Battle Control System of Systems (SoS) Engineering Analysis

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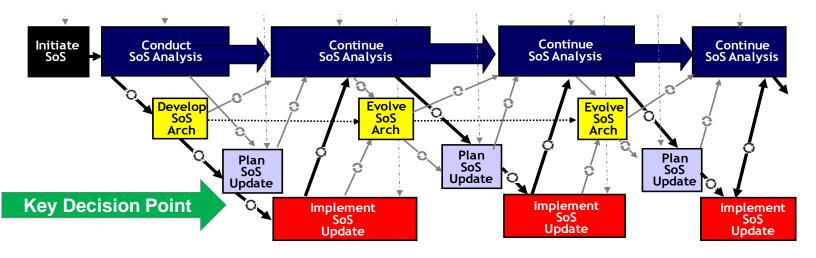


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Bottom Line Up Front

- <u>Objective</u>: Demonstrate utility of System of Systems (SoS) analysis capability to enable evidence-based decision making for future investments
- Approach: Model one air defense mission thread and show how potential system upgrades could provide operational mission benefits using an unclassified scenario and notional system performance data
- Results: Demonstrated ability to quantify system performance and operational mission benefits metrics of two possible enhancements to an initial baseline Use Case
- Future Potential: Linkage with cost modeling could permit rapid iterations in support of course of action option generation and analysis; Easily extendable to other scenarios or missions; Enhanced realism through use of authoritative program data

System of Systems Wave Model



"An Implementers' View of Systems Engineering for Systems of Systems", Judith Dahmann et al.

- Use SoS model to address potential changes in individual systems and the mission threads
 - Define and analyze "as-is" architecture
 - Assess potential "to-be" options for value and impact on operational capabilities

Motivation: Evidence-Based Portfolio Decisions

Develop an analytic platform to assist answering portfolio level questions:

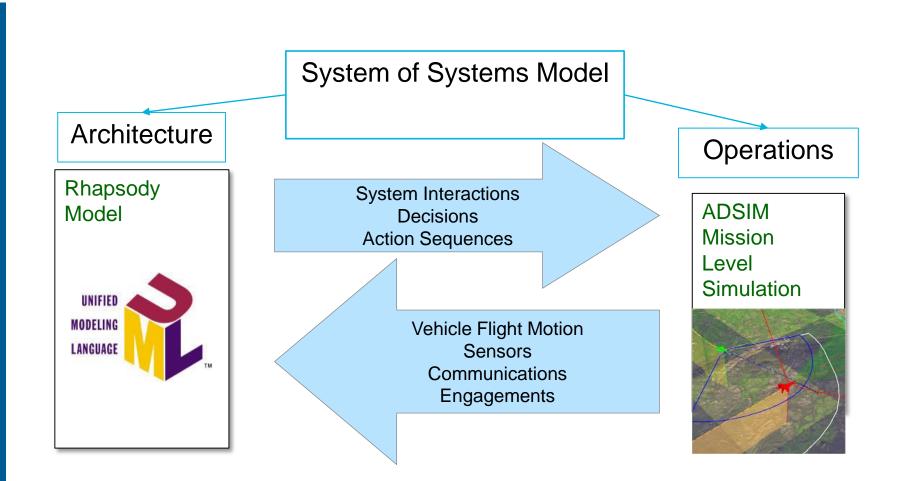
- What are the impacts of
 - Sensor improvements
 - Communication systems improvements
 - Command and control software upgrades

on operational mission effectiveness, schedule and cost?

How can cost savings be realized without compromising performance?

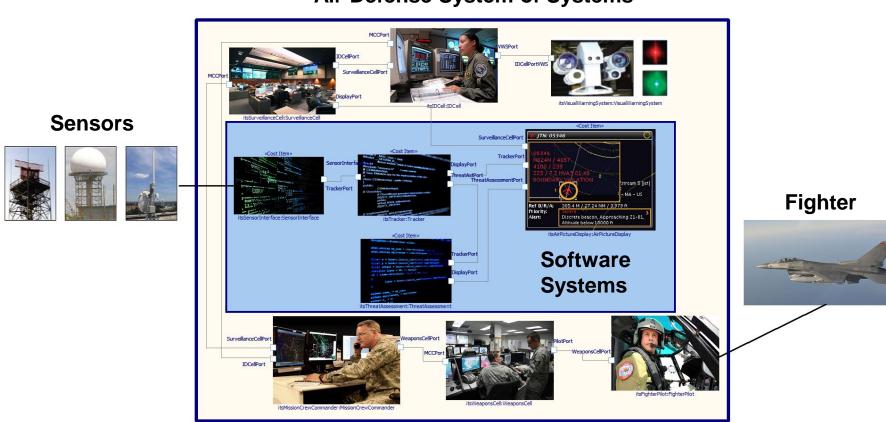


Analytic Approach





SoS Modeling Approach



Air Defense System of Systems

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Use Case

- Rogue aircraft approaching protected facility
 - Detection
 - Visualization
 - Identification
 - Coordination
 - Decision-making
 - Response

- Variations modeled
 - Baseline Case
 - Upgrade #1: Sensor with improved altitude discrimination
 - Upgrade #2: Automated a step in ID processing
 - Upgrades #1 and #2 combined





- Private pilot plans low altitude overflight of major outdoor stadium event
- Files flight plan to land at nearby airfield
- Instead of landing, continues on to event location
- During event, fighters are on Combat Air Patrol (CAP)

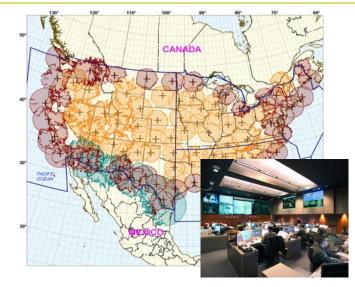


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Technical and Operational Metrics

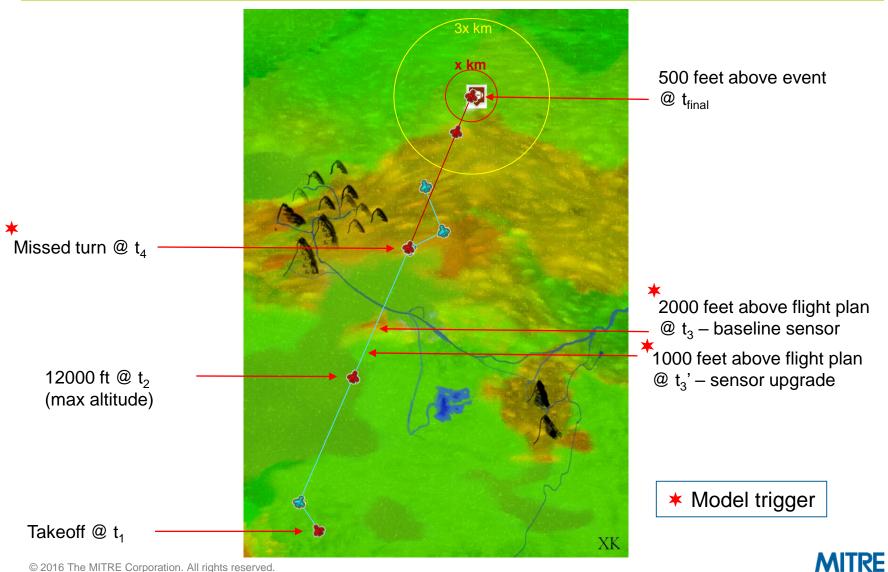
- Measures of Performance (MOPs) – System Focus
 - Coverage timelines
 - Processing delays
 - Investigation time
 - ID time
 - Decision delays
- Measures of Effectiveness (MOEs) – Operations Focus
 - Total ingress range into defended airspace
 - Ingress flight time







Scenario Timeline



Executable Architecture (Rhapsody) 1/7

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Executable Architecture (Rhapsody) 2/7

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Executable Architecture (Rhapsody) 6/7

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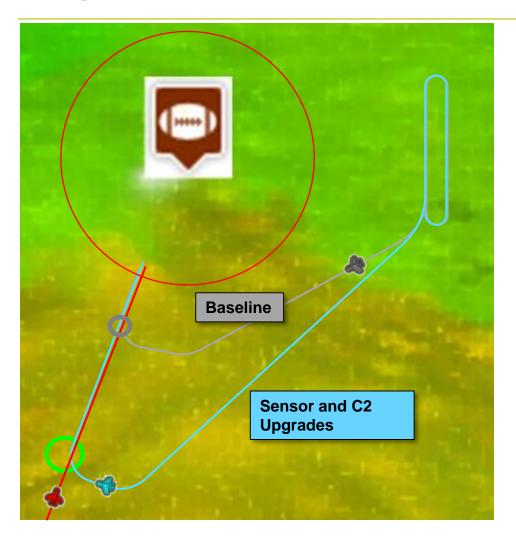


Executable Architecture (Rhapsody) 7/7

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Fighter Intercept Route: Sensor and C2 Upgrades

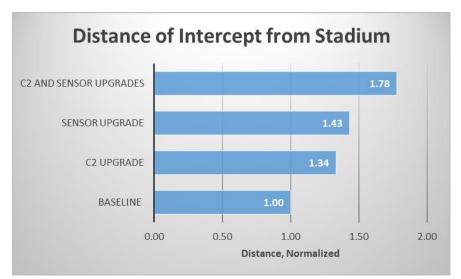


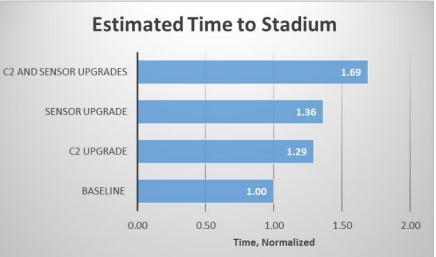
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- Improved sensor: rogue aircraft discovered off flight plan earlier than baseline case
- Improved C2: it takes less time to decide to vector fighter after rogue discovered off flight plan



MOE Summary Over All Cases



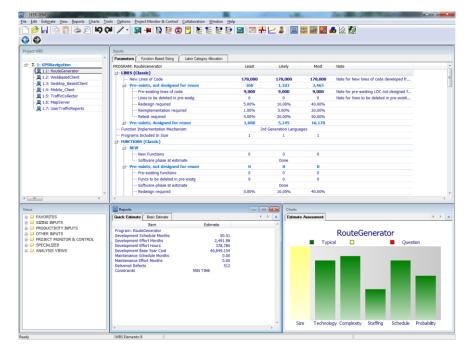


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Integration of Architecture Model with Cost Estimation Tool

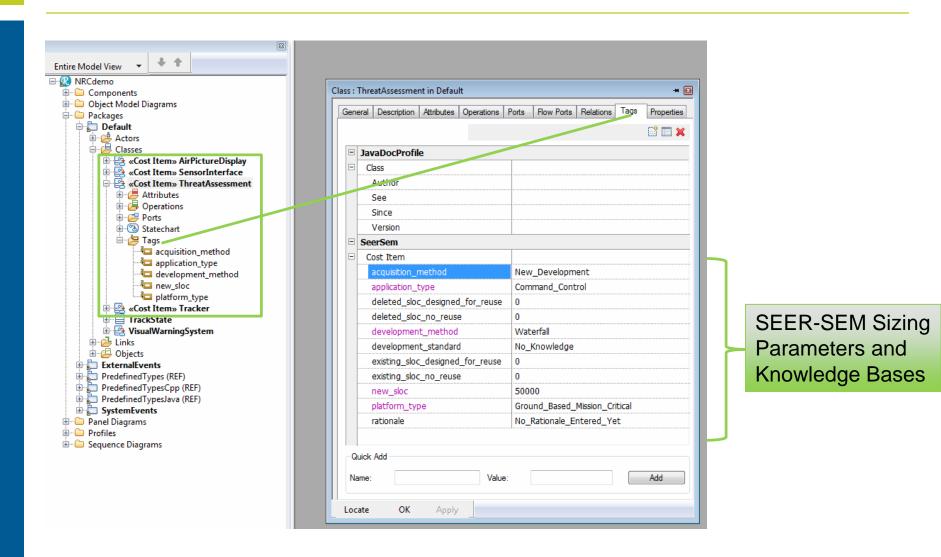
- Executable architecture model is enhanced by including cost parameters:
 - New lines of code
 - Existing lines of code
 - Platform knowledge base
 - Application knowledge base
- Adapter utility extracts cost parameters from Rhapsody model and constructs an input to Galorath SEER-SEM
- Cost model is completed by Cost Estimator
- Affordability of various upgrades to systems and interfaces can be evaluated

Example of SEER-SEM invoked from Rhapsody





Example of Software Cost Item



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Summary

Accomplishments

- Developed SoS-MBSE analytic capability
- Stood up mission and architecture models
- Defined interface between mission and architecture models
- Executed analysis of the chosen mission thread

Lessons Learned

- SoS analysis helps identify gaps in understanding and documentation
- Engineering workflow for SoS work is still under development
- Engagement between MBSE, SoS and MS&A experts is crucial for making progress

Questions? Aleksandra Markina-Khusid at amk@mitre.org