Mission Engineering: A Strategic Imperative | Course Ahead (Executive Brief)

Final Deliverable Report

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Executive Summary

Project Background

The Department of Navy (DON) aims to improve and formalize the application of Mission Engineering (ME) to transform the DON into a strategically agile organization that makes data-informed decisions to achieve priorities laid out in strategic naval priorities and objectives. Currently, however, the DON requires an enterprise approach to ME and enabling digital engineering (DE) disciplines for improved decision-making processes. The DON Office of Strategic Assessment (OSA) assigned Applied Research Laboratory for Intelligence and Security (ARLIS) and VT-ARC to explore foundational elements for an enterprise-wide ME approach. This initiative aims to ensure consistency, effectiveness, and scalability, leveraging DE for data-driven decision-making. The goal is to enhance strategic agility and portfolio management. The team will develop, apply, and gather recommendations surrounding an Applied Mission Engineering Process, capturing future-state needs along the foundational layers depicted in figure 1, moving the DON toward an enterprise approach to ME.

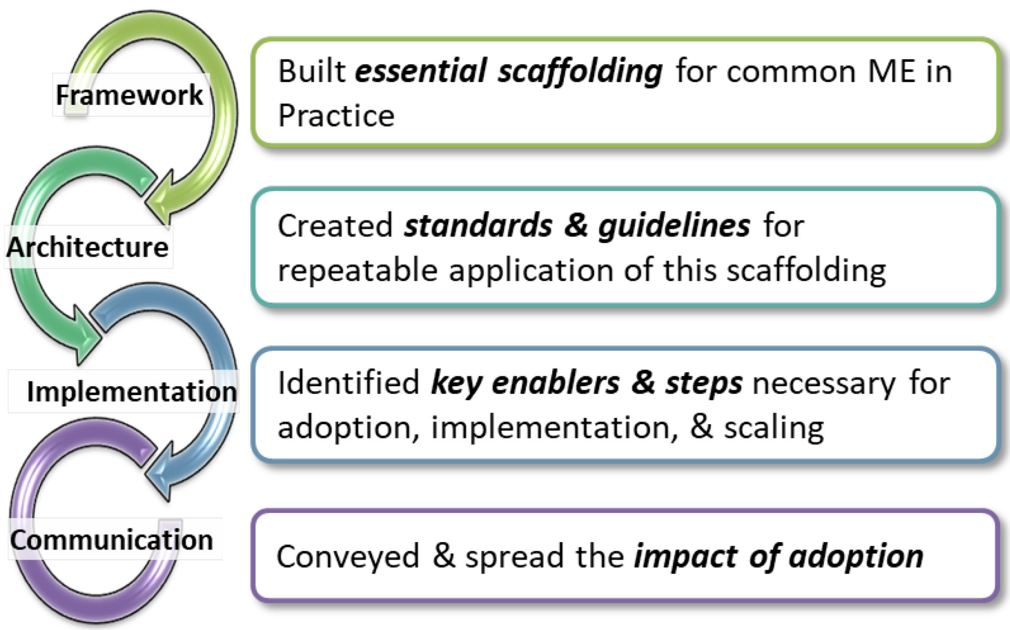

Figure 1 Macro Foundations for Developing an Applied ME Process

Report Objective

This report serves as a holistic wrap-up capturing a summary and key insights gleaned across the three major phases of this DON OSA-funded effort – the ME and DE landscape analysis, the development of actionable tools and methods for applied ME, applications of the ME methods and tools through impactful use cases, analysis of historic case studies where ME could have added value and alleviated programmatic and operational shortfalls recorded, and detailed recommendations toward an enterprise wide approach to ME.

Keywords: Department Of Navy; DON; Mission Engineering; ME; Digital Engineering; Data-Driven Decision Making; Mission-Informed Decision Making; Decision Science; Strategic Agility; Portfolio Management; Strategic Decision Making; Enterprise Approach; Applied Mission Engineering

Foreword

“If you don't know where you are going, any road will get you there.”
— Lewis Carroll, Alice’s Adventures in Wonderland

In today’s rapidly evolving operational landscape—defined by contested multi-domain threats, compressed decision cycles, and constrained resources—the Department of the Navy and the Department of Defense can no longer afford to make acquisition and capability decisions disconnected from mission context. Mission Engineering (ME) is not a reinvention process. Rather, it is a strategic necessity, an integrating discipline that ensures warfighter needs and mission outcomes are at the center of how we design, acquire, and field capability.

The ME imperative is clear, and a half-century of acquisition and operational case studies reveal a consistent pattern: programs fail not simply due to cost overruns or technical immaturity. They fail because they lack alignment to the real-world conditions and effects needed for mission success. From fragmented kill chains to misaligned investments, the cost of failing to engineer for mission success has been measured not only in billions of dollars, but in degraded readiness and missed opportunities. ME addresses this head-on by closing the seams between requirements, engineering, operations, and resourcing—orienting all stakeholders toward a common thread: mission impact.

This document reflects a multi-year collaboration across research institutions, operational communities, and government partners to institutionalize and scale ME across the enterprise. Our contribution is not the invention of a new framework, but the codification and refinement of ME practices already underway, to include aligning them with existing DoD policies and systems engineering processes. In doing so, we position ME not as a replacement, but as a unifier that bridges seams and enhances current systems and tools with a focus on outcomes, traceability, and cross-functional accountability.

Critically, the ability to execute ME at scale depends on the maturation of enabling technologies. Advances in digital engineering, mission-level modeling and simulation, and AI—including retrieval-augmented generation (RAG) for data fusion and decision support—make it possible to conduct mission-informed analysis with unprecedented speed and fidelity. These tools are not peripheral—they are essential to operationalizing ME and transforming it from an ad hoc practice into an enterprise capability.

Ultimately, this report serves not only as a technical foundation, but as a strategic call to action. If the DON and the nation is to maintain advantage in an era of rapidly evolving threats and accelerating technology cycles, it must move decisively to embed ME in its planning, acquisition, and force design activities. The insights presented here offer a blueprint for how that transformation can—and must—be achieved.

Summary of Key Findings

What if our biggest risk is not that we lack new technologies—but that we fail to connect them to missions that matter? In an era of technological acceleration, this question has never been more urgent.

The Department of the Navy (DON)—and the broader DoD—face a stark challenge: our traditional acquisition system continues to produce capability misalignments, delayed deliveries, and operational shortfalls despite decades of reforms. Mission Engineering (ME) offers a disciplined, repeatable, and mission-centric enabler—one capable of unifying fragmented efforts across planning processes, requirements management, systems engineering practices, and acquisition cycles. It does not replace existing processes but reorients them around what matters most: mission outcomes. Enabled by advances in digital engineering, distributed modeling and simulation, and emerging technologies, including rapid advancements in AI, ME now has the technical foundation needed to scale; its success, however, requires more than technology—it demands enterprise commitment.

This report draws on over 100 case studies (summarized in Figure 3, page vi) and years of applied ME research to present the rationale for institutionalizing ME as a strategic imperative across the DON and greater Department of Defense (DoD)—backed by technical findings, policy momentum, and a blueprint with actionable recommendations for DON leadership.

Key takeaways:

- ***A Pattern of Preventable Failure*****:** A review of 100 major program and operational failures over the past 50 years shows that insufficient mission-informed decision-making contributed to more than $929 billion in losses (FY25-adjusted), over 500 fatalities, and thousands of preventable casualties. These are not simply historic examples or isolated incidents; they reflect systemic, recurring shortfalls in aligning capabilities to mission needs. Despite decades of reform, the absence of an enterprise-level, ME framework has allowed the same costly patterns to repeat. This report presents ME as a critical enabler and a strategic imperative—backed by evidence, policy momentum, and a clear path forward.

- ***Mission-Focused Transformation*****:** ME is a proven tool and enabler that serves as connective tissue across acquisition vehicles, acquisition processes, requirements owners, R&D, and existing programs. ME shifts the paradigm from siloed, program-centric decision-making to a system-of-systems approach that aligns all activities with the warfighter's operational needs. It enables decision-makers to ask not only "Is the system working?" but "Is it delivering the effect we need for our mission?"

- ***Tangible Value*****:** Historic case studies reveal how ME could have mitigated or prevented failures by identifying critical gaps, revealing misaligned investments, and clarifying mission-system traceability. These cases reinforce that ME is not theoretical—it is practical and impactful.

- ***Strategic Momentum*****:** Congress and DoD leadership are signaling a shift toward mission-driven acquisition. The SPEED Act proposes the creation of a Mission Engineering and Integration Activity (MEIA), reinforcing policy alignment and providing an opportunity for the DON to lead from the front.

- ***Enabling Technologies in Place*****:** Advances in digital engineering, mission-level M&S, and AI and data science now make it possible to perform rigorous, scalable ME across classification levels and mission threads. These tools must be harnessed as part of any enterprise ME implementation and standardized under a deliberate strategy to codify common practices.

- ***Protecting Our Seed Corn*****:** When applied to technology development, ME serves as a compass—guiding downstream R&D and S&T investments toward the highest operational impact, ensuring that limited development resources are aligned to mission needs. It does not displace investment in low-TRL or basic research; rather, it illuminates their relevance early, creating a disciplined pathway to assess operational payoff, manage risk, and justify continued exploration. ME identifies not only transformative emerging technologies through rigorous capability analyses, but also future technological inflection points—moments where breakthrough advancements, such as resilient autonomy or energy density leaps, could redefine how we fight. It connects early innovation to a process of evolving mission threads, allowing nascent ideas to mature into operational advantage. ME enables bold experimentation, but within a framework that demands clarity of purpose, alignment to mission need, return on investment projections, and accountability for impact; it ensures that research can fail fast, learn faster, and ultimately succeed where it matters most.

- ***Actionable Tools & Path Forward*:** This effort developed actionable ME tools (Figure 2) – a refined, step by step ME process and digital ME development tool – for the DON and greater Department as vital scaffolding toward standardized and scaled ME in practice. This report recommends formalizing ME policy, standardizing lexicon and micro-processes, integrating ME into requirements and acquisition workflows, pursuing further tool development, establishing data sharing requirements to support ME application, and investing in ME workforce development. Quick wins—such as exercise integration and pilot applications—can jumpstart momentum while long-term governance, training, and tool development efforts mature.

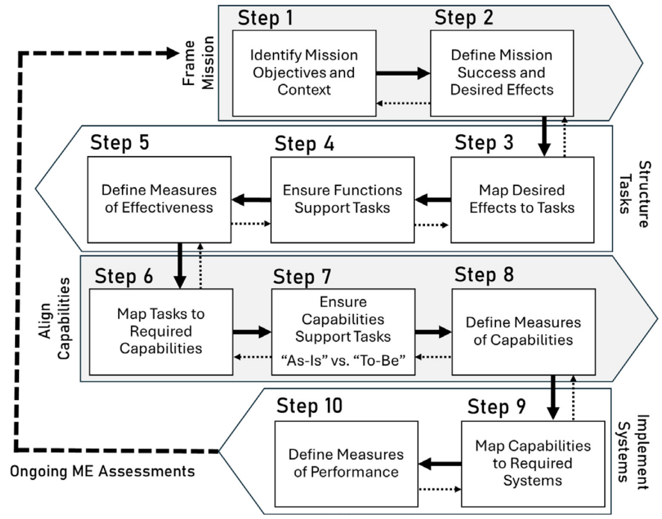

Figure 2 Macro Mission Engineering Process

- ***Decision Point*:** The DON must act now to scale ME as an enterprise discipline. Doing so will improve readiness, reduce program risk, enable faster capability delivery, and enhance operational effectiveness. Failure to act risks perpetuating the same gaps that have cost lives, money, and mission success across five decades. Institutionalizing ME is not optional; it is the only way to ensure our capabilities are engineered to the fight, not just engineered to spec.

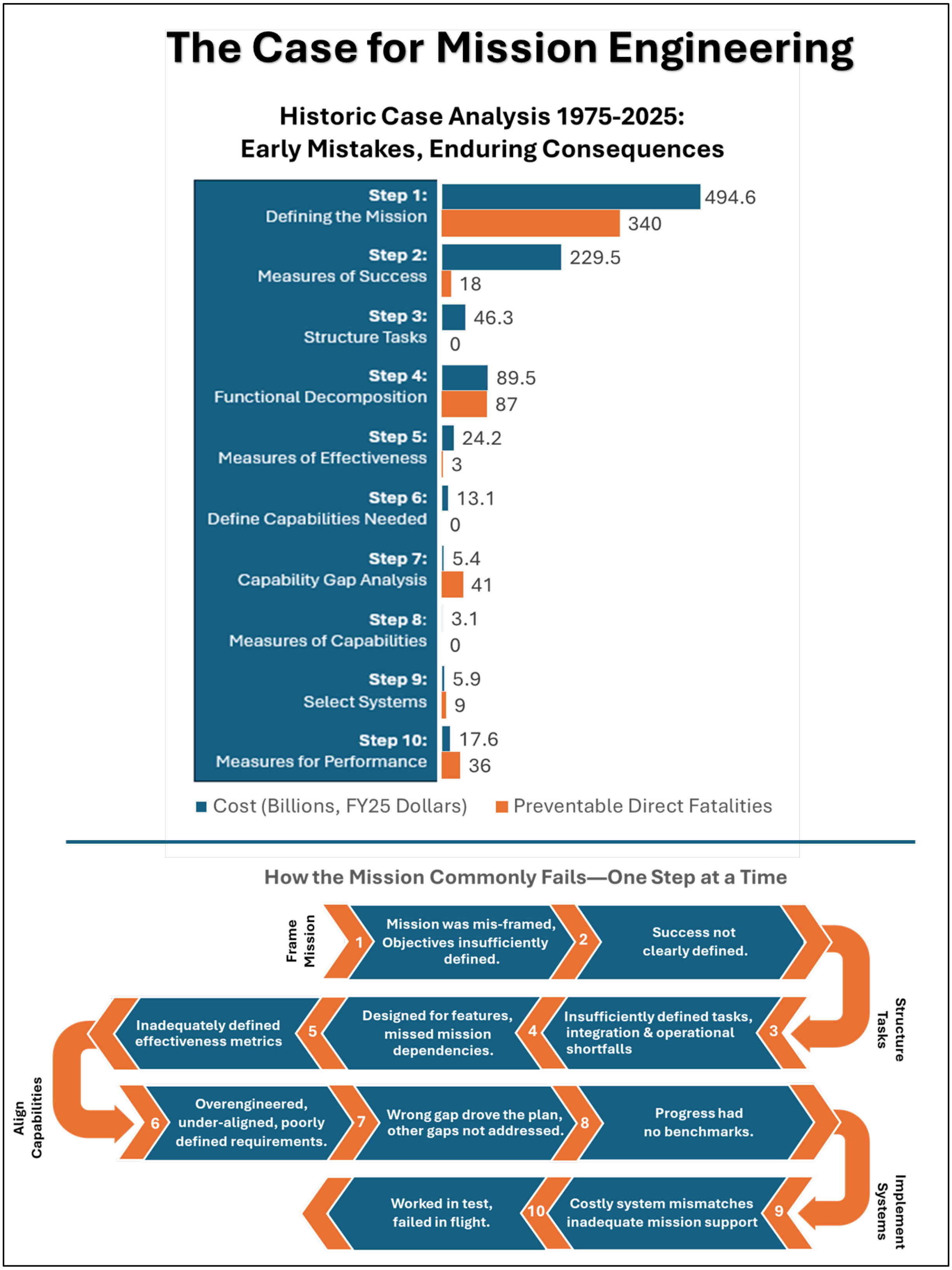

Figure 3 Historic Case Analysis – Impact Across the ME Process (Step Names Abridged for Visual)

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1 Introduction

This report provides a synthesized, strategic assessment of ME as a core enabler of mission-informed capability development and decision making across the DON. Commissioned by the DON Office of Strategic Assessment (OSA), it integrates findings from both historic and prospective operational case studies, foundational research, and applied practitioner insights. It delivers a structured overview of an applied ME process designed to systematically align capability decisions with mission outcomes at speed and scale. Rather than functioning as a comprehensive technical manual, this report targets senior leadership and decision-makers. Its primary objective is to highlight the strategic imperative for institutionalizing ME and to present a clear, actionable roadmap for achieving that transformation. Supporting technical details, including case studies and a detailed process guide, are referenced throughout and provided as annexes.

While ME has seen successful applications in pockets of the DON and broader DoD, this report argues that it is time to scale ME enterprise-wide. Doing so will require policy alignment, governance reform, digital infrastructure development, cross-Service integration, and workforce training. The recommendations presented herein address these dimensions directly.

1.1 Report Purpose

This report was initiated in response to a recognized gap: the lack of a standardized, repeatable, and mission-driven approach to capability development across the DON. Past performance shortfalls, coupled with emerging operational challenges, made it clear that the current acquisition and engineering processes are insufficient to meet the demands of contested multi-domain operations. DON OSA commissioned this assessment to evaluate how ME could serve as the connective tissue bridging seams between strategic guidance, operational planning, engineering execution, and acquisition outcomes.

As part of this work, the team developed an Applied ME Process and a prototype Mission Artifact Development Environment (MADE)—a digital decision-support environment and user interface designed to enable consistent, scalable ME application. MADE allows users to trace capability decisions to mission objectives, construct mission threads, and assess system effectiveness using authoritative data. More detail on the Applied ME Process and MADE is provided in Section 5.1-5.2.

1.2 Report Scope and Limitations

This report synthesizes key research insights, case study applications, and practitioner feedback. It provides a practical roadmap for scaling ME across DON processes, with clear policy, governance, infrastructure, and training recommendations.

What this report does not attempt to do is replace existing engineering frameworks or define a new acquisition system. ME is a unifying overlay—it is designed to enhance current practice and procedures by reorienting decision-making around mission outcomes. The technical details of ME implementation–including data schemas, tool architectures, and modeling techniques–are referenced but not explored in full here. For deeper applications – such as through the applied case studies described in Section 5.3 – there were classification and data access limitations. These are captured in detail in accompanying annexes.

2 Mission Engineering: Definition, Urgency, and Strategic Alignment

2.1 Mission Engineering Definition and Macro Process

Mission Engineering (ME) is an interdisciplinary methodology that integrates strategic, operational, and technical perspectives to systematically align capability development with clearly defined mission outcomes. At its core, ME extends traditional systems engineering by shifting the primary unit of analysis from individual platforms or systems to the broader context of the mission itself. It examines how multiple capabilities—across various systems, domains, and stakeholders—can effectively interact and perform together to achieve mission success in complex multi-domain operations.

As defined in the DoD's Mission Engineering Guide (MEG 2.0), ME "analyzes, designs, and integrates current and emerging operational needs and capabilities to achieve desired mission outcomes." Rather than focusing narrowly on technical specifications or isolated performance metrics, ME holistically evaluates how capabilities function together within realistic mission scenarios—accounting for factors such as adversary behavior, environmental conditions, interoperability requirements, operational timelines, and strategic objectives. Figure 4 provides a simplified view of the ME process as an iterative framework that connects strategic objectives to engineered solutions through continuous feedback and mission validation. It illustrates how ME keeps the mission and the warfighter at the center of every engineering, planning, and acquisition decision.

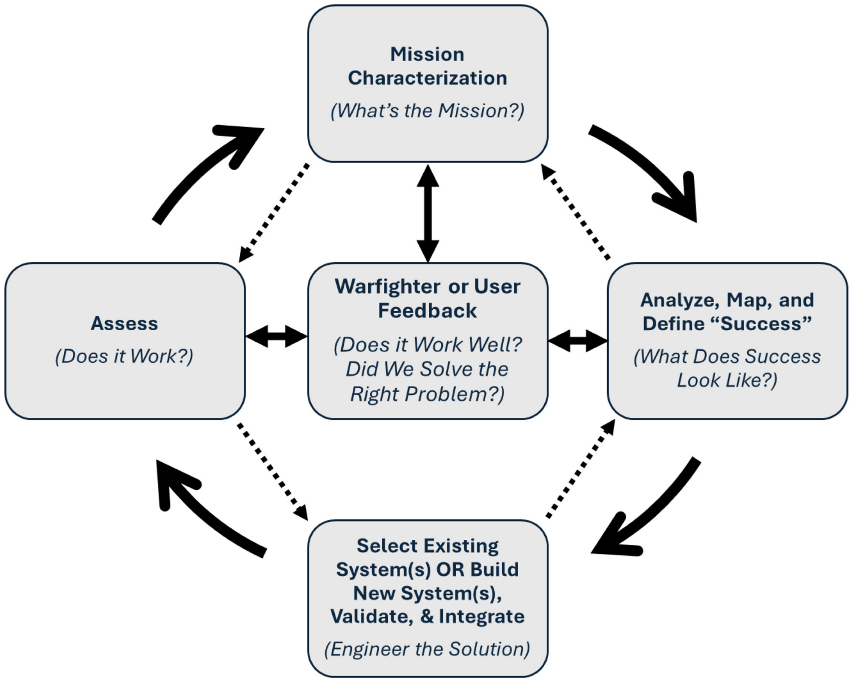

Figure 4 Generalized Mission Engineering Process as a Warfighter-Centric Process

In effect, ME serves as the "connective tissue" linking strategic intent with operational execution and technical decisions across multiple systems. It ensures alignment of capability investments to operationally meaningful outcomes and involves structured steps that include clearly characterizing the mission context; defining mission success criteria; decomposing complex mission scenarios into specific tasks and functional interactions; identifying critical mission conditions; and assessing capability gaps. By integrating Model-Based Systems Engineering (MBSE) tools, digital twins, and mission-centric simulations, ME enables stakeholders to rigorously analyze, validate, and refine mission threads, driving optimized solutions across the full lifecycle of systems and portfolios.

Unlike traditional platform-centric engineering that evaluates system performance in isolation, ME explicitly incorporates considerations of mission effectiveness, interoperability among multiple platforms and capabilities, and resilience under operational stress. It bridges organizational and technical seams by establishing a common language, standardized processes, and digital models that facilitate communication and collaboration among warfighters, engineers, acquisition professionals, and planners. Ultimately, ME ensures that capability development is driven by the strategic imperative of rapidly and reliably delivering operational success in increasingly contested and interconnected battlespaces. Figure 5 provides a tailored macro representation of the ME process, demonstrating how each phase systematically bridges strategic intent, operational tasks, capability alignment, and system performance. This macro process is adapted from the 2019 Moreland Mission Engineering and MEG 2.0 frameworks to codify a structured and iterative approach to mission-informed capability development, emphasizing alignment between strategic objectives, mission execution, capability definition, and technical performance.[1]

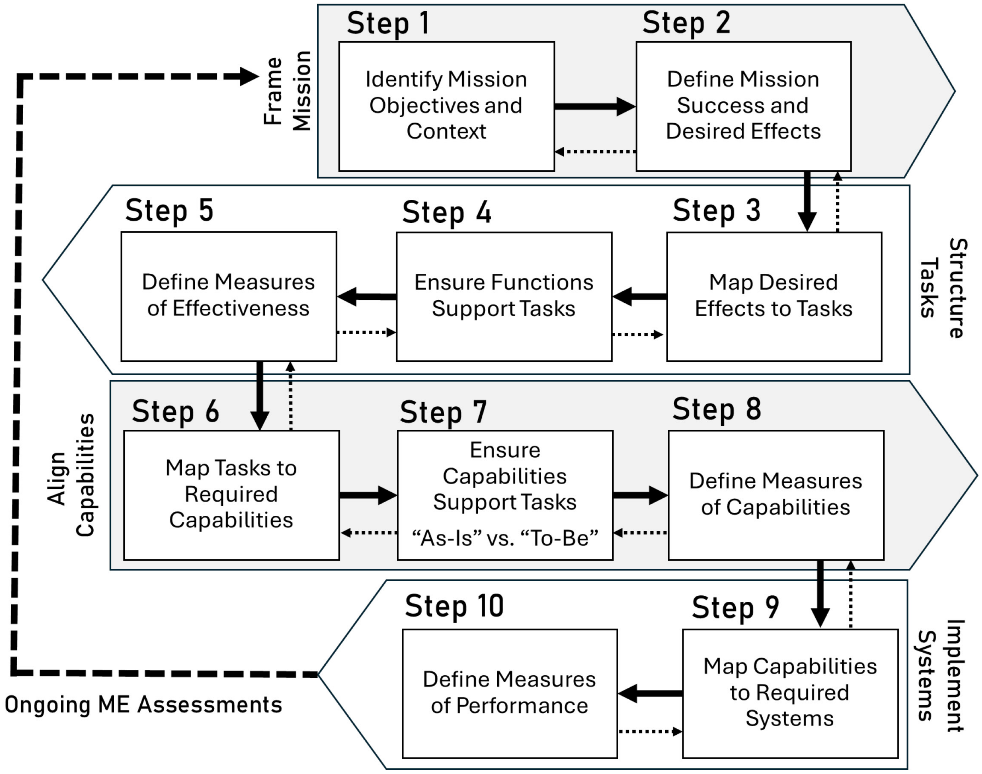

Figure 5 Macro Mission Engineering Process (Repeated)

2.2 Meeting the Moment through Mission Engineering

The DON faces a strategic environment characterized by accelerating threats, rapidly evolving technologies, and peer adversaries who effectively leverage multi-domain operations to disrupt traditional U.S. military advantages. Adversaries such as China and Russia are employing sophisticated capabilities spanning air, sea, land, cyber, and space domains, purposefully designed to exploit vulnerabilities in isolated, legacy systems and our traditional acquisition processes. These threats highlight an urgent need to overcome historically fragmented and siloed decision-making that no longer sufficiently addresses the complexities of modern warfare.[2,3]

At the same time, Congressional mandates and DoD strategic imperatives have intensified the push for accelerated capability delivery and greater mission-focused alignment. Recent legislative actions— particularly the recently introduced *SPEED Act of 2025*—explicitly call for a shift toward rapid, mission-centric acquisition, mandating the establishment of a Mission Engineering and Integration Activity (MEIA) to rigorously test and validate capabilities within operational mission contexts. The act emphasizes the importance of aligning capability development directly with warfighter needs, establishing clear Congressional expectations for streamlined acquisition timelines and tangible operational outcomes.[4]

Traditional systems engineering practices, while essential for individual system performance, often neglect critical interdependencies between systems and broader mission impacts. As a result, promising technologies frequently stall in the so-called "valleys of death"—a phenomenon where innovative capabilities fail to transition effectively from concept to operational deployment due to misalignment with actual mission needs and real-world conditions. Such misalignments result in costly delays, capability gaps, and reduced warfighter effectiveness.[5] Meeting the moment requires more than learning from past failures, it demands action grounded in the realities of today's operational environment. The subsequent section outlines enduring insights, common shortfalls, and recurring failure modes drawn from historical case studies which underscore the need for mission-focused discipline.

Ultimately, ME has become imperative not simply due to previous failures or shortfalls, but because those same gaps persist and continue to accelerate.ME directly addresses immediate and future challenges by shifting the analytical focus from isolated platform performance to holistic mission effectiveness. It provides a structured framework to make earlier, data-driven decisions about which capabilities to develop, integrate, and field, based explicitly on their contribution to mission outcomes. By leveraging digital engineering (DE) methodologies such as digital twins and model-based simulations, ME supports dynamic evaluation and continuous refinement of capabilities, ensuring that development aligns tightly with operational realities and strategic objectives. [3,6] Furthermore, ME facilitates essential cross-system and cross-domain trade-off analyses. It systematically identifies integration points and vulnerabilities across organizational boundaries, proactively addressing interoperability and operational risks before costly integration issues emerge in late stages of acquisition. This approach not only reduces risk but enhances agility, enables rapid adaptation to the emerging threats, and accelerates the deployment of new capabilities that directly contribute to mission success.[5]

By adopting ME now, the DON gains the capacity to outpace adversaries through faster, more precise capability integration and improved strategic alignment. Implementing ME is not merely a technical adjustment; it represents a fundamental shift toward a mission-first mindset, enabling rapid identification, validation, and integration of capabilities that provide decisive operational advantage. As articulated in the DoD Digital Engineering Strategy and reinforced by the SPEED Act, the integration of ME into defense acquisition processes is no longer optional—it is imperative to maintaining strategic superiority in an increasingly contested global environment.[3,4]

Crucially, emerging breakthroughs in artificial intelligence (AI)—including advanced cognitive architectures, adaptive machine learning, and autonomous mission analysis systems—present an unprecedented opportunity to develop a digitally-enabled ME ecosystem. These advanced techniques can dynamically integrate and synthesize vast volumes of multi-domain operational data, enabling automated, real-time mission assessments, optimization of complex systems-of-systems, and predictive decision-support capabilities that were previously unimaginable, let alone unattainable. Recent academic literature emphasizes that such intelligent ME frameworks can revolutionize military decision-making by delivering enhanced situational awareness, adaptability, and precision at operational tempos beyond human cognitive limits.[6,7] This fusion of advanced AI with mission engineering will facilitate agile adaptation to rapidly evolving threat environments, bridging historical gaps between strategic intent and real-time execution.

In this moment, ME represents not merely a doctrinal shift but a strategic imperative. Leveraging cutting-edge DE environments and advanced AI-driven capabilities positions the DON to proactively shape future conflicts and maintain decisive advantage in the global strategic competition. By creating a next-generation, AI-enhanced, mission-centric ecosystem, the DON will ensure strategic agility, operational resilience, and maritime superiority in an increasingly complex and contested battlespace.

2.3 Alignment with DoD Strategy

Mission Engineering (ME) is rapidly becoming a strategic enabler of the Department's shift toward integrated, agile, and outcome-focused capability development. This alignment leverages foundational initiatives such as the 2018 DoD Digital Engineering Strategy and the 2020 DoD Data Strategy, both of which advocate for a transition to model-based, data-driven decision-making processes. Where DE provides the infrastructure and tools, ME delivers the mission-driven framework to ensure those tools are applied with operational relevance and purpose.

While DE benefitted from top-down policy mandates and formal governance structures, ME emerged organically—driven by operational necessity and championed by Naval Warfare Centers, SYSCOMs, and forward-leaning program offices. This bottom-up growth has produced valuable innovation but also inconsistency. Institutionalizing ME now offers the opportunity to unify efforts under a common lexicon and process, aligning capability development with strategic warfighter priorities across the enterprise.

As DoD accelerates its shift toward rapid capability delivery in response to peer competition, ME provides a structured, repeatable process for integrating operational requirements directly into engineering and acquisition workflows. This ensures that warfighters receive capabilities built for mission execution—not just systems that meet technical compliance. Formalizing ME across the DON will improve interoperability, accelerate force design, and support cross-Service and coalition integration efforts. In short, ME is not just aligned with DoD strategy—it is the means of operationalizing it at speed and scale.

This is not simply alignment—it is the mechanism by which the DON can translate strategy into operational advantage at speed and at scale.

3 Costs of Misalignment: The Price of Ignoring Mission Engineering

3.1 Key Insights Derived from Over 100 Historic Cases

An extensive analysis of over 100 major defense acquisition and operational shortfalls and challenges spanning from 1975 to 2025 reveals a clear, persistent pattern of costly misalignment between delivered capabilities and their intended operational missions. These cases collectively resulted in:

- **Over $929 billion** (FY25-adjusted) in unnecessary expenditures and financial losses at least partly due to mission misalignment.
- **More than 500 preventable fatalities** and thousands of additional casualties directly linked to operational shortfalls.
- **Persistent and systematic capability gaps and strategic vulnerabilities** at least partly due to inadequately defined mission objectives, measures, and capability needs.

Cases were methodically selected based on objective criteria reflecting the most consequential shortfalls and challenges in U.S. defense acquisition and operations. Programs were identified through consistent appearances in formal registries—such as Nunn-McCurdy breaches—through documented operational shortfalls, or via high visibility reporting in U.S. Government Accountability Office (GAO), DoD Inspector General (IG), and Congressional testimony. Cases were chosen not to confirm bias but to reflect examples of mission misalignment, financial inefficiency, and preventable loss. Each selection aligns with a reproducible scoring methodology based on program cost, human life impact, and systemic deviation from mission-oriented principles. (See Appendix A and Annex 7 for selection method and full case study analysis).

Importantly, while many examples highlight acquisition-centric shortfalls—where ME would have prevented cost and performance divergence—others reflect operational or strategic shortfalls where mission-thread decomposition, effects-based planning, and integrated capability-task-function mapping were observed absent or incomplete. The ME framework is inherently scalable and cross-functional: it is not limited to supporting programmatic decisions but also offers a powerful framework for shaping and supporting operational planning, identifying gaps in mission execution pathways, and improving Joint Force integration. As such, the identified cases span both procurement and operational shortfalls, reflecting ME's broad applicability across the defense enterprise. These cases exemplify conditions where a robust, mission engineering approach—that links clear success criteria, mission-thread decomposition, and system performance validation together—was either absent or flawed. Below is a summary of representative cases, each illustrating a specific shortfall or challenge to align acquisition or operations to mission-engineered outcomes.

- **Expeditionary Fighting Vehicle (EFV), USMC:** Narrowly defined performance parameters—namely, achieving 25-knot over-the-water speed—at the expense of survivability, reliability, and adaptability was a contributing factor to the cancelation of the EFV program in 2011, after consuming over $3 billion in development costs. As the operational environment evolved with the rise of A2/AD threats, the high-speed ship-to-shore transit concept was rendered tactically obsolete. GAO reports from 2006 and 2009 repeatedly warned that the EFV was unable to meet evolving threats or withstand operational stress.[8,9] Mission engineering could have revealed early that the measure of success (MOS) (speed) did not map effectively to operational needs, and the vehicle's measure of effectiveness (MOE) and survivability metrics were improperly scoped.
- **Littoral Combat Ship (LCS), US Navy:** Initiated in the early 2000s, the LCS struggled with ambiguous and overly ambitious multi-mission requirements—mine countermeasures, anti-submarine warfare, and surface warfare—that in part diluted the engineering trade space and prevented optimization for any one role. Limited specificity in mission success criteria, and challenges with juggling competing priorities contributed to shortfalls in system effectiveness, including underperforming weapons, unstable modularity, and poor survivability. GAO reports from 2010- 2021 identified chronic underperformance and cost overruns.[10] Despite fielding, LCS ultimately failed to provide reliable capability across its advertised missions, resulting in early retirements and truncated procurement.
- **Mayaguez Incident (1975):** A joint rescue operation launched to recover the SS Mayaguez crew from Cambodian forces resulted in the deaths of 41 U.S. servicemembers and multiple operational shortfalls. Based on the research team's observations, the mission exhibited poor decomposition of mission tasks (ME Macro Process Step 3), failure to ensure functions supported those tasks (Step 4), and an absence of rehearsed coordination among joint forces. Post-action analyses, including RAND's 1980 review and CJCS critiques, cited poor alignment between operational objectives and execution.[11] A rigorous mission engineering thread would have clarified the task-function mappings,

validated key operational dependencies, and surfaced the need for real-time intelligence and force integration—potentially saving lives.

- **Zumwalt-Class Destroyer, US Navy:** Approved in the early 2000s and capped at three ships by 2009, the Zumwalt program exemplifies a disconnect between technical ambition and defined mission utility.[12] The destroyer featured numerous immature technologies, such as the Advanced Gun System and integrated power systems, but the research team observed that the effectiveness metrics underpinning the platform were poorly defined. Notably, the unaffordable per-unit cost (> $800,000 per round) contributed to the cancellation of the AGS's Long Range Land Attack Projectile and rendered the platform's primary mission capability moot. The mismatch between system performance and achievable mission outcomes highlights the shortfalls that could have been at least partially alleviated through mission engineering analysis and trade-space prioritization.

- **UCLASS Carrier-Launched Drone Program, US Navy:** The UCLASS program (2011–2016) was conceived to deliver an autonomous carrier-launched UAV providing persistent ISR and/or strike. However, the research team observed that ambiguity in defining the required mission capabilities and inconsistent success criteria between OSD, DON, and Fleet stakeholders likely contributed to constant requirement churn.[13] This instability challenged development with competing visions oscillating between ISR-first and strike-first roles. GAO's 2016 review emphasized that the shifting mission baseline caused schedule slips and precluded stable design progress. In the absence of consistent mission-thread decomposition and validated capability measures, UCLASS was restructured into the MQ-25 tanker—a much narrower, logistics-focused platform.

These representative examples illustrate observed shortfalls and challenges across historic cases in the absence of a formalized and rigorous ME process. The recurring theme across these and other cases is that a structured, mission-focused approach to defining and managing requirements and capabilities is essential to avoiding costly and strategically damaging outcomes. Appendix A and Annex 7 dives deeper into this analysis, further examining patterns and themes across cases through the lens of a well-defined ME framework, detailing opportunities where structured application of ME could alleviate issues of misalignment and enable the delivery of operationally relevant and strategically aligned capabilities.

It is increasingly clear—through retrospective case analysis and frontline practitioner experience alike—that shortfalls and challenges typically originate well *before* system performance evaluation. They are not just challenges of execution, but of conception: misaligned objectives, unclear measures of success, mismatched task-capability structures, and failure to account for operational conditions. In effect, the system often fails not because it was poorly built, but because it was built to the wrong mission assumptions or optimized against the wrong goals.

The mission-centric process of ME offers a corrective path and valuable opportunities for improvement—not only because it begins with the mission, but because it uniquely integrates strategic intent, operational context, functional architecture, and system capabilities into a single holistic process. As a structured, repeatable, and scalable discipline, ME centers on explicit articulation of mission objectives, desired effects, and functional and capability mappings that link those outcomes to measurable performance. Unlike traditional systems engineering, which often begins with system requirements, ME begins with the mission—and then works backward to validate which systems, capabilities, and functions are required to achieve it. This makes ME equally applicable across the acquisition lifecycle, joint operational planning, and strategic concept development. It enables both vertical traceability (from objectives to systems) and horizontal alignment (across the Services, warfighting concepts, domains, and functional stakeholders of the acquisition system).

3.2 Analysis and Comparison of Historic Cases

Despite decades of process reform and systems engineering rigor, major acquisition and operational shortfalls and challenges remain a defining feature of the modern defense landscape. In many cases, these shortfalls are not the result of unforeseeable technical hurdles or battlefield surprises, but at least in part stem from early-phase misalignments—instances where the mission was poorly framed, success criteria were ambiguous or contradictory, or key operational conditions and dependencies were not adequately captured and mapped. As defense missions become increasingly multi-domain, interdependent, and time-compressed, the limitations of traditional linear planning models and stovepiped acquisition practices have grown more acute.

To illustrate the accelerating urgency for ME adoption, the chart below presents a trend analysis of selected high-impact program and operational shortfalls from 1975 to 2025. These cases were selected based on documented Nunn-McCurdy breaches, GAO or DoD IG findings, major Congressional oversight, or clear evidence of human or strategic loss. Figure 6 presents a trendline illustrating the growing prevalence of mission-relevant programs and operational shortfalls. The data reflects the cumulative count of selected high-impact shortfalls by 15-year interval, based on mission misalignment, cost, and strategic consequence. The projection assumes continuation of current patterns in complexity and institutional gaps without formalized ME integration. The data reveal not only a persistent pattern of shortfalls, but a marked increase in frequency and prominence over time, particularly since the early 2000s. With the absence of institutionalized ME approaches, this trend is projected to continue or worsen.

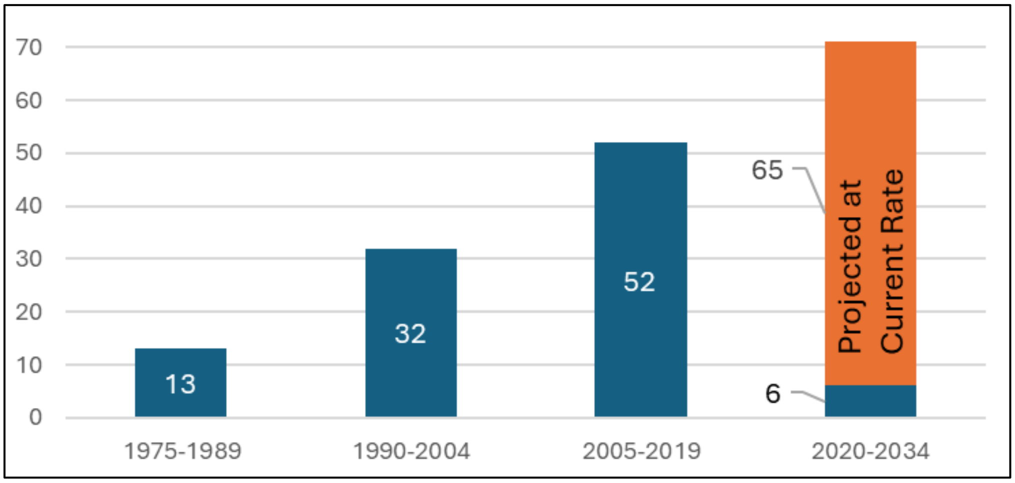

Figure 6 1975–2025: Selected Cases as a Barometer of Accelerating Shortfall Prominence

3.2.1 Common Phases and Contributing Factors Behind Shortfalls

To understand precisely where ME is essential, our analysis systematically mapped each of the 100 major defense program and operational shortfalls against the structured phases and specific steps of the MEG 2.0 ME framework. This detailed analytical mapping provided clarity on which aspects of mission-focused planning and capability development consistently fell short across cases, causing significant misalignment and adverse consequences.

Through this comprehensive evaluation, it quickly became clear that shortfalls disproportionately stemmed from early phases of the ME process. Specifically, analysis indicated that a majority of consequential shortfalls originated during initial mission problem definition and characterization phases, with fewer consequential shortfalls resulting from the later capability mapping, architecture, and detailed analysis steps. These insights underscore the critical need for rigorous and clearly defined ME practices, beginning at the earliest stages of mission definition and characterization, to avoid costly downstream consequences.

Figure 7 summarizes these insights, illustrating the research team's efforts to clearly map how analyzed shortfalls relate to the structured phases of mission problem definition, mission characterization, mission architecture, detailed engineering analysis, and final results and recommendations. The chart highlights that the research team found that the majority of costly and consequential shortfalls originate during early mission problem definition and characterization phases (>70% of failures), reinforcing the need for early and rigorous application of structured ME practices. The data from these cases vividly reinforces that the greatest vulnerabilities—and thus the greatest opportunities to prevent future shortfalls—reside within clearly and accurately defining mission problems and rigorously characterizing mission conditions from the outset.

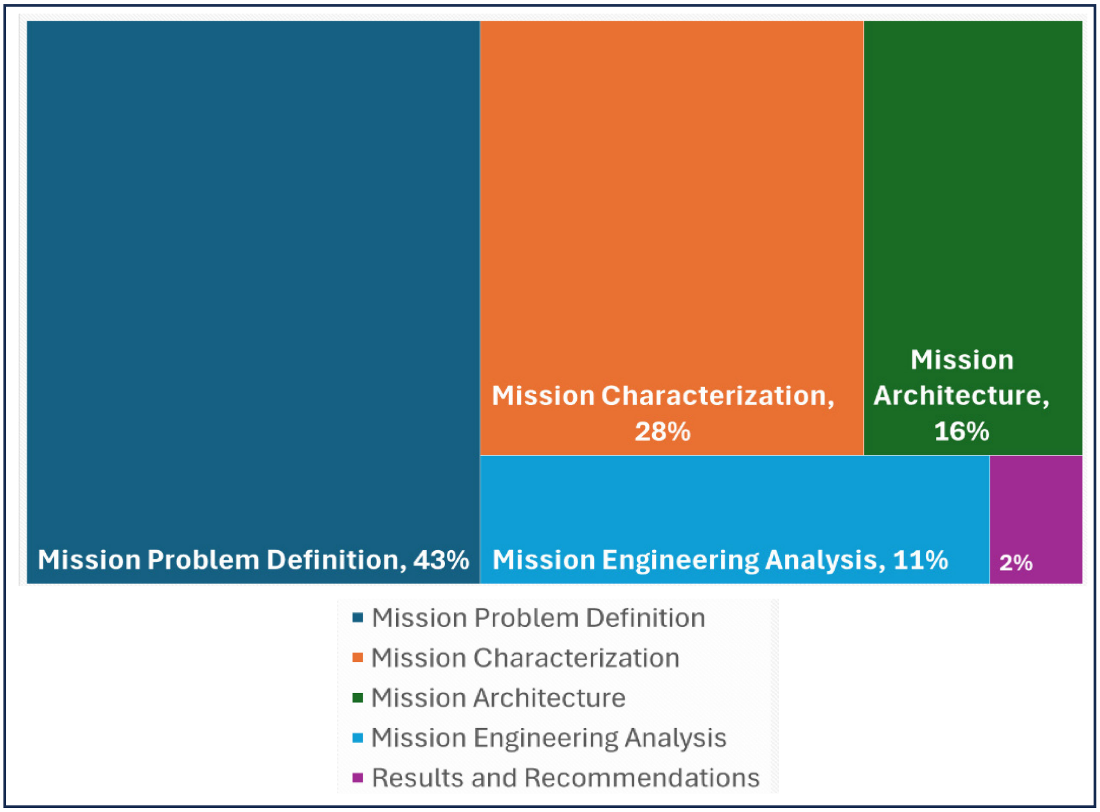

Figure 7 Pinpointing Areas Where ME Could Have Made the Difference Across Historic Cases

3.2.2 Diving Deeper into Contributing Factors Behind Shortfalls Across Historic

This section narrows to more granular insights across case studies, pinpointing examples across steps from the Macro ME Process that most frequently underpin critical shortfalls. The Macro ME Process consists of ten structured steps – adapted from the 2019 Moreland ME Process – spanning critical phases of mission definition, task characterization, capability mapping, and performance measurement (Figure 8). By methodically applying these steps as analytical lenses, the research team examined each historical example to identify the most prominent contributing factor for the shortfalls observed.

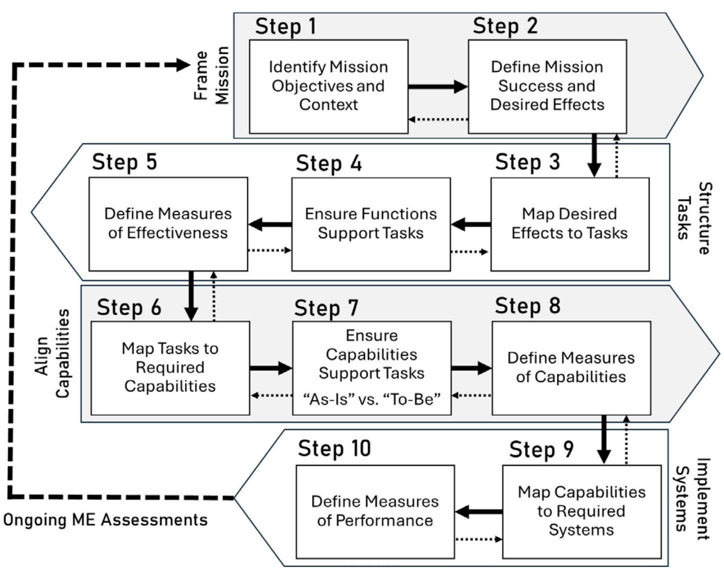

Figure 8 Macro Mission Engineering Process (Repeated)

Figure 9 provides a high-level summary of the analysis, illustrating the ME process step in which contributing factors to critical shortfalls were most frequently rooted. The distribution illustrates how shortfalls most frequently stem – at least in part – from deficiencies at the earliest steps of clearly defining and characterizing missions, setting clear success measures, and adequately structuring functional tasks, underscoring the critical need for rigorous early-stage mission engineering. While the team focused on highlighting concrete examples of breakdowns that occurred at each step of the ME process, the team acknowledges that each historic case may have multiple breakdown points throughout the ME process that contributed to compounding shortfalls and challenges seen across steps.

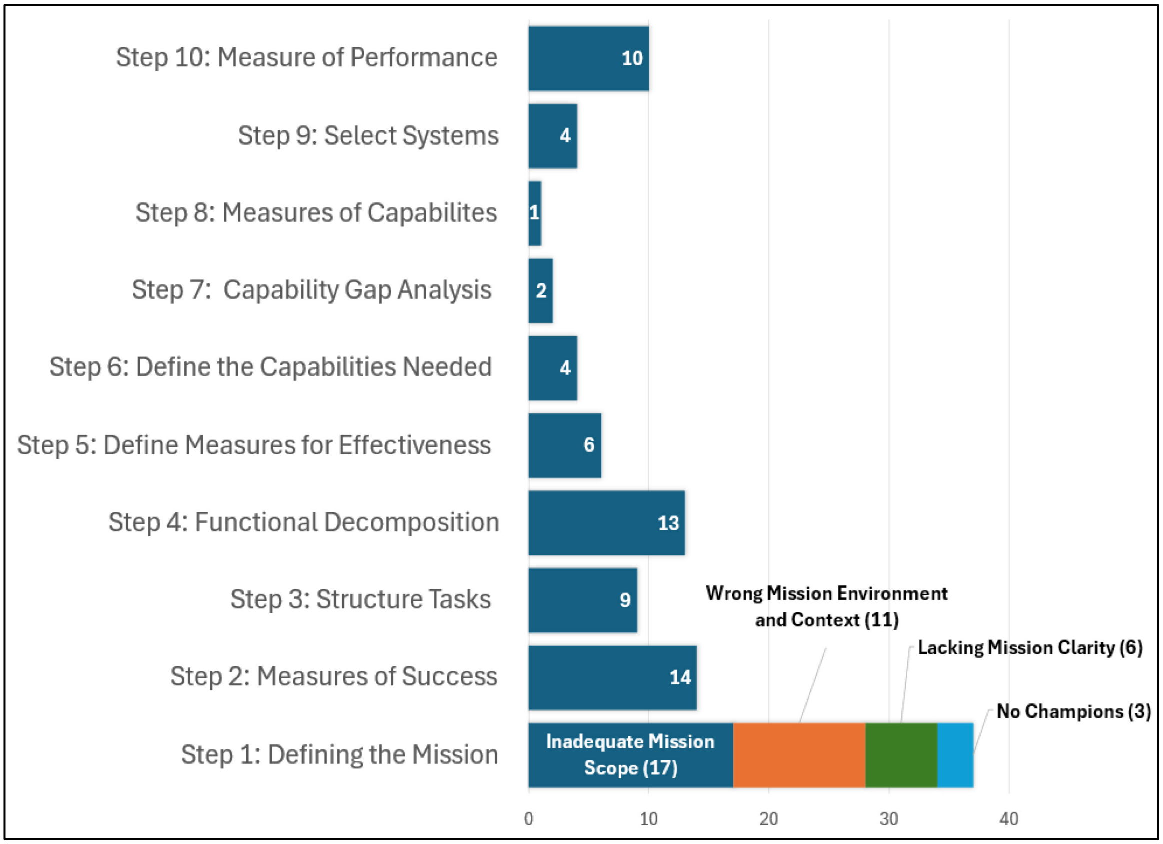

Figure 9 Frequency of Historic Defense Program Shortfalls Mapped to Macro ME Process Steps (Step Names Abridged for Chart Readability)

3.3 Where Mission Engineering Steps Offers Gates Against Shortfalls

While the historic cases highlight the primary step contributing to shortalls due to a lack of a standardized ME approach, challenges can stem from breakdowns at any step and often create compounding impacts and misalignment across later steps. Therefore, it is critical to recognize that each ME step represents a vital gate or checkpoint to identify and mitigate misalignment early and continuously throughout the program lifecycle. Figure 10 illustrates the frequency with which rigorous application of each ME step could have prevented or reduced the severity of shortfalls observed across the 100 historical cases. This analysis underscores the importance of each step as a critical checkpoint against mission failure, emphasizing that structured ME practices can significantly reduce risk, costs, and operational shortfalls. Early intervention clearly offers the greatest cost savings and operational effectiveness; however, even later ME steps offer significant opportunities to course-correct and mitigate consequences. Crucially, effective ME requires that initial mission assumptions, conditions, and inputs be continuously identified, validated, and updated throughout the lifecycle to ensure ongoing alignment with changing operational realities.

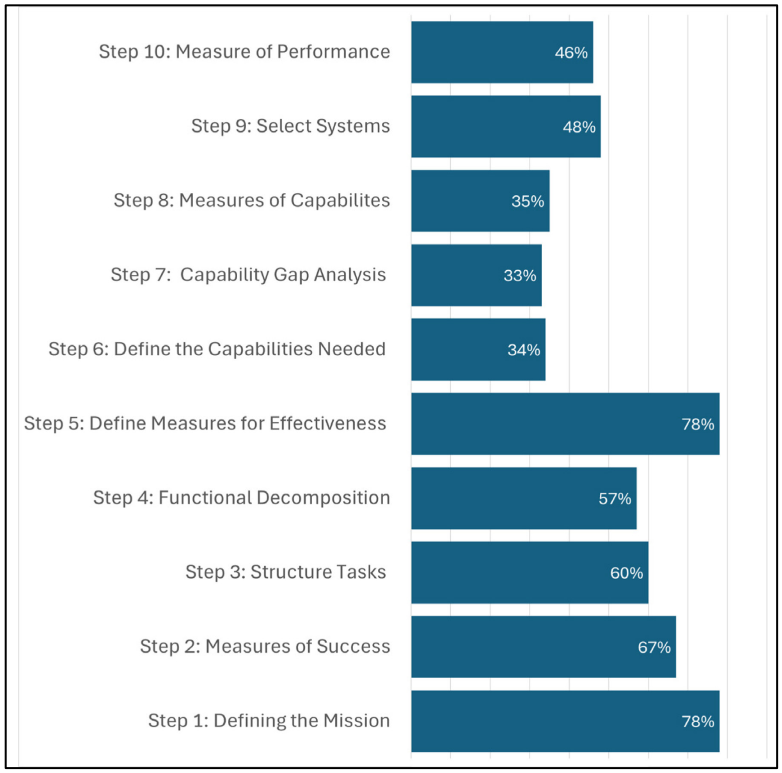

Figure 10 Historic Case Study 1975–2025—Frequency of Opportunities to Mitigate Shortfalls through Rigorous Application of ME Steps

Early foundational steps—defining the mission, measures of success, and clear essential tasks—prove pivotal and would directly address most shortfalls observed by ensuring clarity, realistic scoping, and operational alignment from the onset. Later steps involving functional decomposition, capability definitions, and robust performance metrics serve as critical checkpoints, providing opportunities to validate, realign, and maintain mission relevance amid evolving operational conditions. Ultimately, application and continuous revalidation at each step can effectively preempt the costly, cascading shortfalls that have characterized many high-impact defense acquisition programs and operations.

4 Current State of Mission Engineering in the Department of the Navy

The research team conducted a multi-phased assessment of ME application across the DON, drawing from policy analysis, case studies, technical walkthroughs, tooling evaluations, and lexicon analysis. Previous landscape assessment reports that are included as annexes to this report incorporate data-driven knowledge graph methodologies, stakeholder interviews, and comparative benchmarking across DoD Services and Allied partners. The result is a comprehensive, multidimensional view of the current state of ME—one that affirms its operational value while clearly identifying institutional, cultural, and technical barriers that constrain its scale and effectiveness. This section presents a summation of that analysis, beginning with findings that confirm fragmented ME adoption across the DON, followed by insights into recent progress and opportunities that offer momentum toward institutional change. For details regarding these summarized findings, refer to Annexes 5 and 6.

4.1 Fragmented Adoption and Gaps

While the DON has promising ongoing ME efforts, its application remains uneven and constrained by five persistent structural and cultural barriers. These conclusions emerged from an integrated research methodology that combined applied case study evaluations, technical tool landscape analysis, workforce data synthesis, and structured semantic modeling using knowledge graphs, closeness centrality, and lexicon clustering. These five primary gap areas include:

- ***Decentralized, Champion-Led Implementation*:** Across the DON and broader DoD, ME remains largely practitioner-driven, adopted organically by subject matter experts (SMEs) at Naval Warfare Centers, SYSCOMs, or PEOs. This decentralized implementation has led to inconsistent methodologies, objectives, and analytical depth. ME-related tool usage and research outputs cluster in isolated nodes with weak interconnections, reflecting institutional silos in practice adoption. These findings align with McDermott et al.'s observation that ME progress is often localized to "cylinders of excellence," lacking integration into portfolio-level governance frameworks.[14]

- ***Governance and Policy Vacuum*:** Unlike DE, which benefits from top-down policy direction, ME lacks formal mandates, policy incentives, or authoritative charters within the DON. Survey data and document analysis from landscape assessments reveal that 47 percent of participating organizations either do not engage in ME at all or do so without a defined process or reporting requirement. This lack of governance structure is a common finding across literature and similarly identified as a key barrier to scaling mission-centric approaches.[15]

- ***Terminological Incoherence and Process Misalignment*:** The lexicon analysis conducted as part of the team's landscape assessment showed significant divergence in how terms such as "mission thread," "measure of effectiveness," and "mission engineering" are defined differently across Services, contractors, industry, and academic communities. The dendrograms and PCA plots revealed multiple disconnected clusters, a condition that hampers collaboration, tooling integration, and repeatable practice across stakeholder communities.

- ***Tooling Fragmentation and Data Isolation*:** Though DE tools such as Cameo, Valispace, and Riskion are in use, ME-specific digital workflows remain immature and inconsistently supported. The team's tooling landscape review noted over 1,000 tools associated with DE, but ME-specific usage remains ad hoc, with poor interoperability and limited mission-level simulation integration. Authoritative data required for ME—such as threat characteristics, system performance under mission conditions, or joint operational task mappings—is fragmented across classification boundaries and organizational repositories, with no single source of truth or governance mode.

- ***Workforce and Cultural Barriers*:** Culturally, many stakeholders remain wary of new digital and mission-level methods, preferring legacy requirements processes. ME is inherently interdisciplinary, requiring collaboration across engineering, operations, and acquisition communities. Yet training pipelines, billet structures, and cultural norms remain aligned to legacy requirements processes. The landscape assessment found that only a small number of SMEs practice ME full-time, and ME competencies are largely absent from formal training curricula, career development frameworks, or performance evaluations. This creates a steep barrier to adoption at scale.

These findings are not speculative; rather they reflect a rigorous synthesis of landscape assessments, semantic analyses, and applied case studies. Together, they illustrate that while applied ME shows tactical utility in isolated contexts, its strategic potential for improving acquisition outcomes, interoperability, and mission readiness remains under-realized due to persistent structural, cultural, and technical barriers.

4.2 Recent Progress and Opportunities for Institutionalizing ME

Despite institutional inertia and fragmentation with ME adoption, several developments within the DON and broader DoD indicate a readiness to transition from isolated practice to enterprise-wide implementation. This includes the recent passage of the Streamlining Procurement for Effective Execution and Delivery Act of 2025," or SPEED Act. In addition to other updates in the acquisition system, requirements process, and the relationship between industry and the defense industrial base, the SPEED Act calls for the establishment of the Mission Engineering and Integration Activity (MEIA). MEIA will lead cross-service activities to develop, identify, and analyze integrated technology solutions to address joint operational problems and provide analysis and recommendations to a new acquisitions and programming directorate.

Progress in institutionalizing ME derives from a combination of programmatic experimentation, policy-driven DE transformation, and increasing political momentum for acquisition reform. Importantly, these shifts align with both historical patterns of successful innovation diffusion and core tenets of systems-of-systems (SoS) engineering—namely, iterative integration, multi-domain feedback loops, and common lexicon convergence. There is a lot of existing capability that can be leveraged to make systemic gains.

- ***Pockets of Excellence*:** Several DON organizations are piloting advanced ME practices, often tied to DE or exercise-based planning efforts. The research team's case studies and interactions identified early adopters—including NAVAIR's PMA 298 and NAVSEA elements supporting unmanned system integration—that have embedded mission thread modeling into requirements refinement and acquisition planning. These efforts build upon foundational work by NSWC Crane, which established a notional ME process tailored to naval kill chain analysis. These distributed but promising initiatives mirror what Madni and Sievers (2018) call "innovation beachheads"—entry points that serve as scalable exemplars of new engineering methodologies. Such programs offer critical testbeds for formalizing repeatable ME processes and refining integration workflows.[16]

- ***Digital Engineering Foundation*:** The DON's relative maturity in DE provides a ready-made scaffold to support ME institutionalization. The 2020 *Digital Systems Engineering Transformation* (DSET) Strategy and the 2018 *DoD Digital Engineering Strategy* codified common data standards, modeling practices, and toolchain requirements that are essential to enterprise interoperability. Centrality analysis conducted as part of the team's landscape assessment revealed that DE-related publications and tools form tightly interconnected hubs with high eigenvector scores, indicating high influence across disciplines. Leveraging this infrastructure for ME—especially through tools like digital twins, simulation environments, and authoritative model repositories—enables a synergistic workflow where mission effectiveness becomes a new axis of model-based design.[17]

- ***Recognition of the Problem*:** Senior leaders increasingly acknowledge the drawbacks of the status quo. Institutional stakeholders and Congressional leadership are increasingly vocal about the systemic failure of compliance-driven acquisition to meet warfighter needs at pace. Proposals codify this through language that mandates alignment of acquisition with operational outcomes. The team's review of FY25 and FY26 NDAA draft language and Defense Acquisition University (DAU) commentary further underscores the urgency for reforms that incorporate ME into the requirements and portfolio management processes. These policy trends align with the necessary building blocks within the organizational change literature—specifically Kotter's model, which highlights the role of "establishing a sense of urgency" and "building a guiding coalition" as critical early steps in scaling transformation. [18] In this context, ME stands as a concrete, evidence-based pathway for translating strategic intent into executable technical decisions—precisely the capability that policymakers are demanding.

Given the current momentum surrounding professionalization and standardization in ME, conditions are increasingly favorable for a deliberate, policy-backed institutionalization of ME. The challenge is no longer awareness, but execution: ensuring that promising pilots are coalesced into a coherent and repeatable enterprise ME framework applicable outside of individual silos.

5 Advancing ME in Practice: ME Process Design and Application

The preceding sections emphasize the strategic imperative, historical challenges, and illustrative consequences of fragmented ME adoption. This section transitions from analysis to application—introducing a tailored, repeatable process and a prototype toolset intended to formalize and scale ME as a structured discipline across the acquisition and operational planning landscapes.

At the center of this effort is the micro-level Applied ME Process—a rigorously defined process grounded in the Moreland 10-step ME framework (previously depicted in Figure 5). The Applied ME Process exhibited here provides an added level of granularity to equip practitioners with a repeatable and scalable methodology. Complementing this process is the prototype Mission Artifact Development Environment (MADE)—a practitioner-focused digital guide and user interface to operationalize the process. This Section will provide an overview of the Applied ME Process, describe how the MADE tool is positioned to enable consistent and scaled execution, and describe a series of use cases the team explored for application of and refinements to the Applied ME Process.

Together, these elements represent maturation from community-driven ME practice to a disciplined approach supported by tooling, standards, and alignment with broader ME and DE efforts. While ME has historically been executed via disparate methods and institutional silos, the Applied ME Process and the MADE tool represent a scalable pathway to mission-informed, data-driven decision-making across capability development and operational planning lifecycles.

5.1 Overview of the Applied Mission Engineering Process

The Applied ME Process depicted in Figure 11 decomposes the Moreland 10-step framework into sub-steps to offer practitioners a more granular, repeatable, and scalable method for ME. The research team designed this process to remain Service-agnostic and for usability at strategic, operational, and tactical levels – enabling traceability from mission outcomes to system-level performance in a format suitable for integration into existing processes across all operational and force planning timelines, and across the requirements, science and technology, capability development, and strategic decision-making communities. The Applied ME Process aims to streamline and enhance common methods and cross-stakeholder collaboration – leveraging existing processes and authoritative data/information to the extent possible while ensuring a mission-driven approach – as not to hinder or create burden on practitioners.

The Applied ME Process incorporates a blend of high-level steps, best practices, and architecture standards and guidance from the Moreland 10-Step ME framework, OUSD R&E's MEG 2.0, OUSD R&E's ME Architecture Style Guide, and integration considerations with existing processes such as JCIDs to ensure top-down and bottom-up alignment with existing standards and defense ecosystem structures.[19, 20]

This section provides an abridged overview of each step and the contained sub-steps. A more detailed walkthrough of each sub-step of the process is included in Annex 1 and exemplified through case study walkthroughs in Annex 2-4.

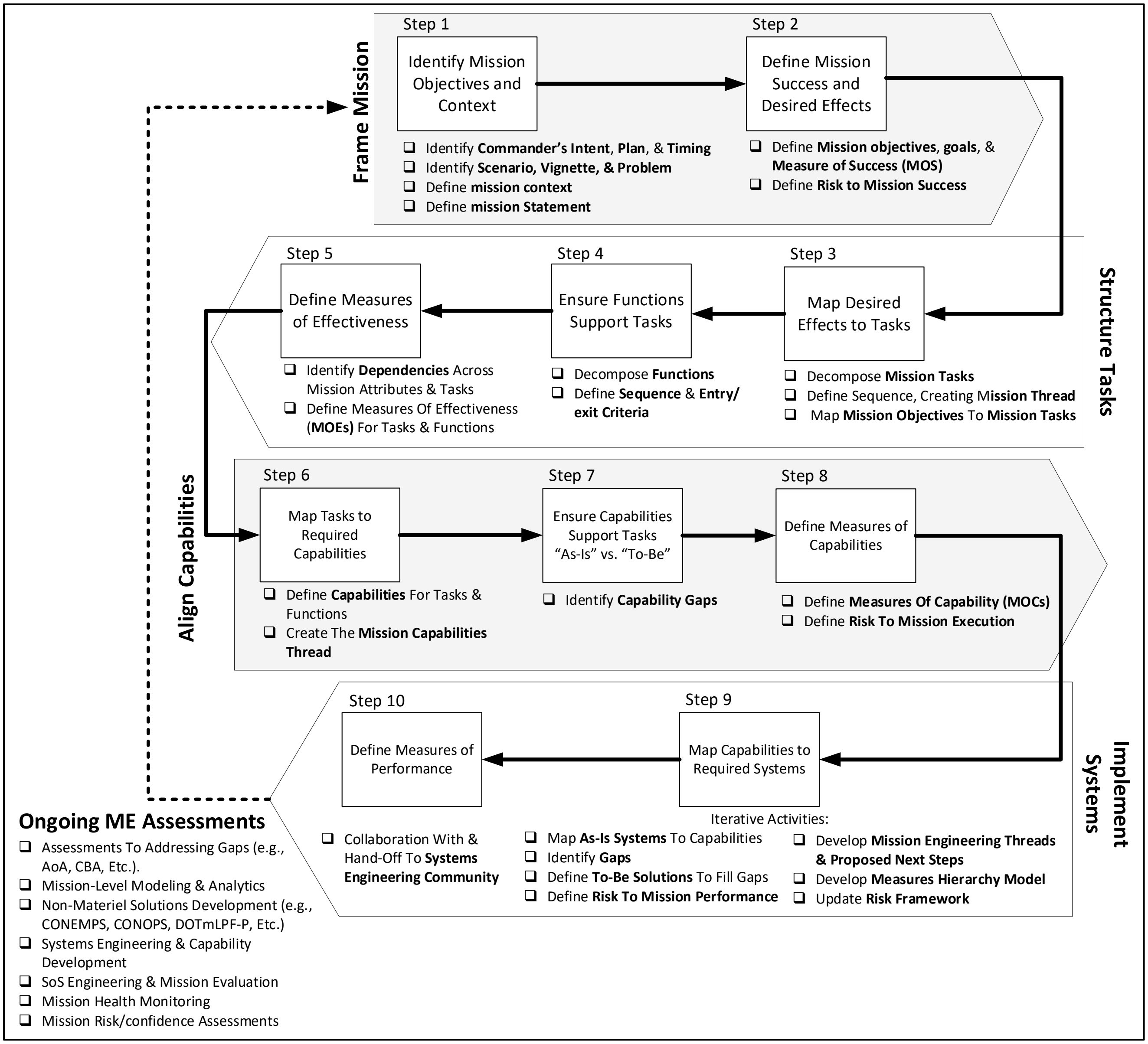

Figure 11 Micro-Level Applied ME Process

5.1.1 Applied ME Process Step 1: Identify Mission Objectives and Context

It is imperative that ME practitioners capture the overarching strategic and operational context of the mission they are analyzing and planning, as this sets the groundwork for mission scoping, identification of core objectives, and pertinent operational information that will drive what success must look like for the mission. As exemplified in the 100 historic case studies covered in Appendix A and Annex 7, the majority of cases saw failures or shortfalls partly due to ineffective or unclear mission context and objectives.

In this step, practitioners systematically capture the provenance of their mission, ultimately tracing it up to the commander's intent. This tracing is crucial to ensuring that all mission, system of system, and system architectures in relation to this mission have a common end-state tied to strategic and operational goals of the Joint Force. The practitioner will refer to authoritative strategic and operational documents and interface with existing joint planning processes for the following sub-steps:

1. ***Identify Relevant Commander's Intent, Plan, & Timing –*** Capturing key mission scoping information, setting the context and timing of the mission.

2. ***Identify Scenario, Vignette, & Problem Statement* –** Maintaining alignment to overarching context, tracing the mission down from the higher-level scenario within which it is situated.
3. ***Define Mission Context Capturing Mission Attributes* –** Decomposing the problem and translating the operational environment into core mission context attributes that will drive mission definition, mission metrics, and solution performance parameters.
4. ***Define Mission Statement* –** With the overarching context documented, defining the mission.

5.1.2 Applied ME Process Step 2: Define Mission Success and Desired Effects

This step ensures the practitioner captures clear, measurable success criteria for overall mission execution. All mission artifacts created beyond this point should capture metrics, data, and information traceable to the identified success criteria, aligning capability development and evaluation activities to overarching objectives. This will equip stakeholders with robust means and data/information necessary to clearly assess, validate, and ensure that capabilities enable the Joint Force to meet the measure of success. In this step, practitioners define mission objectives and success criteria for the mission at hand, given the overarching operational goals and context previously captured. The practitioner will refer to authoritative strategic and operational documents for the following sub-steps:

1. ***Define Mission Objectives, Goals, & Measure of Success (MOS)*** – Deriving and decomposing mission objectives, threshold and objective goals, and the measure of success for defining what success looks like, heavily informed by operational SMEs to reflect warfighting perspectives.
2. ***Define Risk to Mission Success*** – First risk check-in, capturing risk to mission success, with mission objectives, success criteria, and mission context attributes in mind.

5.1.3 Applied ME Process Step 3: Map Desired Effects to Tasks

Crucial to effective mission planning and capability development is clear task definition, which translates the key mission objectives into actionable tasks required to achieve mission success. The importance of this step is two-fold. First, it systematically constructs the flow of mission tasks, which ensure a detailed understanding and prioritization of integration, interoperability, and operational coordination necessary through a mission-driven approach. Second, this step captures the foundational mission architecture (the mission thread), which will be further decomposed and will serve as a holistic artifact to identify, evaluate, track progress of, and validate capabilities tied to the mission. In this step, practitioners leverage existing authoritative strategic, operational, and tactical references to complete the following sub-steps:

1. ***Decompose Mission Tasks* –** Identifying the essential tasks required to complete the end-to-end mission and achieve mission success.
2. ***Define Task Sequence, Creating Mission Thread* –** Capturing the interactions and sequencing of the tasks for an end-to-end mission thread.
3. ***Map Mission Objectives to Mission Tasks* –** Ensuring that all mission objectives are addressed through the tasks identified, optimizing and prioritizing core tasks necessary for mission success.

5.1.4 Applied ME Process Step 4: Ensure Functions Support Tasks

This is an iterative step that builds upon Step 3, mapping and decomposing the operational functions performed as part of each task. This step ensures that practitioners clearly define the functional architecture and interactions between functions, which will capture vital operational exit/entry criteria and task/function dependencies for later identification of capability dependencies, interoperability and interface considerations, and redundancy and resiliency requirements. In the fourth step, the practitioner will leverage existing authoritative strategic, operational, and tactical references to complete the following sub-steps:

1. ***For Each Mission Task, Decompose Functions* –** Identifying the functions necessary to execute each task.
2. ***Define Function Sequence & Entry/Exit Criteria* –** Capturing the interactions, dependencies, and sequencing of the functions for an added level of detail to the end-to-end mission thread.

5.1.5 Applied ME Process Step 5: Define Measures of Effectiveness

The practitioner translates success criteria, mission objectives, mission context, and overarching operational information captured previously into measures of effectiveness. This ensures operational effectiveness is clearly quantifiable, which will drive required and optimal capability identification in later steps, and captures clear metrics for evaluating and validating the capabilities' ability to meet the desired effects for each task and function. In the fifth step, practitioners evaluate the mission context and, through close engagements with operational SMEs, define MOEs at the task and function level. The step involves the following sub-steps:

1. ***Identify Dependencies Across Mission Attributes & Tasks –*** Evaluating dependencies and conditions present in the operational environment and mission context in relation to the tasks and functions across the end-to-end mission.
2. ***Define MOEs for Tasks & Functions –*** Considering the dependencies and conditions surrounding each task, and the mission objectives and success criteria previously captured, derive and decompose quantifiable MOEs for each task and function.

5.1.6 Applied ME Process Step 6: Map Tasks to Required Capabilities

As an intermediate step in the transition from the functional and mission thread mapping to the physical solution space, Step 6 involves defining the specific capabilities needed to achieve operational tasks and objectives across the mission thread. Importantly, this step focuses on the capability level first and will inform capability requirements, before diving into individual systems. This step is done iteratively with Step 7. Importantly, practitioners will engage with the capability portfolio management, development, and operational communities to identify existing capabilities needed and to assess capability gaps across the mission. The practitioner will refer to existing capability references and operational planning documents for the following sub-steps:

1. ***Define necessary Capabilities for each Function –*** Mapping the capabilities to each function necessary to conduct the end-to-end mission.
2. ***Identify Gaps in Capabilities –*** Iteratively assessing and capturing where capability gaps exist across the functions.
3. ***Create the Mission Capabilities Thread –*** The mapping of capabilities to functions will form the Mission Capabilities Thread, portraying the interactions/sequence between capabilities as they perform each function across the mission.

5.1.7 Applied ME Process Step 7: Ensure Capabilities Support Tasks

The practitioner iteratively conducts this step with Step 6, focused on assessing and capturing capability gaps and "To-Be" capability needs. This intermediate step will inform later steps of defining the "To-Be" solutions that stakeholders will need to pursue to close gaps and develop a system of system with the necessary capabilities to complete the end-to-end mission. Importantly, this step will lead into and can leverage input from existing processes outside of ME for documenting and assessing capability gaps. In this step, practitioners assess the mission objectives, context, and success criteria and iteratively identify where existing ("As-Is") capabilities fall short:

1. ***Identify Gaps in Capabilities*** – Iteratively assessing and capturing where capability gaps exist across the functions.

5.1.8 Applied ME Process Step 8: Define Measures of Capabilities

Building upon the defined evaluation criteria and metrics captured thus far (MOS, MOEs), the practitioner defines clear and quantitative metrics for evaluating individual capabilities. These essentially lead into and can leverage input from existing processes outside of ME for documenting capability requirements. This step requires the practitioner to engage with the capability development and operational communities. This includes the following sub-steps:

1. ***Define Measures of Capability (MOCs) for Capabilities –*** Capturing quantifiable measures for the inherent ability needed of each capability to meet objectives through their execution of respective functions.
2. ***Define Risk to Mission Execution –*** A second risk check-in focused on capturing risk to mission execution, with capabilities and their required measures in mind.

5.1.9 Applied ME Process Step 9: Map Capabilities to Required Systems

In this step, practitioners take the capabilities and associated metrics identified previously and map existing systems, noting whether those systems can either fully meet or partially meet the required capabilities. This is a highly iterative step that requires close cross-functional collaboration and coordination between the ME practitioner, capability portfolio managers, capability development stakeholders, engineers, and operational SMEs. Practitioners conduct the following sub-steps iteratively:

1. ***Map As-Is Systems/SoS to Capabilities –*** Looking across existing system architectures, mapping "As-Is" systems to the required capabilities and noting key limitations, assumptions, and dependencies with other systems.

2. ***Assess & identify Gaps –*** Assessing where systems fall short or where a capability or system performance gap exists that will need to be filled with a future ("To-Be") solution.
3. ***Define To-Be Solutions to fill gaps –*** Assessing what future ("To-Be") solutions are necessary to fill capability or system performance gaps.
4. ***Define risk factors – Risk to Mission Performance –*** A third risk check-in focused on capturing risk to mission performance, with existing systems and surrounding limitations, gaps, and assumptions identified surrounding their performance.
5. ***Develop As-Is & To-Be METs & Proposed Next Steps –*** Translating the system-to-capability mappings into a holistic end-to-end view of the mission, the mission engineering thread, which forms the baseline decision aid to track capability development progress, evaluation results, and strategic decisions in terms of their impact to mission success. Next steps surrounding "To-Be" solutions are captured, driving ongoing assessments that occur outside of the practitioner's purview.
6. ***Develop Mission Elements & Measures Hierarchy Model –*** Building a holistic view of the metrics from mission success down to individual system performance measures, as a traceable framework to track evaluations and validation activities across the mission.
7. ***Finalize Initial Risk Factors Framework for ongoing assessment –*** A final risk check-in prior to integrating identified risk factors into the broader structured risk assessment and mitigation processes involved in Joint Planning and capability development.

5.1.10 Applied ME Process Step 10: Define Measures of Performance

The final step marks the gradual hand-off from mission engineer to systems engineer and capability developers, setting precise technical performance criteria for selected systems and solutions. The ME practitioner does not define MOPs themselves but rather ensures the mission-focused activities continue through tight coordination and collaboration iteratively with the engineering community. Through iterative engagement and continuous feedback loops, the ME practitioner, operational, and engineering communities work together to translate the mission architecture, functional and capability needs, and As-Is versus To-Be systems identified into technical and performance requirements that drive subsequent solution exploration, design, development, evaluation, integration, and fielding activities across the defense ecosystem. This step involves the following sub-step:

1. ***Iterative collaboration with and eventual hand-off to Systems Engineering Community***

5.1.11 Applied ME Process Step: Ongoing ME Assessments

This step occurs outside of the ME practitioner's purview, but marks the importance for continuous collaboration, coordination, and feedback loops between stakeholder communities to ensure the systems and solutions identified will be developed and evaluated effectively to meet mission success.

Mission engineering is not a one-time activity for a given mission and does not occur in a vacuum but rather as part of a complex overarching defense ecosystem with many stakeholders playing a role in readying the Joint Force for current and evolving operational conditions. The practitioner completes the above steps to create an initial baseline for a given mission – scoped according to that practitioner's goals for ME application. This baseline sets the foundation to be iteratively refined and used within mission-focused activities that then unfold through existing processes across the capability development, joint and operational planning, and service-specific force planning communities. Mission engineering artifacts serve as a vital input and means for upholding the connective tissue across stakeholders, driving prioritization, scoping, and mission-based risk assessments of these activities.

1. ***Assessment activities to identify courses of action for addressing gaps identified in the mission artifacts*** (e.g., AoA, CBA, DOTMLPF-P Analysis, trade analyses, etc.).
2. ***Modeling & analytics for mission-level optimization, efficiency, redundancy/resiliency, resource prioritization & allocation.***
3. ***Non-materiel solutions planning and execution*** (e.g., development of CONEMPS, CONOPS, TTPs, and other solutions under DOTmLPF-P).
4. ***Systems engineering and capability development planning and execution.***
5. ***System of systems (SoS) engineering, assessments, and evaluation for a given mission.***
6. ***Mission health monitoring across SoS via cost, schedule, and performance metrics.***
7. ***Mission-based risk and confidence interval assessments.***

5.2 Mission Artifact Development Environment (MADE) – Prototype Overview

5.2.1 Motivation for an ME Tool

The research team developed a prototype Mission Artifact Development Environment (MADE) to operationalize the Applied ME Process. MADE is a practitioner-focused tool designed to provide a uniform, user-friendly, and actionable toolset that guides practitioners through the Applied ME Process step-by-step and aims to streamline consistent and scalable ME applications. The toolset embeds best practices, authoritative data/information traceability, and a shared lexicon directly into the software environment to ensure consistency and scaling across ME practitioners. MADE captures complex relationships across mission artifacts (e.g., mission threads, capability-function mappings, METs) in a backend database.

The MADE tool acts as a "mission engineering cockpit"—a centralized workspace streamlining cross-stakeholder collaboration integral to the ME process to capture mission scope, build mission threads, map capabilities and systems/solutions, and capture interdependencies and risks along the way. This approach improves analytical rigor and facilitates cross-functional collaboration by offering a common structure to define and refine mission elements. Importantly, the Applied ME Process and MADE tool stresses integrating ME steps and artifacts effectively with current joint planning, requirements, capability development, and experimentation processes – as to not reinvent or disrupt the defense acquisition system but instead streamline activities and use ME to bridge stakeholder community seams for mission-focused assessments. The intent is to enable repeatable, consistent application of ME methods and to ensure that ME outputs lead to actionable, comparable, and mission-informed decision making. Figures 12-13 provide snapshots of the MADE tool prototype webpages, showcasing key features.

Figure 12 MADE Tool Prototype "Frame the Mission" Strategic and Operational Context Page

5.2.2 Key Features of the MADE Tool

The prototype MADE tool incorporates several core features designed to support structured ME applications. Central to the interface is a mission thread builder that allows users to select and populate mission elements—including tasks, systems, and associated risk factors—using a structured library grounded in a common lexicon and capture of the overarching operational context of the given mission. This allows for rapid construction of complex mission threads while ensuring alignment in terminology, analysis methods, and operational traceability across user groups.

Another critical feature is authoritative data source integration. The prototype includes the ability to ingest relevant system performance characteristics, environmental constraints, and functional requirements from trusted technical and intelligence databases. This capability is essential to ensure the analytical output is grounded in accurate and current information, and that this vital information is captured in a structured way that enables streamlined export for uses in modeling and simulations downstream. However, challenges remain regarding data availability and access—particularly when relevant datasets are fragmented across multiple systems or restricted based on user credentials.

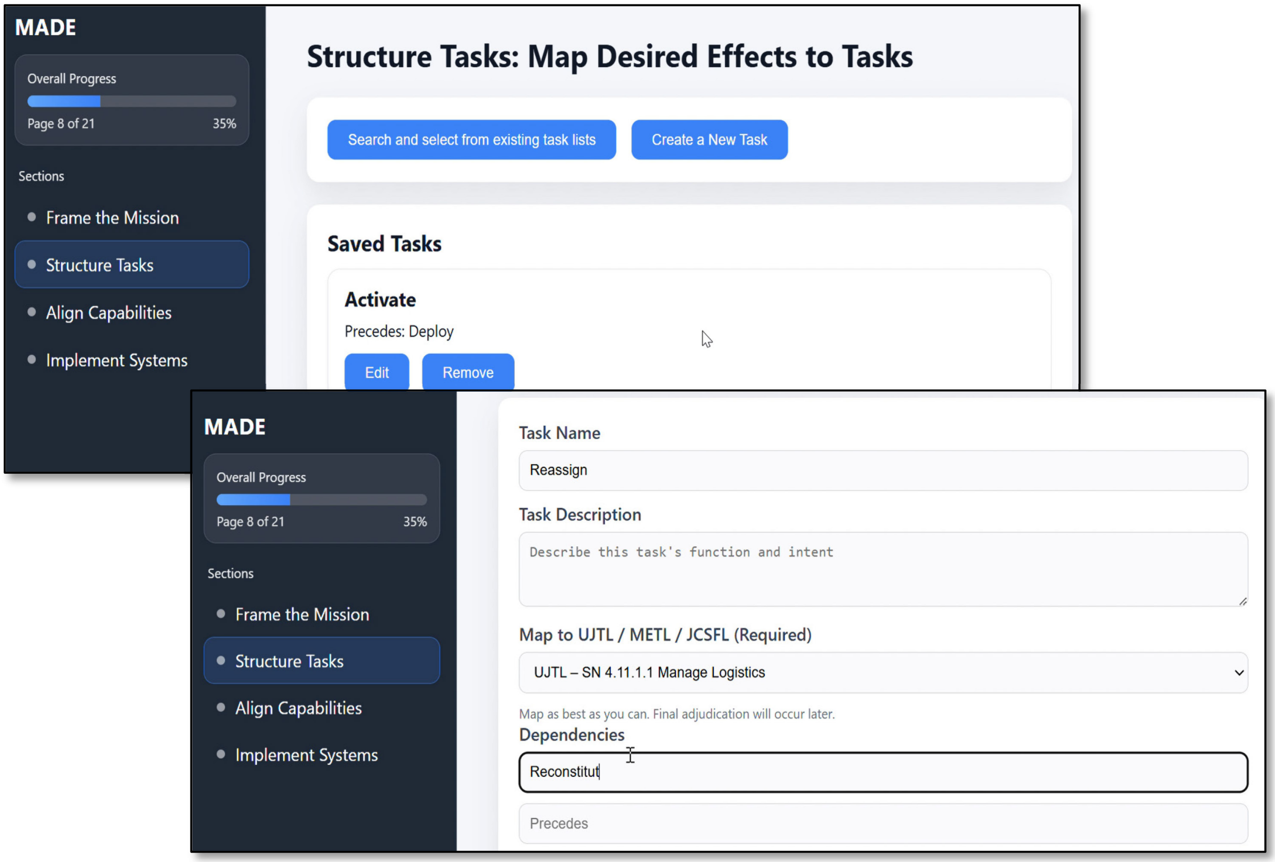

Figure 13 MADE Tool Prototype "Structure Tasks" Webpage with Alignment to Authoritative Data Sources

Visualizations embedded within the tool offer users a dynamic view of mission and mission engineering threads and serve as a means to evaluate the structure of their artifacts as they construct them. Rather than simply tracking quantitative metrics, the dashboards focus on highlighting mission task dependencies, functional and capability gaps, and system contributions. Users can explore how these elements relate to one another; identify mismatches, gaps, and redundancies; and make targeted adjustments to improve overall optimization and alignment with mission objectives. This supports a more intuitive understanding of mission architecture and encourages iterative refinement.

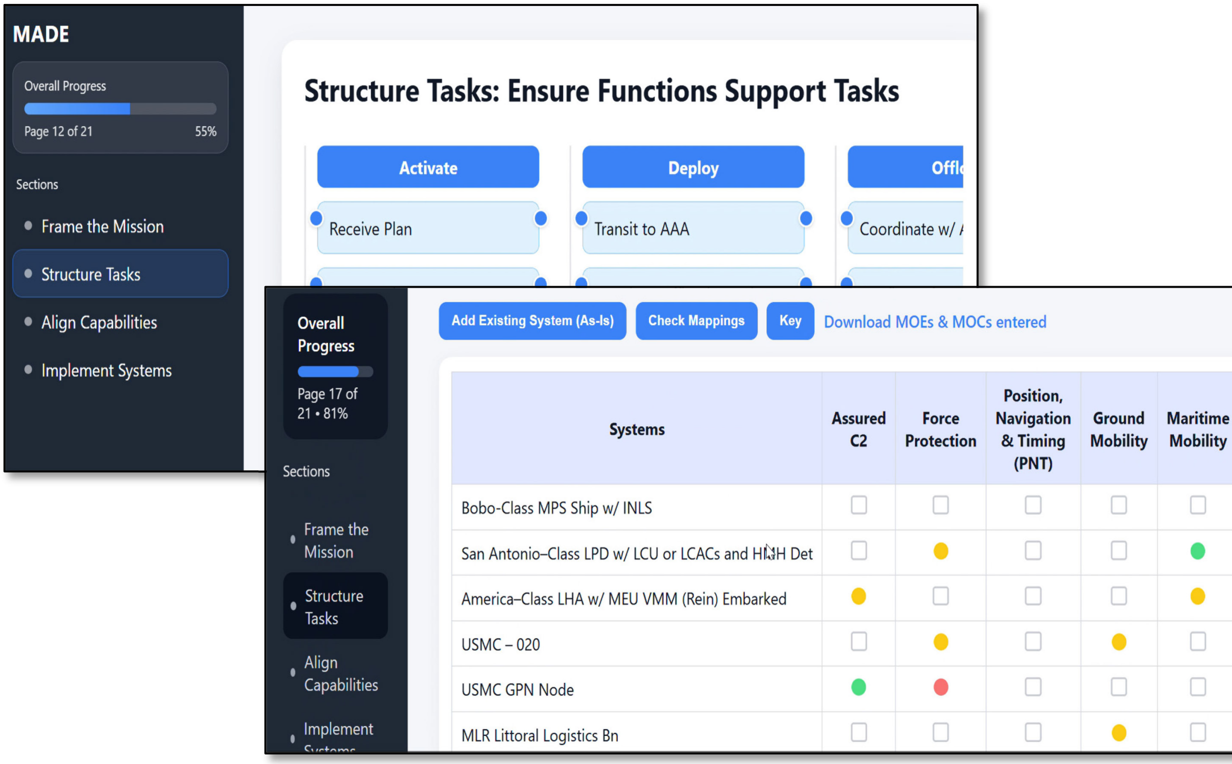

Figure 14 MADE Tool Prototype Visualizing Mission Threads and Mission Engineering Threads

Collaboration is another integral feature envisioned for the tool. The tool envisions enabling multiple experts—operators, engineers, and planners to contribute their knowledge surrounding the given mission within a shared environment. Operators can define operational alignment, mission context, success metrics, and mission tasks, while engineers can input detailed system data and constraints. This collaborative functionality supports distributed, cross-stakeholder planning efforts and helps bridge communication gaps between the operational, research and engineering, and acquisition communities.

5.2.3 Scalability and Design Considerations

The user interface was designed with scalability, future extensibility, and tailoring to multiple levels and types of stakeholders in mind. While the current prototype is extended to Department of the Navy (DON) use cases, the stakeholder-agnostic architecture allows for future expansion into other Services, Joint, or Allied applications. The interface emphasizes accessibility and intuitive design, enabling a broad range of users—from action officers to senior planners—to navigate the tool with minimal training. This usability focus is critical for widespread adoption in diverse operational environments.

Although security considerations (e.g., access control, cross-enclave data/information implications, and classification management) was not implemented in the current phase, future tool development will need to address the challenge of handling artifacts that may span multiple classification levels. For example, files and inputs provided by users—such as operational documents, system specifications, or threat intelligence—may have varying levels of sensitivity or classification. A future capability under consideration is a classification-aware architecture, where content can be flagged or routed based on sensitivity and integrated securely with classified data environments as necessary.

5.2.4 Challenges and Next Steps

Several challenges and gaps were identified during the course of prototype development. A central issue is data access control: users will need appropriate permissions to retrieve certain data sources, and there must be clear mechanisms for identifying whether data is unavailable or access is simply restricted. Lack of transparency on this point can lead to analytical blind spots or redundant effort. Addressing this will require a robust permissions framework and user notifications when data access is limited.

Looking ahead, the integration of artificial intelligence and large language models (LLMs) presents a promising opportunity. These technologies could support users by recommending tasks based on mission objectives, identifying similar historical scenarios, or suggesting alternative system configurations when capability gaps are detected. This type of intelligent assistance would enhance the speed and depth of analysis and reduce manual workload.

Recommendations in Section 7 of this report propose continued development of the ME tool—either by evolving the current prototype or adapting an existing platform—and piloting it with end users in operational contexts. User feedback will be essential in refining functionality, addressing data access and classification challenges, and ensuring the tool aligns with real-world mission planning needs.

5.3 Applied ME Use Cases – Summary and Key Findings

This section discusses three use cases (visualized in Figure 15) the research team explored to illustrate how the standardized integration of the Applied ME Process – streamlined through tools such as the MADE prototype – can enable data-driven insights and alignment across stakeholders to ensure Joint Force readiness. The research team selected a variety of use case themes – spanning broader capability exploration for a mission with integration and allies/partners themes, planning support missions like logistics, and key technology insertion for a specific mission – to capture a wide array of examples for investigating where applied ME can add value.

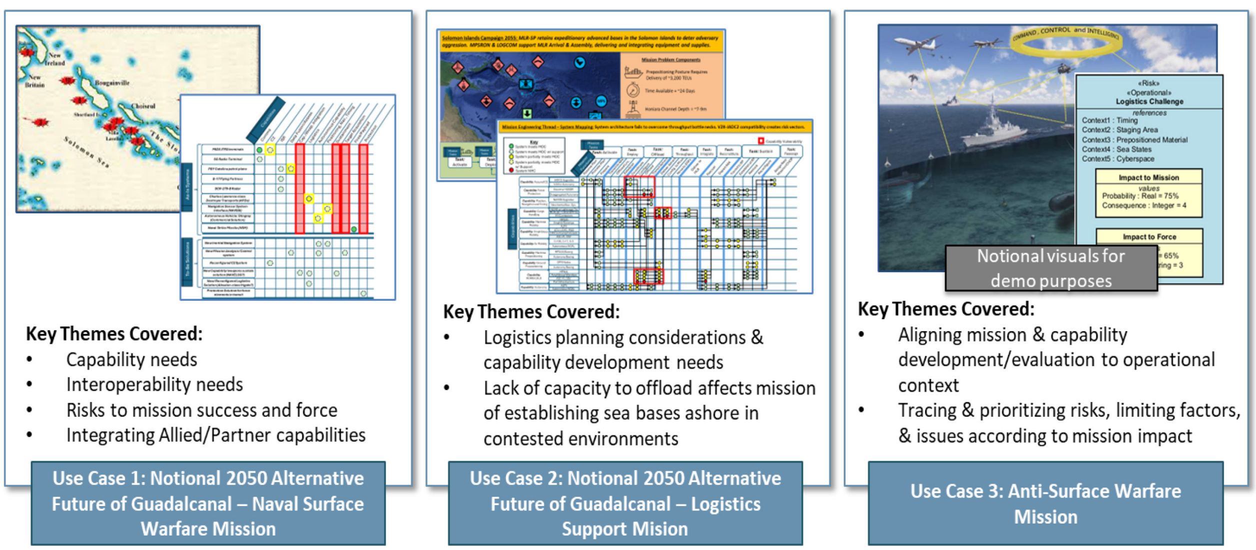

Figure 15 Overview of Applied ME Use Cases

5.3.1 Applied ME Use Cases – Overview of Cases

Use Case 1 – Guadalcanal Alternative Futures Naval Surface Warfare Mission Analysis applies the ME process in the evaluation of a broad set of capability options for a notional naval surface warfare mission in support of overarching operational objectives to defend the Solomon Islands from Red Force invasion. The mission artifacts captured in this use case were informed by public historical information and unclassified doctrine with an alternative futures approach that blended historical facts with future-oriented emerging technologies to provide a widely shareable example of the application of ME. Key themes associated with Use Case 1 are described below; further detail is included in Annex 2.

Use Case 2 – Use Case 2 – Guadalcanal Alternative Futures Logistics Mission Analysis derives its findings from the same notional scenario as Use Case 1, analyzing the interdependency between mission context, doctrinal employment templates, and capability development for expeditionary operations. Using the doctrinal templates and standard planning factors for expeditionary deployments, the use case introduces complicating factors that challenge traditional solutions to the employment template, thus allowing the mission engineer to trace the implications of context variables to "as-is" and "to-be" systems. Key themes associated with Use Case 2 are described below; further detail is included in Annex 3.

Use Case 3 – Unmanned System Anti-Surface Warfare Mission Analysis applies the ME process to a case surrounding the insertion of new technology into a specific anti-surface warfare mission. Key themes surrounding Use Case 3 are described at a high level in this report; further details for this case are available in Annex 4, which can be shared by request. Use Case

3 mission artifacts and key findings are based on authoritative strategic, operational, and engineering documents provided to the research team.

5.3.2 Applied ME Use Cases – Key Findings Across of Cases

While these use cases have different starting points and types of supporting source documentation, they each demonstrate the value of applied ME in four key areas:

1. ***Aligning missions with the broader operational context*** to ensure that concepts of employment and strategic priorities can be traced through missions to capability and systems, and ensure that those individual missions connect to broader operations or campaigns.
2. ***Providing a systematic approach*** that complements existing Joint Planning and Acquisitions to trace requirements and determine best systems to achieve Joint Force operational objectives.
3. ***Integrating mission context into mission measures*** (MOS, MOEs, MOCs, and MOPs) to ensure the SoS is able to perform as needed to achieve desired effects in the appropriate context in order to meet mission success criteria.
4. ***Providing a holistic overview and aid*** for capturing and tracking dependencies, decisions, and the SoS to enable evaluation of overall mission readiness, evaluated risk to mission readiness, and to inform formalized activities such as analysis of alternatives, trade studies, non-materiel solution development, and capability development.
5. ***Identifying Interdependencies between stakeholders*** for reinvestment strategies for "to-be" systems, allowing mission driven decisions for acquisition priorities and divestment strategies across stakeholders to manage impacts of system modernization across mission architectures.

All use cases benefitted from the systematic approach that the ME process lends a practitioner, ensuring the mission and related systems were analyzed in terms of what best suits Joint Force operational objectives. In the Use Case 1 and 2, ME enabled the evaluation of different systems' abilities to conduct the mission, resulting in the identification of capability gaps and shortfalls in existing architectures and the need for new capabilities to fill these gaps. In Use Case 3, ME identified that the narrow focus on the insertion ,of a specific technology in the context of a single mission prevented exploration of other technologies for the mission and/or consideration of other missions for which the technology might be best suited.

Application of the ME process to the use cases also identified the importance of aligning missions with the broader operational context. Mission threads exist in larger mission architectures, meaning that associated systems must perform functions within a broader context. The broader context is important to understand the operational and technical dependencies that will drive effective capability and system development. In Use Case 1, ME helped identify where critical capability gaps existed, particularly surrounding force protection, pre-and post-operations logistics, and communications. Use Case 1 solutions to fill these gaps focused heavily on integration of Allies and Partner capabilities and the integration of new capabilities with existing platforms to ensure required capabilities were accounted for, given dependencies identified surrounding the greater context. In Use Case 2, ME helped to identify the need for coordinated reinvestment strategies across stakeholders, evolving force protection requirements to meet varying employment concepts, exploring options to analyze augmentation from commercial or ally systems, and rescoping systems integration requirements across manned, unmanned, and hybrid platforms. In Use Case 3, ME highlighted the importance of understanding the overarching operational objectives for ensuring the mission and related capabilities/systems mapped are designed in a way that successfully contributes to overall operational success.

The ME process also identified the importance of developing mission metrics (MOS, MOE, MOPs) in the context of the circumstances in which the SoS must operate. In Use Case 2, ME identified environmental limitations, timing constraints and contested logistics factors that resulted in existing systems not being able to accomplish the mission, necessitating identification of new capabilities. In Use Case 3, ME identified several key operational environment and DOTMLPF-P factors that need to be considered and prioritized in SoS evaluation to ensure that the SoS can perform in the mission and overarching operational context.

Lastly, the ME process highlighted the value of a holistic approach to evaluating mission readiness. Use Case 1 and 2, ME outlined the requirements deemed necessary to enable mission success, providing a baseline against which to perform an Analysis of Alternatives and consider the feasibility of autonomous solutions and capability integration across platforms for the respective missions. In Use Case 3, ME identified the utility of a holistic method for tracking assumptions, risks, and decisions to enable assessment of overall mission readiness rather than the evaluation of systems in silos.

5.3.3 Applied ME Use Cases – Areas for Future Application and Exploration

In addition to the benefits identified through these three use cases, further application and scaling of the applied ME process would enable other mission-driven activities and alignment across stakeholders to ensure Joint Force readiness. Application of this ME process to additional real-world use cases and data, for instance, would demonstrate its efficacy for evaluating technical tradeoffs and redundancy and resiliency needs. Its future implementation at scale would also enhance capability portfolio management by enabling the identification of most-used and under-used systems, evaluation of the effects of system sunset across mission threads, understanding the ramifications of funding and defunding, and transitioning and integrating early prototypes and emerging technologies.

The standardized ME process is also promising for the expansion of M&S and red teaming operational plans. Capture of mission context attributes mission tasks, and subordinate functions for a mission in the ME process provide a baseline from which to develop modeling and simulations (M&S) for missions, scenarios, and vignettes. This type of M&S could facilitate early evaluation of an identified mission's ability to achieve identified metrics of success, enable refinement and modifications to mission threads, mission engineering threads (MET), and systems well before mission execution, and improve the probability of mission success. Finally, this standardized ME process could also be applied to evaluating the capabilities of the adversary to inform Joint Force operational planning, potentially including M&S of the interactions of Blue Force-Red Force METs to determine the mission metrics required for victory.

6 Future State Vision: ME at Scale for the DON and Beyond

Imagine a DON where every decision—strategic, operational, or technical—is directly tied to its impact on mission success. This is the future state enabled by institutionalized, scaled application of ME. No longer an ad hoc tool or niche methodology, ME becomes the connective tissue linking force design, requirements, acquisition, training, and operations into a coherent, mission-focused enterprise. The following vision illustrates how a fully integrated ME practice will transform the Navy and the Marine Corps and their its joint and allied partners:

- ***Enterprise Mission Threads and Portfolio Management***: In the future, the DON will maintain a living library of mission threads and associated engineering data for all priority operational plans and capability portfolios. Traceability will be captured between Mission and Systems Engineering models, allowing Senior leaders to be able to query, "How does Capability X contribute across our missions?" and immediately visualize its relevance across multiple threads. This enables true portfolio management—identifying high-leverage systems and spotlighting those that are orphaned or obsolete. Leaders will be able to simulate the impact of system divestiture or delays on operational outcomes, as well as explore how targeted investments yield outsized mission gains. ME becomes the analytic foundation for optimizing the force, aligning resources with the capabilities that matter most.

- ***Accelerated Capability Delivery:*** In this future state, ME is embedded at the front end of the acquisition lifecycle. No requirement is approved, and no program is funded, without a mission engineering analysis validating its necessity and shaping its scope. This ensures that capabilities are not just technically sound, but mission-relevant from the outset. Unnecessary features are eliminated; latent needs are surfaced. The result is faster, more focused requirements development, shortened acquisition cycles, and capabilities that arrive ready to operate in joint mission contexts—precisely the acceleration envisioned in reforms like the SPEED Act. The DON acquires what it truly needs, when it needs it.

- ***Rapid Mission Planning and Platform Matching***: ME-enabled toolsets will allow operators and planners to rapidly compose new missions or adapt existing ones, querying databases to identify which platforms or systems can achieve specific mission effects under defined conditions. This shortens the time needed to plan quick-turn operations—such as ISR surge or emergent deterrence taskings—by matching available assets to mission needs in seconds. ME becomes a decision aid for rapid response and emergent planning.

- ***Enhanced Test & Evaluation (T&E) and Training***: ME-driven development means that systems are tested and evaluated not in isolation, but in the context of the SoS and mission requirements. T&E criteria are derived directly from ME outputs, ensuring alignment between performance metrics and mission impact. Digital Engineering of both missions and systems will provide traceability from all system measures through the mission measure of success, providing a path to better test the way we fight. At the same time, Live, Virtual, and Constructive (LVC) training environments will be built using ME artifacts—mission tasks, environmental conditions, thresholds for success—providing realistic, relevant, and rapidly deployable scenarios. Over time, ME shortens the loop between concept, test, and training, producing forces that are more capable and better prepared for integrated operations.

- ***Science and Technology Inflection Mapping***: The ME framework will illuminate where scientific and technological breakthroughs can yield mission-level leaps. For example, analysis may show that high-energy-density batteries dramatically improve unmanned loiter times for force protection missions. By tracing which tasks, capabilities, and mission threads would benefit from this advance, ME identifies all dependent users, generating clear justification for targeted S&T investments. This linkage ensures that innovation is focused on game-changing mission impact—and that future gains are rapidly pulled forward through prioritized investment and transition planning.

- ***Intelligence-Informed Operations (Red Teaming):*** The ME framework is not only for designing Blue capabilities—it also supports rigorous adversary analysis. Future ME tools will incorporate intelligence on Red force capabilities, behaviors, and doctrinal preferences, enabling planners to identify adversary centers of gravity, stress points, and likely Courses of Action. Mission threads will account for these variables, allowing Blue force planning to test against adversary counters and refine objectives accordingly. ME becomes a tool for wargaming in the broadest sense: not just simulating our operations but anticipating and countering theirs. This enhances operational effectiveness and increases warfighter lethality through better-informed plans.

- ***Interoperability and Joint/Allied Integration:*** Standardized ME methods and tools will unlock new levels of collaboration across Services and with Allies. With a shared lexicon and interoperable modeling environments, planners from multiple nations will be able to co-develop combined mission threads and assess cross-force contributions. ME enables transparent coalition planning, identifying interoperability gaps in advance and surfacing solutions before execution. Over time, ME becomes an integral part of multinational exercises, joint planning processes, and operational concept development, driving integrated combat effectiveness and enabling coalition forces to train and fight as one.

Continuous Mission Readiness Monitoring: In this future, ME informs not just planning, but real-time readiness. By linking unit and system readiness data to specific mission threads, commanders gain visibility into "mission health"—not just platform availability. They can assess, for example, that Mission A is only 80% executable due to a downed enabler or delayed system fielding—and act accordingly. This moves the Navy and Marine Corps from force readiness to mission readiness, aligning sustainment and operational availability with actual mission requirements. It is a more accurate, holistic view of naval combat power.

7 Conclusions and Recommendations

The preceding sections describe the rationale, process, and envisioned future for ME in the DON and broader defense ecosystem. But vision alone is insufficient. To close the gap between aspiration and impact, senior leaders must now act—with urgency, direction, and sustained follow-through. This section outlines the specific steps required to institutionalize ME across policy, tools, training, and organizational practice. These recommendations are intended to be practical and scalable, offering both near-term wins and long-term institutional change. While some actions fall within DON purview, others will require close coordination with the Office of the Secretary of Defense (OSD), the Joint Staff, Congress, and Allied partners to ensure alignment and enterprise-level coherence.

Mission engineering is not a buzzword. It is a fundamental shift in how we design, evaluate, and deliver warfighting capabilities—anchored in mission outcomes, informed by operational context, and enabled by data and digital engineering. Achieving the vision described in this report will require clear leadership endorsement, rapid mobilization of resources, and disciplined execution across the DON. The actions below represent a roadmap for getting there.

7.1 Policy and Governance

To institutionalize mission engineering, policy must lead. The passage and funding of the SPEED Act will help the DON and DoD develop a formal strategy to unify ME implementation across organizations and establish it as a standard, not a side effort. Equally important is the emerging focus on accountability and governance: without designated leadership, ME risks becoming fragmented and inconsistent. This section outlines key steps to codify ME in policy and establish oversight structures that will coordinate activity, set expectations, and guide continuous improvement.

- ***Develop and Issue a DON ME Strategy & Policy*:** Publish a DON Mission Engineering Strategy (analogous to the DoD Digital Engineering Strategy). This should codify a unified vision, architecture framework, definitions, and objectives for ME across the Navy and Marine Corps, building upon the work of the DON's ME TAB and the findings in this report. Accompanied by a SECNAV or CNO policy memo, it will formally establish ME as a required practice in relevant processes.
    - *Near-term (within 6-12 months):* Charter a task force (with OPNAV, SYSCOM, and Fleet reps) to draft this strategy, drawing on this report's findings.
    - *Long-term:* Update joint doctrine in alignment (work with Joint Staff to incorporate ME into Joint Publications so all Services move together).

- ***Build Upon Existing ME Governance*:** Designate an executive lead for mission engineering (e.g., within OPNAV N7 or N9, or a Deputy ASN) to champion implementation. Create a cross-SYSCOM ME coordination body to set standards and share best practices (NAVAIR, NAVSEA, NAVWAR, Marine Corps Systems Command, etc. all represented). This body can align efforts, prevent duplication, and ensure that when one organization develops a useful tool or method, it is shared enterprise-wide.

    - *Near-term:* Stand up this governance structure and assign clear roles (could tie into the new DoD-level MEIA if established by Congress, ensuring DON has a seat at that table).

- ***Policy Alignment with Joint Planning:*** Work with Naval and Joint planners (e.g., Fleet HQs, Joint Staff J7) to embed ME concepts into operational planning doctrine. For instance, update Navy and Marine Corps doctrine, standards, and planning manuals to include conducting mission engineering analysis as a precursor to war games or plan development. Ensure that ME outputs (like mission thread diagrams, measures of effectiveness) are compatible with existing planning processes (JOPES/JPP).

- *Far-term:* Advocate for inclusion of ME in DoD directives and CJCSI on requirements and acquisition, leveraging Congressional interest (i.e., if the SPEED Act is funded, help shape the implementation of MEIA and JROC changes to incorporate mission engineering principles).

7.2 Common Standards and Lexicon

Mission engineering cannot scale without shared language and common methodology. Inconsistent definitions and bespoke processes are barriers to integration, collaboration, and data reusability. This section provides recommendations to formalize a common lexicon, standardize process templates, and ensure ME products align with existing DoD frameworks like JCIDS and DoDAF. These actions will enable interoperability—within the DON and across the broader defense enterprise.

- ***Develop Standards for ME Methodology and Template Formalization*:** Create and formalize a standard "ME micro-process" guide or template that practitioners can follow. This would detail how to conduct mission thread analysis, what minimum data to capture, how to format the results, etc., ensuring repeatability. It could be an annex to the ME Strategy or a standalone DON handbook. This could build upon the Applied ME Process introduced in this report and its Annex 1. Provide example templates for mission thread documentation, gap analysis reports, and mission engineering study briefs.
    - *Near-term:* Pilot these templates in one or two commands and refine them, then promulgate DON-wide.

- ***Adopt an Authoritative ME Lexicon*:** Establish a single, authoritative lexicon for mission engineering across the DON (and ideally DoD). Start with the terms and definitions in the OUSD(R&E) Mission Engineering Guide 2.0, the ones harmonized in our Phase B lexicon analysis, and the fields used in the standardized ME methodology and templates. Publish this lexicon as an official reference (perhaps as a DON-wide memo or addendum to a DON ME strategy) and require its use in all ME-related documentation.
    - *Enforcement:* Tie adoption to gating processes – e.g., any new requirements document or analysis must use these terms (the recommendation is to formally enforce usage of unified definitions).

- **Integrate ME into Existing Processes and Frameworks:** Ensure that the ME standards complement and map to existing processes and related documents like capability development and requirements documents, Defense Acquisition System templates, joint planning documents, and Digital Engineering models. For example, require that Analysis of Alternatives (AoA) or Initial Capabilities Documents explicitly include a mission engineering section. Align mission thread data models with the Unified Acquisition Framework (UAF) and DoD Architecture Framework (DoDAF) so that mission views (OV-1, OV-5 etc.) are consistent and can feed into architecture products. This standardization will make it easier to exchange information with other DoD components and allies, and to build enterprise tools.

- **Leverage AI for Terminology Management:** Consider using AI/NLP tools to provide recommendations for lexicon and authoritative source-consistent terminology. For instance, deploy a natural language processing tool that suggests standardized replacements for non-standard or non-authoritative terminology use. Over time, use AI to mine past documents (requirements, after-action reports) to spot where inconsistent terminology may have led to misalignment or gaps – feed these insights back into refining the lexicon and training.
    - *Long-term:* As language evolves (new technologies, etc.), maintain the lexicon as a "living document," updated periodically by the governance body using data-driven insight into how terms are used.

7.3 Tools and Digital Infrastructure

Executing ME at scale requires tools that are intuitive, authoritative, and secure. The DON must invest in enterprise-grade platforms to support mission thread development, system-to-task mapping, and performance analysis. This section identifies actions to deploy a scalable ME toolset, ensure data governance and discoverability, and integrate ME within ongoing digital engineering and modeling and simulation environments. It also addresses security architecture and cross-domain access control, which are foundational to any ME implementation.

- **Implement a DON Mission Engineering Tool Suite:** Building on the prototype UI, invest in a scalable ME tool or toolkit for enterprise use. This could involve further developing the in-house prototype or evaluating commercial/off-the-shelf solutions that align with our requirements. The tool should integrate with existing Digital Engineering ecosystems, allowing import/export of models (SysML, etc.), and be accessible on relevant networks (with both unclassified and classified instances).

  - *Near-term:* Fund a pilot program to deploy the ME tool for select operational planning purposes (e.g., a particular exercise that includes evaluation of system options) to refine requirements.
  - *Long-term:* Make the tool available DoD-wide, potentially as part of the MEIA initiative, so all Services use a common or interoperable system.

- **Enhance Data Governance and Access for ME:** Identify and begin curating the authoritative data sources needed for mission engineering, potentially including operational data (threat databases, intel reports), systems data (performance, specifications, logistics data), and enterprise architecture data. Assign data stewards for mission engineering data and ensure appropriate data-sharing agreements are in place (e.g., between SYSCOMs and Fleet, or with Joint organizations).
  - *Near-term:* As a start, determine the "minimum essential data" set required to execute a basic ME analysis (e.g., list of missions, tasks, systems, and key parameters), and make that easily accessible in a centralized repository.
  - *Long-term:* Develop a unified digital infrastructure (cloud-based if possible) where authorized users can pull in data for their mission models on demand. This may tie into ongoing DON digital transformation efforts or OSD's Advancing Analytics initiatives.

- **Integrate Modeling & Simulation (M&S) and Digital Twins:** Expand the use of digital twin environments and high-fidelity simulations for mission engineering. For example, create digital mission models of critical mission threads where one can plug and play different systems to see outcomes (a recommendation from Phase A). Use wargaming simulations with real system data to test mission plans.
  - *Near-term:* Launch a "Mission Digital Twin" pilot for a high-priority mission (perhaps pick an urgent operational problem and model it end-to-end with current vs proposed capabilities).
  - *Long-term:* Institutionalize this process, creating digital mission models to evaluate how systems contribute to missions throughout their lifecycle (supporting both acquisition and training uses).

- **Cybersecurity and Cloud Architecture:** Since ME tools and data will be highly mission-critical (and possibly classified), ensure that the IT backbone is secure and resilient. Partner with DON CIO and cybersecurity offices to incorporate ME workflows into the DON's cloud and DevSecOps environment. Possibly treat the ME tool as a DON "software factory" output that can continuously improve with user feedback and ensure all ME activities comply with data classification and handling rules – e.g., building a multi-level security solution if needed so that users can integrate classified intel with unclassified models safely.

7.4 Workforce and Culture

No institutional transformation succeeds without people. Sustained adoption of ME depends on a trained, empowered workforce and a culture that values mission-centric decision-making. This section outlines a tiered training strategy, cultural change initiatives, and organizational role recommendations to embed ME into the fabric of DON acquisition, planning, and force design. These efforts must be paired with incentives, recognition mechanisms, and communities of practice to ensure lasting change.

- **Training and Education:** Embed ME into the workforce development pipeline. Develop a tiered certification or training program for mission engineering. For instance:
  - *Tier 1:* Basic awareness for all officers and acquisition professionals (what is ME, why it matters).
  - *Tier 2:* Practitioner level for systems engineers, analysts, and planners who will actually conduct ME (how to do mission thread analysis, use of tools, etc.).
  - *Tier 3:* Expert level for those leading ME efforts or developing new methodologies.

- **Implement ME curricula**: Implement organization-agnostic curricula through crawl-walk-run approach across near and long term:
  - *Near-term:* Stand up pilot courses to quickly start skilling up a cadre.
  - *Longer-term:* Require ME training as part of qualifications for certain billets (e.g., chief engineers, requirements officers).

- **Culture Change Initiatives:** Acknowledge that getting buy-in requires demonstrating value and changing mindsets. Recommend high-visibility pilot projects and leadership messaging to shift culture:

- *Encourage and Expand the "Coalition of the Willing"*: Build upon the work of the DON's ME TAB. Engage the group to identify previous successes in the application of ME for publicization and work with the group to determine additional use cases and potential partners for ME pilots.

- *Highlight Flagship Successes.* Identify a few flagship programs or operational planning events where ME will be applied and successes publicized ("ME helped Program X avoid $Y in cost by identifying overlap" or "ME analysis in Exercise Y led to a 20% improvement in mission outcomes" – tangible, shareable results). Celebrate these wins in DON forums.

- *Adjust Incentives:* Incorporate ME objectives in performance evaluations (e.g., incentivize incorporation of ME into operational planning and use of outputs to information decision making). Additionally, consider awards or recognition for examples of ME applications that have meaningful impact to signal its importance.

- **Organizational Roles:** Create dedicated ME teams or billets that enable ME practitioners to embed in operational planning events. Embedding ME practitioners in operational planning events would provide an opportunity for gathering core data—much of which is captured during this process and later documented in authoritative sources, such as campaign plans—in addition to insights from the warfighter for the ME process. This integration would also enable the ME practitioner to provide outputs of the process, such as compiling information on the mission context, in real time to inform mission plans.

- **Joint, Combined, and Industry Engagement:** Broaden training and collaboration beyond the DON. Host joint workshops with Army, Air Force, Marine Corps, and Allied and Partner ME practitioners to align methods (perhaps via the MEIA once established). The MITRE insight of engaging industry early in mission understanding to accelerate innovation is pertinent – the DON can include that in R&D programs or prototyping efforts (e.g., provide industry with mission thread contexts so they build more relevant solutions).

7.5 Near-term "Quick Wins" (Next 12-18 Months)

Several actions can and should be taken immediately to generate momentum, demonstrate value, and signal leadership commitment. This section outlines low-regret, high-impact steps that will deliver visible progress within the next year. These include launching pilot programs, inserting ME into requirements reviews, engaging stakeholders across the enterprise, and securing initial resources. These quick wins are designed to be catalytic—not just proving concepts but establishing patterns for scalable adoption.

- **Stakeholder Outreach:** Conduct a Mission Engineering Roadshow – brief all major stakeholders (SYSCOM commanders, TYCOMs, OPNAV leadership, Marine Corps CD&I, etc.) on this report's findings and the planned way ahead. Solicit proposals for ME pilot program, which will be described further in the next bullet. Also engage OSD (Office of Secretary of Defense) staff, so DON efforts align with DoD initiatives (possibly influencing how OSD stands up the MEIA). Early broad communication will build the "coalition of the willing" into a coalition of the leading.

- **Launch ME Pilot Programs:** Kick off a series of pilot mission engineering projects, as recommended by our study. For example, select one critical mission (perhaps Pacific theater naval conflict scenario) and embed ME practitioner to perform a full ME assessment with current force and near-term enhancements. These types of pilots will demonstrate real-world value ("learning by doing") and produce case material to justify broader adoption.

- **Integrate ME into Requirements Generation (now):** Work with the requirements community (OPNAV N9/N8) to insert ME early in the next cycle of requirements reviews. For any new capability gap identified, mandate an accompanying short mission engineering analysis. This can be done via an interim policy memo while the formal strategy is in the works. It will immediately start shifting the requirements process to be more mission-focused, in spirit of congressional intent.

- **Integrate ME Outputs into M&S:** Work with DON M&S communities to identify the outputs of ME that can enable simulation of mission threads' success and capabilities' performance. Identification of these and other required inputs for M&S along with the data formats needed for direct ingestion into M&S tools will enable scaling of M&S and earlier evaluation of mission threads and systems' performance in a mission context. More frequent and earlier evaluation of mission threads and systems' performance will buy down risks, such as interoperability issues, capability performance in a mission context, and ability of a given mission threat to contribute to mission success.

- **Resource Allocation:** Secure initial funding (via reprogramming or FY26 budget insert) for key enablers: tool development and process refinement, a few dedicated billets for ME, and perhaps contract support for developing the strategy and training materials. Having resources in place ensures these recommendations don't stall. One idea is to align these needs under the umbrella of implementation of the SPEED Act, as that will likely draw attention and funding – essentially, position DON ME efforts as the means to achieve the Act's goals of speed and integration.

7.6 Long-term Initiatives (18 Months-5 Year Horizon)

To fully institutionalize ME, the DON must think beyond pilot efforts and short-term initiatives. This section presents the strategic actions required to sustain and evolve ME as a core discipline. Recommendations include codifying ME into acquisition governance, extending ME to joint and coalition environments, and investing in research and development to continuously advance ME tools, methods, and integration with artificial intelligence. These are the foundational moves that will ensure ME remains a durable pillar of Navy and Marine Corps force development in the years ahead.

- **Scale and Institutionalize ME:** Expand the Navy and Marine Corps adoption of the ME process through updates to doctrine and policy, resourced training and practitioner billets, and scaled, deployment of enterprise tooling. In 2-3 years, when people talk about any major program, they should naturally ask "what's the mission engineering saying?" as a standard part of oversight. Work with Congress if needed to adjust Title 10 or report language reinforcing this (perhaps an annual report on ME activities to defense committees to maintain focus).

- **Expand to Joint, Allied, and Partner ME:** Aim to collaborate with the other Services, OSD, Allies, and Partners on establishing a shared Engineering framework. This could mean joint standards for mission thread data and a sharing mechanism (under appropriate security agreements) for coalition mission analyses. *This long-term effort ensures that by 5 years out, ME is not just a DON process but a competitive advantage for the joint force and our allies.*

- **Continuous Improvement via R&D:** Invest in ongoing R&D to improve ME methodologies – for example, exploring advanced AI support for COA generation, automated "red-teaming" of mission threads, and improved modeling of human decision factors. Partner with academia (the team's involvement of ARLIS and VT-ARC is a model) to keep ME at the cutting edge. A long-term goal could be highly intelligent decision-support systems that, given a mission, can rapidly suggest optimal force package mixes or identify the single most cost-effective improvement for the biggest mission gain.

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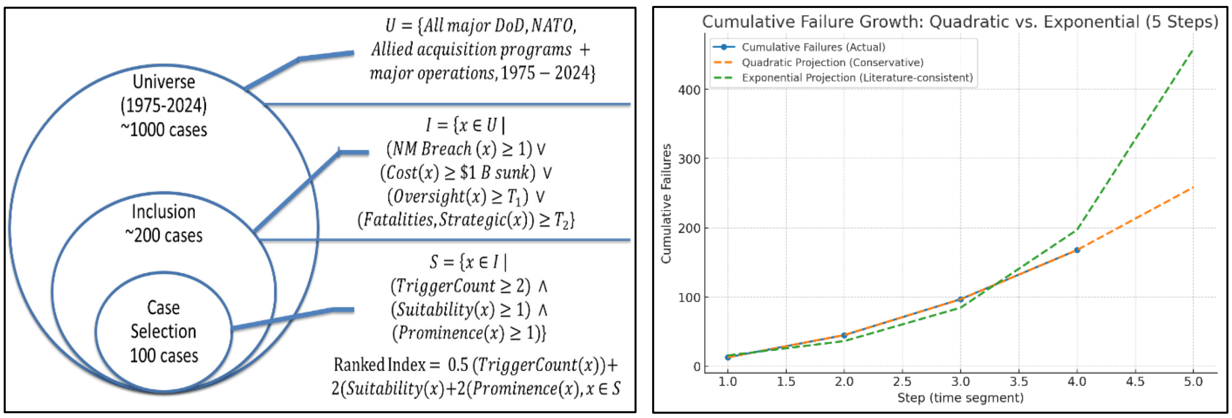
Appendices

Appendix A: Historic Case Study Supplemental

The research team conducted an extensive analysis of over 100 major defense acquisition and operational shortfalls and challenges spanning from 1975 to 2025 revealing a clear pattern of costly misalignment between delivered capabilities and their intended operational missions. This analysis captured opportunity areas where mission engineering could have added value in alleviating these challenges. This appendix details the case selection methodology and more detail for each historic case highlight from Section 3.

The research team methodically selected the cases based on objective criteria reflecting the most consequential shortfalls in U.S. defense acquisition and operations. Programs were identified through consistent appearances in formal registries—such as Nunn-McCurdy breaches—through documented operational shortfalls, or via high visibility reporting in U.S. Government Accountability Office (GAO), DoD Inspector General (IG), and Congressional testimony. The researchers chose cases not to confirm bias but to reflect clear contributing factors to mission misalignment, financial inefficiency, and preventable loss. Each selection aligns with a reproducible scoring methodology depicted in Figure 16, based on program cost, human life impact, and systemic deviation from mission-oriented principles.



$$\text{Inclusion} = (NM \geq 1) \lor (Cost \geq \$1B) \lor (Oversight \geq Threshold) \lor (Fatalities/Strategic \geq Threshold)$$

Where:

U.S. Oversight: GAO ≥3, DoD IG ≥1, or Congressional hearings ≥2
Allied Oversight: National Audit/Parliament ≥1, or Defense literature ≥5–10
NM: ≥25% PAUC/APUC or ≥50% program cost growth defined by statute
Fatalities/Strategic: U.S. or Allies ≥10 and/or national-level strategic failure

$$\text{Selected Case} = (TriggerCount \geq 2) \land (AnalyticSuitability \geq 1) \land (Prominence \geq 1)$$

1. Analytic Suitability Score (0–2)
Measures how well a case can be mapped to the ME 10-step framework.
•**0 = Not mappable** → Failure is vague, purely budgetary (e.g., a minor cost accounting anomaly).
•**1 = Partially mappable** → Case can be linked to ME broadly, but not to a single clear step.
•**2 = Fully mappable** → Case can be pinned to a specific ME step (e.g., EFV → Step 1, LCS → Step 2, JTRS → Step 4, Zumwalt → Step 5, etc.).

2. Prominence Index (0–2)
Measures visibility in oversight + literature (teaching value).
•**0 = Low prominence** → <3 oversight reports + <5 scholarly/media citations.
•**1 = Medium prominence** → ≥3 oversight reports OR ≥5 citations in defense literature.
•**2 = High prominence** → ≥5 oversight reports OR ≥10 scholarly/media citations.
Threshold: Only cases with score ≥1 are retained. The 100 cases skew strongly toward **2**

Figure 16 Historic Case Study Selection and Analysis Methodology

For selected case highlights, the research team captured key examples across each of the ten macro-ME steps. The steps described below provide a structured breakdown, clarifying how mission misalignment or critical omissions at each stage served as contributing factors to the shortfalls documented in these examples. This narrative underscores the importance of carefully adhering to each step to effectively mitigate risks and prevent future misalignment and operational shortfalls.

Step 1 – Identify Mission Objectives and Context (*Defining the Mission*): This foundational step establishes clear, well-defined mission objectives and intent. Shortfalls commonly arise from insufficiently defined objectives, overly ambitious or poorly scoped missions, unclear continued need or ownership ("No Champions"), or incorrect assumptions about operational conditions ("Wrong Mission Environment and Context"). Collectively, these shortfalls drive significant downstream challenges in capability misalignment and wasted resources.

Historic Case Highlight – Expeditionary Fighting Vehicle (EFV), 2001-2011:

Initially designed with narrow performance parameters—specifically high-speed amphibious assault from extended distances offshore—the EFV's requirements did not evolve with changing threat environments and technological developments (e.g., improved hinterland mobility solutions). The observed prescriptive definition of the EFV's mission contributed to its poor alignment with evolving operational realities, contributing at least in part to spiraling costs and ultimate program cancellation.

The EFV program aimed to provide the U.S. Marine Corps with an amphibious assault capability that could deploy rapidly from over-the-horizon distances. However, the research team observed the core mission definition and objectives as overly prescriptive and narrowly scoped—centered primarily around achieving a specific high-speed water transit requirement. The observed poorly defined mission objectives contributed to shortfalls and challenges in terms of the system's design and performance within the mission environment and context. It maintained a performance goal (high-speed amphibious landing from 12 nautical miles offshore) established without adequately adapting to evolving threats, notably the proliferation of advanced anti-ship cruise missiles (ASCMs). Despite growing evidence that contested amphibious landings would require fundamentally different concepts and capabilities, EFV's mission definition remained anchored in previous assumptions.

Simultaneously, the researchers observed that the program neglected parallel advancements in land-based armored vehicle mobility, further undermining the strategic validity of its original mission context. This served as a contributing factor to the EFV program's spiraling costs, technical challenges, and ultimate program cancellation, reflecting an observed misalignment rooted in inadequate assessment and adaptation to the changing mission environment and operational context.

Step 2 – Define Mission Success and Desired Effects (*Measures of Success*): This step identifies clear, measurable criteria for overall mission accomplishment that sets foundation for mission-focused evaluation activities. Shortfalls here frequently result from ambiguous or incomplete mission success criteria, leaving stakeholders without clear alignment or shared definitions of success, thus undermining effective capability development and evaluation.

Historic Case Highlight – Littoral Combat Ship (LCS), 2001-2022:

The Littoral Combat Ship program aimed to deliver a versatile, modular platform capable of performing multiple littoral warfare roles, including anti-submarine warfare, mine countermeasures, and surface warfare. However, the program faced critical shortfalls that could have been alleviated by Step 2 of the process—adequately defining the Measures of Success (MOS). The program witnessed shortfalls in terms of rigorous and quantifiable metrics to evaluate mission accomplishment, contributing to an observed lack of mission-focused evaluation criteria for capability development such as precise operational availability thresholds, clear benchmarks for mission-module effectiveness, survivability standards, or quantified mission duration and reliability targets.

The researchers observed that shortfalls in well-defined and consistent MOS contributed to ambiguity around program success, enabling ongoing requirements to creep and hindering meaningful capability assessment and validation. Unclear operational benchmarks to measure performance in a mission context contributed to challenges in objectively evaluating whether the LCS effectively met its intended missions. Consequently, the Navy repeatedly faced criticism from oversight authorities (including multiple GAO assessments), experienced substantial delays, and encountered continued operational challenges.

Ultimately, the researchers found that unclear measures of success contributed to undermined confidence in the program's capability to fulfill intended missions, resulting in compromised effectiveness, elevated costs, and a protracted struggle to deliver definitive operational value.

Step 3 – Map Desired Effects to Tasks (*Task Structuring*): This step decomposes broader mission objectives into explicit, actionable tasks. Shortfalls occur when missions are insufficiently broken down, leaving critical tasks overlooked, vaguely defined, or misaligned, thereby causing integration difficulties and operational shortfalls.

Historic Case Highlight – Future Combat Systems (FCS), 2000-2009:

The Future Combat Systems program – intended to revolutionize Army modernization by creating a comprehensive, interconnected system-of-systems – saw challenges related to Step 3—Task Structuring. Specifically, the researchers observed that the Army did not effectively decompose broad operational concepts and ambitious mission goals into clearly defined, actionable tasks. Rather than explicitly defining operational tasks required to achieve overarching mission effects, the program pursued broad capability statements and aspirational technology objectives.

The shortfalls in effectively structuring of tasks contributed to ambiguity in identifying essential operational sequences, required interactions, and precise roles among FCS components. This challenged the identification of critical dependencies among individual systems, contributed to integration problems, and complicated validation of operational effectiveness. The inability to clearly identify, structure, and sequence mission-critical tasks likely contributed to the observed cost overruns, schedule delays, and eventual program cancellation in 2009.

This example underscores the fundamental importance of rigorously structuring tasks early in the ME process, clearly defining operational sequences to ensure effective system integration and mission alignment.

Step 4 – Ensure Functions Support Tasks (*Functional Decomposition*): In this step, each defined task is clearly mapped to supporting operational functions. Shortfalls arise from gaps in clearly linking required tasks to supporting functions, resulting in missed dependencies, confusion, and capability redundancies.

Historic Case Highlight – Joint Tactical Radio System (JTRS), 1997-2012:

The DoD envisioned the Joint Tactical Radio System (JTRS) as a revolutionary communications capability providing seamless interoperability across all military services. However, it experienced critical shortfalls observed at Step 4—Functional Decomposition. JTRS functions were not rigorously mapped to tasks, creating confusion and redundancy. Therefore, the system's functional decomposition did not clearly establish how each capability or function contributed explicitly to mission-critical tasks and outcomes.

This functional ambiguity contributed at least in part to confusion over required operational roles, unclear dependencies, and overlapping capabilities. It also likely contributed to integration challenges, delaying system development, causing cost overruns, and undermining intended interoperability objectives. Ultimately, the shortfalls in a rigorous and explicit functional decomposition contributed to costly rework, diminished stakeholder confidence, and the eventual restructuring and cancellation of major components of the JTRS program by 2012.

The JTRS example clearly demonstrates the importance of systematically mapping mission tasks to explicitly defined supporting functions to ensure mission alignment, reduce redundancy, and facilitate effective integration.

Step 5 – Define Measures of Effectiveness (*Define Measures for Effectiveness*): Here, operational effectiveness is clearly quantified at the task and function levels. Shortfalls typically involve inadequately defined effectiveness metrics, causing systems and capabilities to deliver less-than-optimal operational performance and complicating effective evaluation.

Historic Case Highlight – Zumwalt-Class Destroyer, 2001-2016:

The DoD created the Zumwalt-Class Destroyer program to deliver a highly advanced, stealthy surface combatant capable of performing a range of critical missions, including precision land attack and littoral dominance. However, shortfalls arose from challenges surrounding Step 5. The program lacked rigorously defined and quantifiable task-level effectiveness metrics that would explicitly measure how well the ship and its systems performed against critical mission tasks.

As a result, the researchers observed that key operational effectiveness criteria—such as precise standards for stealth effectiveness in contested environments, mission-specific rates of fire for naval gunfire support, and reliability targets for advanced propulsion and radar systems—were ambiguous or inadequately defined. Without clear and rigorous task-and function-level measures of effectiveness, stakeholders lack a coherent basis to objectively evaluate whether systems like the Zumwalt's innovative technologies are truly effective in achieving their intended operational outcomes. A critical omission such as this was a contributing factor to the Zumwalt's escalating costs, protracted schedule delays, and persistent questions about the ship's actual mission utility, contributing to curtailed procurement after just three ships.

The Zumwalt case demonstrates why clearly defining precise, measurable criteria for operational effectiveness is fundamental to ensuring that systems truly deliver intended mission value.

Step 6 – Map Tasks to Required Capabilities (*Capability Definition*): This step defines specific capabilities needed to achieve operational tasks and objectives. Shortfalls commonly result from poorly defined capability requirements, overly ambitious capability objectives, or unclear linkage between capabilities and mission outcomes.

Historic Case Highlight – Unmanned Carrier-Launched Airborne Surveillance and Strike (UCLASS), 2011-2016:

The UCLASS program aimed to develop an autonomous carrier-launched aircraft to provide extended surveillance and strike capabilities from aircraft carriers. However, the research team saw issues surrounding Step 6—Capability Definition. The researchers observed that the Navy witnessed shortfalls surrounding clearly and consistently defining the specific capabilities needed, contributing at least in part to conflicting interpretations of UCLASS's intended roles, from ISR (Intelligence, Surveillance, Reconnaissance) to deep strike or persistent surveillance. Without a stable, operationally grounded capability definition, internal debates persisted over range, payload, stealth attributes, autonomy levels, and sensor requirements.

These unclear and shifting capability parameters likely resulted in confusion within both Navy leadership and industry teams, contributing to repeated delays, ongoing uncertainty, and increasingly misaligned contractor proposals. The research team observed that the absence of well-defined, stable capability criteria impeded meaningful progress and evaluation, eventually contributing to program redirection and restructuring into the MQ-25 Stingray aerial refueling concept.

The UCLASS example underscores how critical it is to rigorously define and stabilize capability requirements early—clearly tying specific capabilities to mission tasks and functions—to ensure coherent, efficient, and effective capability development.

Step 7 – Ensure Capabilities Support Tasks (*Capability Gap Analysis*): At this stage, capability shortfalls are explicitly identified by comparing the existing ("As-Is") and needed ("To-Be") capability states. Challenges frequently occur when capability gap assessments are superficial or incomplete, allowing gaps to persist unnoticed until costly late-stage development or deployment phases.

Historic Case Highlight – Warfighter Information Network–Tactical (WIN-T) 2.0, 2007-2017:

The DoD pursued the WIN-T Increment 2 as a critical mobile communications backbone intended to provide enhanced battlefield network connectivity for tactical units. However, shortcomings emerged at least partially due to challenges associated with Step 7—Capability Gap Analysis. The research team observed that the program inadequately assessed the "As-Is" (existing) versus the "To-Be" (required) capability states, particularly regarding evolving operational threats and emerging technology standards. While the system promised enhanced network mobility and connectivity, the capability gap analysis fell short in adequately accounting for rapidly evolving cyber threats, electronic warfare vulnerabilities, and the complexity of integrating new technologies into a contested electromagnetic environment.

The shortfalls surrounding capability gap analysis contributed to persistent gaps left unaddressed until operational testing and field deployments, which then revealed substantial vulnerabilities. These unforeseen gaps compromised WIN-T Increment 2's effectiveness and survivability on the modern battlefield, contributing to retrofits, delays, and the cancellation of subsequent increments of the program.

The WIN-T example highlights the essential importance of rigorously identifying, validating, and continuously reassessing capability gaps to ensure mission alignment, reduce risk, and avoid costly late-stage corrective actions.

Step 8 – Define Measures of Capability: In this step, clear and quantitative metrics for evaluating individual capabilities are defined. Shortfalls occur when capability metrics are vague or insufficiently rigorous, reducing confidence in capability adequacy and creating ambiguity in capability evaluation.

Historic Case Highlight – C-27J Spartan Aircraft, 2007-2013:

The C-27J Spartan was procured by the US Air Force to provide flexible tactical airlift capability for cargo delivery and medical evacuation in operational theaters. However, critical issues arose at least in part due to inadequate definition of measures of capability at Step 8 of the ME process. The research team observed that the Air Force struggled to rigorously establish clear, quantifiable metrics to evaluate the C-27J's capabilities—contributing to cascading breakdowns in evaluating performance measures such as required payload thresholds, cargo versatility, cost-per-sortie, interoperability standards, and sustainment parameters.

Without clear and rigorous capability metrics, stakeholders likely lacked objective benchmarks to validate the aircraft's suitability relative to existing platforms (notably the C-130) and determine its operational value clearly. This likely contributed to difficulty justifying the continued investment and deployment of the C-27J fleet. Ultimately, the ambiguity surrounding capability evaluation and insufficiently rigorous measures of capability contributed to the Air Force's decision to prematurely terminate the program in 2013, leading to significant financial loss and disruption in planned tactical airlift capabilities.

The C-27J Spartan case underscores the critical importance of explicitly defining robust, quantifiable capability metrics to objectively guide capability investment, assessment, and decision-making.

Step 9 – Map Capabilities to Required Systems: This involves selecting appropriate systems and platforms capable of delivering required capabilities. Shortfalls arise when systems are chosen without rigorous assessment against defined capabilities, resulting in costly mismatches and inadequate mission support.

Historic Case Highlight – RAH-66 Comanche Helicopter, 1988-2004:

The DoD initially envisioned the RAH-66 Comanche helicopter as a next-generation reconnaissance and attack helicopter, intended to replace existing platforms and deliver advanced stealth and multi-role capabilities. The program, however, witnessed shortfalls stemming from Step 9 – Select Systems, which involves explicitly mapping capabilities to required systems through clearly defined Mission Engineering Threads (METs).

The Army selected and pursued highly advanced technologies for the Comanche, including stealth, sensor integration, and avionics systems. The research team observed shortfalls and limitations in verifying that these technologies directly and effectively addressed clearly identified mission-essential tasks. Inadequate system mapping to operational requirements likely contributed to persistent gaps between intended operational missions and the helicopter's actual capabilities. As operational mission contexts evolved, the mismatch between selected Comanche systems and real-world mission requirements became increasingly evident. The helicopter's capabilities proved either redundant or insufficient relative to defined METs, contributing to escalating costs and persistent development delays.

Ultimately, the observed shortfalls related to clearly and explicitly map required capabilities to selected systems through METs – and track impacts of the evolving mission context on these mappings – contributed to the cancellation of the Comanche program in 2004 after significant investment. This example highlights the critical importance of rigorously selecting systems only after clearly defining and validating their explicit linkage to mission-essential tasks, ensuring true operational relevance and effective mission execution.

Step 10 – Define Measures of Performance: The final step sets precise technical performance criteria for selected systems and solutions. Shortfalls frequently result from inadequately defined or overly optimistic performance thresholds, leading to systems that do not meet required operational standards and causing significant operational, budgetary, and schedule impacts.

> ***Historic Case Highlight – AGM-154 Joint Standoff Weapon (JSOW), 1992-2008:***
>
> The Navy developed the AGM-154 Joint Standoff Weapon (JSOW) to provide precision-guided standoff strike capabilities designed to reduce aircraft vulnerability. The program encountered significant issues the research observed stemming from inadequately defined and unrealistic Measures of Performance (MOP). ME Process Step 10 translates the operational and mission context captured in the upfront steps into system MOPs. Initial testing suggested that the JSOW met its defined technical performance criteria; however, these criteria did not accurately reflect realistic operational conditions—particularly environments involving electronic warfare, GPS-denial, or contested airspace.
>
> When deployed operationally, JSOW experienced unexpected performance degradation, including significant accuracy issues under GPS-jamming conditions and reduced reliability when facing realistic threat scenarios. These unforeseen operational shortfalls at least in part stem from the inadequate and overly optimistic technical performance thresholds set during early testing phases, causing the weapon to underperform significantly when it was most critically needed in real-world missions.
>
> This example highlights the fundamental necessity of rigorously defining realistic, quantifiable, and operationally relevant performance measures at the outset, ensuring that systems deliver expected operational effectiveness under actual combat conditions and not merely within controlled testing environments.

This analysis of historical defense acquisition and operational program shortfalls and challenges across the ME process highlights the critical need for rigorous ME in practice. The shortfalls underscore a recurring pattern: inadequate early mission definition, unclear mission objectives, poorly structured tasks and functional decomposition, and lack of consideration of the mission context in defining measurable evaluation criteria consistently led to significant downstream consequences.

Each example demonstrates that disciplined, structured ME practices—applied throughout the lifecycle—can effectively mitigate mission misalignment, capability shortfalls, and operational risks. Clear mission objectives, explicit task and capability definitions, and realistic performance metrics are essential for success. Institutionalizing these practices within capability development and planning processes with a mission-centric approach remains critical to minimizing costly failures and for achieving mission success.

Accompanying Annexes

There are several standalone documents created over the course of this DON OSA-funded effort to accompany this report. For copies of Annexes, please reach out to Mr. Ryan Loehrlein (ryan.s.loehrlein.civ@us.navy.mil), Dr. Timothy Sprock (tsprock@arlis.umd.edu), and Dr. Maegen Nix (maegen.nix@vt-arc.org).

Annex 1: Practitioner's Applied ME Process Guidebook

This standalone unclassified document provides detailed how-to guidance and illustrative examples of each step of the Applied ME Process. This guidebook leverages the *Use Case 1 – Guadalcanal Alternative Futures Naval Surface Warfare Mission* and *Use Case 2 - Guadalcanal Alternative Futures Logistics Mission* to provide detailed examples demonstrating practitioner considerations, input data, and mission artifacts created in executing each step.

Annex 2: Use Case 1 – Guadalcanal Alternative Futures Naval Surface Warfare Mission

This standalone unclassified document provides a detailed example to demonstrate practitioner considerations, input data, and mission artifacts created in executing each step of the Applied ME Process, with a focus on a traditional capability exploration use case. This document was created in tandem with the Practitioner's Applied ME Process Guidebook.

Annex 3: Use Case 2 – Guadalcanal Alternative Futures Logistics Mission

This standalone unclassified document provides a detailed example to demonstrate practitioner considerations, input data, and mission artifacts created in executing each step of the Applied ME Process, with a focus on supporting logistics mission planning. This document was created in tandem with the Practitioner's Applied ME Process Guidebook.

Annex 4: Use Case 3 – Unmanned System Anti-Surface Warfare Mission

This standalone classified document provides a detailed analysis of a technology insertion case to demonstrate practitioner considerations, input data, and mission artifacts created in executing each step of the Applied ME Process, with a focus on exploring how mission engineering could enable mission-informed activities surrounding key technology insertion.

Annex 5: DON ME & Digital Enablers Landscape Report 1

This standalone unclassified report provides an integrated macro and micro-level understanding of the ME efforts and enabling DE methods and tools leveraged across the DoD for strategic decision-making. This report illuminates key areas that the DON should consider in an enterprise approach. The team built upon an adjacent landscape analysis conducted for DON OSA, led by Ryan Loehrlein (Digital Mission Engineering Chief Engineer at Naval Surface Warfare Center (NSWC) Crane Division) and Jasmine Webb (Computer Scientist at NSWC Crane Division).

Annex 6: DON ME & Digital Enablers Landscape Report 2

This standalone unclassified report provides a lexicon and centrality analysis that augments the previous report, Landscape Analysis: Integrated DON Understanding of Mission Engineering Efforts & Digital Tools, providing additional insights and strategic recommendations for key actions the DON and greater DoD should consider in an enterprise-wide approach for ME and DE.

Annex 7: Detailed Analysis Package of the 100 Historic Case Studies

This standalone unclassified analysis package provides the structured and unstructured data underlying the key findings and case examples highlighted in Section 3 and Appendix A of this report.

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