

# SoSECIE Webinar

Welcome to the  
2020 System of Systems Engineering Collaborators  
Information Exchange (SoSECIE)



*We will start at 11AM Eastern Time*

*Skype Meeting +1 (703) 983-2020, 46013573#*

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# NDIA System of Systems SE Committee

- **Mission**

- To provide a forum where government, industry, and academia can share lessons learned, promote best practices, address issues, and advocate systems engineering for Systems of Systems (SoS)
- To identify successful strategies for applying systems engineering principles to systems engineering of SoS

- **Operating Practices**

- Face to face and virtual SoS Committee meetings are held in conjunction with NDIA SE Division meetings that occur in February, April, June, and August

# Simple Rules of Engagement

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- If you need to contact me during the briefing, send me an e-mail at [sosecie@mitre.org](mailto:sosecie@mitre.org).
- Download the presentation so you can follow along on your own
- We will hold all questions until the end:
  - I will start with questions submitted online via the CHAT window in Skype.
  - I will then take questions via telephone; State your name, organization, and question clearly.
- If a question requires more discussion, the speaker(s) contact info is in the brief.

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# **2020-2021 System of Systems Engineering Collaborators Information Exchange Webinars**

*Sponsored by MITRE and NDIA SE Division*

**September 8, 2020**

***A System-of-Systems Approach to Optimize a Real-time Risk Situational  
Awareness System***

*Dr. Cihan Dagli and Yu Li*

**September 22, 2020**

***SoS Meta-Architecture Selection for Infrastructure Inspection System Using  
Aerial Drones***

*Dr. Cihan Dagli and Muhammad Monjurul Karim*

**October 6, 2020**

***A System-of-Systems Approach to Optimize a Real-time Risk Situational  
Awareness System***

*Dr. Flavio Oquendo*

**October 20, 2020**

***Situation Awareness and Decision Making for Constituent Systems***

*Dr. Pontus Svenson and Dr. Jakob Axelsson*

**November 3, 2020**

***Challenges for System of Systems in the Agriculture Application Domain***

*Dr. Benjamin Weinert and Dr. Mathias Uslar*



# Addressing Mission Engineering from a Lead Systems Integration Perspective

Presented to  
System of System Engineering Community Information Exchange  
July 28<sup>th</sup>, 2020

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  - Ms. Jamelaa Jones - Naval Undersea Warfare Center Division Newport
  - Mr. Prasanth Kamarsu - Naval Air Warfare Training Center Systems Division
  - Ms. Truc Lee - Marine Corps Systems Command
  - Mr. Oscar Pineiro - Naval Undersea Warfare Center Division Newport
  - Mr. Anthony Pratley – Naval Air Systems Command
  - Ms. Jodie Streeter - Naval Information Warfare Center Pacific
  - Mr. Luis Velazquez - Marine Corps Systems Command

# Background

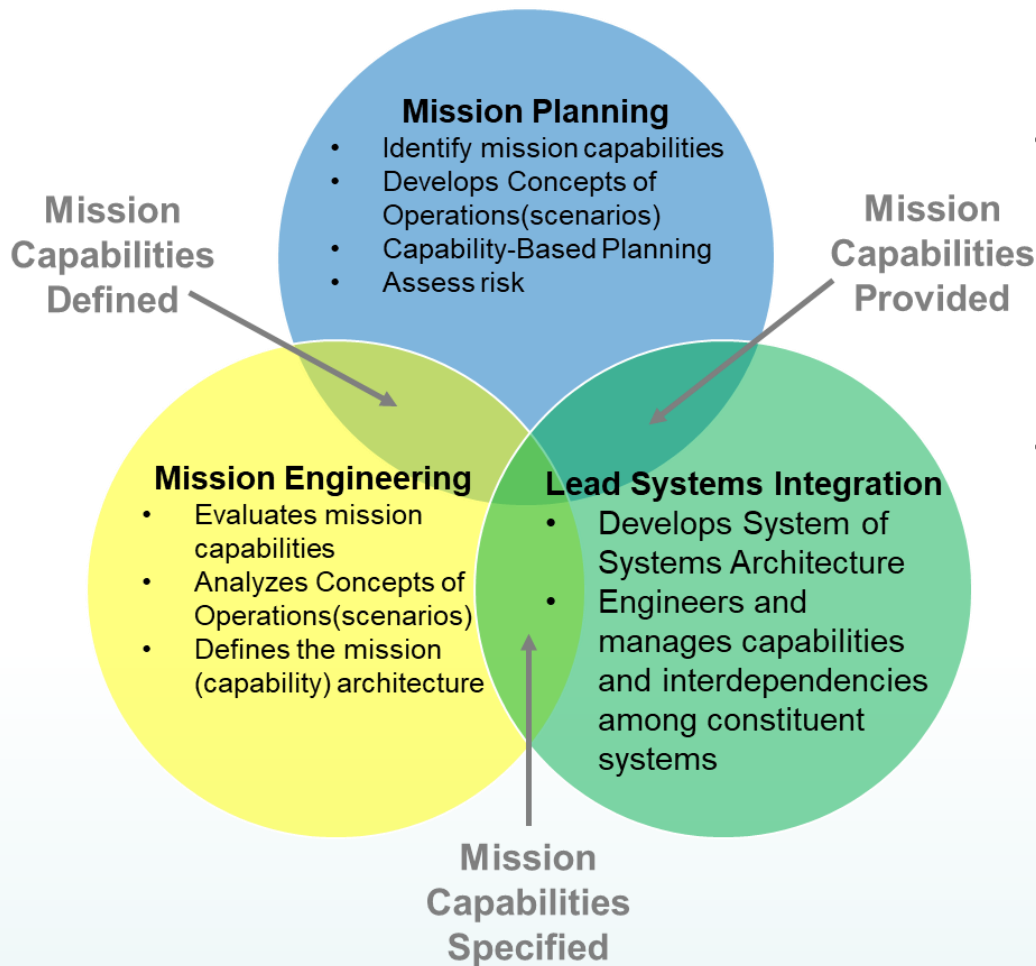
- Mission success requires a careful orchestration between mission planning, engineering, and analysis of the mission, and an acquisition strategy that acquires systems, and assembles system of systems for mission-capability satisfaction.
- The challenge is to develop an enterprise framework that demonstrates continuity of mission capabilities from the Strategic Objectives and Policies to the individual platforms.



**Accomplishing a mission has always been a SoS endeavor, but “knitting” the multiple systems together has frequently been left to small communities of systems or to the operators themselves.**

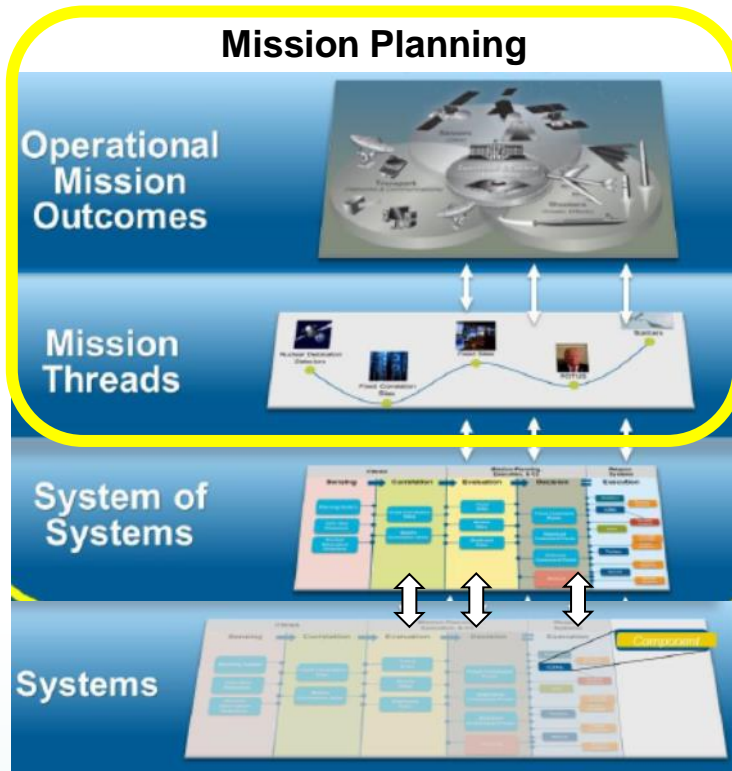


# Commonality Among Mission-Based Disciplines



- Address the problem from a mission (capability-based) perspective.
- System of Systems is fundamental to mission operations and ultimately achieving mission success.

# Mission Planning



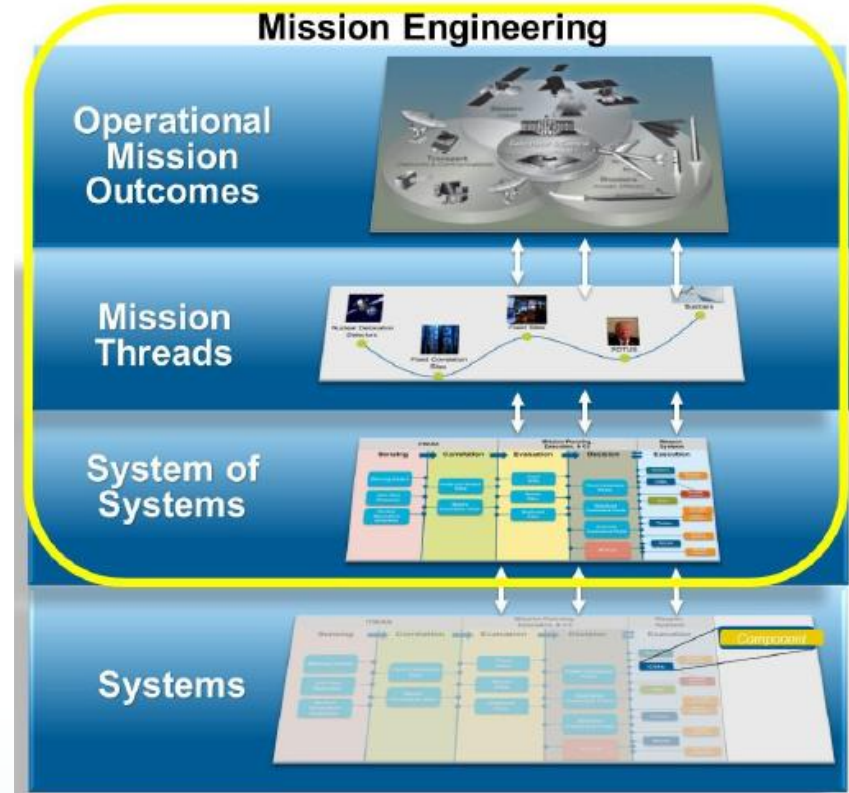
- Describes a method for employing joint (or single service) mission capabilities to achieve a stated objective within the context of a specified operating environment or against specified force challenges.
- Iterative design process that includes:
  - Mission Analysis
  - Course of Action (COA) Development
  - COA Comparison and Analysis
  - COA Determination and Approval
  - Orders Production

***Planning is the art and science of envisioning a desired future and laying out effective ways of bringing it about.***

- Marine Corps Doctrinal Publication (MCDP) 5, Planning

# Mission Engineering

- Mission engineering treats the end-to-end mission as the system.
- Mission engineering addresses the system of systems (SoS) in the mission context.
  - Cross cutting functions
  - End-to-end control
  - Trades across systems

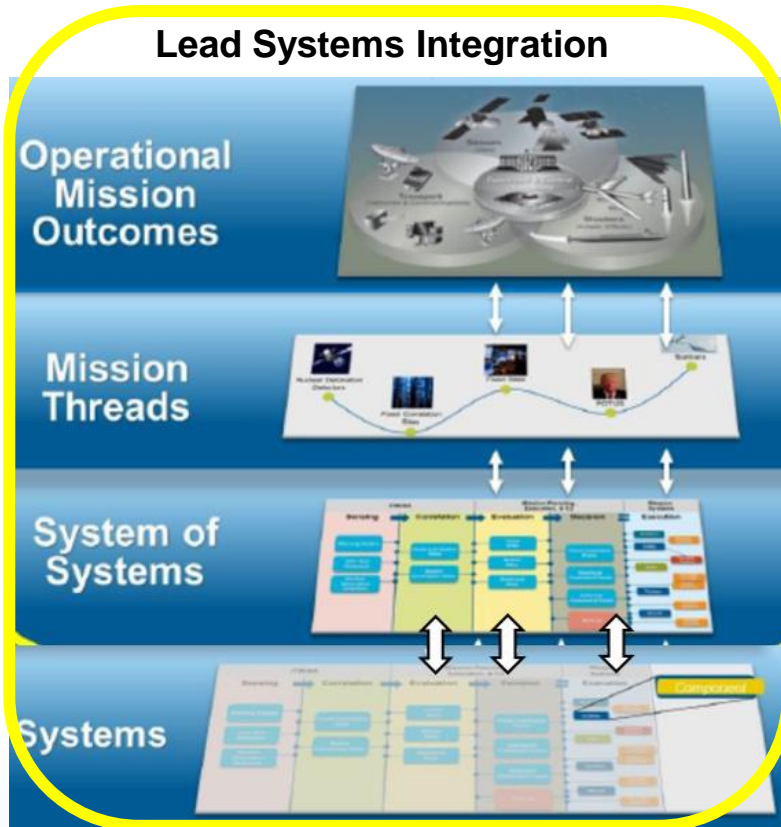


Reference: Dahmann, J., S. Doskey, and A. Tolk (April 21, 2020). Mission Engineering, Systems Engineering and Systems of Systems Engineering.

***Mission engineering is the deliberate planning, analyzing, organizing, and integrating of current operational and system capabilities to achieve desired mission effects.***

- Gould 2016

# Lead Systems Integration (LSI)

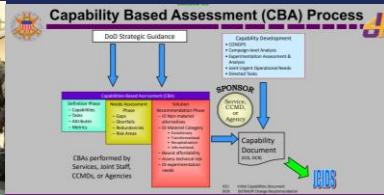


- Directed by Congress in 2008 Public Law 110-18.
- Assert and execute system, SoS, and stakeholder trade space to affordably optimize a collection of interoperable platforms and nodes acting as a single system to achieve a mission capability.

***Lead Systems Integration*** – An acquisition strategy that employs a series of methods, practices, and principles to increase the span of both management and engineering acquisition authority and control to acquire system of systems or highly complex systems.



# Intersection of Mission-Based Disciplines



**Mission Capabilities Defined**

## Mission Planning

- Identify mission capabilities
- Develops Concepts of Operations(scenarios)
- Capability-Based Planning
- Assess risk

**Mission Capabilities Provided**

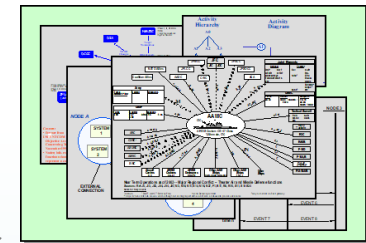
## Mission Engineering

- Evaluates mission capabilities
- Analyzes Concepts of Operations(scenarios)
- Defines the mission (capability) architecture

## Lead Systems Integration

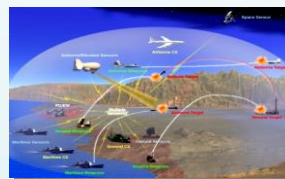
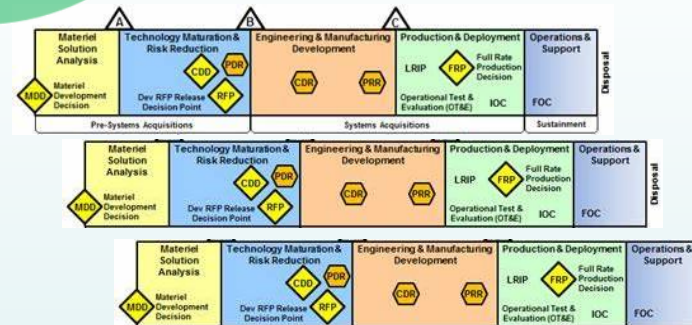
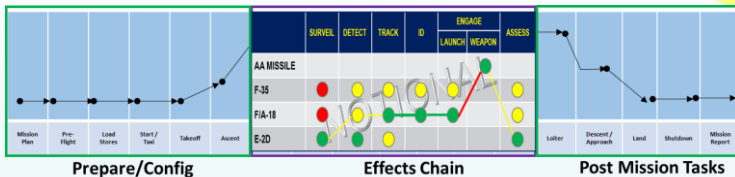
- Develops System of Systems Architecture
- Engineers and manages capabilities and interdependencies among constituent systems

**Mission Capabilities Specified**



**Operational Plans**

**Initial Capabilities Description**

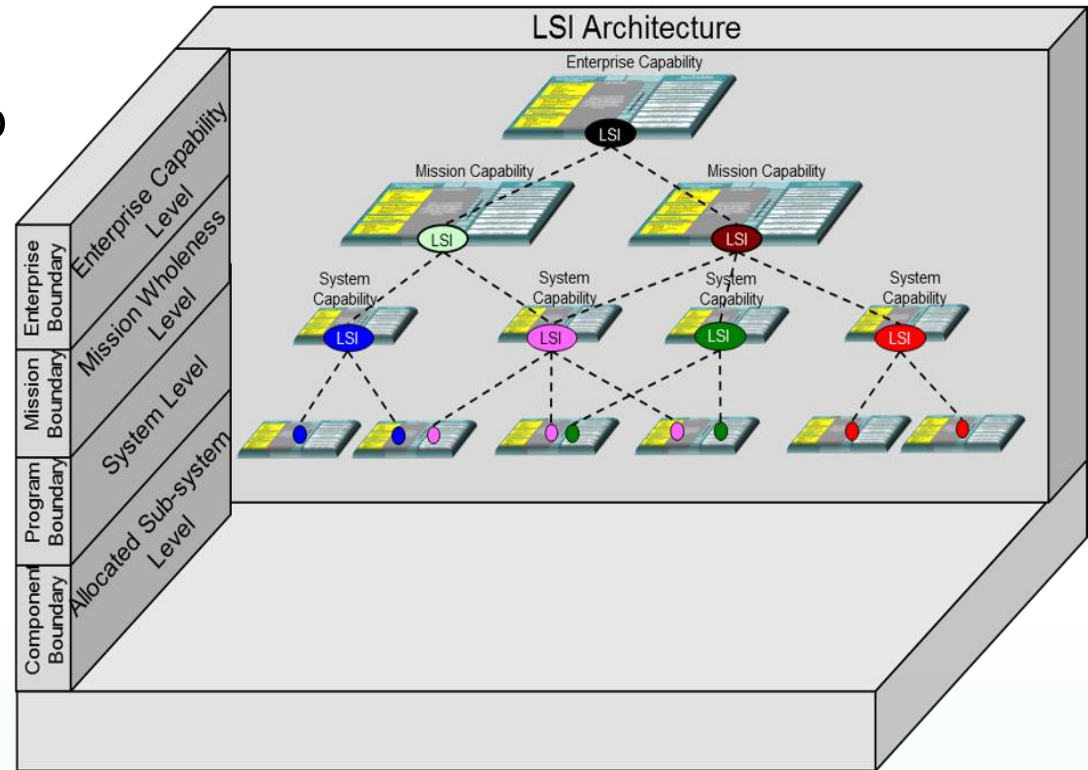


**SoS Capability Development Document**

# LSI Enterprise Framework

## LSI Enterprise Framework

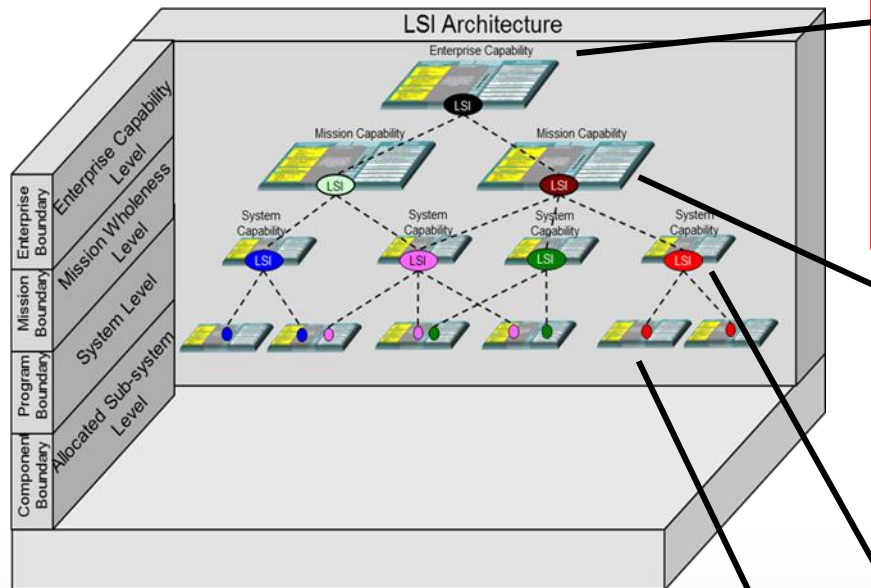
- Provides a framework to identify and manage stakeholders both horizontally and vertically
- The framework spans four levels
  - ❖ Enterprise Capability Level
  - ❖ Mission Wholeness Level
  - ❖ System Level
  - ❖ Allocated Sub-system Level



**Mission success requires analysis at several level of the LSI Architecture simultaneously.**

# Ten Layers within the Four LSI Enterprise Levels

- The LSI Framework contains a ten-layer model within the four enterprise levels.



- The **LSI Framework** provides the decomposition from strategy to system elements to analyze mission success.

## 10. Strategic Objectives and Policies

- Top-level strategic guidance

## 9. Enterprise Mission Area

- Mission Areas

## 8. Enterprise Mission Threads

- Mission scenarios

## 7. Enterprise Mission Tasks

- Universal Tasks required to accomplish the mission

## 6. SoS Mission Operations

- System of Systems Concept of Employment

## 5. SoS Mission Structures

- Structure of platforms and systems that comprise the SoS

## 4. Platforms

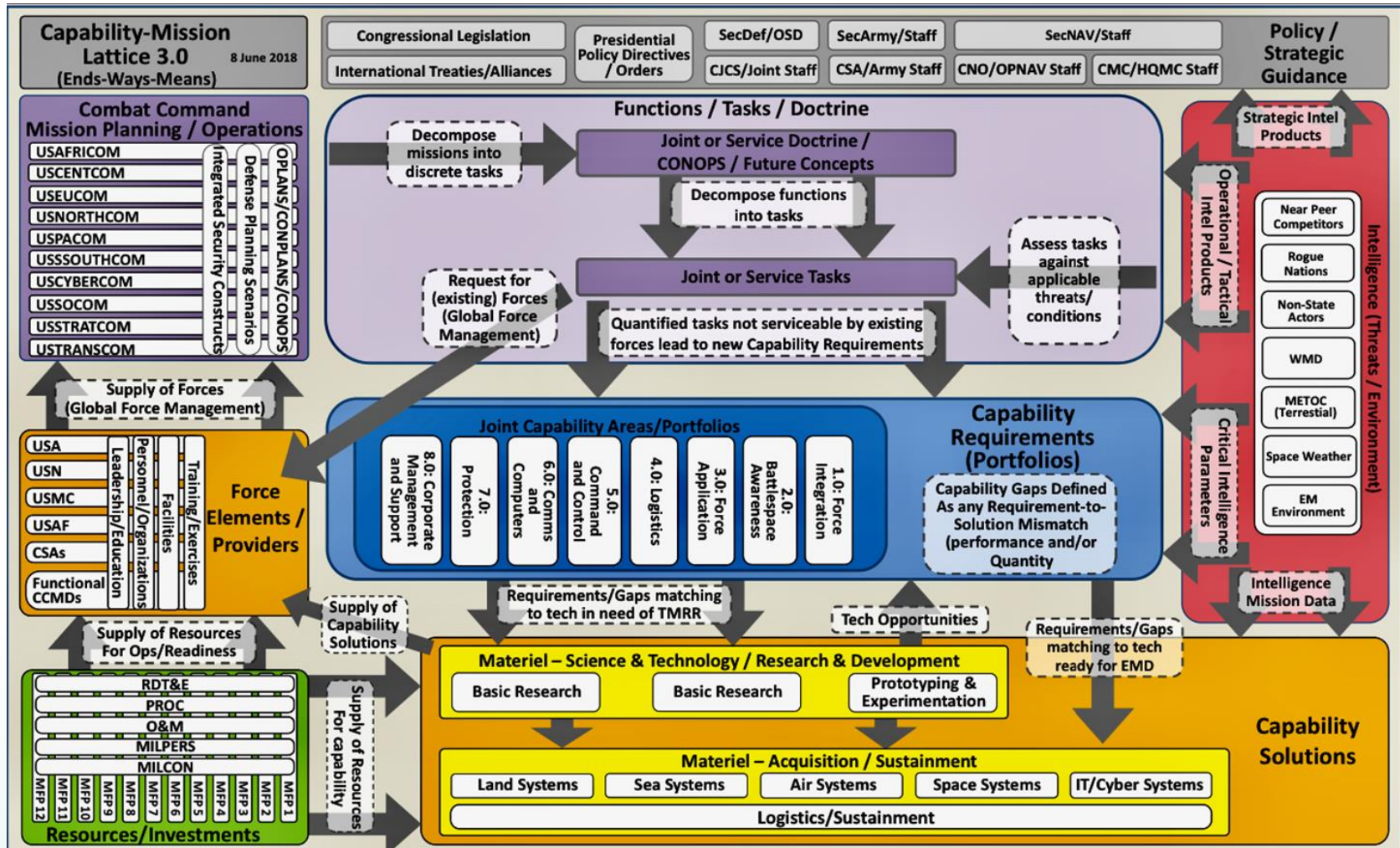
## 3. Systems

## 2. Sub-Systems

## 1. Assemblies and Components



# Capability-Mission Lattice



The **Capability-Mission Lattice** is used as an integrating construct for identification of capability requirements and the development of capability solutions.



# LSI Framework + Capability-Mission Lattice

## Enterprise Capability Level

10. Strategic Objectives and Policies

9. Enterprise Mission Area

8. Enterprise Mission Threads

7. Enterprise Mission Capabilities

## Mission Wholeness Level

6. SoS Mission Operations

5. SoS Mission Structures

## Program/System Level

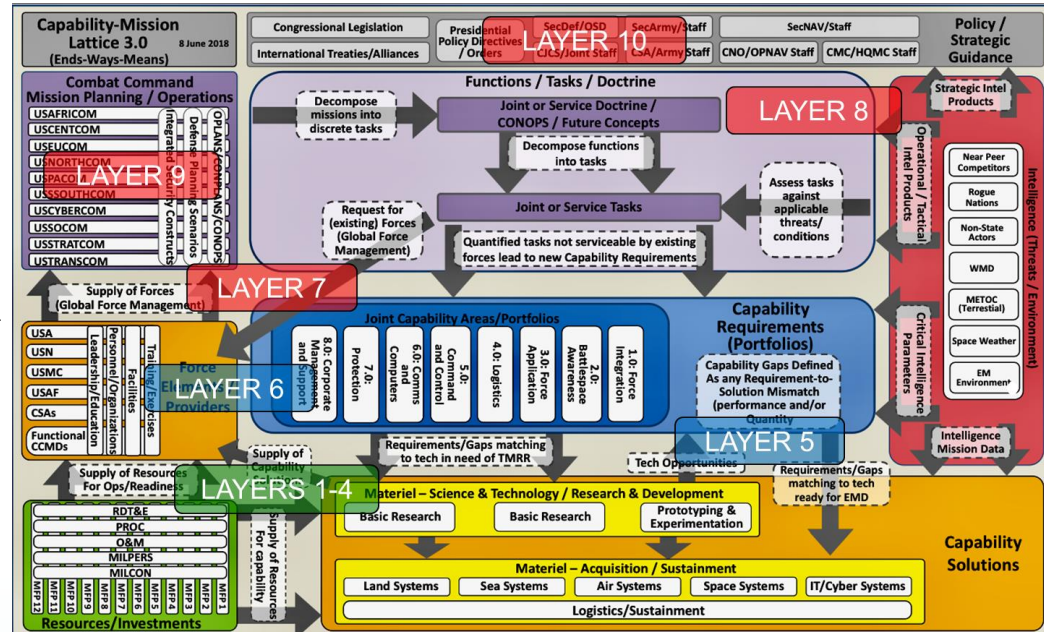
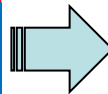
4. Platforms

3. Systems

## Allocated Sub-System Level

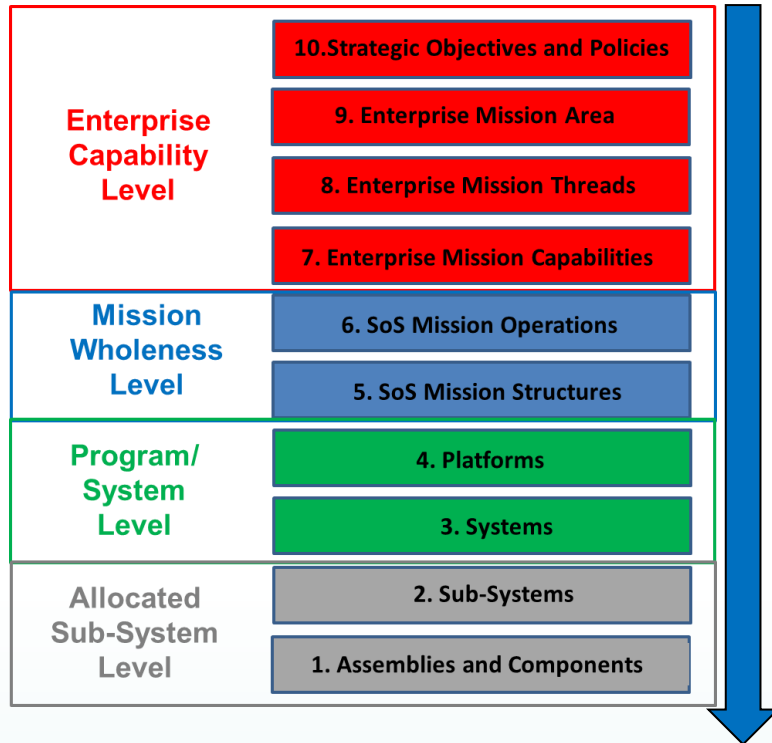
2. Sub-Systems

1. Assemblies and Components



The combination of the Framework and the Capability-Mission Lattice provides a roadmap of how strategies are implemented.

# Uses of The LSI Enterprise Framework

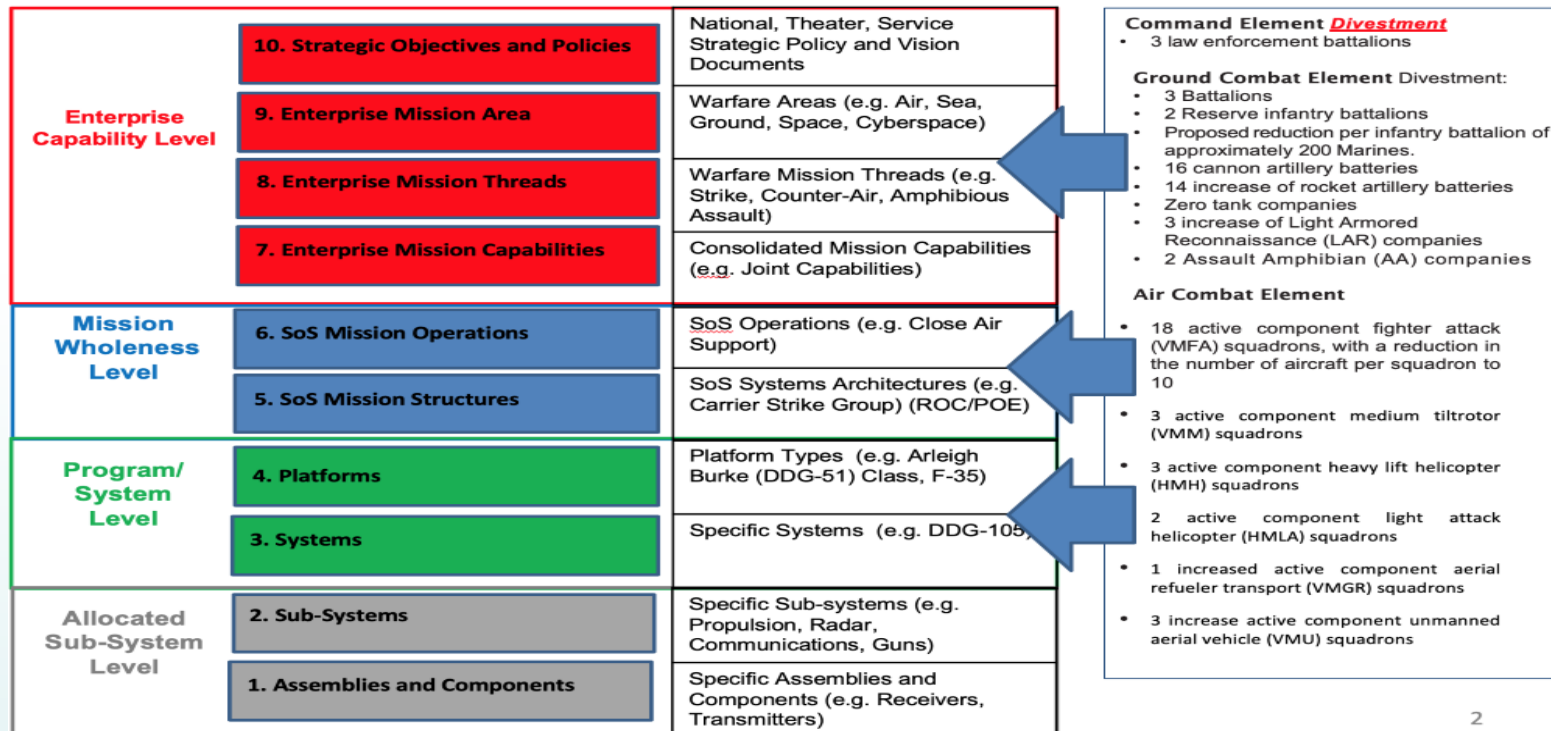


- Testing that mission-capability needs adequately support the strategic objectives.
- Ensure the strategic objectives, policies, and guidance are supported by the current, or future, portfolio of systems.
- Assist in making prioritization and budget decisions.
- Identify enterprise capabilities that are not being addressed or are overly addressed.
- Identifies technological trends and outliers.
- Identifies functions, systems, and services that exist within the Enterprise.

# Application

## Marine Corps Force Design 2030

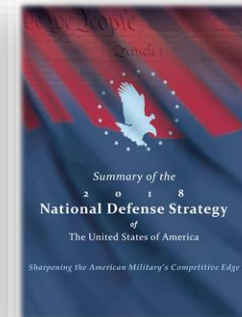
- LSI Enterprise Framework can help determine the best means of reducing infantry battalions while proportionally reducing the organizations dedicated to supporting these battalions.
  - There is an assumption that the Marine Corps will not receive additional resources in the out-years.
  - The Marine Corps must divest certain existing capabilities and capacities to free resources for essential new capabilities.



# Summary

## *The LSI Enterprise Framework: A potential Government LSI enabler to “think and act differently”*

- The LSI Enterprise Framework can be used to show the continuity of mission-capabilities from strategic objectives to individual systems.
- The framework will assist the Resource Sponsor with portfolio management (top-down perspective).
- The framework will aid the program level LSI with requirements discovery and mission level insights (bottom-up perspective).







# NAVAL POSTGRADUATE SCHOOL

## SYSTEMS ENGINEERING

EST. 2002

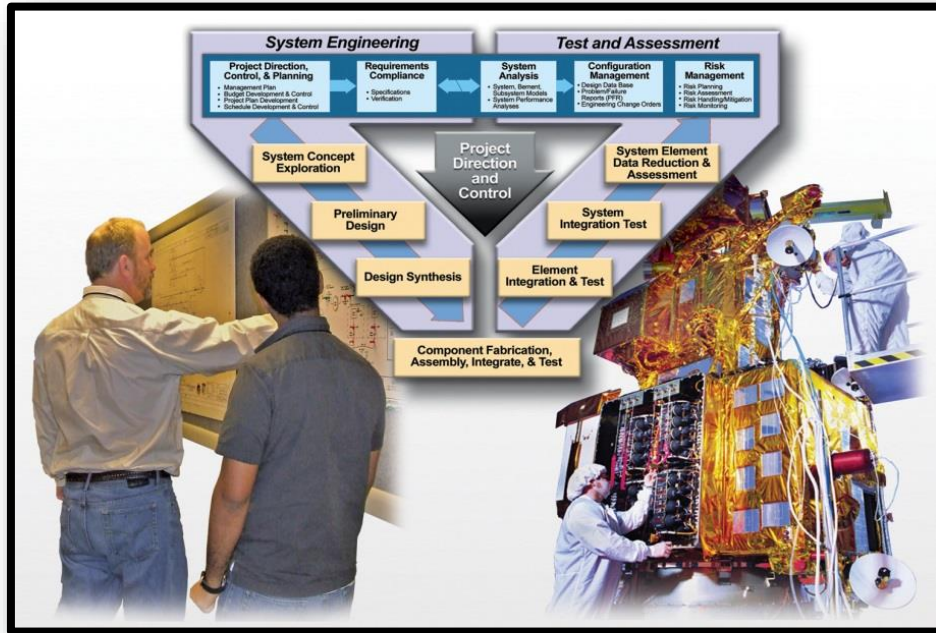




# Lead Systems Integration Supplemental

# Lead Systems Integration (LSI)

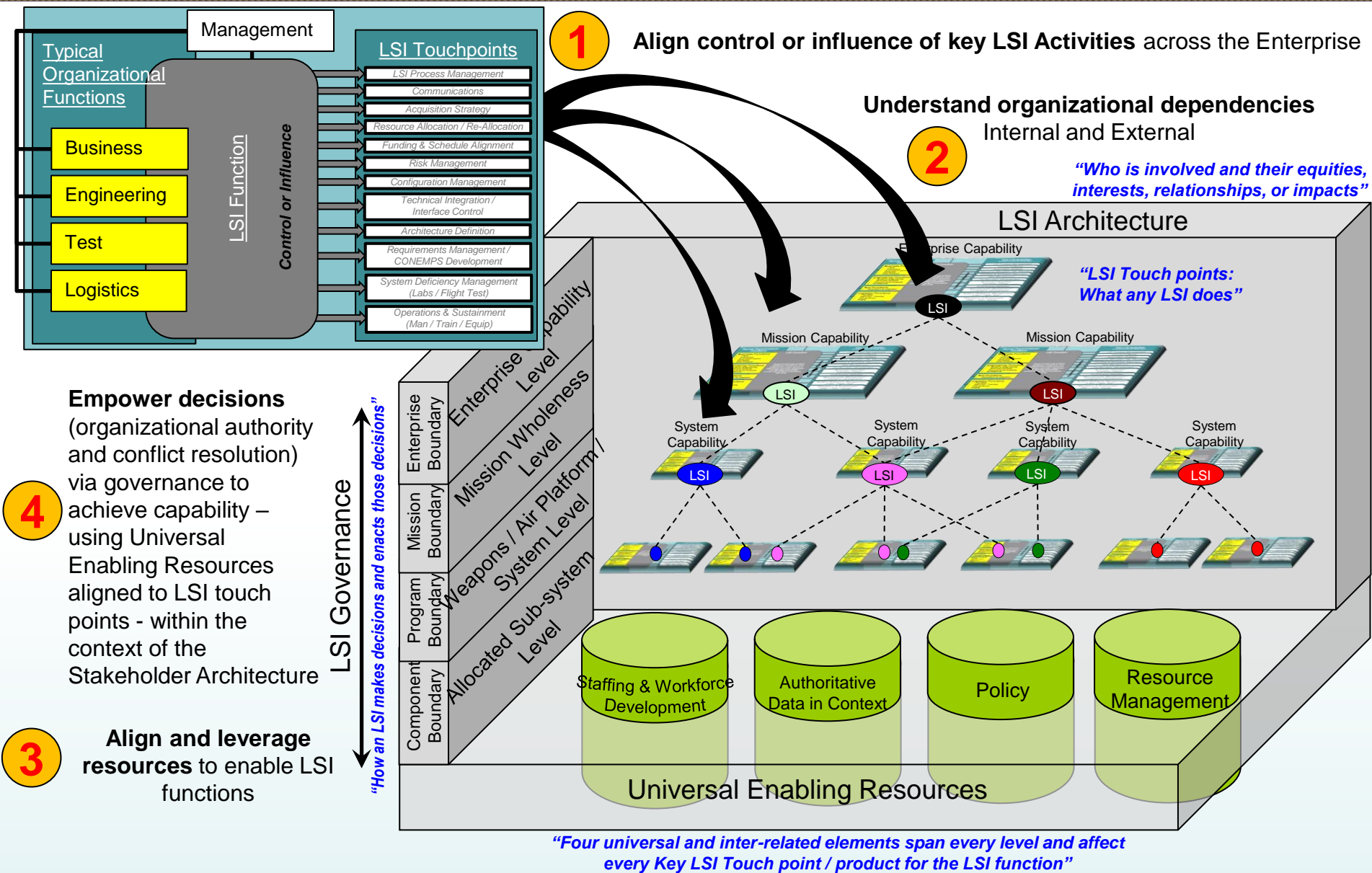
- **LSI Function** - Assert and execute system, SoS, and stakeholder trade space to affordably optimize Integrated Warfighting Capabilities across the SoS lifecycle.
  - The roles of the LSI are similar to the roles of any Systems Engineer (SE) or System Integrator (SI). The primary difference is the span of design and integration authority that persists throughout system or SoS acquisition and lifecycle.



Graphic Source: [www.meicompany.com](http://www.meicompany.com)

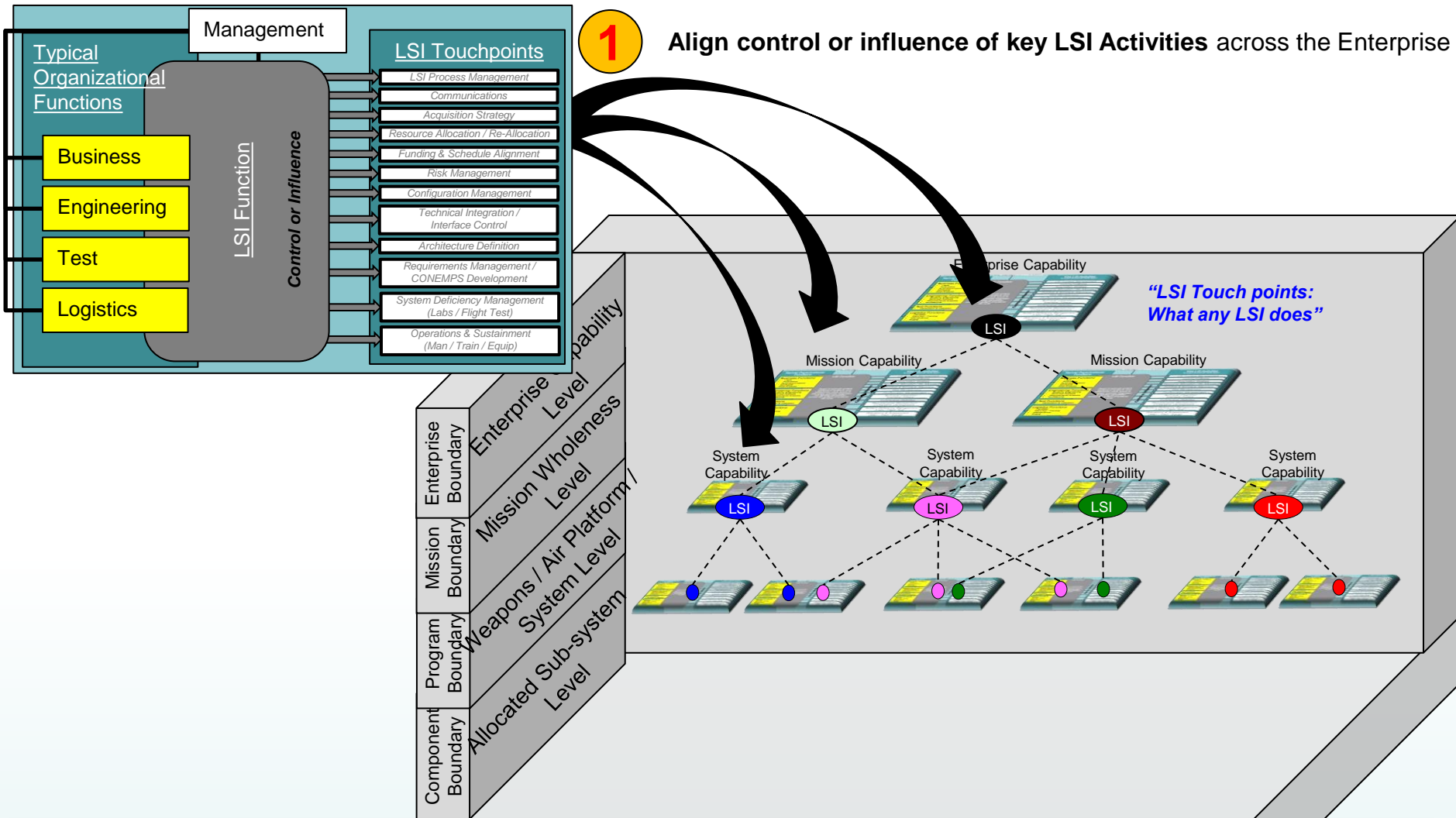
**Key objectives: Affordability; Speed to the Warfighter; Agility; Maximize the Value of Complex Systems.**

# The LSI Enterprise Framework



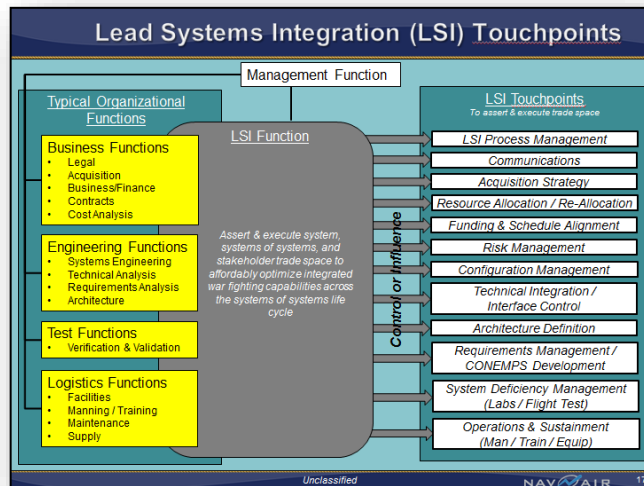


# LSI Touchpoints in the Enterprise LSI Framework

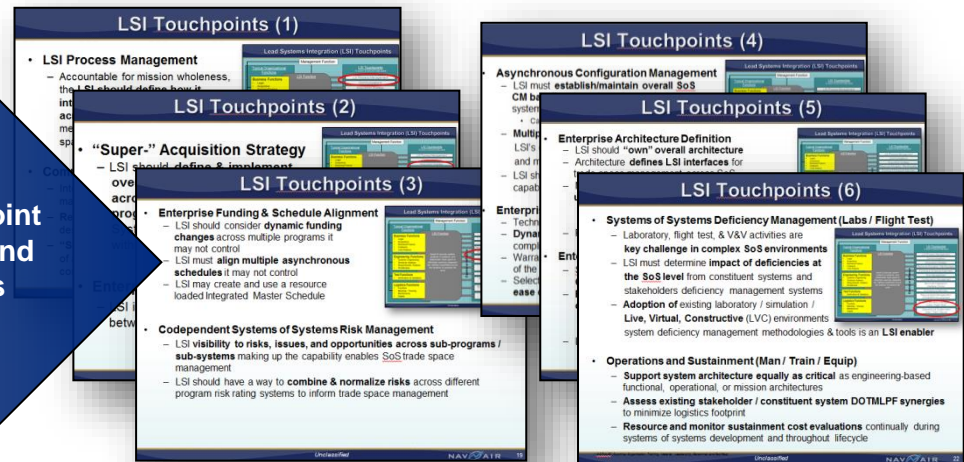


**LSI Touchpoints: highest payoff points of control or influence – aligned across the enterprise**

# Lead Systems Integration (LSI) Touchpoints



## LSI Touchpoint Attributes and Principles



## LSI Touchpoint Methods & Practices: "Roles & Responsibilities"

**LSI Roles and Responsibilities (2)**

Function	LSI Unique role (*)	LSI Touchpoints	Products	Tools
Legal	Similar role as traditional acquisition but with agreements (data rights/licensing) for competing SoS			
Acquisition (PM)	EXPANDED role to embracing a get L Strategy with a identified LSI govt trust and empower team to be actively managing O/S/P trade space SoS at varying act cycles			
BFM	Similar role as traditional acquisition but for SoS budget/fin systems at various phases with diff color/year/amount			

**LSI Roles and Responsibilities (3)**

Function	LSI Unique role (*)	LSI Touchpoints	Products	Tools
Contracts	Similar role as traditional acquisition but for complex and multiple SoS with acquisition phases with different color/year/amount of money			
Cost	Similar role as traditional acquisition but for complex and multiple SoS with acquisition phases with different color/year/amount of money			
Engineering	EXPANDED role from typical T&E Engineer to include multiple SoS Test events using extensive LVC and modeling to capture holistic SoS test results	LSI Process Mgmt, Acq. Strategy, Comm, Resource Allocation, Funding/Schedule, Risk, System Deficiency Management (Labs / Flight Test)	TEMP Test Plan, Test Reports, Live Fire Waiver/report, Interoperability Certification, ISP	MS office, MS Project, DOORS, Risk Exchange, Test TMRT, Report, ePower
Logistics	Similar role as traditional acquisition but for complex SoS which includes multiple systems with various supply, support and training requirements	LSI Process Mgmt, Acq. Strategy, Comm, Resource Allocation, Funding/Schedule, Risk, CM, Ops & Sustainment	Supportability/Analysis Plan, Life Cycle Support Plan	MS office, MS Project, Integrated Data Environment (full access to vendor data), DECKPLATE, Project

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**Multidisciplinary – apply at any “level” of LSI**

**Identifies highest payoff points of LSI control or influence to assert and execute trade space – aligned across the enterprise**

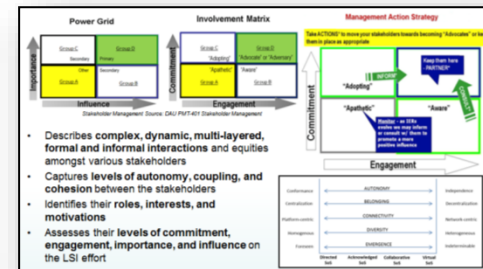
**Enables organizational agility**

# LSI Architecture Core Elements

- Stakeholder Definition / Characterization
  - Define and characterize all stakeholders via PMT-401 stakeholder analysis matrix and SoS coupling/cohesion analysis
- Stakeholder “Physical Architecture” model
  - Aggregation of static organizational charts which define levels of formalized / administrative stakeholder interactions & empowerment
- Stakeholder “Functional Architecture” model
  - Dynamic Systems model that aggregates actual stakeholder interactions and data flows
- Stakeholder “Process Model”
  - Enables governance framework, processes, and adjudication methods
  - Includes layered enterprise coordination/communication strategy, “battle rhythm,” and LSI “control” or “influence” touchpoints
- Stakeholder Charter
  - Defines roles/responsibilities to enable enterprise governance decisions within the Enterprise LSI Framework

**The Architecture informs LSI processes, communication methods, and governance strategies in order to best influence trade space**

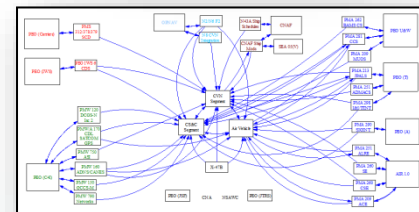
SOURCE: NPS Cohort 2 Report, 2015



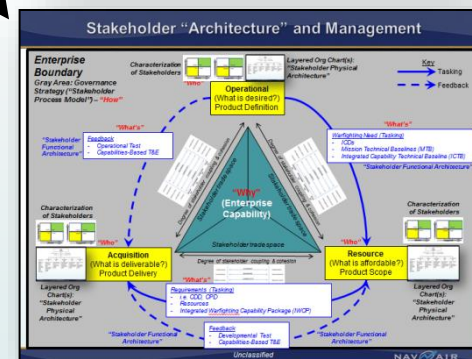
**Stakeholder Identification / Characterization**  
Source: DAU PMT-401 Stakeholder Management, SoS coupling/cohesion



**Stakeholder “Physical Architecture” model**  
Existing formal organizational charts...



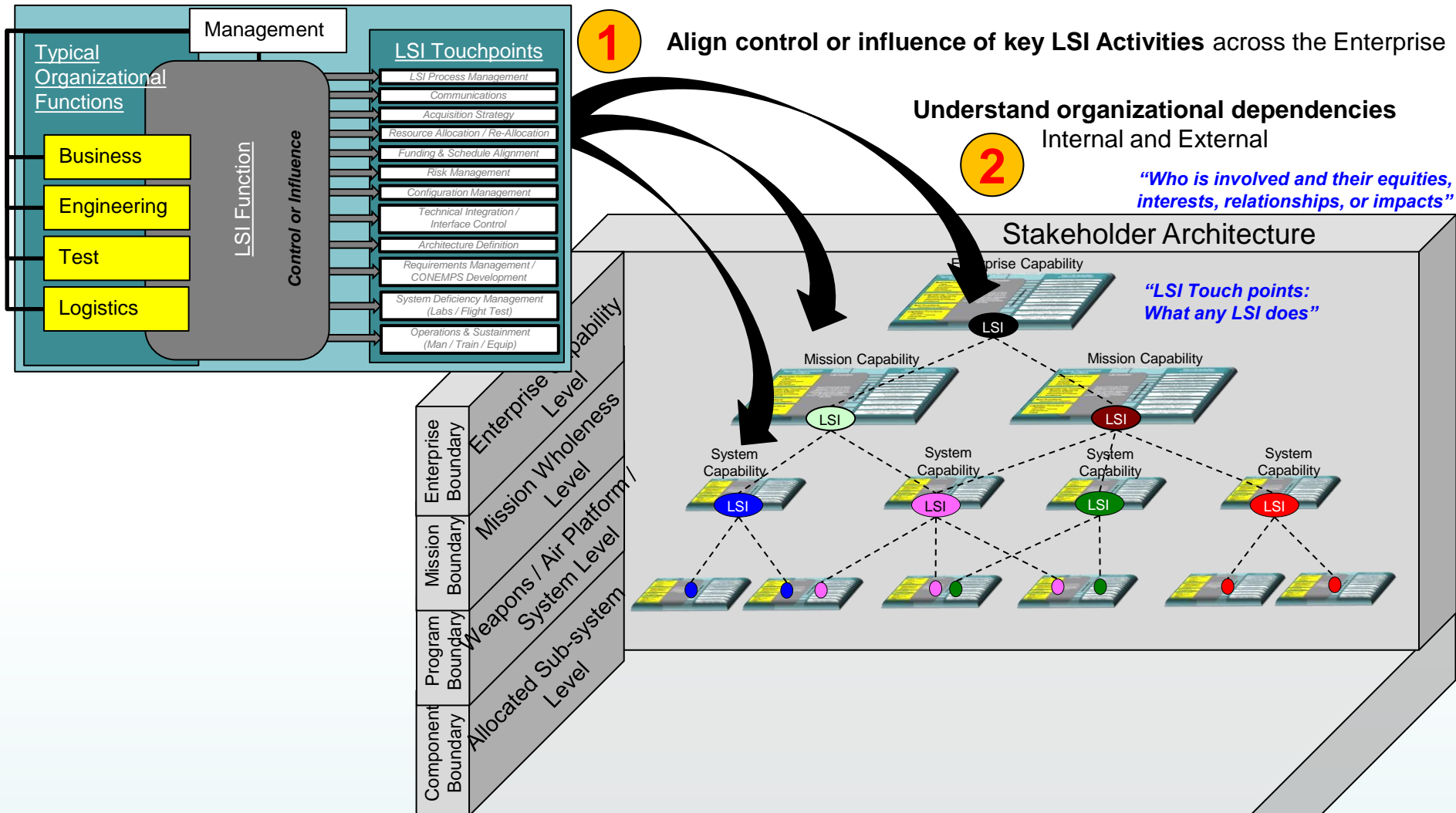
**Stakeholder “Functional Architecture” model**  
e.g. Dynamic systems modeling



**Stakeholder “Process Model”**  
Combination of steps 1 through 3, applied at any level of the LSI effort across a “Stakeholder trade space”

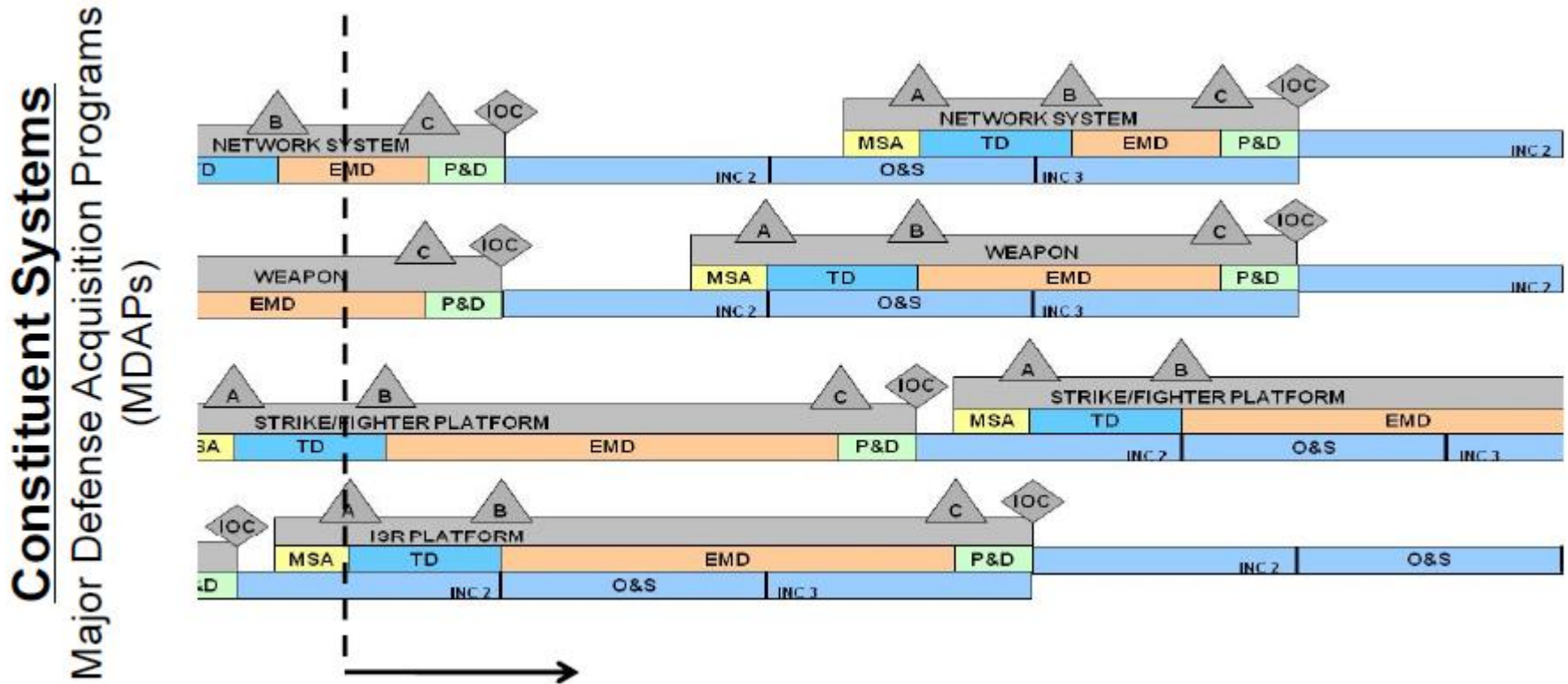


# Stakeholder “Architecture” / Management in the Enterprise LSI Framework



**Stakeholder “Architecture” / Management: Who is involved and their equities, interests, relationships, or impacts**

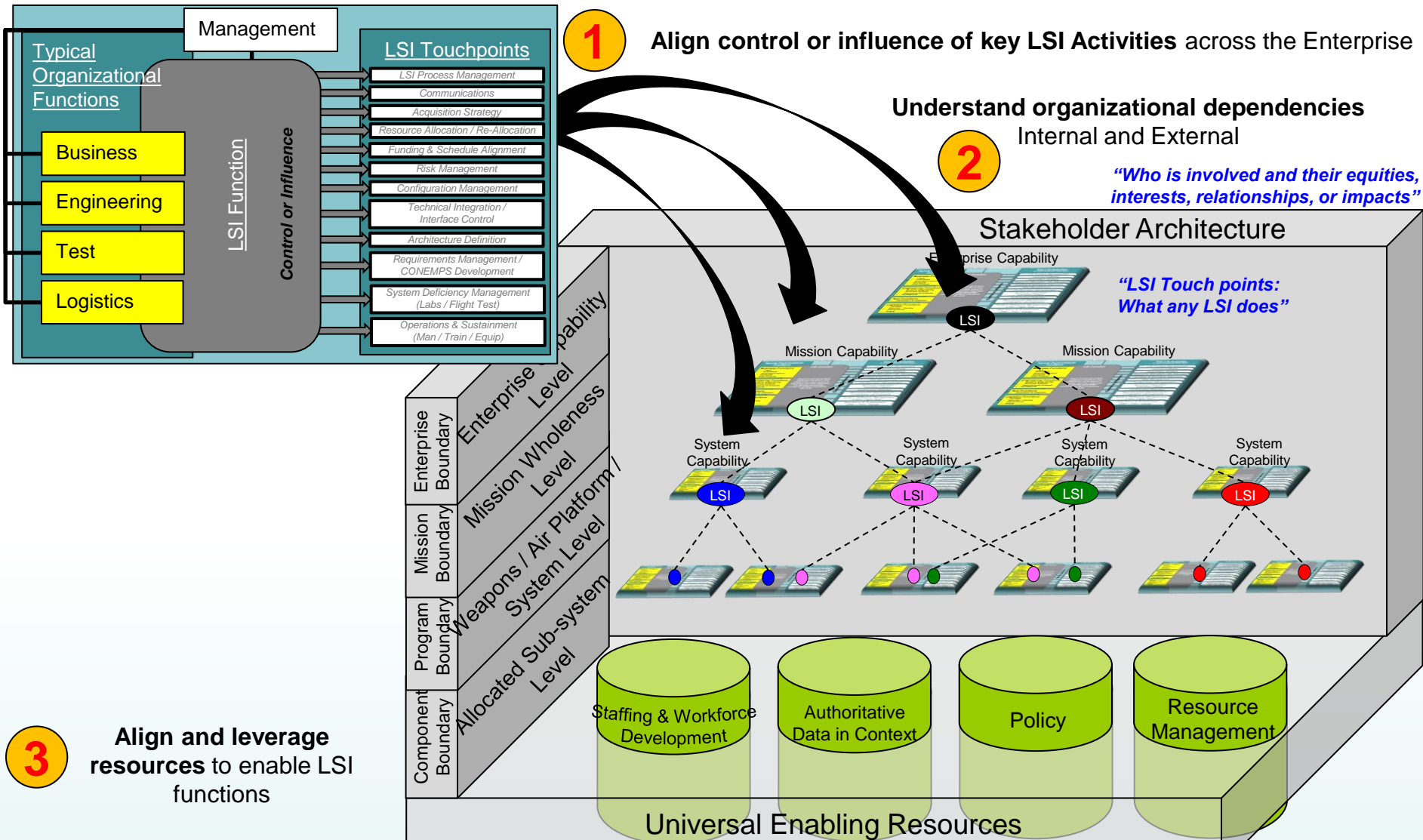
# LSI Architecture Challenge



- Constituent systems are developed asynchronously
- LSI architecture must guide and inform simultaneous and distributed concept development, technology development, and system engineering and manufacturing.

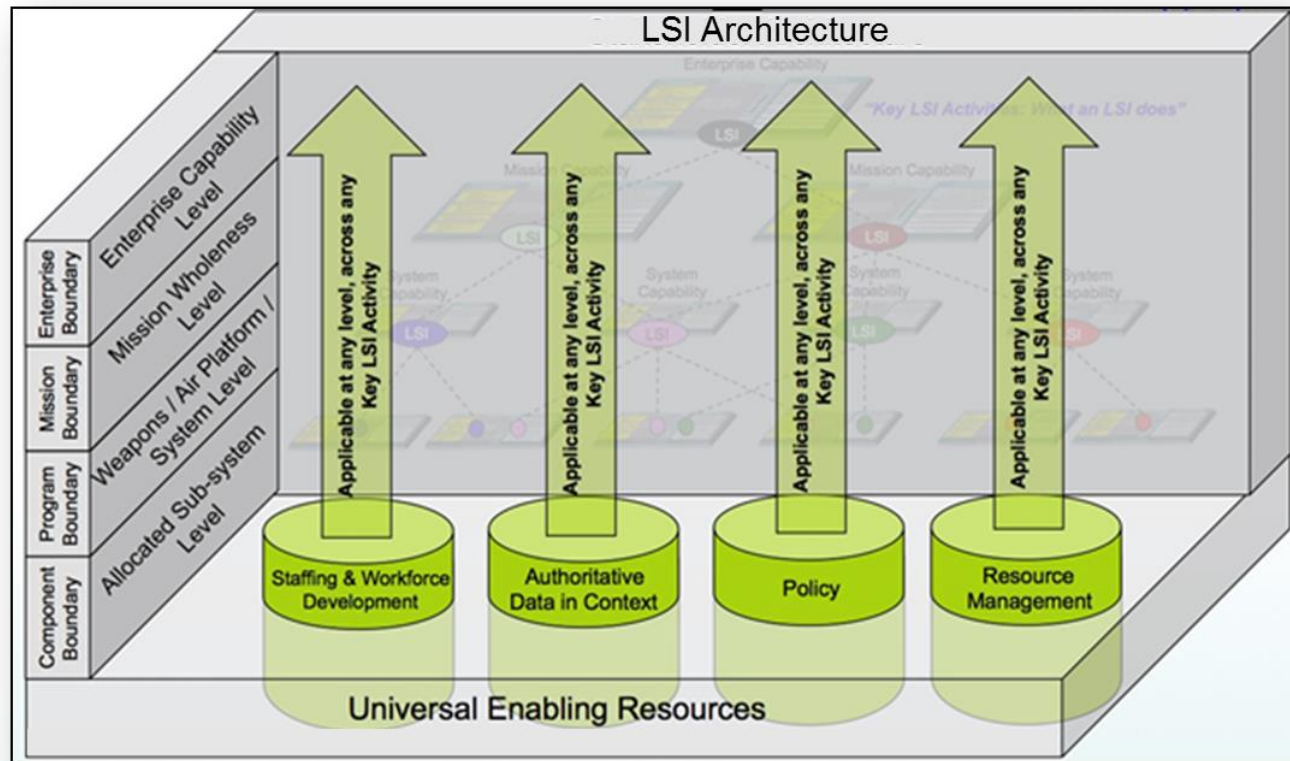
GRAPHIC SOURCE: Herdlick, B. (2012). Establishing an Operational Context for early System-of-Systems Engineering Activities

# Universal Enabling Resources in the Enterprise LSI Framework



**Universal Enabling Resources: four universal and inter-related elements span every level and affect every LSI touch point required for the LSI function and mission**

# Universal LSI Enablers



- “Universal Enabling Resources” are **resources** any LSI uses to **support LSI-unique execution** at each of the “LSI touchpoints” – to assert and execute trade space
- These **four fundamental enablers** apply at any level in the Enterprise LSI Framework

SOURCE: NPS Cohort 2 Report, 2015



# Governance Objectives in the LSI Enterprise Framework

***“Governance is the structure and relationships among key stakeholders that determine an organization’s direction and performance.”***

Invigorating Defense Governance, A Beyond Goldwater-Nichols Phase 4 Report: Kathleen H. Hicks, March 2008

- Provide the **set of decision-making criteria, policies, processes, and actions that guide the responsible organizations** (within the stakeholder architecture) to achieve Enterprise SoS goals and objectives
- Define **communication paths and decision authority** within the stakeholder “architecture” for conflict resolution
- Charter decision bodies to **alter the actions of individuals and organizations** in support of the LSI effort
- Governance **derives from the agreements between key stakeholders**, at all levels of LSI, on how to achieve a common goal

## LSI Governance Challenges (1)

LSI will struggle or fail to achieve its goals unless new sets of rules are established at all levels of the organization. The governance structure existing today procures platforms. It will not be effective for the purpose of efficiently developing and acquiring capabilities.

*“Acquisition practices have allowed capabilities to be developed in isolation and based on a system architecture built simply for compliance, and have resulted in systems that fall short of the expected military utility. Emerging DoD and Navy policies require acquisition practices that ensure systems will integrate into an enterprise architecture.”*

Navy Integration and Interoperability (NII) Integrated Capability Framework (ICF), Operational Concept Document, March 2012

*“Many proposed changes have faltered because they failed to account for and find ways to alter the likely behavior of individuals and organizations. As Goldwater-Nichols taught, the ability to affect incentive structures is the most indispensable ingredient of any successful reform. Attempts to simply rework organizational wiring diagrams or create new and seemingly more nimble processes will fail unless they are buttressed by changes in the underlying incentives that motivate individual and organizational actions.”*

*“Governance in DOD strongly favors the provider, who is typically better staffed, resourced, and represented than customers in key forums and processes.”*

Invigorating Defense Governance, A Beyond Goldwater-Nichols Phase 4 Report, Kathleen H. Hicks, March 2008

## LSI Governance Challenges (2)

The attributes of a systems of systems enterprise makes governing difficult. From the enterprise down to the programs, the LSI must manage the scale and complexity of SoS, the Title 10 supply and demand division between providers and customers\*, and the dynamics of a diverse stakeholder community.

\* Invigorating Defense Governance, A Beyond Goldwater-Nichols Phase 4 Report, Kathleen H. Hicks, March 2008

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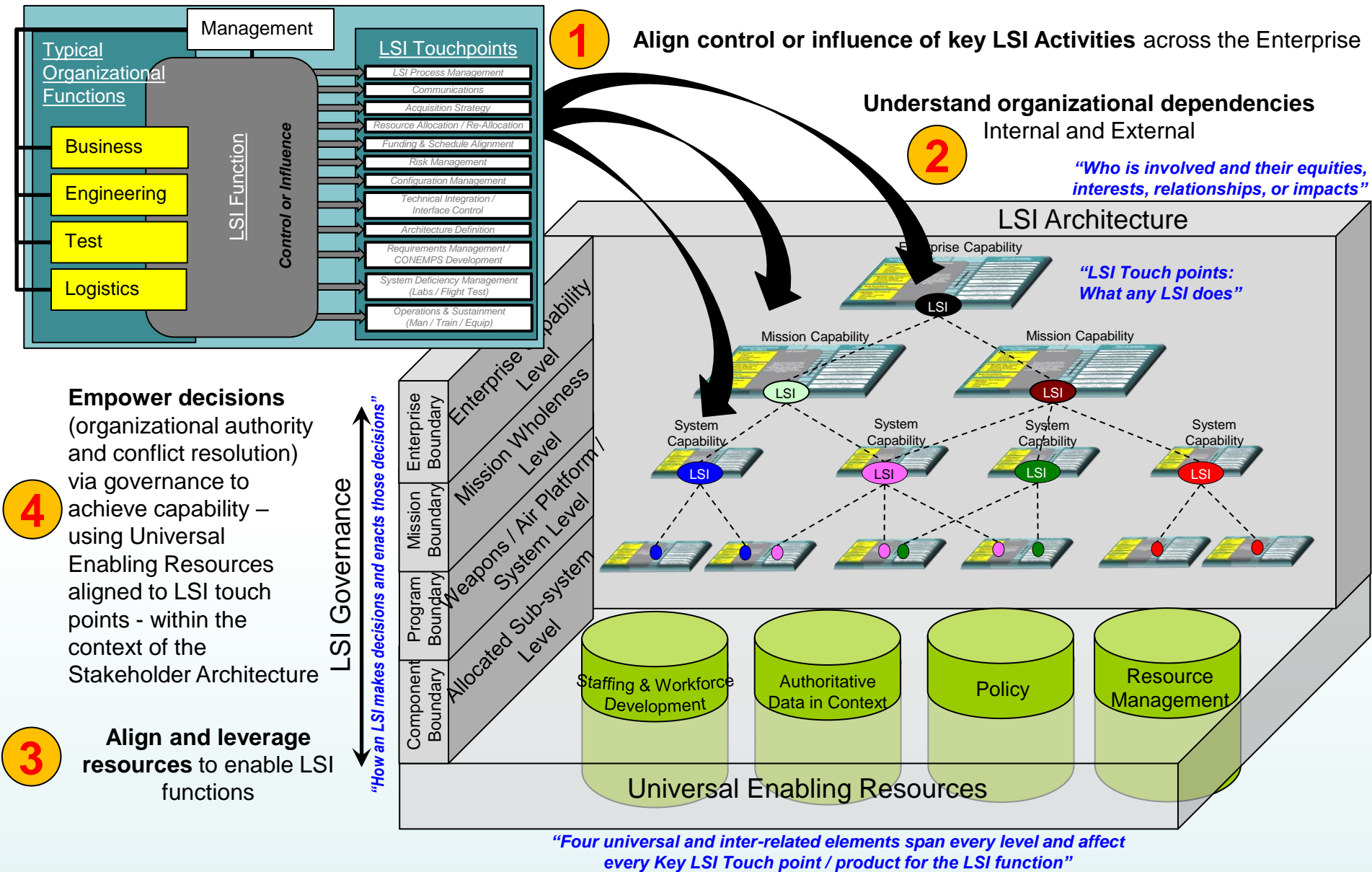
NAVJAG 100

**Governance Considerations: “The Framework in Motion”**  
**How any LSI makes decisions and enacts those decisions**

SOURCE: NPS Cohort 2 Report, 2015



# The LSI Enterprise Framework in Review



# Lessons Learned

- Funding is at the program (system) level
  - Power and decision authority follows money
  - Organizations that are doing it, take it out of hide
- LSI is an unknown career path
  - LSI framework and tasks have been identified but career path is not
- Mission Integration occurs at the policy and operational levels, but not engineering level
- Policies need to change to shift authority to SoS level
  - SoS are not Programs of Record and do not have mandated design reviews
  - SoS governance must be clearly defined, sourced, and allocated