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# **Framework for Mission Engineering** Competencies



# Overview

- 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.

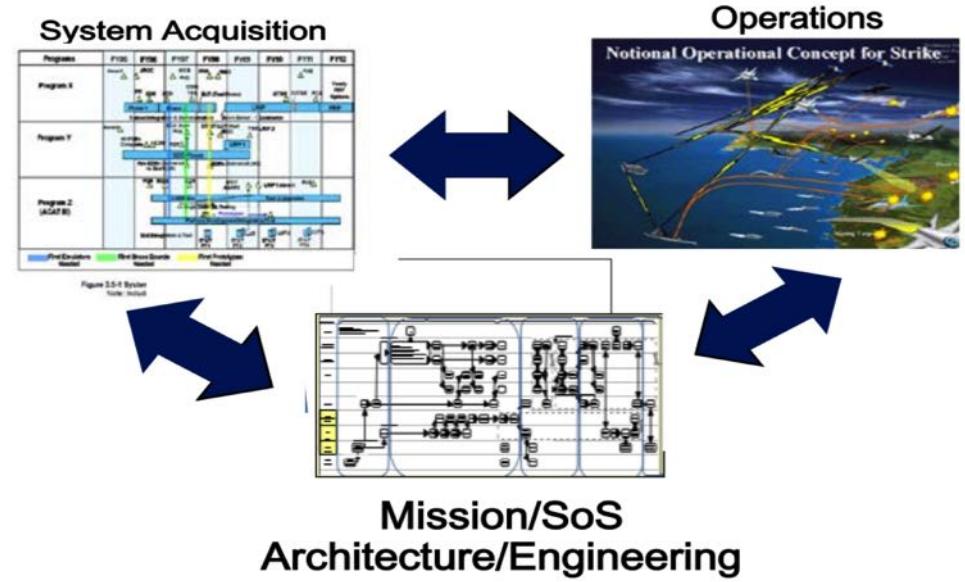


# Mission Engineering Definition

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

- **Or, more simply put . . .**

**The mission *is* the system.**





# Mission Engineering Context

- Mission engineering and mission analysis
- 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 DoD's needs for capabilities requiring multiple linked systems that are greater than the sum of the capabilities of the constituent parts.
- Several other allied nations use the term “capabilities engineering” rather than mission engineering.
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# Research Tasking and Objectives



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.

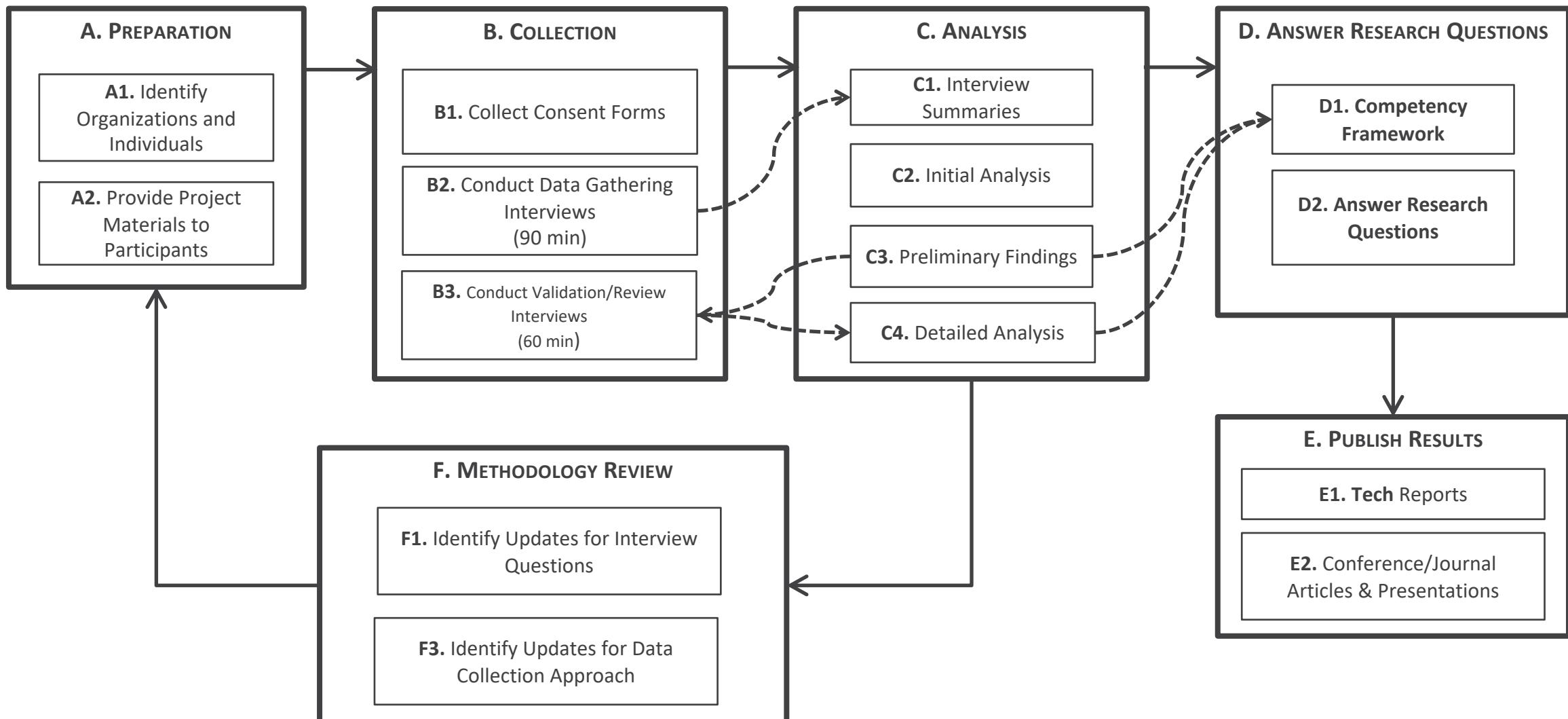


# Mission Engineering Competency Study

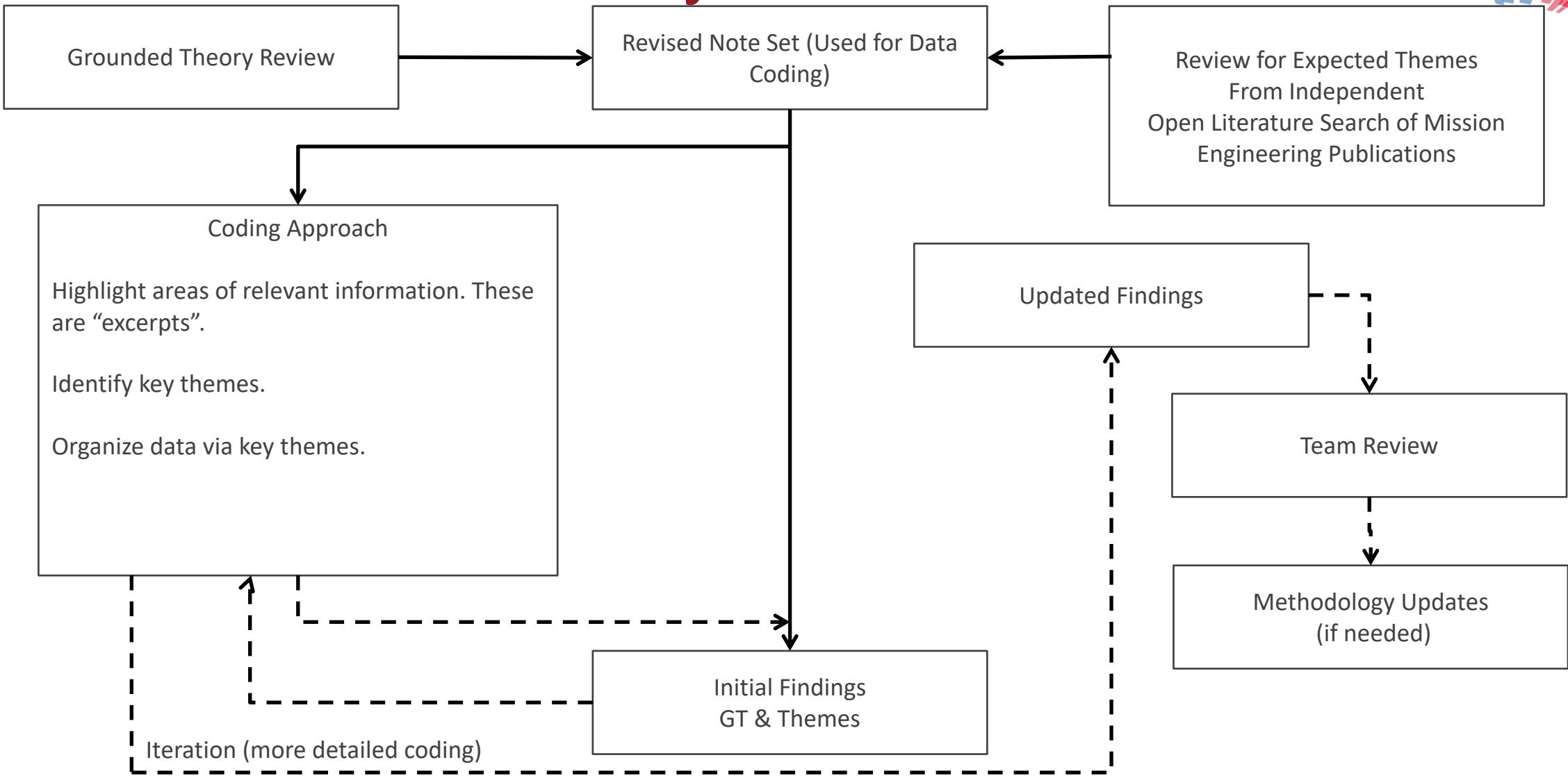
- Mission engineering (ME) competency model lays out the skills, abilities and behaviors that are critical to ME and whether they are unique or overlap with systems engineering.
- The research draws heavily from the Helix methodology on developing effective system engineers.
- Reflects industry approaches and best practices.



# Interview Methodology



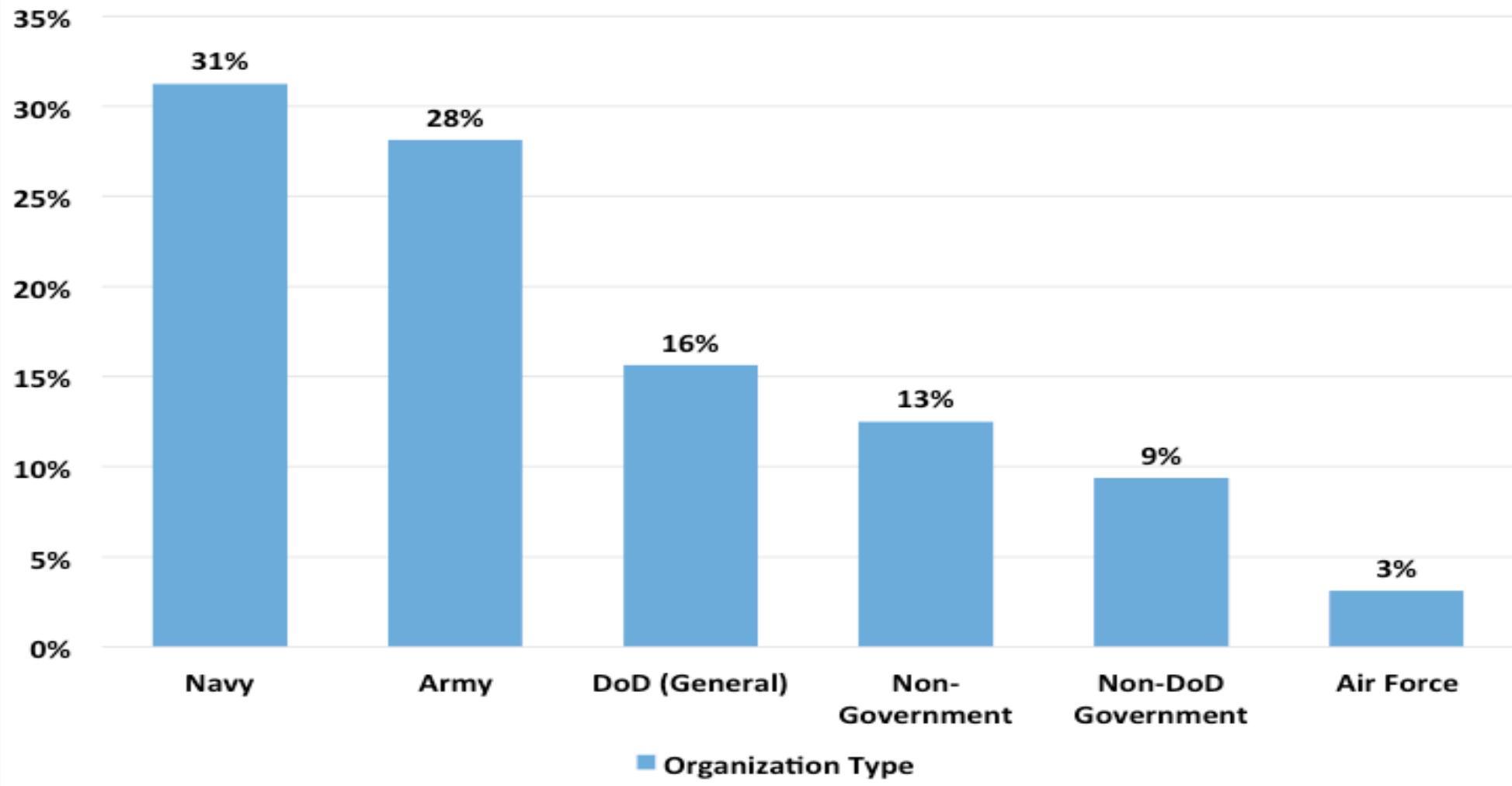
# Interview Data Analysis



# Dataset

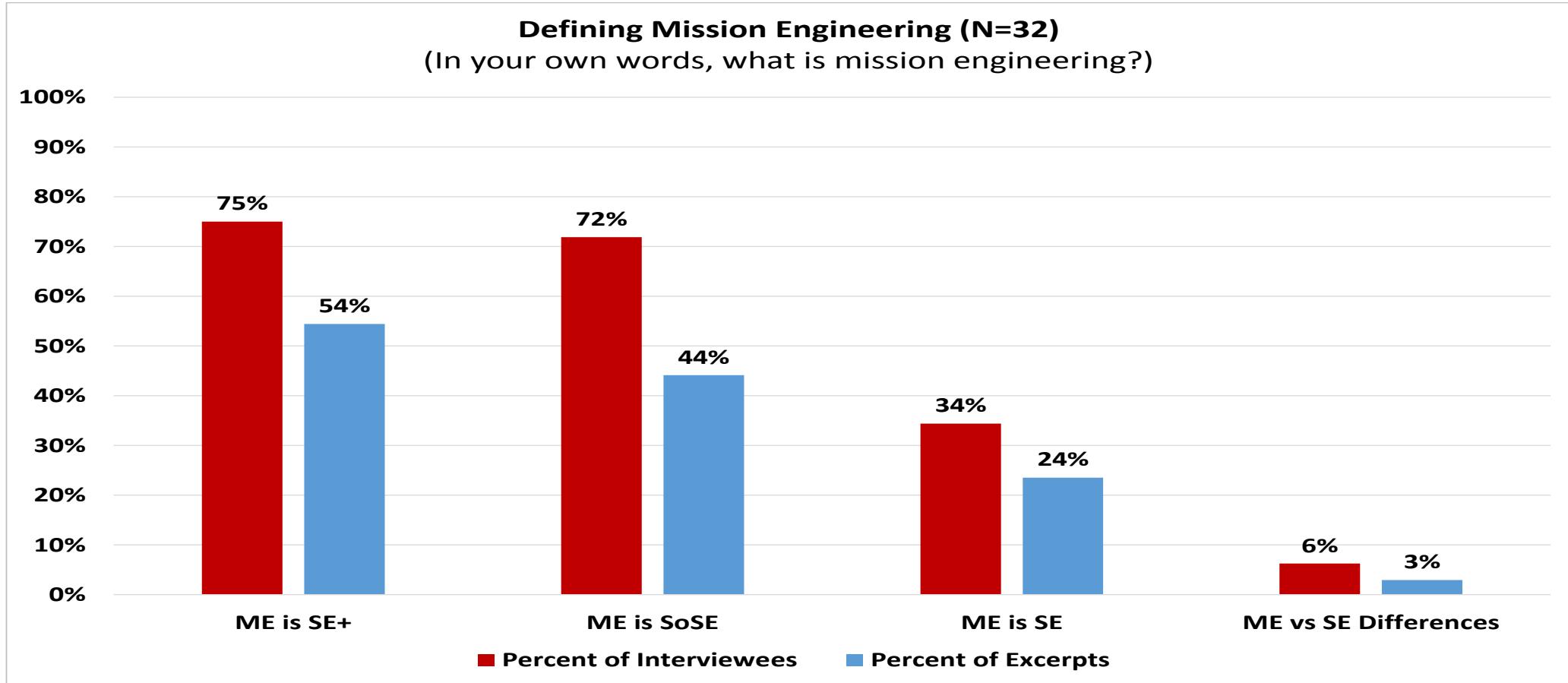


Percentage of Participants by Organization Type (N=32)





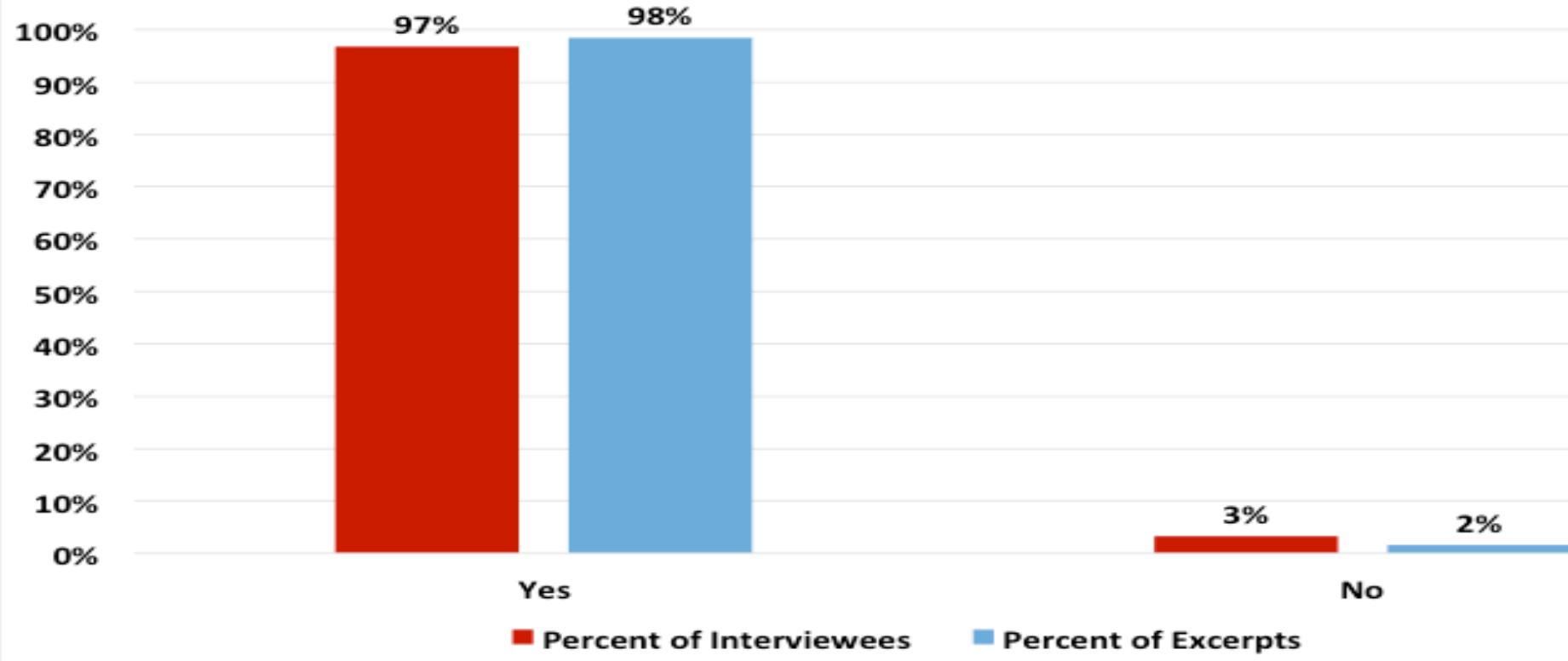
# Q: What is mission engineering?



# Q: Mission engineering and systems engineering



**Overlap between Mission Engineering and Systems Engineering (N=31)**  
(Do you see any overlap in the activities of systems engineering and mission engineering?)

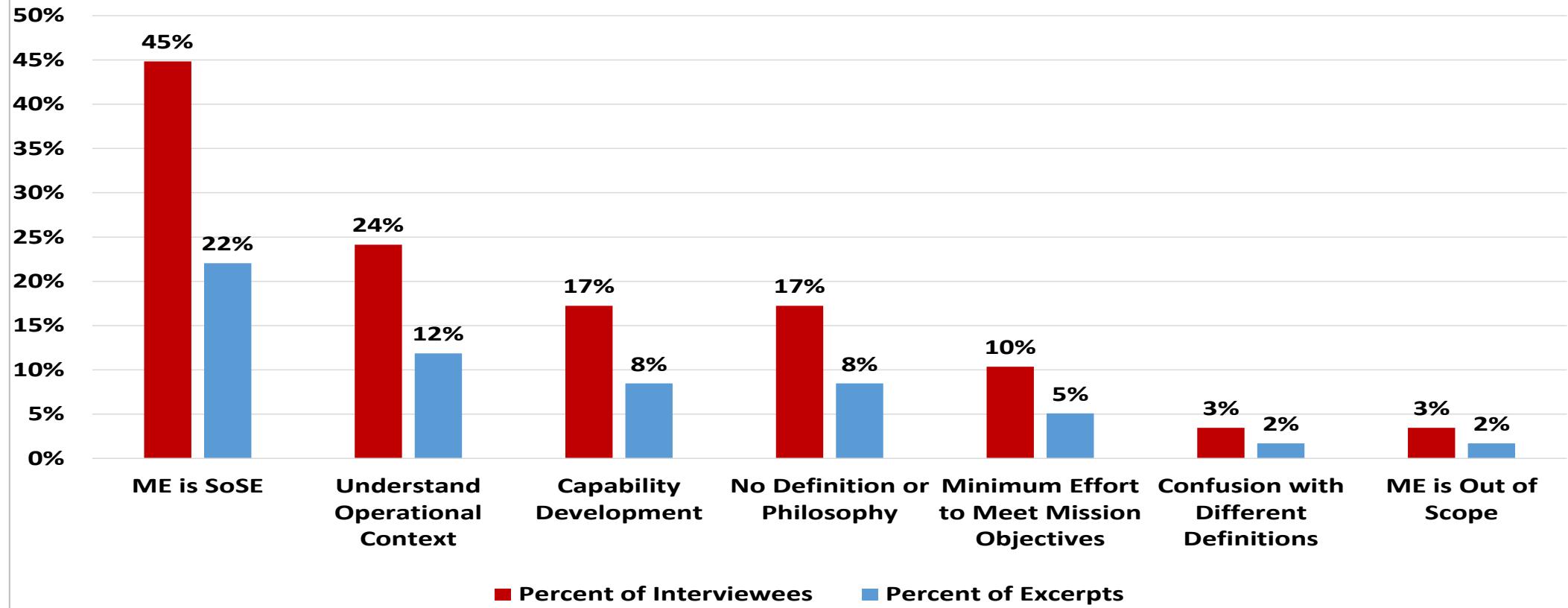


# Q: What is the Philosophical Approach to



## Organization Definition and Philosophy on Mission Engineering (N=32)

(What is your organization's philosophy on mission engineering?)

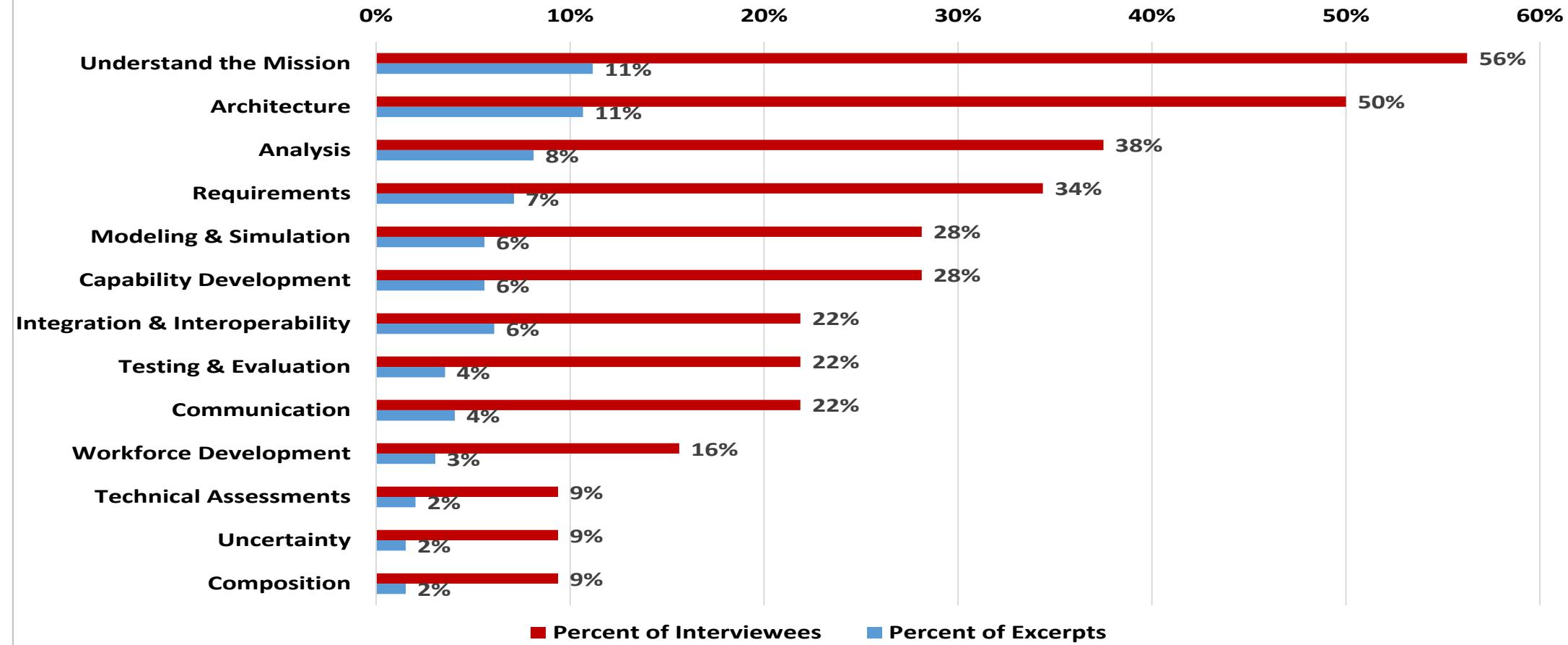


# Q: What are Mission Engineering Activities?



## Mission Engineering Activities (N=32)

(Please describe your current position. What are your key responsibilities? What is the key value you provide in this position? What is the most critical thing you do to be effective in your current position?)



# Analysis Approach: Initial Coding



Windows 8.1 File Edit View Actions Devices Window Help

Windows 8.1

MissionEngineeringCompetency\_MASTER\_v0.2\_12Sept2017\_NH.nvp - NVivo Pro

FILE HOME CREATE DATA ANALYZE QUERY EXPLORE LAYOUT VIEW

Calibri 12

Normal

PDF Selection

Text

Region

Find

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Spelling

Reset Settings

Paragraph

Styles

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Go Refresh Open Properties Edit Paste Cut Copy Merge

Clipboard

Format

Look for Search In Interview Summ Find Now Clear Advanced Find

Sources

Internals Interview Summaries

Externals

Memos

Framework Matrices

Interview Summaries

Name	Nodes	References
Interview Summary -	24	66
Interview Summary -	14	29
Interview Summary -	16	36
Interview Summary -	13	36
Interview Summary -	25	70
Interview Summary -	19	40
Interview Summary -	14	31
Interview Summary -	14	40

Technical Systems Mindset Soft Skills Interview Summary - D31\_01 -

RT-171: Mission Engineering Competencies

Interview Summary from

In your own words, what is mission engineering?  
Essentially it's systems engineering (SE)

Code... Ctrl+F2

Code to Recent Nodes Ctrl+F8

Uncode... Ctrl+Shift+F2

Uncode from Recent Nodes

Edit Ctrl+E

Export Document... Ctrl+Shift+E

Print Ctrl+P

Cut Ctrl+X

Copy Ctrl+C

Paste Ctrl+V

Paste As See Also Link

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Select All Ctrl+A

Links

Document Properties... Ctrl+Shift+P

Activate Windows

Go to PC settings to activate Windows.

NAH 8 Items Nodes: 24 References: 66 Read-Only Line: 14 Column: 0

Code At Systems Mindset (Nodes\Competencies)

Internal

14

# Analysis Approach: Review Excerpts and Update Coding Structure Based on Details



Windows 8.1 File Edit View Actions Devices Window Help

Windows 8.1 MissionEngineeringCompetency\_MASTER\_v0.2\_12Sept2017\_NH.nvp - NVivo Pro

FILE HOME CREATE DATA ANALYZE QUERY EXPLORE LAYOUT VIEW NODE

Coding Context Coding Excerpt Coding by Users Coding Information

Rich Text Coding Stripes Highlight Code Code In Vivo Spread Coding Unicode from This Node Coding Query This Node Query

Nodes

Nodes Cases Relationships Node Matrices

Look for Search In Nodes Find Now Clear Advanced Find

Nodes

Name	Sources	References
Career Path	5	12
Challenges in SoS	4	7
Competencies	8	98
Most Helpful Personally	2	4
Soft Skills	6	17
Communication	3	3
Relationships	1	1
SME Network	1	1
Team Building	3	4
Technical Leadership	2	2
Translation	4	6
Systems Mindset	8	26
Technical	8	44
Analysis	2	3
Architecture	4	5
Breadth	4	4
Complexity	2	4
Depth	5	6
Flexibility	2	2
Model-Based	6	7
Operational Context	6	14
Problem Solving	1	1
Requirements Process	2	2
Uncertainty	2	4
Vision	1	1

Drag selection here to code to a new node

Code At Systems Mindset (Nodes\\Competencies)

54 Items Sources 8 References 44 Unfiltered

Internal

Chart Compare With Word Cloud Explore Diagram Visualize Node

Technical Systems Mindset Soft Skills Interview Summary

<Internals\\Interview Summaries\\Interview Summary -> - 5 references coded [5.16% Coverage]

Reference 1 - 0.41% Coverage

- Know all the disciplines to some degree.

Reference 2 - 0.35% Coverage

- Being able to understand the system

Reference 3 - 0.23% Coverage

- be flexible in thinking

Reference 4 - 0.62% Coverage

- Need help to solve a problem or to understand the technology.

Reference 5 - 3.55% Coverage

modeling and simulation?

- I oversee a lot of that in the organization. It's critical in ME. We don't do a lot of testing (i.e. flight testing) because of the high cost (eats a lot of the budget). For digital modeling of systems, we need to do end-to-end predictive analysis. We need high-fidelity performance modeling but we can't always find people.

<Internals\\Interview Summaries\\Interview Summary -> - 6 references coded [7.07% Coverage]

Reference 1 - 1.39% Coverage

modeling and simulation skills?

- In my organization, we're interestingly matrix. In my team, we are engineers and operators.

Activate Windows Go to PC settings to activate Windows.

Summary Reference Text

Technical skills, high resolution, high-fidelity skillset needed to conceptualize, and bigger picture. Operating at a conceptual level

Personal Characteristics

Operational Context

Breadth Systems Mindset Soft Skills Model-Based

15

# Coding: An Iterative Analysis



- 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

- 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

# Analysis Approach: Initial Coding



Windows 8.1

MissionEngineeringCompetency\_MASTER\_v0.1\_20June2017.nvp - NVivo Pro

FILE HOME CREATE DATA ANALYZE QUERY EXPLORE LAYOUT VIEW

Calibri 12

Format Paragraph Styles Editing Proofing

Go Refresh Open Properties Edit Paste Copy Merge

Workspace Item

Sources

Interview Summaries

Name	Nodes	References
Interview Summary	13	34
Interview Summary	11	21
Interview Summary	10	20
Interview Summary	10	14
Interview Summary	9	14
Interview Summary	8	12

Soft Skills Technical Competencies ME Critical Activities Competencies Interview Summary - D31\_01 -

RT-171: Mission Engineering Competencies

Interview Summary from [REDACTED] (June 16, 2017)

Essentially it's systems engineering

Code Selection At Existing Nodes... Ctrl+F2

Code Selection At New Node... Ctrl+F3

Code Selection At Current Nodes Ctrl+F9

Recent Nodes

- Breadth (Nodes\\Competencies\\Technical)
- Systems Mindset (Nodes\\Competencies)
- Soft Skills (Nodes\\Competencies)
- ME Critical Activities (Nodes)
- Operational Context (Nodes\\Competencies\\Technical)
- Model-Based (Nodes\\Competencies\\Technical)
- Competencies (Nodes)
- Technical (Nodes\\Competencies)
- ME is SE+ (Nodes\\Definition of ME)

Personal Characteristics

Soft Skills ME Critical Activities Competencies D31 D31\_01 Coding Density

Current Effectiveness

Activate Windows

717

NAH 6 Items Nodes: 13 References: 34 Read-Only Line: 15 Column: 42

# Analysis Approach: Review Excerpts and Update Coding Structure Based on Details



FILE HOME CREATE DATA ANALYZE QUERY EXPLORE LAYOUT VIEW

Project Documents PDFs Dataset Audios Videos Pictures Memos From Other Sources Classification Sheets Attribute Values Report Extract Items List Project Classification Sheets To Other Destinations Purchase Transcript Check Status Export Transcription

Import

**Nodes**

Nodes Cases Relationships Node Matrices

**Nodes**

Name	Sources	References
Competencies	7	41
Soft Skills	4	11
Systems Mindset	7	11
Technical	6	15
Breadth	3	3
Model-Based	3	4
Operational Context	3	7
Current Effectiveness	5	8
Definition of ME	6	10
ME is a Different Discipline from SE	0	0
ME is SE	2	2
ME is SE+	4	5
ME is SOSE	2	2
ME vs SE Differences	2	2
ME Critical Activities	6	10
Personal Characteristics	3	7

Sources

Nodes

Classifications

Collections

Queries

Reports

Maps

**Competencies**

[<Internals\Interview\\_Summaries\Interview\\_Summary - \[6.64% Coverage\]](#)

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

- Soft skills are important.

Reference 4 - 0.82% Coverage

- 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

Nodes	Name	Sources	References
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ME is a Different Discipline from SE		0	0
ME is SE		2	2
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ME is SOSE	Node	2	2
ME vs SE Differences		2	2
ME Critical Activities		6	10
Personal Characteristics		3	7

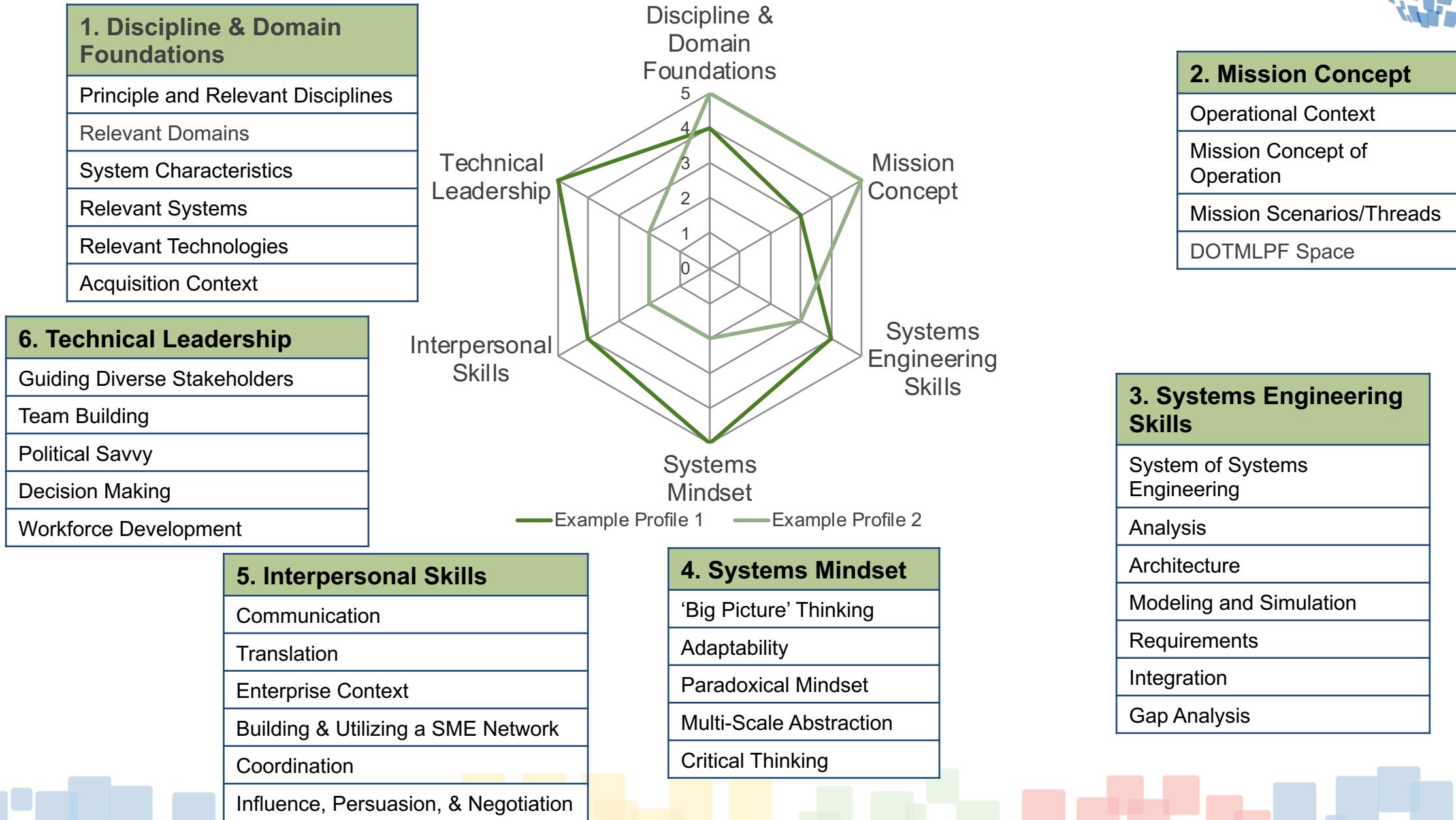
Total number of times the theme was mentioned across all interviews

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

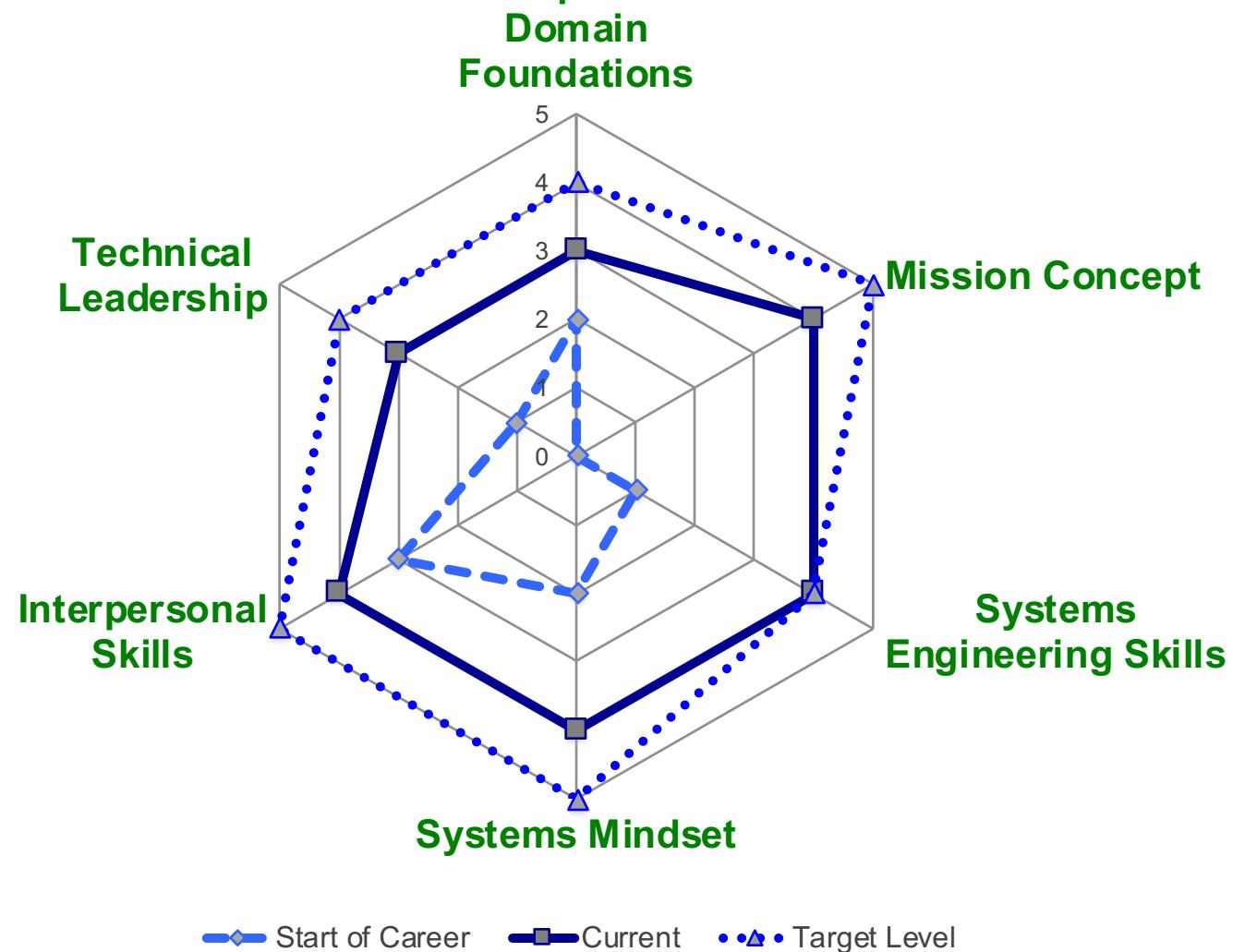
Preliminary findings:

- 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

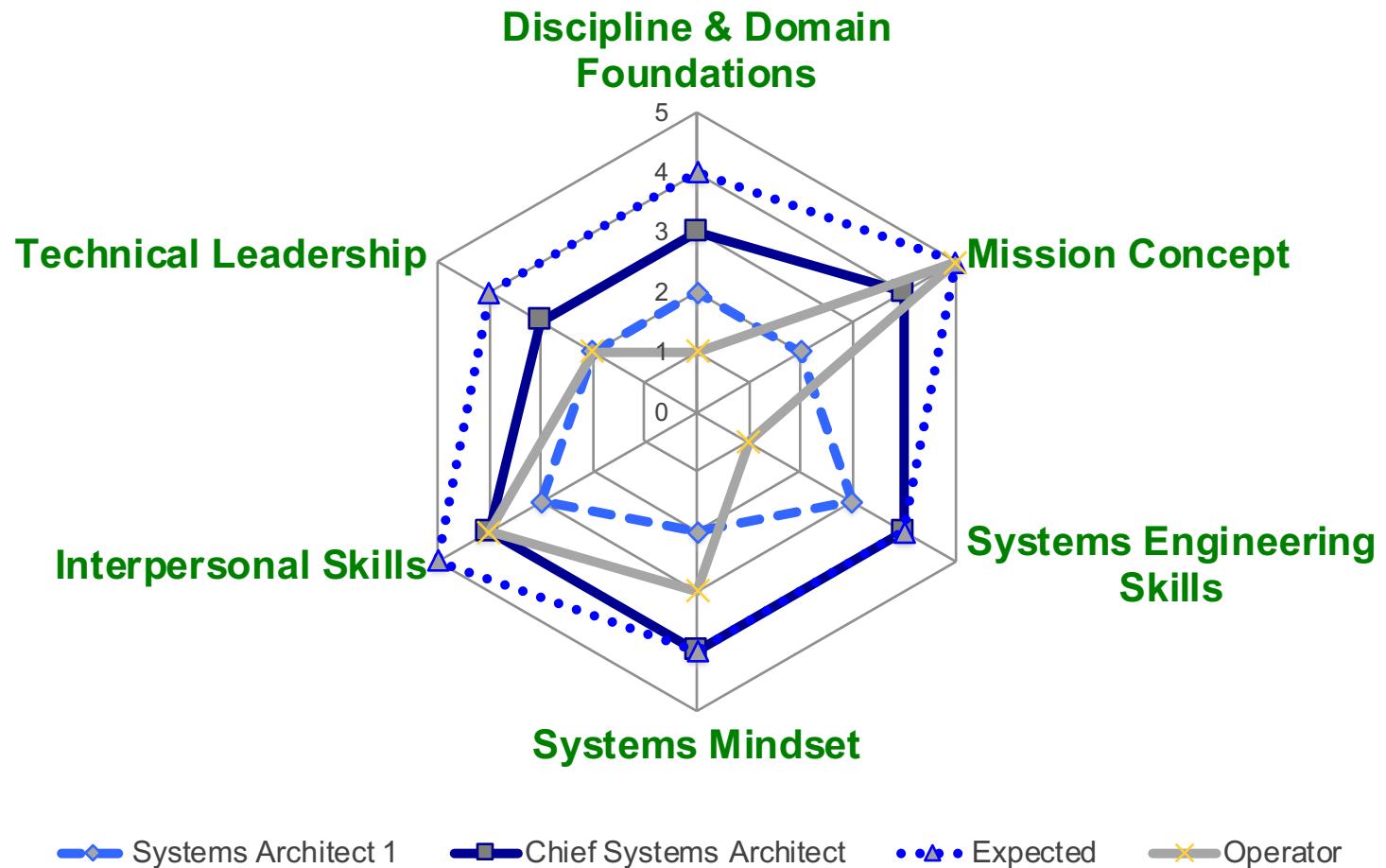
# Initial Mission Engineering Competency Framework



# Competency Profiles



# Team Profiles

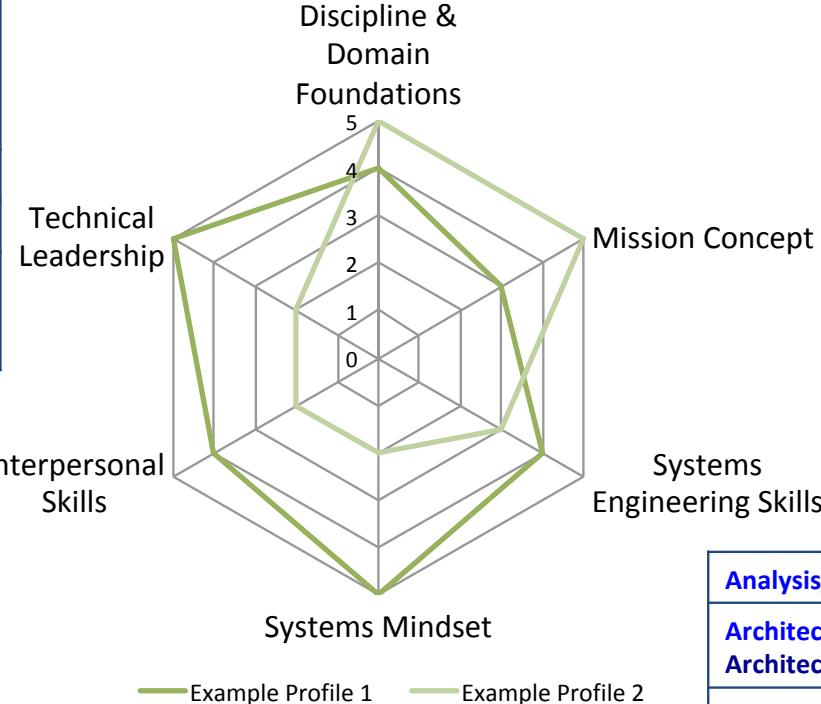


# Comparison to Other Competency Models



Technical Leadership/Leadership
Team Dynamics/Team Dynamics and Management/Leading High Performance Teams
Stakeholder Expectation and Definition/Stakeholder Requirements Definition/Managing Stakeholders
Facilitation
Decision Analysis
Coaching and Mentoring/Mentoring and Coaching/Coaching and Mentoring

Software Engineering
Acquisition Strategies and Procurement/Acquisition



Communication/Communication/Communication
NASA Interior and Exterior Environment
Negotiation/Negotiations
Organization

Critical Thinking
Systems Thinking
Strategic Thinking
Problem Solving

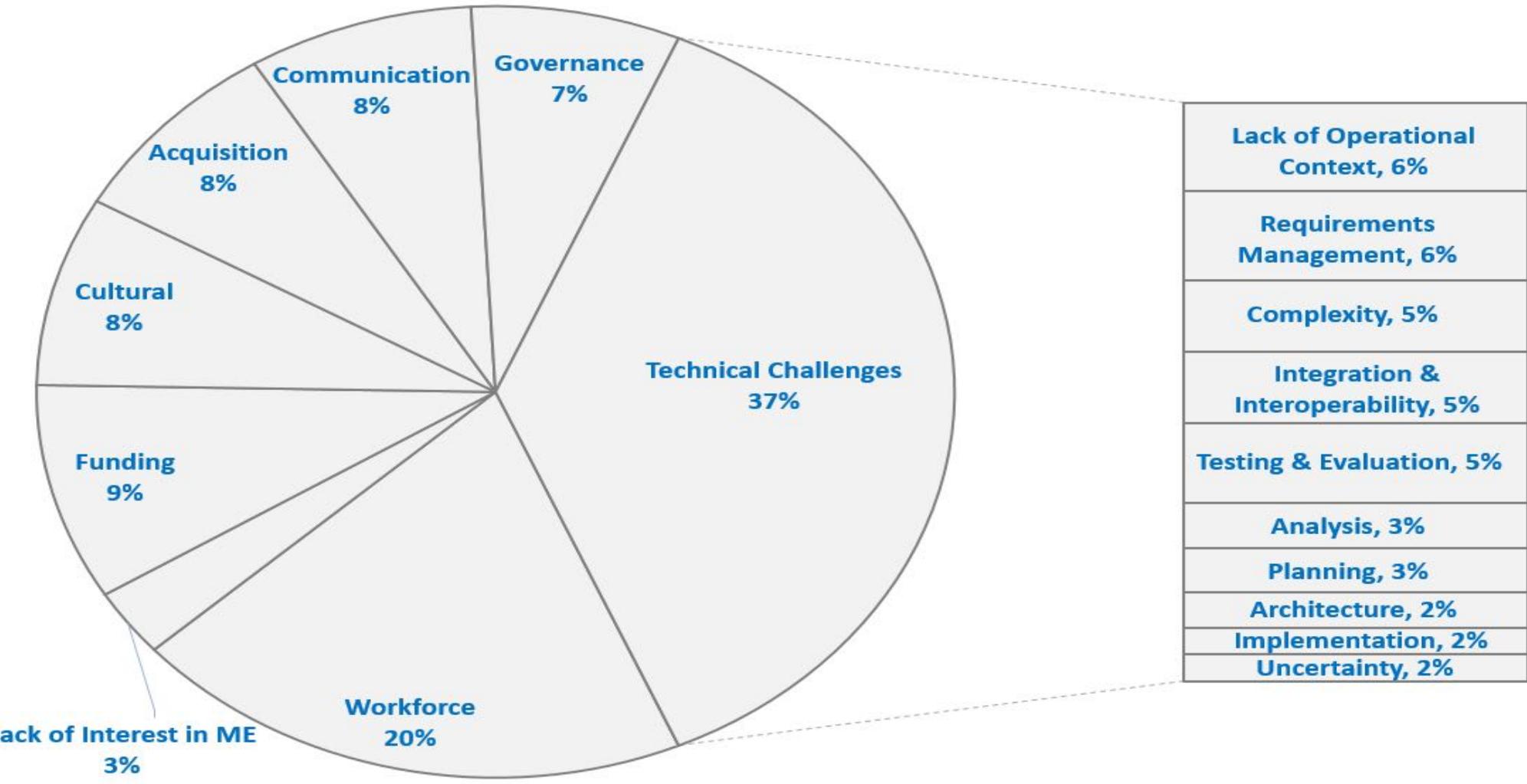
Capability Engineering
Mission Needs Statement
System Environments/External Relationships
Mission Level Assessment
Mission and Results Focus

Analysis/Logical Decomposition
Architecture/System Architecture/Architecture Design
Modeling
Requirements/Technical Requirements Definition/ Requirements Management/ Stakeholder Requirements Definition/ Requirements Analysis/ Requirements Management
Product Integration/Integration/ Interface Management/Interface Management
Trade Studies

INCOSE Competency Framework
NASA Systems Engineering Competencies
NAVY SE Competency Model



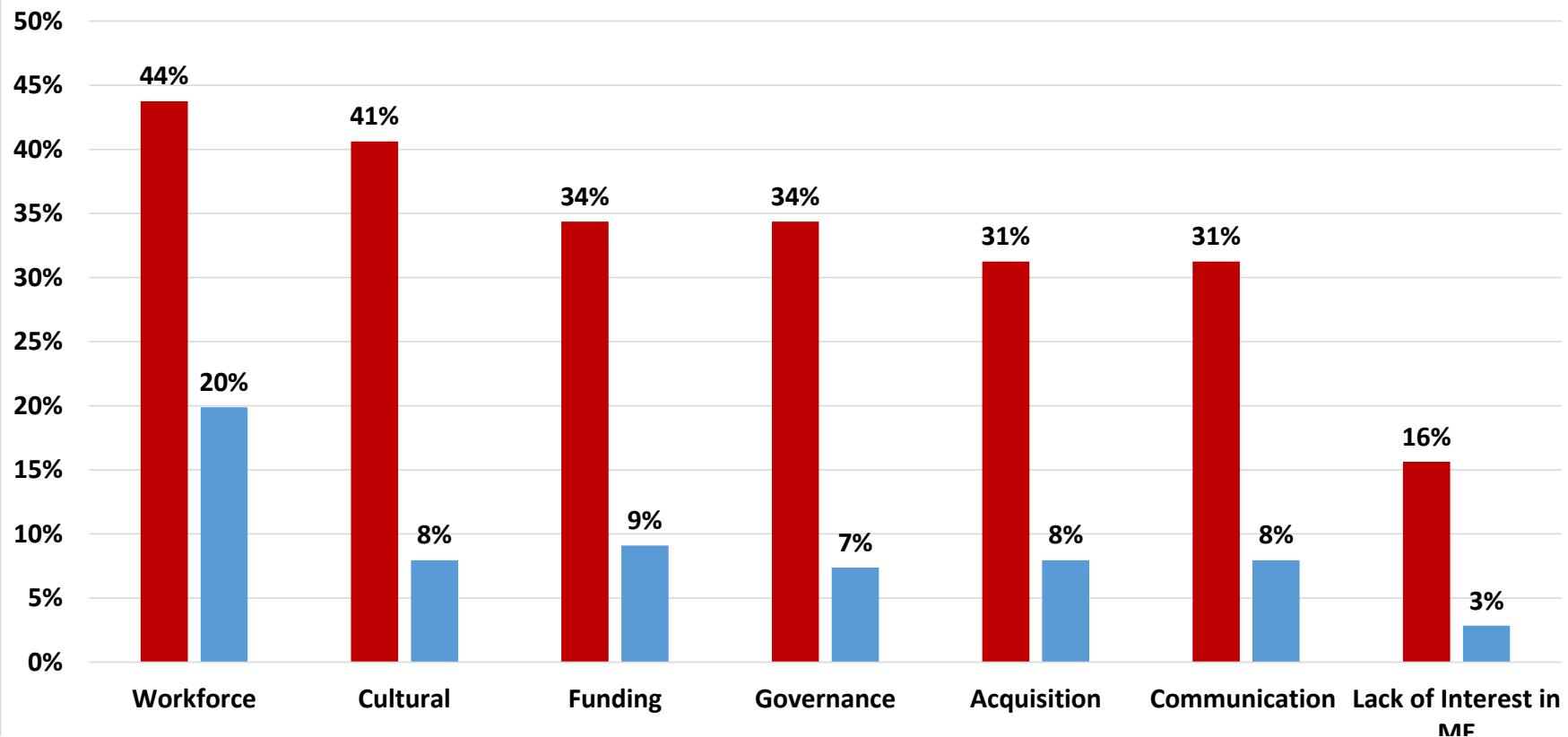
# Critical Challenges in Mission Engineering





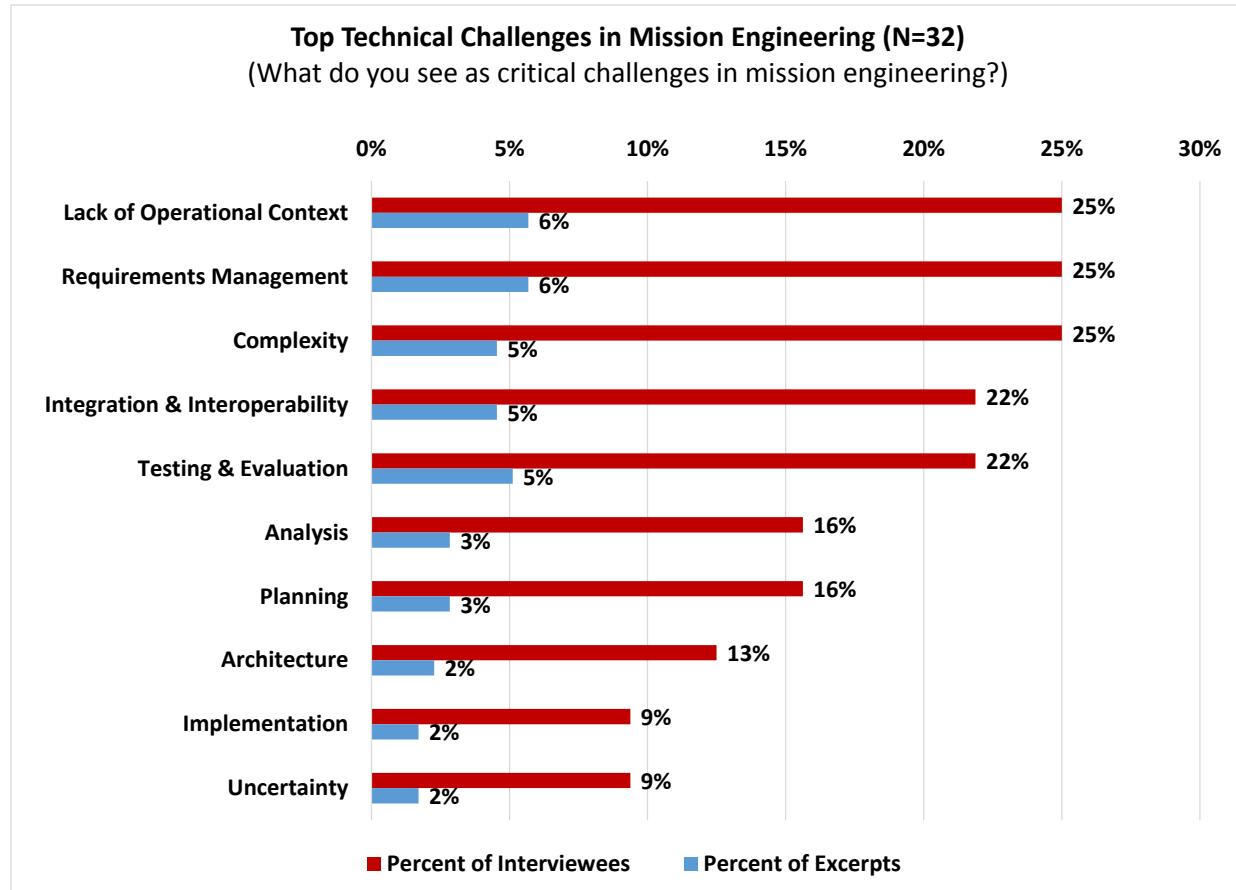
# Non-Technical Challenges

**Non-Technical Implementation Challenges in Mission Engineering (N=32)**  
(What do you see as critical challenges in mission engineering?)





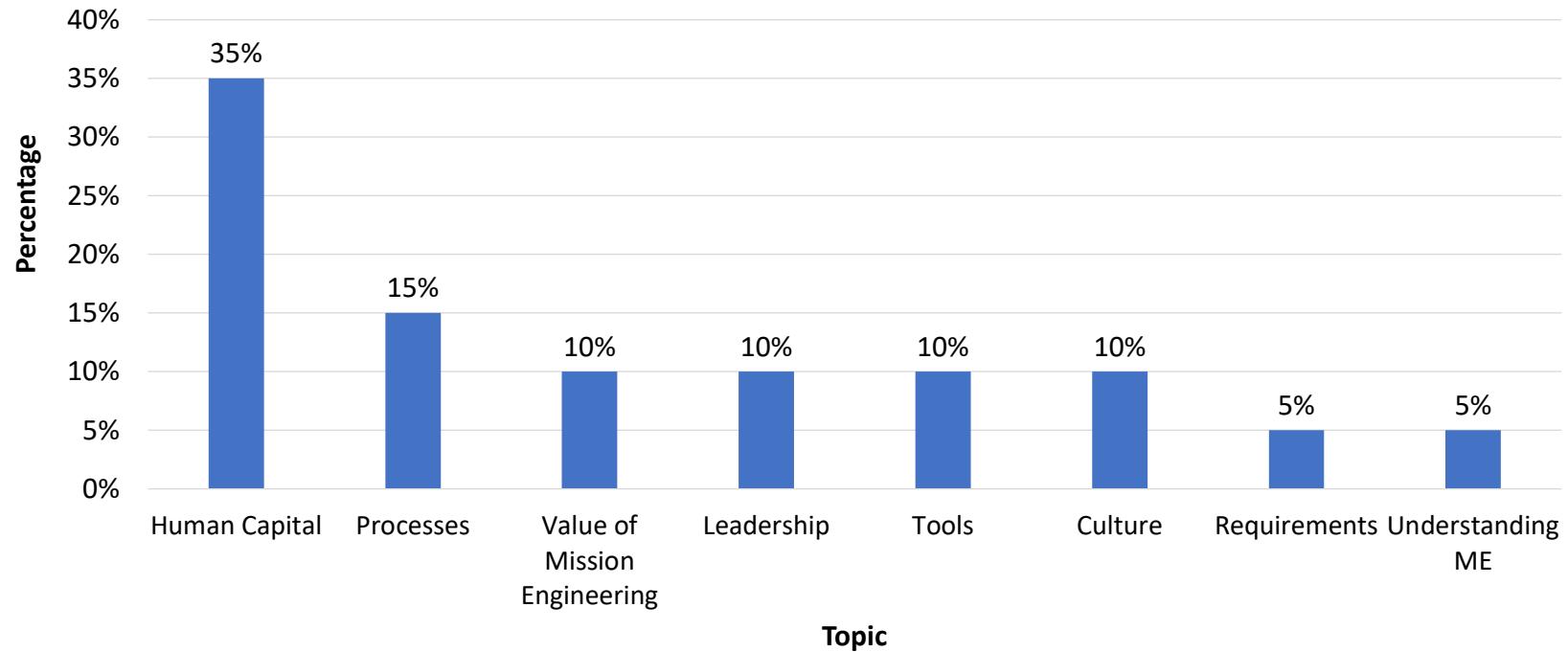
# Technical Challenges





# Q: Risks for future of Mission Engineering?

**What do you see as the key risks to your organization developing the mission engineering workforce it will need five years from now?  
(N=24)**





# Summary

- For mission engineering, the mission is the system
- Mission engineering competencies overlap heavily with systems engineering competencies tailored to:
  - System of Systems
  - Operational Context
  - Acquisition
  - Higher orders of abstraction
- Team concept for mission engineering: a mix of systems engineers and operators

# Questions



Internal