International Council on Systems Engineering
A better world through a systems approach

Unleash the Power of Systems: A 30-Minute Introduction to Systems Engineering Architecture

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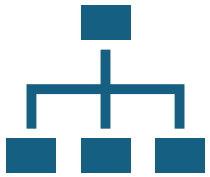
My goal for the next 30-minutes is for us to:

- Discover what architecture truly is (and isn’t!),
- explore its critical role in successful systems,
- and learn how to recognize and achieve "good" architecture.

Architectures, Architects, or Architecting[1]?



Architecture *(thing)*

The basic ideas and rules for how a system works, changes, and interacts with its surroundings over time

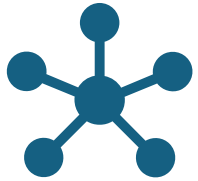
Architects *(person)*

Understand needs and strategies

Define the boundaries, goals, and functions of a system

Create the Concept

Manage complexity



Architecting *(process)*

Creating a vision for how the system will work (the architecture)

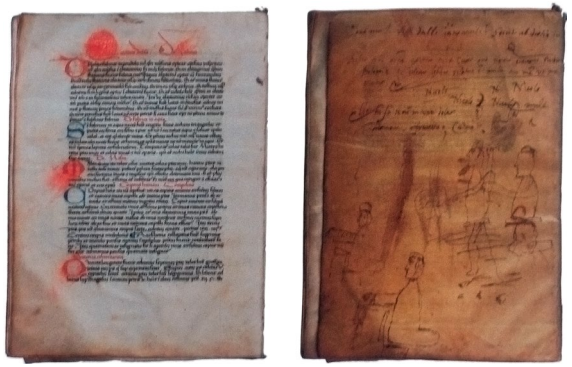
Sharing this vision with stakeholders and the team

Using this vision to guide the design and creation of the system

What is Systems Architecture?

Is	Is Not
Definition of the structure and behavior of a system	Collection of parts
Guidance for the design and creation of the system	Concern with individual components
Focus on the overall vision and goals	Focus on technical details
Involvement of stakeholders and team collaboration	Isolation
Consideration of the entire life cycle of the system	Limitation to the initial design phase
Balance of various factors like flexibility, efficiency, and modularity	Ignorance of trade-offs and constraints
Assurance that the system meets its intended purpose	Aesthetics or superficial aspects

Good Architecture involves three key elements[2]:



Manuscript of Vitruvius; parchment dating from about 1390 [3]

Firmness:

- The system stays strong and useful over time.
- It adapts to changes and can be rebuilt, reused, or recycled.

Utility:

- The system does what it's supposed to do.
- It meets the needs of users, both immediately (like power output) and over time (like reliability).

Beauty:

- The system is pleasing and elegant.
- It looks neat and simple, and users enjoy using it.
- An elegant design works smoothly and efficiently, with all parts fitting together well.

Good architecture is guided by principles and supported by methods and tools to achieve these elements.

(A few) Principles of Architecture

Principles are the underlying and long enduring fundamentals that are always (or almost always) valid.

The following selections are from my own Journal of Architecting Principles that I use as a **guide** for successful architecting, to enable **Processes** and subsequently **Tools** to be used in the architecting discipline.

Keep it Simple

Tag Line:

“Make everything as simple as possible, but not simpler.”
Albert Einstein

Descriptive Version:

The human mind can better understand relationships and interactions to make decisions with a minimum set of elements presented at any one time.

Prescriptive Version:

When presenting concepts, systems, models, and data one should express the relationships with a minimum set. Utilize abstractions and layering to simplify the model with minimum elements.

Tools to help manage complexity [4]

Tension

Tag Line:

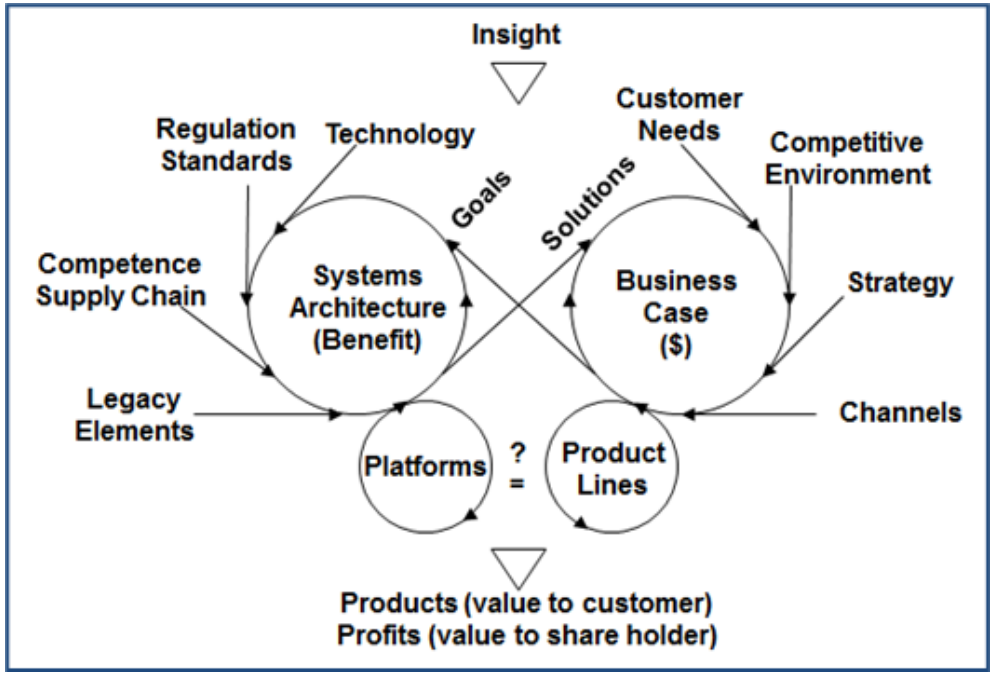
Tensions are not problems that can break your system, but sources of strength that can move you forward – if you go in the right direction. [5]

Descriptive Version:

Very many factors will influence and act on the conception, design, implementation and operation of a system. For any interesting and real problem, there will be essential tensions among the goals set for the system. Creativity in architecture is the process of resolving the tensions in the pursuit of good architecture. [1]

Prescriptive Version:

Use tension to your advantage while architecting (synthesizing) a solution. Listen to the voices and inputs that are at tension to leverage their passion to determine a best possible architecture or design.



Product Synthesis – Cycles of Tension [1]

Risk

Tag Line:

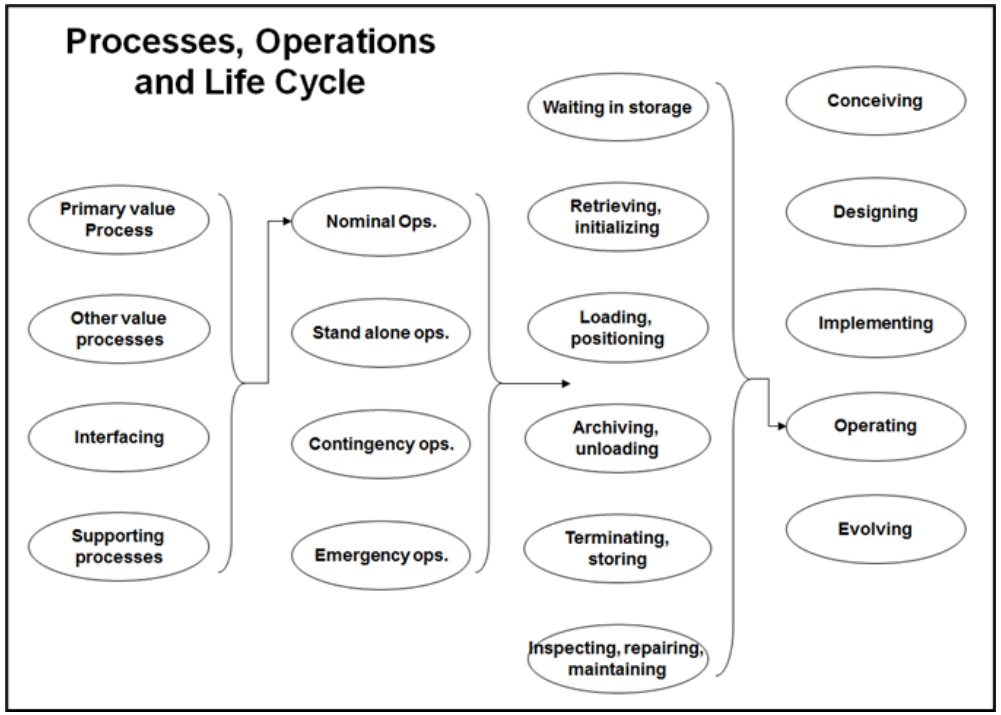
No system is perfect. Plan for it.

Descriptive Version:

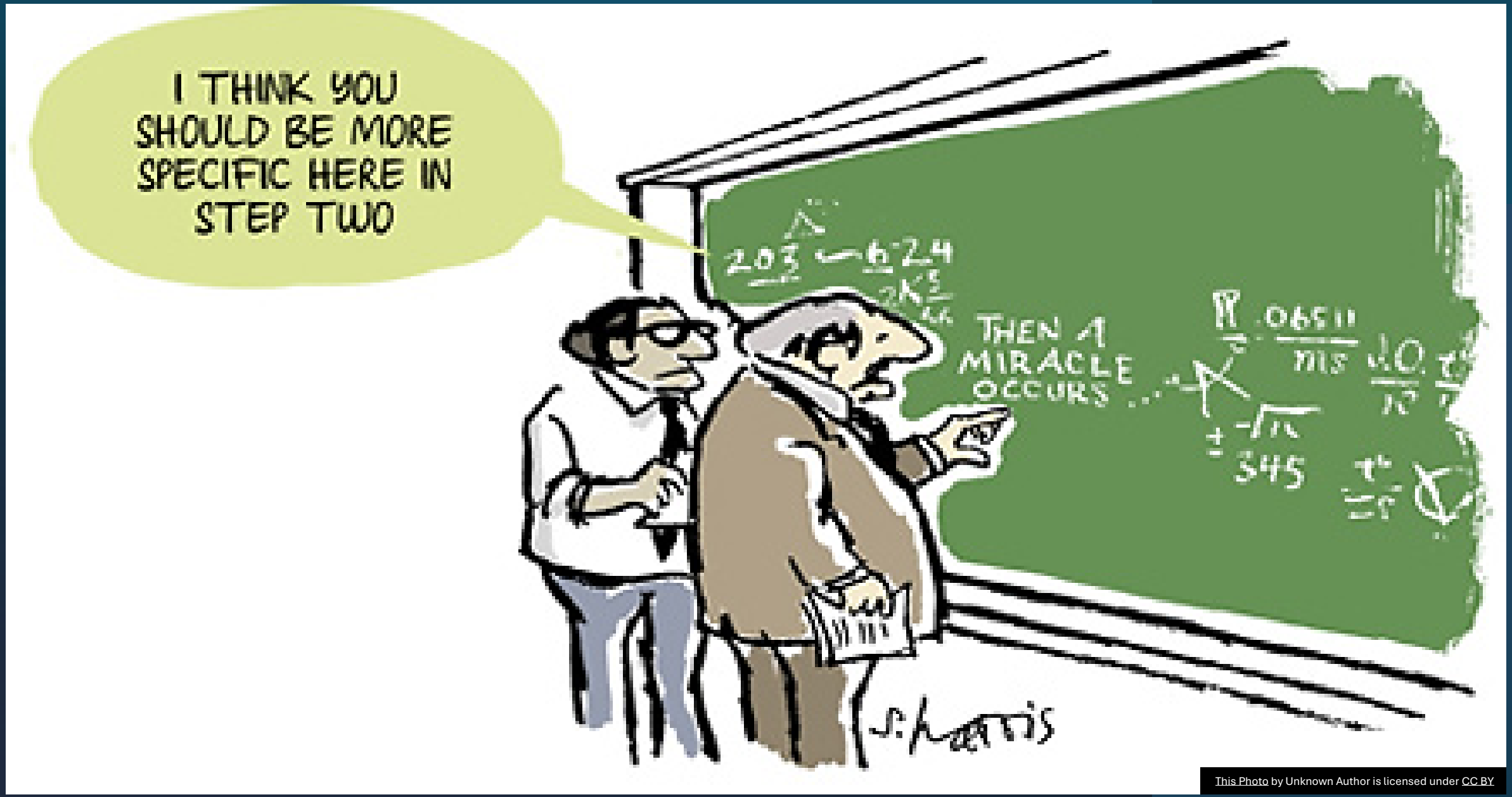
Risk of failure to achieve the goals and intent of a system is ever present. Risk can be of multiple types: technical, program management, functional / processes, manufacturing, sourcing, etc.

Prescriptive Version:

First realize that every endeavor has risk. Then appropriately assess and plan for risks to occur while at the same time focusing on optimizing the beneficial aspects of the system.



Processes throughout an architecture life cycle [1]



Function / Concept / Form

Tag Line:

Functions without Form cannot be performed. Form without Function is without value.

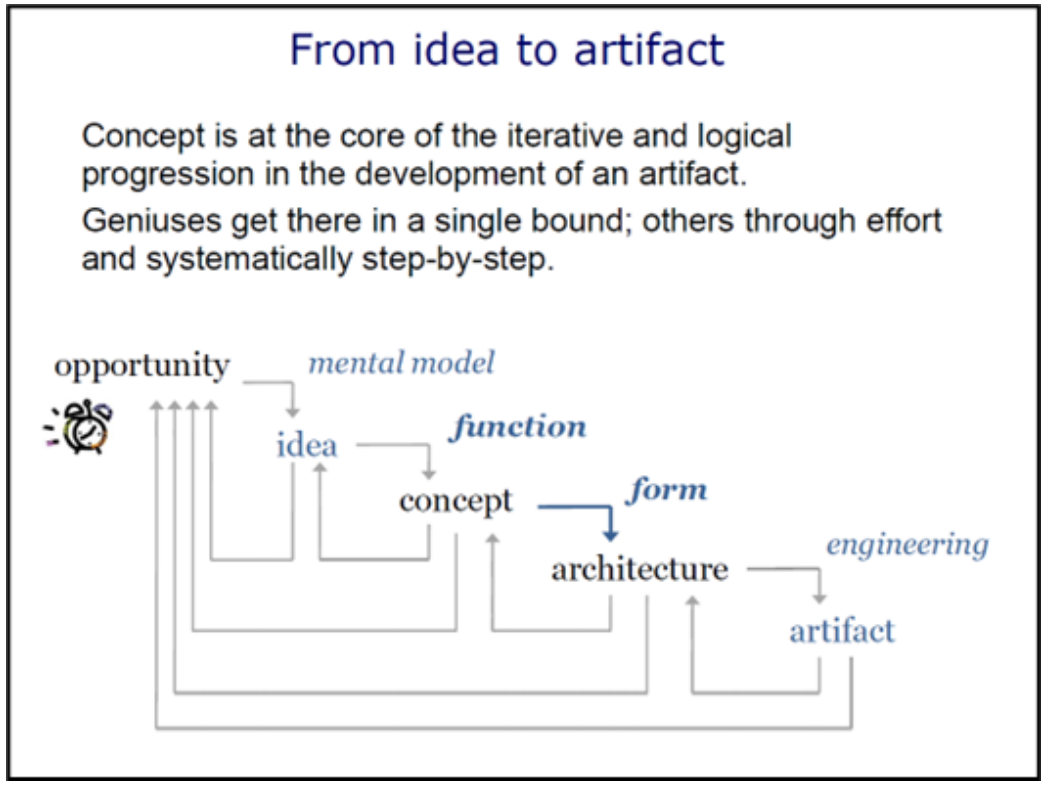
A Concept maps Functions and Forms to each other, clarifying the intended solution.

Descriptive Version:

Functions of a system in a Form structure are related through a particular Concept.

Prescriptive Version:

A concept of the general operation, order, structure, and interfaces must exist to map the Functions of a system to its Form elements.



Don't try to be a genius [in one step] [7]

Deliverables of the Architect

- The architect will deliver: [1]
  - A clear, complete, consistent and attainable (with 80%-90% confidence) set of goals (with emphasis on functional goals)
  - A description of the broader context in which the system sits, and the whole product context
  - A functional description of the system, with at least two layers of decomposition
  - A concept for the system
  - A design for the form of the system, with at least two layers of decomposition
  - A notion of the timing, operator attributes, cost, risks, and the implementation and operation plans
  - A document or process that ensures functional decomposition is followed, and the form at interfaces is controlled

Want more?

People & Competencies / Training

- INCOSE.org/PDP *(54 Learning Resources for "System Architecting" Awareness Proficiency Level)*
  - **Competencies:** Systems Thinking, General Engineering, Critical Thinking, Systems Modelling and Analysis, System Architecting, Operation and Support, Decision Management
- INCOSE.org/library *(580 resources from "architecture" search)*
- Multiple academic courses & certificates *(over 30 have INCOSE Academic Equivalency for SEP knowledge exam!)*

Process

- INCOSE SE Handbook *(2.3.5.4 System Architecture Definition Process)* & ISO/IEC 15288
- SEBoK (Guide to the Systems Engineering Body of Knowledge)
  - e.g., Architecting Approaches for Systems of Systems https://sebokwiki.org/wiki/Architecting_Approaches_for_Systems_of_Systems
- INCOSE Architecture Working Group
  - https://www.incose.org/communities/working-groups-initiatives/architecture
- ISO/IEC/IEEE – 42020 Architecture Processes

Tools

- INCOSE SE Lab Demo Days!
- SE Tools Database (www.systemsengineeringtools.com) 411 results aligned with SE Handbook Architecture Definition Process.

Data Metamodels & Architecture Description Languages

- ISO/IEC/IEEE – 42010 Architecture Description, …
- SysML, UAF, OPM, S*Metamodel, TOGAF, ArchiMate, …

What questions would you like to share?

Works Cited & Primary References

Works Cited

1. Crawley, Ed. ESD 34. System Architecture, Rev 2.0. Cambridge, MA : Massachusetts Institute of Technology, 2011. See https://ocw.mit.edu/courses/esd-34-system-architecture-january-iap-2007/ for MIT OpenCourseWare version.
2. Vitruvius (Translated by Morris Hicky Morgan, Ph.D., LL.D.). The Ten Books on Architecture. Cambridge : Harvard University Press, 1914 (Translation). See https://en.wikipedia.org/wiki/De_architectura.
3. Manuscript of Vitruvius; parchment dating from about 1390. By Georges Jansoone (JoJan) - Self-photographed, Public Domain, https://commons.wikimedia.org/w/index.php?curid=5622441.
4. Schwadron, Harley. 9 to 5. GoComics. [Online] October 24, 2011. [Cited: October 31, 2011.] http://www.gocomics.com/9to5/2011/10/24.
5. Reyes, Patrick. Catalyst 2010 – The Tension is Good . [Online] Rochester Media, October 13, 2010. [Cited: December 4, 2011.] http://www.rochestermedia.com/catalyst-2010-the-tension-is-good/.
6. Intent Specifications: An Approach to Building Human-Centered Specifications. Leveson, Nancy G. s.l. : IEEE Transactions on Software Engineering, 2000, Vols. SE-26, No. 1.
7. Nagano Winter Olympics 1998: IT Architecture Case Study. Tang, Victor W. Cambridge : Massachusetts Institute of Technology, 2011. ESD.34, Class 10. See https://ocw.mit.edu/courses/esd-34-system-architecture-january-iap-2007/ for MIT OpenCourseWare version.

Primary References

- INCOSE. 2023. Systems Engineering Handbook: A Guide for System Life Cycle Processes and Activities, version 5.0. Hoboken, NJ, USA: John Wiley and Sons, Inc, ISBN: 978-1-119-81429-0.
- Rechtin, E., and M. W. Maier. The Art of Systems Architecting. Boca Raton, FL: CRC Press, 2025. ISBN: 978-1032774381.
- Ulrich, K. T., and S. D. Eppinger. Product Design and Development. 7th ed. New York, NY: McGraw-Hill Inc, 2019. ISBN: 978-1260566437.
- Tim Weilkiens, Jesko G. Lamm, Stephan Roth, Markus Walker; Model-Based System Architecture – 2nd Edition; John Wiley & Sons Ltd., 2023

Thank you!

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