Integrating RAG, HCD, and PD in MBSE for Mission Problem Framing:

A human-centered, evidence-grounded approach to improve early Mission Engineering framing.

DATAWorks2026 April 23rd, 2026

Mission Engineering is not only about modeling systems. It is also about framing the right mission question early enough to guide those models.

This article proposes a structured, stakeholder-centered method to improve mission framing under ambiguity.

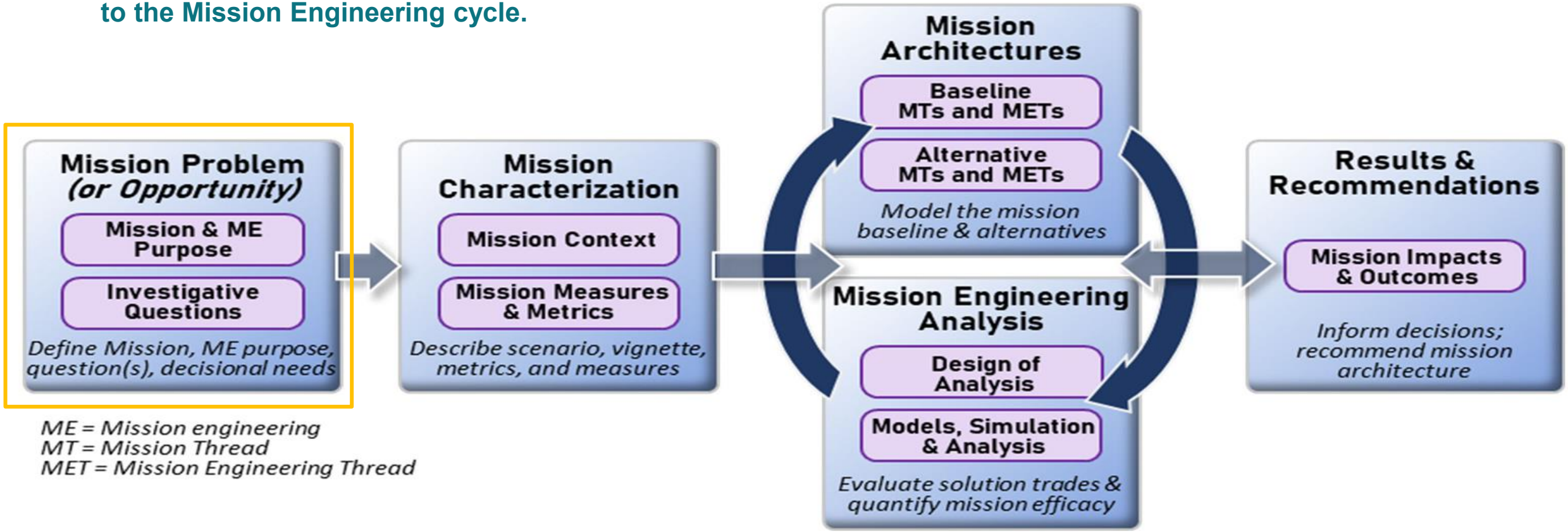
ITEA Journal | Volume 46, Issue 2 | June 2025

Old Dominion University | Systems Engineering

Rafi Soule, Ph.D.

Why Mission Framing Matters

Mission problem framing is the entry point to the Mission Engineering cycle.



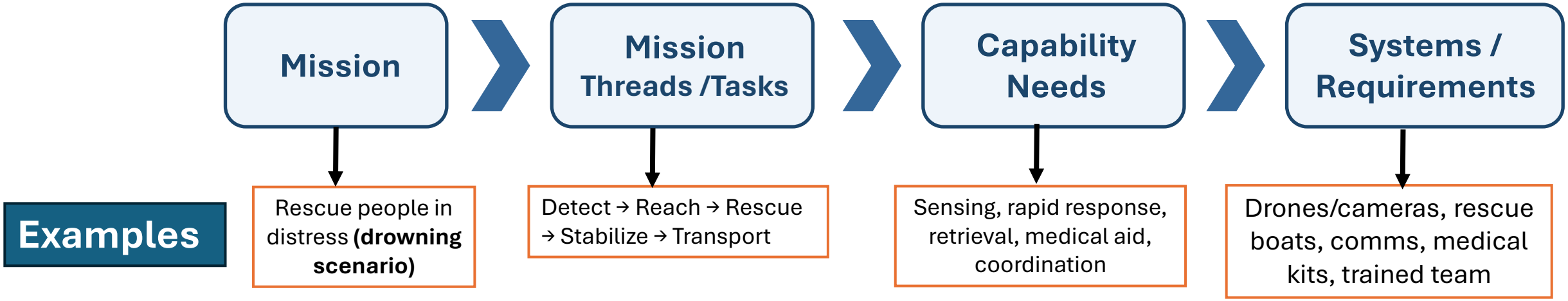
ME = Mission engineering
MT = Mission Thread
MET = Mission Engineering Thread

DoD MEG 2.0 Mission Engineering Methodology Overview *(OUSD (R&E), 2023)*

MEG 2.0 (OUSD R&E, 2023)

Mission Definition & Mission Engineering Mapping Logic

From Mission Intent to System Requirements



Key Insight: Each element traces directly to the strategic mission, enabling requirements validation, architecture decisions, and impact analysis throughout the system lifecycle.

Key Definitions:

Mission: A strategic operational objective or problem to be solved within a defined context *(MEG 2.0 (OUSD R&E, 2023)*.

Mission Threads: End-to-end sequences of tasks, activities, and events to execute a mission *(Butler, 2017)*.

Mission Engineering Threads (METs): Mission threads that include the capabilities and systems required to execute tasks *(MEG 2.0 (OUSD R&E, 2023)*.

MEG 2.0 (OUSD R&E, 2023); Butler (2017); Dahmann et al. (2022); Hutchison et al. (2018); INCOSE Systems Engineering Handbook (INCOSE, 2023).

The Problem With Current Mission Framing

What is broken in current mission framing

Mission problem framing is the foundation of ME, yet current practices remain fragmented across technological, organizational, and human dimensions.

Goal Ambiguity

Goals, constraints, and mission boundaries are often weakly specified at the start.

Divergent Assumptions

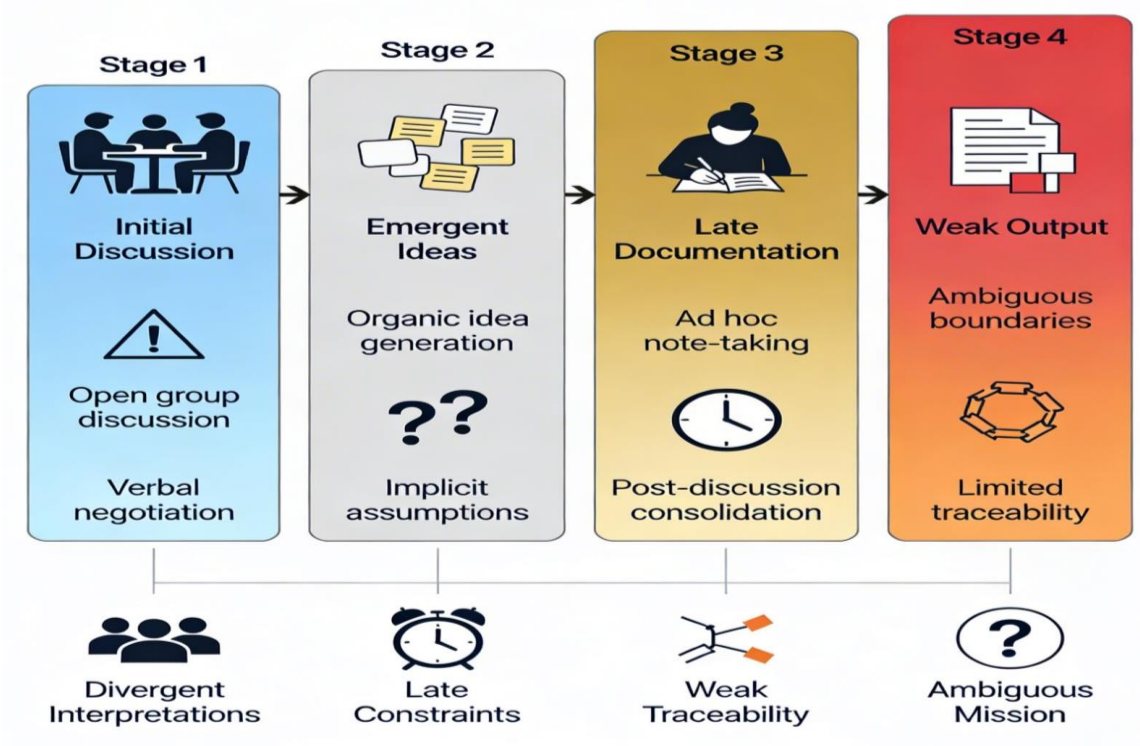
Different groups work from different assumptions, documents, and interpretations.

Mapping Friction

Weak framing leads to rework, delayed decisions, and mapping problems.

These are the symptoms on the left; the ad hoc process on the right is what keeps producing them.

Traditional/Current Mission Framing Approach



Source: DoD MEG 2.0, 2023; ITEA Journal Vol 46-2

Three Forms of Fragmentation

Technological, organizational, and human fragmentation

The core claim is that better mission framing requires addressing more than one form of fragmentation at a time.

Technological

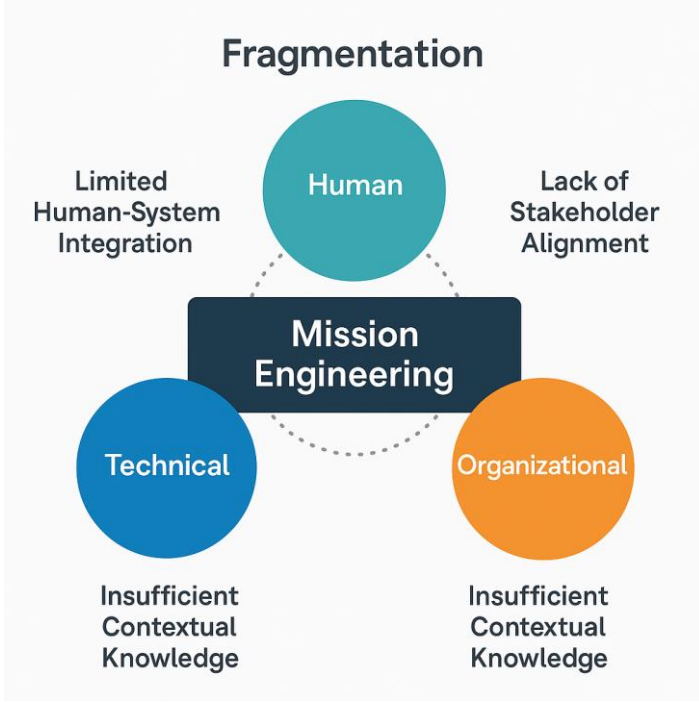
Knowledge and mission data are scattered across tools and repositories.

Organizational

Different groups work from disconnected assumptions, documents, and priorities.

Human Dimension

Technical framing dominates while stakeholder perspective and operational context are underrepresented.



MBSE is Necessary — but Not sufficient

MBSE provides rigor and traceability. The gap is that it does not automatically resolve stakeholder divergence, contextual nuance, or evidence fragmentation.

What MBSE already gives us

- Formal structure for mission elements, requirements, and system relationships.
- A persistent modeling environment that can carry decisions forward.
- Traceability across evolving mission threads and system views.

What it still struggles to capture on its own

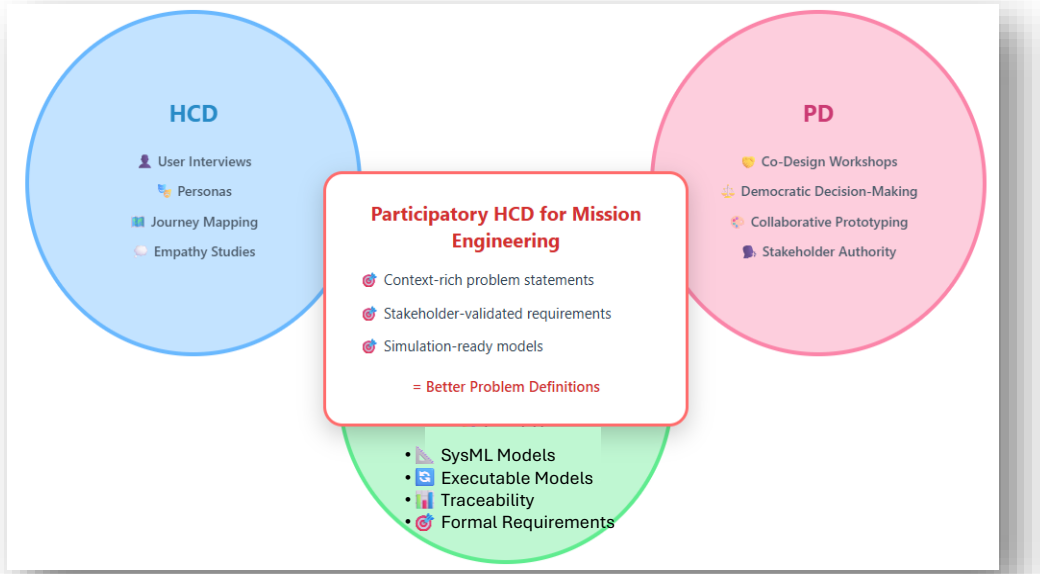
- Non-technical stakeholder perspective and operational nuance.
- Shared sensemaking across groups with different vocabularies and priorities.
- Retrieval of relevant evidence from scattered organizational knowledge.

That gap is what the integrated framework is designed to address.

INCOSE (2007); ISO/IEC/IEEE 15288/15289 (2019).

Proposed Approach: MBSE + HCD + PD + RAG

Keep MBSE as the backbone but augment it with participatory practice and evidence-grounded retrieval.



MBSE

Structure, mission logic, and traceability across views.

HCD

User and context understanding to surface operational nuance.

PD

Co-creation, shared sensemaking, and visible stakeholder reconciliation.

RAG

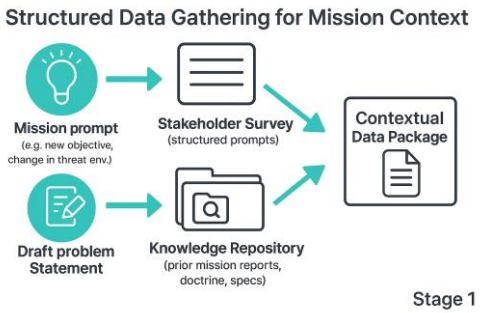
Retrieval from a curated knowledge base to ground the evolving mission frame.

How the Framework Works in Practice

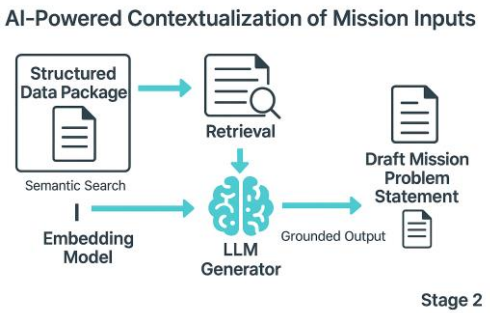
A structured co-design and retrieval workflow

A 4-stage co-design cycle that synchronizes stakeholder feedback, organizational knowledge, and AI-driven analysis within MBSE.

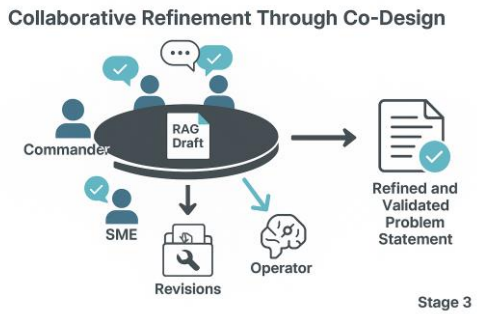
1 Collect Context



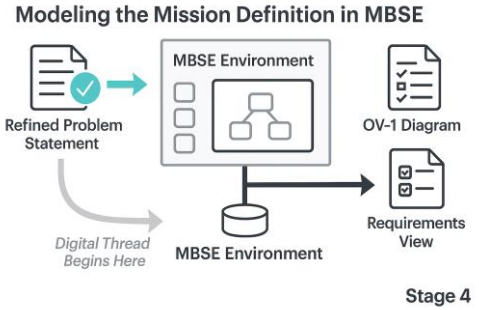
2 Retrieve & Analyze



3 Co-design & Refine



4 Capture in MBSE

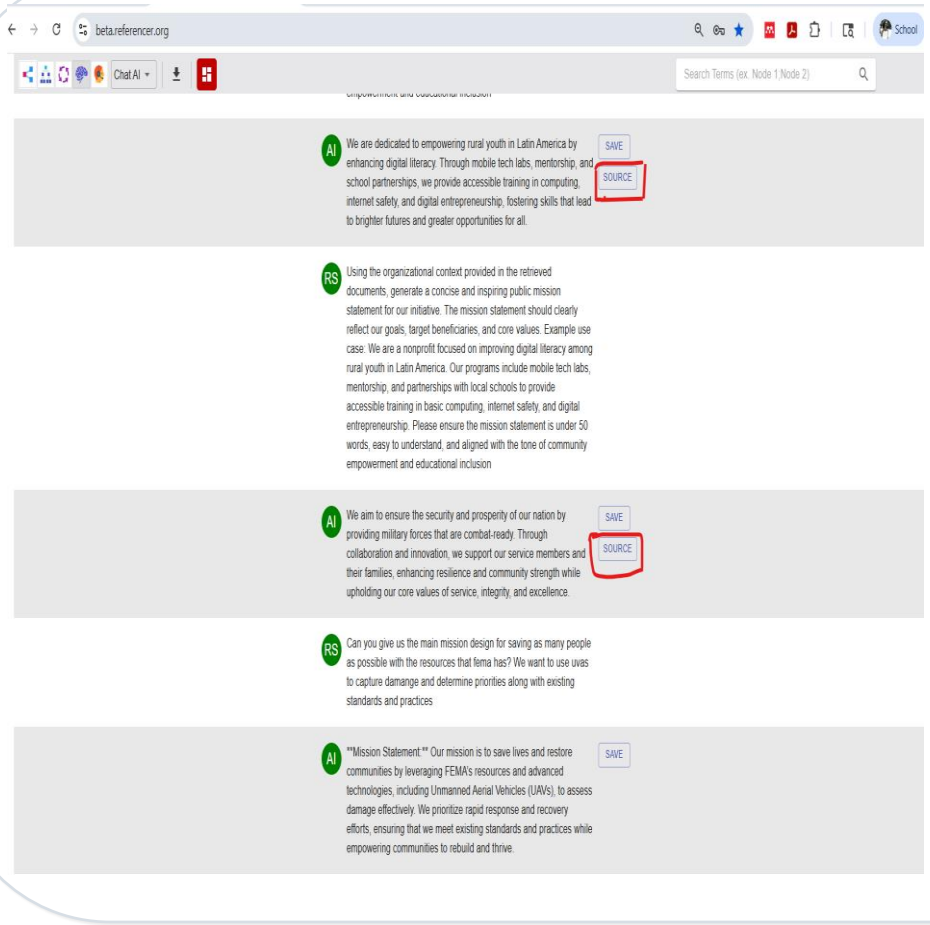


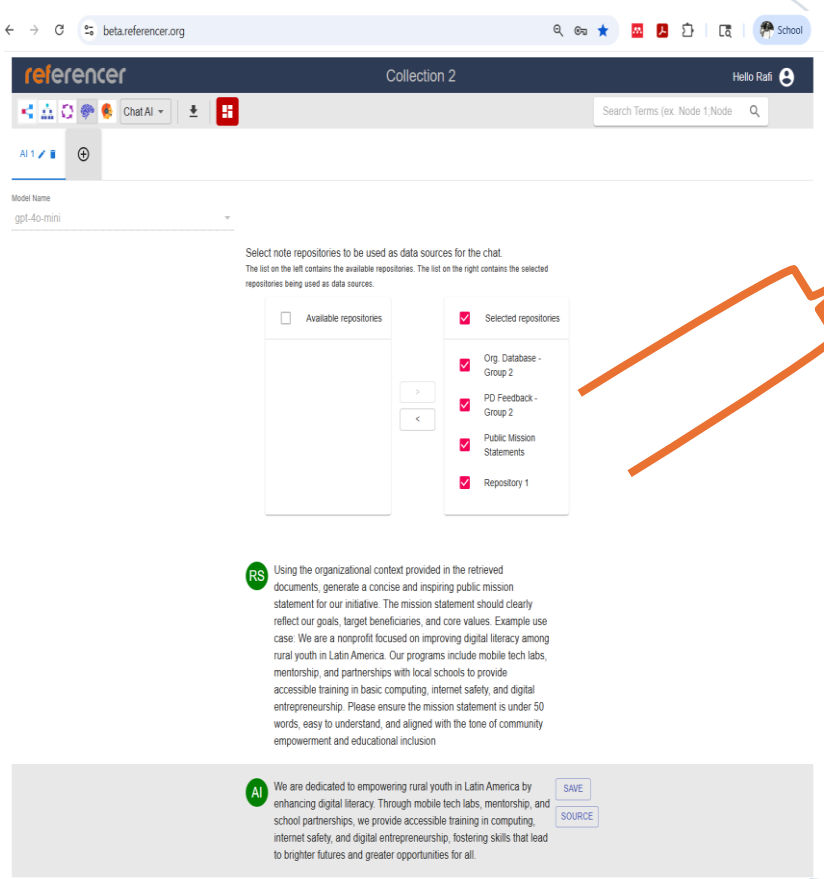
The cycle is iterative: as mission context changes, the problem frame and supporting evidence can be revised without losing traceability.

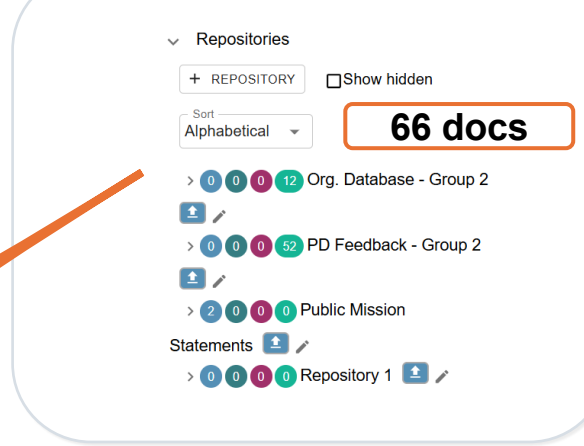
Source: Lewis et al., 2020 (NeurIPS); NVIDIA, 2025; INCOSE, 2007; Fant & Pettit, 2023

Practical Example: *Evidence-Grounded Mission Framing*

The value of the approach is not just a mission statement. It is a mission-framing artifact with visible rationale and retrievable support.







What this makes possible

- Visible rationale in the drafted mission statement.
- Retrieved evidence linked back to source repositories.
- A shared basis for review, revision, and later modeling.

Small interface detail, big process value: explicit access to sources makes the mission rationale reviewable.

Source: (Soule, 2026)

Expected Benefits and outcomes

The goal is not more process for its own sake. It is better mission framing early enough to improve what follows.

Clearer problem definitions

Teams make goals, constraints, assumptions, and mission boundaries more explicit from the start.

Stronger stakeholder alignment

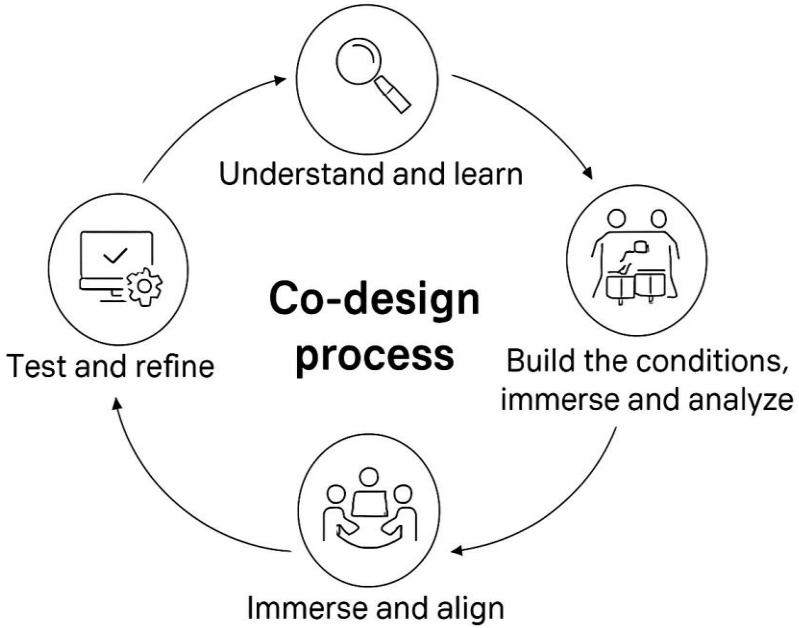
Differences become visible earlier and can be reconciled before they cascade into later decisions.

Better knowledge integration

Stakeholder input, organizational context, and technical evidence are brought into one working frame.

Auditable rationale and traceability

The evolving mission frame is supported by visible rationale, source links, and a clearer review trail.



MBSE-based Co-Design Process Cycle for Mission Problem Framing – adapted from McKercher, 2020

Integrated human-centered retrieval gives MBSE a stronger starting point: clearer, more collaborative, and more traceable mission framing.

Key Takeaways

1. Mission problem framing is the most critical and most neglected phase of Mission Engineering.
2. The challenge is multi-dimensional: technological, organizational, and human fragmentation reinforce each other.
3. MBSE remains the backbone, but it needs stakeholder-centered practice and retrieval-grounded evidence support.
4. A structured co-design cycle can make early mission framing clearer, more collaborative, and more traceable.

If you remember one thing from this talk: ***better mission outcomes begin with better mission framing.***

Future Work

Key areas for refinement, validation, and adoption of the integrated framework

Pilot Studies	Structured pilot deployments in defense and aerospace contexts to validate framework efficacy.
Comparative Exercises	Side-by-side evaluation of integrated vs. traditional Mission Engineering approaches using agreed metrics.
Tool Integration	Deeper integration with MBSE platforms, digital thread repositories, and retrieval tooling.
Metrics Development	Standardized measures for problem-definition quality, stakeholder alignment, and traceability.
Cross-domain Use	Extension to healthcare, energy, critical infrastructure, and other domains with complex mission contexts.

Thank You / Questions

Integrating RAG, HCD, and PD in MBSE for Mission Problem Framing.

Rafi Soule, Ph.D.

Old Dominion University
Systems Engineering

Email: rsoul003@odu.edu

Published in ITEA Journal, Volume 46, Issue 2 | June 2025

Google Scholar: https://scholar.google.com/citations?user=erFmYdEAAAAJ&hl=en

LinkedIn: https://www.linkedin.com/in/quiacle/