Mission Engineering, Digital Engineering, MBSE, and the Like: The One Underlying Essential Attribute

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Goals

- Put All Initiatives and Frameworks into Perspective
- Test New vs. Classic Paradigm(s)
- Identify Central Entity Common to All

> Simplicity boils down to two steps:
> 1) Identify the essential. 2) Eliminate the rest.
> Leo Babauta, writer

Topics for Discussion

1) (Re) Emerging Disciplines and Frameworks
2) The Classic Approach
3) New Paradigm
4) Fresh Insights from Asking: “How Different?”

Digital Engineering

Mission Engineering

Model-Based Systems Engineering

Model-Based Engineering

Mission Engineering

<u>Mission Engineering</u>: The deliberate planning, analyzing, organizing, and integrating of current and emerging operational and system capabilities to achieve desired war fighting mission effects.[1]

- Attributes:
  - – Enterprise-Level Thinking
  - – Elements & Relationships
- System of Systems (SoS)-Centric
- Capabilities and Functions
- Potential Benefits:
  1) Identified Participants / Relationships
  2) Capability Synergies
  3) Pre-Exposed Functional Gaps

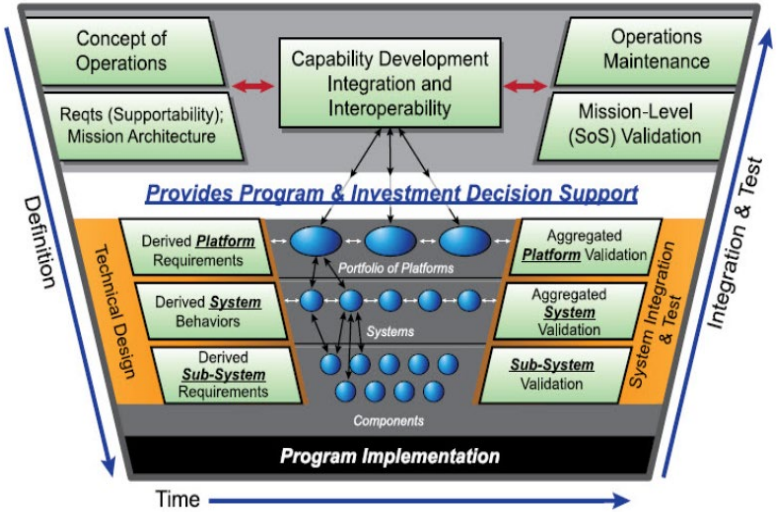
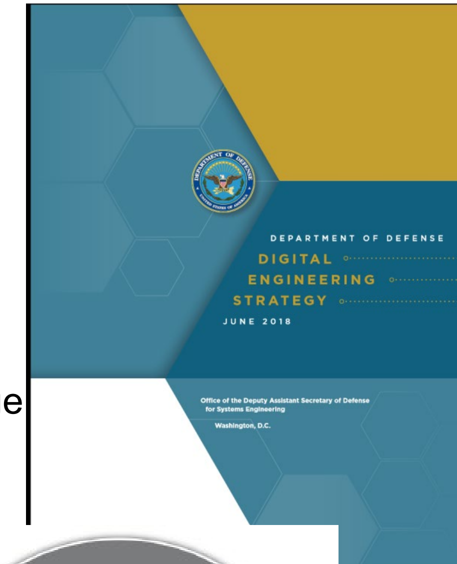


Figure 2: Mission Engineering within the Systems Engineering 'V' Model (Moreland 2015)

Observation: Architecture Forms the Framework of a Mission

Digital Engineering



Digital Engineering (DE): An integrated digital approach that uses authoritative sources of systems' data and models as a continuum across disciplines to support life cycle activities from concept through disposal. (DAU Glossary) (Defense Acquisition Guidebook)

- A Workflow: DE Emphasizes continuity of models across the lifecycle.[2]
- System Maturity-Driven
- Addresses Long-Standing Challenges w/Complexity, Uncertainty, Rapid Change
- Strategy:
  - Formalize Development, Integration, and Use of Models
  - Enduring, Authoritative Source of Truth
  - Technical Innovation to Improve Engineering Practice
  - Supporting Infrastructure and Environments
  - Transform Culture and Workforce to Support DE Across Lifecycle
- Expected Benefits:
  - Better informed decision making
  - Enhanced Communication
  - Increased Understanding of and Confidence in the System Design
  - More Efficient Engineering Process

Observation: Architecture Forms the Basis of Process Relationships in a Digital Engineering Flow

Model-Based Engineering

Model-Based Engineering: An approach to product development, manufacturing and lifecycle support that uses a digital model and simulation to drive first time quality and reliability. (NIST)

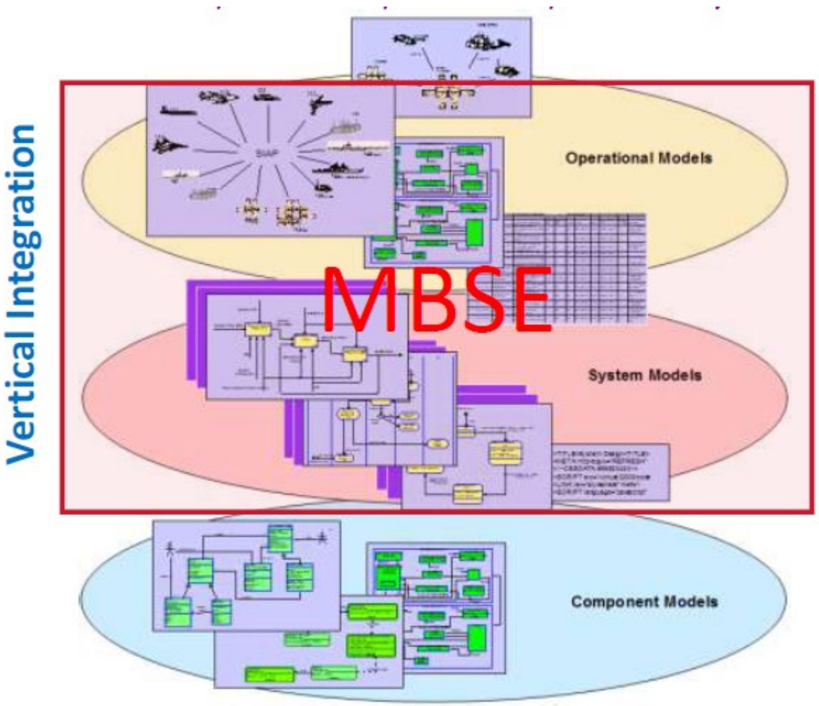
- A Process
- Architecture is the design of the physical attributes of Engineered Systems and Components
- Expected Benefits:
  - Faster Product Development
  - Integration of people, process, tools & data
  - Models replace documents
  - Elimination of costly manual transfer of data
  - Faster and better data-driven decisions

Observation: Resultant Models Consist of Organized Structure and Relationships of Elements (i.e., An Architecture)

Model-Based Systems Engineering

<u>Model-Based Systems Engineering</u>: Execution of Discipline (Systems Engineering) using digital model principles for system-level modeling and simulation of physical and operational behavior throughout the system lifecycle (INCOSE)

- A Process
- Architecture is the Model
- Expected Benefits:
  - Formalizes System Development via Models
  - Broad in Scope: SoS to Components-Level
  - Management of Complexity
  - Broadened Trade Spaces



Source: Introduction to MBSE and SYSML, Hart, Laura E.; Used with Permission

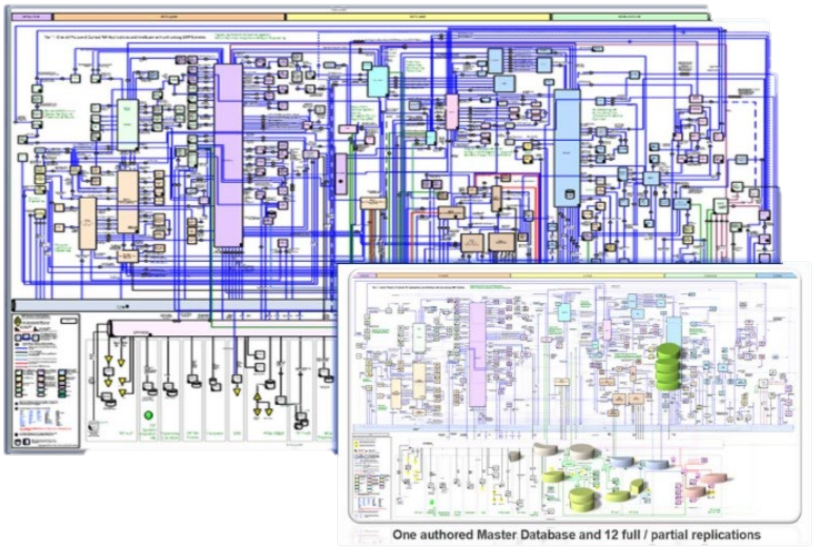
Observation: MBSE Process Provides Orderly Definition of Model Elements, Relationships and Attributes in a Balanced System Design Architecture

Architecture: The Essential Attribute

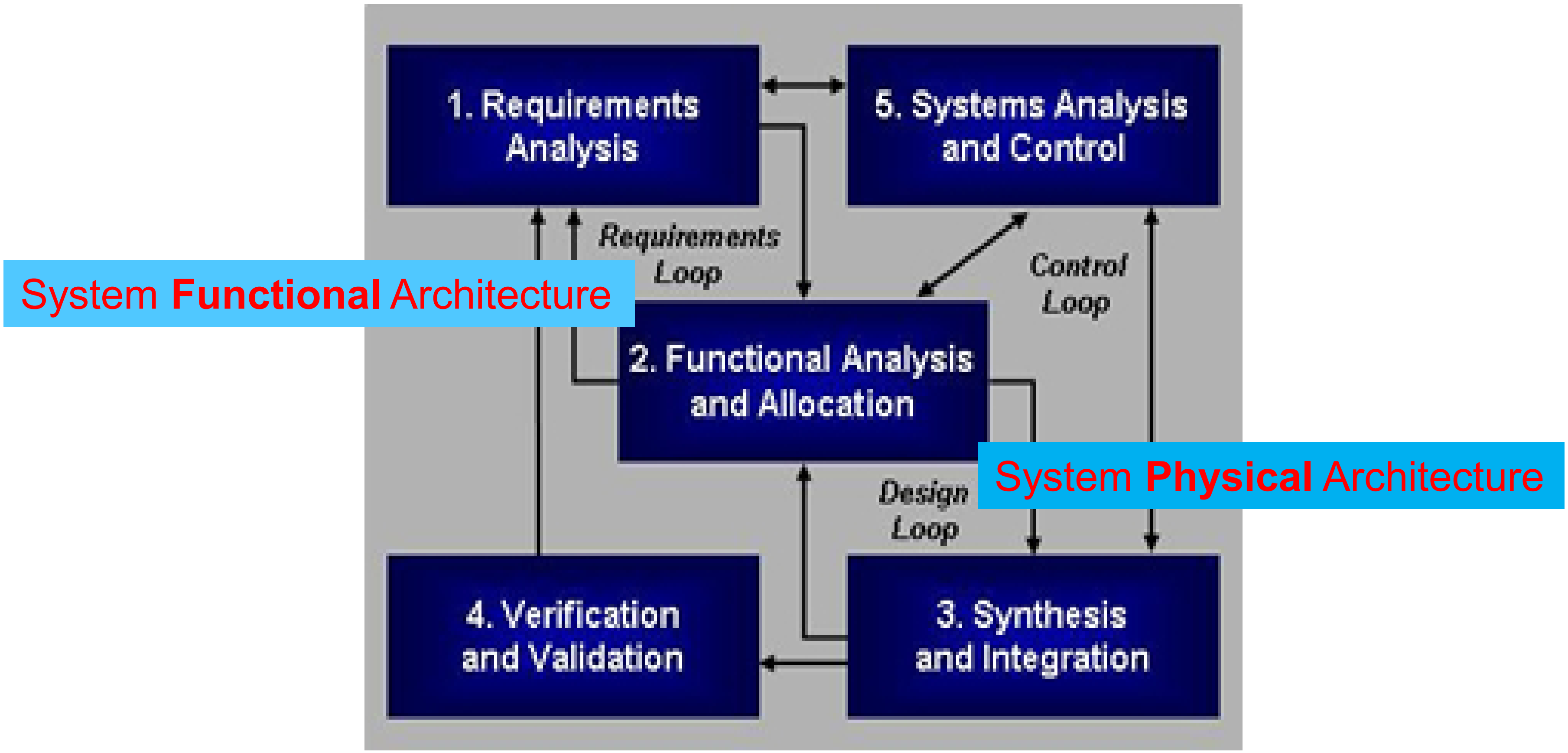
Architecture: System fundamental concepts or properties of a system in its environment embodied in its elements, relationships, and in the principles of its design and evolution (ISO 42010)

Value of an Architecture / Architecting:

1. Common understanding of resultant system via maturation process
2. Organization/Abstraction of complexity
3. Flow to lower-level design details
4. Structure, function, behavior
5. Interfaces, relationships, data flows
6. Hardware & software relevance
7. Potential for what-if analysis



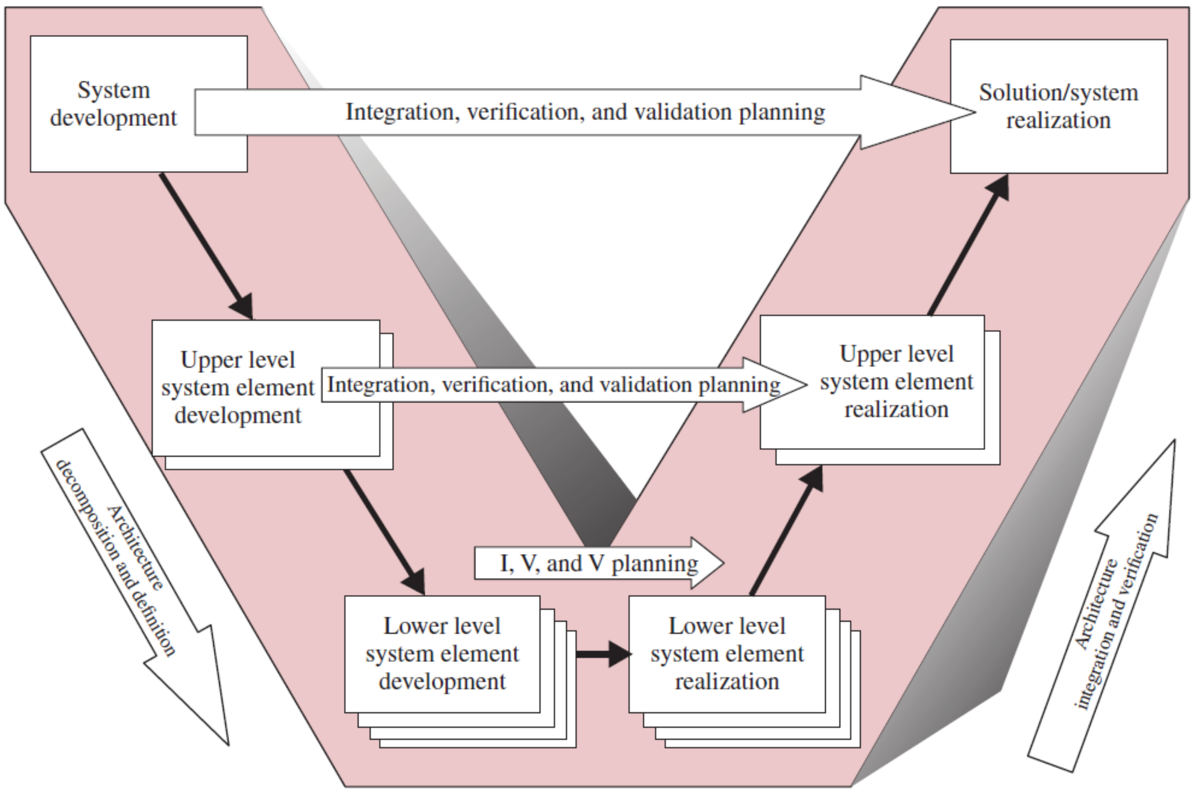
Reviewing a Classic: Systems Engineering Engine



The Systems Engineering "Engine"

Source: Boeing

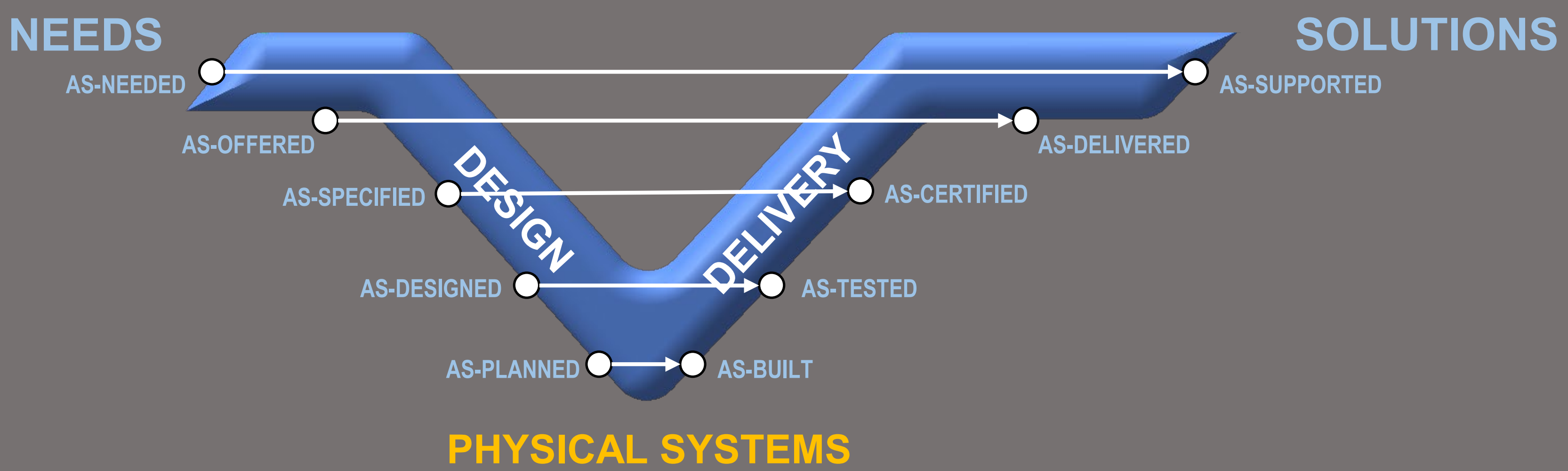
Reviewing a Classic: Systems Engineering Vee[3]



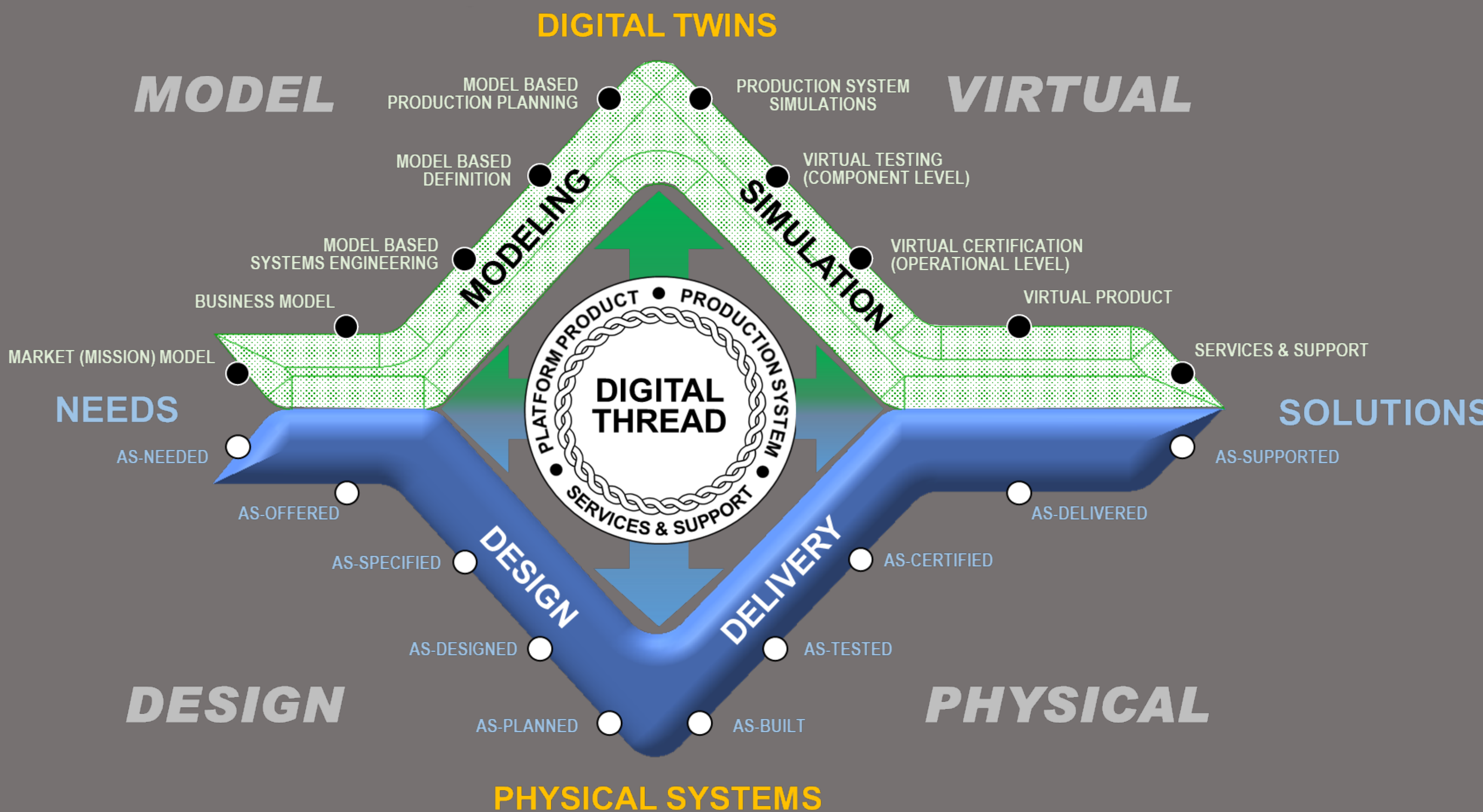
Decomposition via Architecture **Integration via Architecture**

Source: "Vee Model", Systems Engineering Handbook, 4th Edition; INCOSE, Pg. 34

Re-Thinking the SE Vee[4]



A New Paradigm: Boeing MBE Diamond[5]



Observation: Rooted in Functional, Logical, and Physical Architectures

Underlying Architectural Precepts

Initiative / Framework	System Structure	Dependencies
Mission Engineering	System of Systems (SoS) Architecture	Coupling and Interoperability
Digital Engineering	System Process Architecture	Process Interfaces and Flow
Model-Based Systems Engineering	System Development Architecture	Orchestrated Development and Maturation
Model-Based Engineering	Engineered System Design Architecture	Physics-Based Element Descriptions and Interfaces

Architecture: Discover it Again for the First Time

- Today's Paradigms (ME, DE, MBSE, MBE, etc.) Still Founded on Classic Application of Architecture
  - Defined Relationships Between Elements, with Associated Attributes
- Technique for Synthesizing Solution Space Choices Based on Needs in Problem Space
- Value Captured via
  - Analysis and Definition of Mission (ala Mission Engineering)
  - Process Orchestration (ala Digital Engineering)
  - Balanced Product and Process Definition (ala Model-Based SE)
  - Functional/Behavioral/Physical Representations of Engineered Systems (ala Model-Based Engineering)

Aspects of Architecting with Enduring Value Today

- **Boundaries and interfaces: System in Its Environment**
- **Derivation of Content for "Authoritative Source of Truth"**
- **Capability Verification and Validation Enablers**
- **Use Cases: Identifying Functions, Leading to Behavior**
- **Configuration Identification/Control Enablers**
- **Architecture Languages & Frameworks (UML, SYSML, UAF, etc.)**
- **Architectural Practice Enablers (Traditional/Waterfall, Agile, Hybrid)**

Conclusion

- Architecture is Central to All Initiatives & Frameworks
- Architectures Can be Process-Based or Product-Based
- Value of Architecture and Architecting Varies
  - Depends on Purpose
    - Coordination and Planning
    - Explore Alternatives for Balanced Design
    - Prediction; Answer “What-If’s”
  - Depends on Application
    - Strategic Intent for Enduring Value
    - Where It’s Done
    - When It’s Done

NDIA SE Division Architecture Committee

- **Central Themes of Architecture and Architecting**
- **Acquirer/Supplier White Paper on Modular Open Systems Approach (MOSA), incl. Recommendations**
- **Follow-On Committee Focus Areas**
- **Meetings Bi-Weekly**
- **Open to All NDIA Members**
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  - Ed Moshinsky, Lockheed Martin, Committee Co-Chair
    - edward.a.moshinsky@lmco.com

References

1. RT-171: Mission Engineering Competencies Technical Report, Dr. Gregg Vesonder, Stevens Institute of Technology; SE Research Center, April 30, 2018
2. "Digital Engineering Strategy", Department of Defense, June 2018, Pg. 3
3. "Vee Model", Systems Engineering Handbook, 4^{th} Edition; INCOSE, Pg. 34
4. "The System Engineering 'V' - Is It Still Relevant In the Digital Age?", Global Product Data Interoperability Summit 2018; Dan Seal, Boeing
5. Ibid

Abstract

Today's systems challenges involve a desire to apply new approaches to produce and exploit innovative systems much faster and more affordably than ever before. Prior practices are questioned as to their relevance in today's fast-based society that seemingly identifies new threats on a daily basis. Emerging methods to counter these threats include Mission Engineering, Model-Based System Engineering, and Digital Engineering. While each of these may have relevance to solving particular aspects of stakeholder problems, they all fundamentally share the same integral or resultant attribute at their core: an architecture.

This presentation addresses the vital role that systems architectures play in the midst of the various approaches to creating, modifying, or just understanding a system. While integrated tools, agile practices, new technologies, and different thinking may form the basis of this new age, the old-fashioned notion of a system architecture is still very much involved. An explanation is offered that shows how system fundamentals involving relationships between elements ultimately has to be a shared attribute and ultimately forms the basis for taking our systems thinking to the next level.

Short Version for Program:

Today's systems challenges involve a desire to apply new approaches to produce and use innovative systems much faster and more affordably than ever before. This presentation addresses the enduring role and new thinking that systems architectures play now in the midst of system developments.

Biography

Bob Scheurer is an Associate Technical Fellow at the Boeing Company with over 35 years of experience in engineering and the application of systems engineering principles in a variety hardware and software developments, both in defense and commercial settings. Bob has participated in numerous professional society events/symposia, served on conference panels, delivered keynote addresses, and taught systems engineering. He also served on the industry working group that created the ISO/IEC/IEEE-15288.1 & .2 SE Standards and currently chairs the NDIA SE Architecture Committee.

Bob was granted his Professional Engineer license in 1987 and is a certified Project Management Professional (PMP) by the Project Management Institute. He holds a Master of Science degree in Electrical Engineering from Washington University, St. Louis and a Bachelor of Science degree in Electrical Engineering from the University of Illinois in Urbana/Champaign.