33rd Annual INCOSE international symposium

hybrid event

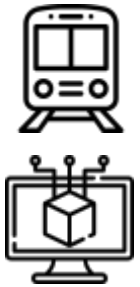
Honolulu, HI, USA
July 15 - 20, 2023

David Long
President, Blue Holon
INCOSE Director for Strategic Integration, Past President, and Fellow

Making Sense of Alphabet Soup: MBSE and DE

Appreciating a Changing Context

From Static Products to Intelligent Systems of Systems

Product	Smart Product	Smart, Connected Product	Product System	Systems of Systems
				

Electro-mechanical

Cyber

Connected

Coordinated

Collaborating

Icons made by Freepik from www.flaticon.com
Adapted from Claas, November 2019

Exploding Complexities and Expectations

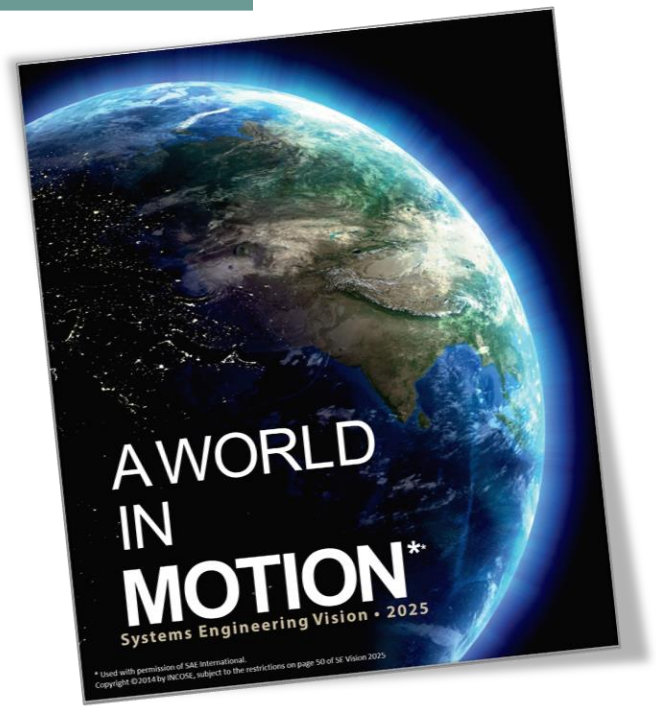
Exceeding the Capabilities of Traditional (S)E

1. Mission complexity is growing faster than our ability to manage it . . . increasing mission risk from inadequate specifications and incomplete verification.

2. System design emerges from pieces, rather than from architecture . . . resulting in systems that are brittle, difficult to test, and complex and expensive to operate.

3. Knowledge and investment are lost at project life cycle phase boundaries . . . increasing development cost and risk of late discovery of design problems

4. Knowledge and investment are lost between projects . . . increasing cost and risk: dampening the potential for true product lines.



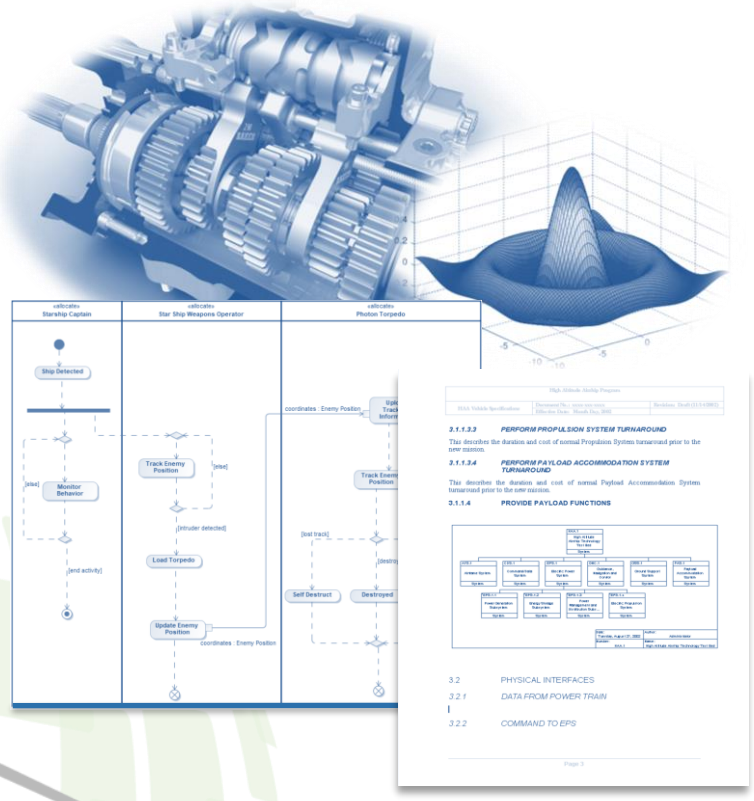
It is not necessary to change.
Survival is not mandatory.

Responding to a Changing World

“Defining” Models and MBSE

A graphical, mathematical (symbolic), physical, or verbal representation or simplified version of a concept, phenomenon, relationship, structure, system, or an aspect of the real world

www.businessdictionary.com



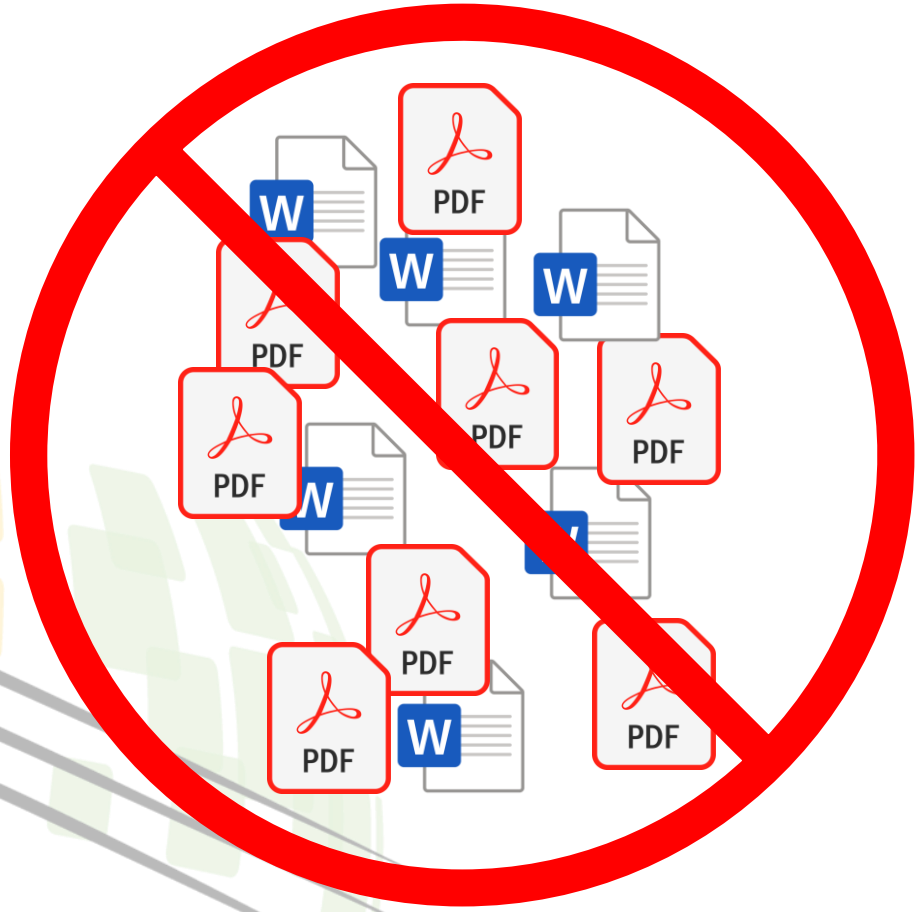
A physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process

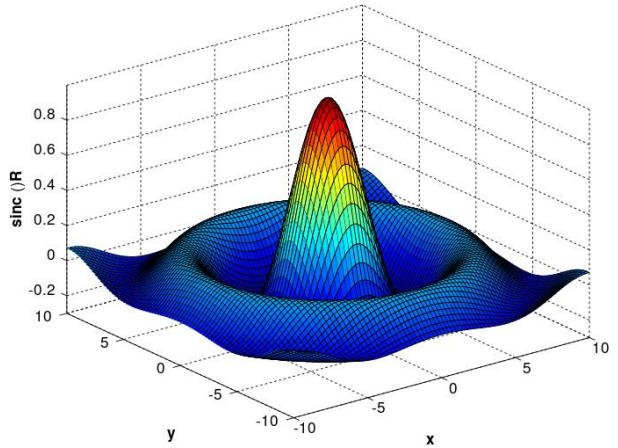
DoD5000.59-M 1998

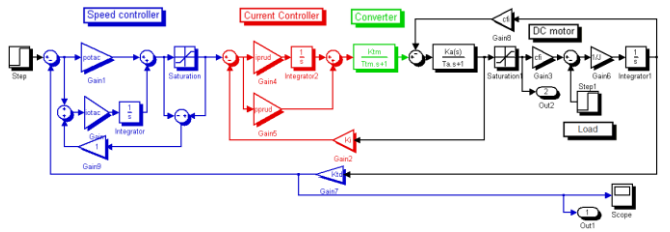
Much of the confusion in MBSE is the ambiguity in “model”.
If everything is a model, everything qualifies as MBSE.

Recognizing Myths and Misconceptions

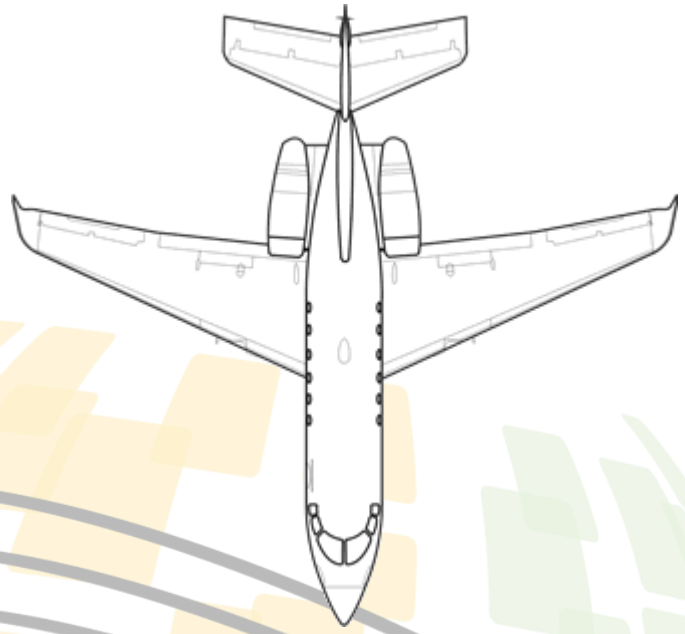
What MBSE Is Not

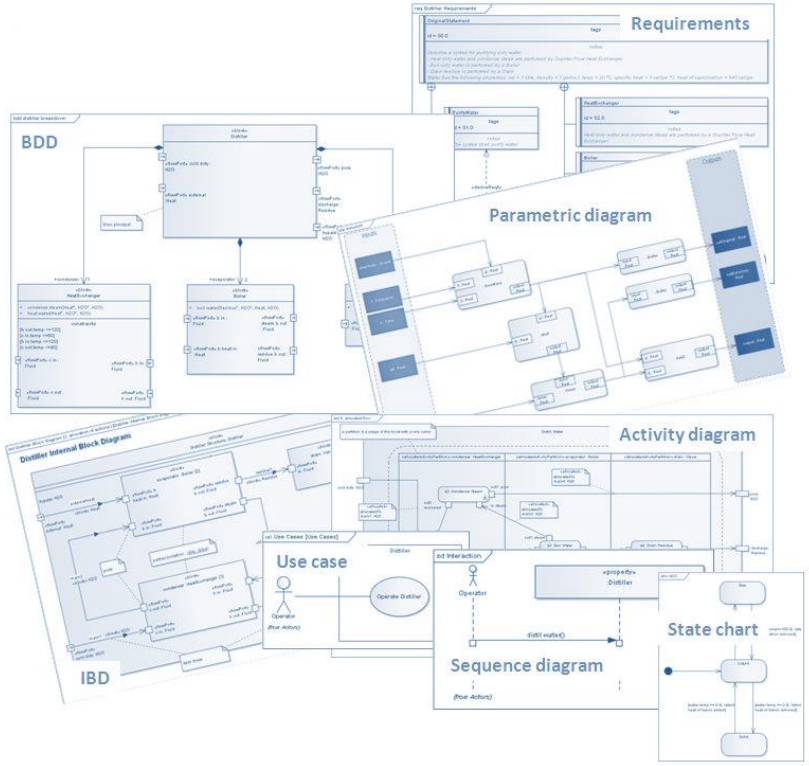


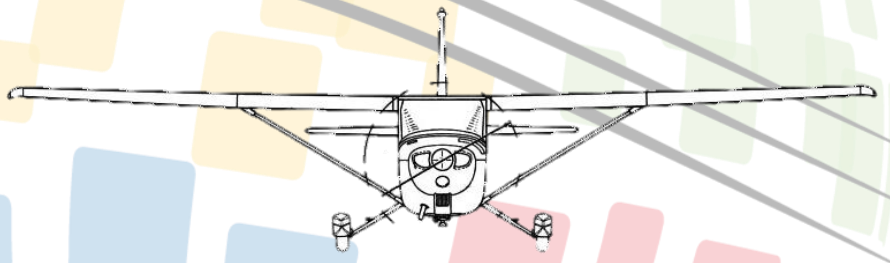


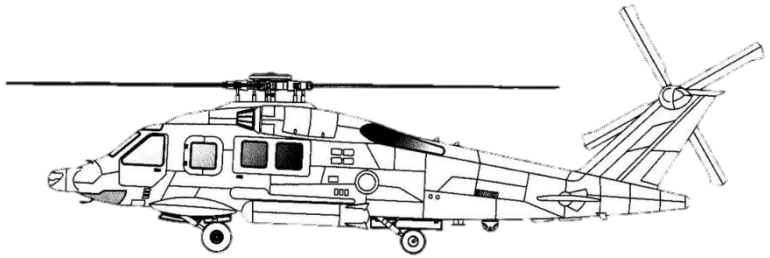


Recognizing the Decoy of Diagram-Based SE



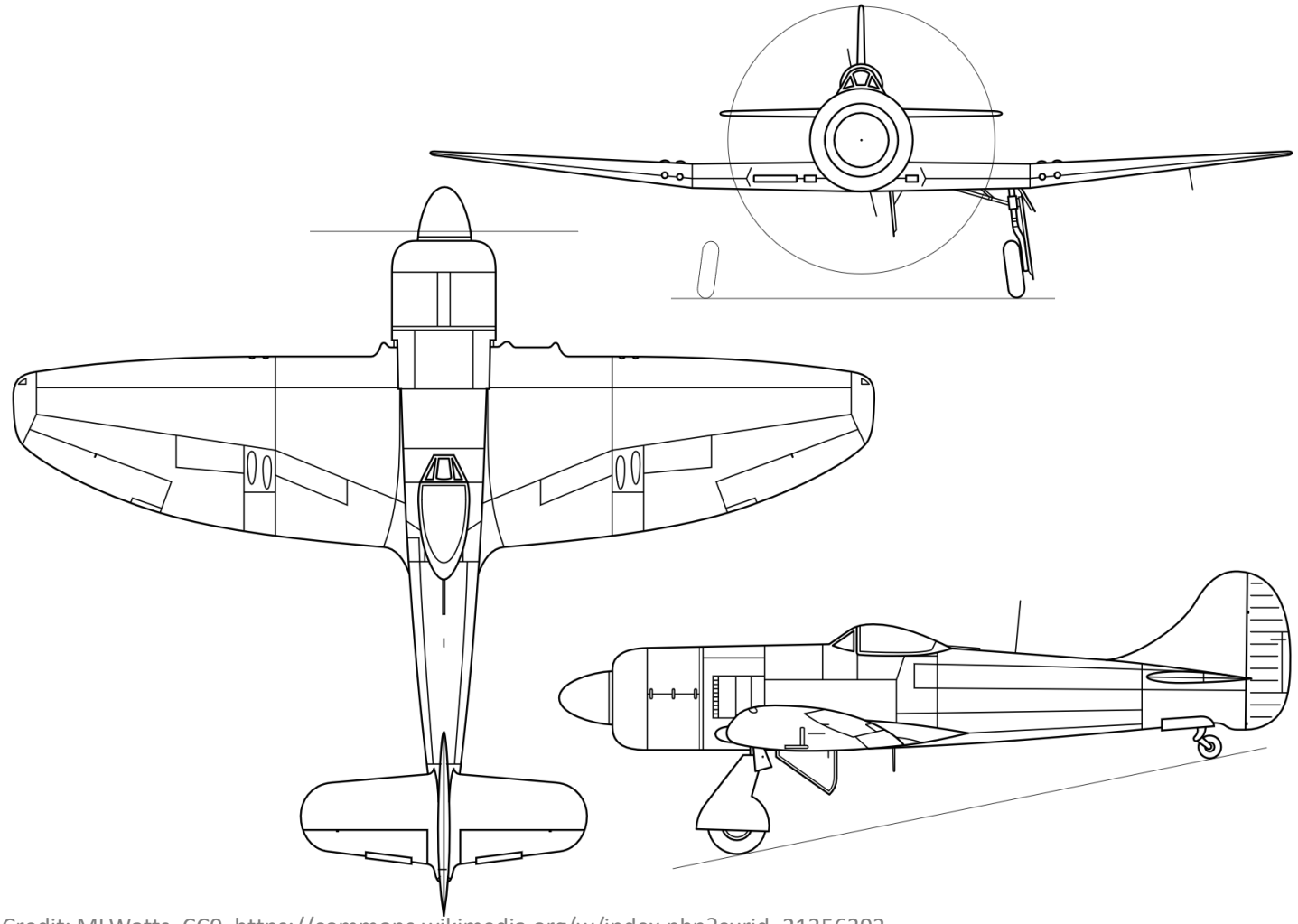






Focusing on Essential Information and Clarity

Looking to Data over Visualization

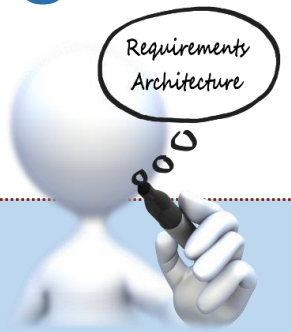


Points

Vectors

Credit: MLWatts. CC0, https://commons.wikimedia.org/w/index.php?curid=21356392

Representing the Fundamental Concepts of Systems Engineering

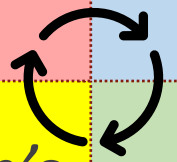


PROBLEM

A System's ***WHY***

BEHAVIORAL ARCHITECTURE

A System's ***HOW***



A System's ***PROOF***

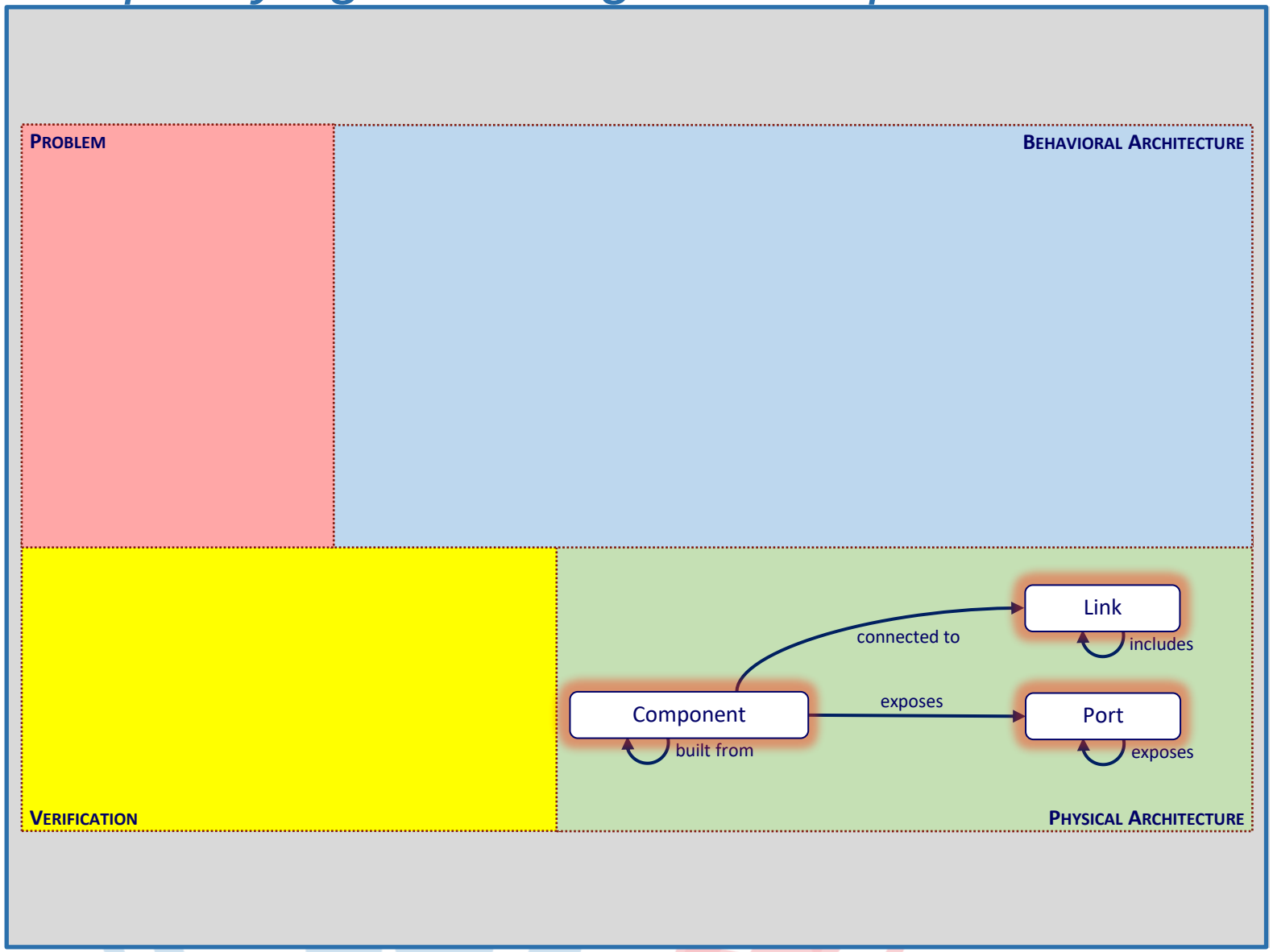
VERIFICATION

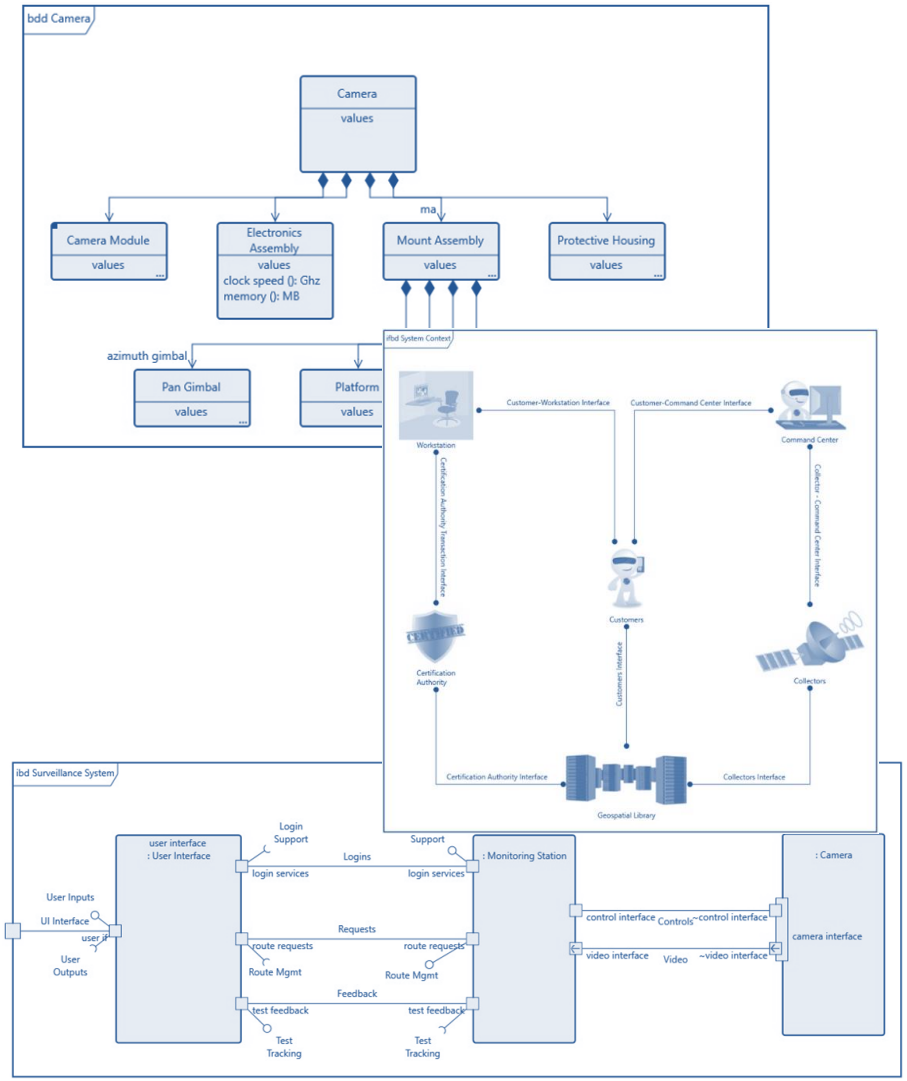
A System's ***WHAT***

PHYSICAL ARCHITECTURE

Representing the Foundational Concepts

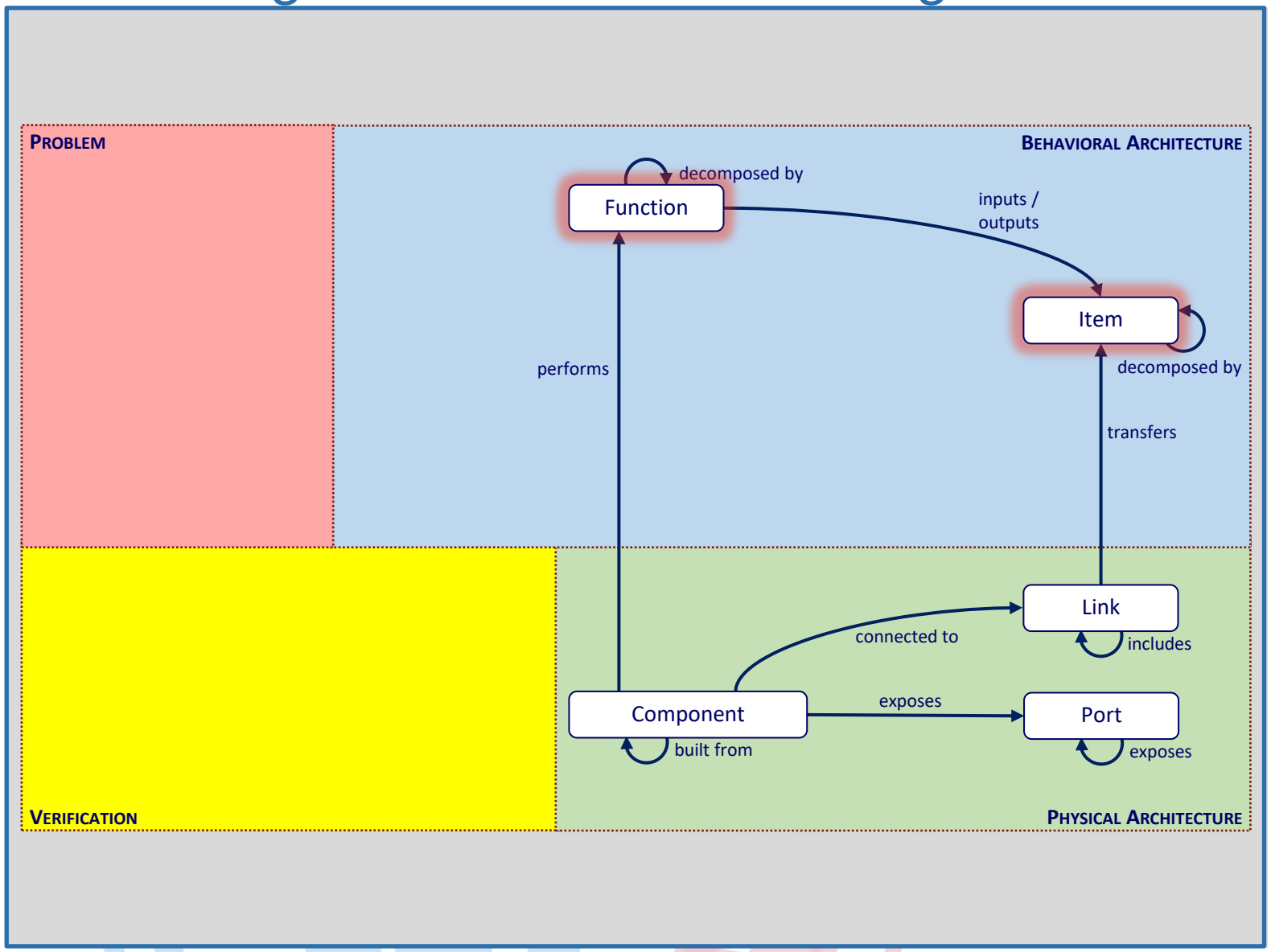
Specifying the Design Envelope and Interfaces

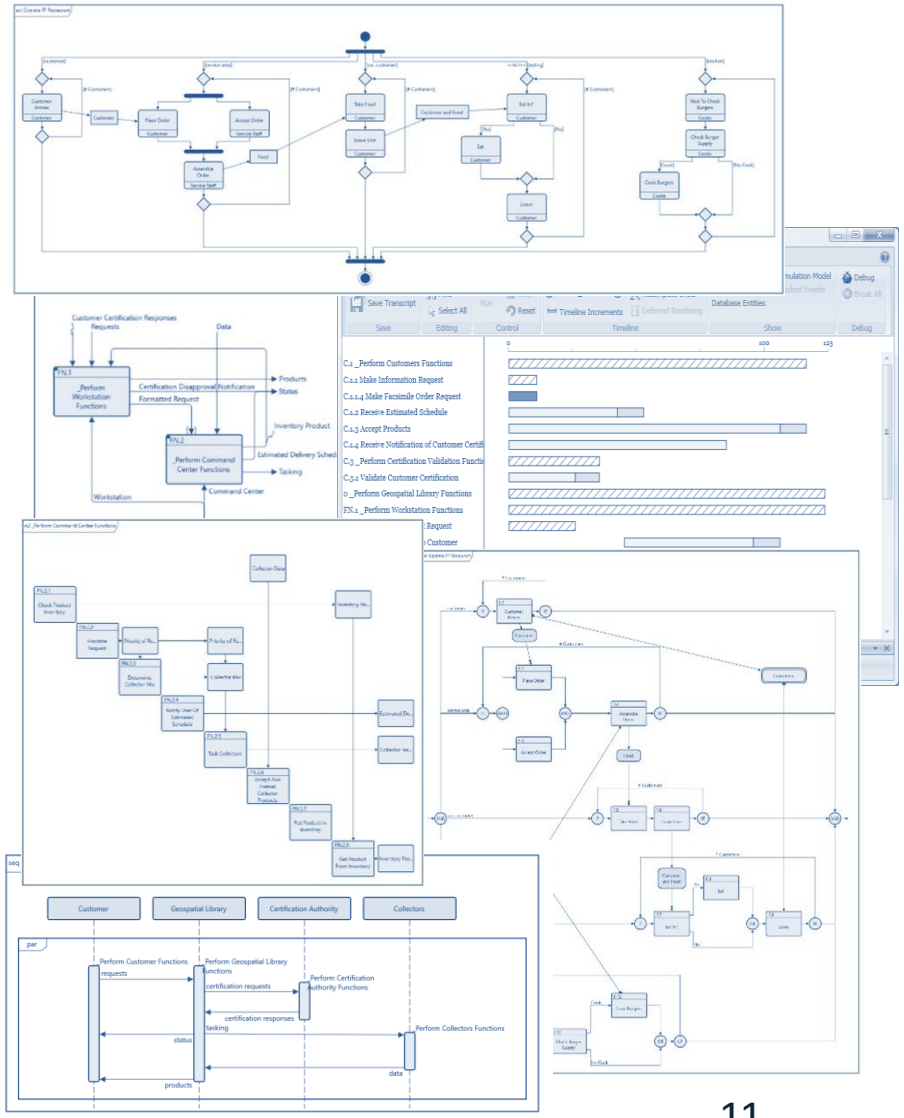




Representing the Foundational Concepts

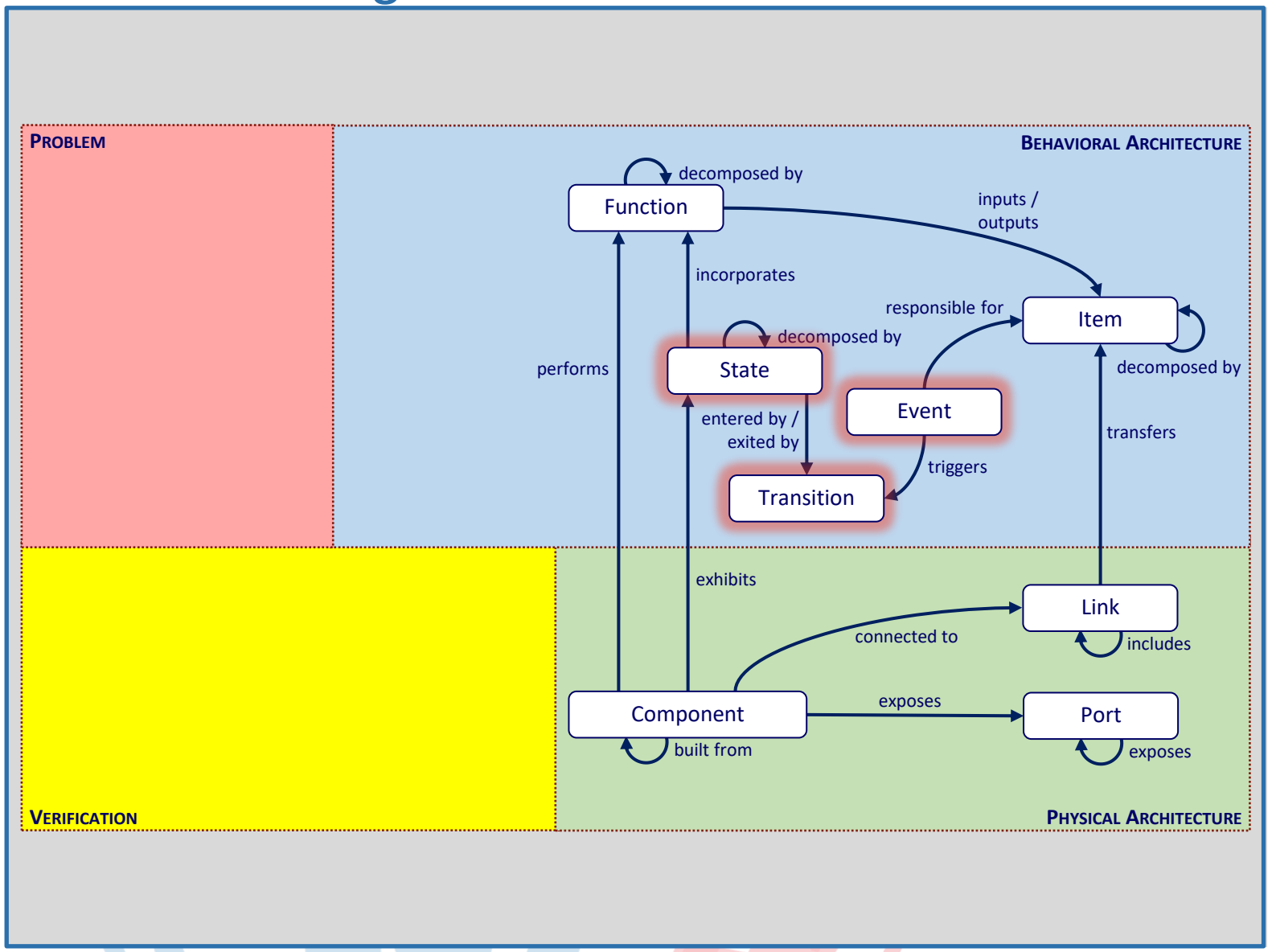
Defining Functions and Exchanges

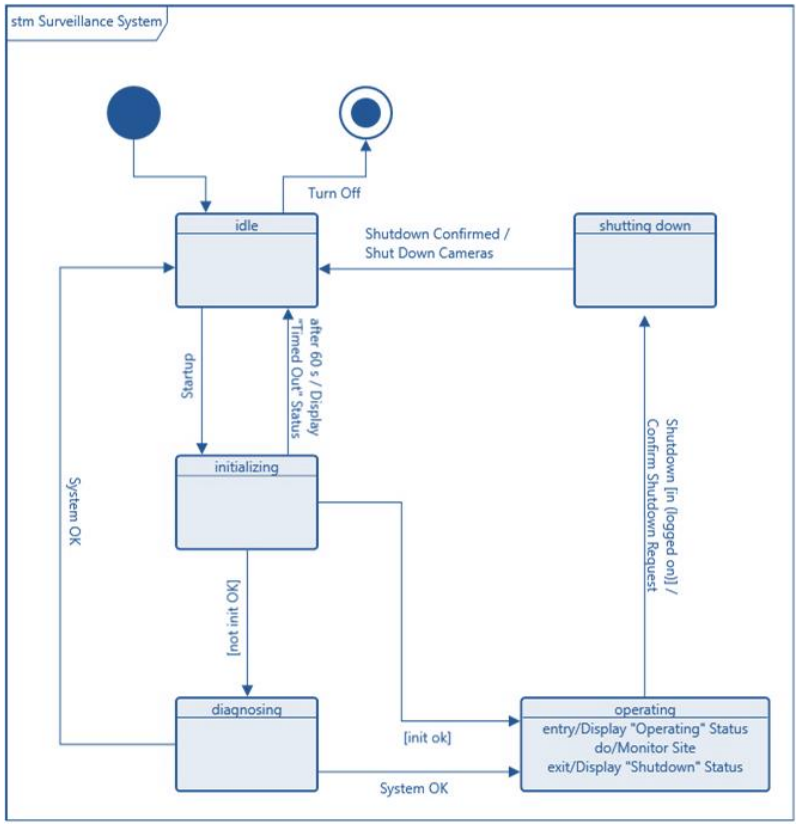




Representing the Foundational Concepts

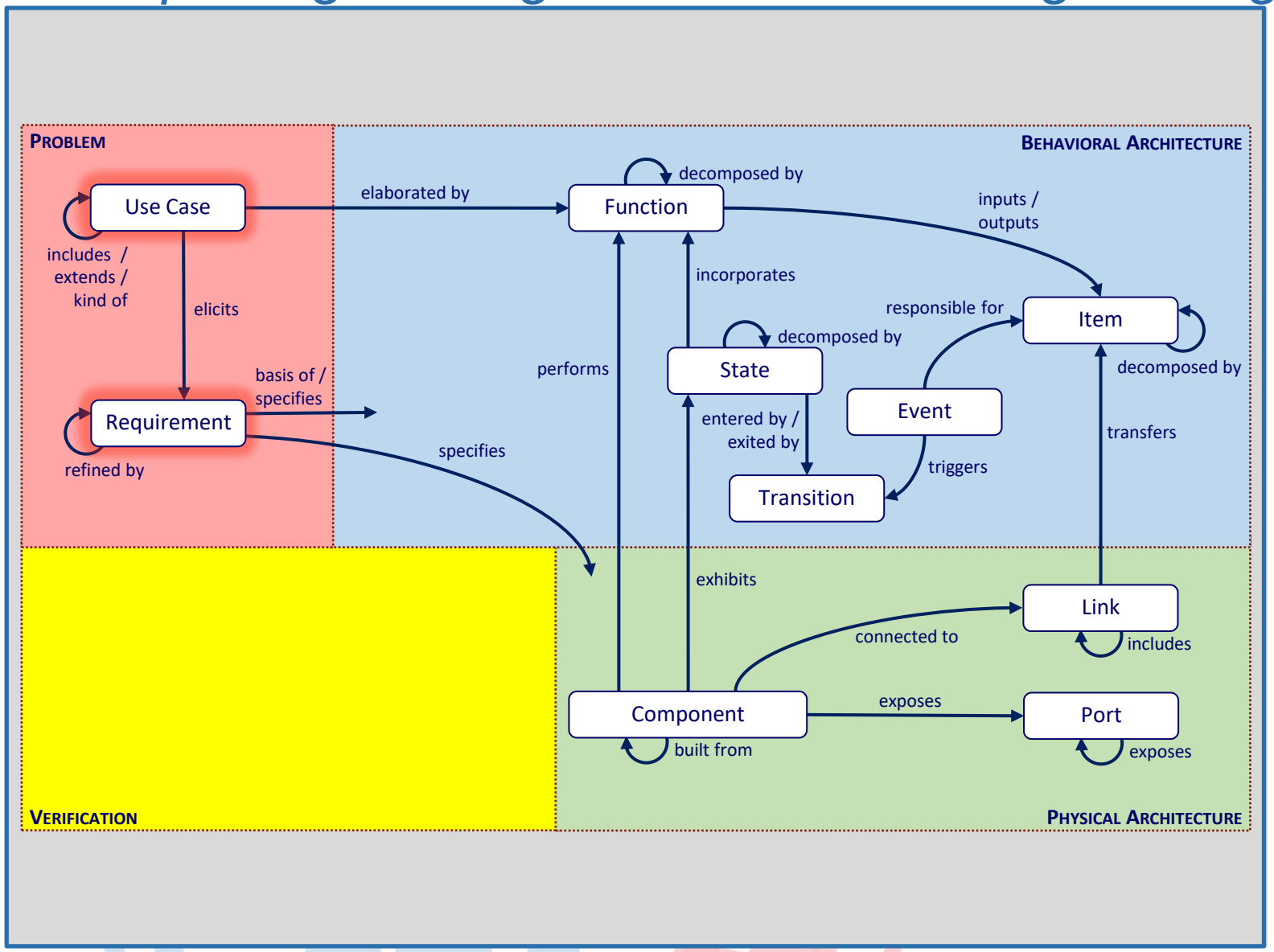
Considering All States

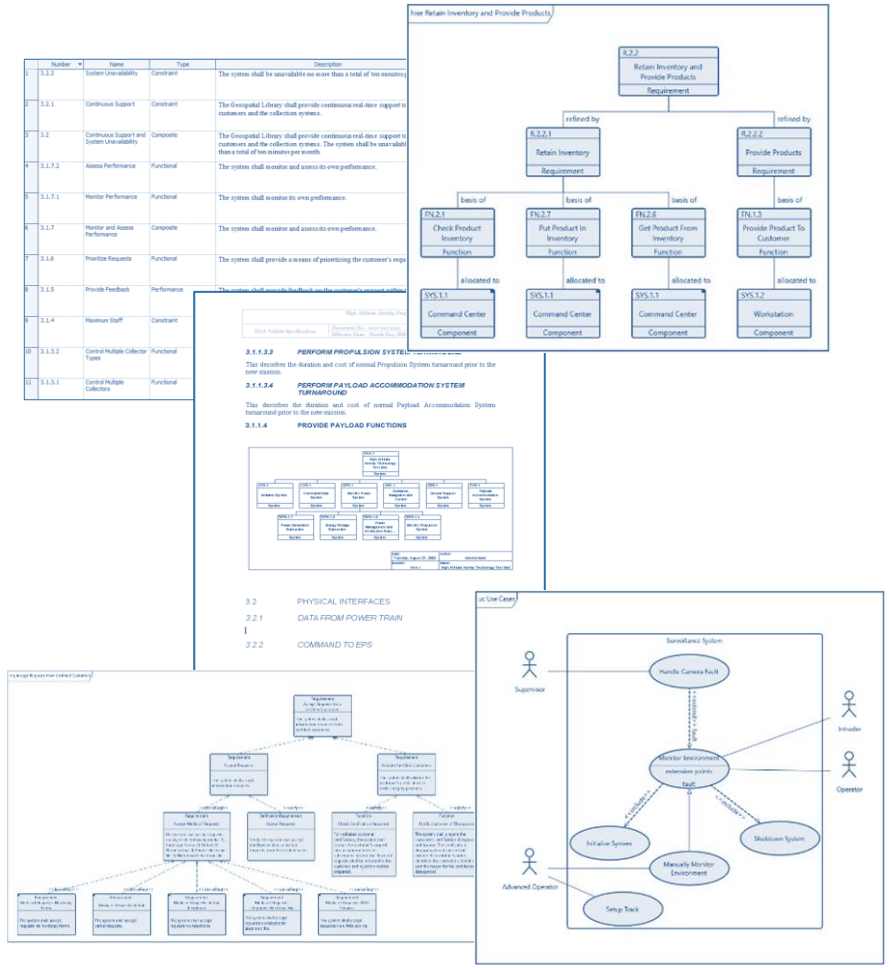




Representing the Foundational Concepts

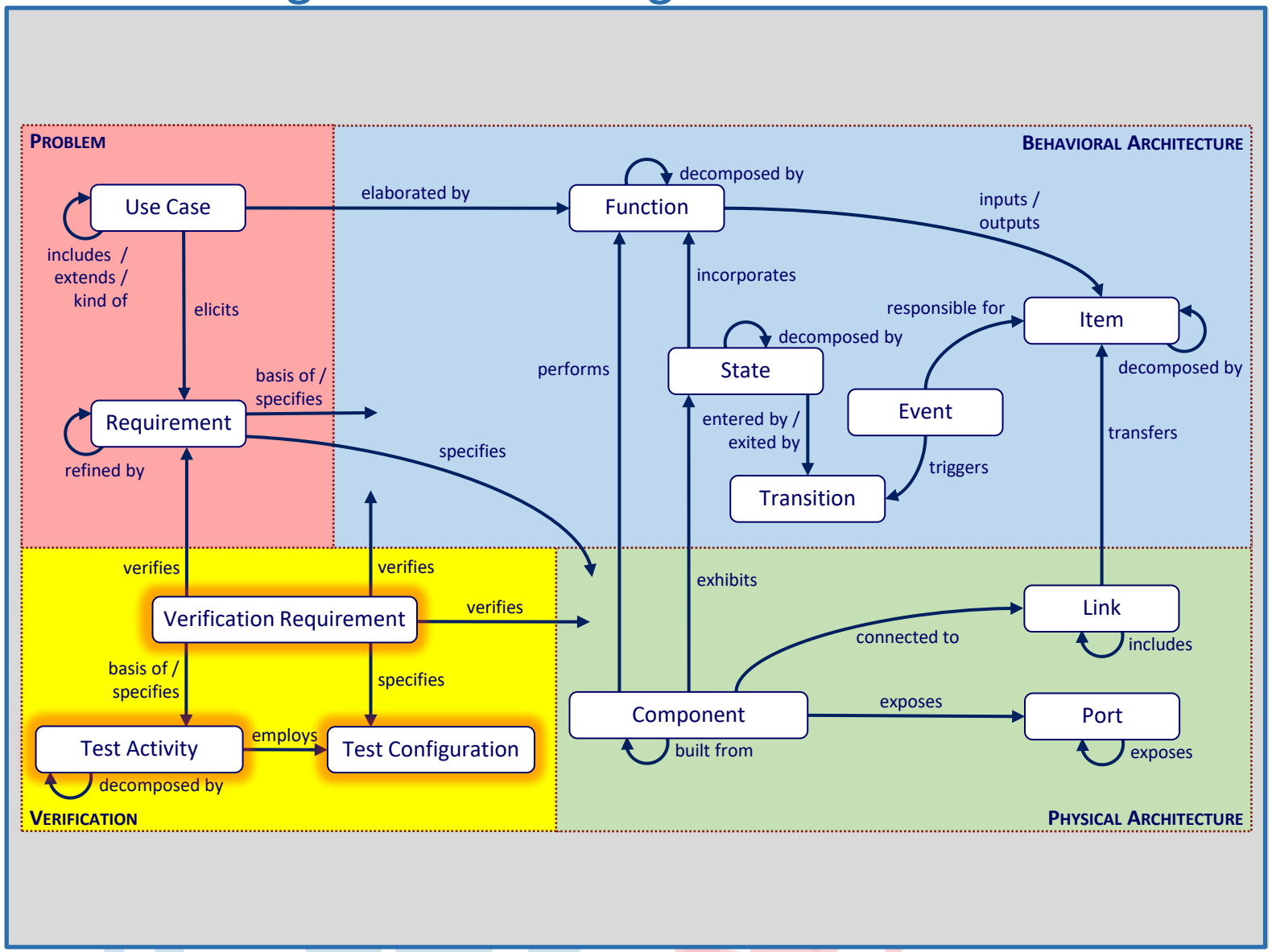
Capturing the Right Problem, Tracing Throughout

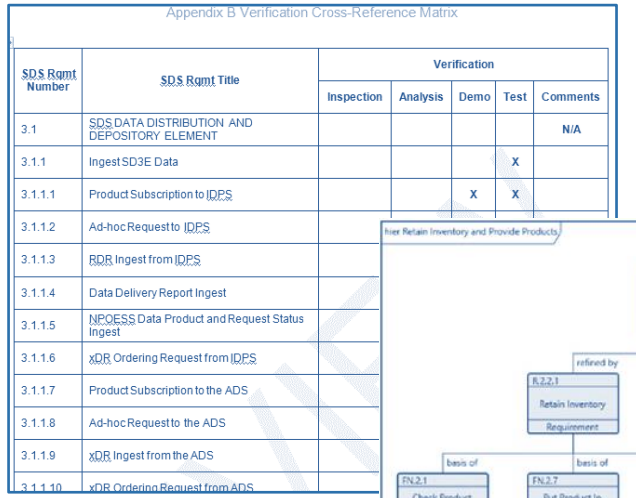




Representing the Foundational Concepts

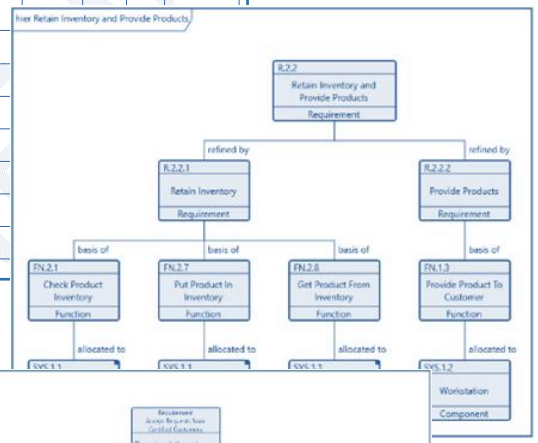
Planning and Tracking Verification

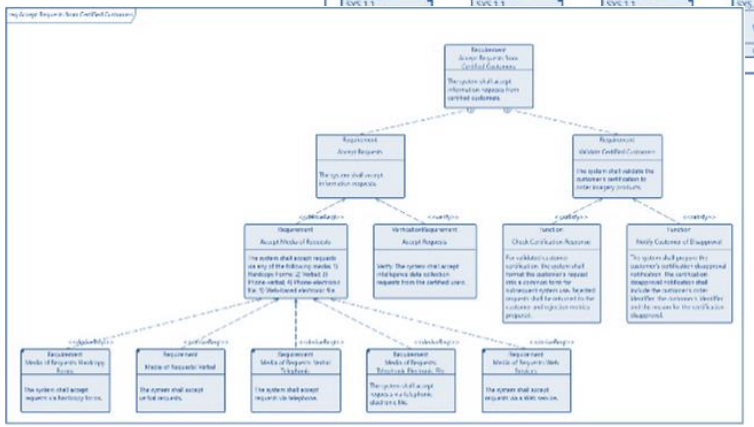




Appendix B Verification Cross-Reference Matrix

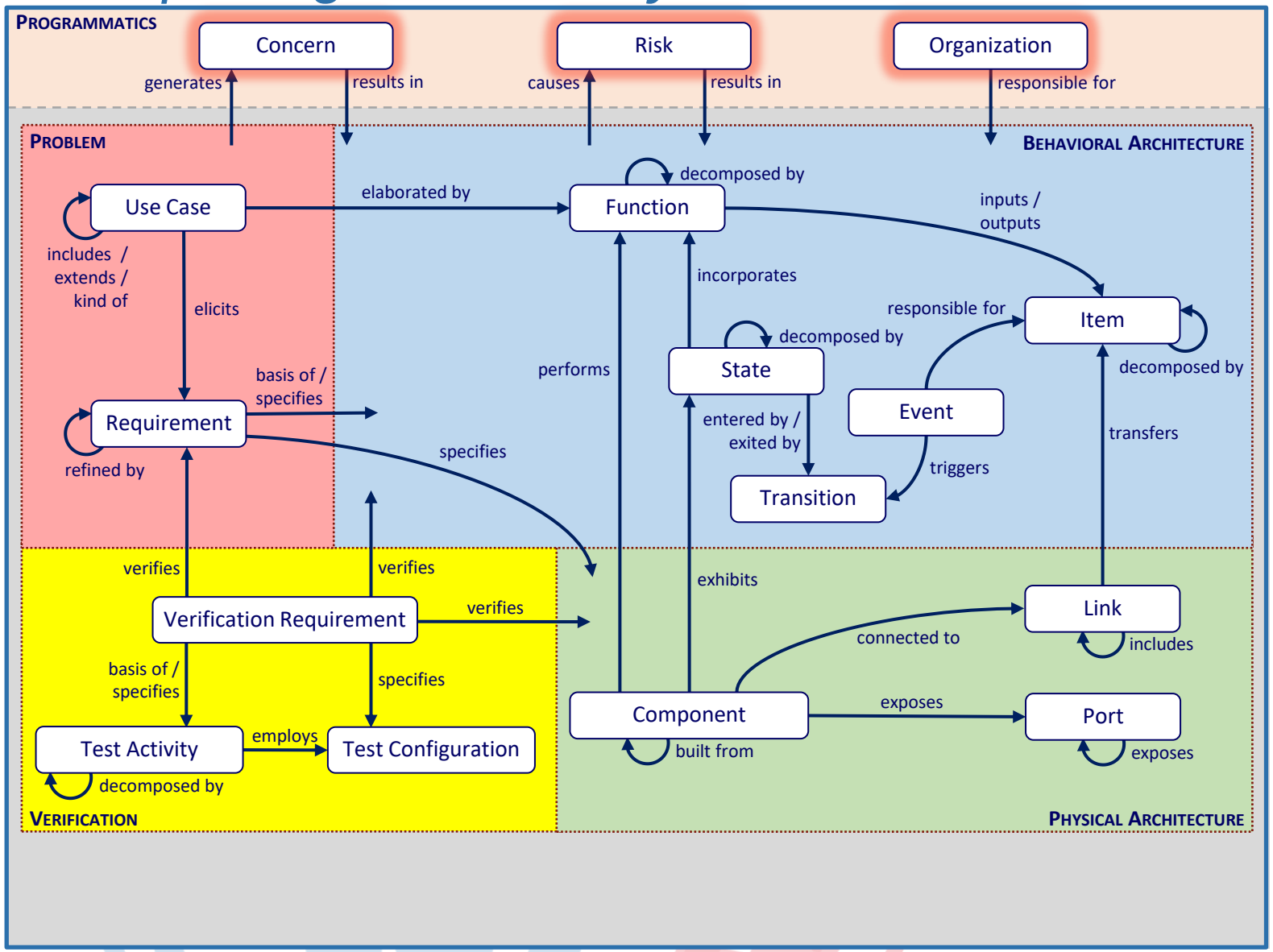
SDS Rqmt Number	SDS Rqmt Title	Verification				
		Inspection	Analysis	Demo	Test	Comments
3.1	SDS DATA DISTRIBUTION AND DEPOSITORY ELEMENT					N/A
3.1.1	Ingest SD3E Data				X	
3.1.1.1	Product Subscription to IDPS			X	X	
3.1.1.2	Ad-hoc Request to IDPS					
3.1.1.3	RDR Ingest from IDPS					
3.1.1.4	Data Delivery Report Ingest					
3.1.1.5	NPOESS Data Product and Request Status Ingest					
3.1.1.6	xDR Ordering Request from IDPS					
3.1.1.7	Product Subscription to the ADS					
3.1.1.8	Ad-hoc Request to the ADS					
3.1.1.9	xDR Ingest from the ADS					
3.1.1.10	xDR Ordering Request from ADS					

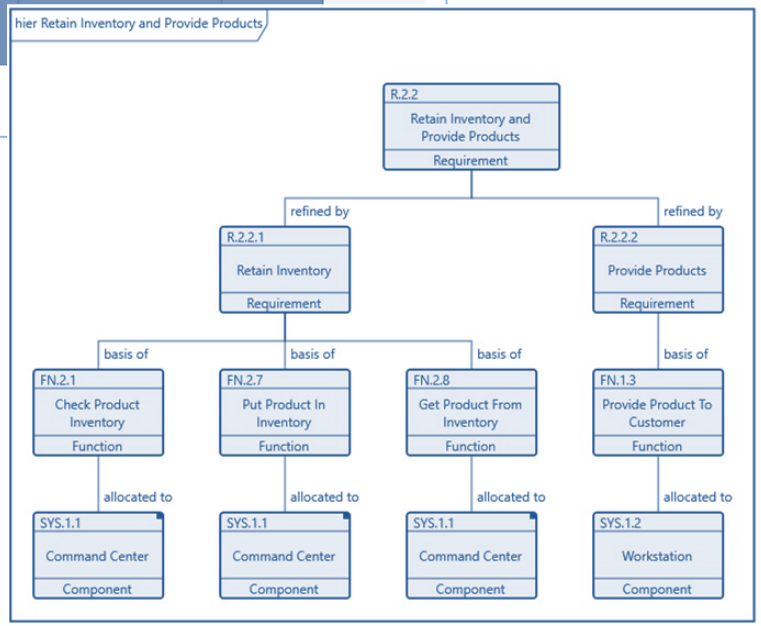




Representing the Foundational Concepts

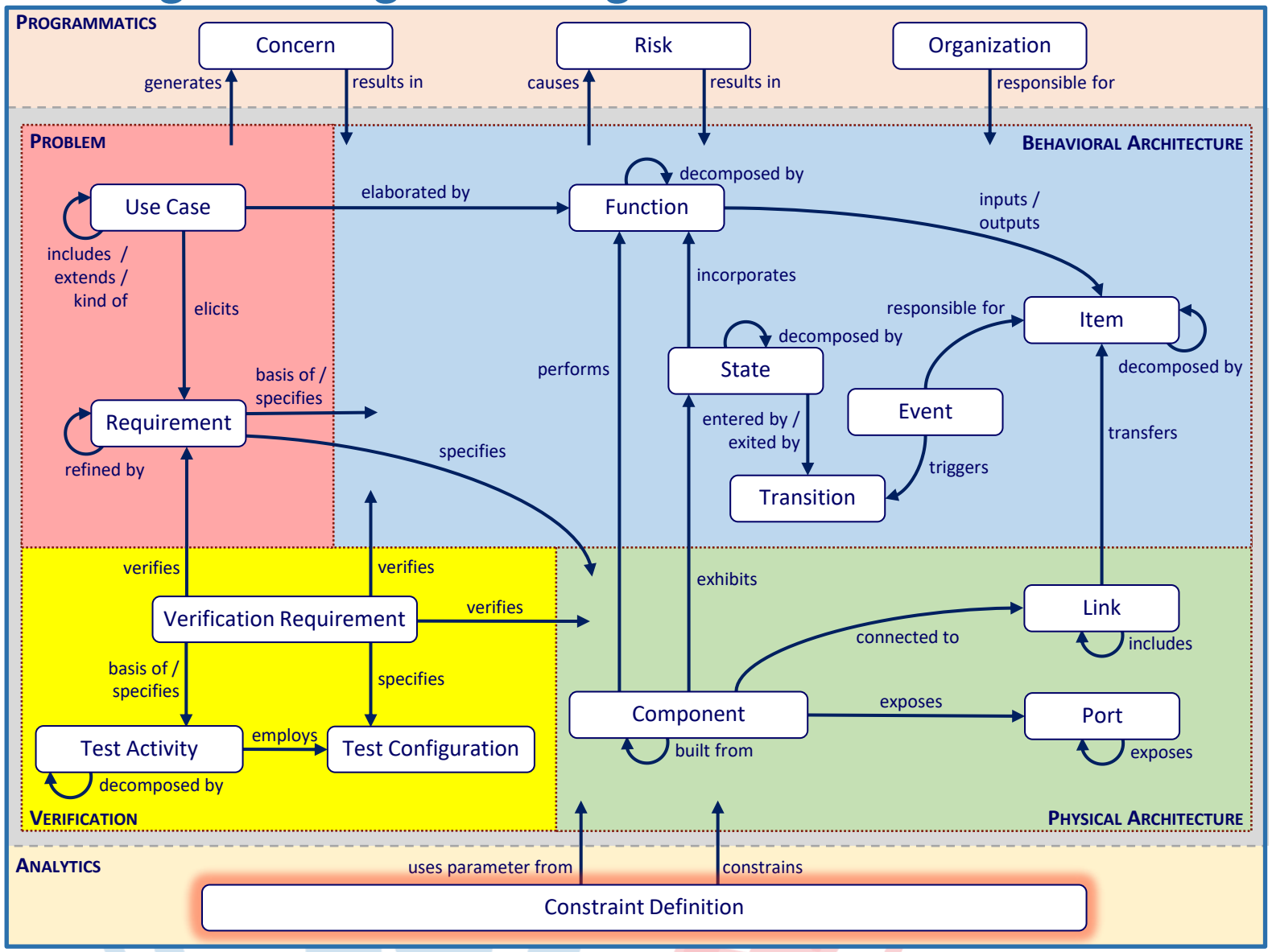
Capturing the Journey

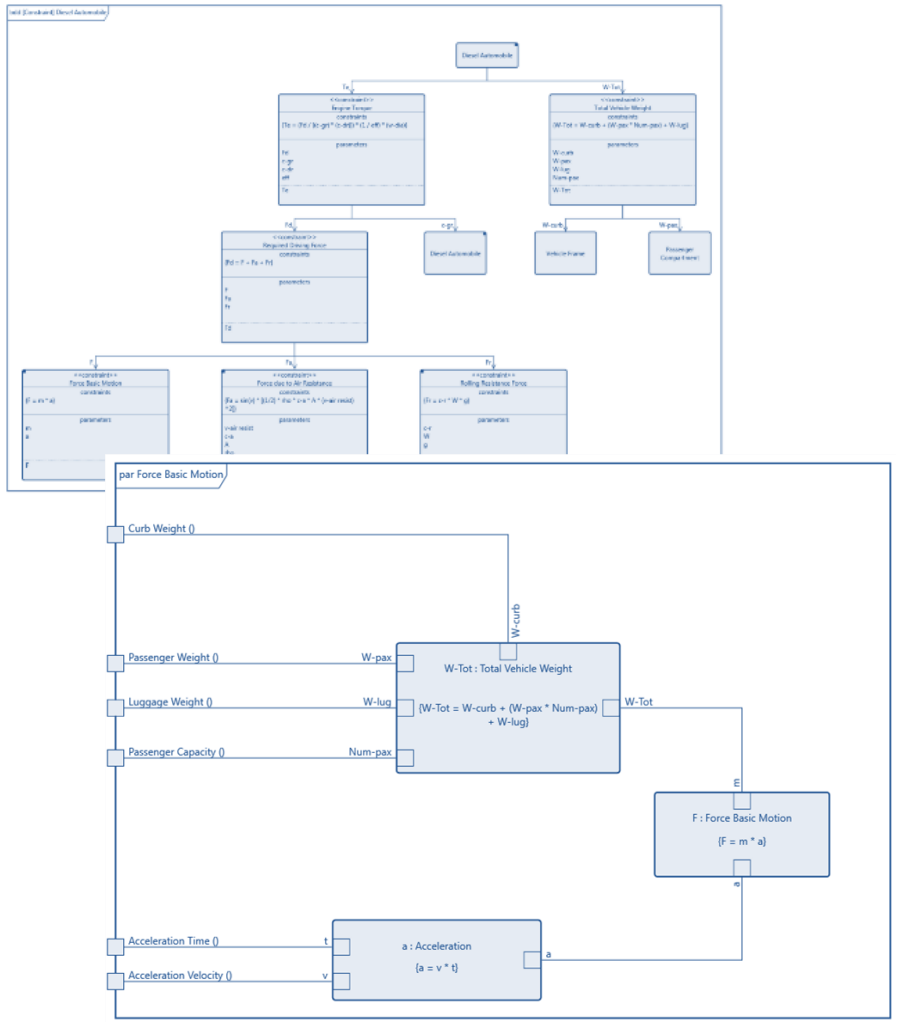




Representing the Foundational Concepts

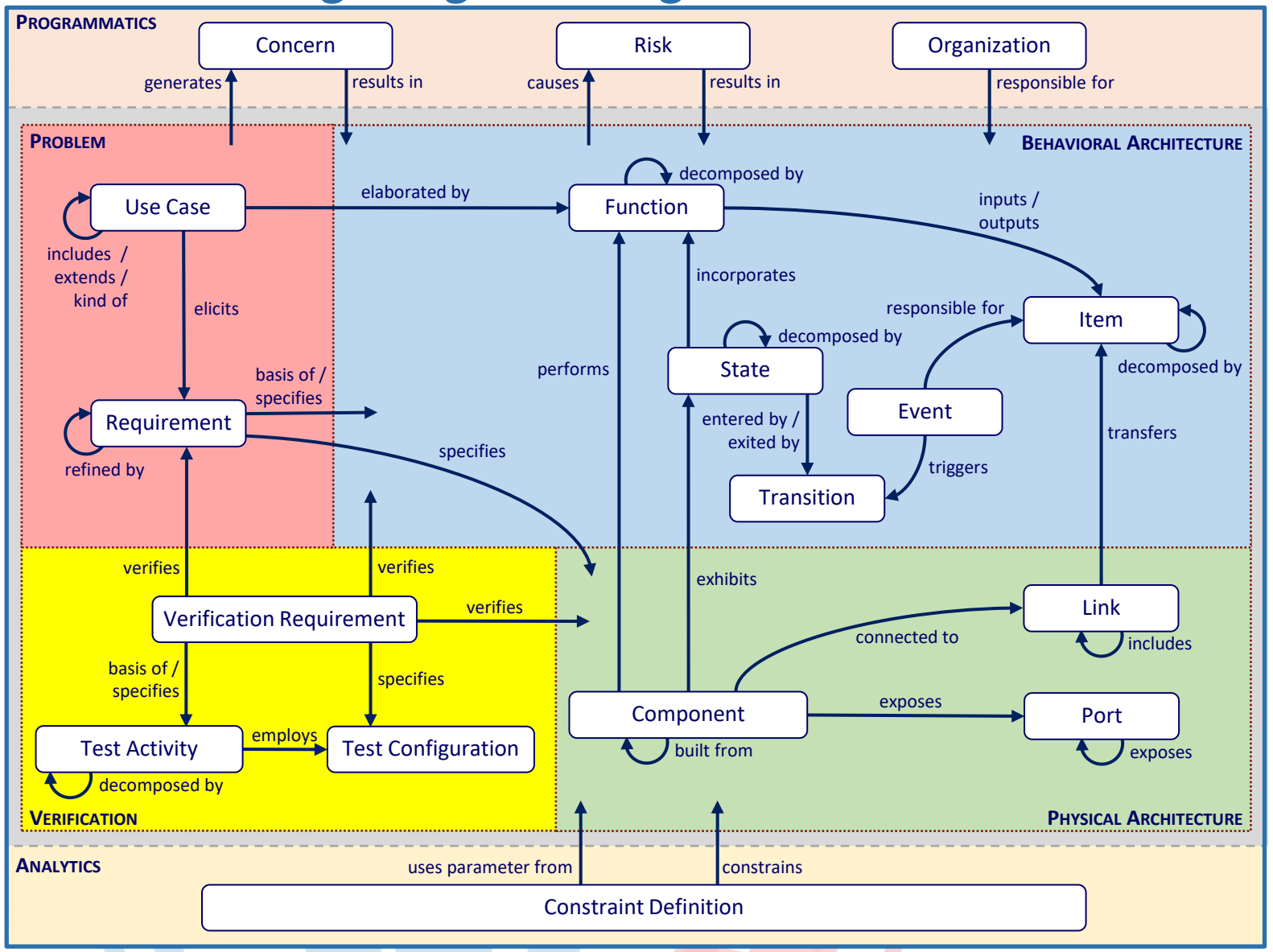
Engineering with Rigor





Representing the Foundation

Delivering Engineering and Business Value



…more than diagrams

…more than a data dictionary

…more than capture

EXPLICIT OVER IMPLICIT

CLARITY OVER AMBIGUITY

ACCURACY || PRECISION

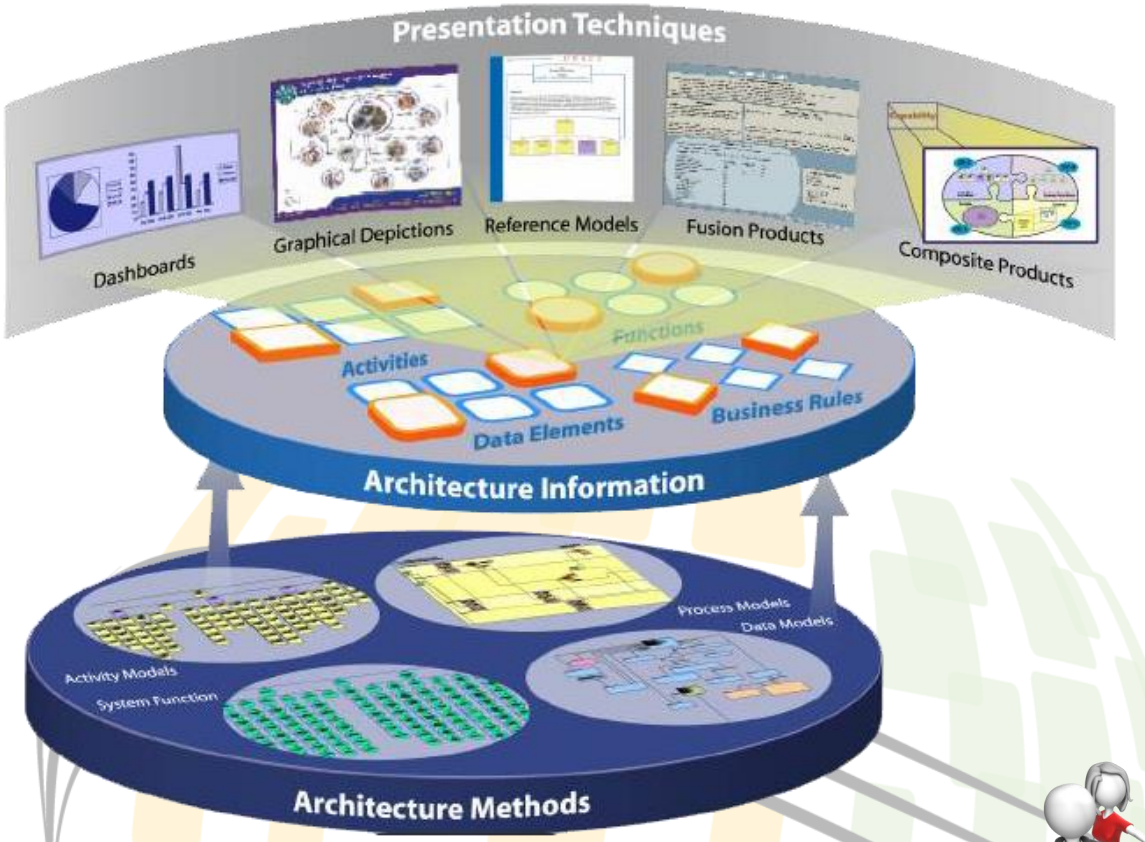
Expressing the Fundamentals of MBSE

Model-Based Systems Engineering is about…

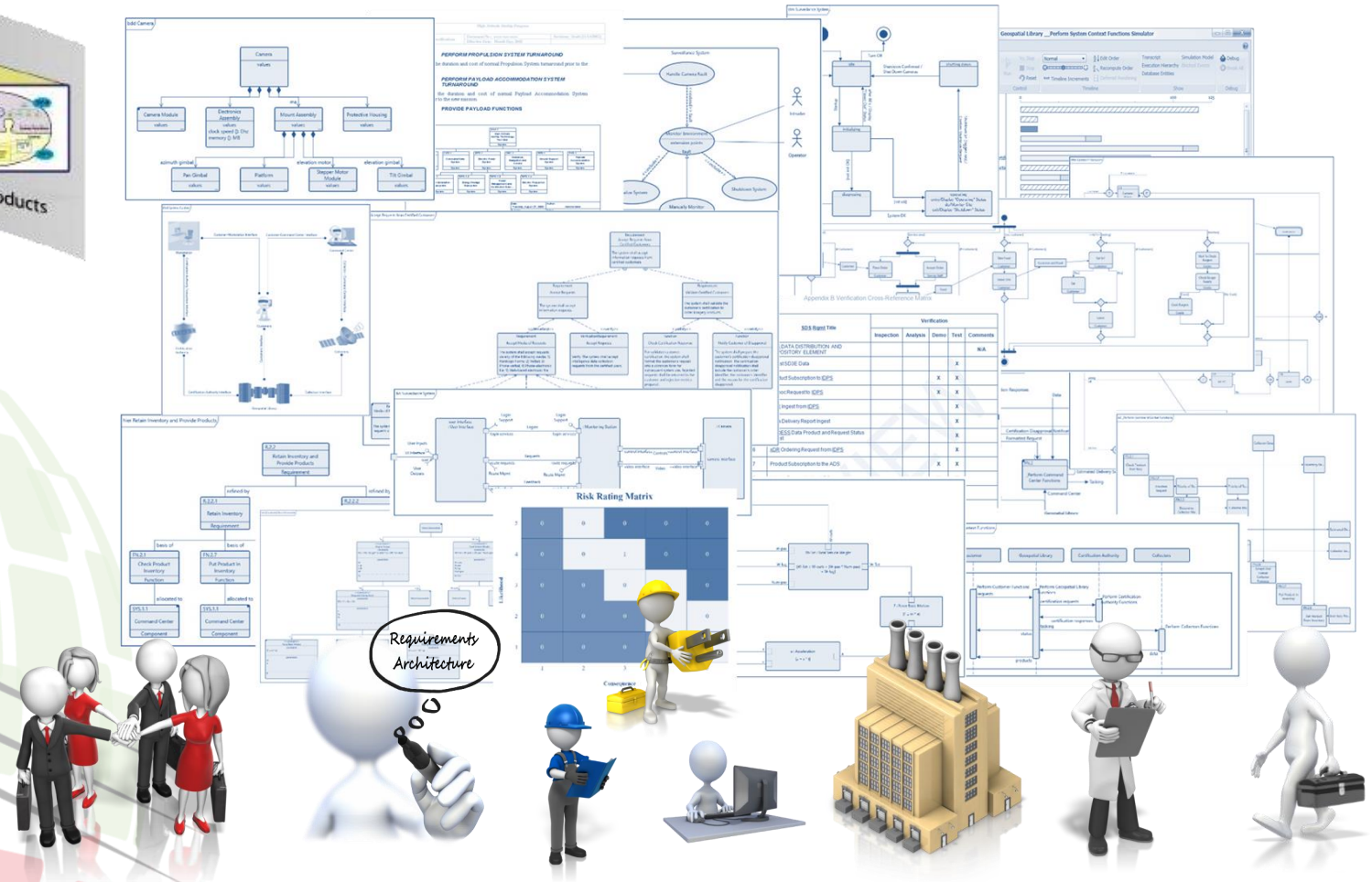
- Making system architectural and analytical models **explicit**, **coherent**, **consistent**, and **actionable** through the power of digital
- Leveraging models for communication and analysis
- Developing and using authoritative data for engineering systems
- Ensuring consistent design and specification (when done well)
- Providing an explicit system model to engineering teams

Supporting “Fit for Purpose” Views

A Model-Based Approach to Visualization and Artifacts

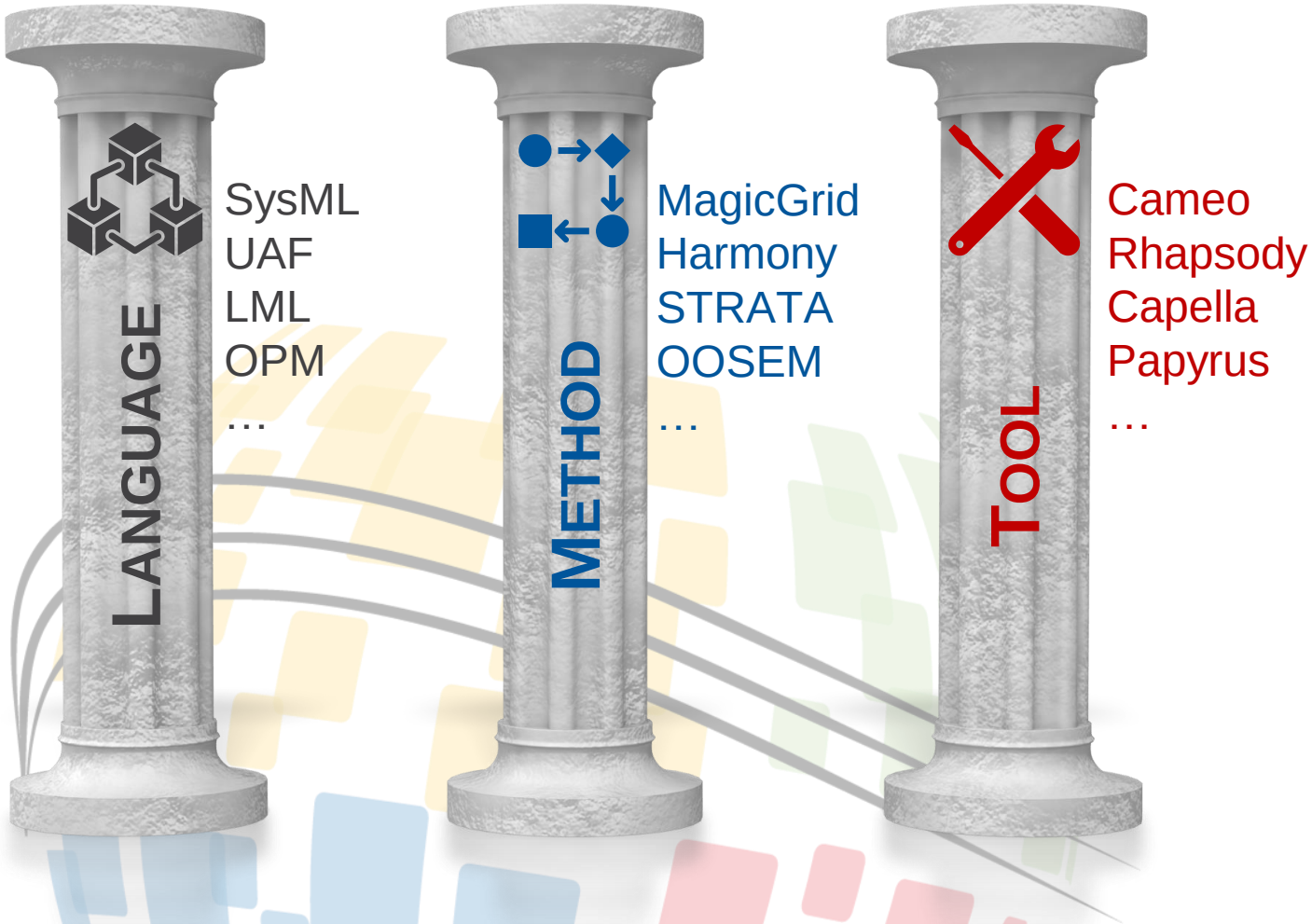


Credit: Department of Defense Architecture Framework (DoDAF) 2.0, May 2009



Understanding the “Three Pillars of MBSE”

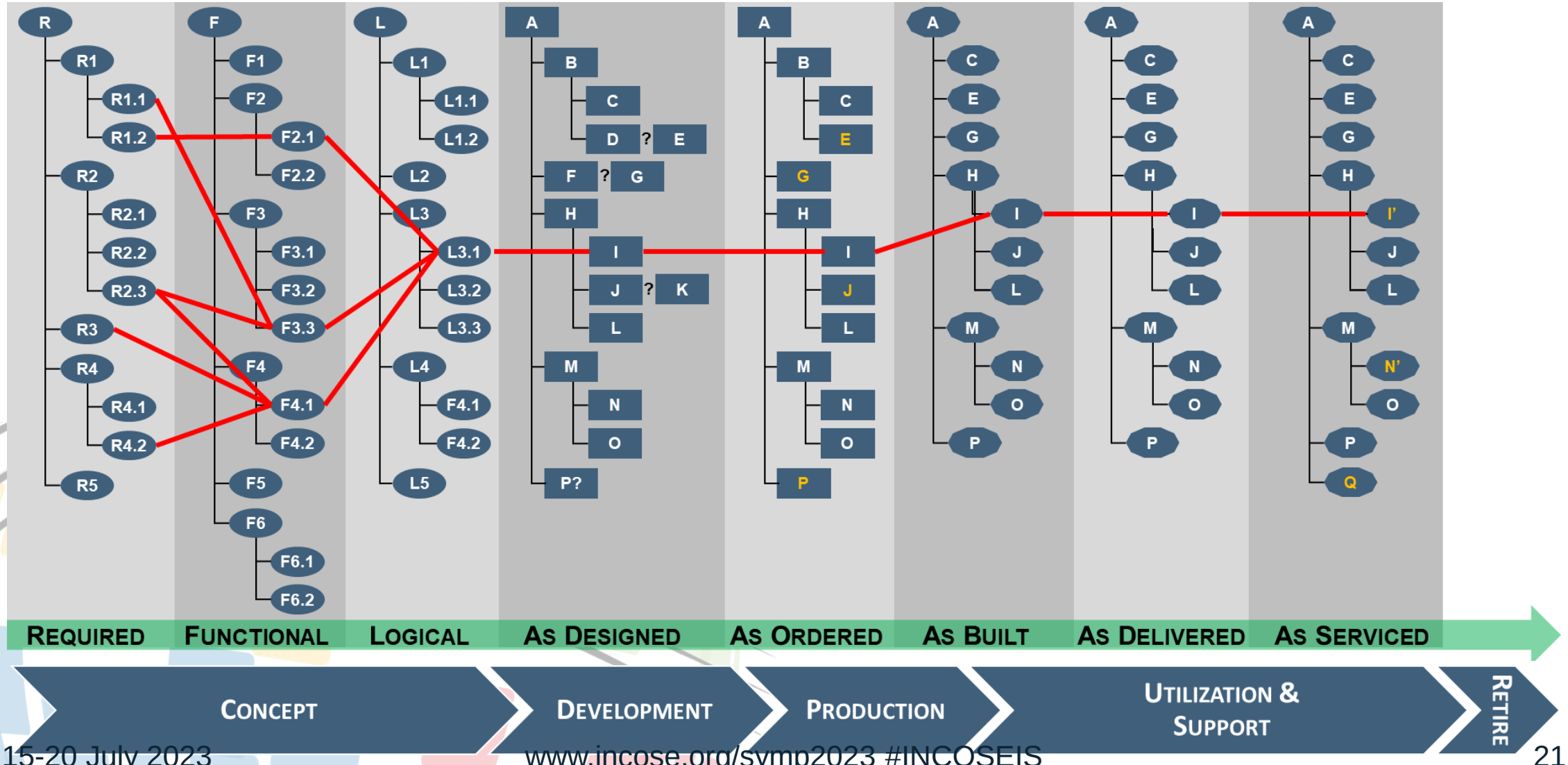
Awareness with Caution



SysML ≠ MBSE

Maintaining an Unbroken Thread of Traceability

The Power of the Digital Thread



Adapted from Aras Corporation, 2018.

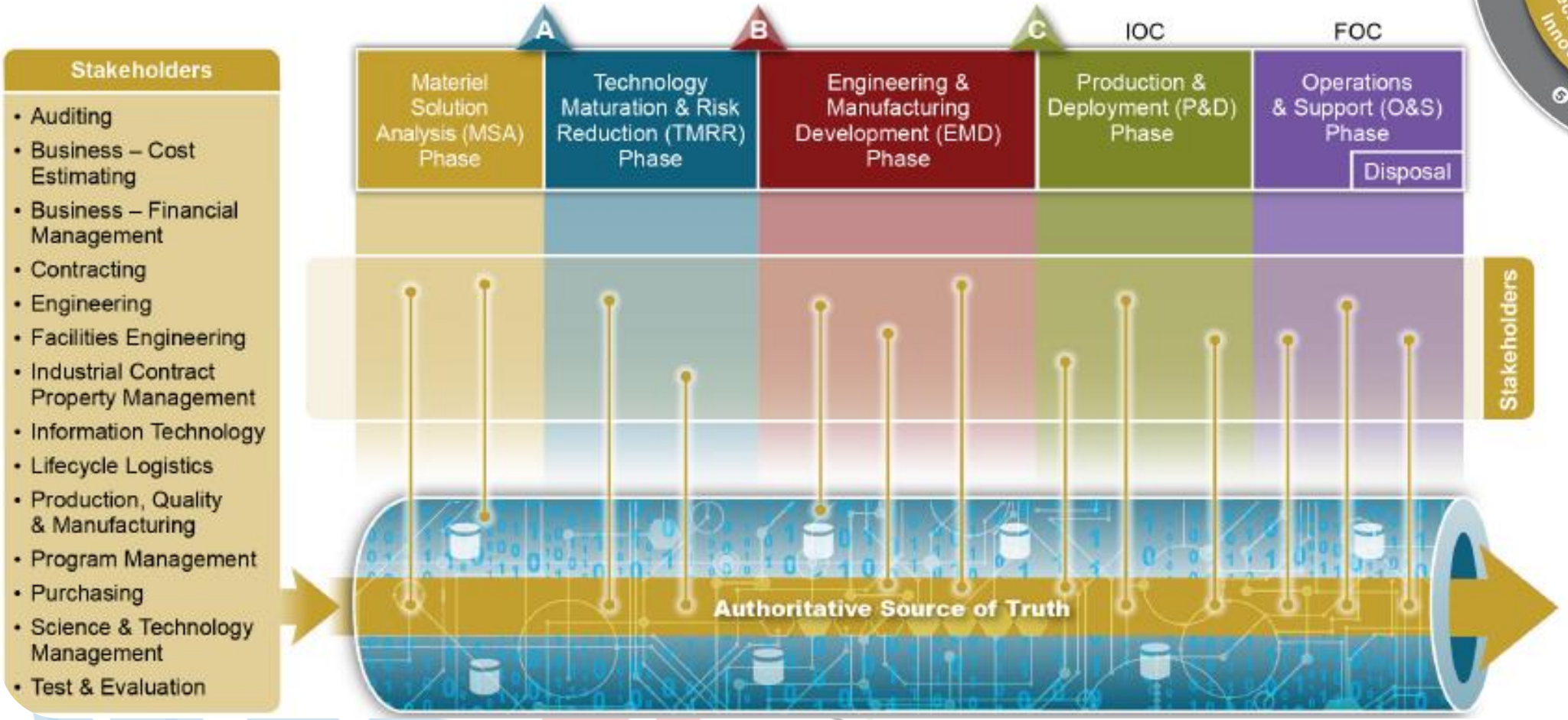
Leveraging the Power of Digital

A "Smart" Digital Twin Connecting Design and Operation

Credit: Sumit Awinash, Creative Commons 4.0

Connecting the Engineering Lifecycle

The Authoritative Source of Truth



Credit: US Department of Defense, 2018

Relating the Key Concepts

The Foundations of DE and Our Digital Transformation

Digital Engineering *a critical enabler for the modern engineering enterprise*

MBSE

connective tissue of the Digital Engineering environment

Systems Engineering

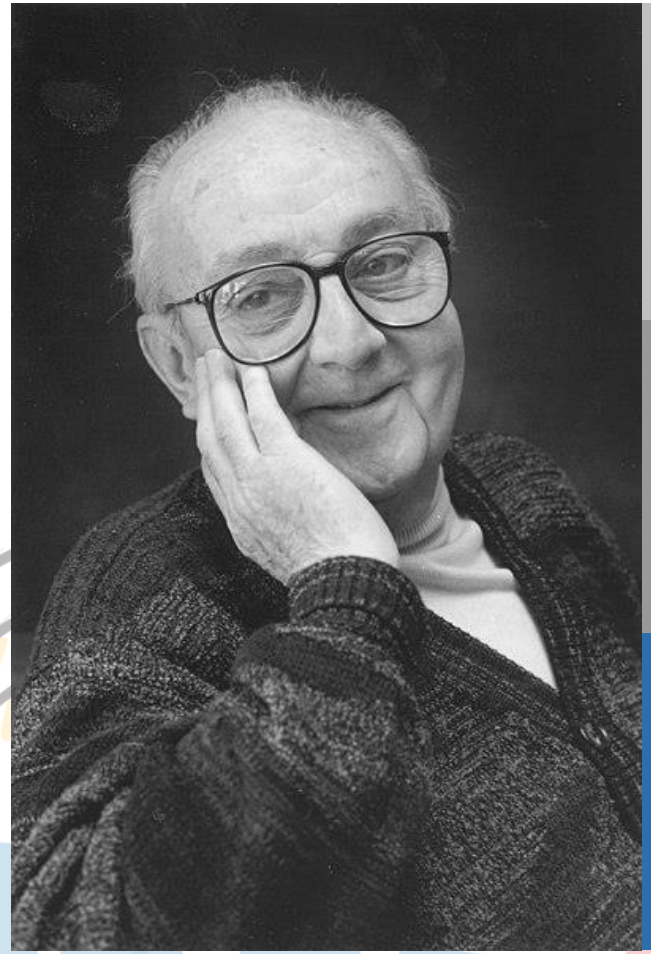
technical connective tissue of the project team

Data

oxygen fueling 21st century engineering and operations

Leveraging the Thinking of George Box

Both Caution and Guidance



All models are wrong

All models are wrong
but some are useful

The question is how wrong a model can be and still be useful

Making your model work for you

Realizing the Benefits of MBSE

Unlocking the Power of Multiple Perspectives

From Customer to C-Suite, from First Concept through Life

Aligning across the Engineering Enterprise

Right Data, Right Place, Right Time, Right Presentation

Reasoning about Completeness and Integrity

Reducing Defects, Rework, and Lifecycle Cost

- *Do all blocks have descriptions?*
- *Are all requirements satisfied?*
- *Are all leaf-level activities allocated?*
- *Are all requirements verified?*

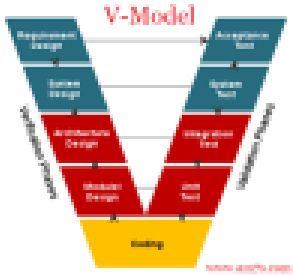
- *Do all parameters satisfy the design constraints?*
- *Have I accounted for inputs/outputs in decomposition?*
- *Do links exist to transfer signals and data between activities allocated to different blocks?*

- *Is my design dynamically valid?*
- *What happens under heavy loads?*
- *What is the impact of this changed requirement? new technology?*

Meeting the Pace of Change

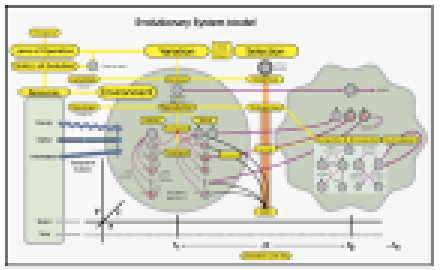
Serial Engineering in a Dynamic Parallel World

The Transition



From: Systems Engineering 1.0

- Systems built to last
- Opinion-based decision making
- Paper-based documentation
- Deeply integrated architectures
- Hierarchical organizational model
- Satisfying the requirements
- Phase-based Verification & Validation



To: Systems Engineering 2.0

- Systems built to evolve
- Model and Data-driven decision making
- Simulation-based documents
- Modularized architectures
- Ecosystem of partners
- Constant experimentation and innovation
- Continuous Verification & Validation

18

Credit John Wade, Engineering the Value Supply Chain: Ethical Sustainability, INCOSE International Symposium, June 2022

Evolving from Custom-Built to Composability

Accelerating through Reference Architectures, MOSA, and Reuse

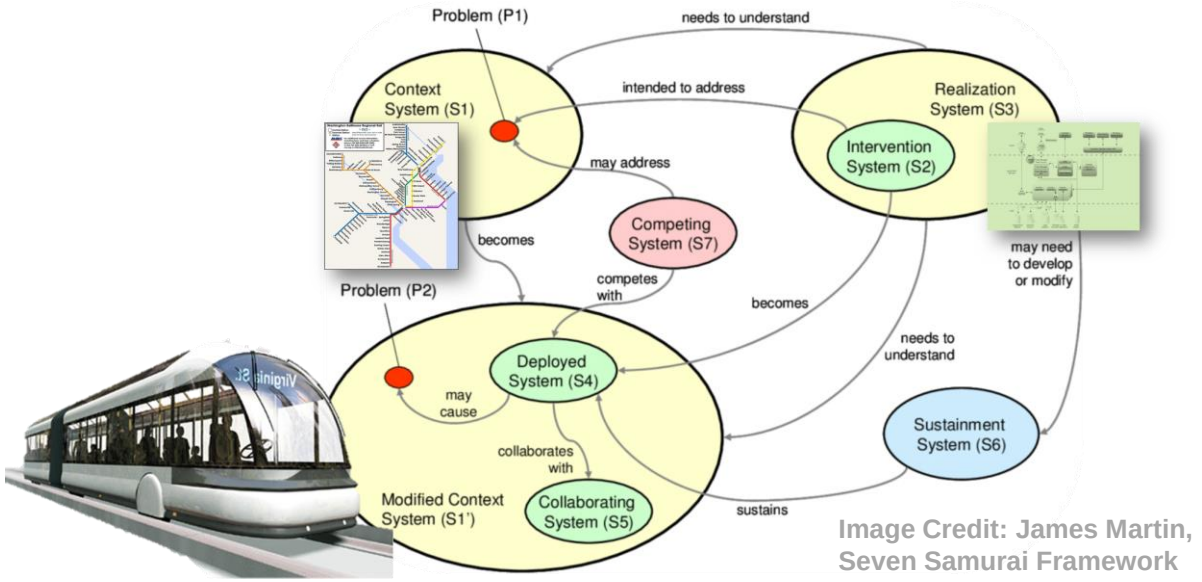


Image Credit: James Martin, Seven Samurai Framework

A system is a system is a system

Systems Engineering Your MBSE and Dx Deployment

Identify Traps before You Begin

Classic Errors on the Journey to MBSE and DE

- Thinking it's a tool (or a technical) issue
- Implementing someone else's solution
- Ceding responsibility to a (tool) vendor
- Starting too big or too small
- Overlooking middle management
- Thinking sprint not marathon

Find Your Customer

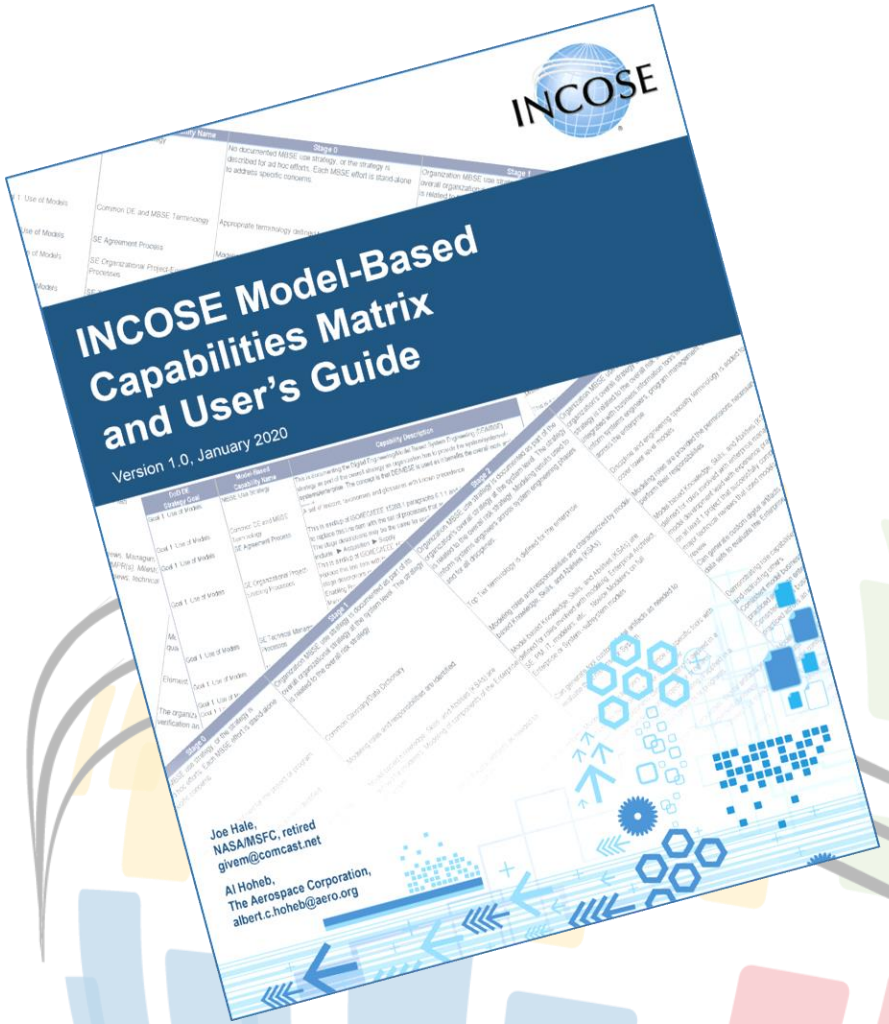
aka Your Champion

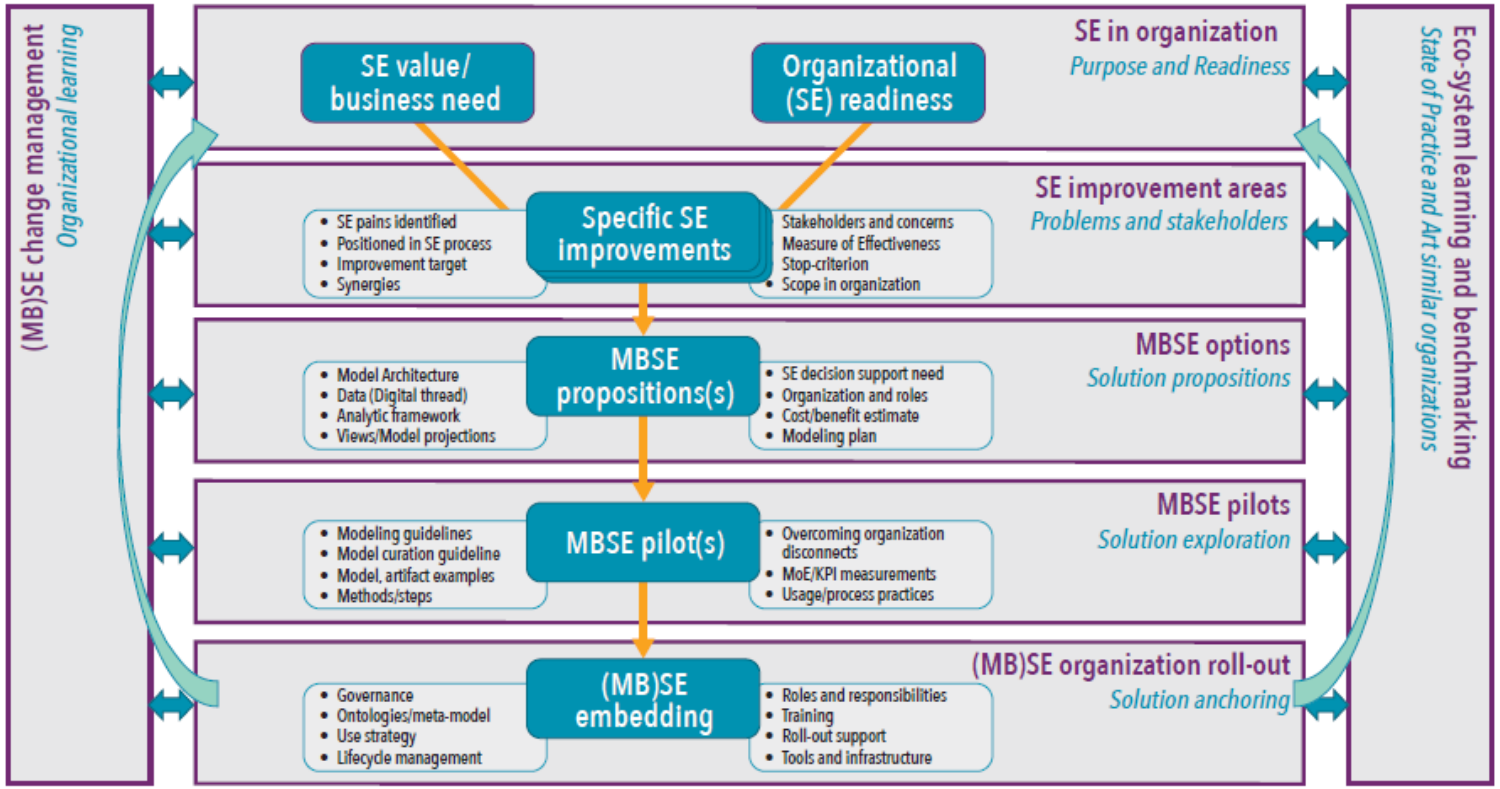
Find the people in your system most susceptible to having their situation improved. Focus on them, not technology.

Larry Leifer
Dancing with Ambiguity
INCOSE IS 2016

Assess Where You Stand Today

Undertaking a Journey Requires Both an As-Is and To-Be

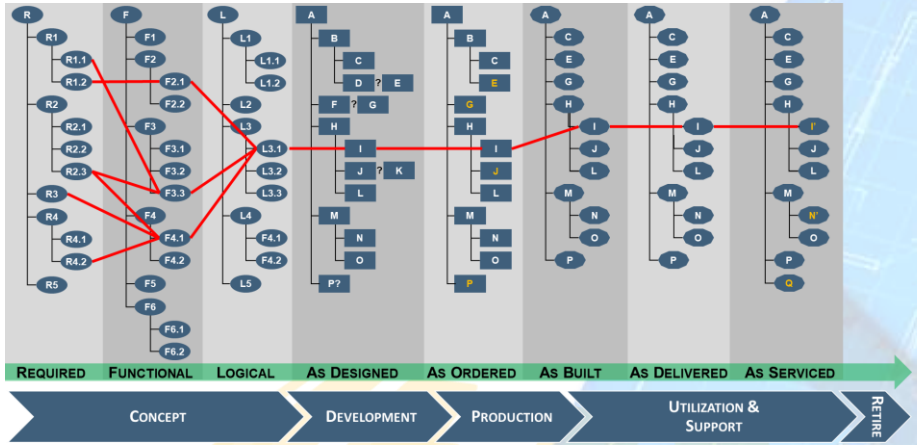




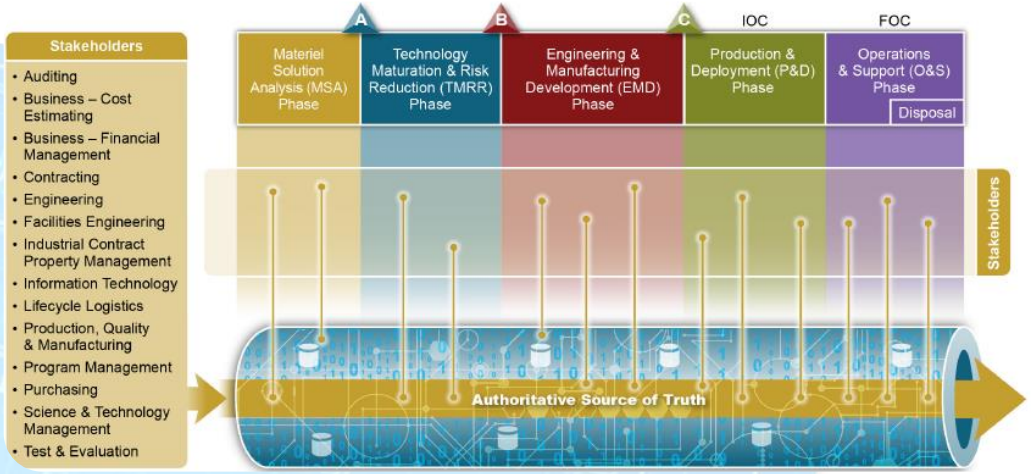
Credit: Creating Value with MBSE in the High-Tech Equipment Industry, Hendriks et al., INCOSE Insight Volume 25 Issue 4, December 2022.

Define Your Reach for MBSE and Dx

Where You Need to Be not Want to Be – SE, EoS, or Beyond?

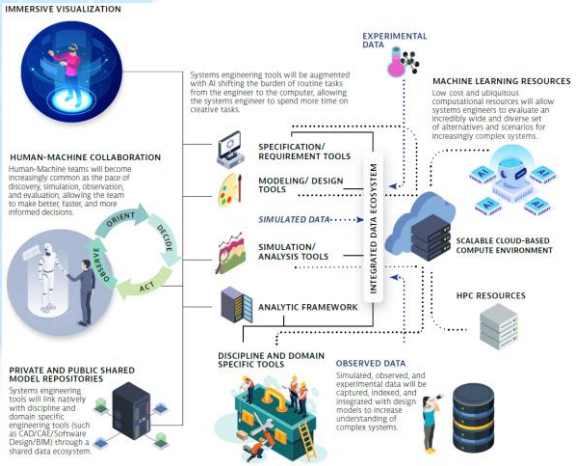


Adapted from Aras Corporation, 2018



Credit: US Department of Defense, 2018

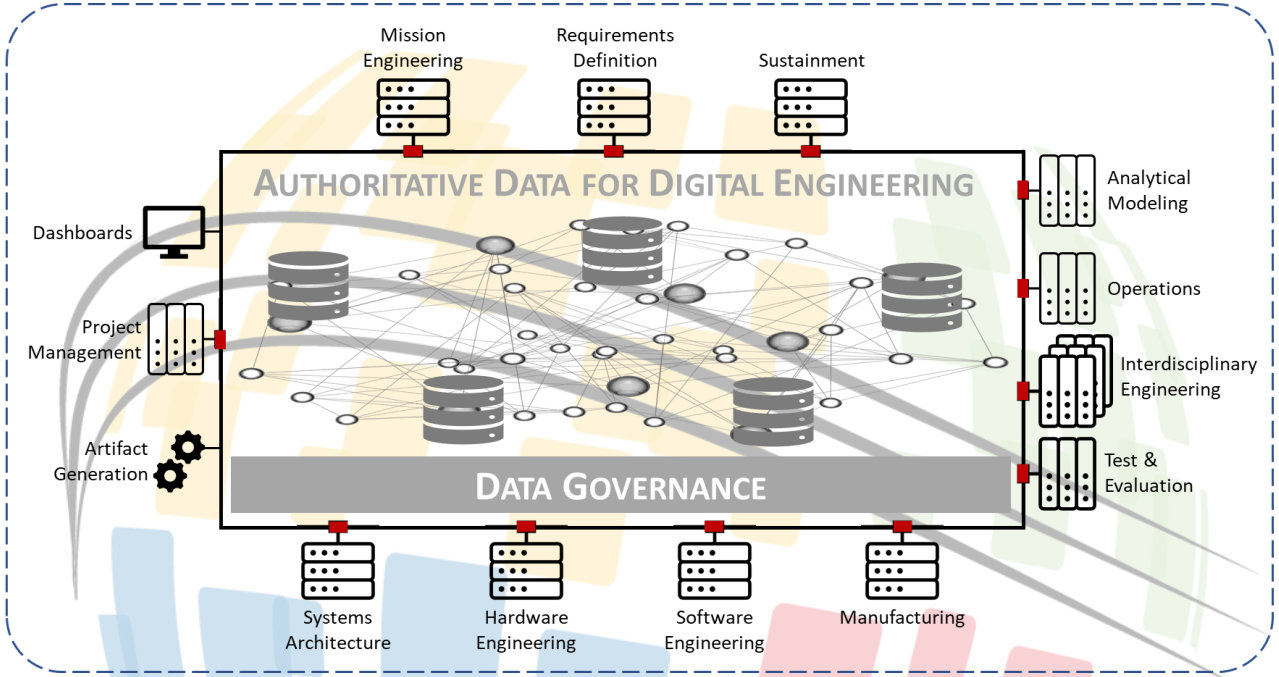
Credit: Sumit Awinash, Creative Commons 4.0

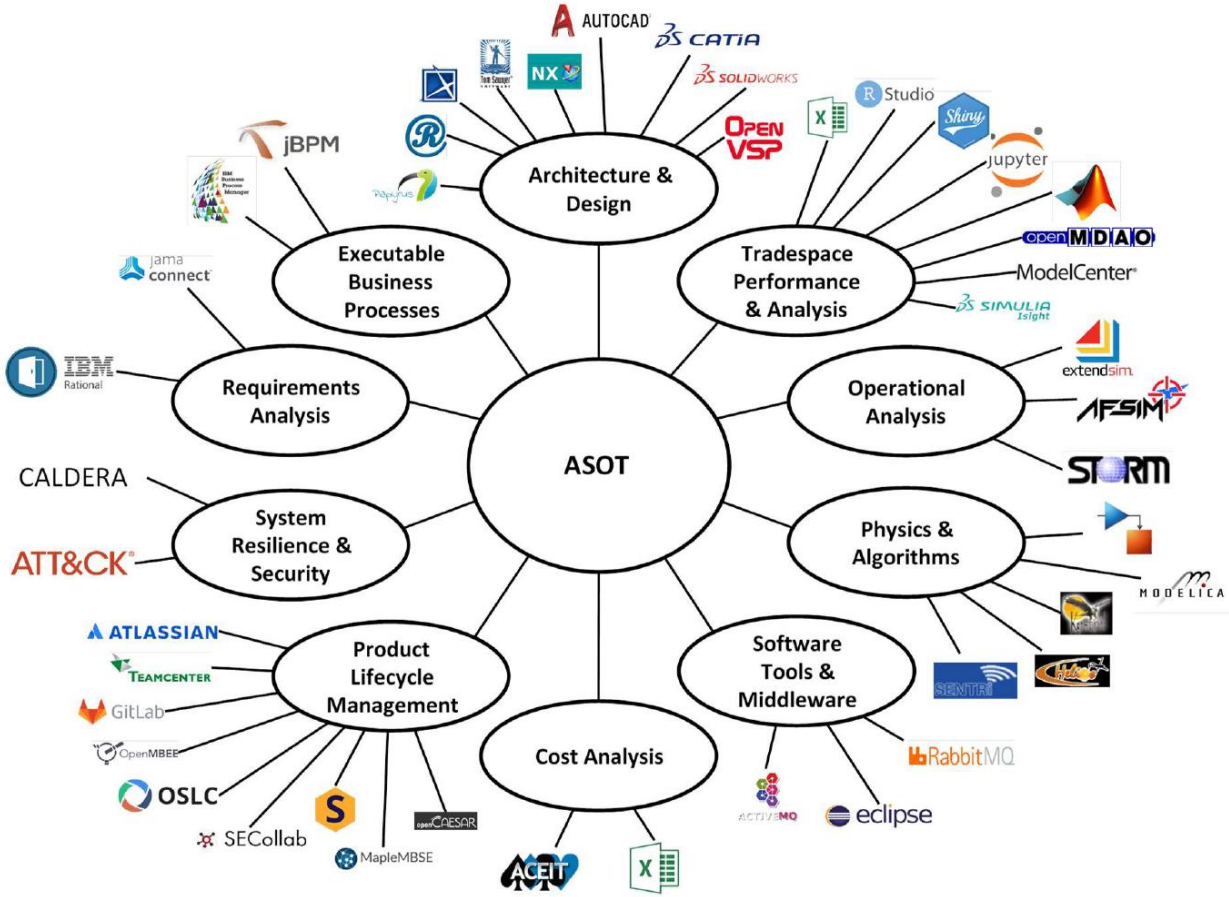


Credit: SE Vision 2035. Copyright © 2021 by INCOSE.

Appreciate and Honor Your Scope

Neither Benefit nor Difficulty Increase Linearly

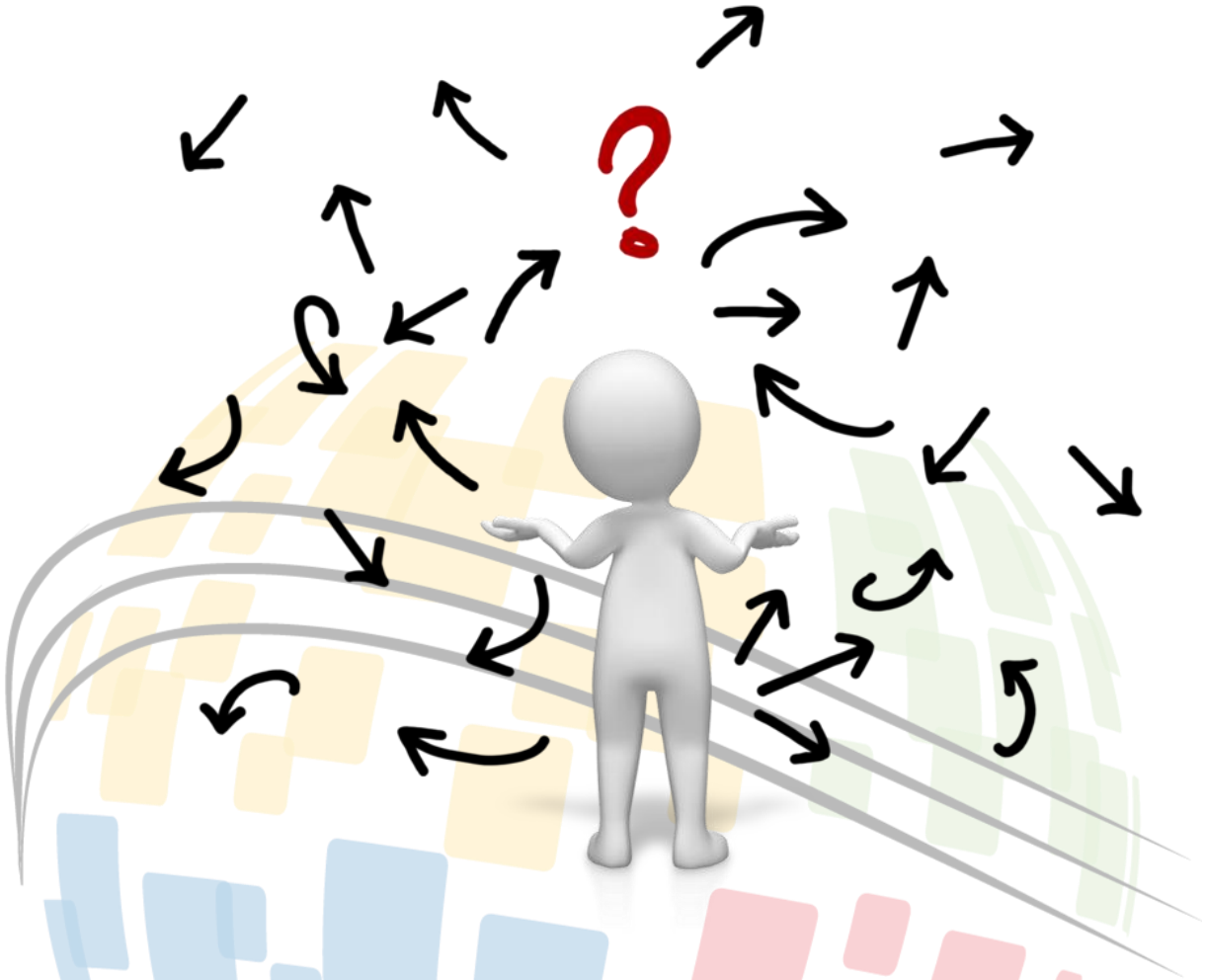




Credit: WRT-1051, Program Managers Guide to Digital and Agile Systems Engineering Process Transformation, August 2022

Elicit Requirements

Understanding Both Project and Journey



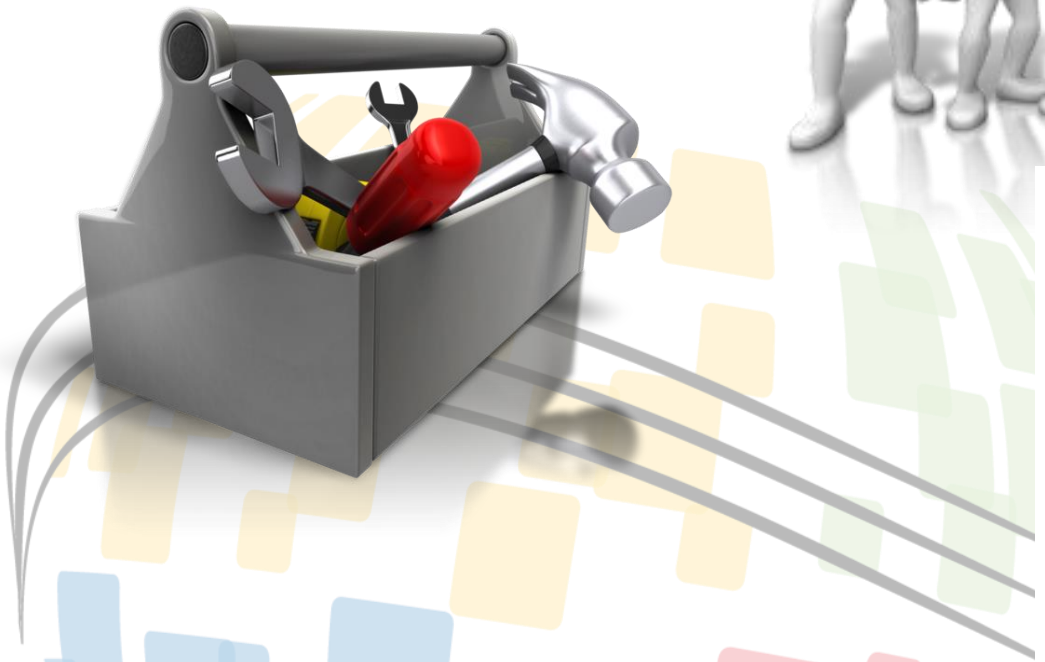
NEEDS

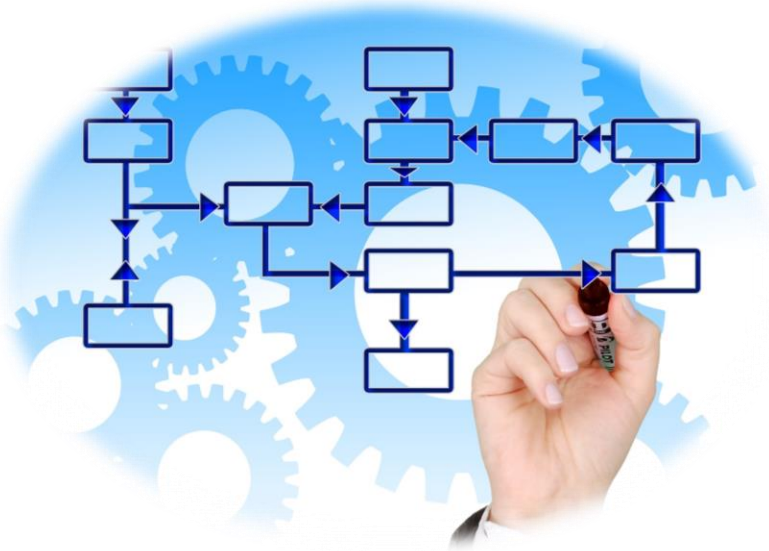
DESIRES

CONSTRAINTS

Identify the Components and Allocate

Tools, Infrastructure, Processes, Workflows, Training, People





Leverage the Power of the Black Box

Managing the Change Boundary

- ✓ Compartmentalize change
- ✓ Empower change agents
- ✓ Honor existing interfaces
- ✓ Honor interface formats
- ✓ Expand intentionally

Lead the Change –In, Out, and Up

From Customers to the C-Level

- Be informed – about the topic, customer, team, vision, and journey
- Move beyond positions to interests
- Align to and guard the why
- Sell through attunement, buoyancy, clarity – *To Sell is Human* (Pink)
  - Sell technologies only to technologists
  - Move the conversation from cost to value (but beware the Shanri-La of ROI)
  - Under-promise and over-deliver
- Drive better solutions through holistic understanding of problem and context
  - Don't underestimate the costs of transformation
- Champion systemic considerations and systemic change
  - Through-life considerations and concerns
  - Thinking and engineering

Prioritize your letters – E then S before D and M then lastly B

Continuing the Conversation

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