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#

You can download today's presentation from the SoSECIE Website:

https://mitre.tahoe.appsembler.com/blog

To add/remove yourself from the email list or suggest a future topic or speaker, send an email to sosecie@mitre.org

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

NDIA SE Division SoS Committee Industry Chairs:
Mr. Rick Poel, Boeing
Ms. Jennie Horne, Raytheon
OSD Liaison:
Dr. Judith Dahmann, MITRE

Simple Rules of Engagement

- I have muted all participant lines for this introduction and the briefing.
- If you need to contact me during the briefing, send me an e-mail at 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.

Disclaimer

- MITRE and the NDIA makes no claims, promises or guarantees about the accuracy, completeness or adequacy of the contents of this presentation and expressly disclaims liability for errors and omissions in its contents.
- No warranty of any kind, implied, expressed or statutory, including but not limited to the warranties of non-infringement of third party rights, title, merchantability, fitness for a particular purpose and freedom from computer virus, is given with respect to the contents of this presentation or its hyperlinks to other Internet resources.
- Reference in any presentation to any specific commercial products, processes, or services, or the use of any trade, firm or corporation name is for the information and convenience of the participants and subscribers, and does not constitute endorsement, recommendation, or favoring of any individual company, agency, or organizational entity.

2020-2021 System of Systems Engineering Collaborators Information Exchange Webinars

Sponsored by MITRE and NDIA SE Division

July 28, 2020
Addressing Mission Engineering from a Lead Systems Integration Perspective
Dr. Warren Vaneman

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

Mission Engineering: An Implementation Approach

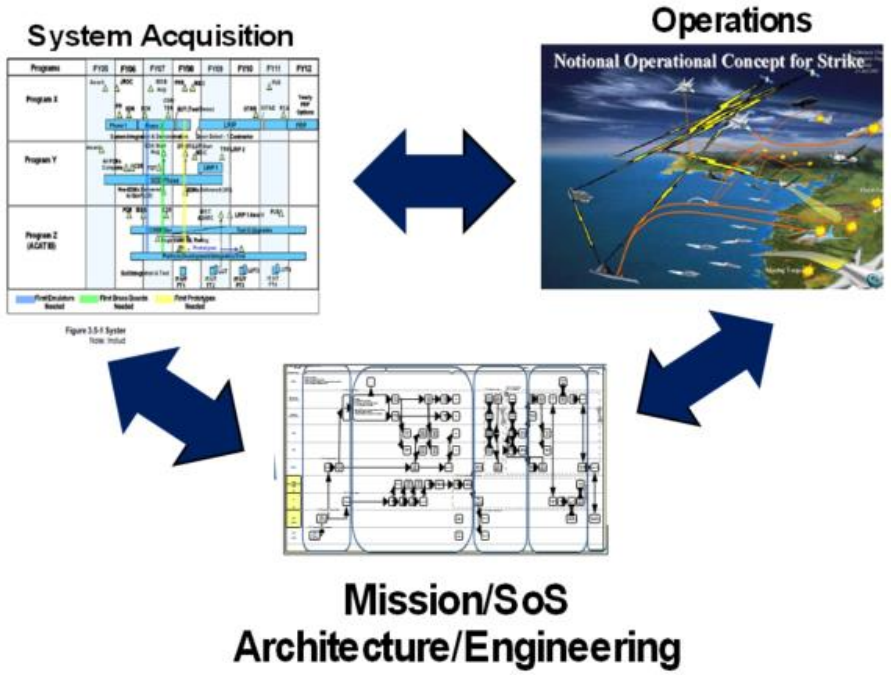
Dr. Judith Dahmann

NDIA Systems and Mission Engineering Conference

October 24, 2019

MITRE

What do we mean by 'mission engineering'?



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

- Mission engineering treats the **end-to-end mission** as the "**system**"
- Individual systems, including organizations and other non-material elements, are components of the larger **mission 'system'** or system of systems
- Systems engineering is applied to the systems-of-systems **supporting operational mission outcomes**
- Mission engineering goes beyond data exchange among systems to address cross cutting functions, end to end control and **trades across systems**
- **Technical trades** exist at multiple levels; not just within individual systems or components
- Well-engineered **composable mission architectures** foster resilience, adaptability and rapid insertion of new technologies

MITRE

Why 'mission engineering'?

Proactive: ME …

- Is initiated based on the recognition of the primary importance of mission or enterprise outcome
- Addresses the 'health' of the 'end-to-end mission' to identify gaps, issues or opportunities to maintain or enhance mission outcomes
- May lead to the identification of gaps or issues which may be affecting the mission outcomes or may do so in the future (risks)

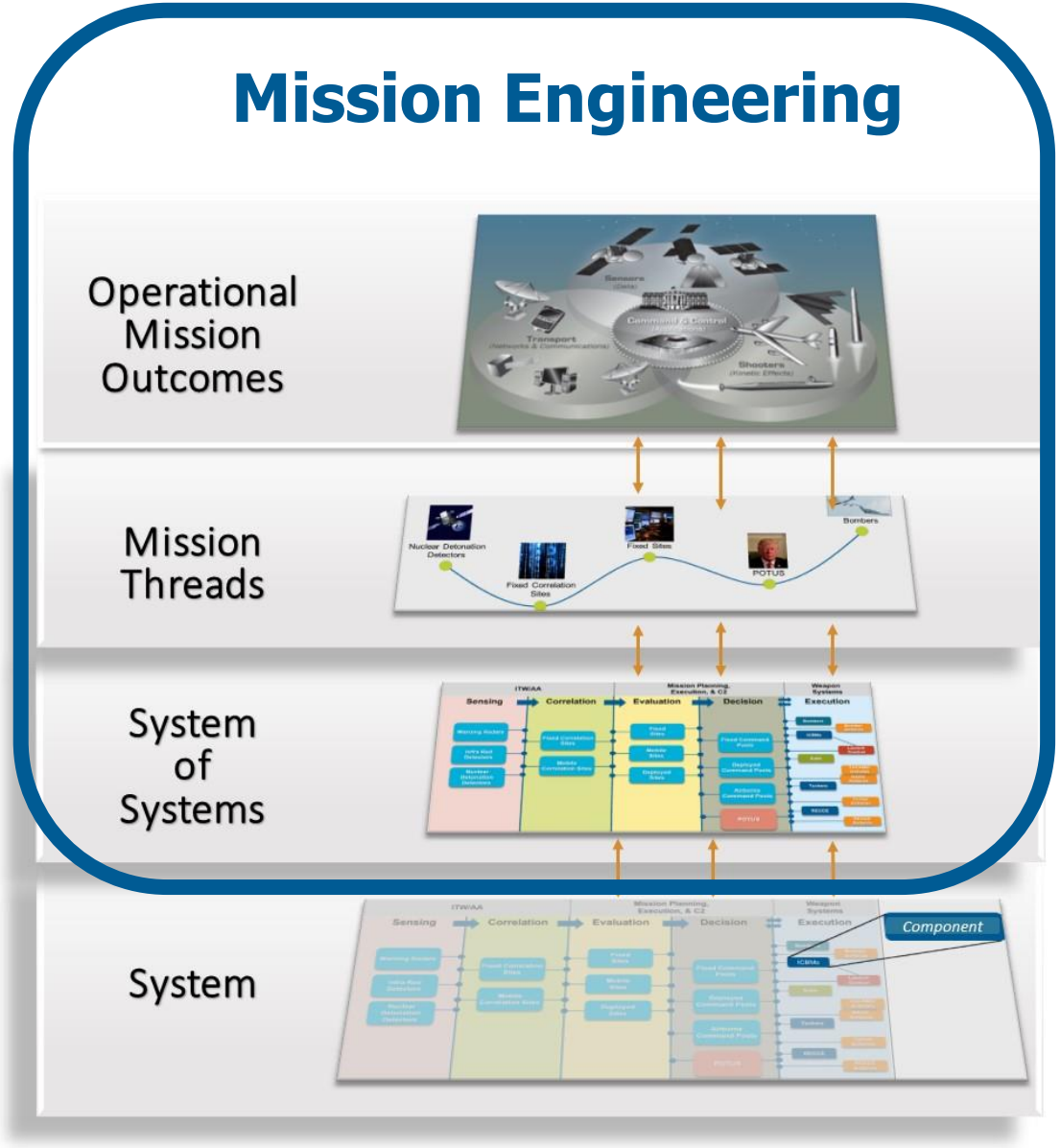
Reactive: ME …

- Is triggered by **issues or gaps** identified in the mission performance or an element supporting the mission
- Identifies the **sources** of mission gaps or the **effects** of problems with systems or other elements on mission outcomes
- Assesses the **impact of possible changes** to address issues or gaps on other elements or systems supporting the mission

Opportunistic: ME…

- Responds to a potential new technology or other change which offers potential mission advantage technology
- Addresses the question of the impact on mission outcomes by introducing new technology, systems or processes

MITRE



Systems of Systems in a mission context

Mission thread links technical performance to operational outcomes

MITRE

Key Steps in Implementing Mission Engineering

Establish the context and motivation for ME

Form ME team

Describe the key elements of the mission and drivers

Assess current situation

Delineate mission context

Identify options and conduct trades

Prototype and experiment

Recommendations

MITRE

Form ME Team

Develop ME plan

- **Broad range of perspectives – both technical and operational**
  - ME team lead supporting systems engineers
  - Operational and requirements SMEs
  - External environment SMEs
  - Component team members for the key systems and organizations
  - Management and resourcing

- **Data, models, & analysis**
  - Key activities, mission threads , scenarios, mission context
  - Systems, behavior, performance
  - Outcomes, measures
- **Technical & operational analyses**
  - Baseline analysis of SoS & mission operations
  - Identification of options
  - Approach to analyzing options and tradeoffs

Establish the context and motivation for ME

- **Recognize that the issue, gap or opportunity needs to be addressed in terms of the larger enterprise or mission outcomes**
- **What is potential impact on mission?**

- **Questions to be addressed**
  - What is **motivation** for the ME effort – what is driving the need to conduct engineering and analysis in terms of the mission outcomes?
  - What is the **mission context** – what are the types of activities and expected outcomes for the mission?
  - What **part of the enterprise** is affected? Which organizations or systems? Who are the key stakeholders?

Establish the context and motivation for ME

- **Recognize that the issue, gap or opportunity needs to be addressed in terms of the larger enterprise or mission outcomes**
- **What is potential impact on mission?**

- **Questions to be addressed**
  - What is **motivation** for the ME effort – what is driving the need to conduct engineering and analysis in terms of the mission outcomes?
  - What is the **mission context** – what are the types of activities and expected outcomes for the mission?
  - What **part of the enterprise** is affected? Which organizations or systems? Who are the key stakeholders?

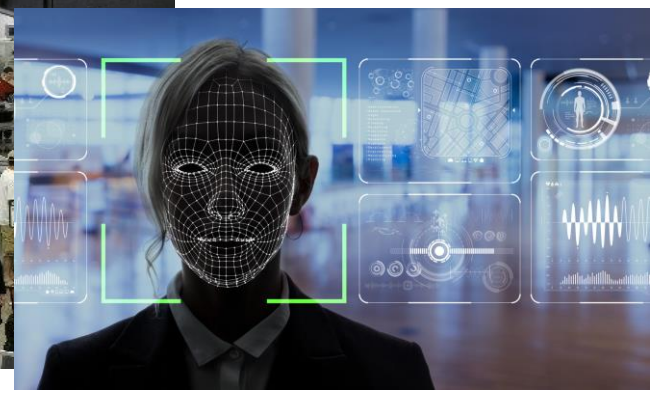
-- Example --

Opportunity: Biometrics Technology

Mission: Airport safety through passenger screening

- ***How can insertion of technology impact mission outcome?***

To assess value requires understanding how they could be integrated into the current system of systems and the passenger screening sequence of actions ('mission thread') and the impact on the outcomes



MITRE

Delineate mission context

- **Collection of the mission-related data to provide the context for in assessing current technical capabilities and assessing options**

Mission Related Data

- Mission Thread(s)
  - Descriptions of activities and dependencies
- Scenarios
  - Descriptions of the scenario context(s) for executing mission
- External Environment factors
  - Current and projected external environment (e.g. threat, legal, social) actions and behaviors
- Measures of SoS performance and mission effectiveness

Delineate mission context

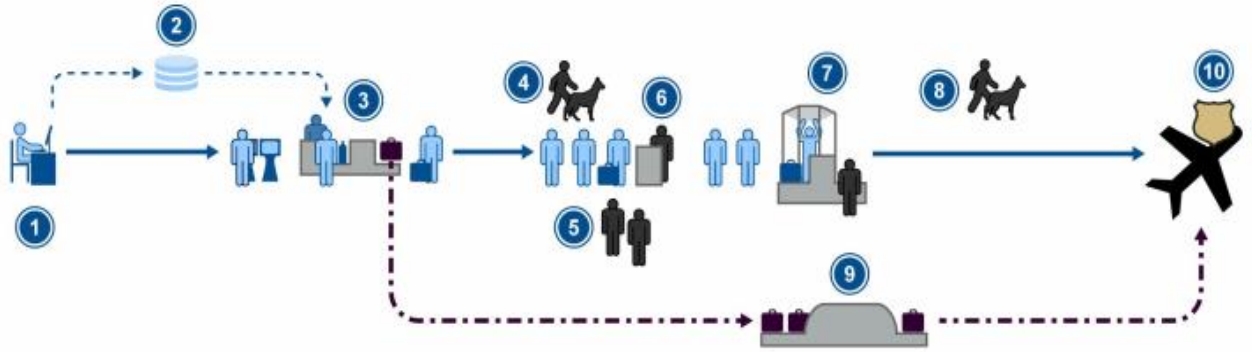
- **Collection of the mission-related data to provide the context for in assessing current technical capabilities and assessing options**

Example

- "Passenger screening mission thread"
- Operational outcome measures, e.g.
  - Time through queue
  - Average wait time at checkpoints
  - Screening 'success rate'

Mission Related Data

- Mission Thread(s)
  - Descriptions of activities and dependencies
- Scenarios
  - Descriptions of the scenario context(s) for executing mission
- External Environment factors
  - Current and projected external environment (e.g. threat, legal, social) actions and behaviors
- Measures of SoS performance and mission effectiveness



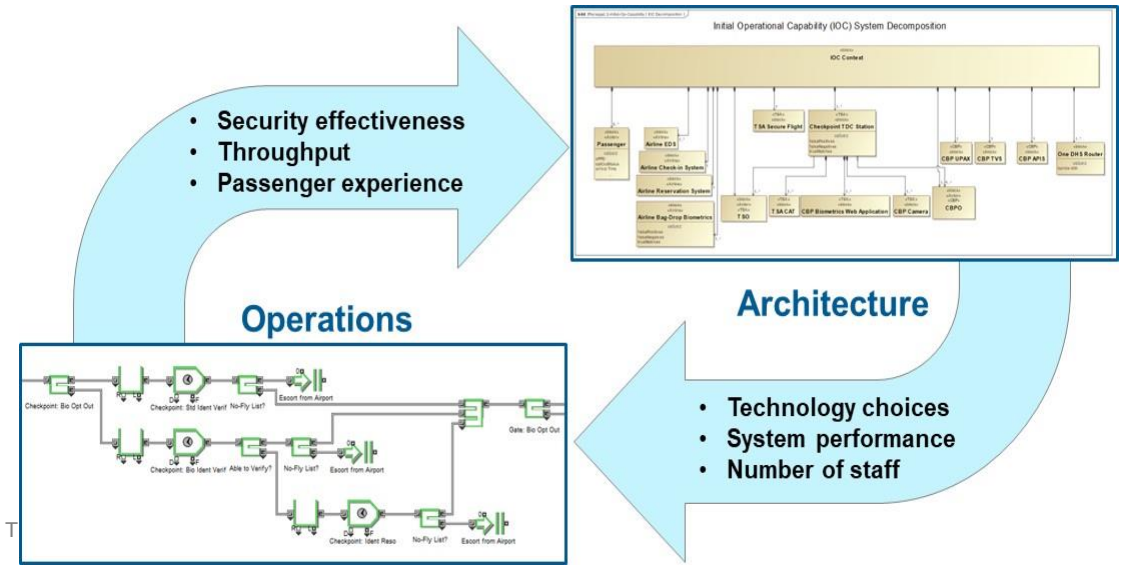
Assess current mission capabilities

- **Analyze current capability to establish baseline state of the mission**
  - **Technical Assessment: Characterize performance of current SoS - systems/ nodes/organizations supporting the mission thread**
  - **Operational Assessment: Assess performance of current systems/nodes/organizations operating together to evaluate/measure mission outcomes**

- **Behavior and performance of the SoS which supports the mission thread**
  - **Organizations and human decision-making and supporting systems including communications**
  - **Capture the data for use in this and future analyses**
- **Analyze the performance of the systems in the execution of the mission thread against the expected mission outcomes and other constraints – e.g. cost, personnel**
  - **End to end mission execution in terms of both technical performance and operational impact**

Assess current mission capabilities

- **Analyze current capability to establish baseline state of the mission**
  - **Technical Assessment: Characterize performance of current SoS - systems/ nodes/organizations supporting the mission thread**
  - **Operational Assessment: Assess performance of current systems/nodes/organizations operating together to evaluate/measure mission outcomes**



- **Behavior and performance of the SoS which supports the mission thread**
  - **Organizations and human decision-making and supporting systems including communications**
  - **Capture the data for use in this and future analyses**
- **Analyze the performance of the systems in the execution of the mission thread against the expected mission outcomes and other constraints – e.g. cost, personnel**
  - **End to end mission execution in terms of both technical performance and operational impact**

MITRE

Identify options and analyze trades

- **Identify alternatives and analyze their technical feasibility & mission impacts**

- **Identify options**
  - Stakeholders and extended technical community identify a range of options
  - Define needs/opportunities for prototyping and experimentation
- **Analyze Options and Trades**
  - Using current capabilities as baseline, make changes to reflect options
  - Assess impact of options on technical performance & on mission outcomes
- **Conduct review of alternatives & trades**

Identify options and analyze trades

- **Identify alternatives and analyze their technical feasibility & mission impacts**

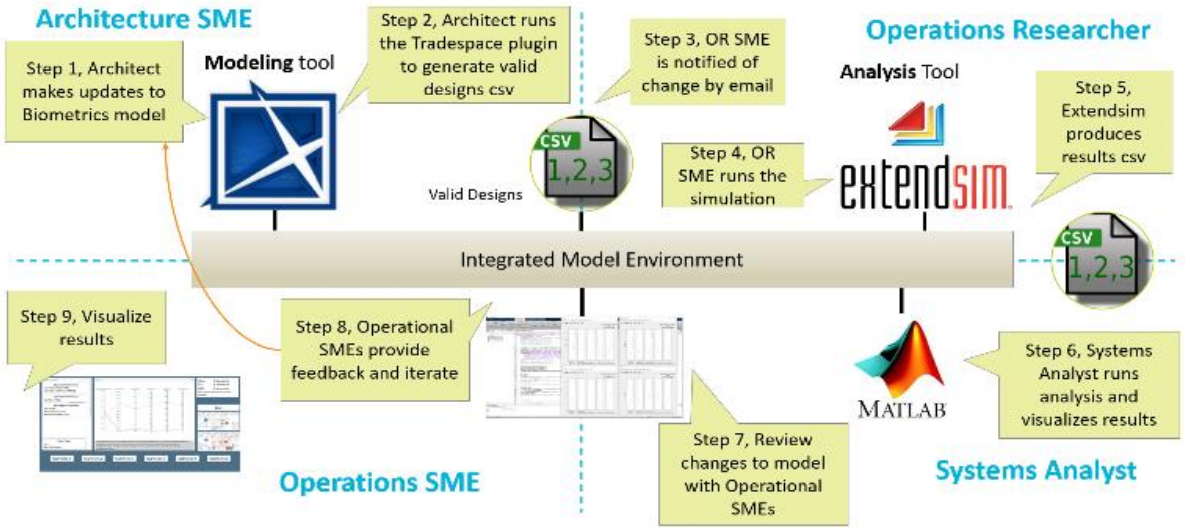
- **Identify options**
  - Stakeholders and extended technical community identify a range of options
  - Define needs/opportunities for prototyping and experimentation
- **Analyze Options and Trades**
  - Using current capabilities as baseline, make changes to reflect options
  - Assess impact of options on technical performance & on mission outcomes
- **Conduct review of alternatives & trades**

Example

Compare set of alternatives

- **Base Case (Current security process)**
- **Limited opt-in and capabilities (ranges and combinations of values for parameters)**
- **Full Capability (more extreme rates for parameters)**

Generate a full design space across all valid combinations of parameters – experimentation to support design space exploration



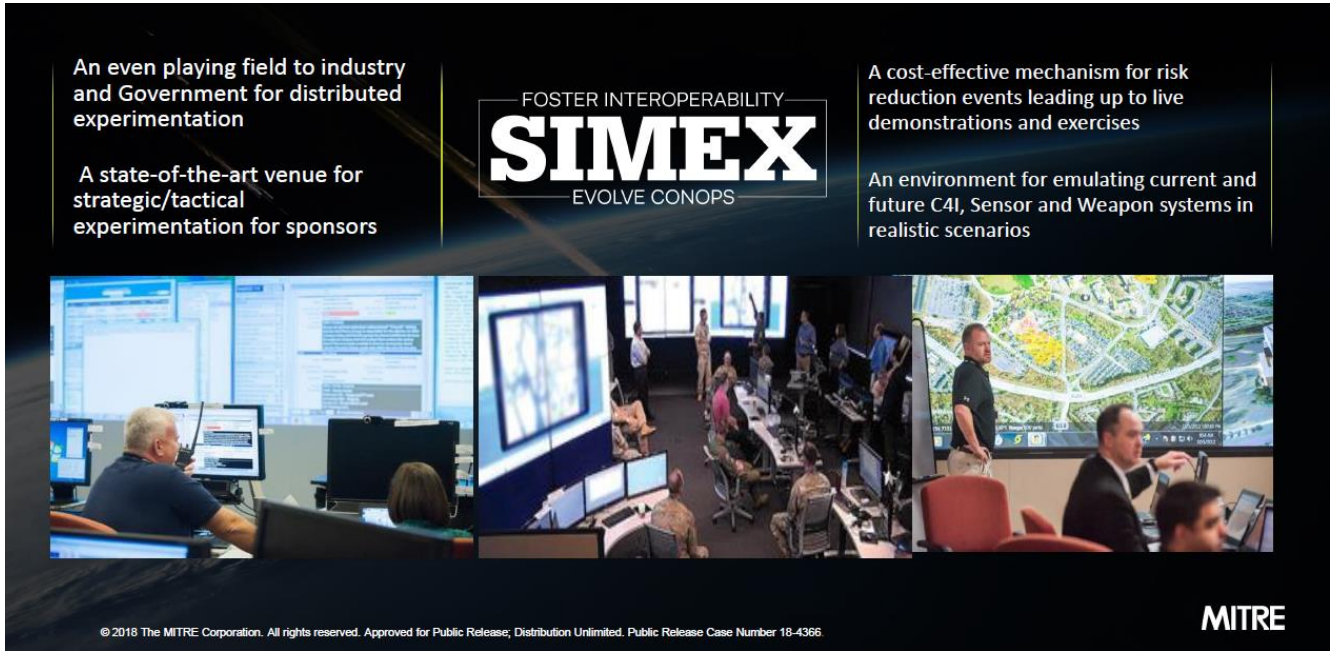
Prototype and experiment

- **Implement a physical prototype or conduct a technical or man-in-the-loop experiment to address uncertainties**

- **Develop a prototype or conduct an experiment to generate data to assess viability of an option**
- **Approach**
  - **Range of options** – models, prototype systems, operational experiment, man in the loop SIMEX, insertion of surrogate into operational context, …
  - Allows for exploration of new, innovative approaches
- **Incorporate results into analysis**
  - Value is based on the **data and insights** supporting the analysis of alternative capabilities to support the analysis of options and trades

Prototype and experiment

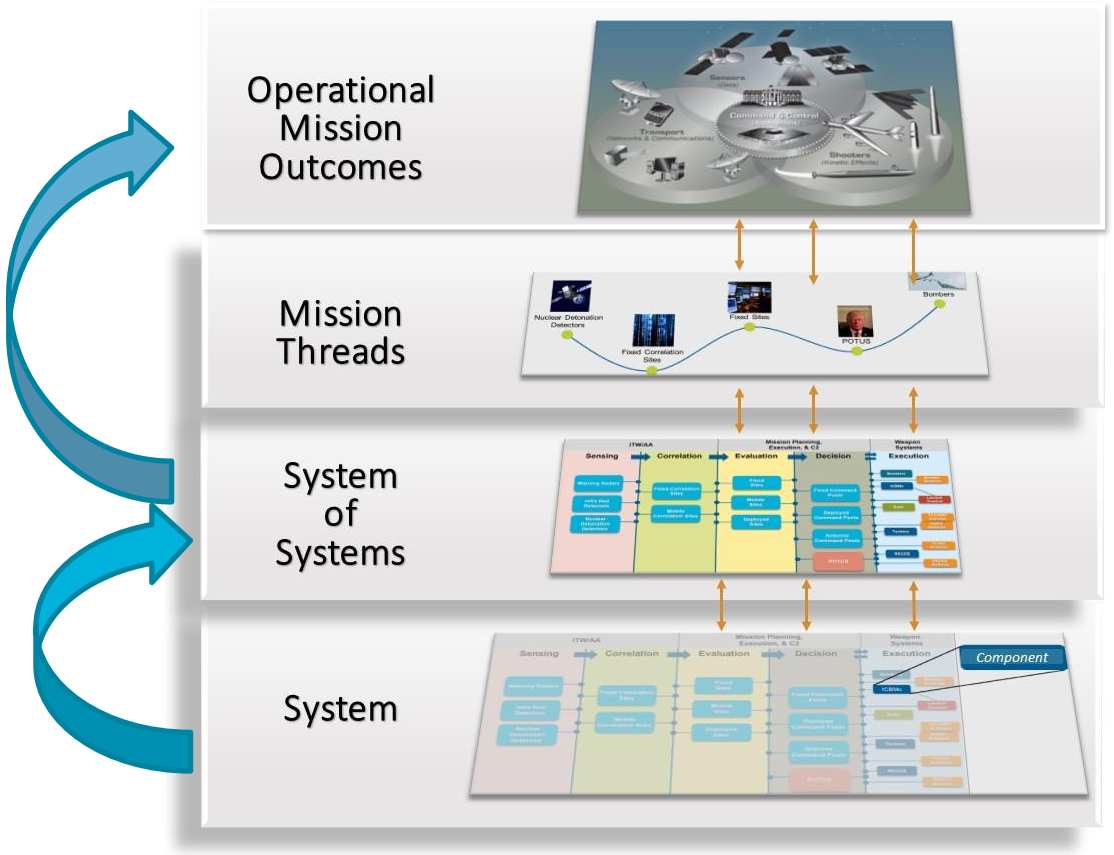
- **Implement a physical prototype or conduct a technical or man-in-the-loop experiment to address uncertainties**



- **Develop a prototype or conduct an experiment to generate data to assess viability of an option**
- **Approach**
  - **Range of options** – models, prototype systems, operational experiment, man in the loop SIMEX, insertion of surrogate into operational context, …
  - Allows for exploration of new, innovative approaches
- **Incorporate results into analysis**
  - Value is based on the **data and insights** supporting the analysis of alternative capabilities to support the analysis of options and trades

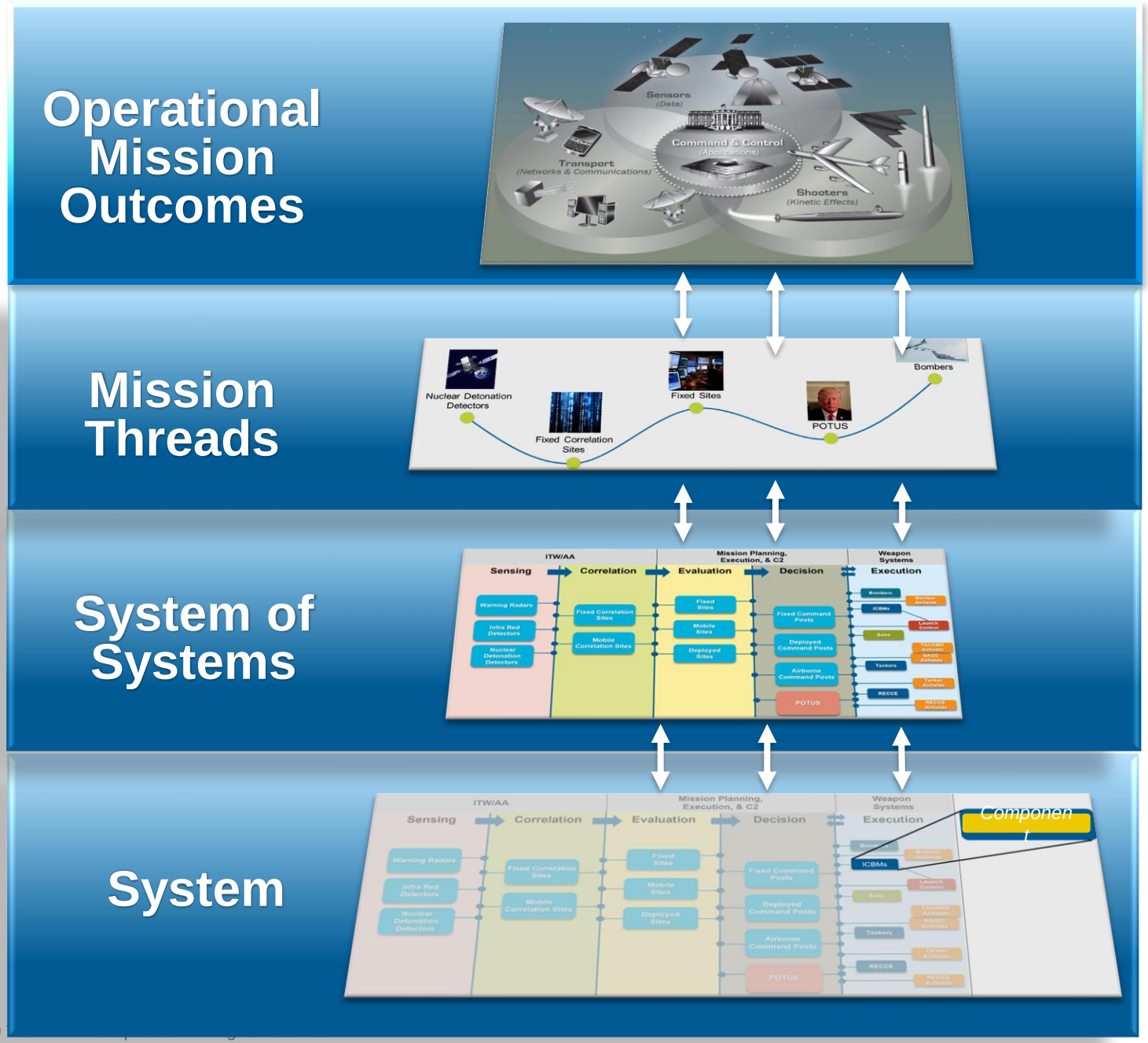
Recommendations

- Present a recommended actions, often in terms of changes with supporting evidence to address issue
- Supports decisions on systems and systems of systems SoS in terms of implications on mission outcomes



MITRE

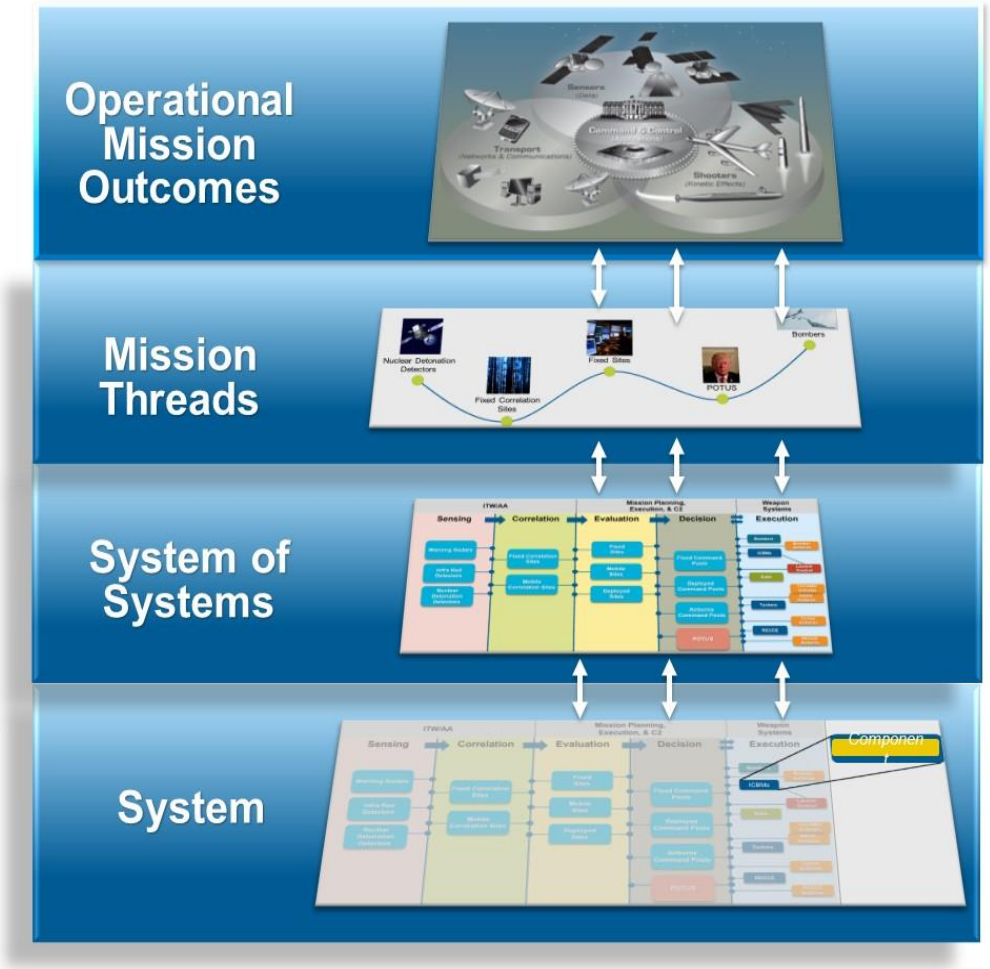
Discussion

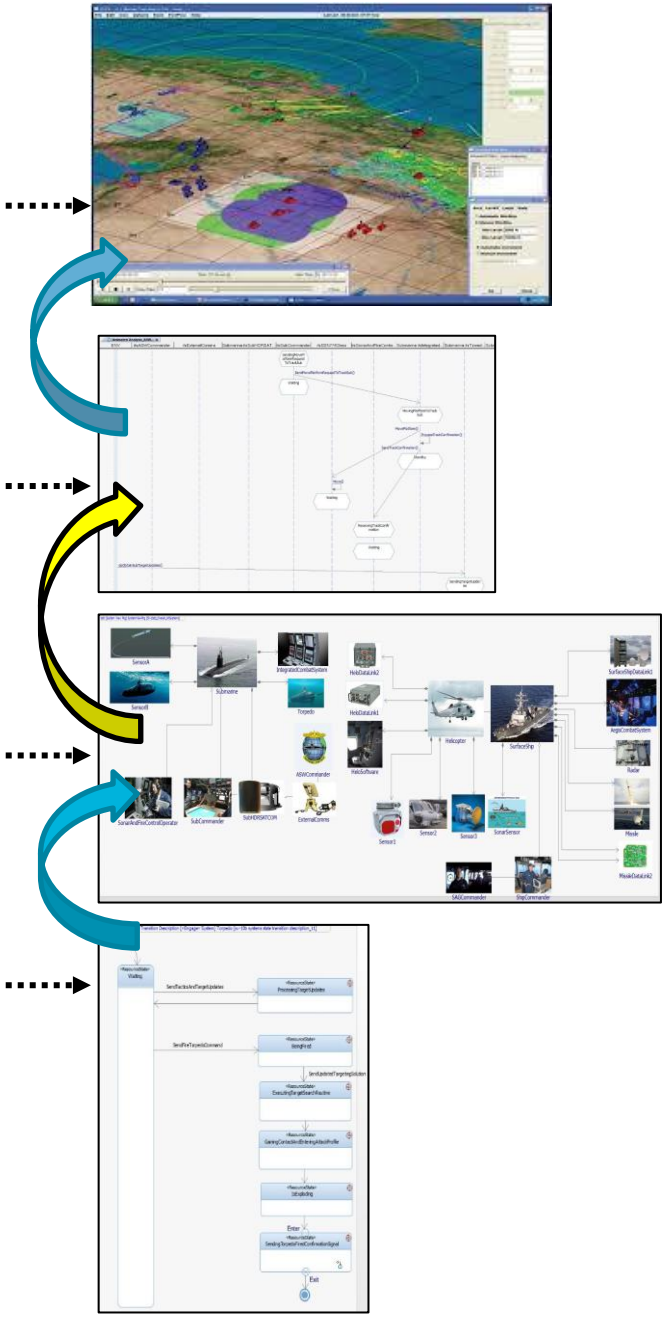


Systems of Systems in a mission context

Mission thread links technical performance to operational outcomes

MITRE





Mission Engineering benefits from executable digital engineering model-based approaches