

# System Of Systems Architecture Development

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# Outline



- Definitions (“system of systems” and “architecture” )
- Architecture Planning
- Scope and Purpose
- Elements of an Architecture

# SoS Defined



Defense Acquisition University Guidebook: <http://akss.dau.mil/dag>

- Mix of existing and new systems.
- Capability greater than the sum of the capabilities of the constituent parts.
- Top-down, comprehensive, collaborative, multidisciplinary, iterative, and concurrent technical management process.
- May include existing, partially developed, and yet-to-be-designed independent systems.
- Subject to the same systems engineering processes and best practices as applied to individual systems.

# SoS Definition Concept

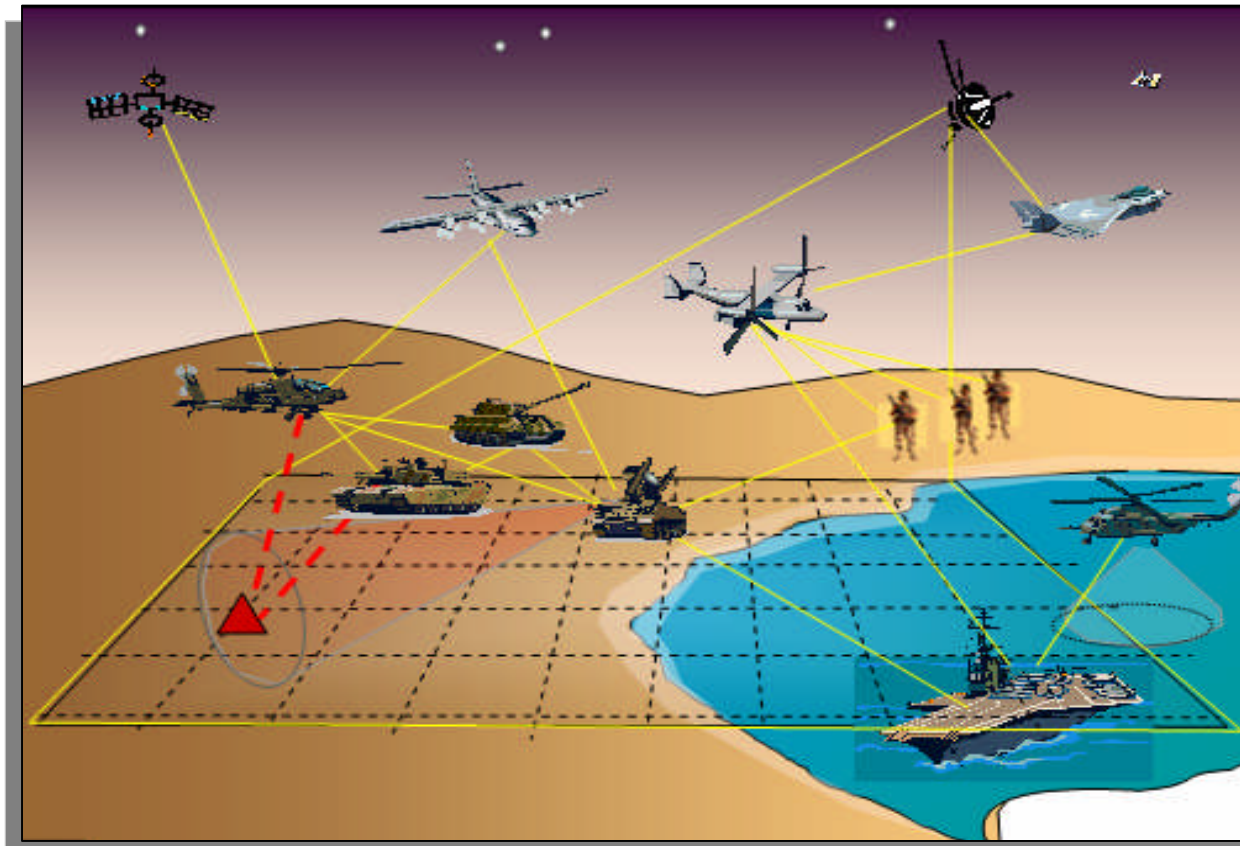


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Individuals, platforms and organizational elements collaborating to achieve some capability in support of a mission objective.

# SoS Characteristic Attributes



- Ambiguous changing boundaries
- Independent component systems
- Important contextual influences
- Counter productive solutions
- Self organizing capabilities
- Complex dynamic issues
- Continual architectural reconfiguration
- Interoperability
- Recomposability
- Technical & non-technical factors
- Advanced cybernetic capabilities
- Counter intuitive behaviors
- Emergent non-linear properties
- Evolving complex relationships
- Collaborative dynamic engineering

**The nature of a SoS Enterprise is an inherent contrast with the idea of establishing an architecture baseline.**

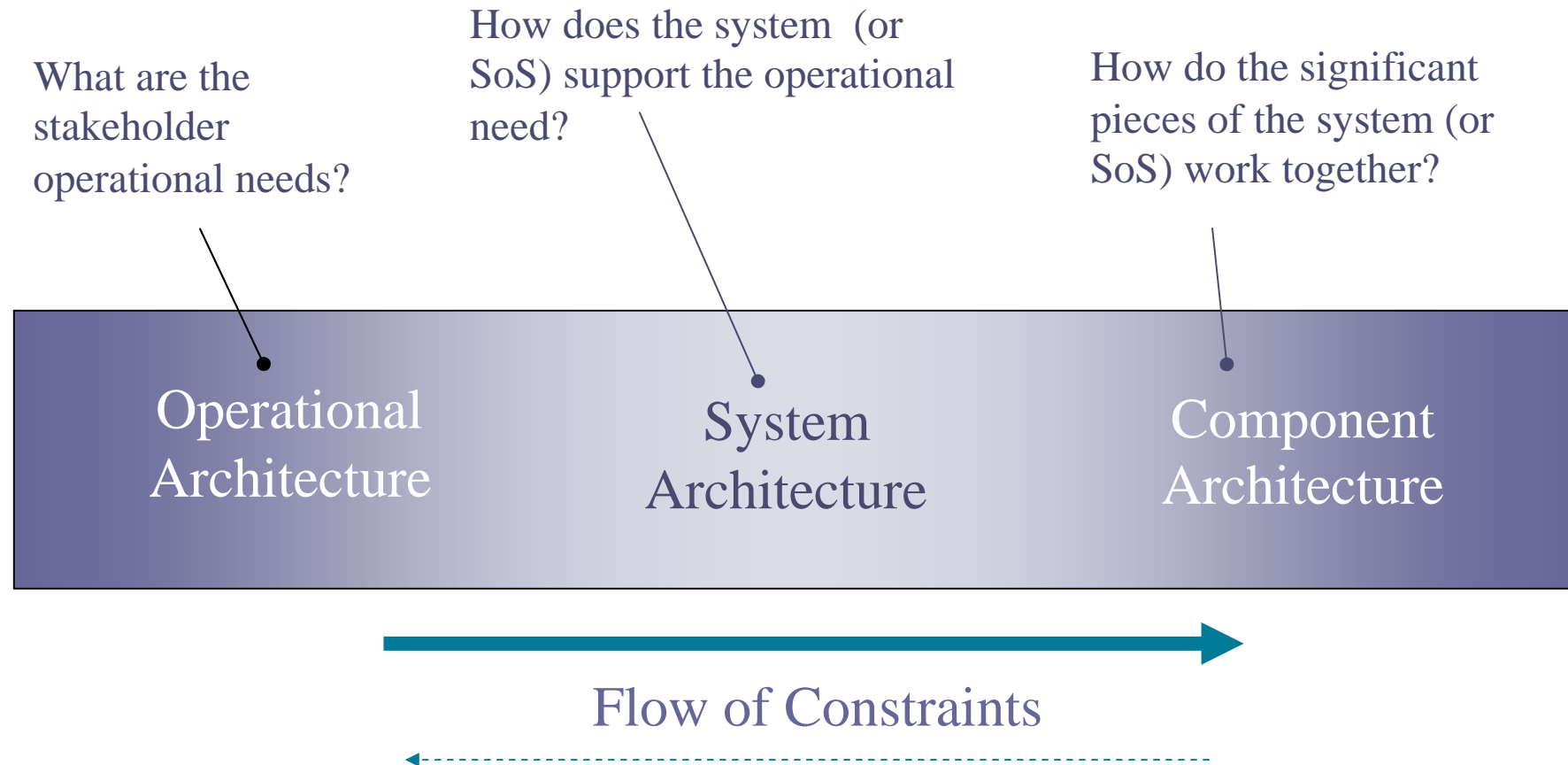
# Architecture Defined



- A unifying or coherent form.
- A design plan and an abstraction of the product envisioned to be implemented.
- A set of elements, form, and rationale.
- The fundamental organization of a system embodied in its components, their relationships to each other, and to the environment, and the principles guiding its design and evolution (IEEE 200a, p.9).
- The structure of components, their relationships, and the principles and guidelines governing their design and evolution over time. (DoD Framework)
- A vehicle for communication among stakeholders.
- A reusable, transferable abstraction of a system.
- A plan for maximizing the quality attributes of a system (suitability, usability, availability, flexibility, composability, portability, maintainability, reliability, etc...) .

**Traditional definitions: Lean toward rigidity. Don't sufficiently address the need to accommodate continual paradigm shifts.**

# Architecture Decomposition Spectrum



The basic desired flow: Operational need constrains and drives the technical solution, not vice versa. Natural conflict with the desire to “reuse”.

# Is it Architecturally Significant?



- Will it change manpower requirements?
- Will it change the way the mission is executed?
- Will critical stakeholders have strong opinions about it?
- Will it have a significant training impact?
- Is there a safety or security risk associated with it?
- Is there a significant system/component architecture impact?
- Does it involve a significant cost/schedule impact?
- Is there a significant infrastructure (ex. testing) requirement impact?
- Is there an interface impact?
- Is there a logical data model impact?
- Is there a key performance impact?
- Is there a significant sustainment impact?
- Is it applicable to a product line?
- Is a waiver or deviation from an applicable standard or practice required?
- Is it a pattern or repeatable template solution?

The definition of “architecture” is constantly evolving in a SoS enterprise.

What was architecturally significant yesterday is not architecturally significant today. Evaluate issues based on current contextual influences.

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# SoS Architecture Planning



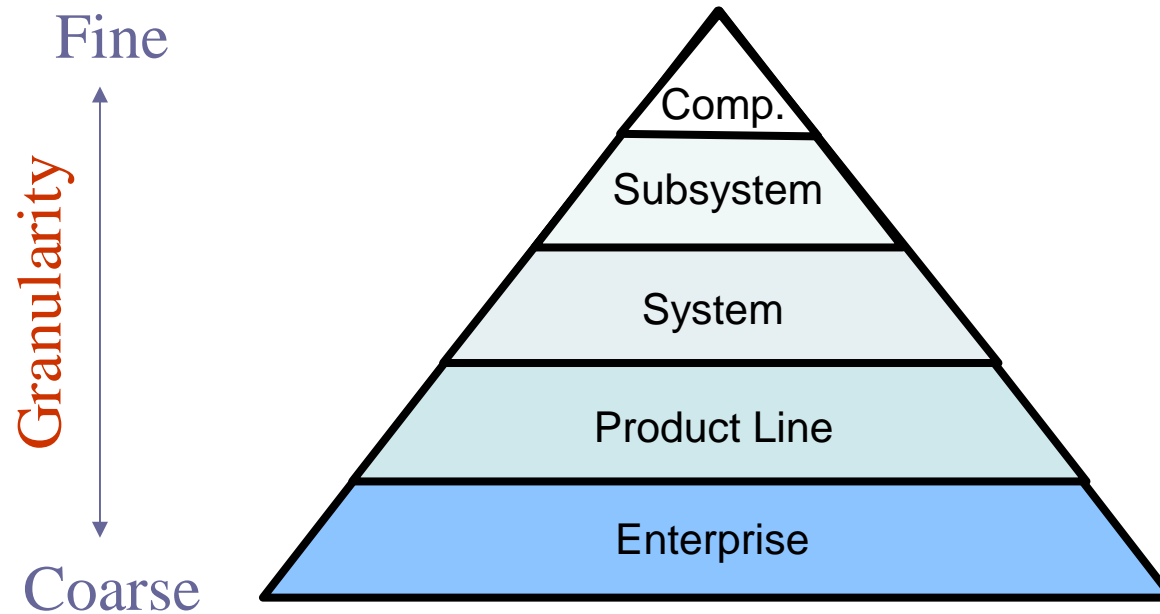
- Plan to baseline the architecture BEFORE starting design work, but don't wait until it's perfect (because it never will be) to move ahead. Instead address major risks, and save others for the next "spiral".
- Plan on developing infrastructure, process, and product architectures.
- Plan to develop work breakdown structures (WBS) and Integrated Product Teams (IPTs) around architectural elements → product based WBS and IPT structure as opposed to functional structure.
- Plan to execute the architecture development process concurrently and in synchronization with the requirements development process.
- Plan on verifying and validating architecture products before releasing them to the design effort.
- Plan on taking time to institutionalize architecture products.
- Plan on including technology insertion and portfolio management as part of a never-ending cyclical architecture development process.

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## Scope



A SoS architecture is an enterprise architecture. It will also require additional architectures at finer levels of granularity to be built on top of it.

# Purpose

- Even the best architecture is of no use if it sits on a shelf and gathers dust.
- To develop the architecture, you need to know the purpose of the product that is to be built from it, but...
- ... To make the architecture useful, you need to also know the purpose of the architecture itself.
- Need to identify stakeholders for the architecture as well as stakeholders for the product system (or SoS).
- Design the architecture products to address those stakeholder needs.
  - Ex: Managers: Will use the architecture as basis for forming development teams, work breakdown structures, allocation of project resources, tracking of progress.
  - Ex: Testers and Integrators: Will use the architecture to specify the correct black-box behavior of the pieces that must fit together.

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# Views

- Definition: A “view” is a representation of a whole system from the perspective of a related set of concerns.
- Example: System = a city.
  - Zoning view.
  - Road Planning view.
  - Terrain view.
  - ...
- Documenting an architecture is a matter of documenting the relevant views and then adding documentation that applies to more than one view.
- View Correspondence: Identifying design rules and heuristics to relate views.



# Models and Frameworks

- Zachman Framework
- RM-ODP
- 4+1 View Model
- DoD Architecture Framework (DoDAF) (see also MoDAF and NAF)
- Academic Software Architecture (SEI)
- TOGAF
- Siemens 4 Views
- ANSI/IEEE-1471-2000
- Domain Analysis

A SoS enterprise will involve architecture descriptions at various levels of granularity, developed using different models, frameworks, views, and patterns. Need to know that the relationships and cross constraints of this heterogeneous set are understood by the applicable stakeholders.

# Scenarios, Threads, Vignettes, Use Cases



- Representative statements of usage.
- Good for validation purposes.
- Use different types of scenarios to explore various aspects and limits of the architecture:
  - Use case scenarios: How will version 1.0 work in the field?
  - Growth scenarios: How will version 2.0, 3.0, x.0 work?
  - Exploratory scenarios: “What if” scenarios to explore limits and uncover implicit assumptions.

In traditional system development, the “growth” and “exploratory” scenarios are often overlooked, but they are critical for a SoS enterprise.

## End

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Architectural planning is critical for SoS development, and special considerations need to be integrated to properly tailor and extend traditional architecting practices and recourses to support an enterprise level scope.

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