EGGLER
INSTITUTE OF TECHNOLOGY

A PRACTICAL TUTORIAL IN MISSION ENGNINEERING & SYSTEM DESIGN









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Unlocking the Power of MBSE:
A Practical Tutorial in Mission Engineering and System Design



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Welcome

- Scope
  - Introduction
  - Mission engineering
  - Requirements generation
  - System architecture
  - Barriers to MBSE adoption
- Tutorial booklet
- Tutorial feedback



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Introductions

- Personal introductions
  - Name
  - Current Role
  - Brief background
  - Why are you here?
  - What you hope to learn from the tutorial





What is Systems Engineering?





Operational Needs



Systems Engineering Processes



Mission Products

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Traditional Systems Engineering

- Traditional systems engineering focusses on documents to specify and support design, development and sustainment
- Reading of documents is a linear process
- Document updating and change control problematic
- This is a big disadvantage!



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Based on your experience, what motivates organisations to do MBSE?



Nobody has responded yet.

Hang tight! Responses are coming in.

Start the presentation to see live content. For screen share software, share the entire screen. Get help at pollev.com/app

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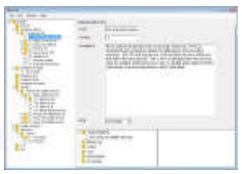
Engineering: Paper to Digital



Document-based systems engineering



Digital model-based systems engineering



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When you lose track of the mission!



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What is MBSE?







Operational Needs



Systems Engineering Processes



Mission Products

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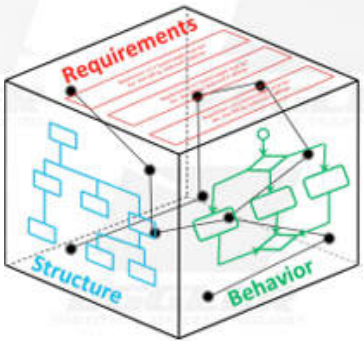
Model-Based Systems Engineering

- Modern database tools can shift the SE paradigm
- MBSE focusses on *designing the system model*
- A single model has many views
  - Operational views
  - System behaviour diagrams
  - Test views
  - Interface views
  - 'Document views'



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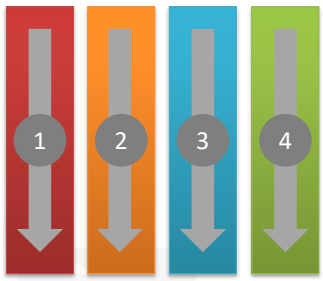
mbSE – How's it Different?



Traditional Systems Engineering[1]

Government



Industry

mbSE Using Layered Approach (Simplified)

1. Adapted from: *A Primer for Model-Based Systems Engineering*, 2nd Edition, 2011. Vitech Corporation

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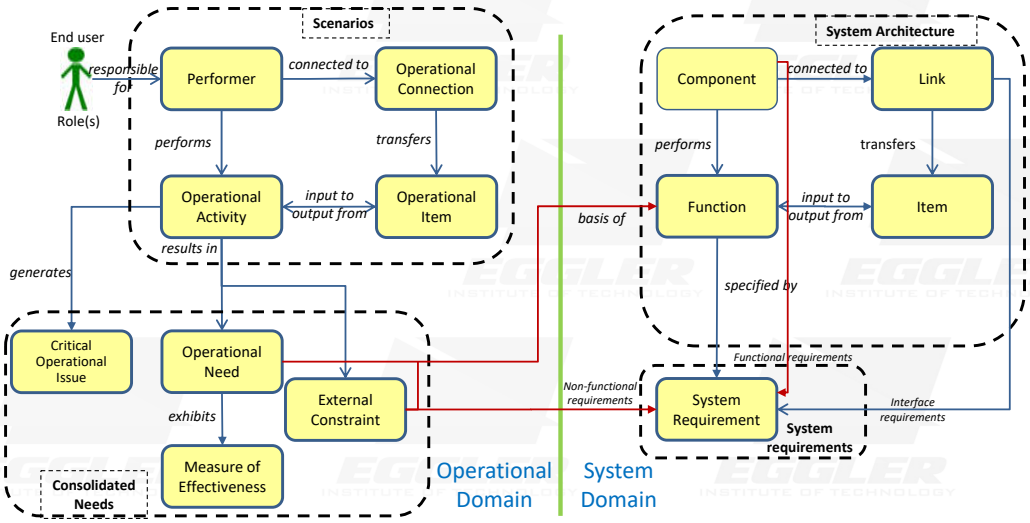
MBSE Information Design Schema



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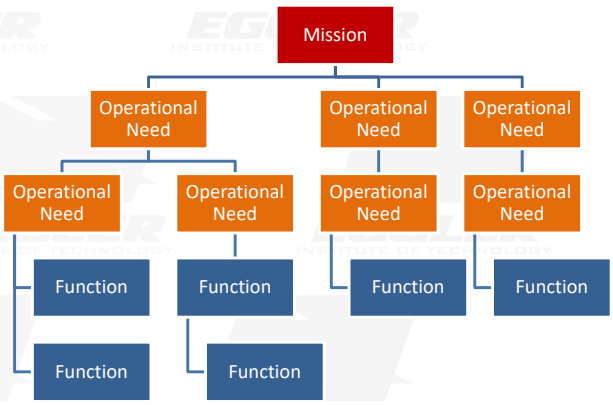
It All Starts With the Mission!





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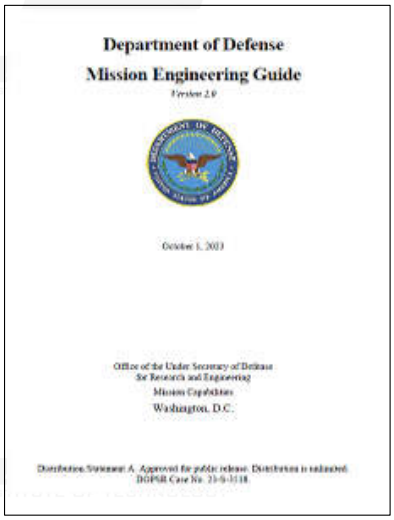
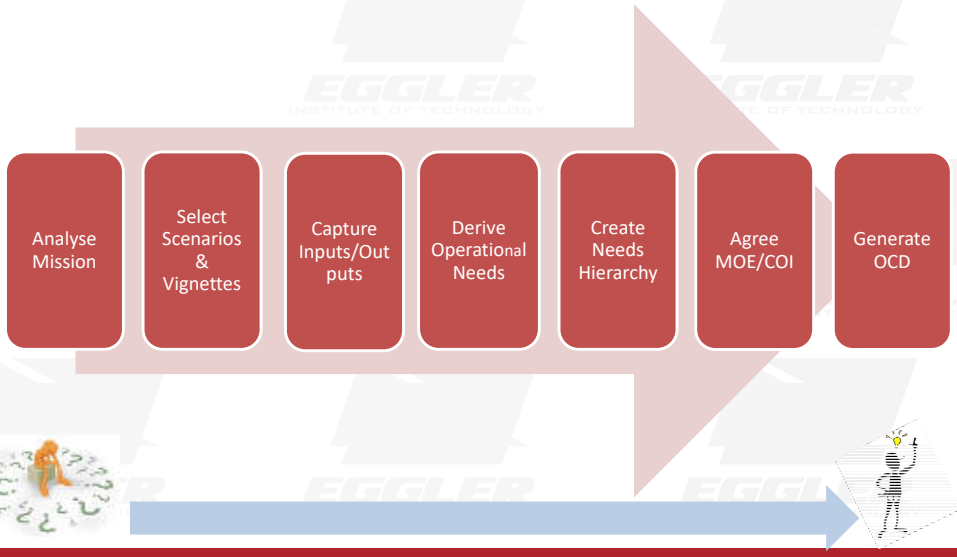
Mission Engineering

Mission engineering is an interdisciplinary process encompassing the entire technical effort to analyze, design and integrate current and emerging operational needs and capabilities to achieve desired mission outcomes.


Department of Defense
Mission Engineering Guide
Version 2.0
October 1, 2023
Office of the Under Secretary of Defense
for Research and Engineering
Mission Capabilities
Washington, D.C.
Distribution Statement A. Approved for public release. Distribution is unlimited.
DOPSR Case No. 23-S-3118

Handout Source: Mission Engineering Guide, DoD, v2.0 (2023)

Mission Engineering (Operational Analysis) Process



Handout

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Example – Heavy Tank Recovery Mission

"The mission of the Heavy Tank Recovery Vehicle is to recover and transport a casualty M1A1 Abrams tank from a battlefield location to a field repair facility in support of mechanised operations within Australia and our Regional Area of Operational Interest."

Recovery needs

Transport needs

Terrain, Protection needs

Support interface

Environmental needs

Transportability needs

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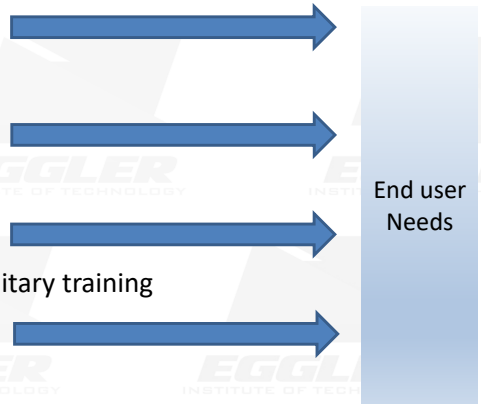
Agree Scenarios and Vignettes

- Scenario 1: Deploy to regional location and perform recovery operations in a contested environment
  - Vignette 1: Deployment into the area of operations
    - Transportability Needs
    - Support Interface
  - Vignette 2: Contested recovery operation by day
    - Recovery Winch Capacity
    - Transport Vehicle Needs
    - Terrain Handling
    - Protection
  - Vignette 3: Uncontested recovery at night
    - Recovery Winch Capacity
    - Terrain Handling
- Scenario 2: Deploy within Australia to support military training
  - Vignette 1: Deployment
    - Environmental Needs



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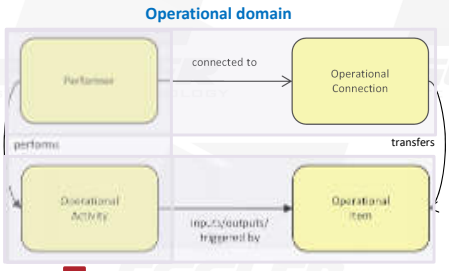
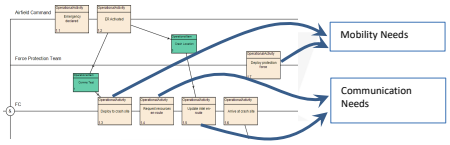
Operational Analysis



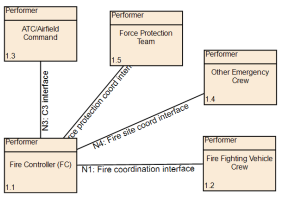




Operational Activity Diagrams

Operational Needs

OCD



Performers and Operational Connections

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Functional Analysis & Requirements Generation



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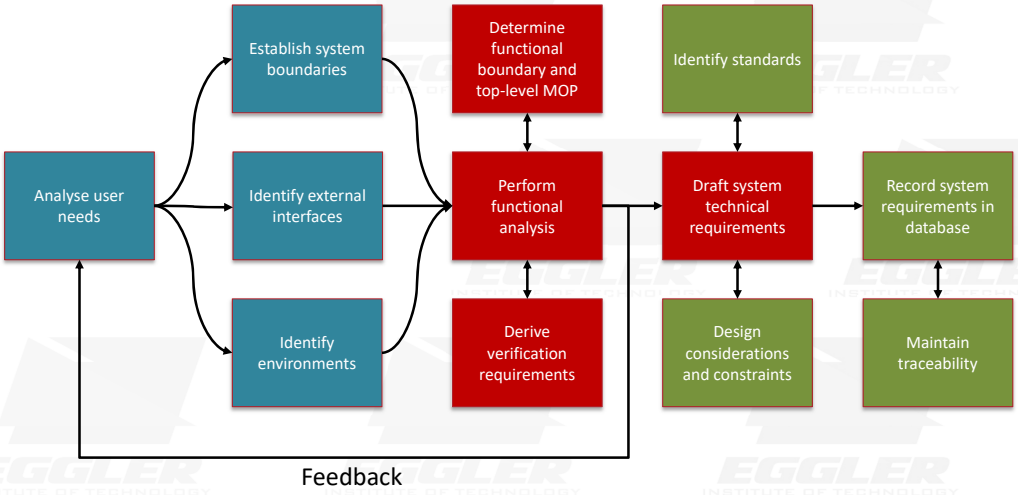
Functional Analysis Process



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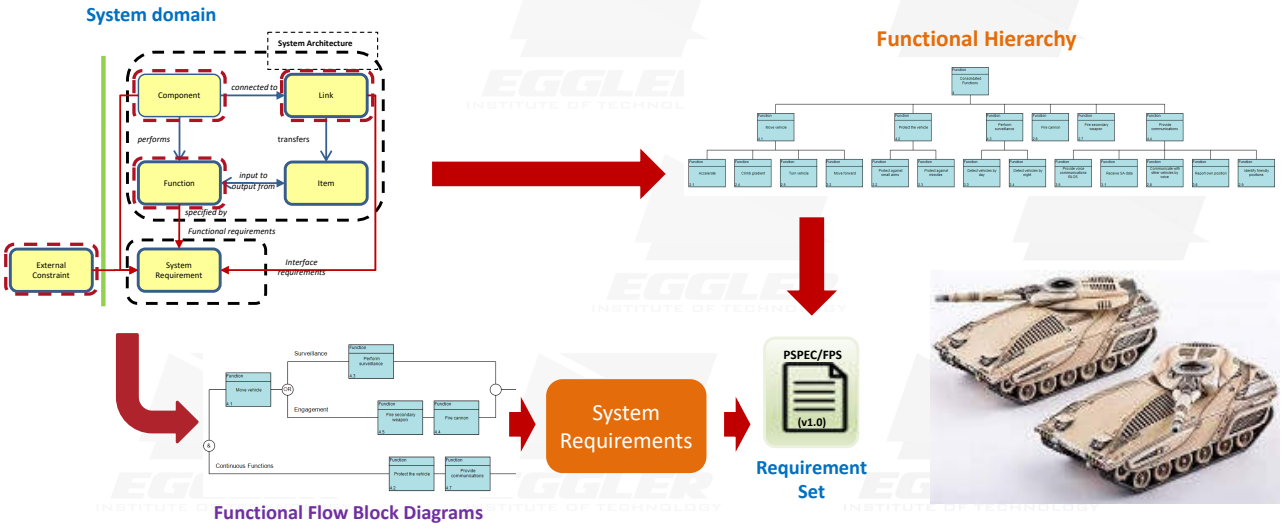
Functional Analysis & Requirements



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System Design & Synthesis



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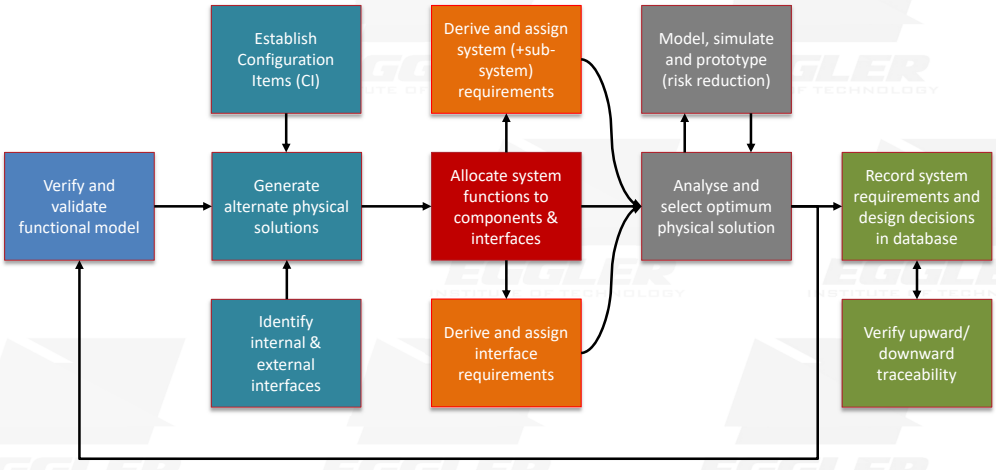
Process Diagram



Verify functional and physical solutions are consistent

Source: Adapted from INCOSE Handbook, p102

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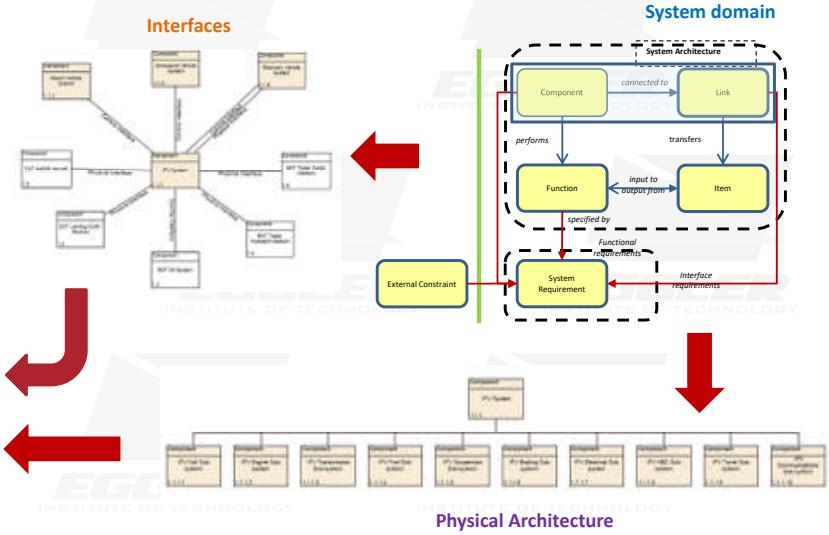
System Design & Synthesis





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MBSE: A Different Way of Working

- MBSE shifts the effort from writing documents to designing the system/capability model – support systems thinking
- We do our engineering work in a MBSE tool
  - There is a training overhead to 'learn the tool'
  - Operational, functional, constraints and requirements can be 'viewed' consistently
  - The key design documents are generated automatically from the tool



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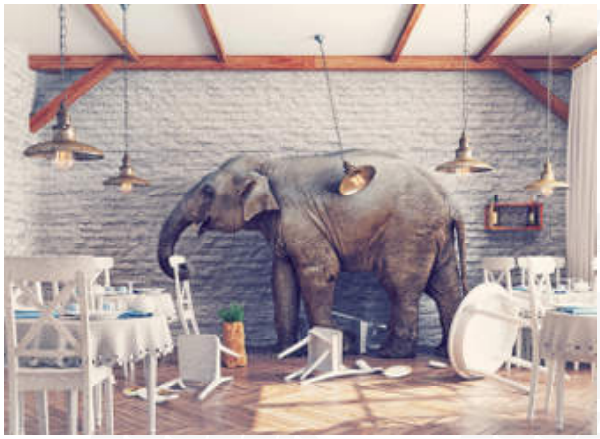
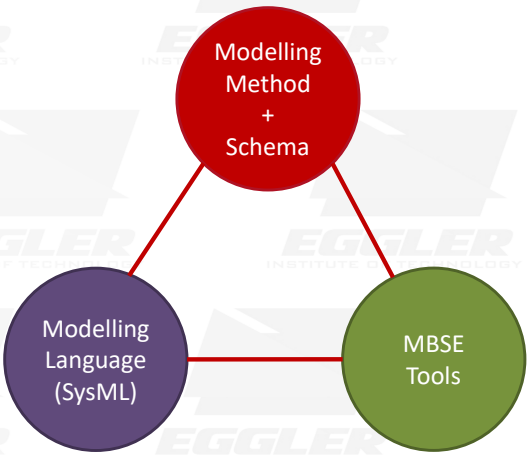
MBSE Adoption Challenges





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Systems Engineering Capability Must Evolve

Capability	Traditional SE	Model-Based SE
People	• Engineers trained in SE	• Engineers trained on MBSE tools and SysML
Process	• Repeatable SE design processes	• Model-oriented processes for requirements development, design and V&V
Tools	• Design tools	• Model-based SE design tools
Governance	• Effective SE governance	• Model-based governance processes

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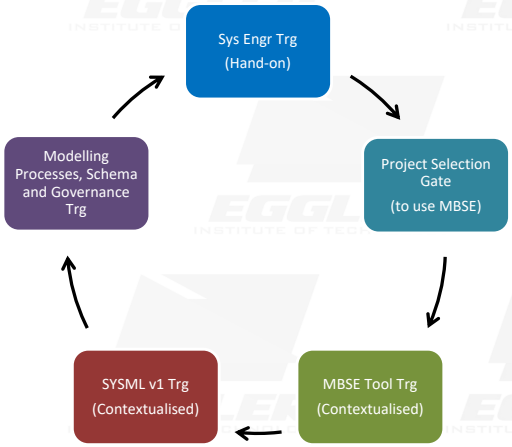
Barriers to Implementation (Systems Engineering & MBSE)



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MBSE Tools

- MBSE Tools provides
  - central repository
  - traceability
  - diagram support
  - document generation
- Simple interface
- Rich schema of design artefacts

Eggler Institute does not recommend any vendor tools

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Adoption Barriers: What the Research Says

The Dream

"The incentive to adopt (MBSE) is that by combining it with rigorous engineering and authoritative sources of data and models (one) can achieve rapid design optimzation, test for safety and assess proposed capabilities."

The Reality

- Many MBSE implementations fail – it's no silver bullet
- Organization planning, execution…not providing long-term stability
- Overcontrolling governance discouraging learning & experimentation
- Lack of investment in staff upskilling, tool infrastructure and analytical tools
- Value still not proven by evidence

Source: *An Independent Assessment of the Army Implementation of Digital Engineering*, The Army Science Board. 2023



So Why Do MBSE?

Management benefits

- Structured framework for logical analysis
- Uses consistent language
- Eliminates uncontrolled documents
- Easy to identify full impacts of change
- Provides 'patterns' for improved system design productivity

Technical benefits

- Considers entire engineering problem
- Provides 'single source of truth' for data
- Reduces error rates
- Provides rich traceability
- Allows layered analysis which can easily been seen and reviewed

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Questions



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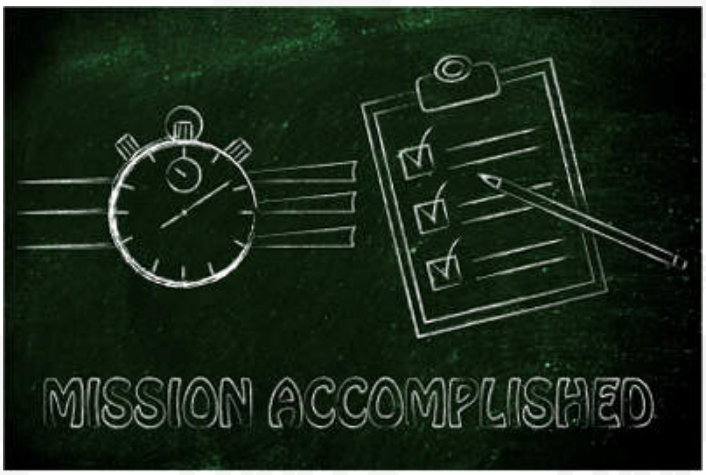
Tutorial Wrap Up



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Feedback





https://forms.cloud.microsoft/r/ze3JYvMuW2

Thank You For Attending

- Thanks for your participation and feedback
- Participation certificates and digital badges will be available tomorrow
- Stay in touch & keep learning!



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To Learn More

To get in touch scan the QR Code and let's connect!



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Mission Engineering – Other Definitions

- **Mission Engineering Analysis:** The approach to evaluate mission architectures within the specific scenario-based mission context to provide quantitative outputs that explore mission impacts
- **Mission Thread:** A sequence of end-to-end mission tasks, activities and events presented as a series of steps to achieve a mission
- **Mission Engineering Thread:** Mission threads that include the details of the capabilities, technologies, systems and organizations required to execute the mission

Source: Mission Engineering Guide, DoD, v2.0 (2023)

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Recommended Reading List

Systems Engineering

Serial	Reading	Essential (E)/ Desirable (D)	Copyright (Yes/No)
1.	INCOSE, *Systems Engineering Handbook*, Fifth Edition, 2023	E	Yes
2.	ISO Standard, ISO 15288, *Systems and software engineering-system life cycle processes*, 2015	E	Yes
3.	NASA Systems Engineering Handbook Revision 2 (NASA 2020)	D	No
4.	Gabb A., *Front-end Operational Concepts – Starting from the Top*, INCOSE, 2001	E	Yes
5.	Sproles N., *Formulating Measures of Effectiveness*, INCOSE, Vol. 5, No. 4, 2002	D	Yes
6.	ANSI/AIAA G-043A-2012, *Guide to the Preparation of Operational Concept Documents*, 1992	D	Yes
7.	US DoD Architectural Framework v2.02	D	No
8.	Henderson, K., *Value and Benefits of Model-Based Systems Engineering (MBSE): Evidence from the Literature*, Wiley, Dec 2020	E	Yes
9.	Madni, A., *Economic Analysis of Model-Based Systems Engineering,* MDPI, 2018	D	Yes
10.	Constantine, J., *SysML Modelling of Off-the-Shelf Option Acquisition for Risk Mitigation in Military Programs*, Wiley, Mar 2009	D	Yes
11.	Michael D. Griffin, "*How Do We Fix Systems Engineering?*" – 61st International Astronautical Congress, Prague, 2010	D	Yes

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