Continuing Madness: Methods Behind System Architecting Challenged

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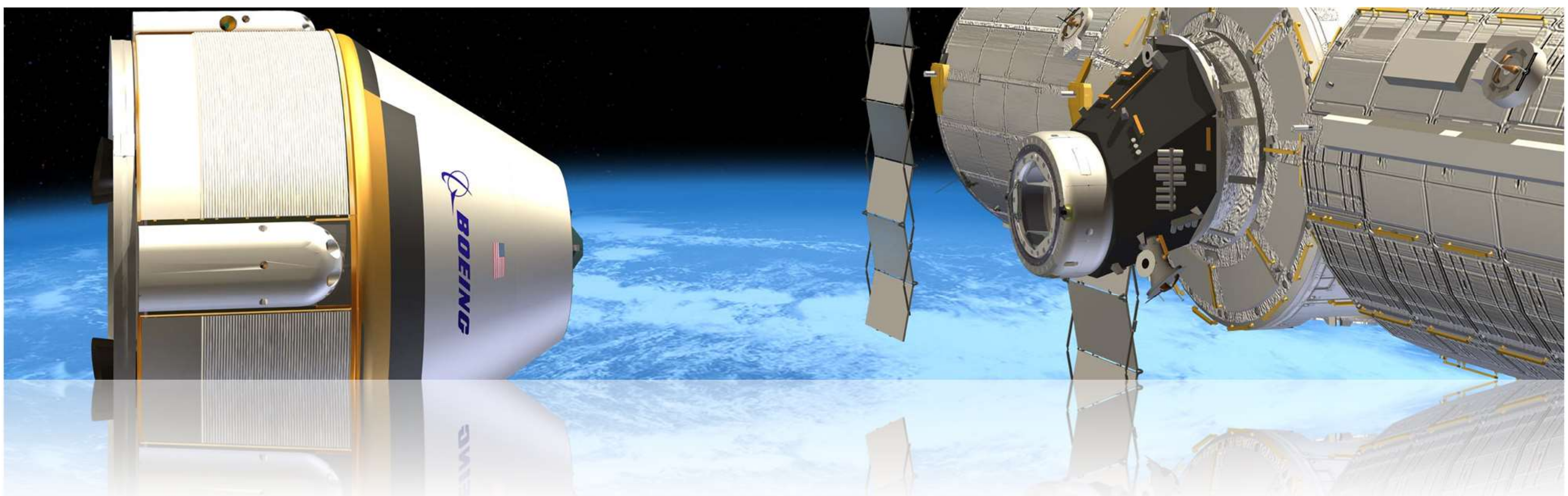
Topics

1. System Architectures/Models: An Evolution
2. Modeling Frameworks and Methods: Today's Reality
3. Toward Better Architectures, More Useful Methods, and Best Outcomes: The Challenges
4. Summary and Conclusions

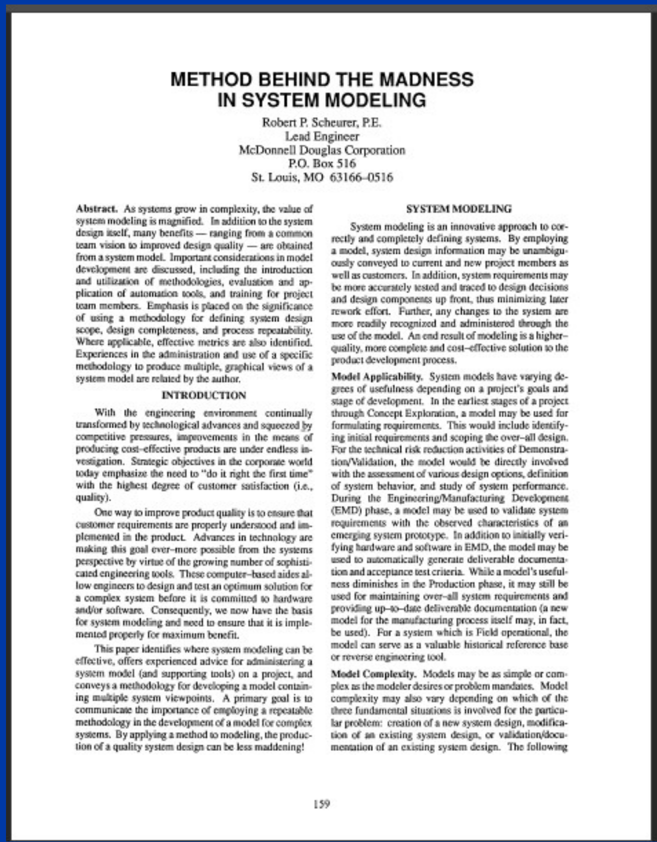


Architecting/Modeling: Recipe for Success

- 1993 Paper: "*Method Behind the Madness in System Modeling*"

- Premises for Successful Modeling:
  - ✓Disciplined Methodology
  - ✓Automation via Computer-Based Tools
  - ✓Proper Training in Method and Tool

- Conclusion: Modeling Method is Needed in Order to Avoid
  - ➢ Right Solution to the Wrong Problem
  - ➢ Wrong Solution to the Right Problem
  - ➢ No Solution to any Practical Problem



METHOD BEHIND THE MADNESS IN SYSTEM MODELING

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Abstract. As systems grow in complexity, the value of system modeling is magnified. In addition to the system design itself, many benefits — ranging from a common team vision to improved design quality — are obtained from a system model. Important considerations in model development are discussed, including the introduction and utilization of methodologies, evaluation and application of automation tools, and training for project team members. Emphasis is placed on the significance of using a methodology for defining system design scope, design completeness, and process repeatability. Where applicable, effective metrics are also identified. Experiences in the administration and use of a specific methodology to produce multiple, graphical views of a system model are related by the author.

INTRODUCTION

With the engineering environment continually transformed by technological advances and squeezed by competitive pressures, improvements in the means of producing cost–effective products are under endless investigation. Strategic objectives in the corporate world today emphasize the need to "do it right the first time" with the highest degree of customer satisfaction (i.e., quality).

One way to improve product quality is to ensure that customer requirements are properly understood and implemented in the product. Advances in technology are making this goal ever–more possible from the systems perspective by virtue of the growing number of sophisticated engineering tools. These computer–based aides allow engineers to design and test an optimum solution for a complex system before it is committed to hardware and/or software. Consequently, we now have the basis for system modeling and need to ensure that it is implemented properly for maximum benefit.

This paper identifies where system modeling can be effective, offers experienced advice for administering a system model (and supporting tools) on a project, and conveys a methodology for developing a model containing multiple system viewpoints. A primary goal is to communicate the importance of employing a repeatable methodology in the development of a model for complex systems. By applying a method to modeling, the production of a quality system design can be less maddening!

SYSTEM MODELING

System modeling is an innovative approach to correctly and completely defining systems. By employing a model, system design information may be unambiguously conveyed to current and new project members as well as customers. In addition, system requirements may be more accurately tested and traced to design decisions and design components up front, thus minimizing later rework effort. Further, any changes to the system are more readily recognized and administered through the use of the model. An end result of modeling is a higher–quality, more complete and cost–effective solution to the product development process.

Model Applicability. System models have varying degrees of usefulness depending on a project's goals and stage of development. In the earliest stages of a project through Concept Exploration, a model may be used for formulating requirements. This would include identifying initial requirements and scoping the over–all design. For the technical risk reduction activities of Demonstration/Validation, the model would be directly involved with the assessment of various design options, definition of system behavior, and study of system performance. During the Engineering/Manufacturing Development (EMD) phase, a model may be used to validate system requirements with the observed characteristics of an emerging system prototype. In addition to initially verifying hardware and software in EMD, the model may be used to automatically generate deliverable documentation and acceptance test criteria. While a model's usefulness diminishes in the Production phase, it may still be used for maintaining over–all system requirements and providing up–to–date deliverable documentation (a new model for the manufacturing process itself may, in fact, be used). For a system which is Field operational, the model can serve as a valuable historical reference base or reverse engineering tool.

Model Complexity. Models may be as simple or complex as the modeler desires or problem mandates. Model complexity may also vary depending on which of the three fundamental situations is involved for the particular problem: creation of a new system design, modification of an existing system design, or validation/documentation of an existing system design. The following

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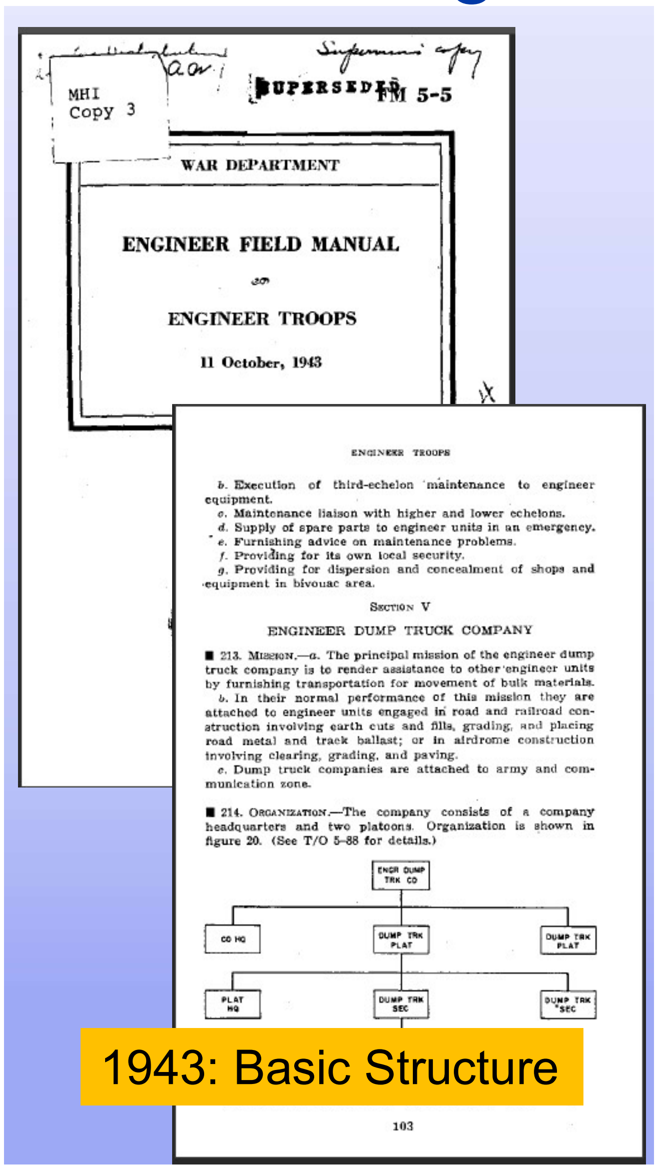
Architecting/Modeling: Then to Now



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SUPERSEDED FM 5-5

WAR DEPARTMENT

ENGINEER FIELD MANUAL

ENGINEER TROOPS

11 October, 1943

ENGINEER TROOPS

b. Execution of third-echelon maintenance to engineer equipment.
c. Maintenance liaison with higher and lower echelons.
d. Supply of spare parts to engineer units in an emergency.
e. Furnishing advice on maintenance problems.
f. Providing for its own local security.
g. Providing for dispersion and concealment of shops and equipment in bivouac area.

SECTION V

ENGINEER DUMP TRUCK COMPANY

■ 213. MISSION.—*a.* The principal mission of the engineer dump truck company is to render assistance to other engineer units by furnishing transportation for movement of bulk materials.
b. In their normal performance of this mission they are attached to engineer units engaged in road and railroad construction involving earth cuts and fills, grading, and placing road metal and track ballast; or in airdrome construction involving clearing, grading, and paving.
c. Dump truck companies are attached to army and communication zone.

■ 214. ORGANIZATION.—The company consists of a company headquarters and two platoons. Organization is shown in figure 20. (See T/O 5-88 for details.)

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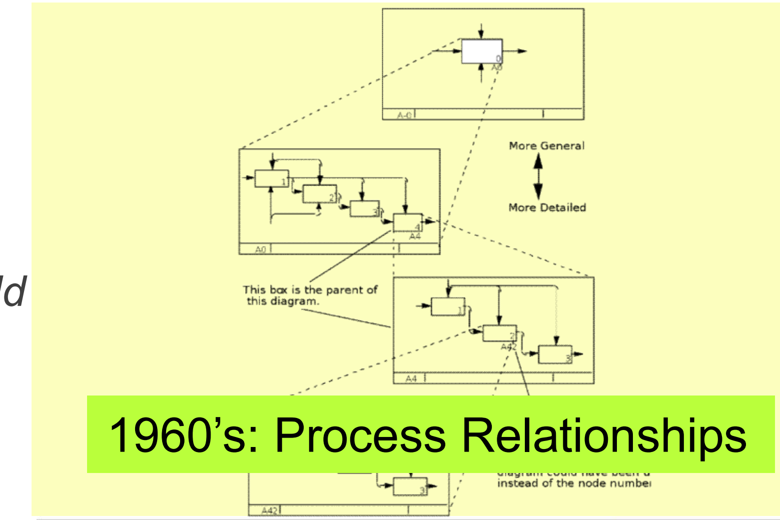
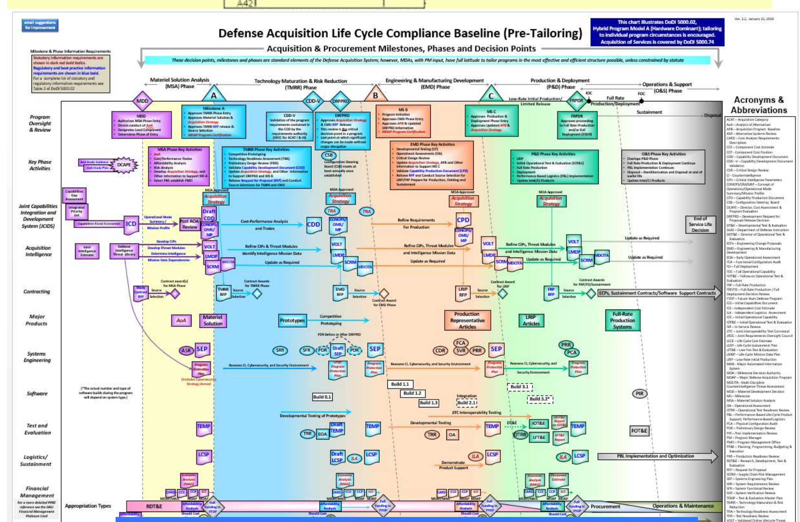
1943: Basic Structure

Lessons Learned from Modern History:

- Genesis of Formal SE: **1943** *Army Field Manual*
- Modeling Language Frameworks Evolution (Late **1960's** – *Structured Analysis & Design Technique*
- DoD-5000 Defense Acquisition Life Cycle Evolution **Today**



1960's: Process Relationships



2019: Tailored Processes

Today's Condition with Architectures [1]

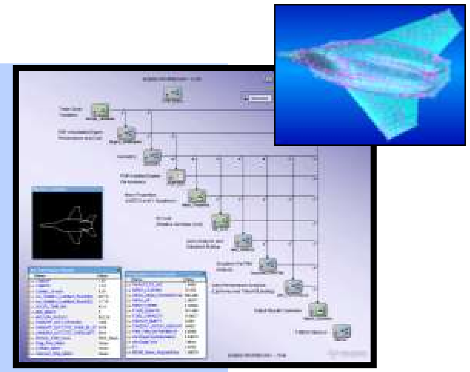
- **Higher Fidelity and Functional Diversity**: Experience in Multiple Technical Fields Necessary
- **Extended Objectives**: Digital Twin, Economy, Enduring Relevance
- **Constraining Objectives**: Modular Open Systems Approach; Cybersecurity; Affordability; Hardware / Software Re-Use
- **Extended Applications**: Systems of Systems (SoS), Mission Engineering, Digital Engineering

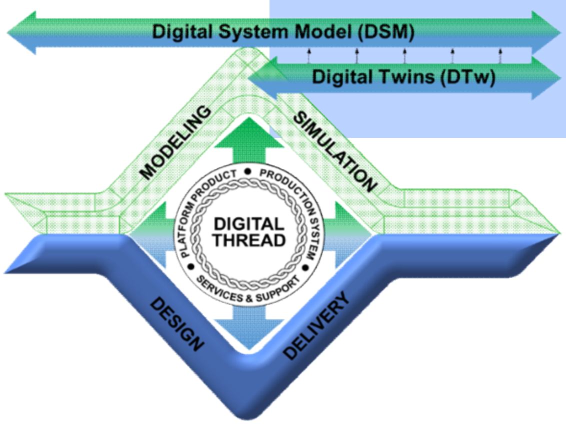
Lingering Doubts

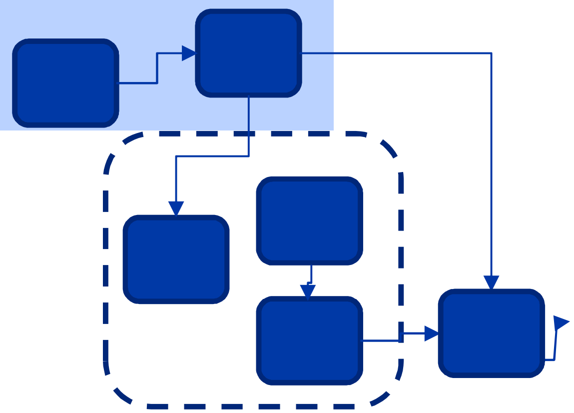
- Dualities of Expectations: Traditional and Model-Based approaches (together) on Programs
- Gartner Predictions: "2018 Hype Curve"
- SE vs. Model-Based SE (MBSE): How Different?
- *If one is challenged at executing the Systems Engineering process, can one be expected to be better at MBSE – an SE process using models?*

So What's Different: Now vs. Then?

- System Complexities
- Tools / Computing Platforms
- Hardware-Intensive vs. Software-Intensive Systems
- SE Vee vs. Boeing SE Diamond

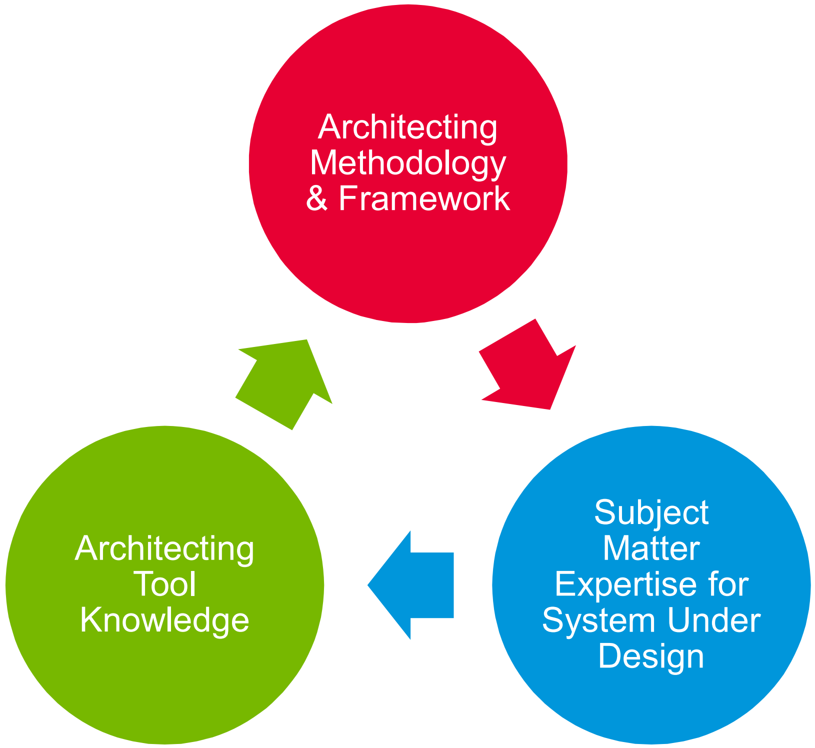






In Some Respects, Everything has Changed
In Other Respects, Nothing has Changed

Three Necessary Components in System Architecting Process



Pre-Conditions to Starting the Architecting or Modeling Effort[2]:

1. Models should not be built until the questions to be answered are known; and
2. Most-fundamental questions of benefit vs cost expected to be addressed for the key stakeholders in a timely and cost-effective manner.

Popular Architecting Frameworks Today

- DoD Architecture Framework (DoDAF)
  - Formalized a set of products associated with a set of views and viewpoints
- Unified Architecture Framework (UAF)
  - Defines an enterprise architecture that enables stakeholders to focus on specific areas of interest
- The Open Group Architecture Framework (TOGAF)
  - Describes an integrated hierarchy of architectures: Business Architecture; Info Systems Architecture; Technology Architecture
- Zachman Framework (for Enterprise Architecture)
  - Relates the intersection of two historical classifications
    1. Communication fundamentals: primitive interrogatives What, How, When, Who, Where, and Why
    2. Reification: Transformation of an abstract idea into an instantiation

<u>Framework</u>: The Ontology for Description; Structure

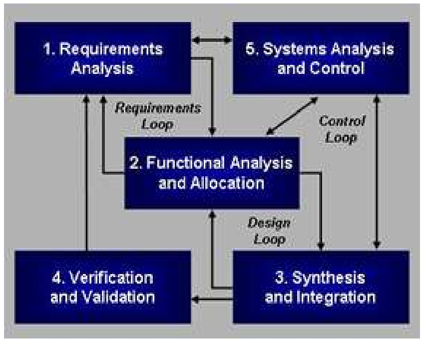
Frameworks: Complexities & Roadblocks

Having an Architectural Framework is Necessary but Insufficient Condition for Successful Modeling

Popular Architecting Methods & Tools Today

Method	Tool	Developer
Arcadia	Capella	Open Source
Harmony	Rhapsody	IBM
MagicGrid	MagicDraw	No Magic (Dassault)
Model-Based Sys. Eng.	Core, Genesys	Vitech
Object Process Method (OPM)	OPCAT	Dov Dori
Ad Hoc	Various	Stakeholders

<u>Methodology</u>: The Process



The Systems Engineering "Engine"

Toward Better Architectures, More Useful Methods, and Best Outcomes: The Challenges

Common Vision: Architects & Engineers

- Roles and Responsibilities
- Program/Project Objectives
- Executing the “Systems Engineering Fundamentals”

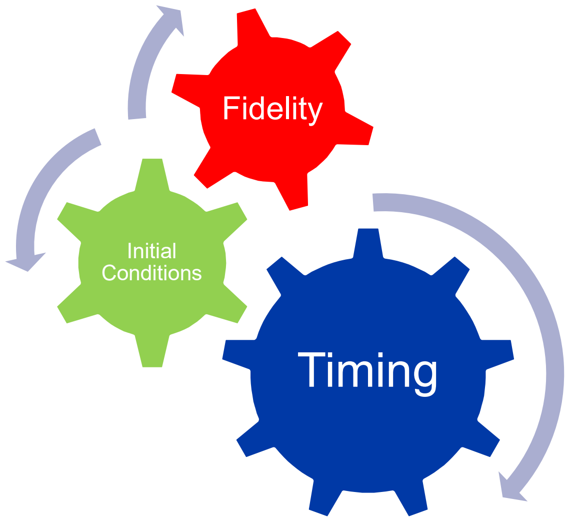
Enabling Environment for Architecting

- Stakeholders Participation
  - Acquirer / User
  - Supplier(s) / Supply Chain
- Tools & Taxonomies
- Skills & Training

Essential Element: (Model-Based Systems Engineering) Method

Challenge: Planning the Modeling Method

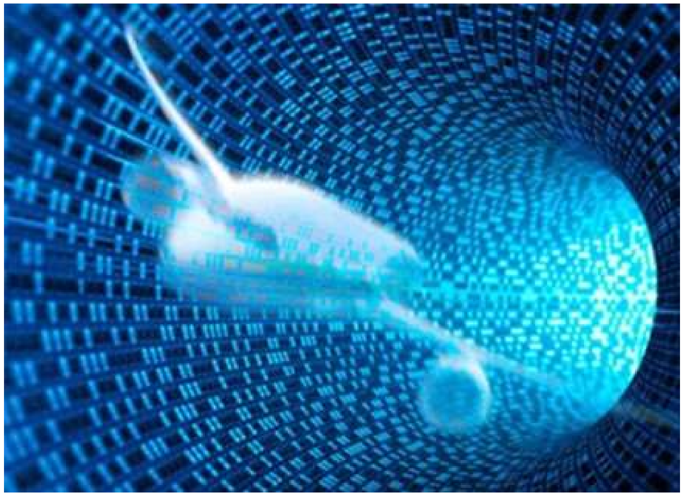
- Start and Timing of the Method: *Where is T_0 and What Happens Then?*
- Initial Conditions: *How do they Impact the Model & Methodology?*
  - Off-the-Shelf/Re-Used Components vs. Clean Sheet Elements
  - Program Phase
  - Available Data
  - Skills Involved
- Fidelity: *When is the Modeling Complete?*
  - Expectations & Detail Needed
  - Requirements Traceability
  - Utilization in Verification
  - Utilization in Validation



Challenge: Deploying and Using the Modeling Method

- Schedule for Model Development
- Funding of Modeling Effort
- Ownership of the Resultant Model, Particularly Joint Efforts
- Misalignment of DoD-5000 Phases for Architecting Effectiveness
  - Need for Architectures at Different Points of Lifecycle, Especially Early Phases
- Impact from Acquisition Lifecycle Changes
  - Accelerated Acquisition
  - Hardware-Centric Systems
  - Software-Centric Systems
- Organizational Alignment
  - System Complexity ← → Organizational Complexity

Challenge: Long-term Use and Curation of the Architectural Model



- Method and Tool Evolutions Over Time
- Architectural Model Relevance and Enduring Value
- Technology Obsolescence Issues
- Archive Preparation and Maintenance Costs
- Model LOTAR (Long-Term Archiving and Retrieval) Standard
  - Application Protocol AP-233: Systems Engineering (Very limited Success)

Summary & Conclusion

Architecting as or More Valuable Today as 25+ Years Ago

- Traditional (Systems Engineering) Challenges Remain

Significant Advancements in Tool Technologies

- More Variety, Capability, & Power

Stakeholder Awareness and Participation Essential

- Appreciation, Experience, and Training Issues

Organizational Planning and Alignment

- Orchestration of Participants More Critical than Ever

It is Still Imperative to have a *Method Behind the Madness in System Modeling / Architecting*

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

Contacts:

- **Bob Scheurer, Boeing, Committee Chair**
  - robert.p.scheurer@boeing.com
- **Ed Moshinsky, Lockheed Martin, Committee Co-Chair**
  - edward.a.moshinsky@lmco.com

References

1. “Model-Based Design for Effective Control System Development”, Wei Wu, IGI Global, © 2017
2. “Enhancing the Value by Architecture Models”, James Martin, MBSE Lightning Round, INCOSE IS 2019

Abstract

System architecting has been performed for multiple decades now, yet positive outcomes are still elusive in far too many cases. Observations and lessons learned in a paper written by the author 25 years ago are as relevant now as they were in 1994. Visions shared by leaders today have an appealing allure, just like those shared in times past: claims of greater system development accuracy, completeness, traceability to requirements, and over-all better development economics and customer satisfaction are among those being proclaimed again today. Resultant architectures still suffer from problems for developers and complaints from users and other stakeholders. Then as now, certain necessary ingredients to an architecting process are needed in order to achieve the often illusive benefits. So, is there anything different today which can lead to better outputs and outcomes than many years ago?

This presentation will re-examine the architecting methods, tools, training, and other elements of an enabling environment that are used (or not used) today to see what may have really changed. Questions will be raised and answered as to what can be helping versus hurting attainment of architecting success and useful system architectures. It will also explore architecting frameworks today and their implementation to understand if they are meeting their intended purposes. Finally, observations as to what is needed to get to better, more useful architectures and architecture processes will be offered, including the integral need to employ a methodology to reduce or eliminate architecting madness.

Biography

Bob Scheurer is an Assoc. Technical Fellow at the Boeing Company with over 35 years of engineering experience in both defense and commercial industries. He is currently involved with defining, applying, and assessing Systems Engineering and integration practices across Boeing Defense, Space, and Security (BDS), including architecting and MBSE.

Bob currently leads the NDIA SE Architecture Committee and was a member of the working group that created the IEEE-15288.1 & .2 standards for applying, reviewing, and auditing SE processes in defense systems. He was granted his Professional Engineer license in 1987, is a certified Project Management Professional (PMP) by the Project Management Institute, and is certified in SE by INCOSE.

He holds a MS degree in Electrical Engineering from Washington University, St. Louis and a BS degree in Electrical Engineering from the University of Illinois in Urbana/Champaign.