SYSTEMS ENGINEERING RESEARCH CENTER

SERC TALKS

WELCOME

"Mission Engineering": Systems of Systems Engineering in Context"

August 5, 2020 | 1:00 PM ET

Dr. Judith Dahmann, Technical Fellow, The MITRE Corporation | **CONTACT**

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Dr. Judith Dahmann
The MITRE Corporation

MITRE

Mission Engineering: Systems of Systems Engineering in Context

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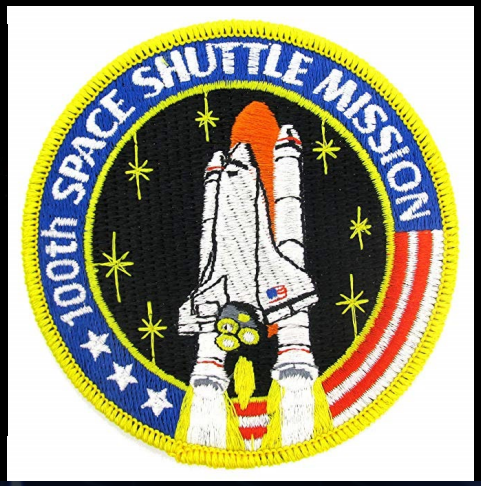
IMPOSSIBLE


NASA SPACE MISSION


100th SPACE SHUTTLE MISSION


MISSION:
ACCOMPLISHED


MISSION
SHAKTI


mission statement
A written declaration of an organization's core purpose and focus that normally remains unchanged over time. Properly ...
BD
BusinessDictionary


Huntington
City Mission
— WHERE HOPE BEGINS —


MISSION BBQ
The American Way.


MISSION CX 8000

What do we mean by ‘mission’?

- Any important task or duty that is assigned, allotted, or self-imposed
- An important goal or purpose that is accompanied by strong conviction
- A set of tasks that fulfills a purpose or duty
- Purpose, aim, objective
- Military mission - operation assigned by a higher headquarters

Systems of systems and systems engineering

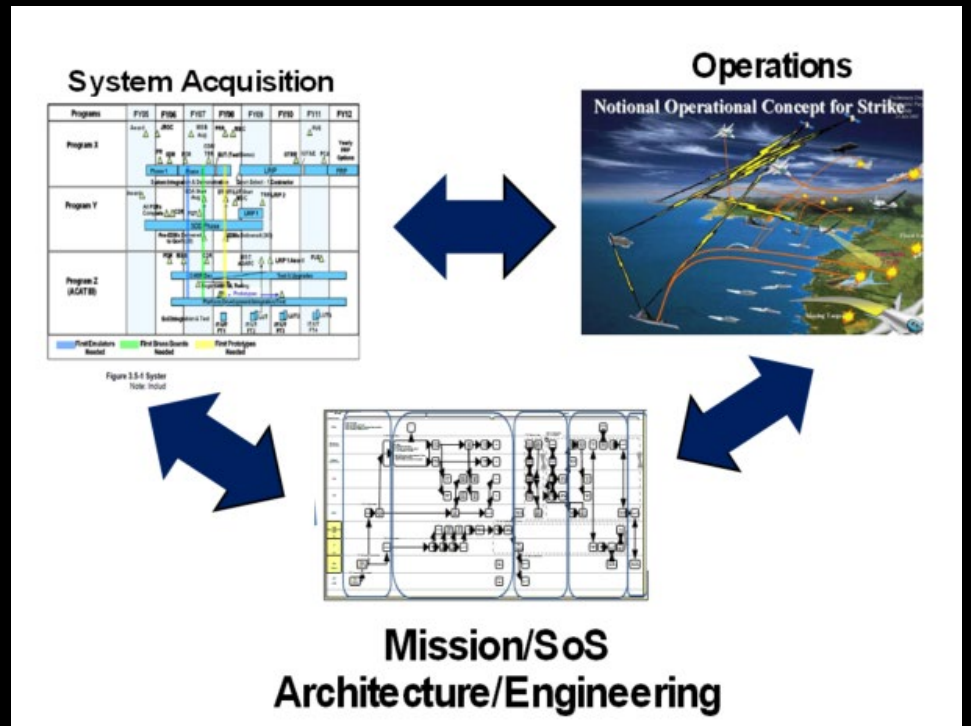
System of Systems

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

Systems of Systems Engineering

The process of planning, analyzing, organizing, and integrating the capabilities of a mix of existing and new systems into a system-of-systems capability that is greater than the sum of the capabilities of the constituent parts

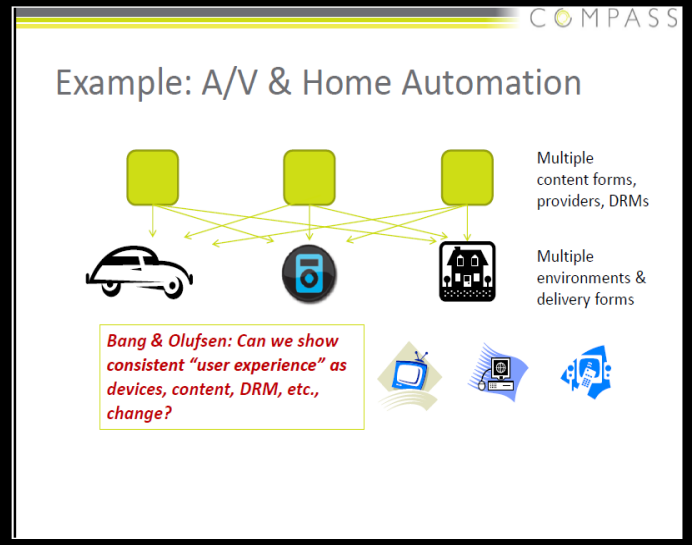
What do we mean by ‘mission engineering’?

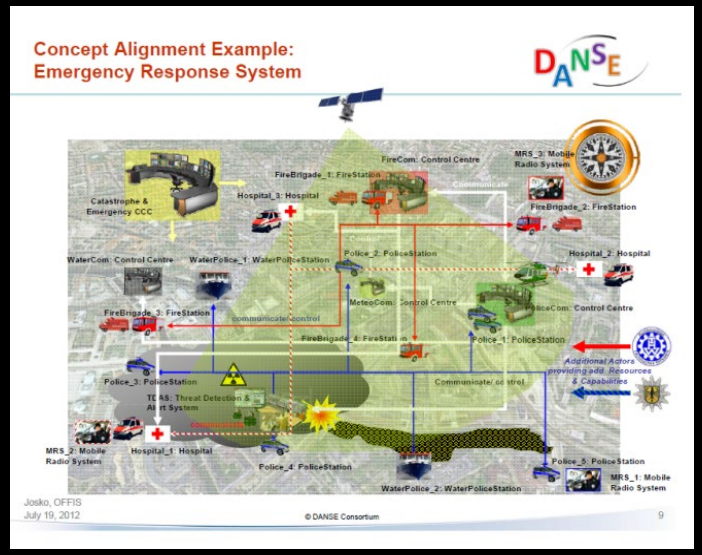


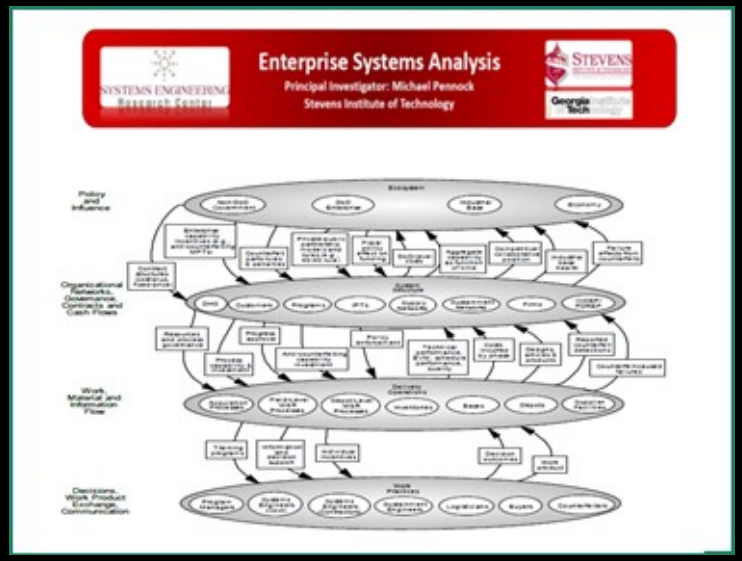
Mission Engineering is the deliberate planning, analyzing, organizing, and integrating of current and emerging operational and system capabilities to achieve desired operational mission effects

- 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

Scale and scope of SoS

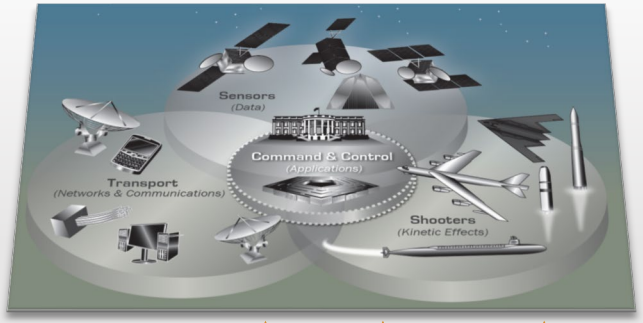




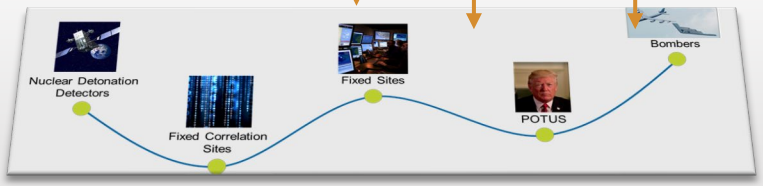


Technical ----- Socio -Technical ----- Enterprise

Operational Mission Outcomes

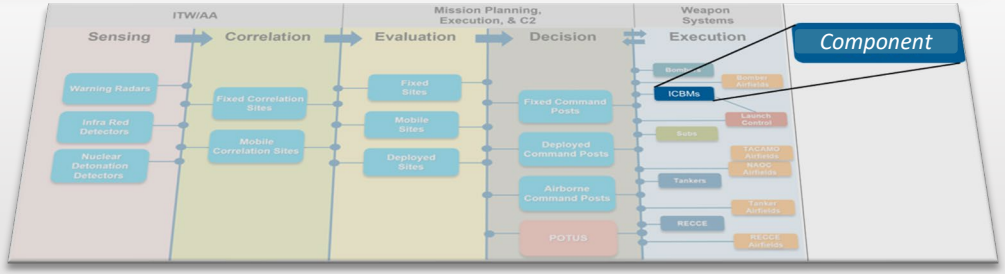


Mission Threads



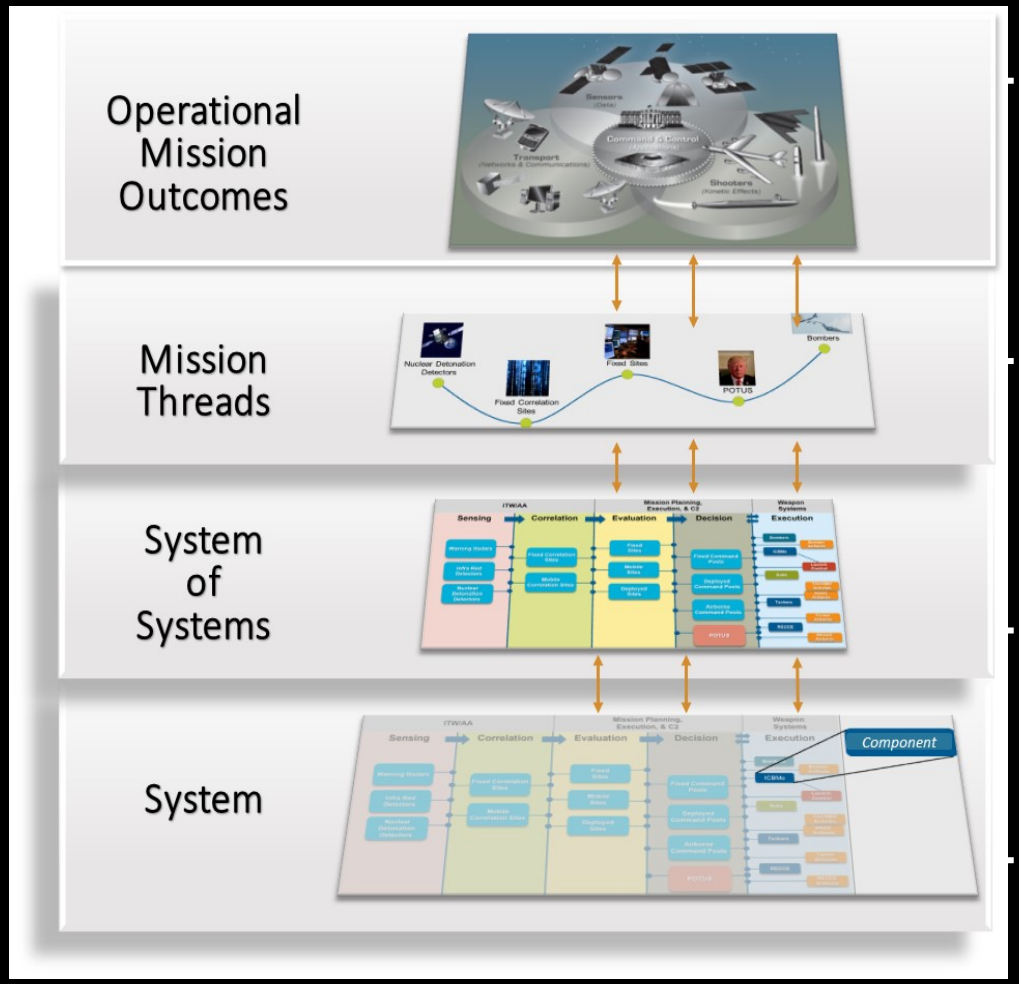
System of Systems

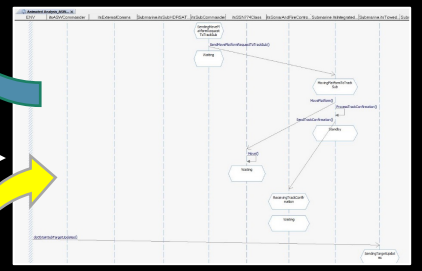
System

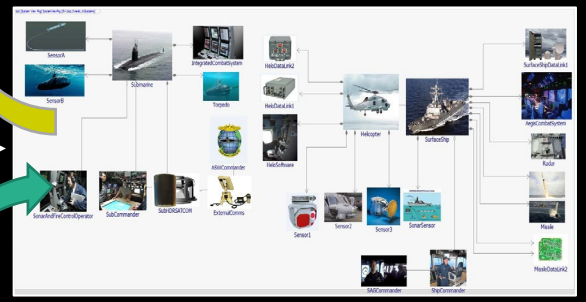


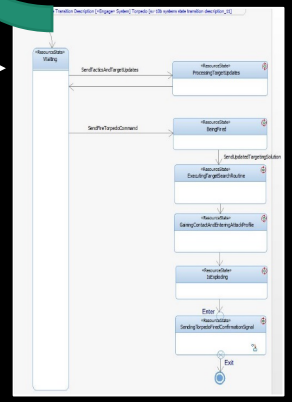
Systems of Systems in a mission context

Mission thread links technical performance to operational outcomes









Mission Engineering benefits from executable digital engineering model-based approaches

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)

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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

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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

What are the steps in ‘mission engineering’?

Establish the context and motivation for ME

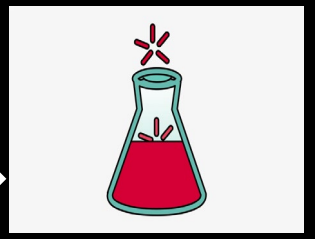
Form ME team

Describe the plan for data, models & analyses

Assess current situation

Delineate mission context

Identify options and conduct trades



Prototype and experiment

Recommendations

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?

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-- 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

Form ME Team

- **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

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Develop ME plan

- **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

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

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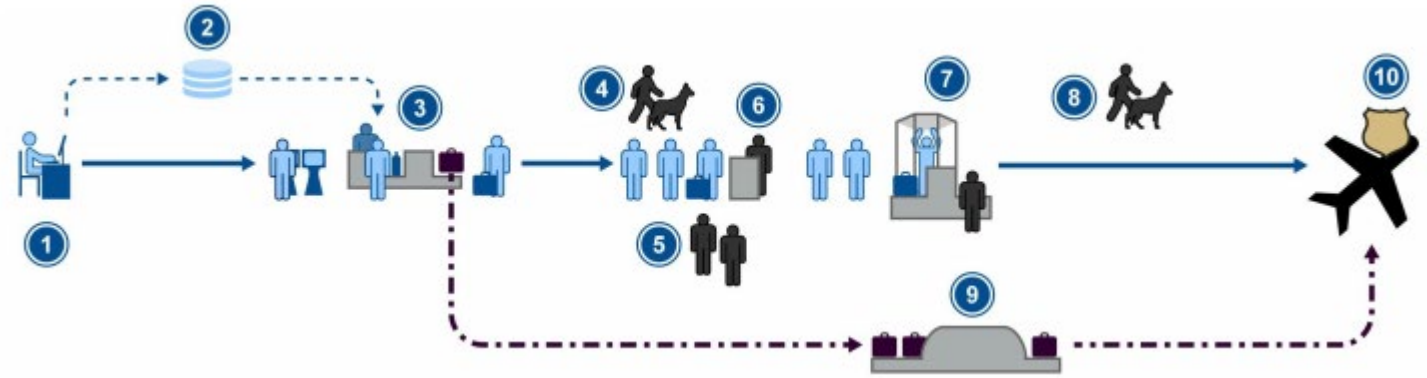
Example

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



Source: GAO Analysis of TSA Information GAO -17-794

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 steps in the mission activity sequence (e.g. threads)
  - 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

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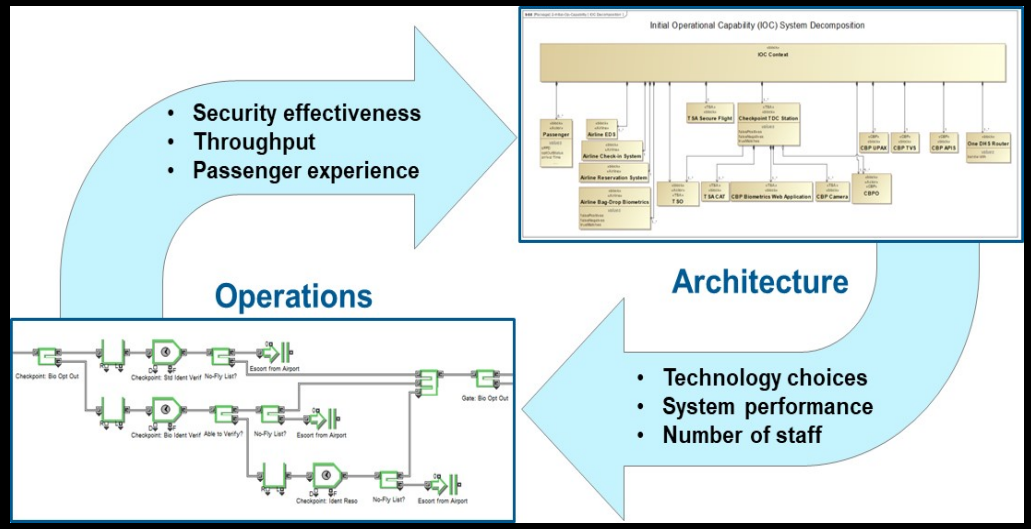

Identify options and analyze trades

- Identify alternatives and analyze their technical feasibility & mission impacts

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

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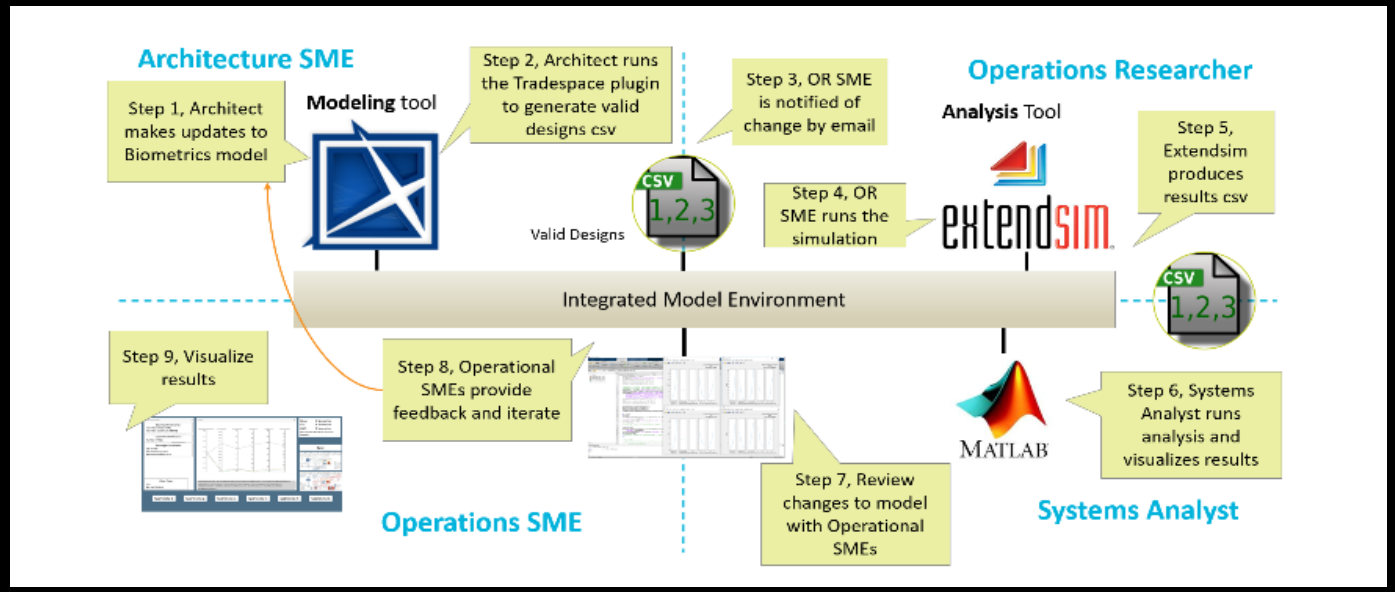
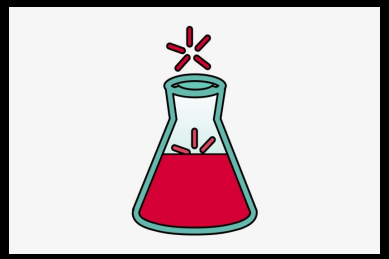
Example

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

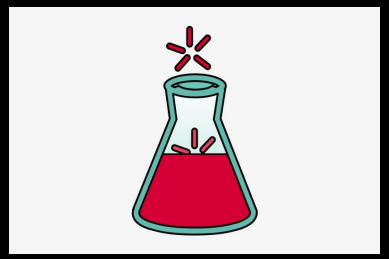




Prototype and experiment

- 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**
  - May include a 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



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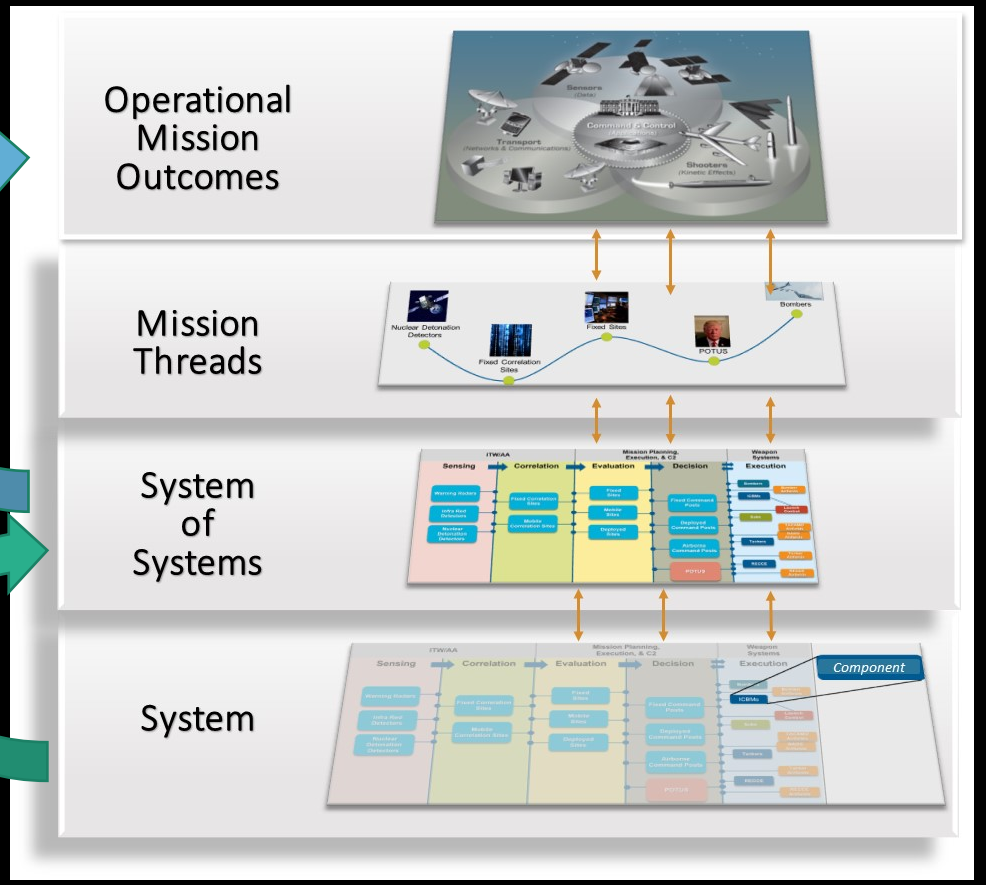
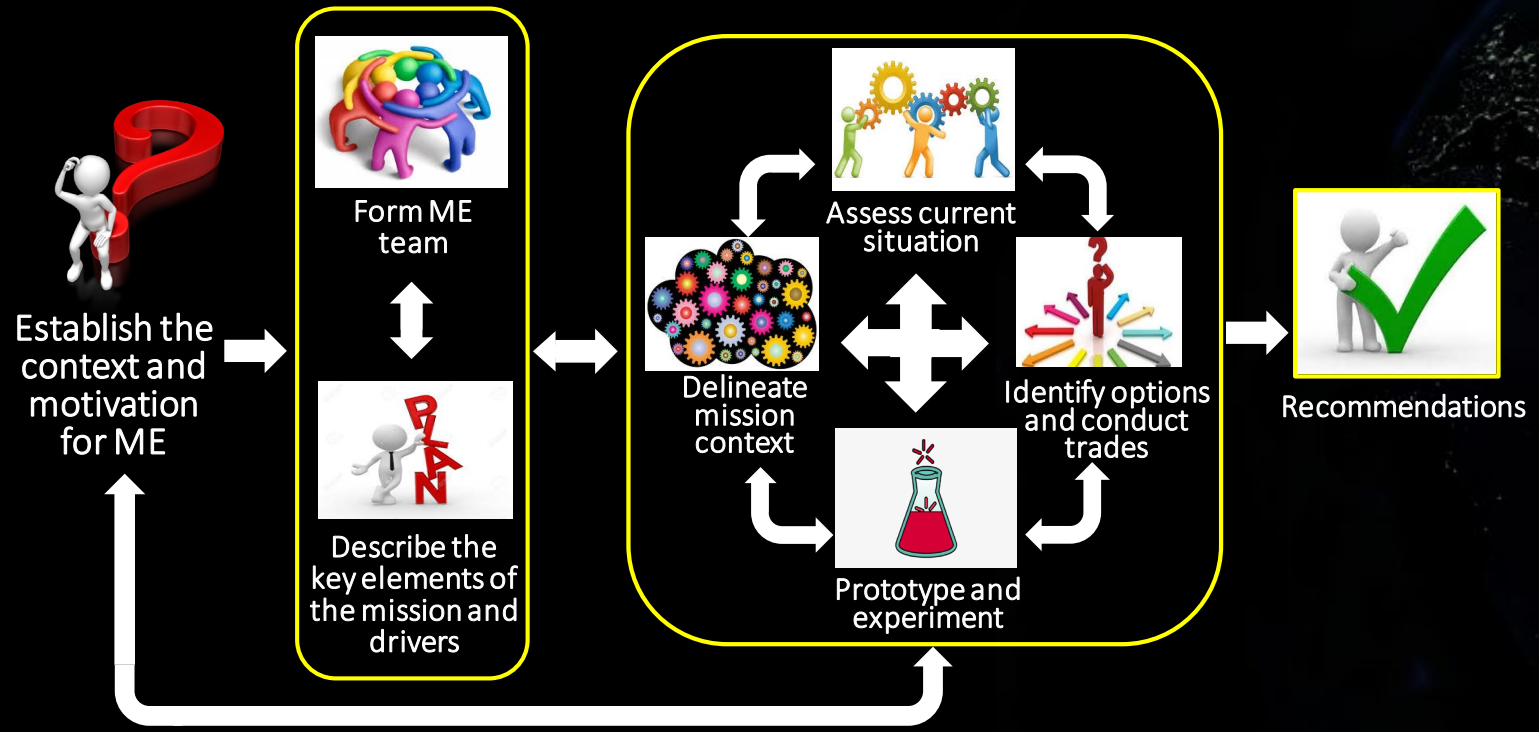
- Incorporate results into analysis
  - Value is based on the data and insights supporting the analysis of alternative capabilities to support the analysis of options and trades

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



In sum.....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Form ME team
PLAN
Describe the key elements of the mission and drivers
Assess current situation
Delineate mission context
Identify options and conduct trades
Prototype and experiment
Recommendations

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"Mission Engineering" Series

Tentative Dates:

Wednesday, October 7, 2020

Wednesday, December 2, 2020

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