The Boeing System of Systems Engineering (SoSE) Process and Its Use in Developing Legacy-Based Net-Centric Systems of Systems

Marion L. Butterfield, Alaka Shivananda, and Dennis Schwarz (The Boeing Company)

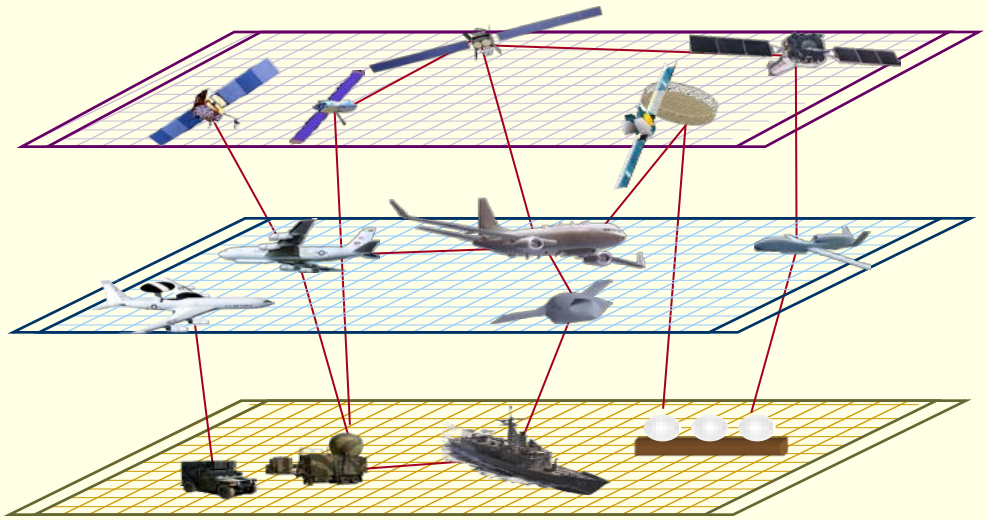
National Defense Industrial Association (NDIA) 12th Annual Systems Engineering Conference, October 26-29, 2009
Conference Session: Net-Centric Operations

Systems to Systems of Systems: The Evolving Challenge of Complexity

Complex Single System

Boeing's role as a developer of commercial and military net-centric enterprise systems of systems (SoS) has resulted in the requirement to perform Systems of Systems Engineering (SoSE) over a wide range of mission and system domains.

For example, many future military SoS's will be comprised of legacy systems from the Air Force, Army, Marines, and Navy. Effective approaches are required to transform these legacy systems into net-enabled systems capable of performing effectively as a part of these net-centric SoS's.



Net-Enabled System of Systems

System of Systems Engineering (SoSE) Process
What it is and What it does

An Enterprise (SoS) Engineering Process for development of both commercial and military complex systems and systems of systems

- Provides a disciplined and more detailed SE process
- Follows industry standards
- Applicable to *all* system development programs

An architecture-centric, model-based approach that results in a single SoS/Systems Architecture Model when used in a collaborative environment

- Horizontally integrates program engineering disciplines
- Results in a single truth-model
- Incorporates a common modeling language for architecture dev.

A methodology that provides detailed guidance on the net-enablement of legacy systems and their use in net-centric systems of systems

- Supports industry NCO standards and strategies
- Improves implementation of acquisition strategies
- Supports system evolution

What is a System?

A collection of components organized to accomplish a specific function or set of functions.

Reference: IEEE Recommended Practice for Architectural Description of Software-Intensive Systems, IEEE Std 1471-2000

What is a “System of Systems?”

- ***Definition:***

  A System-of-Systems (SoS) is a “super-system” comprised of elements that are themselves complex, independent systems which interact to achieve a common goal.

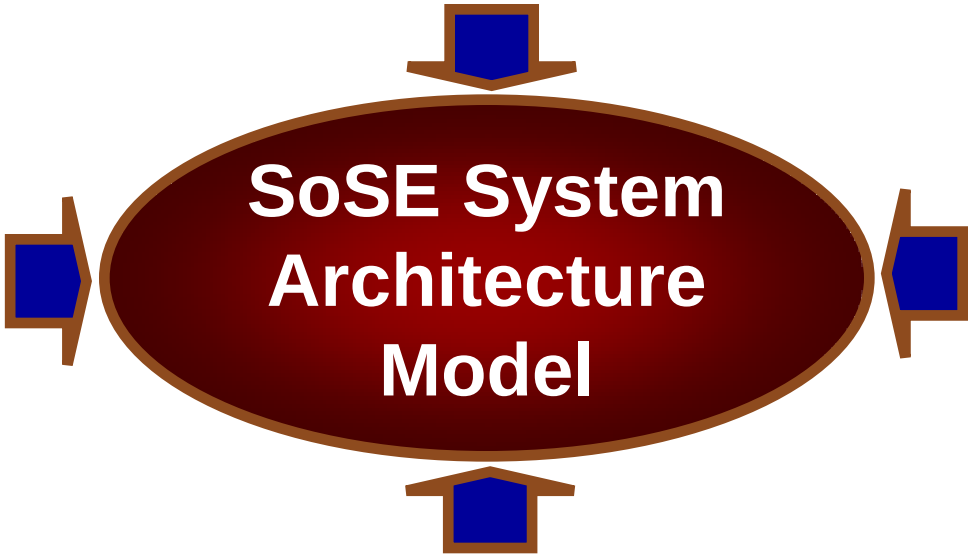
- ***Common Characteristics:***
  - **The component systems achieve well-substantiated purposes in their own right even if detached from the overall system**
  - **The component systems are managed in large part for their own purposes rather than the purposes of the whole**
  - **It exhibits behavior, including emergent behavior, not achievable by the component systems acting independently**
  - **Constituent systems and functions may be added or removed during its use**

***After Maier, Sega, Levis**

SoSE Process is the Boeing Model-Based Best-Practices Approach to Developing a SoS/System Architecture Model

SoSE is Architecture-Centric: The system's architecture model is used as the **primary artifact** for conceptualizing, constructing, managing, and evolving the system

Provides a continuous model stream from the Stakeholder-Goal level to the architecture base level

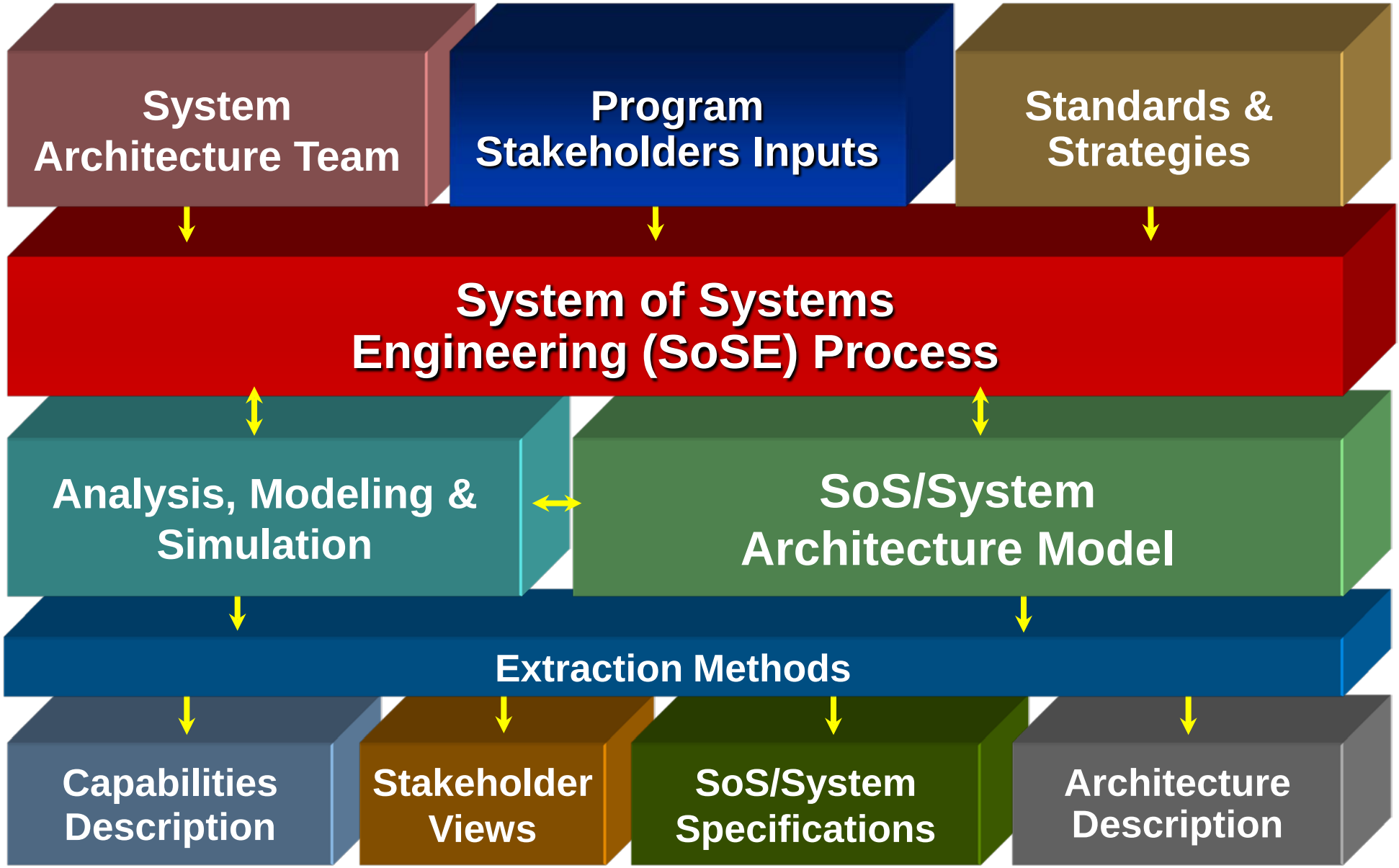


Improves traceability by defining functional requirements and system objects at each system development level

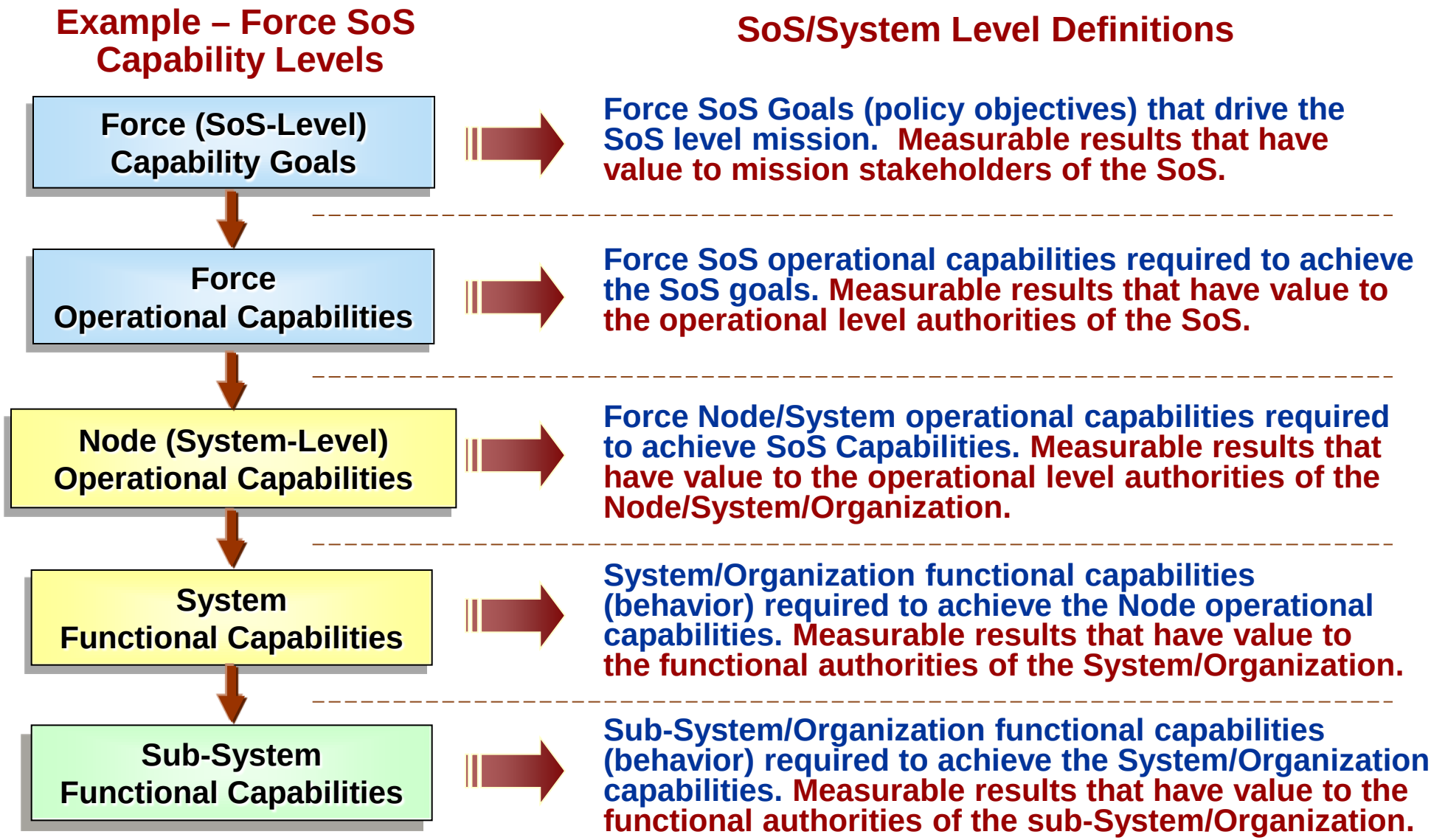
Identifies requirements, system elements, and interfaces at each level to support early design activities for all of a program's engineering disciplines

SoS/System Architecture Model: A description of the structure of a system's components, the relationships between those components, and capabilities assigned to those components.

SoSE Process Transforms the Stakeholders' Goals into a Balanced SoS/System Architecture Model

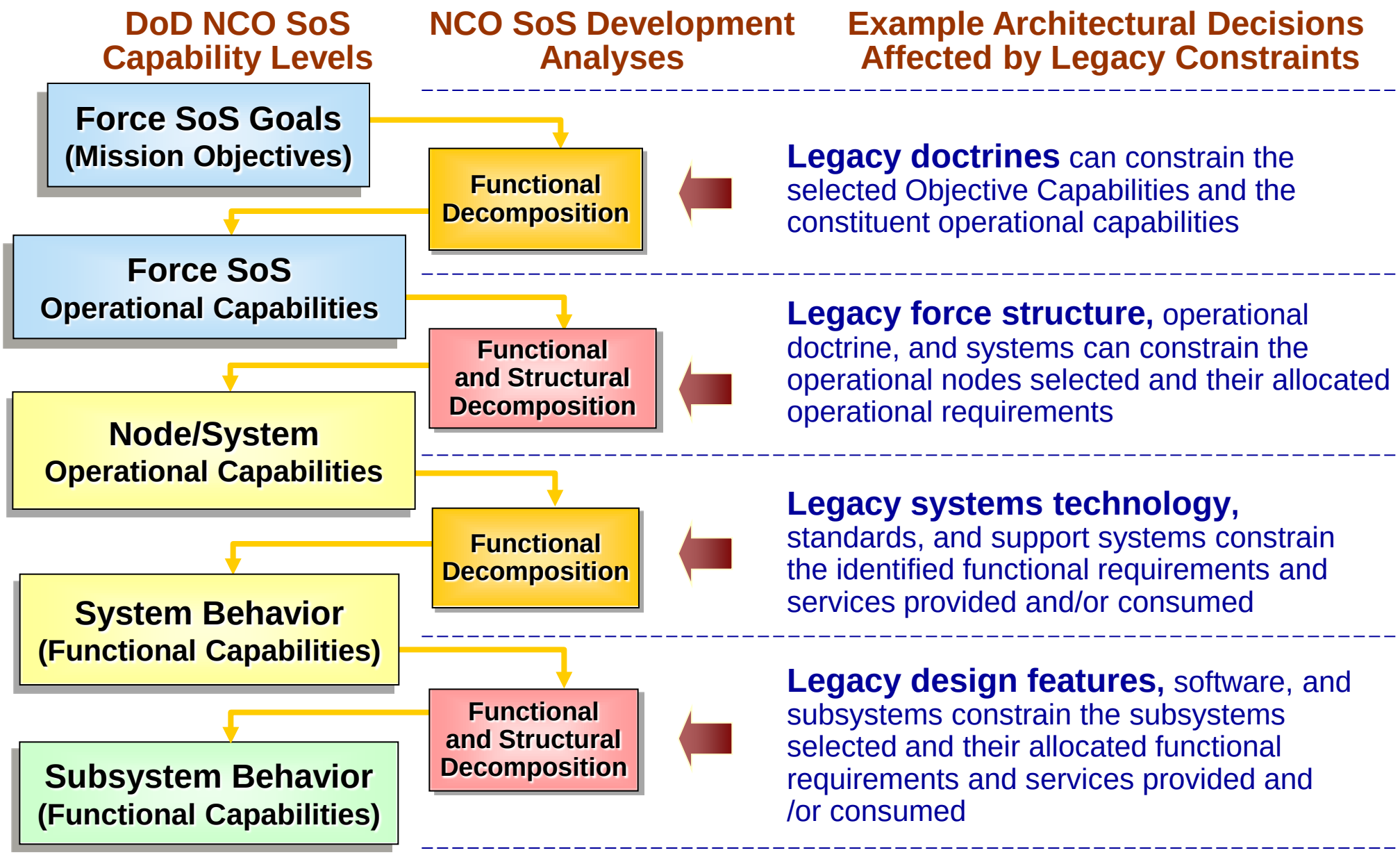


SoSE Architecture Model Includes Required Architectural Levels of Commercial and/or Government NCO SoS/Systems

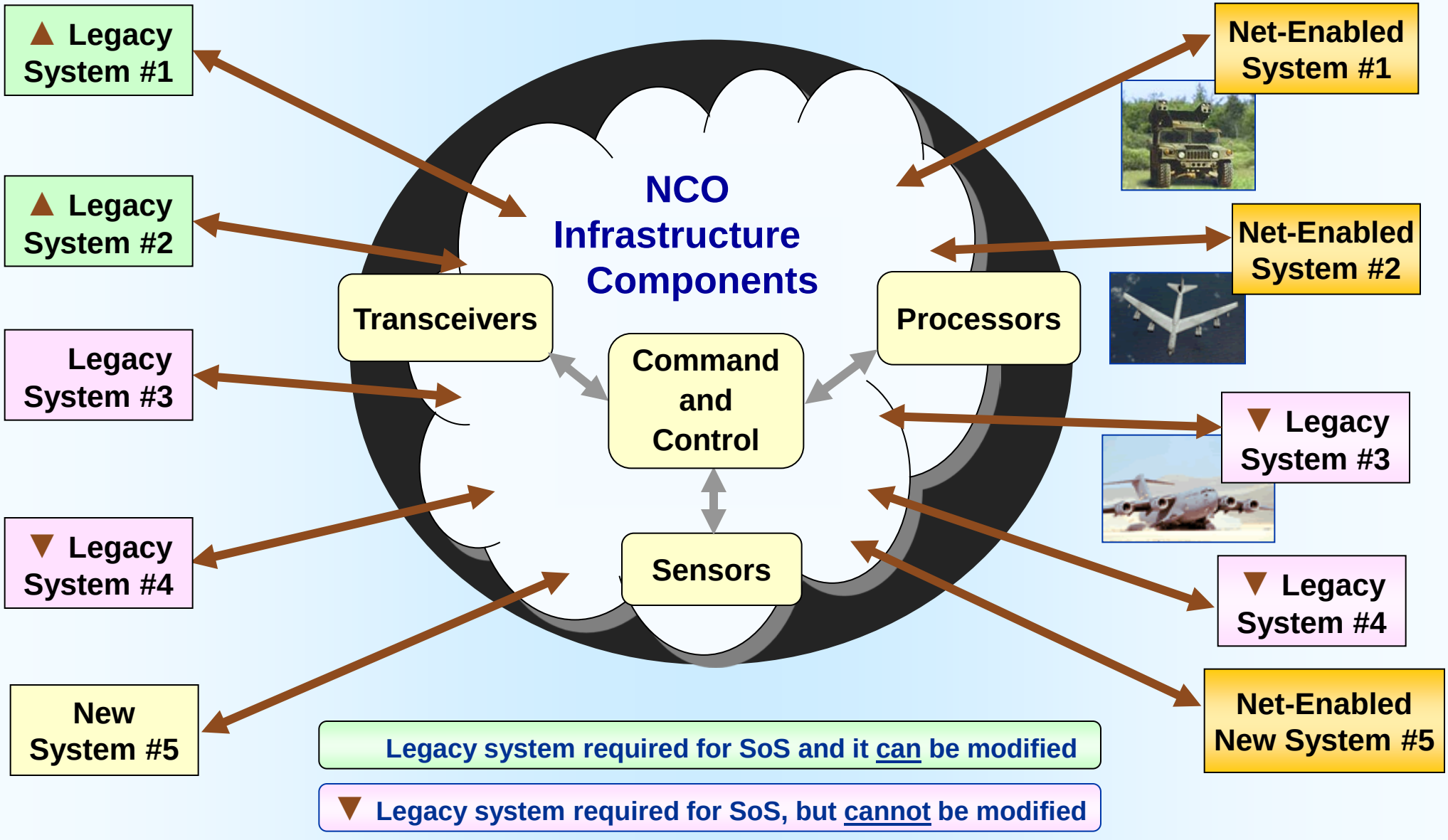


SoSE Operational Approach Supports all Commercial and/or Government Missions

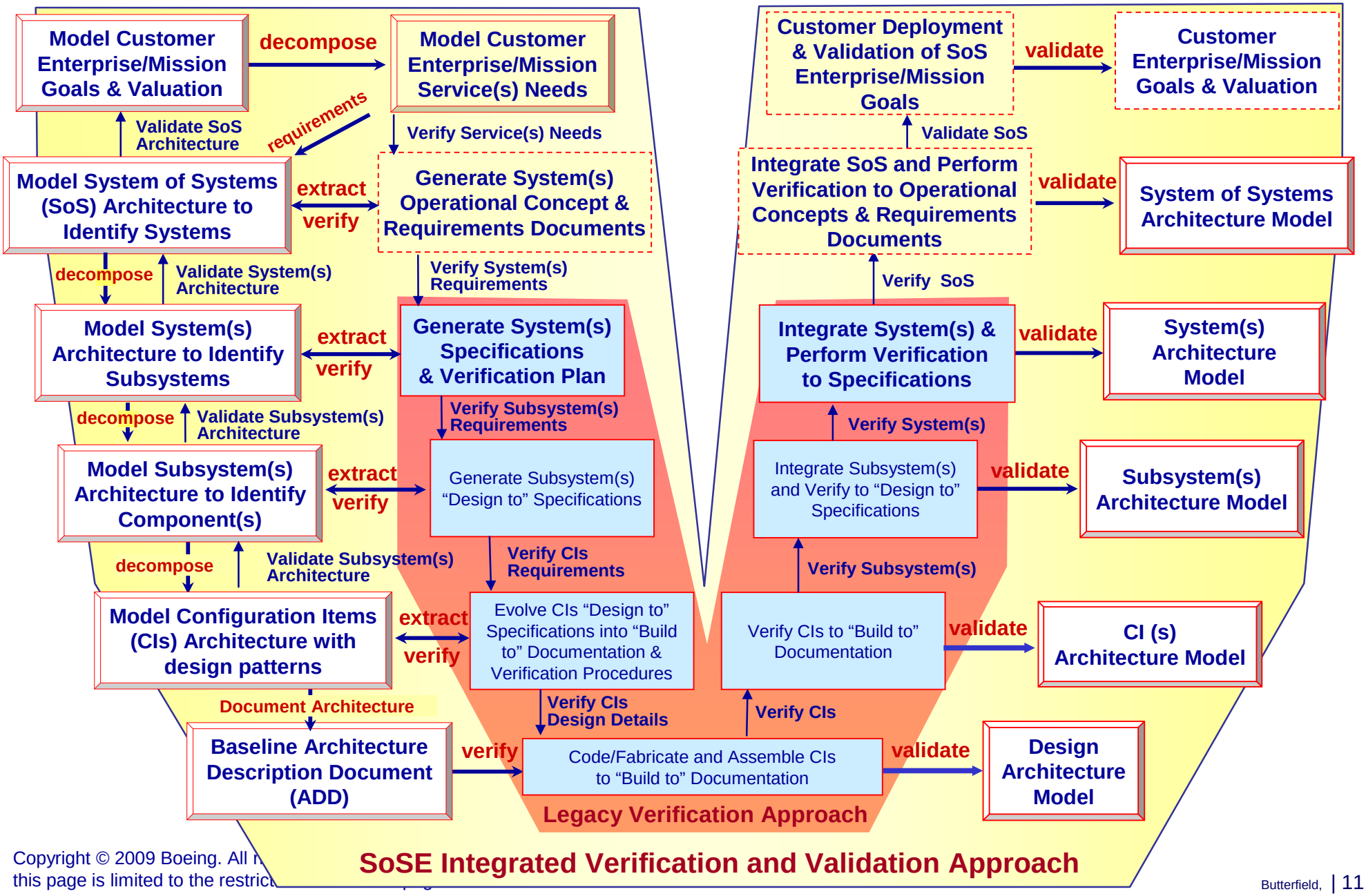
Legacy Constraints Can Drive the SoS Architecture Model at all SoS and/or System Capability Levels



Both New and Legacy Systems are Expected to be used to Develop Net-Centric Systems of Systems



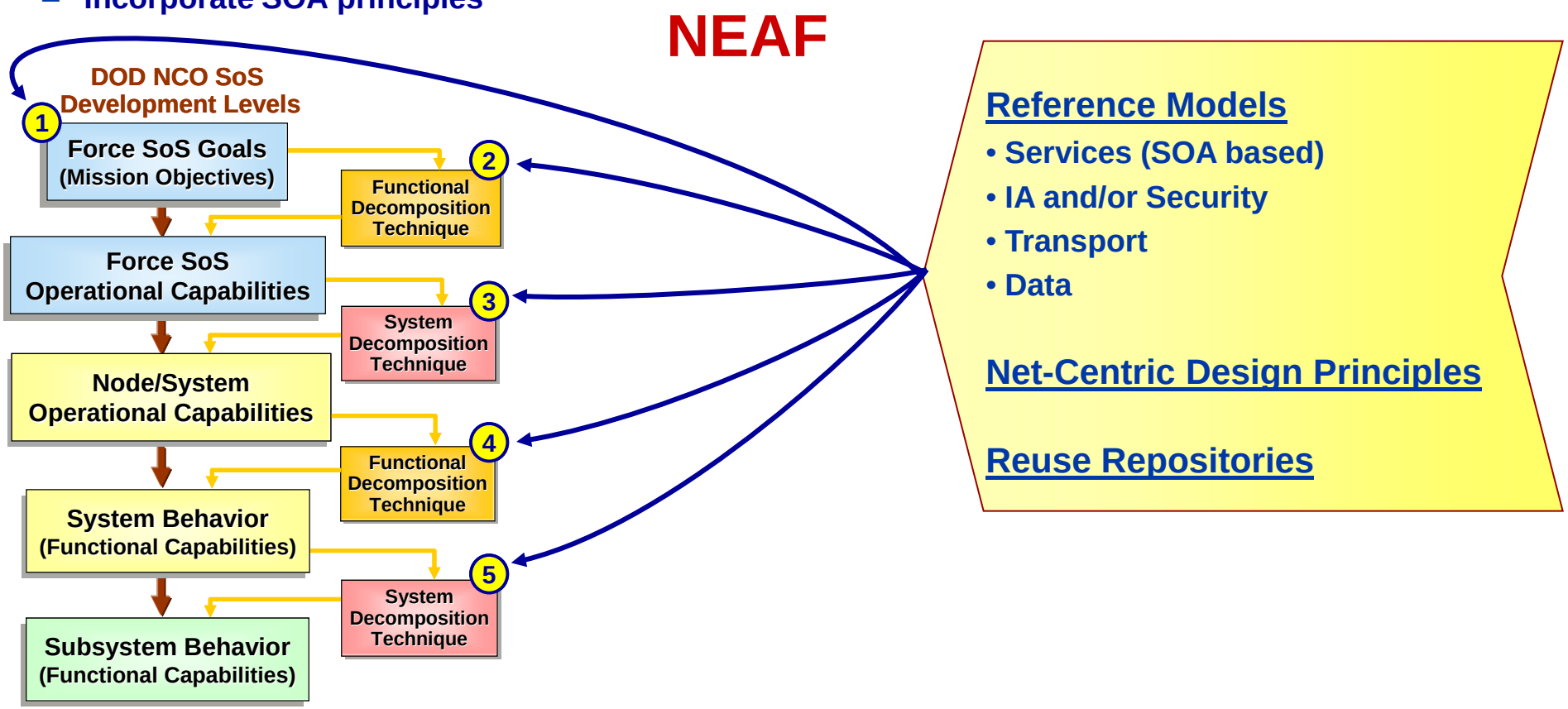
SoSE Architecture-Centric Approach Extends Legacy Methods for Verification & Validation



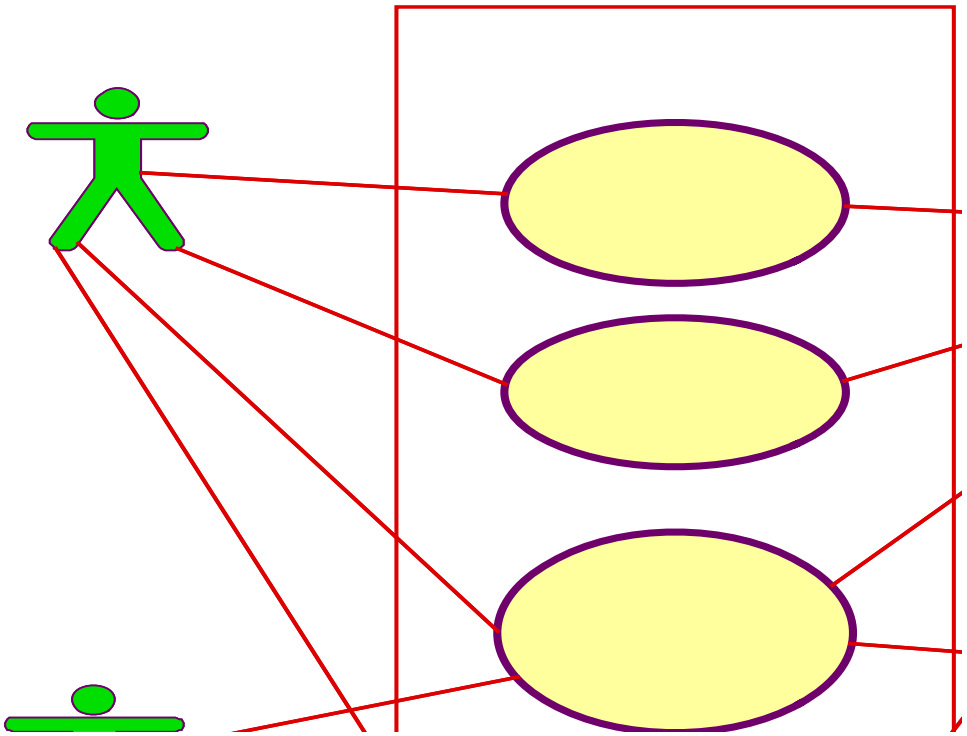
A Net-Enabling Architecture Framework (NEAF) was created to Augment the SoSE Process to Assist Net-Enabling Product Teams

NEAF Provides Product Teams Best-Practices Guidance on how to

- Develop System Architecture models using the Boeing SoSE Process
- Implement Net-Centricity and net-enable systems
- Organize and present the net-enabling aspects of the system architecture
- Develop and use a Net-Enabling Reference Architecture (NERA)
- Incorporate SOA principles



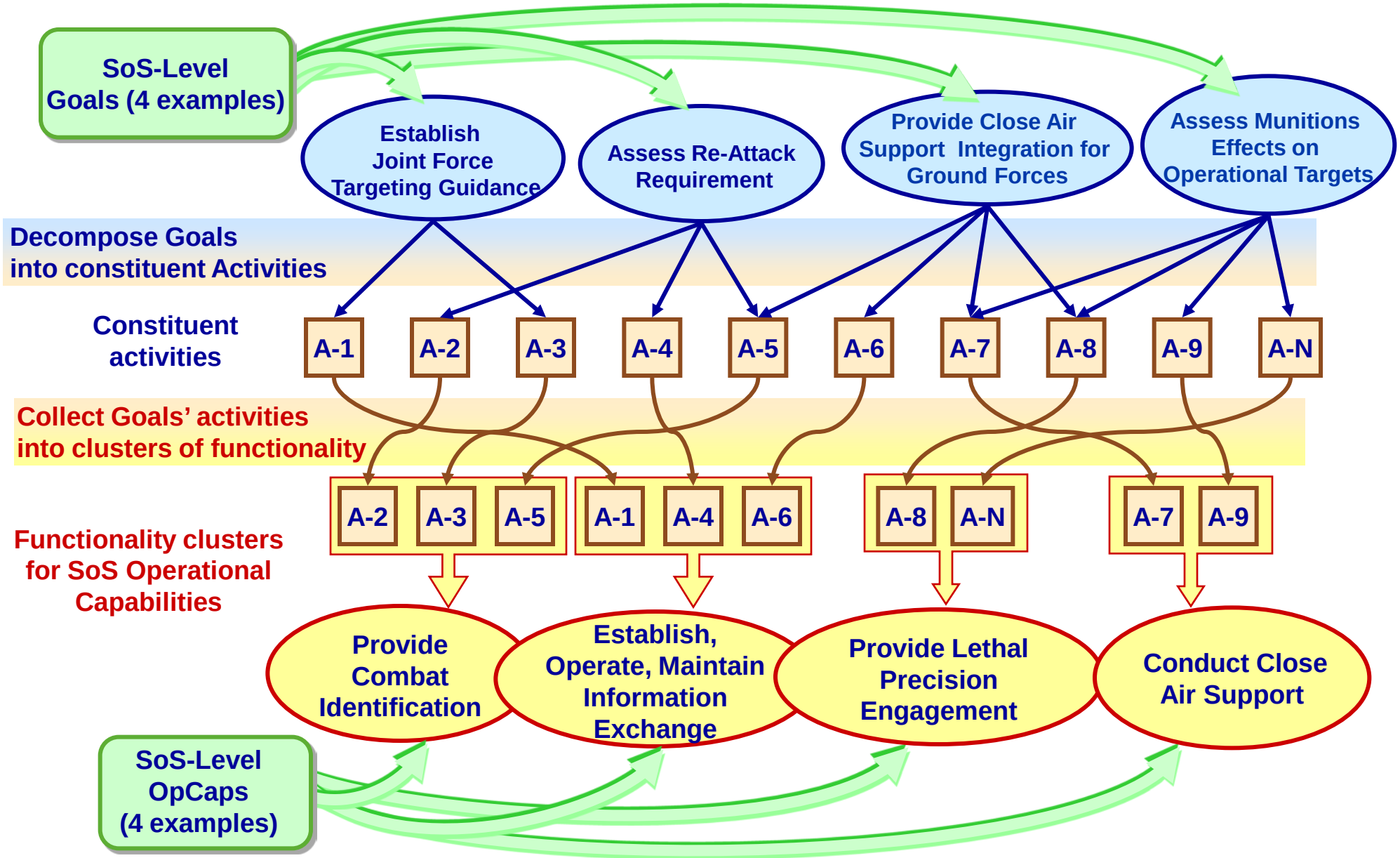
Close Air Support (CAS) Example Use Case Diagram – Enterprise Operational Capability



Example, Notional Scenario

Decompose SoS-Level Goals into SoS Operational Capabilities (OpCap) – CAS Example

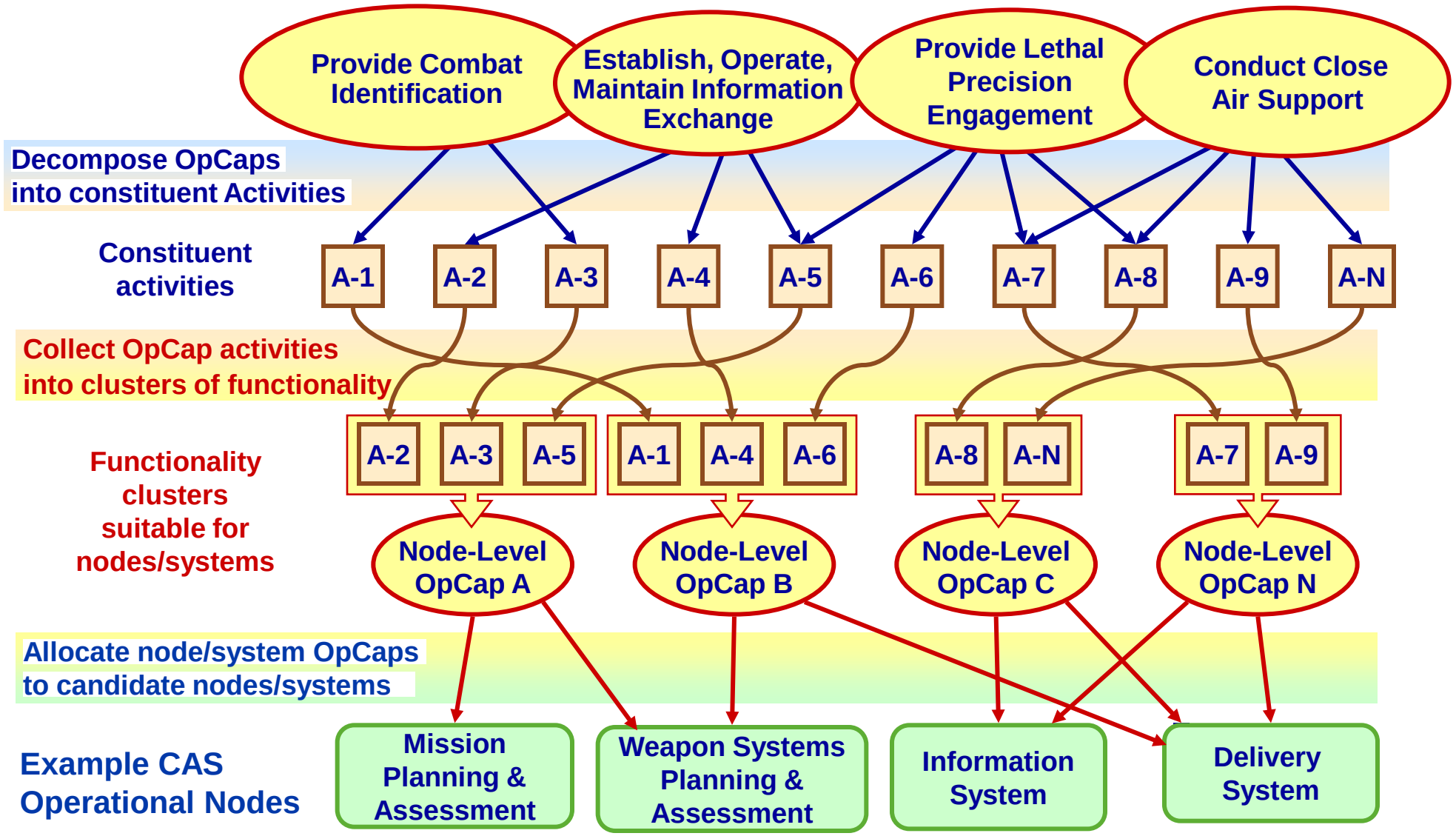
2



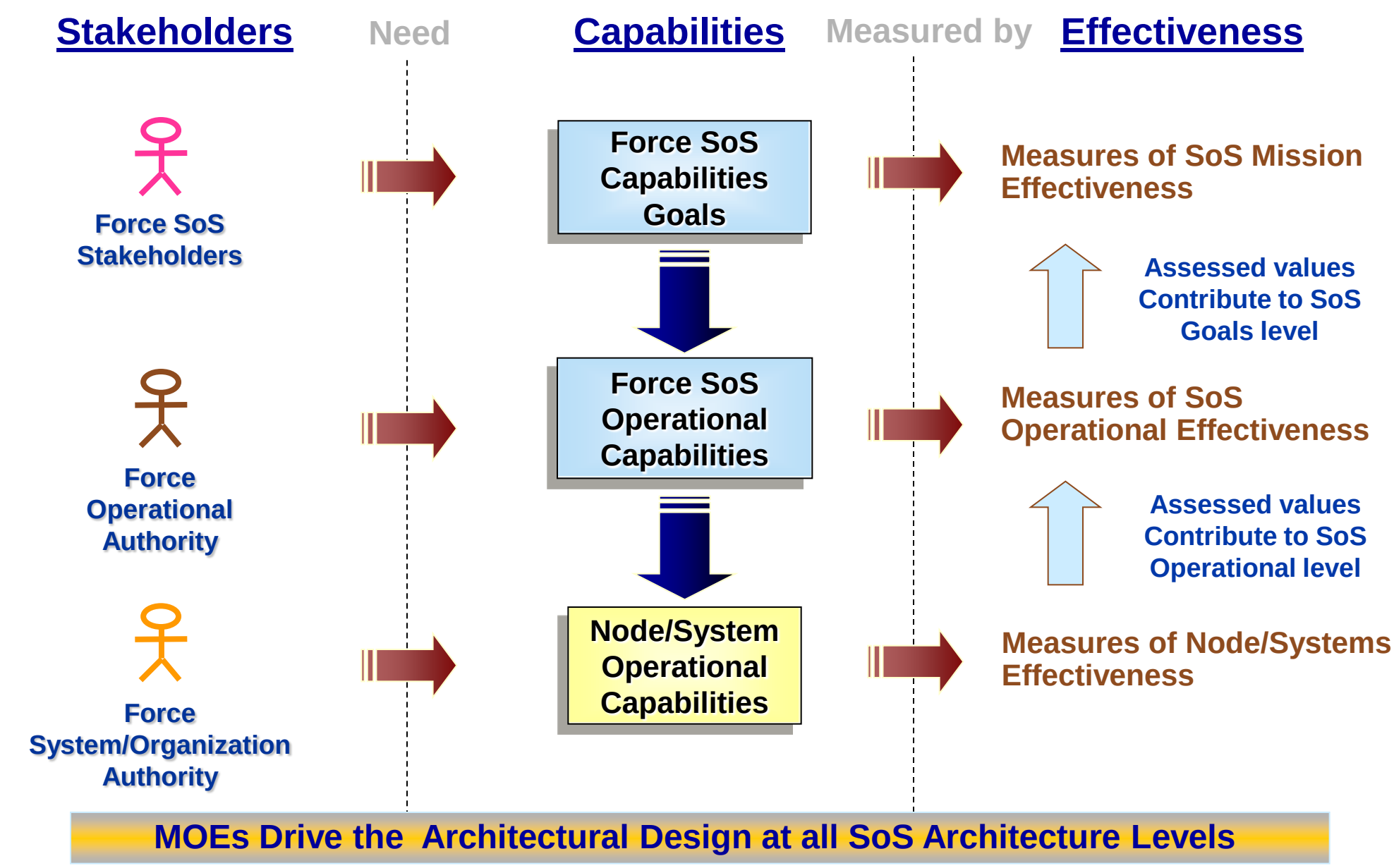
Decompose SoS-Level OpCaps into Node/ System OpCaps – CAS Example Capabilities and Nodes

3

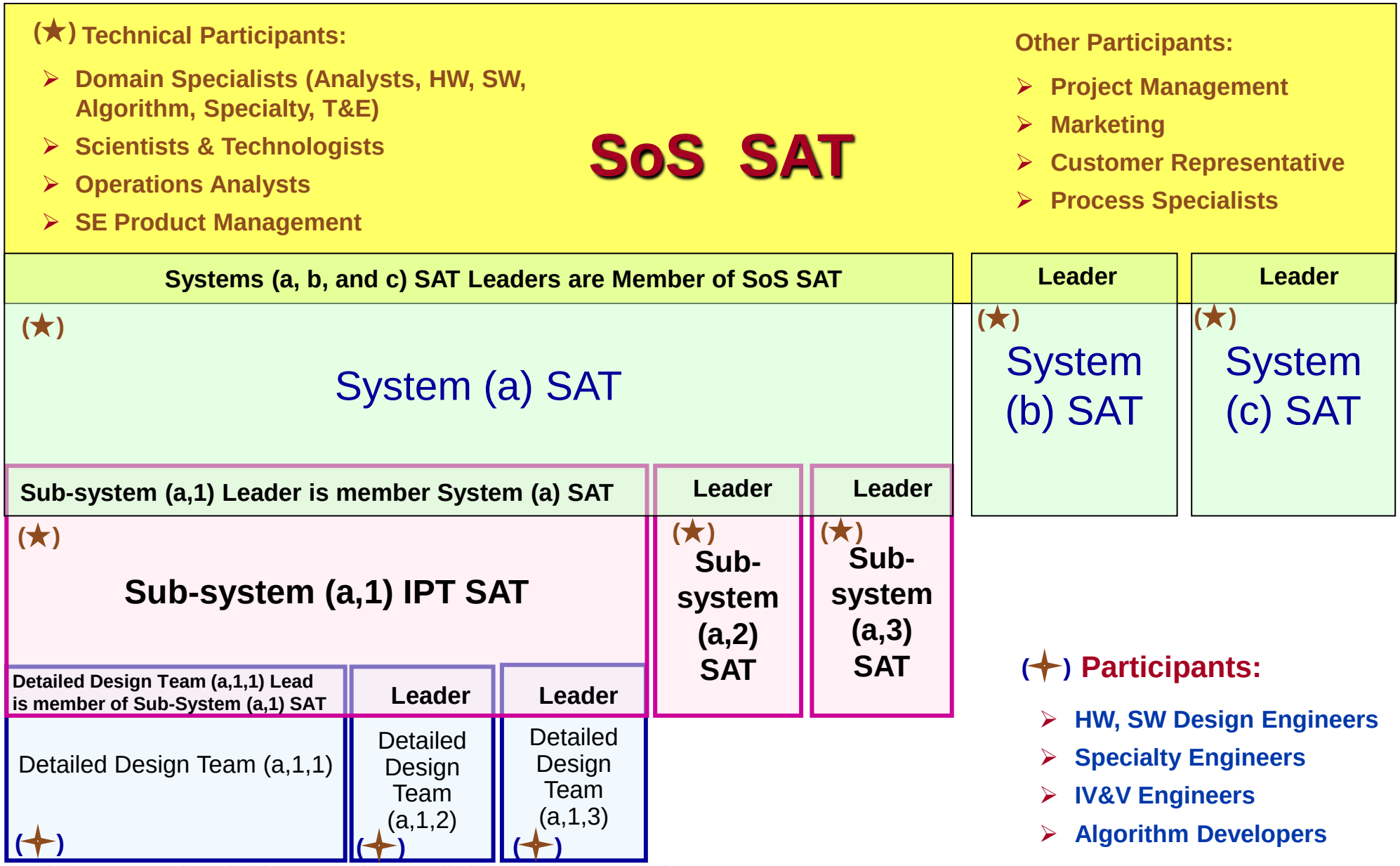
Example CAS SoS-Level Operational Capabilities



Relationship of Force SoS Structure (the "who") to the Force Operational Capabilities (the "need") to Measures of Effectiveness



Program Shared Situational Awareness is Achieved through Interlocking System Architecture Teams (SAT)



Summary

SoSE **is a systematic and disciplined system engineering process for defining SoS and System capabilities and net-ready compliant architectures; allocating such capabilities to a set of elements: systems and subsystems; and coordinating strategy of design, production, sustainment throughout the life cycle of a system.**

Develops the system architecture model to serve as a single common "Truth" model with the ability to incorporate the design view points of all engineering disciplines and provide architecture "situation awareness" for technical and program leadership

Establishes a "Top-Down" analytical framework for determination of the mission effectiveness for a system of systems

Incorporates open architecture development strategies and techniques and incorporates commercial and/or legacy systems

The system architecture model is the single most important development product of the System Architecture Team

References

- *Net-Centric Checklist, OASD for Networks and Information Integration*, Ver. 2.1.3. 12 May 2004.
- *Net-centric Service Framework*, NIF Ver. 2. NCOIC NIF Working Group. 20 August 2008.
- *Recommended Practice for Architectural Description of Software-Intensive Systems*. ANSI/IEEE-std-1471-2000. date.
- *Reference Architecture for Service Oriented Architecture,* Ver. 1.0. OASIS. 23 April 2008.
- *Network Centric Operations Conceptual Framework*, Ver. 1.0. Prepared for John Garstka, Office of Force Transformation, Evidence Based Research, Inc., November 2003.
- *Overarching Architecture for FMLS 2010 Technical System*. Sweden FMV. LT1K P05-0074. 29 February 2006.