Impact of Systems of Systems on Acquisition Programs

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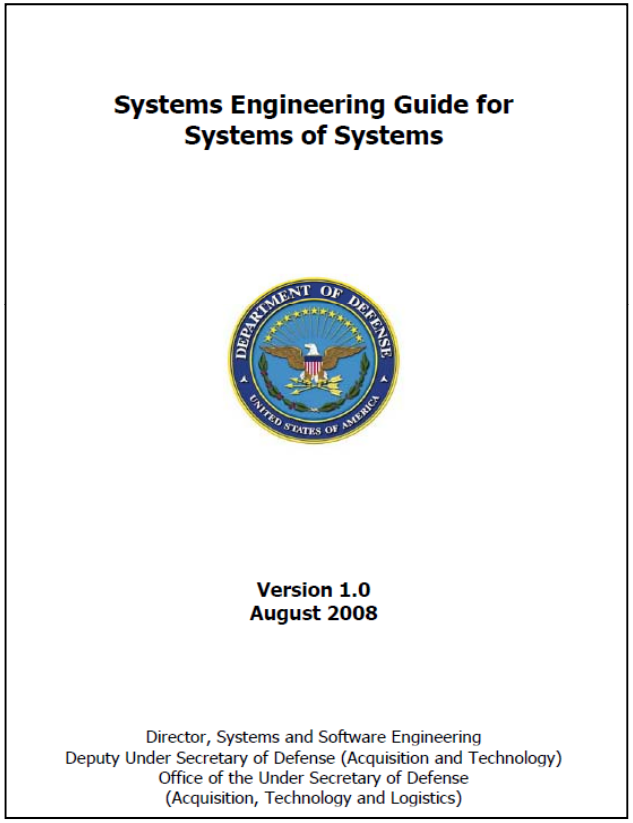
Presented to the System of Systems Engineering Collaborators Information Exchange (SoSECIE)

May 22, 2012

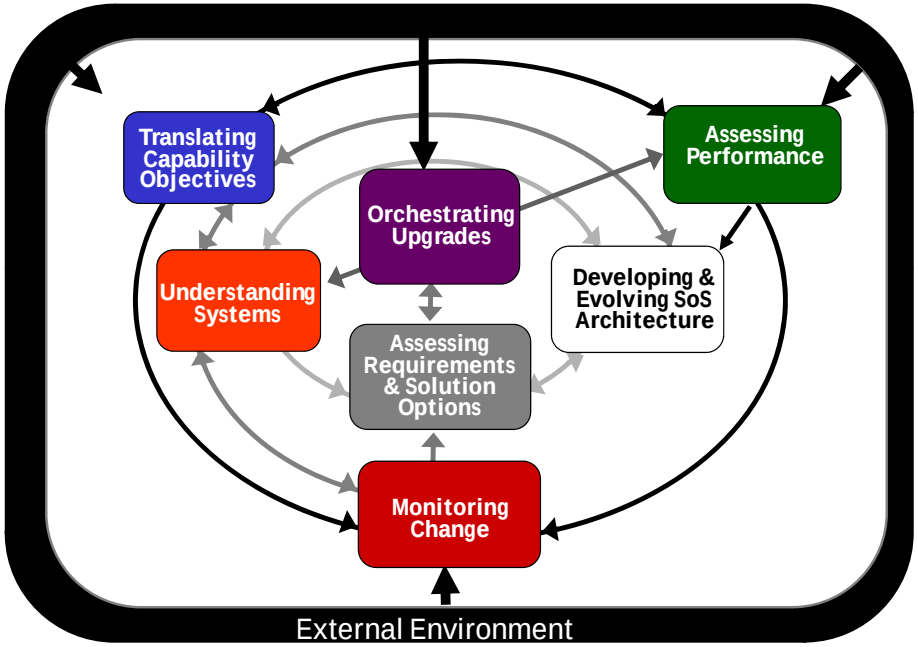
Introduction and Overview

- US DoD has recognized the
  - Importance of systems of systems (SoS)
  - Need to apply systems engineering (SE) to ensure that SoS effectively support user needs that cannot be satisfied with individual systems
- With this recognition has come the need to clearly understand expectations for systems in terms of their ability to effectively operate in a SoS context
  - DoD requirements, acquisition and systems engineering policy and guidance all reflect issues related to context from the initial material development decision through to operational test and evaluation
- Most acquisition programs produce systems that are part of one or more SoS or in some cases, address SoS themselves
- Presentation examines the
  - Relationship between DoD system acquisition and SoS
  - Implications in terms of SoS risk to acquisition program success

Foundations



Trapeze Model*



SE Model for SoS Based on 7 Core Elements of SoS SE

* Department of Defense, Systems Engineering Guide for System of Systems, Version 1.0, 2008.

DoD Guide to SoS SE presents a model of SoS SE based on the core elements of SoS SE and their interrelationships

SoS Definition and Types

SoS: A set or arrangement of systems that results when independent and useful systems are integrated into a larger system that delivers unique capabilities

Types of SoS

- Directed: SoS objectives, management, funding and authority; systems are subordinated to SoS
- Acknowledged: SoS objectives, management, funding and authority; however systems retain their own management, funding and authority in parallel with the SoS
- Collaborative: No top down objectives, management, authority, responsibility, or funding at the SoS level; Systems voluntarily work together to address shared or common interest
- Virtual: Like collaborative, but systems don't know about each other

Actual situations are often combinations of these types

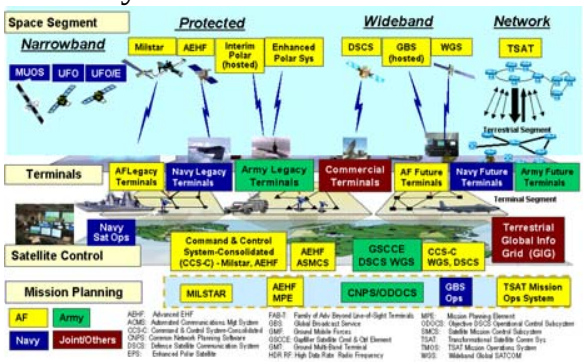
DoD SoS Domains

Joint Lightweight Tactical Vehicle

Platforms

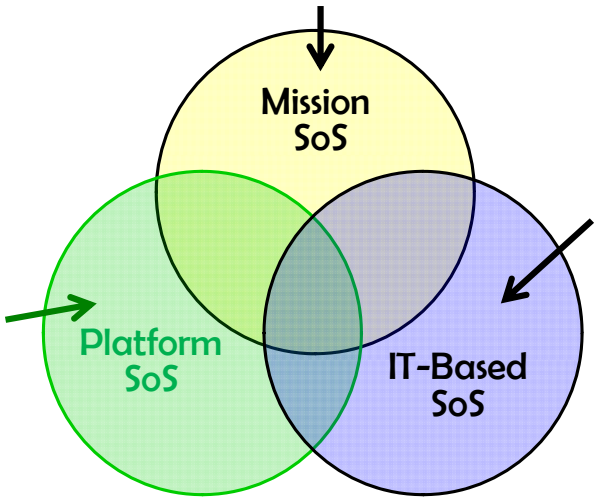
A military platform (e.g. ship, aircraft, satellite, ground vehicle) equipped with independent systems (e.g. sensor, weapons, communications) needed to meet platform objectives

Military Satellite Communications



Missions

Sets of systems working together to provide a broader capability or mission



Air Operations Center

AOC Weapon System Process

Information Technology

Networked information systems to support operations within or across platforms or systems to meet mission or capability objectives

Scope of the Presentation

- Examine relationship between SoS and acquisition for

Types of SoS

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SoS Domains

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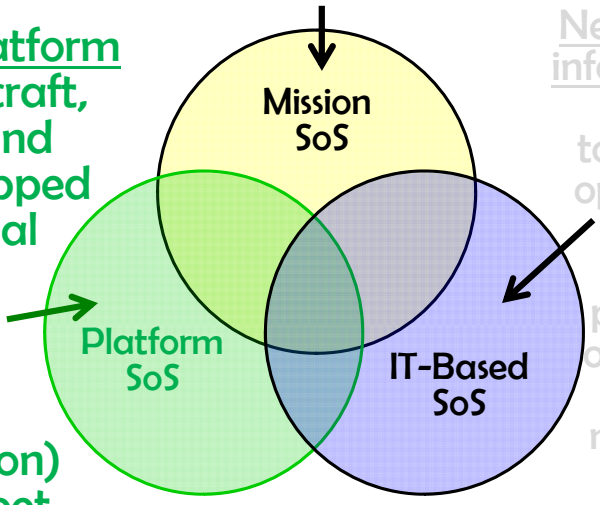
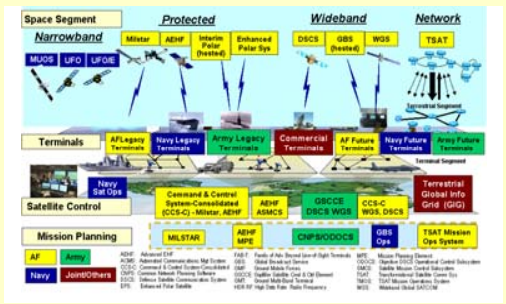
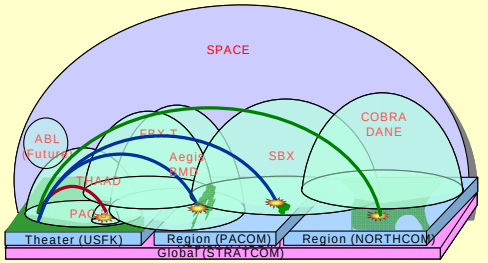


Networked information systems to support operations within or across platforms or systems to meet mission or platform objectives

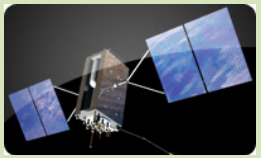
What Is Being 'Acquired'?

'Missions'





'Platforms'



'Systems'

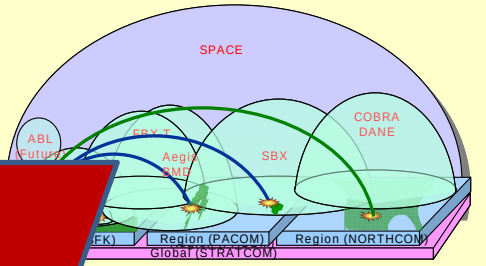
Current Major Defense Acquisition Programs (MDAPs) include some acquisitions which address systems, some which address platforms, others which address missions, or some combination

What Is Being 'Acquired'?

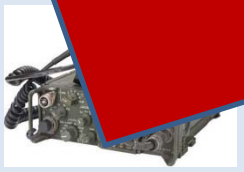
'Missions'

'Platforms'

'Systems'



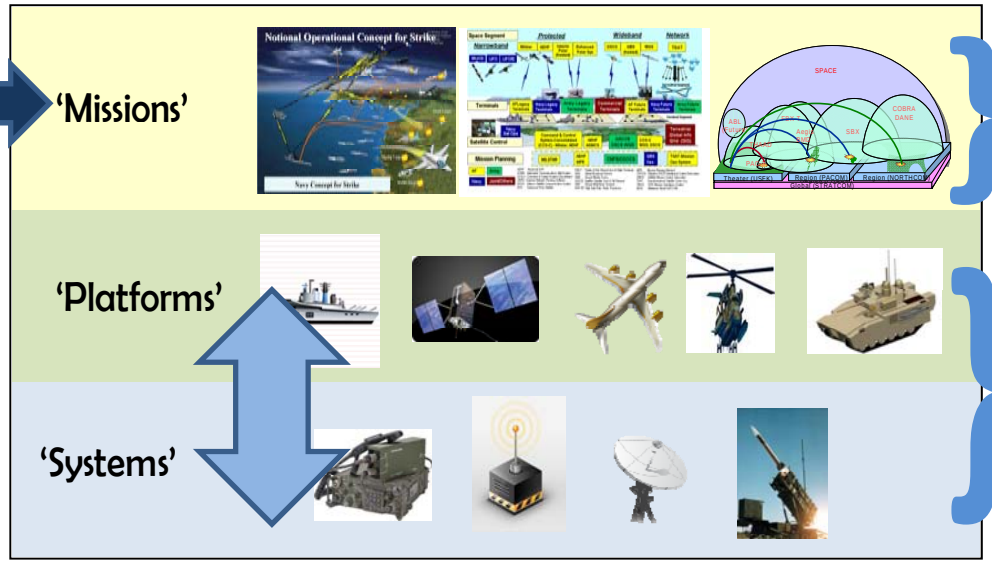
Understanding SoS risk to an acquisition program begins with an understanding of what is being acquired



Current Major Defense Acquisition Programs (MDAPs) include some acquisitions which address systems, some which address platforms, and others which address missions

What is Being Acquired? Three SoS Related Cases

III. Acquisitions of mission SoS



II. Acquisitions of systems and of platforms which support mission SoS

I. Interdependencies between acquisitions of systems and acquisition of platforms

I. Systems and Platforms

Acquiring a system which supports one or more platforms

Acquisition program is responsible for a system (e.g. radio) which will become part of multiple platforms which are being developed/evolved independently from the system

- KPPs, reviews, testing all focus on systems (e.g. radio) and not performance as part of the platform SoS

Acquiring a platform which depends on one or more systems

Acquisition program is acquiring a platform which is dependent on independent system (e.g. radio) acquisition(s) for critical platform capability

- KPPs, KSAs of the platform depend on the independently developed systems; no provision in acquisition to account for the dependency

I. Systems and Platforms Risks

Acquiring a system which supports one or more platforms

Acquiring a platform which depends on one or more systems

Questions

- Have the system requirements considered the constraints of the host platforms (e.g. SWAP-C?) Have the platforms considered constraints of the systems?
- Is there a provision for regular technical reviews which include both the systems and platforms?
- How are disconnects in schedule, interfaces, functionality, performance, etc. identified and addressed?
- Are there plans and funding for the platform integration?
- Are responsibilities clear?

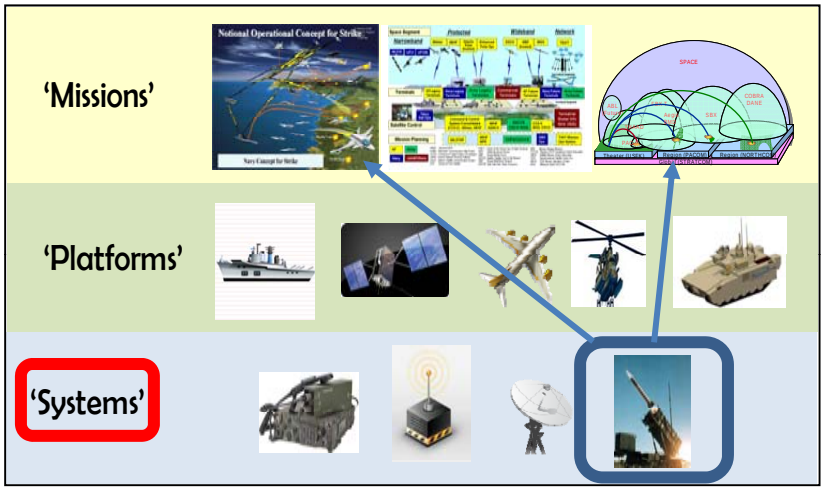
Potential risks:

- Technical, schedule, performance, or funding disconnects between systems and platforms, i.e.
  - System doesn't 'fit' on platform
  - No funding or plan for integration
  - System is not delivered in time for the platform

Potential risks affect acquisition program success

II. Systems/Platforms Supporting a Mission SoS

Acquiring a system which supports one or more mission SoS



Acquisition program is responsible for a system (e.g. missile) which supports one or more mission SoS

- KPPs, reviews, testing all focus on systems (e.g. radio) and not system's contribution to the mission SoS

Acquiring a platform which supports one or more mission SoS

Acquisition program is acquiring a platform which supports one or more mission SoS

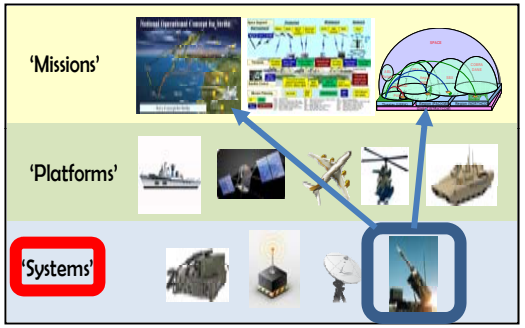
- KPPs, KSAs of the platform address platform performance not contribution of the platform to the mission SoS

Mission SoS may be

- Acquisition programs themselves [e.g. DCGS AF, AIAMD]
- Recognized initiatives but not operated as acquisition programs [e.g. NIFCA, DACAS]
- No formally recognized organization or authority (de facto) [e.g. TST, CAS]

II. Systems/Platforms Supporting a Mission SoS Risks

Acquiring a system which supports one or more mission SoS



Acquiring a platform which supports one or more mission SoS

Questions:

- Has the mission context for the system/platform been established?
- Does the system/platform support one or more missions?
- Is there some established authority for the mission (e.g. mission area manager or SoS manager)?
- Have the demands of the mission on the system been defined and factored into the system requirements?
- Are there multiple missions with different (and conflicting) demands? Do the mission needs conflict with the needs of the immediate system users?

Potential risks:

- Critical dependencies may not be considered in the acquisitions
- Delivered product may not effectively support the capability that motivated its development
- Product may not be delivered when needed (e.g. ground terminals not available when satellites have been launched)

Potential risks affect operational user but not acquisition program success

III. Acquiring Mission SoS

Acquisition program is focused on the mission level SoS

Acquisition program responsible for a mission-level SoS as a whole

Examples: Air Operations Center (AOC); Littoral Combat Ship Mission Modules

- KPPs, reviews, testing focus on SoS level performance

OR

Acquisition program acquiring a specific element to support the SoS (versus the SoS as a whole)

Example: Army Integrated Air Missile Defense (AIAMD) program which is developing the cross program C2 element

- KPPs, KSAs, reviews, testing focus on the element being acquired versus SoS level performance

III. Acquiring Mission SoS (1 of 2) Risks

Acquisition program is focused on the mission level SoS

Potential Risks

- Conflict between SoS decisions and constituent system decisions can lead to disconnects between the systems and the SoS
- May be difficult to get closure on current acquisition milestone reviews because of risk of the SoS dependencies on systems decisions not considered in current milestone criteria

Acquisition program responsible for a mission-level SoS as a whole

Examples: Air Operations Center (AOC); Littoral Combat Ship Mission Modules

- KPPs, reviews, testing focus on SoS level performance

All activities are done as part of an acquisition program

- Includes analysis, architecture development, assessing, planning, and changes in systems
- Milestone criteria are applied to SoS as a whole despite the fact that the SoS does not have authority over the constituent systems it depends on

In most cases, system changes are also implemented under system level acquisition programs

- Means that each system individually specifies requirements and works through acquisition activities (e.g. AoA and milestones)

Potential risks affect acquisition program success

III. Acquiring Mission SoS (1 of 2) Risks

Acquisition program is focused on the mission level SoS

Risks
- Design of the component does not adequately address SoS capability needs
- Integration into/with constituent systems is not adequately planned of funded across the SoS

Acquisition program acquiring a specific element to support the SoS (versus the SoS as a whole)

Example: Army Integrated Air Missile Defense (AIAMD) program which is developing the cross program C2 element

- KPPs, KSAs, reviews, testing focus on the element being acquired versus SoS level performance

Acquisition program may be described as an SoS but it is really focuses on one component of the SoS

- Larger questions of SoS integration and impact on SoS objectives are addressed independently from the acquisition
- Milestones do not consider uncertainty for the SoS and impact on the SoS components dependent on constituent systems

Acquisition really focuses on the component as a 'system' acquisition

- KPPs, reviews, testing focus on component (not SoS)

Potential risks affect acquisition program success

Summary and Conclusions

- DoD has recognized the importance of SoS and the role of SE in SoS
- Acquisition programs face potential 'SoS risks'
  - By understanding what is being acquired in an acquisition program and its relationships to other programs and mission capabilities, areas of potential SoS risk can be identified
- Risks are tied to
  - Interdependencies between programs which may not be recognized or adequately addressed
  - Overlap in authorities along with multiple, possibly conflicting needs
  - Limited provision in the acquisition policy and processes for addressing cross program issues
- Understanding potential risk areas for programs under different circumstances provides opportunity to identify and address risks to both acquisition program success and support to operational users

For more information:

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