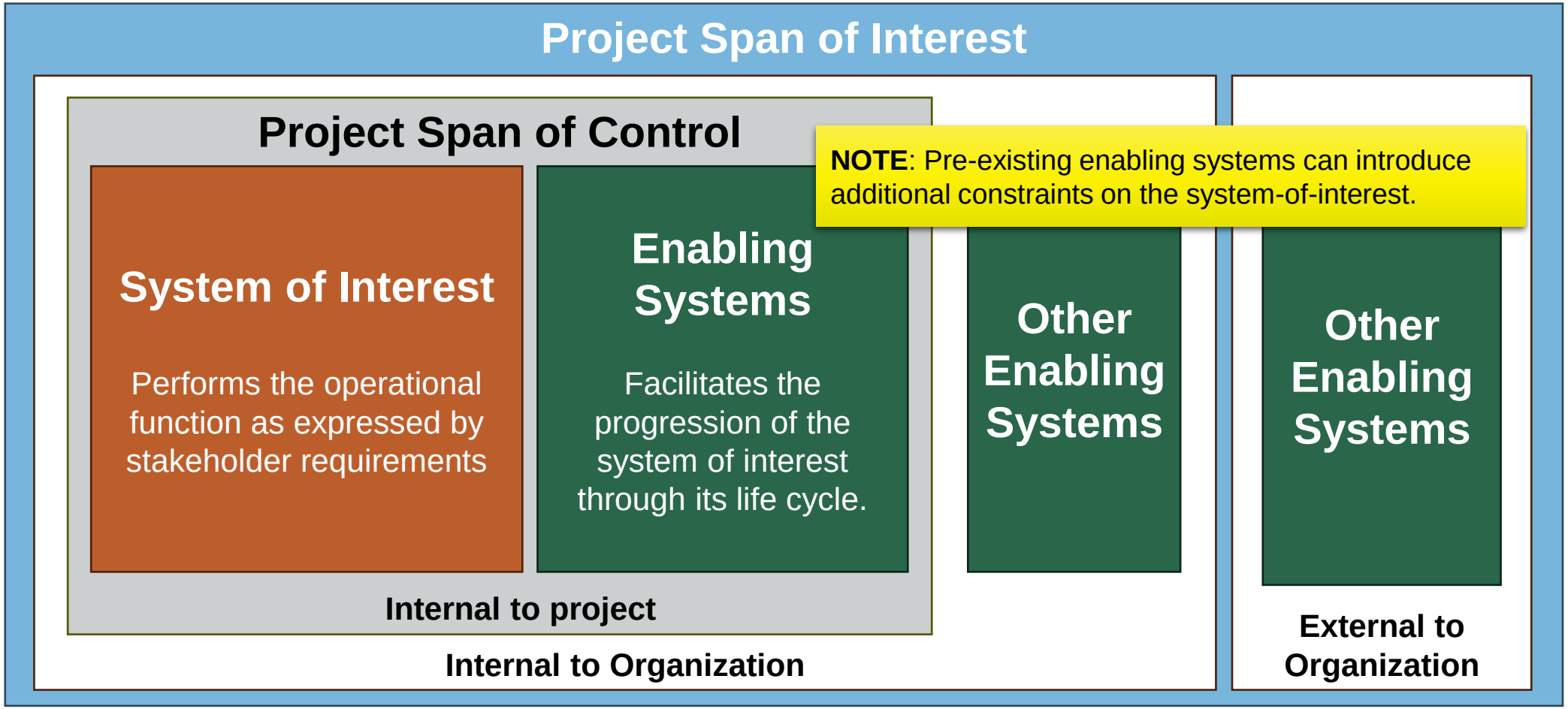
Reference: ISO/IEC/IEEE 15288:2023, Chapter 5.2.3

- **Enabling systems facilitate progression of the system-of-interest (SoI) through its life cycle.**
- **Enabling systems contribute *indirectly* to the services provided by the SoI.**



During any stage in the system life cycle, the relevant enabling systems and the system-of-interest are considered together.

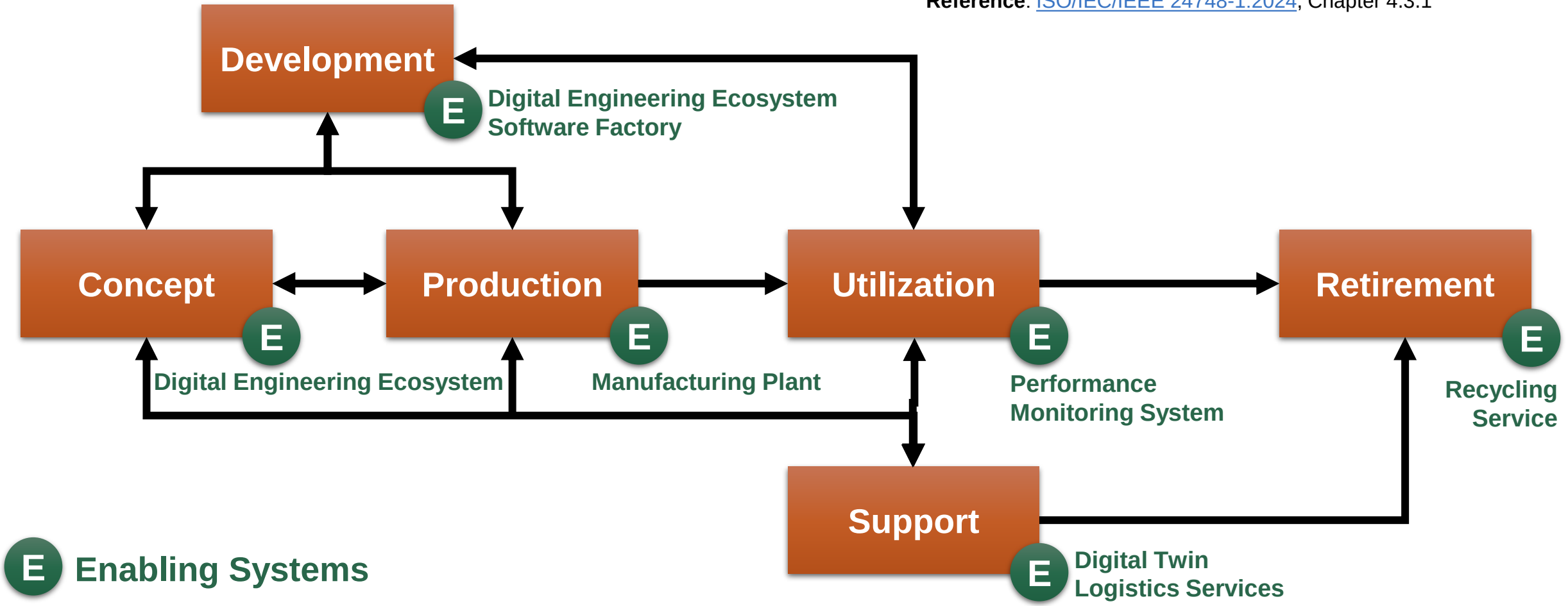
Enabling Systems within the Project Span of Interest



The project should identify any enabling systems that are needed and ensure their availability for use at the appropriate times.

Generic Life Cycle Stages for a System of Interest

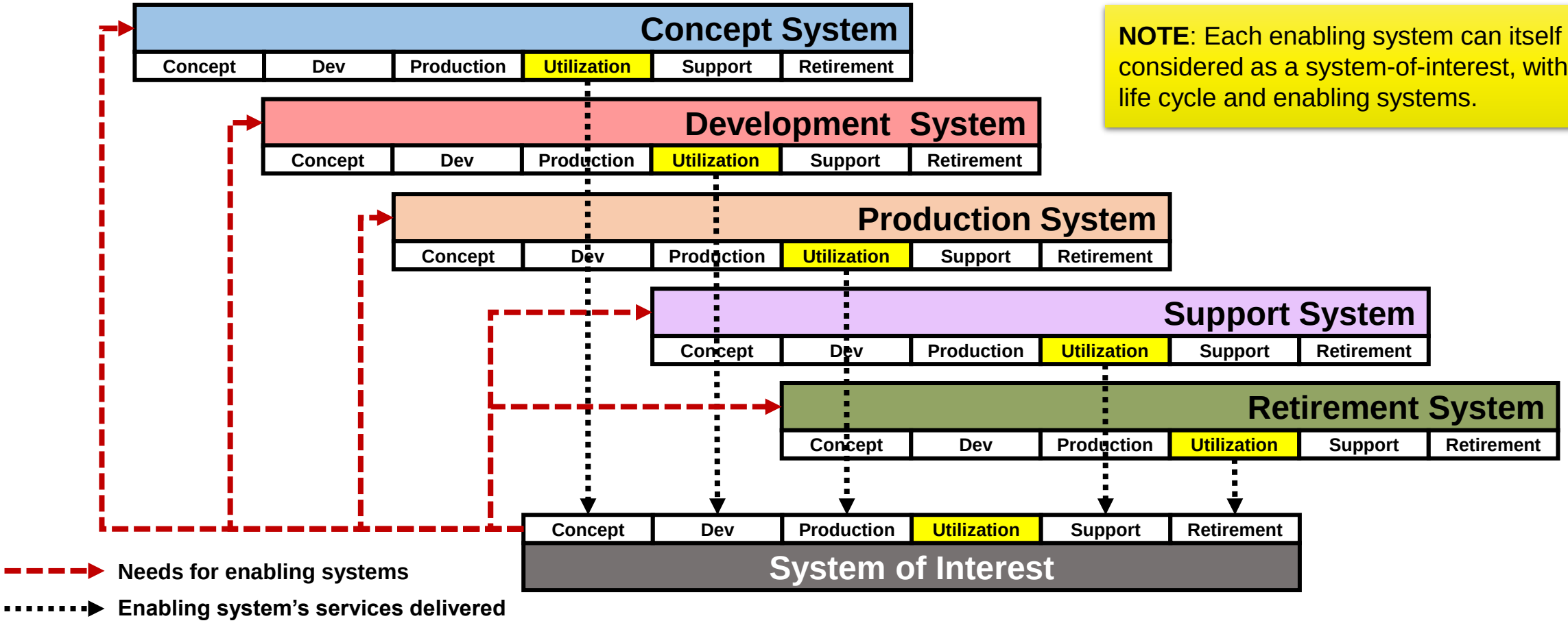
Reference: ISO/IEC/IEEE 24748-1:2024, Chapter 4.3.1



Enabling systems should be available for each stage in order to achieve the outcomes of the stage.

Generic Life Cycle Stages for a System of Interest

Reference: ISO/IEC/IEEE 24748-1:2024, Chapter 4.3.3

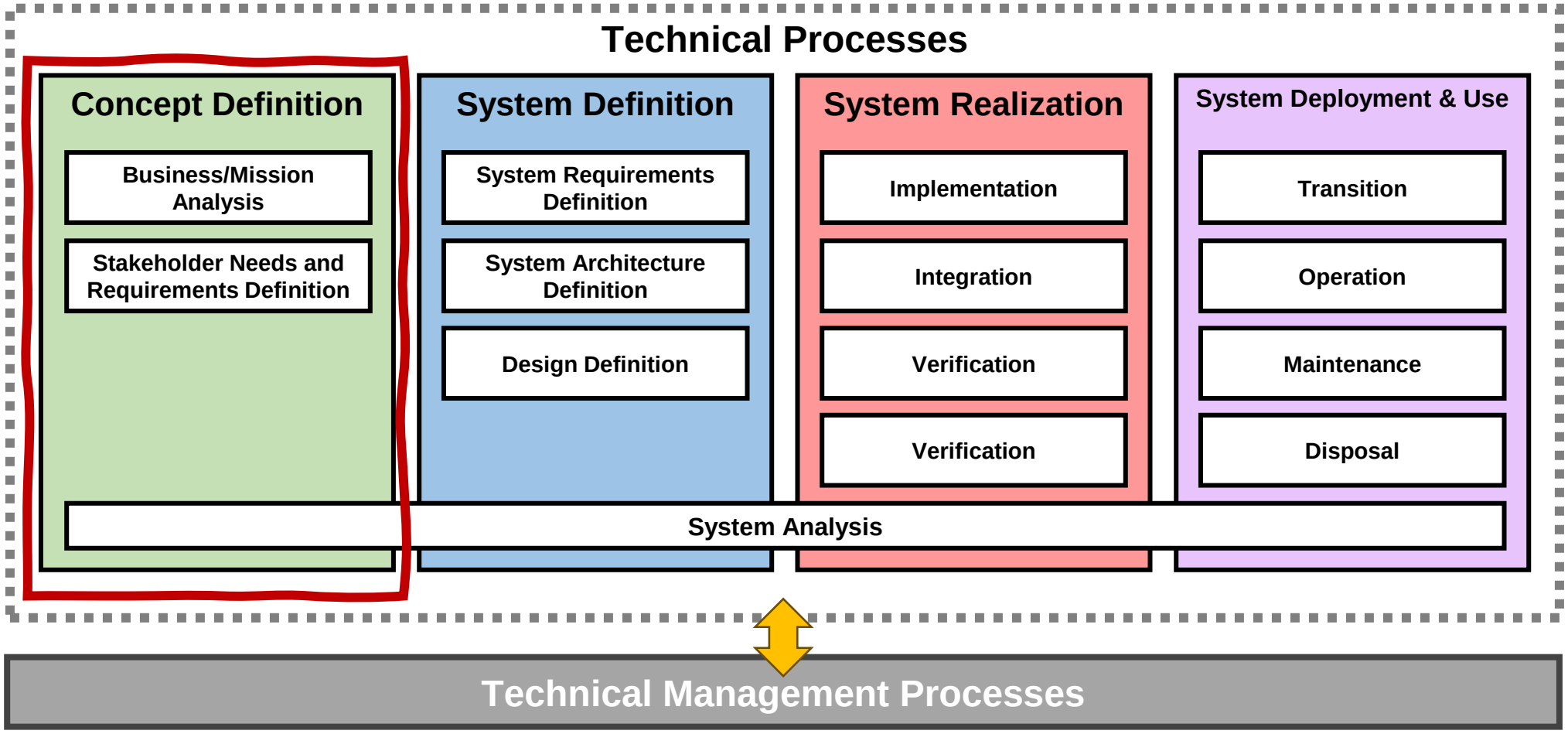


NOTE: Each enabling system can itself be considered as a system-of-interest, with its own life cycle and enabling systems.

Failure to adequately engineer complex, enabling systems can have catastrophic effects on the stakeholders of a system of interest.

SYSTEM LIFE CYCLE CONCEPTS

System Life Cycle Processes



NOTE: It is presumed that the enterprise has already deployed enabling systems to support the *Concept Definition* stage.

NOTE: There may one or more enabling systems for each system life cycle process!

Reference: INCOSE Systems Engineering Handbook (5th Edition), Chapter 2.3

Preliminary life cycle concepts—which includes the identification of enabling systems–are developed during the Concept stage.

Business or Mission Analysis Process

NOTE: It is presumed that the enterprise already has enabling systems and processes to support Business/Mission Analysis.

Typical Inputs

- Organization strategy
- Source documents
- Organizational / Mission CONOPS

Activities

- Define the problem or opportunity space
- Characterize the solution space
- Evaluate solution classes that span the potential solution space

Typical Outputs

- Problem / Opportunity statement
- Critical business / mission success measures
- Preliminary life cycle concepts
- Preferred solution class(es)

NOTE: Enterprise Architecture and Mission Engineering includes Business/Mission Analysis.

Reference: INCOSE Systems Engineering Handbook (5th Edition), Chapter 2.3.5.1

Preliminary life cycle concepts and associated enabling systems are initially defined as part of the *Business/Mission Analysis* process.

Identify **major stakeholder groups**–including adversaries and detractors–for each system life cycle stage.

Define the preliminary life cycle **concepts** at the organization level for the selected class(es) of solutions.

- Includes high-level, potential **use cases/scenarios**, and/or **usage** of the **system-of-interest** and/or its **enabling** systems.
- Identified enabling systems may be internal to a project, internal to an organization or external to an organization.
- Identified enabling systems may be pre-existing or non-existing systems.

Iteratively **refine** these concepts throughout the system life cycle.

Defining preliminary life cycle concepts drive and constrain the *Stakeholder Needs & Requirements Definition* process.

Stakeholder Needs and Requirements Definition Process

NOTE: It is presumed that the enterprise already has enabling systems and processes to support Stakeholder Needs and Requirements Definition.

Typical Inputs

- Organizational / Mission CONOPS
- Problem / Opportunity statement
- Critical business / mission success measures
- Preliminary life cycle concepts
- Preferred solution class(es)

Activities

- Develop the operational concept and other life cycle concepts
- Elicit / Derive stakeholder needs
- Transform stakeholder needs into stakeholder requirements
- Analyze stakeholder needs and requirements

Typical Outputs

- Life cycle concepts
- Stakeholders
- Stakeholder needs and requirements
- Critical performance measurement needs and data
- Requirements imposed on enabling systems
- Traceability mapping

Reference: INCOSE Systems Engineering Handbook (5th Edition), Chapter 2.3.5.2

Preliminary life cycle concepts are further refined and elaborated as part of the *Stakeholder Needs & Requirements Definition* process.

For each preliminary life cycle concept of a [enabling] system-of-interest (SoI) defined in Business/Mission Analysis:

- Define one or more contexts of use—see ISO/IEC 25063:2014.
- Identify stakeholder needs—see UX Stakeholder Engagement 101.
- Prioritize (using the Decision Management process) and down-select (using the System Analysis process) needs.
- Define the stakeholder needs and associated sources and rationale—see INCOSE Guide to Writing Requirements.

Refining and elaborating the preliminary life cycle concepts helps identify a comprehensive set of stakeholder needs.

For each context of use for a [enabling] system-of-interest (SoI):

- Elaborate use cases/scenarios to identify all required system functions.
- Describe the interactions between the system-of interest, external entities (e.g., systems, users, natural environment), enabling systems and other stakeholders.
- Identify constraints on the SoI and/or its enabling systems.
- Identify risks associated with the SoI and/or its enabling systems.

Refining and elaborating preliminary life cycle concepts helps identify a comprehensive set of stakeholder needs.

Common Pitfalls of System Concept Definition

Failure to identify life cycle needs and the necessary enabling systems can result in significant program **schedule delays** and **cost overruns**, as well as **unintended consequences** on the environment.

Poorly-designed enabling systems can significantly decrease **program productivity**, **employee engagement**, **mission agility**, **mission effectiveness**, and much more.

"Oops! We didn't think through how we would retire the system and recycle its hardware components, so we don't have adequate funding for retirement. What can we do?"

"Our system architecture, design and implementation have drifted miles apart. What happened?"

"Our manufacturing facility can't produce the initial quantities of the system in time. We're going to have to delay the initial operational test & evaluation of the system."

"Hackers got into our training system and they may have stolen some of our employees' personal data."

A better *collective* understanding of a [enabling] system's life cycle concepts leads to better outcomes for all stakeholders!

How can achieve a better collective understanding of a [enabling] system's life cycle concepts across all stakeholders of system-of-interest?

Capturing all the data in documents? Sure, but that's so 90s. ☺

Today, we utilize DESCRIPTIVE MODELING!

RECOMMENDED MODELING APPROACHES FOR SYSTEM LIFE CYCLE CONCEPTS

Recommended Modeling Approaches for System Life Cycle Concepts

Recommendation #1: Utilize the Enterprise Architecture (EA) Guide for Unified Architecture Framework (UAF), Version 1.2 to support Business/Mission Analysis and describe a potential system's preliminary life cycle concepts using the UAF Modeling Language (UAFML).

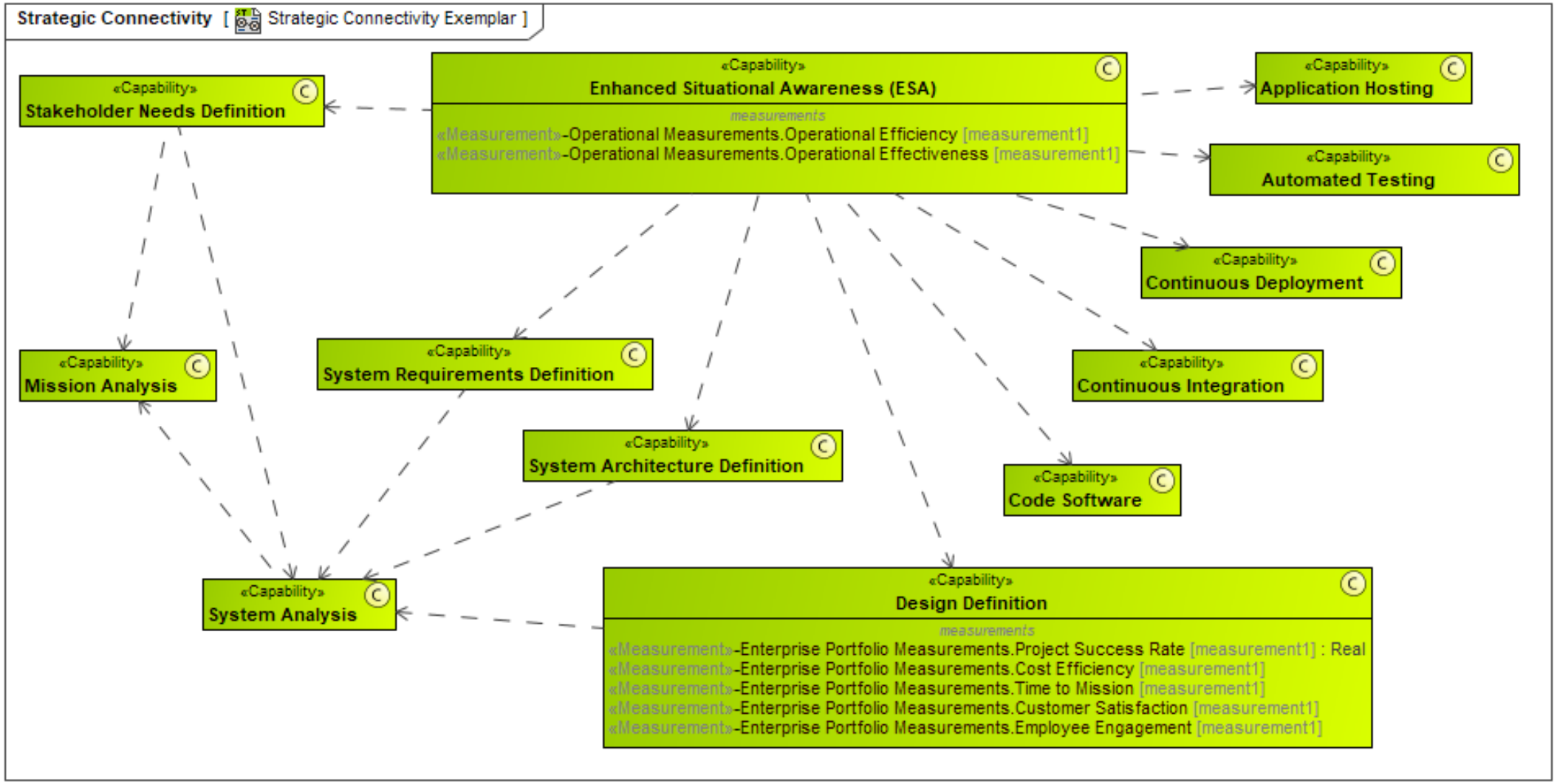
- Includes enabling systems & services

Recommendation #1.1: In addition to the Capabilities that describe the enterprise's ability to achieve desired business/mission effects through various ways (e.g., activities/processes) and means (e.g., systems/products, services, people/organizations), define any additional Capabilities that *enable* some/all the business/mission Capabilities—along with associated measures. (**Step 2.2**)

Recommendation #1.2: Define dependency relationships between business/mission Capabilities and *enabling* Capabilities. (**Step 2.3**)

Recommended Modeling Approaches for System Life Cycle Concepts

Utilize the EA Guide for UAF V1.2 to describe a potential [enabling] system's preliminary life cycle concepts

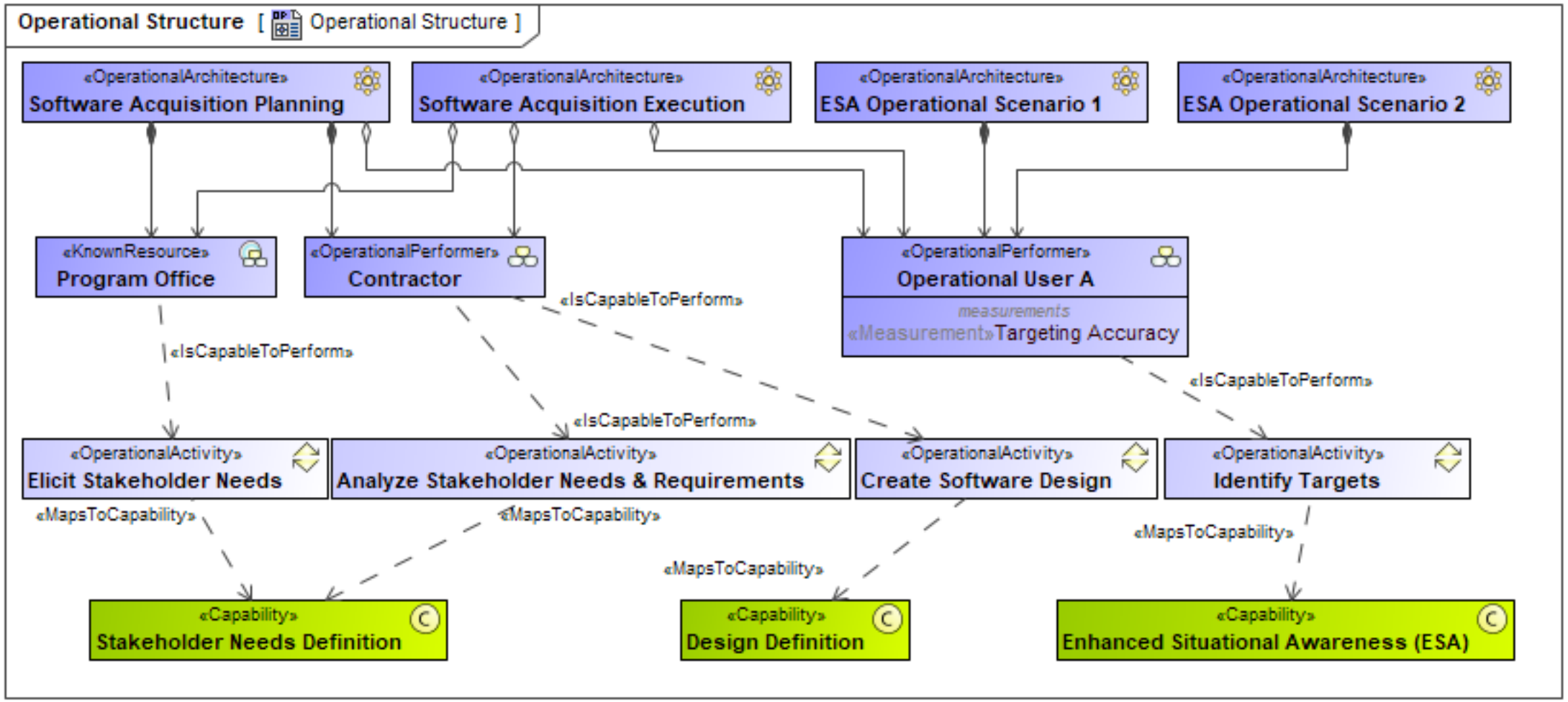


Recommendation #1.3: Define and evaluate one or more [logical] Operational Architecture alternatives that implement the business/mission *and* enabling Capabilities. (**Step 3.0**)

- Defines/Updates the enterprise and/or mission CONOPS
- Defines a logical view of the [enabling] system-of-interest's preliminary life cycle concepts

Recommended Modeling Approaches for System Life Cycle Concepts

Utilize the EA Guide for UAF V1.2 to describe a potential [enabling] system's preliminary life cycle concepts



Recommendation #1.4: Define and evaluate one or more Service Architecture, Resource Architecture and/or Personnel Architecture alternatives that implement the [optimal] [logical] Operational Architecture. (**Steps 4.0**, **5.0** and **6.0**)

Recommendation #1.4.1: For a given [enabling] system-of-interest, define one or more Capability Configurations for each life cycle concept. (**Step 5.1**)

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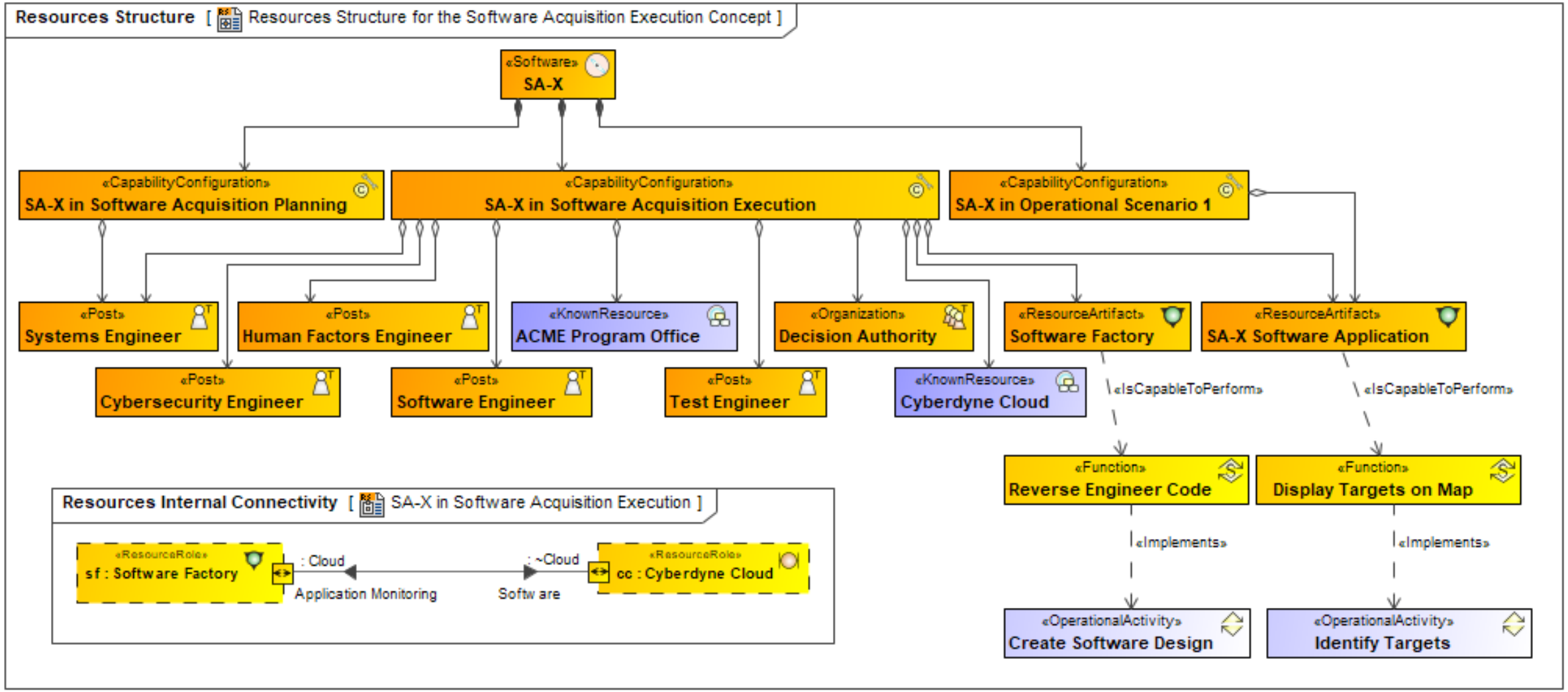


Recommended Modeling Approaches for System Life Cycle Concepts

Recommendation #2: Utilize the MagicGrid Book of Knowledge, 2nd Edition to support Stakeholder Needs and Requirements Definition and refine & elaborate the [enabling] system-of-interest's preliminary life cycle concepts identified during Business/Mission Analysis using the Systems Modeling Language (SysML). (Chapter **Problem domain**)

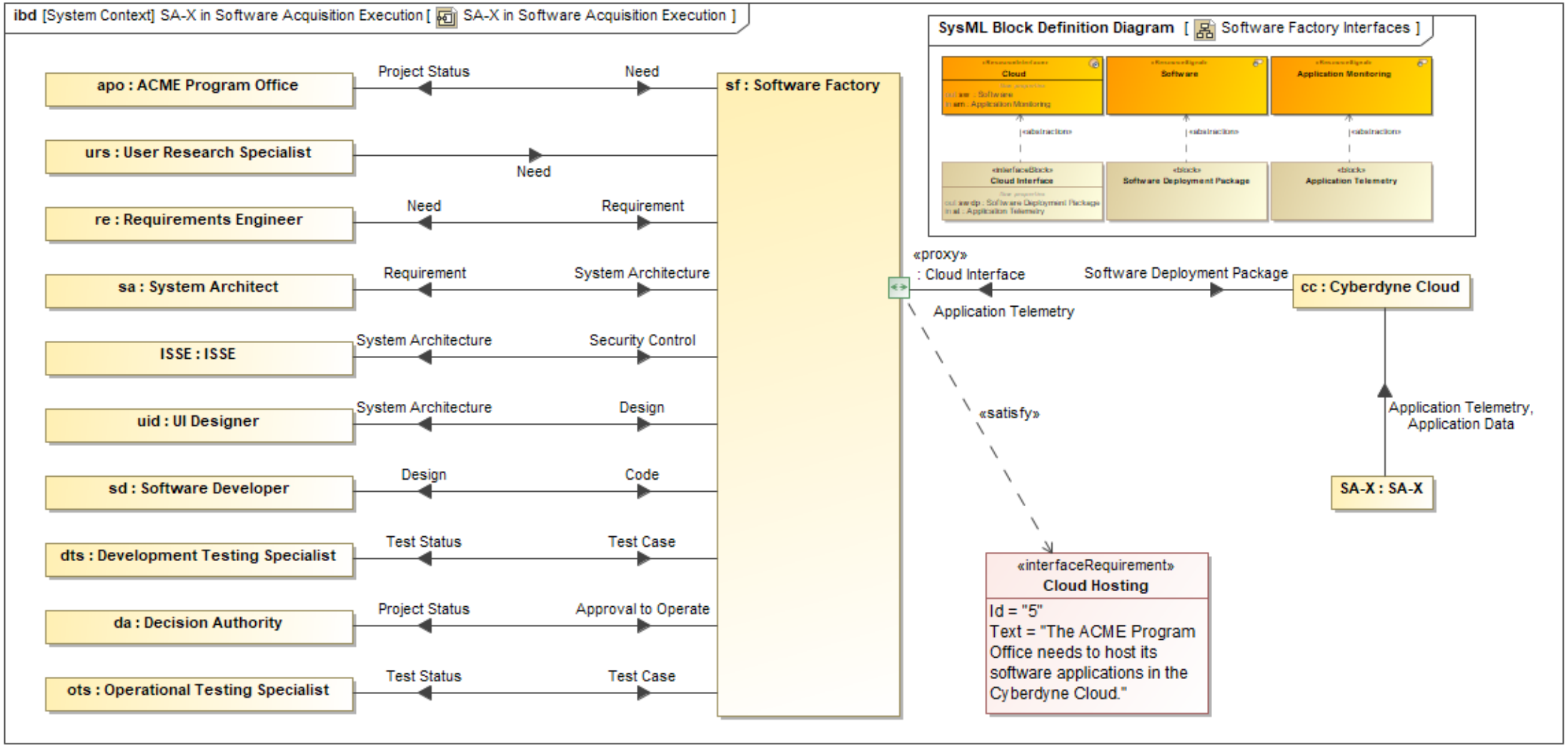
MagicGrid Standard			Pillar				
			Requirements	Structure	Behavior	Parameters	Safety & Reliability
Domain	Problem	Black Box	Stakeholder Needs	System Context	Use Cases	Measures of Effectiveness (MoE)	Conceptual and Functional Failure Mode & Effects Analysis (FMEA)
		White Box		Conceptual Subsystems	Functional Analysis	MoEs for Subsystems	Conceptual Subsystems FMEA
	Solution		System Requirements	System Structure	System Behavior	System Parameters	System Safety & Reliability (S&R)
			Subsystem Requirements	Subsystem Structure	Subsystem Behavior	Subsystem Parameters	Subsystem S&R
				System Configuration Structure	System Configuration Behavior	System Configuration Parameters	System Configuration S&R
	Implementation		Implementation Requirements				

Recommendation #2.1: Define one or more system context diagrams (ibds) for each life cycle concept identified during Business/Mission Analysis and described in the UAF enterprise model as a Capability Configuration. (Chapter **System Context**)

Recommendation #2.1.1: Define relationships between the system context elements and the corresponding UAF elements in the enterprise model. (**Annex B: From System of Systems to System Architecture**)

Recommended Modeling Approaches for System Life Cycle Concepts

Utilize MagicGrid to refine & elaborate the [enabling] system-of-interest's preliminary life cycle concepts



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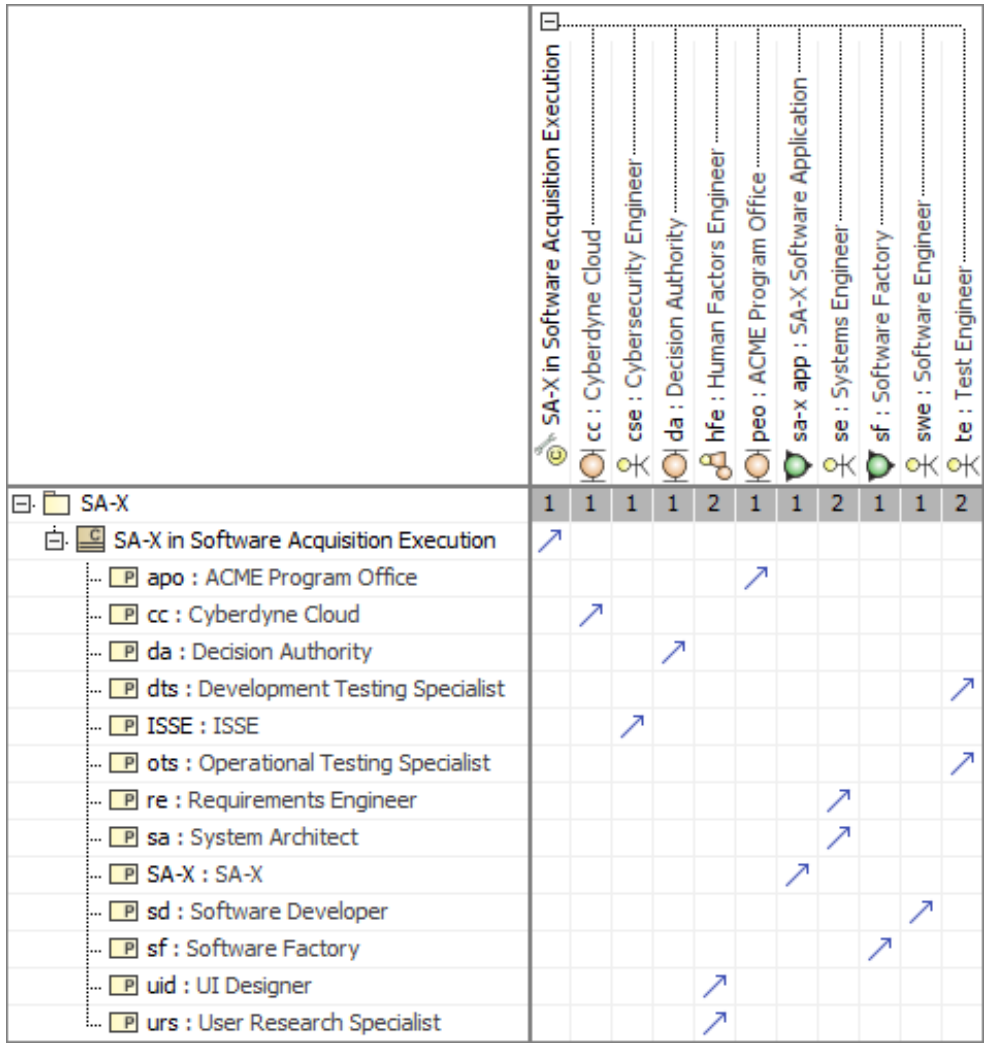


Recommendation #2.2: Define stakeholder needs for each life cycle concept identified during Business/Mission Analysis. (Chapter **Stakeholder Needs**)

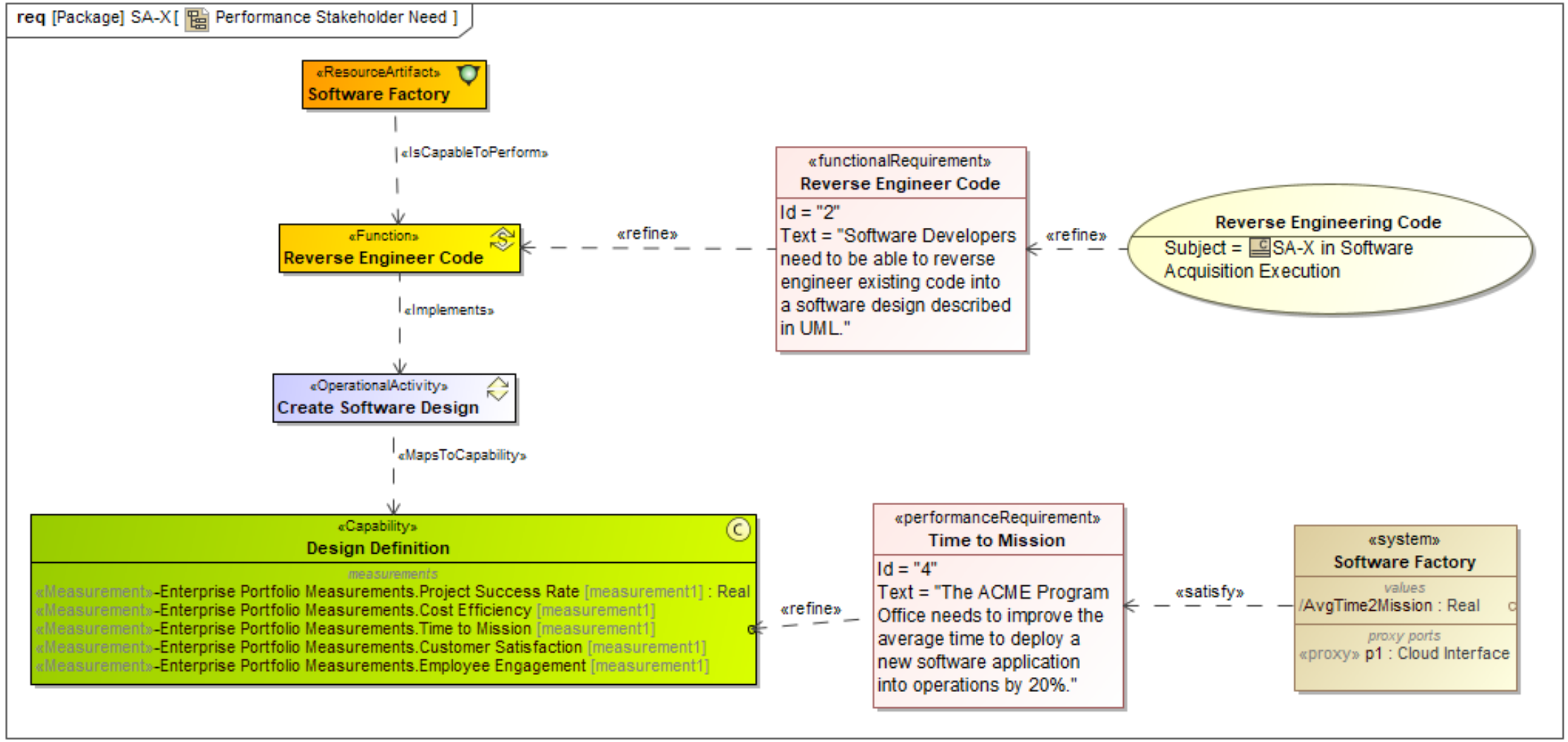
Recommendation #2.2.1: Define Refine relationships between the stakeholder needs and the corresponding UAFML elements in the enterprise model. (Annex **B: From System of Systems to System Architecture**)

Recommendation #2.3: Define one or more use cases and associated use case scenarios for each System Context. (Chapter **Use Cases**)

Recommendation #2.4: Define one or more measure of effectiveness (MoEs) for each life cycle concept identified during Business/Mission Analysis. (Chapter **Measures of Effectiveness**)

Recommended Modeling Approaches for System Life Cycle Concepts

Utilize MagicGrid to refine & elaborate the [enabling] system-of-interest's preliminary life cycle concepts



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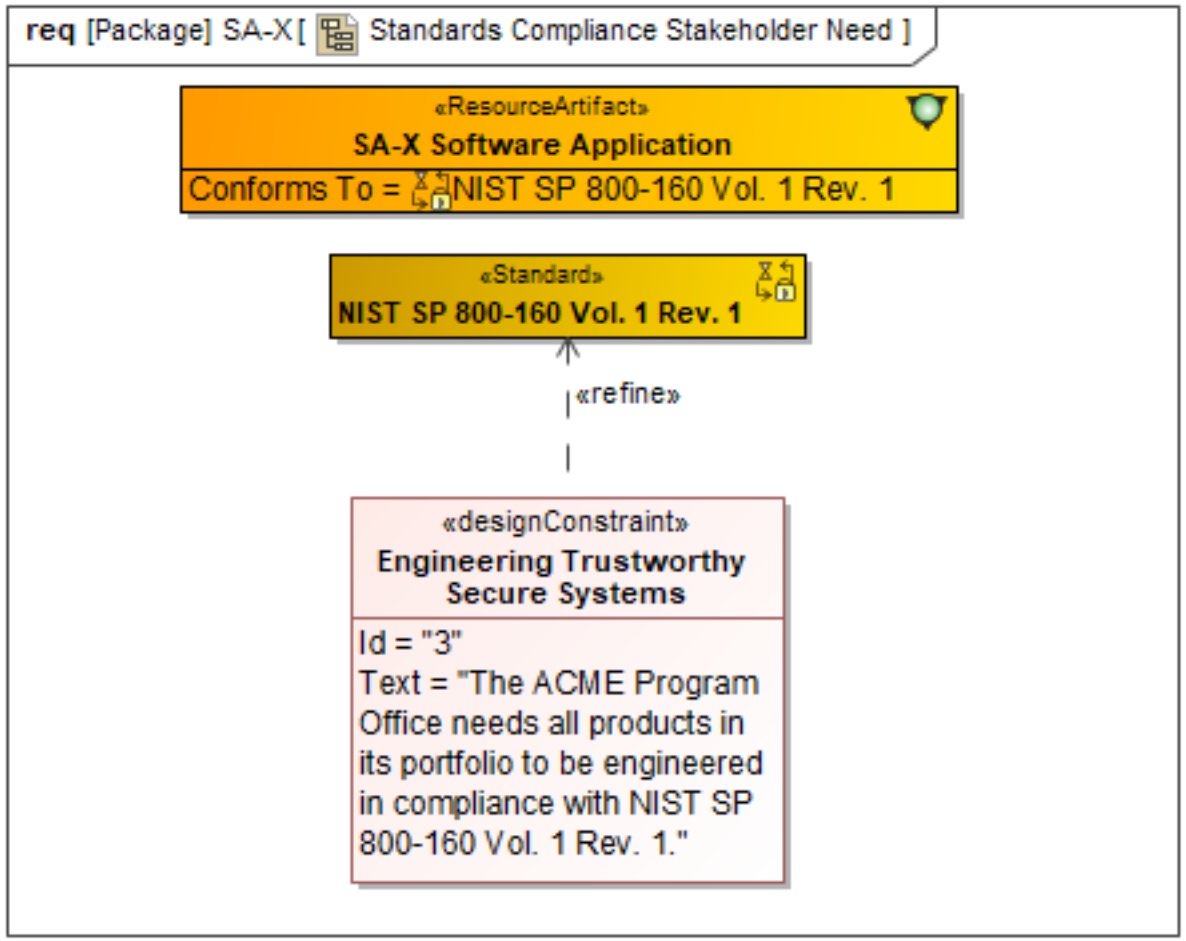

In Summary

A better, collective understanding of a [enabling] system's life cycle concepts leads to **better outcomes for all stakeholders**…

…and descriptive modeling using UAFML and SysML can **improve all stakeholders' understanding** of a [enabling] system's life cycle concepts!