RT-171 Mission Engineering Competencies

Sponsor: DASD(SE)

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• Mission engineering as the application of systems of systems (SoS) engineering in a operational context.

• Research tasking and objectives to identify the critical skills required to successfully accomplish and shepherd mission engineering.

• Competency model builds on grounded theory leverages the Helix methodology on developing effective system engineers using a combination of mission engineer interviews as informed by searching the open source literature.

• Interviews and open source literature covers 1) mission engineering definition and organizational support, 2) identification of competencies and gaps, and 3) future vision.

• Mission engineering overlaps systems engineering competencies with important differentiation in 1) governance, 2) foundational math/science/general engineering skills, 3) operational concepts, 4) interpersonal skills, 5) and leadership skills.
Mission engineering is the deliberate planning, analyzing, organizing, and integrating of current and emerging operational and systems capabilities to achieve desired warfighting mission effects – Gold 2016
Mission engineering differs from mission analysis in that the latter only addresses current operational and system capabilities and not the engineering to assure the mission.

Mission engineering within the Department of Defense (DoD) applies an operational mission context to the complex systems of systems (SoS).

The SoS approach has arisen in response to the DoDs needs for capabilities requiring multiple linked systems that are greater than the sum of the capabilities of the constituent parts.

Mission engineering differs from traditional systems engineering because from the mission engineering perspective, the individual systems that comprise the military capability are inherently flexible, functionally overlapping, multi-mission platforms supported by a complex backbone of information communication networks.

Several other allied nations use the term “capabilities engineering” rather than mission engineering.
The Office of the Deputy Assistant Secretary of Defense for Systems Engineering ODASD(SE) has tasked the Systems Engineering Research Center (SERC) to identify the critical skills required to successfully accomplish and shepherd Mission Engineering.

- Identify competencies for mission engineering that are truly unique, showing where there is separation from the generally demanded acquisition competencies or systems engineering competencies.
- Identify critical overlaps between mission engineering and systems engineering competencies.
- Identify aspects of mission engineering that are general enough to be considered critical by the broader acquisition workforce, yet specific enough to support building interdisciplinary mission engineering knowledge and abilities.
- Develop a mission engineering competency model that supports the DoD engineering community but also provides input to each acquisition career field (e.g. program management, test & evaluation, etc.) unique to their responsibilities to support and manage mission engineering.
- Conduct a gap analysis comparing Defense Acquisition University's (DAU) current curricula against the competency requirements.
- Provide recommendations on creating a mission engineering curriculum, as well as modifying the applicable acquisition career fields’ curricula to build interdisciplinary mission engineering knowledge and abilities.
Mission engineering (ME) competency model lays out the skills, abilities and behaviors that are critical to ME and whether they are unique or overlap with systems engineering.

The research draws heavily from the Helix methodology on developing effective system engineers.

Reflects industry approaches and best practices.
Additional Tasks

• Provide an analysis comparing Defense Acquisition University’s current curricula against the ME competency requirements.

• Review open literature describing ME applications, methods, and tooling.

• Provide recommendations on building an ME curricula to build interdisciplinary ME knowledge and capabilities.
Current Status

• (please note that the actual presentation will contain the latest data)

• Completed 22 ME data gathering interviews to date.

• Ongoing ME expert reviews.

• Rich body of work in the open source literature over the last 10 years including both peer reviewed journals and conferences as well as publically available in-house publications.

• Continuing analysis of interview data and open source literature over the first quarter of calendar year 2018.
Mission Engineering Competency Model
Development Methodology

A. PREPARATION
A1. Identify Organizations and Individuals
A2. Provide Project Materials to Participants

B. COLLECTION
B1. Collect Consent Forms
B2. Conduct Data Gathering Interviews (90 min)
B3. Conduct Validation/Review Interviews (60 min)

C. ANALYSIS
C1. Interview Summaries
C2. Initial Analysis
C3. Preliminary Findings
C4. Detailed Analysis

D. ANSWER RESEARCH QUESTIONS
D1. Competency Framework
D2. Answer Research Questions

E. PUBLISH RESULTS
E1. Tech Reports
E2. Conference/Journal Articles & Presentations

F. METHODOLOGY REVIEW
F1. Identify Updates for Interview Questions
F3. Identify Updates for Data Collection Approach
Interview Data Analysis

Grounded Theory Review

Review for Expected Themes From Independent Open Literature Search of Mission Engineering Publications

Revised Note Set (Used for Data Coding)

Coding Approach

Highlight areas of relevant information. These are "excerpts".

Identify key themes.

Organize data via key themes.

Iteration (more detailed coding)

Updated Findings

Team Review

Methodology Updates (if needed)

Initial Findings GT & Themes

Updated Findings

Initial Findings GT & Themes

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Updated Findings

Team Review

Methodology Updates (if needed)
Analysis Approach: Initial Coding
Analysis Approach: Review Excerpts and Update Coding Structure Based on Details

- Competencies
  - Soft Skills
  - Systems Mindset
  - Technical
    - Breadth
    - Model-Based
    - Operational Context
  - Current Effectiveness
  - Definition of ME
    - ME is a Different Discipline from SE
    - ME is SE
    - ME is SE+
      - ME is SOSE
      - ME vs SE Differences
  - ME Critical Activities
  - Personal Characteristics

References:
- Reference 1 - 0.41% Coverage
  - Know all the disciplines to some degree.
- Reference 2 - 1.34% Coverage
  - Have excellent communication skills. We get SMEs in the area and we they need to communicate with them, both orally and in writing.
- Reference 3 - 0.26% Coverage
- Reference 4 - 0.82% Coverage
  - Soft skills are important.
  - Ability to be deliberate when we look at the challenges in projects that we have.
- Reference 5 - 0.35% Coverage
  - Being able to understand the system
- References 6-7 - 0.24% Coverage
  - be flexible in thinking.
- Reference 8 - 1.12% Coverage
  - There are a lot of issues in engineering systems and we have to bring the right help to deal with these things.
- Reference 9 - 1.47% Coverage
  - Go to outside experts. Have the attitude that we don't know it all and know when to go outside. Some think they know it all but they never will.
- Reference 10 - 0.62% Coverage
  - Need help to solve a problem or to understand the technology.
Analysis Approach: Review Excerpts and Update Coding Structure Based on Details

Total number of times the theme was mentioned across all interviews

Total number of interviews in which the theme was mentioned. (Equates to number of interviewees who discussed this.)

Preliminary findings:
• All interviewees believe that ME is either equivalent to SE or is SE with a different perspective/additional skills
• A quarter have defined ME as SoS or “end-to-end” SE
• Competencies generally align with the three types of competencies outlined in Helix:
  • Soft Skills
  • Systems Mindset
  • Technical Skills
Analysis Approach: Visualizations
• Coding

• Grounded Theory
  — “Bottom up” approach reflecting the patterns seen in the data
  — Paired with a “top down” approach from reviewing the literature (separate)

• Multi-iteration effort
  — “Chunking” into main categories
  — Development of sub-categories
  — Additional refinement

• Career path
  • Challenges in Systems of Systems
  • Competencies
  • Definition of Mission Engineering
  • Definition of System of Systems
  • Personal Characteristics

• Competencies
  Soft Skills
  Systems Mindset
  Technical
  Most Helpful Personally

• Competencies
  Soft Skills
  Communication
  Translation
  Relationships
  SME Network
  Team Building
Proficiency of a Systems Engineer (Helix)

1. Math / Science / General Engineering
   - Natural Science Foundations
   - Engineering Fundamentals
   - Probability & Statistics
   - Calculus & Analytical Geometry
   - Computing Fundamentals

2. System’s Domain & Operational Context
   - Principle and Relevant Domains
   - Familiarity with System’s Concept of Operations (ConOps)
   - Relevant Domains
   - Relevant Technologies
   - Relevant Disciplines and specialties
   - System Characteristics

3. SE Discipline
   - Lifecycle
   - Systems Engineering Management
   - Systems Engineering Methods, Processes, & Tools
   - Systems Engineering Trends

4. SE Mindset
   - ‘Big Picture’ Thinking
   - Paradoxical Mindset
   - Flexible Comfort Zone
   - Multi-Scale Abstraction
   - Foresight & Vision

5. Interpersonal Skills
   - Communication
   - Listening & Comprehension
   - Working in a Team
   - Influence, Persuasion, & Negotiation
   - Building a Social Network

6. Technical Leadership
   - Building & Orchestrating a Diverse Team
   - Balanced Decision Making & Risk Taking
   - Guiding Stakeholders with Diverse/Conflicting Needs
   - Conflict Resolution & Barrier Breaking
   - Business & Project Management Skills
   - Establishing Technical Strategies
   - Enabling Broad Portfolio-Level Outcomes

An Example Systems Engineer’s Proficiency
Initial Mission Engineering Competency Framework

Math/Science/General Engineering are Foundational Skills

1. Discipline & Domain Knowledge
   - Principle and Relevant Domains
   - Relevant Domains
   - Relevant Technologies
   - Complexity
   - Acquisition Context

2. Operational Concept
   - Familiarity with the Mission Concept
   - Familiarity with Mission Scenarios
   - Familiarity with Relevant Systems in the Mission Space
   - Understanding of DOTMLPF Space

3. Systems Engineering Skills
   - Architecture
   - System of Systems Engineering
   - Modeling
   - Analysis

4. SE Mindset
   - ‘Big Picture’ Thinking
   - Paradoxical Mindset
   - System of System Thinking
   - Multi-Scale Abstraction

5. Interpersonal Skills
   - Communication
   - Translation (b/t Operators, Engineers, and Acquisition)
   - Influence, Persuasion, & Negotiation
   - Building & Utilizing a SME Network
   - Organizational Know-How (How work actually gets done in org.)

6. Technical Leadership
   - Guiding Stakeholders with Diverse/Conflicting Needs
   - Conflict Resolution & Barrier Breaking
   - Team Building
   - Trade-off Analysis

An Example Systems Engineer's Proficiency
Initial Findings – Mission Engineering Definitions

Variations in Responses to the Interview Questions

• Mission Engineering is System(s) of Systems Engineering

• Mission Engineering is Systems Engineering

• Mission Engineering is Different than Systems Engineering

• Mission Engineering is Systems Engineering +

• Mission Engineering is a Subset of Systems Engineering
Coverage of Coding Categories

Major Coding Categories

- Career Path
- Competencies
- Current Effectiveness
- Definition of Mission Engineering
- Mission Engineering Critical Activities
- Personal Characteristics
- Workforce Issues

Legend:
- Percent of Excerpts
- Percent of Interviewees
Mission Engineering Competencies

- Technical Skills
- Systems Mindset
- Soft Skills

Percent of Excerpts and Percent of Interviewees
Initial Findings – Mission Engineering Futures

• Responses to Inquiries of Future Vision for Mission Engineering

• Finding the “right” people and the “right” team
  — Competition with private industry creates a shortage of the needed skills and competencies in the government workforce

• Need to know future requirements to do Mission Engineering and to turn these requirements into capabilities to achieve the desired effects

• Need to fix a dysfunctional acquisition process
  — A coalition of the willing to work together to ensure all the services are participating with a truly joint solution
  — Funding a mission test capability is a real challenge; no one program has the resources to assess the end-to-end effects to accomplish the mission

• Mission Engineering is established and embedded in all Systems Engineering organizations
  — Every engineer is a mission engineer in terms of working the mission
Interim Results

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Questions?