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Strategic Alignment at Speed: Modernizing NSW's Capability Development through Digital Transformation

June 2025

LCDR Jason Mariscal, USN

LCDR Dwight J. Cornish, USN

Thesis Advisors: Dr. Leo J. Blanken, Associate Professor
Dr. Nicholas Dew, Professor

Department of Defense Management

Naval Postgraduate School

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ABSTRACT

This capstone investigates how Naval Special Warfare (NSW) can modernize its capability development process by integrating digital tools and mission engineering principles, with a specific focus on improving Doctrine, Organization, Training, Materiel, Leadership, Personnel, Facilities, and Policy (DOTmLPF-P) analysis. Through structured interviews, stakeholder engagement, and a culminating design workshop, this research identified the current process of DOTmLPF-P analysis to be time-consuming, labor-intensive, and lacking analytical transparency. The project proposes a digital decision-support tool tailored to NSW's operational context to accelerate capability assessments, improve traceability, and align resource decisions with mission outcomes. The capstone also recommends a broader shift from the traditional "Acquisition Kill Chain" toward a more agile "Acquisition Kill Web" model, enhancing adaptability in dynamic threat environments. By aligning innovation, strategy, and operational relevance, this research offers a roadmap for NSW and similar organizations seeking to institutionalize digital transformation in capability development. It concludes by outlining a flexible, iterative research agenda for future stakeholders to build on this foundation.

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Thank you all for your support, belief, and contributions. This work belongs to all of us.

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LIST OF ACRONYMS AND ABBREVIATIONS

AI	Artificial Intelligence
AOI	Area of Interest
DE	Digital Engineering
DIU	Defense Innovation Unit
DOTmLPF-P	Doctrine, Organization, Training, materiel, Leadership and Education, Personnel, Facilities, and Policy
DT	Digital Transformation
GAO	Government Accountability Office
H4D	Hacking for Defense
IRB	Institutional Review Board
JCDIDS	Joint Capabilities Integration and Development System
JIFX	Joint Interagency Field Experimentation
KPP	Key Performance Parameter
ME	Mission Engineering
ML	Machine Learning
MT	Mission Threads
NPS	Naval Postgraduate School
NSW	Naval Special Warfare
NSWG	Naval Special Warfare Group
NWSI	Naval Warfare Studies Institute
ONR	Office of Naval Research
PM	Program Manager
PME	Professional Military Education
PMS	Program Management Staff
SOF	Special Operations Forces
SOFCIDS	Special Operations Forces Capabilities Integration and Development System

SOFRRAS	Special Operations Forces Requirements, Resourcing and Acquisition System
USSOCOM	U.S. Special Operations Command
WARCOM	Naval Special Warfare Command

EXECUTIVE SUMMARY

Naval Special Warfare (NSW) is the premier maritime special operations force, operating in an era of accelerating technological change and increasingly complex threat environments. Maintaining operational superiority now depends on advanced capabilities and the speed and precision with which those capabilities are assessed, developed, and delivered. This capstone project explores how NSW can modernize a critical component of its capability development process—Doctrine, Organization, Training, materiel, Leadership, Personnel, Facilities, and Policy (DOTmLPF-P) analysis—by introducing digitally enabled tools and adopting Mission Engineering (ME) principles.

The research was motivated by a clear problem: While NSW possesses a formal, structured process for identifying and resourcing capability gaps, implementation remains slow, labor-intensive, and often disconnected from operator intent. Current practices rely heavily on manual tools (e.g., PowerPoint, Excel), suffer from data fragmentation, and lack transparency across stakeholders and echelons. These limitations delay the transition of emerging technologies into operational use and hinder NSW's ability to adapt at the pace required by modern conflict.

In response, this capstone proposes a digital decision-support tool that would streamline the DOTmLPF-P analysis process, improve traceability, and enable faster, more data-informed decisions. The tool concept was shaped through extensive stakeholder engagement, including structured interviews with NSW operators, program managers, systems engineers, and acquisition leaders, as well as mission partnerships with the Defense Innovation Unit and participation in the Naval Postgraduate School's Joint Interagency Field Experimentation program. A culminating in-person design workshop helped validate research insights and prioritize the specific pain points a digital tool could alleviate.

Key findings emphasize that digital modernization must be paired with organizational change. NSW's future capability development should be supported by a shift away from the traditional "Acquisition Kill Chain" toward a more adaptive "Acquisition Kill Web"—a model that enables decentralized decision-making, iterative feedback loops, and alignment with dynamic operational requirements. Embedding ME frameworks and using tools such as mission threads and digital simulations would further enhance the alignment between technical investments and mission outcomes.

The research concludes with three integrated recommendations:

Pilot a digital DOTmLPF-P decision-support tool to reduce staffing time, improve analytical transparency, and enhance cross-stakeholder collaboration.

Adopt an Acquisition Kill Web model to create more agile, scalable pathways for capability development.

Institutionalize ME early in the planning cycle, enabling NSW to connect strategic intent to tactical capability with greater precision.

This project offers more than just a solution concept; it lays the groundwork for a repeatable approach to research, stakeholder engagement, and capability modernization. Future Naval Postgraduate School students and NSW innovation teams can adopt and iterate on this model to pursue additional tools, refine existing workflows, and expand the digital modernization agenda.

Ultimately, this research reinforces a simple truth: Advantage is not gained solely by acquiring new technologies, but by adopting them faster and more effectively than one's adversaries. In a world where technological cycles outpace bureaucratic timelines, NSW must lead the Department of Defense in embracing data-driven, user-informed, and mission-focused transformation.

GENERATIVE AI USE DISCLOSURE STATEMENT

(a) We described how we would use generative AI tools with both of our advisers, and they permitted us to use those tools to support the development of this capstone report.

(b) We used Grammarly, OpenAI's ChatGPT, and Google's Gemini platforms throughout the writing process.

(c) The primary reason for using these tools was to improve grammar, tone, style, organization, and word usage and to receive assistance structuring the report's flow at the paragraph and section levels.

(d) We used these tools primarily to enhance the editing process. We drafted original content independently, then input sections into the AI tools to identify areas for improving clarity, conciseness, transitions, and academic tone. We also utilized the AI to reorganize paragraphs for improved logical flow, but no AI-generated content was inserted into the final report without careful review and approval.

(e) To mitigate risks associated with generative AI use, such as introducing inaccuracies, misrepresentations, or stylistic inconsistencies, we individually evaluated every AI suggestion before incorporating it. All substantive ideas, findings, and analyses in this report are our own or are appropriately cited. Significant editing and final quality assurance were conducted manually; for example, we utilized the Graduate Writing Center instructors to support our revision process, focusing on grammar, organization, argument construction, and brainstorming. We cross-verified the final document to ensure alignment with the Naval Postgraduate School's academic integrity standards.

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I. INTRODUCTION

In this capstone report, we articulate a proposed enhancement to the capability development process utilized by Naval Special Warfare (NSW), with a focused emphasis on refining the Doctrine, Organization, Training, materiel, Leadership, Personnel, Facilities, and Policy (DOTmLPF-P) analysis through a digital-first methodology. We identify systemic inefficiencies by leveraging insights derived from extensive stakeholder engagement, including interviews, warfighter-centered design workshops, and collaborations with innovation units.

Based on our research findings, we propose a software solution to enhance capability assessment and decision-making processes. In the subsequent chapter, we contextualize this initiative within the overarching framework of Department of Defense (DoD) digital modernization efforts while critically examining the unique operational challenges faced by NSW. This research empowers NSW stakeholders to pursue a more compelling future in maritime special operations. Additionally, we conducted the study from a practitioner–scholars perspective, drawing on operational experience while maintaining analytical rigor.

A. RATIONALE FOR CAPABILITY DEVELOPMENT REFORM

The strategic environment is evolving rapidly, driven by swift advancements in technologies such as artificial intelligence (AI) technologies enabled by advanced machine learning (ML) algorithms, cyber capabilities, and enterprise-level digitization. The People's Republic of China (PRC), one of the United States' key great-power adversaries, is accelerating its defense industrial base, integrating AI, ML, and advanced analytics into its force development cycles. As Aaron Friedberg (2022) argues in *Getting China Wrong*, China has adopted a long-term, strategic approach to military modernization, blending state control with targeted economic and technological advancements. The Chinese Communist Party (CCP) has deliberately cultivated state-backed industries, ensuring that technological innovations benefit its government's objectives, particularly in AI and cyber capabilities, as highlighted by Chinese AI researcher and venture capitalist Kai-Fu Lee (2018, Chapter 3) in his book, *AI*

Superpowers. To a certain extent, this state-driven model enables China to develop a more robust system for integrating emerging technologies into its military operations.

Meanwhile, the U.S. defense acquisition process continues to be hindered by bureaucratic inertia, sluggish procurement cycles, and outdated methods that stifle innovation and delay the implementation of critical technological advancements. Adam Wieser (2020) states, "The responsibility to innovate has shifted to the military, and it is falling behind" (p. v). This issue is widely acknowledged across the defense ecosystem. Organizations such as the Government Accountability Office (GAO), internal DoD assessments, and external policy experts have all pinpointed systemic inefficiencies in acquisition. While initiatives like the Adaptive Acquisition Framework and digital transformation pilots represent essential progress, they are not complete solutions. This is expected. Reform in this arena should be a continuous effort—a steady drumbeat of improvement. Work, Brown, and Lord (2024) emphasize that successful innovation adoption requires technical pathways and a continuous reform mindset, embedding innovation scaling into the core functions of acquisition, budgeting, and operational planning. The most significant risk lies not in imperfection but in assuming the work is done. Inflexibility is more perilous than inefficiency in a rapidly changing strategic and technological landscape. The path forward requires systems that learn, adapt, and evolve in real-time.

With a keen awareness of these challenges, the entire DoD struggles to maintain its relative advantage through the rapid and effective adoption of digital technologies. The DoD's 2018 *Digital Engineering Strategy* directs the military to modernize data practices, "incorporate technological innovation," and "transform the culture and workforce to adopt and support digital engineering" to "support the organization's transition to digital engineering" (Office of the Deputy Assistant Secretary of Defense for Systems Engineering, 2018, p. 4) The DoD's subsequent *Digital Modernization Strategy*, published in 2019, reinforces the view that digital advancement is critical to "afford the Joint Force a competitive advantage in the modern battlespace" and calls for the force to "strengthen overall adoption of enterprise systems to expand the competitive space in the digital arena" (p. 3). The Navy's guidance for implementing digital modernization, published in 2020 as the *United States Navy and Marine Corps Digital Systems*

Engineering Transformation Strategy, provides the stark assessment that existing "engineering and acquisitions processes do not suit the complexity, interconnectivity, and interoperability of modern warfare systems" and urges the Navy to rapidly "transition away from past practices of manually assimilating vast amounts of document-centric data and toward a digital-centric approach" (Jones, 2020, p. 6). The *DoD 2023 Data, Analytics, and AI Adoption Strategy* brings AI to the forefront of the conversation because of the formidability of "the urgency … and scale at which the Department must operate" (Hicks, 2023, p. 3).

NSW's experience reflects these broader institutional shifts, offering a practical lens into how digital modernization is being interpreted and adapted at the tactical edge. In his research into adopting digital engineering within Naval Special Warfare Group FOUR (NSWG-4), David Novotney (2023) underscores the importance of digital transformation, highlighting "the need for a unique ... [digital engineering] … strategy for each component within USSOCOM [U.S. Special Operations Command]" (p. 30). Novotney's (2023) thesis aligns with broader USSOCOM directives emphasizing the leadership role that Special Operations Forces (SOF) have in adopting technological advancements such as trusted autonomy, artificial intelligence, and computational support for decision-making (Fenton & Shorter, 2024, p. 7). While USSOCOM's internal guidance and component-level strategies point toward meaningful change, external voices have called for even more urgent action to confront the growing technological gap.

The book *Kill Chain: Defending America in the Future of High-Tech Warfare* by Christian Brose (2022), widely cited in the field of defense innovation, reinforces this guidance with a warning that the U.S. defense establishment is dangerously behind the power curve in terms of technological and strategic advantage relative to its adversaries. Brose (2022) provides a sobering reality check that the DoD's defense and acquisitions strategies can no longer make the tacit assumption that America is globally dominant (p. 184) and argues that "the capabilities most essential to success will be artificial intelligence, machine autonomy … and other software-defined technologies" (p. 202). This warning reframes the conversation, shifting focus from whether the United States can innovate to out-adopt its adversaries in time to maintain strategic advantage.

At its core, digital transformation is not just about developing new technologies but also about adopting them. The challenge for NSW is not merely recognizing the value of digital tools but determining how to adopt them effectively, which tools to prioritize, and what operational problems to address first. Adoption requires overcoming institutional resistance, reducing implementation friction, and ensuring that technological innovations integrate seamlessly into existing operational frameworks. Rogers' (2003) *Diffusion of Innovations* provides a valuable model for understanding how new technologies spread within organizations, emphasizing that the relative advantage, compatibility, complexity, trialability, and observability of the innovation drive successful adoption. Horowitz's (2010) *The Diffusion of Military Power* builds on this, arguing that a nation's ability to adopt new military innovations depends on two critical factors: financial intensity and organizational capital. In this context, NSW's ability to leverage emerging technologies hinges on reducing bureaucratic barriers and streamlining decision-making processes. Digital tools for NSW should be designed to facilitate technology adoption and reduce the organizational capital required to evaluate, acquire, and integrate emerging capabilities.

B. PROBLEM STATEMENT

NSW faces a critical challenge in its capability development process. While NSW remains the premier maritime special operations force, its ability to identify and integrate emerging technological advances into fully developed operational capabilities faster than the country's adversaries is often hindered by outdated workflows, misaligned priorities, and inefficient resource allocation. The current process is cumbersome, relying on PowerPoint presentations, Excel spreadsheets, and informal decision-making methods that lack traceability and integration with digital engineering tools (Davis, 2024). As modern warfare becomes more complex and combat strategies evolve, NSW must adopt a structured, data-informed approach to capability development that aligns with the broader Joint Force, leverages technological advancements, and fosters a culture of innovation. This perspective is supported by a recent GAO report on the speed of innovation within the DoD's current acquisition programs (Oakley, 2024).

C. PROJECT OBJECTIVE

Our capstone aims to implement the digital transformation established by recent directives and research, which is essential to NSW's capability development process. This process requires manual input at nearly every stage, creating structural friction and delaying the deployment of solutions. Rather than attempting to manage all of that complexity simultaneously, this project focuses on identifying a specific component of the process to serve as a use case for adopting and utilizing emerging technology for significant improvements to the system. Drawing on ME principles, a structured, systems-based approach advocated by the DoD, the project aligns capability development with operational outcomes. ME employs tools like mission threads to trace how individual systems and investments contribute to broader mission objectives. This framework offers a promising perspective for evaluating and enhancing NSW's capability development process, a critical end state for this research.

D. RESEARCH QUESTIONS

This research focuses on the following research questions:

- What aspect of the capability development process will likely benefit the most from digitalization, and how can software tools be utilized to improve its effectiveness?
- How can insights from stakeholders, subject matter experts, emerging digital tools, and AI enhance NSW's capability development and support its broader digital transformation?

E. RESEARCH CONTRIBUTION

The principal contribution of this research to the overall effort of force digitization and modernization is the identification of DOTmLPF-P analysis as a specific component of the capability development process that should be targeted for improvement, along with a proposal for the development of a software tool to achieve this goal. The DOTmLPF-P use case was identified and selected during this project's inquiry into the broader problem of modernizing NSW's capability development processes in the age of rapid digitalization. By systematizing the adoption process, DOTmLPF-P enhances NSW's ability to operationalize digital transformation, ensuring that technological advancements transition from conceptual possibilities to fielded capabilities that improve mission effectiveness.

A second complementary contribution arises from the project's extensive stakeholder engagement effort. Throughout the research, we conducted structured interviews with operators, program managers, engineers, and acquisition professionals across NSW, USSOCOM, the Defense Innovation Unit (DIU), the Office of Naval Research (ONR), and the DoD's Chief Digital and Artificial Intelligence Office (CDAO). These interviews and insights from the culminating design workshop and fieldwork through platforms like the Naval Postgraduate School (NPS) Joint Interagency Field Experiment (JIFX) revealed a clear consensus: NSW's current capability development pipeline is hindered by disconnected data, inconsistent prioritization criteria, and a lack of digital integration. This stakeholder-informed understanding shaped our research design and reinforced the value of decreasing the time and labor burden of DOTmLPF-P analysis. It also created a valuable record of community insights that future researchers can build upon when addressing similar modernization challenges within the broader defense innovation ecosystem.

F. CHAPTER SUMMARY

NSW faces a pivotal moment: transforming its capability development approach to align with the demands of a rapidly evolving threat landscape. This chapter presents the case for a structured, software-assisted DOTmLPF-P process as one response to that challenge. By adopting data-driven tools and ME principles, NSW can streamline decision-making, enhance traceability, and improve integration with the broader Joint Force. The following chapters examine the current state, research methodology, stakeholder perspectives, and actionable recommendations for implementing this transformation.

G. THESIS ROADMAP

Chapter II provides additional contextual background for the project, including a brief description of the practice of DOTmLPF-P analysis and its integral role within the military capability development process.

Chapter III describes the project's research design, methodology, data collection and analysis methods, and the study's limitations.

Chapter IV captures a summation of the data collected and synthesizes the insights gathered during the research process.

Chapter V provides recommendations for NSW to pursue a DOTmLPF-P analysis tool and for future research into force digitization and modernization.

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II. BACKGROUND ON THE CAPABILITY DEVELOPMENT PROCESS

The chapter provides a brief overview of the DoD and NSW capability development processes, as well as a primer on DOTmLPF-P analysis, a key process element.

Like many organizations in the DoD, NSW faces a growing imperative to modernize its capability development processes in an era of rapid technological acceleration. Strategies and guidance documents like the *DoD Digital Engineering Strategy* (Office of the Deputy Assistant Secretary of Defense for Systems Engineering, 2018), the *DoD Digital Modernization Strategy* (DoD, 2019), and the *DoD 2023 Data, Analytics, and AI Adoption Strategy* (Hicks, 2023), which were discussed in Chapter I, guide digital adoption across the Joint Force. These documents emphasize a digital-first approach to developing and acquiring defense capabilities, the importance of enterprise-level data practices, and the urgent need to reduce decision latency through effective utilization of technology. As an enterprise, NSW is leaning into this effort with its recently formed Creating Digital Advantage program, which seeks "to leverage innovative digital technologies to create competitive advantage by enhancing NSW capabilities in data driven decision making, improving business performance and service delivery, managing knowledge systems access and content management, and creating an agile learning organization" (Lawrence, 2024, p. 1).

This drive toward digital modernization in NSW is well-aligned with broader DoD efforts. Wieser (2020) argues that military innovation must go beyond adopting new technologies; it requires an ecosystem in which experimentation, collaboration, and digital transformation are systematically integrated into capability development processes (Wieser, 2020, pp. 12–13). In the same vein, this research aims to identify opportunities for integrating digital transformation into the current capability development process.

A. EXISTING PROCESS

The NSW capability development process is generally consistent with broader defense acquisition best practices and guidance, such as the *Manual for the Operation of* *the Joint Capability Integration and Development System* (JCIDS Manual), which provides comprehensive guidance “to facilitate the timely and cost-effective development of capability solutions” and the development of practical capability requirements such that the fielding of “foundationally flawed” capabilities is prevented (Joint Staff J-8, 2021, p. 1). The JCIDS manual also guides the development of key documents involved in the generation of capability requirements, such as the Initial Capabilities Document (ICD), Capability Development Document (CDD), DOTmLPF-P Change Recommendation (DCR), and system performance attributes (Joint Staff J-8, 2021, p. 2).

For NSW, two key guidance documents work with the JCIDS manual. The first is the Special Operations Forces Capability Integration and Development System (SOFCIDS) process, governed by USSOCOM Directive 71–4 (USSOCOM, 2020), USSOCOM’s implementation of the Joint guidance. The second is NSW’s implementation, the Special Operations Forces Requirements, Resourcing, and Acquisitions System (SOFRRAS), a secure web-based database with which NSW manages overall submission and staffing of documentation for new capabilities requirements (Naval Special Warfare Command [WARCOM], 2025).

Table 1, derived from a review of unclassified working documents related to NSW’s capability development process, outlines the process flow from the identification of a new capability gap at the NSW level to the validation and endorsement of an actual requirement at the SOCOM level (WARCOM, 2025).

Table 1. Naval Special Warfare Requirements Generation Process. Adapted from WARCOM (2025).

Step #	Description	Time
Step 0	New capability gap identified	
Step 1	Establish requirements working group	15 days
Step 2	Requirement Strategy	5 days
Step 3	Requirement Drafting	60 days
	Upload products into SOFRRAS	
Step 4	Draft Requirement Review	10 days
Step 5	NSW Enterprise Staffing	15 days

Step #	Description	Time
Step 6	NSW Staffing Adjudication	10 days
Step 7	Upload products into ITV or KMDS	5 days
	NSW Staffing Adjudication	
Step 8	SOFCIDS/JCIDS pre-Staffing	5 days
Step 9	SOCOM Initial Staffing	25 days
Step 10	NSW Initial Adjudication	20 days
Step 11	SOCOM Final Staffing	25 days
Step 12	NSW Final Adjudication	10 days
Step 13	SOCOM J8 Prebrief Vice Commander	
Step 14	SOCOM Review Board Validation and Endorsement	

As shown in Table 1, each step is time-bound, with durations ranging from 5 to 60 days, requiring coordination across multiple information systems and offices. The workflow reflects the traditional JCIDS-influenced model, where requirements must pass through staffing, review, and adjudication cycles at both the NSW and USSOCOM levels. Again, the process can span over 200 cumulative days, even in relatively straightforward cases. At 60 days, the most extended single portion of the process is Step 3: Requirement Drafting. This is mainly due to the JCIDS-directed mandate to conduct DOTmLPF-P analysis and include documentation within the requirements submission for any acquisition intended to address a capability gap (Joint Staff J-8, 2021, p. B-G-F-1).

B. BRIEF PRIMER ON DOTMLPF-P ANALYSIS

Doctrinally, DOTmLPF-P analysis encompasses all potential non-materiel solutions to or mitigations for a given identified capability gap; includes an analysis of Joint Doctrine, Organization, Training, materiel, Leadership and Education, Personnel, Facilities, and Policy; and is an important component of the analysis that informs the process before the decision to acquire or develop new materiel (Defense Acquisition University, n.d.). It also evaluates all non-material implications and impact considerations required to "fully implement" a new materiel capability acquisition (Joint Staff J-8, 2021, p. B-G-F-1). As such, it is mandatory and provides a valuable framework for conducting impact analysis to guide the commander's decision-making. These considerations and the fact that DOTmLPF-P analysis is one of the most labor-intensive and time-consuming components of the capability development process make it an ideal starting point for digitization.

III. METHODS

This chapter outlines the methodology used to investigate opportunities for digital transformation within NSW's capability development process. Given the evolving nature of the problem space and the limited academic literature regarding its application to special operations, the research adopted a practitioner-focused, exploratory approach. The methodology centered on engaging stakeholders to understand NSW's capability development process and incorporating insights from emerging technologies such as AI, ML, and other digital engineering tools.

A. OVERVIEW OF RESEARCH DESIGN

Key activities included stakeholder interviews, mission partnerships, and a culminating design workshop—each informed by the principles of ME and user-centered design. These engagements enabled us to identify process inefficiencies, assess digital feasibility, and explore the feasibility of a decision-support tool tailored to DOTmLPF-P analysis. We also explored how a decision-support tool might improve the effectiveness and traceability of DOTmLPF-P analysis.

B. STAKEHOLDER NETWORK AND FIELD ENGAGEMENT

The initiative was sponsored by the WARCOM Requirements Directorate (N8), which recognized ME as a potential pathway for enhancing capability development. The sponsor's early involvement provided access to a broad network of stakeholders and helped guide the research toward decision-support tools for DOTmLPF-P analysis. An initial workshop was organized to gather stakeholder input and prioritize process inefficiencies.

1. Naval Special Warfare Command Requirements Directorate

By definition, emerging technologies, techniques, and processes are implemented in real-time, and the existing body of published literature has limited content of direct value to a project focused on a specific application, especially within such a niche arena as the NSW community. Given these facts, this research adopted an application-oriented approach, emphasizing engagement with current practitioners.

2. Defense Innovation Unit Mission Partnership

We partnered with the Defense Innovation Unit (DIU) in Mountain View, CA, to enhance our understanding of defense innovation practices. This partnership was formalized under the auspices of the 2024 Memorandum of Understanding (MOU) between DIU and NPS for collaborative research and support (Beck & Rondeau, 2024). This agreement allowed participation in internal DIU events, including project debriefs and company pitch sessions. These engagements exposed the research team to digital transformation projects and informed our thought process regarding the feasibility of similar tools for NSW.

This collaboration served multiple purposes. First, it allowed the research team to explore the possibilities presented by existing commercial and dual-use technologies. Second, it provided early insights into how stakeholders build networks and identify potential partners within the innovation ecosystem. As part of the engagement process, we aimed to gain situational awareness of current activities in the defense innovation space—understanding which critical facilities and groups were involved and fostering relationships whenever possible to support deeper learning and later-stage interviews.

The DIU environment, enriched by interactions with subject matter experts and exposure to emerging technologies, provided relevant context to inform our understanding of digital capability development. As part of this collaboration, we gained situational awareness of ongoing innovation efforts, refined requirement definitions, and gathered insight into development cycles, capability maturity, and Technology Readiness Levels (TRLs).

Crucially, our engagement with DIU led to an introduction to Peyman Khodabandehloo and Stacie Andrews-Hornak from the Provado Labs Systems Integration and Implementation Verification Team working for the Air Force's Kessel Run software program. Their extensive experience and technical knowledge of building large-scale, complex enterprise-level software informed our approach to capability development, user engagement, and requirements definition.

3. Joint Interagency Field Experimentation Engagement

To expand the scope of our engagement within the DoD innovation ecosystem, we leveraged the NPS JIFX platform. JIFX hosts "broadly scoped" collaboration events designed for government and industry partners to "identify, influence, and accelerate early-stage technology development" (NPS, n.d.). The JIFX construct was critical because it provided a framework for engaging with the Kessel Run developers from Pravado Labs, whose insights and support were crucial in conducting the culminating stakeholder engagement workshop.

C. INTERVIEW METHODOLOGY

The NPS Institutional Review Board (IRB) reviewed the project to ensure research integrity. In compliance with research ethics protocols, we submitted a detailed proposal outlining the scope and nature of the study, including the interviews. The IRB confirmed that this study did not involve human-based research, as it focused on organizational processes, decision-making structures, and departmental functions rather than individual behaviors or personal data.

1. Ethical Review and Institutional Review Board Status

The classification of the project as no human-based research enabled it to proceed without the constraints of formal human-subject research requirements, while still upholding ethical rigor. Interviews were structured to examine organizational dynamics at various levels of NSW, including Naval Special Warfare Command (NSWC), NSW Group ONE (NSWG-1), NSW Group EIGHT (NSWG-8), Project Management System 340 (PMS 340), and other key departments, ensuring a comprehensive understanding of the broader capability development landscape. Interviewees included operators, systems engineers, acquisition professionals, and program managers from Echelon II and III commands, covering the full spectrum of NSW's capability development activities.

2. Participant Selection and Sampling Strategy

The selection of interview subjects was strategically informed by ongoing engagement with our project sponsor, NSWC N8 deputy. Initial recommendations from the sponsor established the foundation for identifying subject matter experts and relevant stakeholders. We then employed a snowball sampling approach, asking each interviewee for additional recommendations on ideal contacts who could provide valuable insights. Mentors and trusted sources within the innovation ecosystem played a crucial role in refining our outreach, ensuring that we connected with individuals who had the necessary knowledge and expertise and were willing to support our research efforts. This iterative selection process enabled us to target stakeholders deeply involved in the innovation and acquisition processes, including operational leaders, decision-makers, engineers, scientists, and program managers.

In selecting NSW stakeholders, careful attention was given to including a broad, representative sample from across the entire capability development "value chain," covering requirements generation, analysis, staffing, funding, program management, and systems engineering. To this end, interviewees included operators, operational leaders, program managers, systems engineers, and key personnel within NSW's Requirements and Program Management ecosystem at both Echelon II and Echelon III levels. Specific roles included the requirements officer, DoD Architectural Framework (DODAF) architect, product support manager, acquisitions strategy manager, and operational end-user, ensuring that diverse perspectives on the challenges and opportunities within NSW's capability development process were captured.

3. Interview Design and Baseline Questions

After receiving IRB approval from NPS, we proceeded to conduct semi-structured interviews. Through these interviews, the project aimed to gather objective insights into NSW's mission planning, capability development, and resource prioritization processes. A baseline set of questions guided discussions focused on ME, Digital Engineering (DE), and Digital Transformation (DT), while also allowing for elaboration on emerging themes such as AI usage, tool integration, and scalability.

The data collected clarified which tools and methodologies are currently in use, identified gaps in adoption, and illuminated the challenges stakeholders face in prioritizing and scaling capabilities. Insights from these interviews directly informed the structure of the final workshop. No personal or sensitive information was collected during the sessions.

4. Interview Baseline Questions for NSW Capability Development

a. Awareness of Mission Engineering, Digital Engineering, and Digital Transformation

- What tools or methodologies are currently used in NSW to align mission planning with strategic objectives?
- Can you describe any framework that decomposes missions into specific tasks and decision points during the planning process?

b. Capability Development Process

- How are technologies and capabilities prioritized during the capability development process in NSW?
- What criteria decide which capabilities should be scaled across multiple units or mission sets?

c. Challenges in Technology Integration

- What are some common challenges NSW faces in integrating new technologies into operational missions?
- How are delays or inefficiencies in capability adoption typically identified and addressed?

d. Use of Mission Threads

- Are mission threads or similar methodologies used in NSW for mission planning and execution? If so, how are they applied?
- How is the sequencing of mission tasks and the assignment of resources managed during mission planning?

e. Feedback and Iteration Process

- What feedback mechanisms exist in NSW to evaluate the effectiveness of a mission's planning and execution process?
- How does NSW use operational data to refine or improve mission planning tools and techniques?

f. Scaling Capabilities

- How does NSW assess whether a capability developed for one mission can be scaled for broader use?
- What are the factors that influence the scalability of a capability across different NSW units or missions?

g. Prioritization of Resources

- How does NSW ensure that resources (personnel, technologies, funding) are prioritized effectively for the most critical capabilities?
- Can you outline existing processes for re-prioritizing capabilities or technologies as mission requirements evolve?

h. Training and Education on Tools

- What training or educational programs are available for NSW planners at all levels using ME tools or methodologies?
- How are NSW personnel made aware of new tools or processes for mission planning and capability development?

The purpose of collecting information through interviews was to gather detailed insights to inform the final phase of the research: the stakeholder engagement workshop. This research aimed to identify gaps in awareness and the application of digital engineering tools, ME and mission threads within NSW by interviewing key stakeholders. The information collected was used to evaluate the effectiveness of current methods, determine how digital engineering tools can enhance capability development and prioritization, and provide evidence-based recommendations for integrating DE/DT/ME into NSW's processes

D. CULMINATING WORKSHOP

After several weeks of interviews with key stakeholders, the capstone project advanced to a 5-hour, in-person workshop at the sponsor's headquarters. This session aimed to validate the preliminary insights gathered during the interview phase and enable participants to collectively identify and prioritize friction points within NSW's capability development process. The workshop served as a structured forum to clarify process challenges, assess which components might benefit most from digital intervention, and highlight potential systems requirements for further exploration in later research stages. These approaches were chosen because they facilitate structured collaboration in environments with high cross-functional coordination and complexity, similar to NSW's acquisition and capability development ecosystem.

1. Purpose and Context

Participants included representatives from WARCOM N8, NSW groups, USSOCOM J8, and PMS-340, ensuring a wide range of input across the capability development value chain. To create a practical structure and enhance participant engagement, the session utilized facilitation techniques from two complementary methodologies:

- User engagement tools from the Strategyzer books, *Testing Business Ideas* and *Value Proposition Design* (Bland & Osterwalder, 2019; Osterwalder et al., 2014) , were employed to visually model complex systems, promote alignment around high-level problem statements, and tease out ground-truth insights from the collective group.
- The Warfighter-Centered Design practices taught by the Naval Warfare Studies Institute (NWSI) offered a user-centered approach tailored to NSW's operational context, ensuring participant inputs were rooted in real-world workflows and decision-making constraints (Centers for Adaptive Warfighting, 2021).

These methods were chosen for their practical application in complex, team-oriented problem environments, especially where both operational and acquisition communities are involved.

The session was designed and led in collaboration with personnel experienced in facilitating defense innovation and workshop planning. It followed a structured agenda that included (a) identifying and refining problems, (b) mapping current workflows, (c) discussing priority pain points, and (d) brainstorming ideas on how digital tools could enhance processes. Supporting materials and whiteboarding exercises were used to maintain focus and capture diverse perspectives. This structured facilitation approach ensured the workshop aligned with research objectives while integrating a wide range of stakeholder expertise into the later design phases.

2. Method: "The Mountain" Exercise

The primary framing tool used to guide the workshop was a warfighter-centered design methodology called "The Mountain," introduced by Lyla Englehorn, the NWSI workshop coordination expert. This design thinking tool, from the *NavalX Warfighter-Center Design: Facilitator's Guide* (Centers for Adaptive Warfighting, 2021, pp. 13–14) , is commonly employed by NWSI and frequently used in defense innovation workshops to facilitate structured dialogue, align diverse participants, and visualize system-level transitions between current-state challenges and future-state goals. First, participants identified pain points associated with the current process at the bottom of the whiteboard. Next, at the top of the board, they visualized an ideal future by describing a fully optimized system. Finally, they brainstormed a potential path between the current state and the ideal future. See Figure 1.

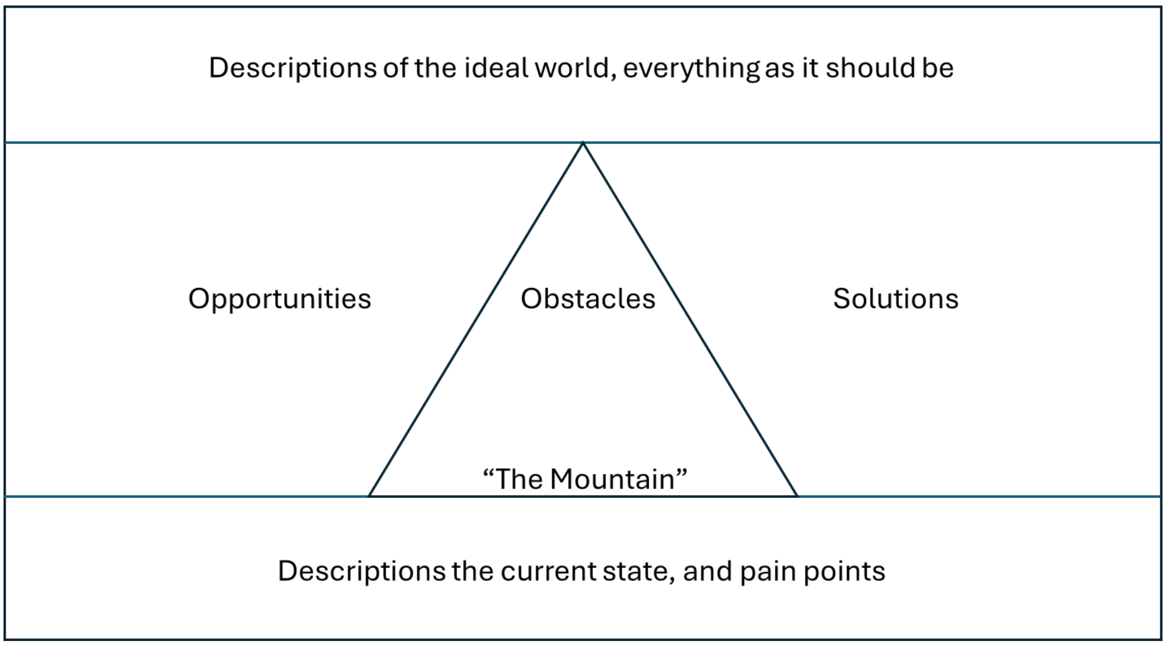

Figure 1. The Mountain Workshop Exercise. Adapted from Centers for Adaptive Warfighting (2021, pp. 13–14).

This chapter outlined the research design and methodology that guided our capstone research into understanding and enhancing NSW's capability development processes. By engaging with a range of stakeholders, we identified key inefficiencies and pain points, enabling us to propose targeted solutions rooted in operational realities. Employing these techniques ensured that our findings were grounded not on assumptions but on direct engagement with NSW practitioners, industry experts, and DoD innovation leaders.

IV. RESULTS AND FINDINGS

This chapter presents the key findings from our research, synthesizing insights from stakeholder interviews, workshop exercises, academic literature, and field observations. It highlights systemic inefficiencies and friction points within NSW's capability development process and captures operational and organizational patterns that emerged across engagements. These findings do not lead to a recommended solution but do inform the groundwork for future exploration into digital, data-informed improvements addressed in Chapter V.

A. OVERVIEW OF RESEARCH INSIGHTS

Actual change in capability development requires more than just new tools—it demands a shift in mindset, culture, and decision-making processes to ensure that innovations are adopted, scaled, and sustained. Whether a requirement emerges from the bottom up through operational needs or is driven top-down by strategic priorities, adequate information flow and rigorous capability assessments are essential to ensuring that investments are aligned with mission objectives.

This chapter captures the pivotal moments, contradictions, and breakthroughs that emerged during our research. It lays the foundation for NSW to critically assess and refine its capability development approach, ensuring that future innovations are not only technologically advanced but also organizationally and strategically viable. These findings served not only as an empirical foundation for analysis but also as a validation of the research direction itself. From the outset, this capstone project was guided by recognition that NSW's capability development process, while supported by a formal framework, faces persistent execution challenges that hinder alignment with operational priorities.

Contrary to assumptions that such a framework does not exist, NSW operates under structured policies aligned with higher headquarters directives, including JCIDS and SOFCIDS, and employs SOFRRAS to facilitate transparency. However, stakeholder engagement revealed that this system experiences notable shortfalls in workflow efficiency, prioritization coherence, and community participation.

These observations informed our working hypothesis: NSW must streamline its capability development process by improving execution, integrating emerging tools such as AI-enabled analysis, and strengthening its feedback loops across organizational layers. Chapter IV documents the insights that shaped this understanding, while Chapter V outlines how future efforts might build upon this foundation to deliver practical and impactful solutions.

B. THEMATIC SUMMARY OF INTERVIEW RESPONSES

To protect confidentiality, this section summarizes key themes from stakeholder interviews using generalized observations instead of individual attribution. Insights were gathered from discussions with operational leaders, acquisition professionals, engineers, and digital transformation experts from NSW, SOCOM, DIU, ONR, and other supporting organizations. Several themes emerged from this research process; they are detailed next.

1. Integrating Digital Engineering and AI-Augmented Analysis

Participants consistently expressed interest in accelerating NSW's transition to digital workflows. Multiple interviewees, particularly those familiar with broader DoD modernization initiatives, highlighted the value of computational tools in supporting strategic analysis. Many viewed AI-enabled platforms and digital engineering as essential for improving DOTmLPF-P traceability, minimizing manual errors, and streamlining acquisition decisions. This theme aligns with DoD-level guidance that advocates for a shift from document to digital, reflecting a strong cultural readiness within NSW to embrace transformation.

2. Developing an NSW-Specific Mission Engineering Approach

Several stakeholders noted that NSW would benefit from adopting a tailored approach to ME that aligns its operational objectives with capability development and acquisition strategies. While the DoD has established broad frameworks, interviewees emphasized the need for a repeatable, NSW-specific process incorporating mission threads and iterative assessments. Suggestions included leveraging the expertise of NPS, particularly its Systems Engineering and Systems Analysis programs, or sponsoring future thesis work focused on developing a model that directly serves NSW's needs.

3. Improving Cross-Echelon Collaboration

Communication gaps between NSW groups, Echelon II/III program offices, and acquisition authorities surfaced as a significant friction point. Although digital tools can assist in information management and process traceability, interviewees emphasized the importance of strong interpersonal relationships and ongoing human collaboration in capability development. Multiple operators and Program Managers (PM) noted that decisions about Key Performance Parameters (KPPs) were often made in committee and away from the field, reducing traceability to original mission needs. Several PMs referred to the ongoing NSWC N8 efforts aimed at enhancing systemic coordination, emphasizing that digitalization should complement, rather than replace, the collaborative culture essential for successful innovation.

4. Observations from the Culminating Workshop

Following weeks of stakeholder interviews, the research team facilitated a 5-hour culminating workshop using the mountain design-thinking exercise to validate findings, surface gaps, and explore desired end-states for NSW's capability development process. The session brought together representatives from across WARCOM, SOCOM J8, and acquisition entities. The mountain exercise was designed to gather insights into the "real" problem, the goal, and what a meaningful solution looks like. It gleaned several salient insights into all three areas.

There is a disconnect between operators, N8 staff, PMs, and subject matter experts. Some participants noted that DODAF architectures are not included early enough in the process, which is a problem because DODAF architectures help highlight how systems must interoperate (i.e., share data and connect operationally) across domains and organizations. Similarly, most participants noted that DOTmLPF-P analysis—used across the DoD to assess capability gaps or implement new capabilities—is no introduced early enough in the process to inform preliminary resourcing decisions.

Other reported challenges include keeping pace with shifting command priorities, which often outpace slower, more restrictive contracting processes. While a commander's ability to adapt strategy in response to evolving conditions is critical for organizational flexibility, the acquisitions staff and capability development processes often struggle to make timely adjustments. Staff may wish for guidance to slow down to match the process, but in reality, the process must accelerate to keep pace with the commander, who must remain agile in the face of a dynamic adversary.

The lumbering nature of capability development is also partially caused by the JCIDS/SOFCIDS cycle, which involves time-consuming processes. During the workshop session, participants expressed the common consensus that one of the most time-consuming aspects of the process is the DOTmLPF-P analysis documentation, which can take up to 2–3 months for each capability. DOTmLPF-P analysis is a Joint doctrinal process required before sourcing any material solution to an identified capability gap. The process ensures that DoD units do everything they can to solve problems internally before spending taxpayer money on acquiring new capabilities. Despite the time it requires, DOTmLPF-P analysis does provide value; when conducted effectively, it not only prevents the procurement of redundant capabilities but also delivers important insights into the broader implications of introducing new material solutions.

5. Ideal World/Goal Formulation

The workshop revealed an ideal process characterized by increased transparency, communication, and stakeholder collaboration. One key finding was the need to remain focused on the operator's perspective throughout the entire development cycle, especially for personnel several steps removed. The current system can make it difficult for well-meaning staff experts further along in the process to maintain a clear understanding of the operator's point of view.

The most tangible recommended change was to speed up DOTmLPF-P analysis and integrate it as early as possible to enable more fully informed recommendations and a more agile decision-making cycle for the command.

6. Meaningful Solutions

The insights from the workshop revealed the recommendation that acquisition teams should be led from a people-centric perspective to maintain frequent engagement between users, operators, requirements sponsors, commanders of their staffs, program managers, and all enabling stakeholders to field solutions to operational deficiencies.

There is no singular technology solution to this complex socio-technological process. However, technological tools have a strong potential to help address difficulties along the path and augment the humans involved as they work hard to deliver warfighting capability. To this end, the findings from the working group indicate that a system that facilitates faster, more comprehensive completion of DOTmLPF-P analysis—and allows its principles to be incorporated earlier in the process—could significantly improve both the speed and quality of capability development.

These themes established the foundation for our analysis, which integrates insights to assess the feasibility and utility of a digital DOTmLPF-P tool designed for NSW's unique operational and acquisition environment. Taken together, the interview and workshop data reveal consistent friction points in NSW's current capability development model, particularly around communication timing, resource prioritization, and analytical transparency. These findings form the basis of the proposed software tool concept and accompanying recommendations.

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V. RECOMMENDATIONS

This chapter translates key findings from Chapter IV into clear, actionable recommendations for NSW leadership and future innovation officers. These recommendations, based on user interviews, field engagements, and direct feedback from operators, engineers, and acquisition professionals, reflect the need for the NSW enterprise to modernize its capability development process.

This research does not provide a rigid, permanent solution. Instead, it presents a flexible, iterative approach that keeps pace with shifting mission demands and operational complexity. As warfare and technology evolve quickly, NSW must adopt a mindset of continuous refinement—not unlike agile business practices. No mission is identical, and no development process should be static. NSW's future advantage depends on moving away from fixed, bureaucratic models and toward adaptable, user-informed frameworks that align with Joint Force priorities.

NSW has successfully embraced this mindset. For instance, the 2011 non-standard acquisition initiative, led by Admiral Eric Olson (2011, p. 1), demonstrated how operational flexibility can accelerate delivery. Today, however, the stakes are higher. The rapid pace of change in machine learning, advanced software, and digital systems demands a new model, one that empowers teams to move faster, test frequently, and evolve continuously. The following recommendations outline a path forward, focused on piloting a digital DOTmLPF-P tool, enabling agile decision-making, and embedding ME into NSW's capability development cycle.

The three recommendations outlined in this chapter are mutually reinforcing. First, NSW should pilot a digital DOTmLPF-P decision-support tool to accelerate planning and enhance traceability. Second, to unlock the full potential of this tool, NSW must transition from a linear acquisition model—termed the Acquisition Kill Chain—to a more adaptive, decentralized Acquisition Kill Web. This model enables quicker feedback loops, flatter decision pathways, and integration across echelons. Finally, NSW should institutionalize agile ME principles to ensure that planning processes remain closely aligned with evolving mission demands. Together, these steps provide a practical roadmap for modernizing NSW's approach to capability development.

A. RECOMMENDATION #1: PILOT A DIGITAL DOTMLPF-P TOOL

While the format of a formal solicitation will ultimately depend on the acquisition strategy that NSW chooses to pursue, the following recommendations are intentionally format-agnostic. Whether implemented through an Operational Deficiency Report (ODR), Area of Interest (AOI), Commercial Solutions Opening (CSO), or another method, the core principles outlined here remain applicable. Appendix A includes a sample description of the requirement modeled on the DIU's approach for reference and brevity. What follows is a research-informed, plain-language articulation of system requirements and design considerations derived directly from this study's stakeholder engagements, interviews, and workshop findings.

This section distills the primary recommendations developed throughout this capstone project, translating technical research findings into actionable guidance for the NSW community. These recommendations reflect extensive engagement with subject matter experts, operational leaders, and digital transformation professionals across NSW and the broader defense innovation ecosystem. They are shaped by the interviews, workshop data, and ME principles applied throughout this project and are intended to guide NSW's next steps in piloting and adopting a digital tool to support DOTmLPF-P analysis.

At the core of these recommendations is a widely acknowledged problem: The capability development process remains slow, fragmented, and overly reliant on manual staffing tools. Specifically, DOTmLPF-P analysis—a mandatory doctrinal step in validating capability requirements—can take months to complete, contributing to delays and ballooning timelines across acquisition cycles. Workshop participants repeatedly noted that by the time a capability is staffed and resourced, it may already be outdated due to the evolving strategic environment or a change in command priorities.

Rather than proposing a specific technical solution, this research outlines a set of essential attributes and design considerations for a future digital tool that can augment

DOTmLPF-P analysis. These attributes were derived from user interviews, validated in the culminating design workshop, and reflect real operational pain points. It is worth noting that while emerging AI tools and methods may be the solution of choice for this use case, this recommendation remains deliberately agnostic regarding the specific type of software that should be implemented. If AI is to be utilized, we recommend viewing it not as a replacement for human cognition but rather as an amplifier, as described by Dr. Stephen Kosslyn (2024) in his book *Learning to Flourish in the Age of AI*.

The following design goals should inform the development and implementation of an NSW-specific DOTmLPF-P augmentation platform:

1. Accelerate Analysis through Structured Information Synthesis

The tool must be capable of ingesting large volumes of enterprise data—both structured and unstructured—and synthesizing that information to identify relevant patterns, dependencies, and implications across the DOTmLPF-P categories. This involves parsing documentation from mission planning systems, financial records, DODAF architectures, and past capability assessments to provide decision-makers with contextually grounded recommendations.

2. Enable Draft Document Generation with Human Oversight

Users voiced a strong need for a tool that could help draft DOTmLPF-P documents in approved formats while ensuring complete transparency over the sources and logic utilized. The system should permit iterative refinement, facilitate easy editing, and enable the uploading of commanders' intent or higher-level guidance to align outputs with mission priorities.

3. Support Human-Machine Teaming and Analyst Control

A recurring insight from stakeholder engagements highlighted the importance of maintaining human control and interpretability. The tool should support—not replace—the judgment of analysts, operators, and decision-makers. It must provide a clear rationale behind every output, including citations and reasoning, so that recommendations can be verified, modified, or rejected by human users.

4. Promote Collaboration across Stakeholders and Echelons

Effective capability development necessitates participation across various commands and disciplines. The platform should foster a collaborative workspace where requirements officers, program managers, and operational leaders can jointly develop recommendations, monitor changes, and maintain a shared understanding of how capability gaps are analyzed and resolved.

5. Deliver an Intuitive, Role-Based User Interface

Considering the diversity of stakeholders involved in DOTmLPF-P, the system must provide customizable workflows and interfaces for various user roles, such as operators, acquisition officers, and systems engineers. The tool should assist users in navigating the DOT-P framework, highlight missing data or critical inputs, and lessen the cognitive load associated with navigating complex documents and processes.

6. Ensure Transparency, Auditability, and Information Assurance

To build trust in the tool, users must verify every output. It should ensure traceability of sources, highlight areas of incomplete information, and avoid drawing conclusions when data is insufficient. Furthermore, it must operate within secure, classified environments and comply with relevant information assurance and cybersecurity standards.

7. Lay the Groundwork for Continuous Refinement

While this project does not prescribe a single solution architecture, it recommends starting any future development with a structured requirements engineering process, such as Pay's Information Architecture methodology. This ensures tool development is based on real user needs and aligns with NSW's operational, technical, and security constraints.

B. RECOMMENDATION #2: TRANSITION FROM ACQUISITION KILL CHAIN TO ACQUISITION KILL WEB

To fully realize the benefits of a digital DOTmLPF-P tool, NSW must transition from a linear acquisition model to a networked, agile framework—referred to in this report as the Acquisition Kill Web. This transition is not theoretical; it is vital for shortening decision timelines, accelerating capability delivery, and ensuring operational relevance in dynamic threat environments.

The traditional Acquisition Kill Chain resembles the structure of the long-range fires kill chain: It identifies bottlenecks, targets inefficiencies, and sequences events to deliver outcomes. However, like its tactical counterpart, this chain is vulnerable, rigid, sequential, and slow to adapt when conditions change. As our interviews and workshops confirmed, this method is no longer sufficient.

The proposed Acquisition Kill Web decentralizes decision-making and allows for multiple adaptive pathways to deliver capabilities. It creates feedback loops between operators, requirements officers, and program managers, enabling real-time updates, iterative refinement, and faster integration of emerging technologies. The DOTmLPF-P tool can be a key enabler of this shift, providing a shared digital environment for traceability, collaboration, and rapid analysis.

The DOTmLPF-P tool can be a key enabler of this shift, providing a shared digital environment for traceability, collaboration, and rapid analysis.

The following are the key design features of the Acquisition Kill Web:

(1) Concentrate on mission-focused and threat-informed capability development and requirements analysis during the tool design process.Replace static, capability-based requirements with **mission thread analysis** tied to real-world operational problems.

(2) Align priorities with current threat intelligence and the commander's intent. Ensure that all relevant guidance and directives are easily accessible and can be referenced quickly to aid in highlighting and analysis. Create AI-enabled decision support tools, and digital engineering options and databases can be accessed and created.

(3) Utilize the DOTmLPF-P tool to synthesize data, create draft recommendations, and identify second- and third-order impacts across DOTmLPF-P.Leverage modeling, simulation, and digital twin environments to refine concepts before resourcing.

(4) Ensure agile acquisition pathways during program development to offer diverse methods of capability delivery, concentrating on three key factors to manage: cost, schedule, and performance.Leverage Middle Tier

Acquisition (MTA) and Other Transaction Authorities (OTAs) to circumvent traditional delays.

(5) Design prototypes that include built-in transition paths for rapid fielding and resourcing solutions and can offer multiple recommendations.

(6) Integrate warfighter involvement frequently and smoothly to enhance applicability and feasibility.

(7) Embed end-users early in the acquisition cycle, enabling iterative prototyping and feedback.

(8) Focus on warfighter outcomes over bureaucratic milestones.

(9) Create consistent metrics for innovation that adapt to capabilities and enable flexible prioritization.

(10) Align program offices, requirements writers, and innovation teams around shared measures of success.

(11) Monitor speed to field, operator utility, and adaptability, not just compliance or documentation.

Christian Brose (2022) argues in *The Kill Chain* that the United States cannot succeed in future conflicts by simply refining the strategies and technologies of past wars. Instead, he emphasizes the need for a fundamental shift in how the United States approaches warfare, particularly in adapting to emerging technologies and new threats (Brose, 2020). The Acquisition Kill Web reflects this truth. It is not just a framework; it signifies a shift in mindset. Capability development must be faster, more responsive, and deeply integrated with those using the tools in the field.

NSW already possesses the organizational agility to lead this change. The DOTmLPF-P tool provides a critical element of support, while the Acquisition Kill Web offers the operational logic. Together, they create a roadmap for modernizing NSW's capability pipeline, aligning with the speed of emerging threats and ensuring that warfighters receive what they need—when needed.

C. RECOMMENDATION #3: INSTITUTIONALIZE AGILE MISSION ENGINEERING EARLY IN THE CAPABILITY DEVELOPMENT CYCLE

While NSW has taken initial steps to explore ME, this research identified a clear need to formalize and institutionalize ME practices throughout the capability development life cycle. Specifically, Mission Threads and ME frameworks should be integrated earlier in the planning and requirements cycles, enabling NSW to align better operational intent, acquisition timelines, and technical solutions.

Stakeholder interviews consistently revealed that ME concepts are not yet widely understood or applied within NSW. Many capability decisions still depend on traditional staffing processes—PowerPoints, Excel sheets, and linear planning models—rather than systems-based approaches that connect capabilities to actual mission outcomes.

To address this gap, NSW should implement a series of improvements, which are discussed next.

1. Adopt Mission Threads as a Standard Planning Tool

Mission Threads decompose high-level objectives into task-level activities and resource dependencies. Embedding them into planning cycles will help.

- Visualize how proposed capabilities support operational goals.
- Highlight integration challenges across domains and systems.
- Guide DOTmLPF-P analysis with real mission data.

The proposed DOTmLPF-P digital tool should support this by enabling users to map capabilities to mission outcomes, simulate alternative courses of action, and generate outputs aligned with the commander's intent.

2. Build a Common ME Lexicon

During interviews and workshops, many participants expressed confusion around ME terminology or how it connects to existing NSW processes. To overcome this, NSW should

- Create a shared ME playbook or quick reference guide for NSW-specific use cases.
- Integrate ME terms and definitions into training, requirement generation templates, and acquisition documentation.

3. Integrate ME into PME and Warfighter Education

For ME to scale, it must be part of NSW's organizational DNA. NSW should

- Leverage PME programs at NPS, DAU, and SOCOM to expose officers and staff to ME tools and case studies.

- Establish ME practicum experiences for students, especially thesis writers, who can use ME frameworks to work on real-world NSW capability challenges.

4. Pilot ME in Joint and Interagency Planning Cells

NSW should explore cross-functional experiments with operations department (J3), Strategy, Plans and Policy (J5), and acquisition directorates to validate ME's effectiveness in real planning environments. These pilots can provide feedback loops for refining the ME approach and inform digital tool development for mission-centric DOT-P.

D. WHY THIS MATTERS

Embedding ME early establishes traceability between operational needs and technical solutions. It prevents capability gaps from being defined too narrowly or too late. When paired with a digital DOT-P platform, ME facilitates iterative, real-time refinement of mission plans, ensuring that capabilities are not only fielded but also fielded for the right mission at the right time. By institutionalizing ME now, NSW can establish a scalable, repeatable approach to capability development that aligns with its mission, is informed by users, and adapts to complex threat environments.

E. LIMITATIONS OF THE STUDY

Before concluding this report, it is essential to address the study's limitations and offer recommendations for future research. One of the primary constraints was time. While we had the privilege of working with a wide range of stakeholders, we were unable to conduct all of the follow-up interviews we originally intended, and a longer list of potential contributors remained out of reach. The temporal constraint also prevented us from continuing the project into more advanced phases, which would have included, ideally, the creation of a prototype DOTmPLF-P tool that could be demonstrated to our community of stakeholders for iterative testing, feedback, and refinement.

This lack of an organic prototyping capability within the research team was another critical limitation. Defense Analysis and Defense Management, by their nature, are not technical programs. The inclusion on the research team of a student majoring in Computer Science, Electrical Engineering, Information Sciences, or another such "technical" discipline may have afforded us the ability to rapidly prototype a tool to gather more quantitative feedback, or at least to generate a more comprehensive set of proposed requirements. Unfortunately, NPS lacks robust, established processes and cultural practices to combine this type of interdisciplinary research team.

We endeavored to mitigate this gap through engagement with defense and industry Subject Matter Experts (SMEs) and by partnering with DIU. This provided valuable insight into the current state of emerging technologies, digitalization, and the development of software for defense applications. However, the DIU program that would have provided the best analogy to our workflow application experienced a quarter of contracting delays, preventing us from fully benefiting from those prototyping efforts and demonstrations.

Because the time-constrained bounded research did not include technical prototyping or iterative system testing, the findings should be interpreted as exploratory and foundational rather than conclusive. Nevertheless, the study benefited from strong access to stakeholders and a committed sponsor, which helped ensure relevance and contextual insight.

F. FOLLOW-ON RESEARCH ROADMAP

Broadly speaking, future research at NPS should include a heavy focus on fully-enabled research teams composed of students from across several academic disciplines, guided by a well-rounded panel of experienced mentors, advisors, and project sponsors. Stanford University's Hacking for Defense (H4D) program provides a good example of how to harness interdisciplinary teams to solve defense-related problems. NPS faculty and future students should consider the H4D framework as a tool for improving future projects. The H4D textbook, *The Hacking for Defense Manual: Solving National Security Problems with the Lean Methodology* by Dr. Jeff Decker (2024) is an excellent resource to inform efforts along these lines.

To sustain momentum and drive meaningful transformation within NSW, follow-on research specific to this project should target critical areas within the DOTmLPF-P framework (Joint Staff J-8, 2021). This research agenda is intentionally flexible and should be treated as a living roadmap, meant to evolve alongside mission demands, emerging technologies, and user insights. While this chapter offers one structured pathway forward, it is not the only route. Future students, researchers, and operational leaders are encouraged to adapt, expand, or refine the approach as needed.

Future studies should explore how emerging tools and digital methodologies impact each DOTmLPF-P domain, focusing on NSW's unique capability development challenges. This work is essential to ensuring integration with broader Joint Force modernization efforts. It provides a foundation for NSW to become a participant in innovation and a driving force within the DoD.

The proposed research directions aim to help NSW leaders assess second- and third-order effects of innovation adoption, specifically, how digital tools can enhance speed, transparency, and rigor in decision-making. These themes align with DoD-wide transformation priorities and present NSW with an opportunity to improve interoperability, accelerate acquisition workflows, and cultivate a technology-enabled force.

These recommendations represent a fundamental step in modernizing NSW's capability development enterprise. They draw on user feedback, operational insights, and lessons learned from digital transformation initiatives throughout the defense innovation ecosystem. As highlighted in many recent Government Accountability Office (GAO) assessments such as GAO-23-106222 Leading Practices Iterative Cycles Enable Rapid Delivery of Complex, Innovative Products; by adopting ME, streamlining capability development processes, and cultivating a culture of iterative experimentation, NSW is well-positioned to become a decisive, agile component within the Joint Force. Overlooking this opportunity risks stagnation. Embracing it ensures NSW remains at the forefront of technological relevance and operational readiness.

History teaches us that militaries that fail to modernize in peacetime often fall behind in war. This research effort helps catalyze a shift toward proactive, data-informed capability development by offering the frameworks and insights needed to convert emerging technologies into operational advantage. The following section outlines how future NPS students and NSW collaborators can carry this work forward through a structured, stakeholder-driven approach to produce a viable prototype and spark sustained change.

Phase 1. Deepen Stakeholder Engagement: Initial research laid the groundwork by identifying broad friction points within the NSW capability development pipeline. However, targeted engagement is necessary to sharpen problem definitions and ensure alignment with real-world user needs.

Objective: Refine the problem statement and identify high-impact areas of the DOT-P process for digital augmentation.

Key Actions:

- Engage Requirements Office (WARCOM N81): Led by Jake Haff, this office is essential for mapping the current DOTmLPF-P workflow and identifying time-consuming analysis points.
- Expand to Group-Level Staff: Understand how DOTmLPF-P is implemented at subordinate commands (e.g., Groups 1 and 2), as variations in process may reveal scalable solutions.
- Connect with PMS 340: As an acquisition sponsor, PMS 340 can advise on how potential solutions align with formal contracting and programmatic pathways.

Goals:

- Validate DOTmLPF-P cycle time reduction as a KPP.
- Identify sub-processes ripe for automation, AI assistance, or redesign.
- Refine and align system requirements with current acquisition workflows.

Phase 2. Conduct a DOTmLPF-P Process Deep Dive: This phase prioritizes a systems-level understanding of how capability development functions in practice.

Objective: Map and analyze the DOT-P process across NSW echelons to uncover inefficiencies and design opportunities.

Key Actions:

- Document current DOT-P workflows at WARCOM, groups, and SOCOM Acquisition, Technology, and Logistics.
- Interview planners, requirements officers, and acquisition professionals.
- Compare timelines and outcomes across multiple capabilities.
- Highlight manual, repetitive, or error-prone steps.

Research Questions:

- Which tasks are most time-consuming, and why?
- How do bottlenecks ripple through the broader development pipeline?
- What is the return on investment of streamlining DOT-P (e.g., fielding speed, documentation quality, or decision clarity).

Phase 3. Industry Scouting and Technology Alignment: NSW should not reinvent the wheel. This phase focuses on discovering existing solutions that could be adapted to NSW's unique needs.

Objective: Identify commercial and government-developed tools that could support a digital DOT-P prototype.

Key Actions:

- Engage with DIU portfolios and SOCOM AT&L offices.
- Explore partnerships with software companies specializing in modeling, simulation, AI, and collaborative planning tools.
- Evaluate parallel efforts at Air Force Futures or Army Futures Command.

Deliverables:

- A landscape report or tool comparison matrix
- Early-stage concept mockups or wireframes
- Identification of potential MVP co-development partners

Phase 4. Facilitate Prototyping and Iteration

Objective: Test early prototypes in live or simulated environments and gather iterative feedback. Innovation requires experimentation. This phase encourages small-scale testing and open collaboration.

Key Actions:

- Conduct trials at venues like JIFX using low-fidelity demos.
- Host an NSW Innovation Sprint or Hackathon in partnership with NPS, DIU, or industry.
- Collect structured feedback using real (non-sensitive) operational data.
- Prioritize modular designs and agile development cycles.

Guiding Principles:

- Build in flexibility for evolving policies and user needs.
- Embrace early failure as a necessary step toward validated solutions.

Phase 5. Expand the Network and Broadcast Results: The long-term success of this research depends on community building and open knowledge sharing.

Objective: Establish a durable innovation network and share results for broader DoD impact.

Key actions:

- Publish progress through white papers, tech forums, and open-access briefings.
- Leverage SOCOM's interest in digital transformation to host symposia.
- Collaborate with other services, labs, and academic institutions to scale impact.

G. EXPLORING COMMANDER'S INTENT MODEL-BASED ENGINEERING OPTIONS AND PROGRAM EXECUTIVE OFFICE-MARITIME DIGITAL INITIATIVES AS RELATED RESEARCH AVENUES

Future researchers should also explore ongoing digital capability development initiatives, such as the Commander's Intent Model-Based Engineering Options (CIMBEO) tool developed for the UK Ministry of Defence and USSOCOM's future programs. CIMBEO applies model-based systems engineering (MBSE) principles to support structured decision-making, capability validation, traceability, and optimization—all core requirements identified in this capstone for improving DOTmLPF-P analysis.

Specifically, CIMBEO's approach to mapping capability gaps, conducting risk analysis, and providing traceable decision support demonstrates a strong potential alignment with NSW's desired DOTmLPF-P augmentation tool attributes. Features such as automated document generation, mission modeling, data traceability, and integration with broader capability management architectures reflect the themes raised by NSW stakeholders during interviews and workshops.

Additionally, the Program Executive Office (PEO)-Maritime Technology Office (MTO) has identified transition challenges from research and development to programs of record that closely parallel the struggles of the NSW community. Their stakeholder documentation highlights the need for a transparent, repeatable, and comprehensive digital framework to manage capability development, a problem set nearly identical to the one addressed in this capstone.

Given these synergies, future NPS students should investigate

- Comparative Analysis: Evaluate how CIMBEO's structure, workflows, and MBSE-driven decision frameworks can inform the development of DOT-P digital tools for NSW.
- Technology Integration Opportunities: Investigate if implementing CIMBEO-like features could hasten NSW's shift to a digital, transparent capability assessment environment.
- Stakeholder Coordination: Engage with PEO-Maritime and USSOCOM Futures personnel to evaluate lessons learned, identify potential pitfalls, and explore opportunities for collaboration on common toolsets or methodologies.

Understanding and leveraging these ongoing efforts can significantly reduce duplication, accelerate prototyping, and enable NSW to leapfrog existing challenges by building on solutions developed elsewhere in the community.

H. FINAL THOUGHTS: A LIVING RESEARCH THREAD

This capstone uncovered a promising software concept and a broader recognition across NSW and SOF that the DOTmLPF-P process is overdue for transformation. This is not a fixed problem but a dynamic, systems-level challenge requiring continuous experimentation and feedback.

Future students and researchers are encouraged to approach this work with curiosity, humility, and a warfighter-first mindset. The most meaningful outcome may not be a polished app; it may be a mindset shift within NSW that proves its development process can be faster, wiser, and more responsive.

APPENDIX A. DRAFT AREA OF INTEREST (AOI) STATEMENT FOR DOTMLPF-P TOOL

A. PROBLEM STATEMENT

The capability development process is cumbersome, relying on labor-intensive staffing processes. Chief among them is the DOTmPLF-P Analysis, which can take two to three months for each capability. This leads to balloon time and poorly informed resourcing decisions. A tool is required to augment the staffing team conducting each element of the DOTmLPF-P analysis. This tool would increase the speed and accuracy of the resulting recommendations and enable capability development to stay abreast of the rapid pace of technological change.

While this Area of Interest (AOI) statement is agnostic to the specific methodology and software approach, it recognizes that emerging AI tools have the potential to augment human operators and staff personnel by processing large volumes of information quickly, generating requirements documents, and conducting impact analysis.

B. CHALLENGES IN IMPLEMENTING SOFTWARE SOLUTIONS FOR DOTMLPF-P ANALYSIS INCLUDE

(1) Enabling human analysts across multiple echelons of command and various stakeholder communities to effectively direct and interact with the system.

(2) Verify the accuracy of and the sources of information for the generated analysis.

(3) Ensure the tool’s analysis and recommendations align with policy, strategic guidance, and the commander’s intent.

(4) NSW seeks innovative solutions to leverage software tools to increase the speed, effectiveness, and quality of DOTmLPF-P analysis within the capability development process while addressing these challenges.

C. DESIRED SOLUTION ATTRIBUTES

1. Information Synthesis and Analysis

(1) Accurately ingest, process, and analyze large volumes of data, including a wide variety of data types and formats (complete/incomplete, structured/ unstructured, and multiple data schemas) from within the enterprise relevant

to DOTMPF-P Analysis, financial, impacts analysis, and DODAF architecture considerations.

(2) Identify key patterns and relationships within the enterprise data.

(3) Assist with analyzing impacts across the DOTmLPF-P categories.

(4) Assist with searching through the data, documentation, and information space to find all relevant information, guidance, regulations, etc., that are relevant to the analysis

2. Analysis Document Generation

(1) Produce or enable draft DOTmLPF-P analysis documents in approved formats

(2) Provide references to supporting documentation and underlying data

(3) Enable easy human review, modification, and refinement of all products

(4) Ingest or upload commander's intent, higher headquarters guidance, and other documentation to shape outputs according to commander's priorities

3. Intuitive User Interface

(1) Provide users with an intuitive interface that allows user control at a non-technical level of abstraction

(2) Guide the user through all critical elements of information and areas of analysis

(3) The platform should provide a collaborative workspace for the joint development of products

(4) The platform should be customizable for different user types across the various disciplines involved in DOTmLPF-P analysis.

4. Transparency and Reliability

(1) Provide accurate references back to data used for analysis to enable 100% source verification by the user

(2) Provide precise insight into the relevant dependencies being considered in the generated analysis.

(3) Highlight when key information is not available to make a high-quality recommendation. If key information is not available, do not make a recommendation.

5. Human-Machine Teaming

(1) As a first principle, the system/solution/tool/platform should employ human-machine teaming and heavily leverage the human user's expertise.

(2) The solution should seek to augment human ingenuity, creativity, and critical thinking, not replace it.

(3) The system must provide the user with a complete train of thought and analysis of the thought process, with all supporting documentation and data used, to facilitate the human user's validation and verification of 100% of the analysis. The system is not intended to replace human analysis.

6. Operational Security and Information Assurance

(1) Operate in classified environments x

(2) Personnel must be able to perform work in classified environments up to the TS/SCI level or equivalent Authority to Operate (ATO) at IL6 or higher.

(3) Provide audit trails and explain any AI-generated content, analysis, or recommendations.

(4) Compartmentalize information as required and implement user access controls.

7. Solution Architecture and Requirements Engineering

(1) As Peyman Khodabandaloo points out in his book, *B2C-B2B: The Role of a Marketing Continuum in Software Design*, a high degree of detail about all of the interdependencies across a given system is crucial in the design of enterprise software (Khodabandehloo, 2023a, p. 15). To this end, the solution approach should commence with a comprehensive, expert analysis to define the platform's specification. Due to the enterprise-level complexity of capability development in general, and DOTmLPF-P analysis in particular, these questions should be answered, to the extent possible, at the beginning.

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APPENDIX B. REFLECTIONS (A.K.A. THE PARKING LOT)

As this research journey concludes, we reflect on a range of content that we gathered along the way and considered for inclusion in this capstone report. While the material in this Appendix did not find a logical home in the final report, and remains something of a disorganized mess, our thesis advisor insisted we keep it as an appendix in the event a future student may find within it some hidden value.

This appendix comprises lessons learned and insights gained that proved informative in shaping our understanding of NSW's capability development challenges, defense integration of emerging technology, and the research process. By preserving these reflections, we aim to reinforce the project's value, clarify complex concepts, and ensure that the knowledge gained can inform ongoing and future initiatives.

A. THE FORMULA 1 ANALOGY: CAPABILITY DEVELOPMENT AS A HIGH-PERFORMANCE TEAM

This capstone project proposes a novel approach to improvement. The following analogy directly supports and describes our contribution. An effective capability development process can be compared to a Formula 1 racing team, where each element must function seamlessly to ensure mission success:

- The warfighter serves as the driver, responsible for executing the mission precisely.
- The vehicle represents the various capabilities and technologies enabling operational effectiveness.
- The pit crew comprises the support staff, acquisition personnel, and resource enablers who refine and optimize performance.

In Formula 1, every component of the race team is focused on incremental improvements, constantly refining processes to gain even the slightest competitive edge. Likewise, capability development in NSW must embrace this mindset, where staff and acquisition professionals continuously optimize processes to improve the warfighter's effectiveness.

Operational deficiencies do not always stem from the warfighter's limitations; they often arise from inefficiencies in the supporting staff and capability development system. In Formula 1, a delayed pit stop can drastically affect the race's outcome. Slow and misaligned acquisition processes in NSW can also cost operational success. Therefore, NSW must adopt a structured, iterative improvement approach to capability development, ensuring that investments are directed toward technologies and resources that enhance mission success while divesting from ineffective capabilities.

A specific example should help to demonstrate what the current process looks like from one perspective.

B. OTHER REFLECTIONS

NSW Example: Misalignment between Capability Development and Operational Needs

NSW operates in an increasingly complex environment where capability development must be directly linked to operational requirements and strategic objectives. However, systemic inefficiencies—fragmented decision-making, a lack of mission thread analysis, and misalignment between operational and acquisition stakeholders—hinder the process. The following case study illustrates these challenges by developing a maritime craft, demonstrating the need for structured ME and digital transformation in NSW's capability development process.

The Problem: A Maritime Craft without Operational Traceability

A maritime craft program of record was designed to enhance speed and endurance, yet it lacked clear traceability to an approved Concept of Operations (CONOPS) or mission thread analysis. Without explicit justification linking capability enhancements to operational necessity, NSW struggled to articulate the requirement within SOCOM's resourcing framework. This misalignment complicated resource allocation decisions, diluted prioritization efforts, and weakened NSW's ability to compete for funding.

The absence of structured analytical tools and a standardized framework for defining operationally relevant capabilities forced NSW to advocate for these improvements without the necessary data-driven justification. The failure to integrate ME in the early stages of capability development illustrates a broader inefficiency in NSW's acquisition and resourcing process.

Identified Challenges

Fragmented Justification for Capability Enhancements

The craft's Key Performance Parameters (KPPs) and Key System Attributes (KSAs) were developed without structured mission thread validation, leaving NSW without a defensible, data-backed argument for its necessity. This lack of analytical rigor created friction in SOCOM's prioritization process and hindered funding approval.

Strategic Misalignment Across NSW Echelons

NSW lacks a standardized framework to synchronize operational needs with long-term acquisition priorities. The absence of a repeatable ME methodology means that NSW groups struggle to prioritize investments, assess trade-offs, and advocate for critical capabilities at the SOCOM and service levels.

Relative Advantage: Its Utility for NSW and Research

Analyzing the factors influencing innovation diffusion within organizations is essential to understanding NSW's challenges in adopting emerging technologies. Everett Rogers' Five Factors of Innovation Diffusion (2003), relative advantage, compatibility, complexity, trialability, and observability, offers a valuable framework for diagnosing why some innovations succeed while others stall. This section applies Rogers' framework to NSW's capability development process, highlighting how systemic barriers hinder technology integration and how ME and digital transformation can drive more effective adoption. Chapter II will explain these factors further.

Rogers' Five Factors of Innovation Diffusion provides a critical lens for understanding how new ideas and technologies are adopted within an organization, and this research applies that framework to propose leveraging emerging technology through a software tool designed to improve DOT-P analysis. These five factors determine the speed and success of an innovation's adoption. Relative advantage refers to the perceived superiority of an innovation over existing methods, while compatibility assesses how well the innovation aligns with current values and operational needs. Complexity considers the difficulty of understanding and implementing the innovation, and trialability reflects the ability to experiment with it on a limited basis before full-scale adoption. Lastly, observability influences how visible the benefits of innovation are to others, shaping broader acceptance. For NSW, understanding these factors is essential in overcoming resistance to change and ensuring that digital transformation efforts, such as AI-enabled decision-making tools and ME methodologies, are successfully integrated into the capability development process. NSW risks continued stagnation without this structured approach to innovation adoption, where promising technologies remain underutilized due to organizational inertia and misalignment with operational needs. This capstone will help identify the need, gap, and requirement for digital tools to improve the processes.

Rogers captured a critical framework to help organizations understand and overcome barriers to innovation adoption, ensuring that new ideas and technologies can be effectively integrated into existing systems. Throughout this analysis, it is essential to highlight the importance of relative advantage as the standout factor that can make or break a product in the industry. Incorporating Rogers's Five Factors of Innovation Diffusion (2003) can provide a framework for understanding why NSW's current capability development processes have failed to integrate emerging technologies effectively. The absence of relative advantage where new digital tools fail to demonstrate superiority over entrenched manual processes creates resistance to change. A clear example is that staffing could take months to reach a decision. Why is that? Because of the time it takes to analyze the effects of the decision, or because the staff is understaffed and working on several projects at a time? Or could it be because there is a shift in strategic focus every week? The answer is all of the above and more. NSW's existing acquisition policies are incompatible with modern innovation cycles, preventing the seamless adoption of new methods, process improvement-driven tools, or emerging technology experimentation. High complexity and low trialability also highlight the rapid prototyping and experimentation necessary for operational integration.

The combatant craft acquisition case study discussed in Chapter 2 is one of many examples of NSW's misalignment in capability development. The failure to integrate mission thread analysis into the justification for key performance parameters (KPPs) and key system attributes (KSAs) led to a lack of operational alignment, reducing NSW's ability to negotiate resource allocation effectively within SOCOM. As Rogers (2003) asserts, innovations that lack observability and clear visibility into their impact fail to gain traction. These inefficiencies are exacerbated by the lack of digital tools capable of mapping capability needs to operational effects, reinforcing the need for structured digital engineering processes.

Mission Engineering Overview

Initially, this research's intent and the expected outcome were to provide either a recommended approach to drive the adoption of ME or propose a means to discontinue efforts in ME integration with in-depth analysis to support it. This will include recommendations on integrating ME and threads into NSW's strategic planning and decision-making, as well as operational planning and approaches. As technology and threats evolve, NSW must develop a structured, repeatable process that aligns with the Department of Defense's Mission Engineering Guide (MEG)**,** Version 2.0, a pivotal document that outlines methodologies for mission-based capability development across the U.S. military (Office of the Under Secretary of Defense for Research and Engineering, 2023, p. 3). ME and mission threads may be valuable tools for streamlining capability development. This research analyzes how NSW can use ME to (a) improve capability prioritization, scaling, and transformation and (b) enhance leadership education and decision-making about capability development.

Upon further assessment and through better understanding from initial key stakeholder interviews and through research of policy and doctrine, we were able to shape our capstone project to be as influential and impactful to the NSW capability development process as possible. Integrating Mission Threads and Mission Engineering Threads into the NSW capability development process offers an opportunity to align operational outcomes with broader strategic objectives. This study addresses the lack of awareness and understanding of these methodologies within NSW, which hinders effective prioritization and scaling of capabilities. By exploring how these tools can enhance decision-making, streamline processes, and ensure the efficient deployment of critical technologies, this research aims to address these gaps and propose solutions for NSW to maintain agility in dynamic operational environments.

This section will provide a primer on ME and lay out its background, context, and relevance to NSW's capability development process.

The Department of Defense's MEG outlines methodologies for mission-based capability development across the U.S. military. The guide's core principles provide a framework for applying ME to NSW's current challenges, particularly in its capability development processes. It highlights the importance of military acquisition processes in effectively delivering capabilities to the warfighter. As described in Professor Mortlock's research, "The Department of Defense is a performance-based bureaucracy that focuses on time, schedule, and budget to evaluate the performance of its programs. The DoD is driven to perform its national security mission and maximize results, making every process and activity as predictable as possible" (Mortlock, 2022, pp. 9–10).

The MEG instruction was approved on October 01, 2023, and it applies to all DoD organizational entities, including the Military Departments, Combatant Commands, and Defense Agencies. It has restructured defense acquisition guidance to enhance process effectiveness by implementing the MEG. It is an example of a bureaucratic culture shift to process improvement and developing flexibility within the system to support new technology, new threats, and, most importantly, the warfighter. Since the 2018 National Defense Strategy (NDS) was published, the Defense Acquisition System (DAS) has evolved "to deliver performance at the speed of relevance" (Department of Defense [DoD], 2022a, p. 4). This aligns with the thesis's goals of enhancing NSW's capability development process to maintain operational readiness and effectively respond to evolving threats. The Defense Innovation Board (DIB) reported systemic challenges and the need for cultural change within the DoD to foster innovation (Defense Innovation Board, 2024, p. 2). This supports this thesis's research aim of enhancing NSW's adaptability and innovation.

By working closely with SOF, conventional units can accelerate the development cycle of new capabilities, ensuring that the entire force remains adaptable and prepared to face evolving threats, enhancing the overall responsiveness and effectiveness of the U.S. military. Many experts agree with this theory, and as Dr. Blanken expresses in his article, "A simple and cost-effective way to improve existing innovation efforts in the field is by aligning military graduate researchers with deployed special operations units to prototype concepts and technologies rapidly" (Blanken et al., 2020). The combination of acquisition framework development, SOF implementation, and graduate research can be a powerful catalyst for innovative capability development.

This literature review synthesizes the key concepts outlined in the MEG and examines its potential to transform NSW's developmental process. It underscores how ME can align strategic objectives with tactical outcomes, prioritize capability needs, and improve mission execution. By focusing on mission threads and Mission Engineering Threads (METs), this review explores how the NSW community can better implement ME to improve its capability development.

Background of Mission Engineering

ME decomposes complex military missions into their constituent parts, allowing military leaders to assess relationships and gaps across an end-to-end mission approach. The MEG describes ME as a critical enabler for improving the Department of Defense's ability to make informed decisions by leveraging quantitative mission-based data, further defining ME as "an interdisciplinary process encompassing the entire technical effort to analyze, design, and integrate current and emerging operational needs and capabilities to achieve desired mission outcomes" (Office of the Under Secretary of Defense for Research and Engineering, 2023, p. 3). Specifically, ME integrates operational needs with system capabilities, resulting in better-informed resource planning and a more agile acquisition process. For NSW, this methodology is essential for addressing inefficiencies in how the organization scales and prioritizes technological advancements.

At the heart of ME lies the concept of Mission Threads, which outline the sequence of tasks required to accomplish operational goals. These threads provide a structured, repeatable process that aligns mission planning with capability integration, making them invaluable for NSW's transformation efforts. Furthermore, METs assign specific actors to these mission tasks, such as personnel, systems, and organizations, ensuring that each task is completed within the required operational framework.

Interagency coordination is an area where MEG faces challenges. Historically, integration and interoperability have consistently been an underlying issue within the

DoD and across federal organizations. It was captured in the 1985 Staff report to the Committee on Armed Services, "the difficulty of these issues is the quickening pace of the technological revolution, the increasing and changing demands of protecting the U.S. security interests in a dynamic international environment and the resistance to needed changes by a substantial portion of the defense bureaucracy" (Locher, 1985, p. 1). The instruction primarily focuses on DoD entities but may not fully address the complexities of working with other federal agencies, international partners, and private sector entities. Programs that require extensive interagency or international collaboration can face significant hurdles. The lack of detailed guidance on collaboration mechanisms and alignment of policies and procedures from different agencies can lead to delays or conflicts in multi-agency acquisition efforts. This is particularly evident in Sections 3.3, which outline some responsibilities but does not provide specific strategies for ensuring smooth interagency coordination. The authority to collaborate is there, but the "how to" details are missing.

The application of ME in NSW's capability development may address some of the command's pressing issues, from integrating new technologies more quickly to educating leadership on the utility of mission threads in strategic and tactical planning. By applying the methodologies described in the MEG, NSW may benefit from more streamlined decision-making processes, improved operational outcomes, and faster adoption of emerging capabilities.

Mission Engineering Analysis/Discussion

Through its structured, data-driven approach, ME allows for rigorous analysis of mission objectives and offers a scalable methodology for aligning operational goals with technological capabilities. Because ME can be complex and highly technical, NSW faces adoption challenges outside the systems engineering field. A software tool that makes ME easier and more intuitive for laypeople to employ could help NSW increase the adoption of the practice at the operational planning level. This could help test and demonstrate to what extent NSW stakeholders can use mission threads and METs to streamline decision-making, prioritize resources, and scale capabilities from tactical to strategic levels.

One of the key insights from the MEG is the importance of digital engineering in the ME process. By employing digital tools and model-based systems engineering, NSW can create accurate simulations of mission scenarios, enhancing their understanding of how different technologies impact mission outcomes. Digital engineering also enables rapid prototyping and iterative development, which are critical for NSW's need to adapt quickly to evolving threats.

METs can also help address NSW's challenges with capability prioritization. By defining clear roles for systems and personnel within mission threads, METs provide a structured approach to capability integration that can be scaled across the force. This process can help NSW better prioritize its resources, ensuring that the most critical technologies and capabilities are integrated into operations efficiently.

ME Theories

The MEG offers a comprehensive framework that NSW can adopt to enhance its capability development process. By integrating mission threads and METs into its operations, the NSW can address existing scaling, prioritization, and technological integration challenges. This research aims to demonstrate the value of ME in NSW's operations, showing how it can transform the command's approach to capability development and improve overall mission outcomes.

Naval Special Warfare (NSW) can serve as a critical catalyst for innovation in capability development by leveraging its unique operational expertise and the MEG principles. NSW's ability to operate in high-risk, complex environments provides a valuable platform for testing and refining emerging technologies and new tactics, techniques, and procedures (TTPs). By embedding NSW in the development process, conventional forces and the broader defense community can benefit from the rapid iteration and real-world validation NSW operators can provide.

This approach echoes the historical role of elite units as innovation incubators; as Cohen has noted, "Elite units are often defended as military laboratories for new tactical systems. Such units, it is argued, can try out new doctrines, test their validity, and then spread the doctrines to the rest of the army" (Blanken et al., 2020). NSW's involvement in capability development aligns with this model, offering a streamlined pathway to integrate cutting-edge technologies and adaptive strategies into the broader military framework. The recommended next steps for NSW are to educate leadership on the utility of ME and initiate pilot projects that incorporate mission threads into critical operational plans. Additionally, integrating digital engineering tools can provide NSW with the quantitative data to make informed decisions about capability prioritization and scaling.

The operation of the MEG Framework presents both significant advantages and notable challenges. On the positive side, the instruction promotes flexibility and adaptability through tailored strategies and multiple pathways designed to expedite shared understanding and the prioritization of capabilities. On the other hand, there are potentially significant setbacks from adopting this framework without proper implementation across the NSW and SOF communities and other federal entities or international partners. This approach aims to enhance the responsiveness of the acquisition process, enabling the DoD to meet urgent operational needs better and leverage emerging technologies. As highlighted by Stacy Cummings, former Under Secretary of Defense for Acquisition and Sustainment (USD(A&S)), "And then most importantly, we wanted to accelerate delivery of timelines, so that we can get the capability into the hands of the warfighter faster.''[6] The framework outlined in the instruction requires all stakeholders to adapt to the new processes and embrace a cultural shift, which may take time and necessitate constant reflection, to accomplish Ms. Cumming's and other policymakers' aspirations.

Lessons Learned for NSW Officers at NPS Conducting Innovation Capstones: Importance of Operational Sponsors

One of the most valuable takeaways from this capstone is the necessity of operational sponsorship to ensure relevance and buy-in from NSW leadership. The early involvement of WARCOM N8 was instrumental in shaping the research direction, providing insights into NSW's challenges, and ensuring alignment with broader operational priorities. Additionally, engaging with DIU, NAVWAR, and SOCOM J8 helped me understand the cross-functional nature of innovation and acquisition.

Recommendation: Future capstone officers should secure a committed operational sponsor early in their research process to ensure their efforts directly address NSW's most pressing needs.

Lessons Learned for Process Improvement and Digitization in the Navy

The Role of Mission Engineering

One of the primary insights gained through this research is the power of mission engineering as a structured approach to aligning operational needs with technological solutions. By mapping mission threads, NSW can better define requirements, improve acquisition efficiency, and ensure new capabilities directly support warfighter effectiveness.

Recommendation: NSW should integrate mission engineering frameworks into capability development to ensure traceability from concept to execution, reducing misalignment and inefficiencies.

Data-Driven Decision-Making

The capstone highlighted the importance of digital engineering, AI, and machine learning in supporting more informed decision-making. By leveraging AI-powered DOTMLPF-P analysis, digital twin modeling, and real-time data analytics, NSW can move away from traditional, manual-intensive processes and toward a more responsive, predictive acquisition approach.

Recommendation: NSW must accelerate the adoption of digital engineering tools to enhance capability planning, reduce risk, and optimize resource allocation.

Reducing Parochialism and Sideways Thinking

A major challenge identified was the siloed nature of NSW capability development, where different teams and commands operate independently, often leading to redundant efforts and inefficiencies. Breaking down these silos requires cross-functional collaboration and a shift in cultural mindset towards greater transparency and shared purpose.

Recommendation: NSW leadership should institutionalize joint capability development forums, digital collaboration platforms, and integrated feedback loops to align enterprise efforts.

Lessons Learned for Officer Development in Innovation and Capability Development

Encouraging Officers to Learn the Acquisition Process

Many NSW officers enter leadership roles with limited exposure to the acquisition process, which hinders their ability to influence capability development decisions. Understanding requirements generation, budgeting cycles, and procurement strategies is critical for officers leading future modernization efforts.

Recommendation: NSW should establish formal acquisition literacy programs for officers, integrating coursework on requirements development, contracting mechanisms, and capability fielding timelines.

Embedding Officers in the Innovation Ecosystem

NSW must embed officers in key innovation hubs such as DIU, AFWERX, and NAVWAR to foster a culture of innovation and provide them with first-hand experience in emerging technologies, rapid prototyping, and alternative acquisition pathways.

Recommendation: NSW should create fellowship programs, industry exchange opportunities, and rotational assignments that expose officers to the DoD innovation ecosystem.

Aligning Officer Development with NSW's Long-Term Needs

Innovation and capability development should not be isolated from NSW's broader mission. Officers must develop a long-term perspective on how their contributions align with warfighter effectiveness, strategic deterrence, and national defense priorities.

Recommendation: NSW should integrate innovation training into officer career progression models, ensuring that future leaders are tactically proficient and strategically aware of how capability development impacts mission success.

Path Forward

This capstone has demonstrated the critical need for NSW to embrace ME, digital transformation, and structured capability development processes. Future officers must leverage their time at NPS to build relationships with operational sponsors, develop acquisition expertise, and drive cross-functional collaboration to advance NSW's modernization efforts.

The following steps involve translating these lessons into institutional recommendations for NSW, ensuring that innovation is not just an initiative but an embedded cultural norm within the force. NSW officers have the opportunity—and the responsibility—to shape the future of special operations capability development by embracing agility, digital transformation, and mission-driven problem-solving.

Recommendations for Better Leveraging the Efforts of Future NPS Students

Future research within this space would greatly benefit from the following recommendations:

- Improve the grad school program to increase ROI:
- NSW should heavily leverage non-SEAL students outside the DA department and push LS to collaborate with outside disciplines for all capstone projects.
- Instead of choosing one thesis topic early and wasting your whole program on it, do several narrow, discrete projects – all of which will provide tangible value – and then choose the best one to flip up into a Thesis.
- Do as many of those projects as possible with Silicon Valley and the greater tech innovation ecosystem.
- All AD4I capstones should be required to be ICW another student from another major – get those departments on board.
- Recs for pursuing AI integrations:
- Do not pursue AI integrations unthinkingly or for the sake of pursuing AI
- Pursue agnostic solutions that lead to the desired outcome.
- Focus heavily on what that outcome should be.
- Specify what is needed.
- Software rapid prototyping – at the command/staff/unit/individual level.
- Provide standing contracting vehicles for Software Prototyping As A Service (ex. Deloitte Optimal Design prototyping division).

- Prototyping must be feasible ON secure systems, WITH secure data to test it.
- NSW should heavily leverage Hackathon opportunities (leverage the brand) – NPS, Shield Capital, etc.
- Try For Free prototyping Software-as-a-Service (SaaS).
- Overall, NSW should foster the ability to embrace emerging technology, apply AI use cases, implement and test as much as possible, find the absolute limitations and breaking points of emerging tools, give them every opportunity to provide actual, tangible value, and learn how to meaningfully assess the value, outputs, accuracy, and epistemology of recommendations and analysis provided.

C. "MODEL-DEFINED WARFARE: QUESTIONS AND IMPLICATIONS FOR A NEW ERA"

This section was adapted from a paper written for a class at NPS, CS4333: Current Directions in AI. It examines a few recent academic papers on AI and presents relevant questions.

The practice of warfare changes over time, based on advancements in technology and the effect those advancements have upon the societies that employ them. Some might go so far as to say that "the only constant is change," and this may very well be true. However, there is another variable related to change that is not constant: the *rate* of change. Whereas in the distant past it would be most common to measure change across centuries, over even across millennia, in today's world change happens so fast it can barely be measured fast enough for us to comprehend it and cope with it. Soldiers living a thousand years ago might not see any change in warfare during their lifetime or even hear about significant differences when listening to stories from their parents, grandparents, and great-grandparents. Contrast that with the lives of servicemembers of today: we experience massive, culture-defining changes to the practice of warfare multiple times within not just a single lifetime, but within a single *career*. This makes it important to hone the ability to recognize changes as they are occurring, and to adapt in real time as we shift from one era to the next.

This section will assess aspects of the transition from hardware- and platform-defined warfare, characteristic of much of the late 20th century, to software-defined warfare, driven by the advent of modern information technology. It will also explore the ongoing shift into the era of "model-defined warfare." The analysis relies mainly on three sources:

- Mulchandani, Nand, and Lt General (Ret) John N. T. "Jack" Shanahan. "Software-Defined Warfare: Architecting the DoD's Transition to the Digital Age." *Center for Strategic and International Studies*, September 6, 2022.
- Kase, Sue E., Chou P. Hung, Tomer Krayzman, James Z. Hare, B. Christopher Rinderspacher, and Simon M. Su. "The Future of Collaborative Human-Artificial Intelligence Decision-Making for Mission Planning." *Frontiers in Psychology* 13 (April 4, 2022).
- Mahowald, Kyle, Anna A. Ivanova, Idan A. Blank, Nancy Kanwisher, Joshua B. Tenenbaum, and Evelina Fedorenko. "Dissociating Language and Thought in Large Language Models." arXiv, March 23, 2024.

In "Software-Defined Warfare: Architecting the DoD's Transition to the Digital Age," Nand Mulchandani and John "Jack" Shanahan present arguments encouraging the Department of Defense (DoD) to evolve past slow, monolithic hardware platforms toward faster, more updateable systems (Mulchandani & Shanahan, 2022, p. 2). Their opinions are certainly what we would consider to be "informed." At the time of writing, Mulchandani was the inaugural Chief Technology Officer (CTO) of the Central Intelligence Agency (CIA), having previously served as the CTO of the Joint Artificial Intelligence Center (JAIC), which was the predecessor to the DoD's Chief Digital and Artificial Intelligence Officer (CDAO). For his part, Jack Shanahan was a three-star General and the commander of the JAIC.

The Software-Defined Warfare (SDW) paper springboards off from Marc Andreeson's 2011 article, "Why Software is Eating the World," which argues that the proliferation of software into basically, well, everything, was beginning to force slow-moving companies built on legacy approaches to product development out of business, in favor of digitally-focused approaches (Andreessen, 2011). Mulchandani and Shanahan describe the DoD, which at the time of writing was still primarily focused on hardware-centric procurement programs, as a legacy, "industrial-aged…organization [which] lags woefully behind the software industry's state-of-the-art," notwithstanding the impressive feats that it has accomplished (Mulchandani & Shanahan, 2022, p. 1).

They go on to say that software is the critical component of the architecture that DoD needs to adopt in order to significantly improve the speed of decisions and execution while lowering the "marginal cost and speed of delivering new functionality" (Mulchandani & Shanahan, 2022, p. 2). The overall point is that like software-defined radio, a platform whose functionality is determined by software rather than hard-wired systems, can be updated, and functionality added, much more easily. This requires an arduous, but necessary, transformation into a "digital age, software-centric, more risk tolerant organization" (Mulchandani & Shanahan, 2022, p. 19). The paper goes on to imply that the software industry has provided the template for this transition, which the DoD can now adopt and implement.

These insights are timely, and the example of commercial industry is worth studying. However, the implicit claim in this paper that the commercial software industry has already mapped out a template for digital transition that the DoD merely needs to implement may be an overstatement and begs some questions. One such question might be, "to what extent does the template enacted by commercial companies directly map onto the DoD use case writ large?" Entire theses have been written about this question, including David Novotney's Purdue University thesis "Applications of Digital Engineering Tenets to Naval Special Warfare Requirement(s) Definition" (Novotney, 2023). Another question is, "What problems has the commercial software industry been solving?" and, more importantly, "Are these the same problems faced by the DoD?"

These questions notwithstanding, it is clear from both the content of the paper, and observation of world events over the past couple of decades, that the great power militaries of the world have indeed entered an era of software-defined warfare (Mulchandani & Shanahan, 2022). The implications of these questions deserve attention. To globally accept the assertion that DoD need look no further than the commercial software industry to figure out everything it needs to do to affect the digital transformation from legacy systems to software-defined systems, will create risks. There are conditions which exist in the military context, that are more complex than anything a commercial company has to contend with, and success and failure are measured by a different set of metrics. No doubt, there is much the DoD can and must learn from industry, but as we navigate through the era of software-defined warfare, we must keep these considerations in mind and navigate our own path through the unique operational complexity created by government-scale defense problems.

With the advent of AI, this becomes even more important. We argue that even while we are moving through the era of software-defined warfare, we are entering another era, both concurrently and in parallel. The SDW paper supports this as well, stating that "at some point, almost every piece of software will be AI-enabled and [often] embedded into hardware systems…" (Mulchandani & Shanahan, 2022, p. 11). Because almost all AI is fundamentally based on machine learning (ML) models, we think of this as the era of "Model-Defined Warfare" which is characterized by having almost every platform, system, decision-making process, and other aspects of warfare imbued with, embedded with, or controlled by AI systems based on machine-learning models.

Questions: This shift towards Software-Defined Warfare and Model-Define Warfare is potentially something akin to another Revolution in Military Affairs (RMA) and has important implications across many warfare areas. If there is indeed to be wide-ranging impact, there are at least two questions we should ask ourselves. Our research has not revealed the answers to these questions, but posing them is still valuable:

1. Does commercial industry always have the answers for DoD problems? The answer to this problem is not always obvious, but is most likely, "it depends."
2. Is it always advantageous to have defense hardware systems integrated via software, embedded with ML-based AI, and completely interconnected? Where should we rush into this approach, and where should we avoid it?

Once such area is in the practice of wargaming and operational decision-making, which is the topic of the paper "The Future of Collaborative Human-Artificial Intelligence Decision-Making for Mission Planning," by Sue Kase and several co-authors. In this paper, the Army Research Laboratory reports on research into the use of AI in wargaming, culminating in several insights and recommendations. They point to three main areas where they feel it is critical to infuse AI into the process using "warfighter-machine interfaces" (WMI): AI-directed decision guidance, computationally-informed decision-making, and realistic representations of decision spaces (Kase et al., 2022, p. 1).

As it becomes more and more challenging to collate and comprehend all of the operational actions and factors unfolding in the battlespace over the course of an operation, the authors argue, risk can begin to accumulate to a dangerous degree. When practicing wargaming, leaders utilize the Military Decision-Making Process (MDMP), which is used to manage the complexity of the unfolding situation on the battlefield and make good decisions. The complexity of today's battlefield makes it such that the collation of "all activities associated with operations is…increasingly…humanly impossible" (Kase et al., 2022, p. 1). The authors recommend applying AI technologies to this problem to augment human cognition within the decision-making process.

They acknowledge many challenges to this application, including the current gaps in AI capabilities to handle the complexity of scenarios involving "multiple actors, incomplete and possible conflicting information, changing unit…and environmental properties, the need to visualize…decisions across many spatial and temporal scales and domains" (Kase et al., 2022, p. 2). These challenges are not trivial – the paper highlights the fact that AI commonly becomes "overwhelmed by the breadth of possible optimal and near-optimal choices" – and they are central to the first of the paper's three recommended applications of AI, namely AI-Directed Decisional Guidance (Kase et al., 2022, p. 4). If they can be addressed however, this domain will provide benefits to military decision-makers by enabling them to "quickly and naturalistically navigate through possible choices," as long as the "decision landscape" is presented effectively (itself a non-trivial task) (Kase et al., 2022, p. 4).

This leads into the second of the three recommended domains for AI application: Computationally Informed Decision-Making, which refers to the use of data for analytics to inform recommendations for leadership decisions. This is the ability of power computing systems to capture, analyze, and store "all components, entities, and state spaces during complex decision-making" (Kase et al., 2022, p. 5). It is a critical component for managing the complexity of an unfolding battlefield simulation, with all the unknowns, shifting interdependencies, and cascading impacts of small changes promulgating through the simulated (and eventually, real) battlespace. Work still needs to be done before AI can truly provide military leaders with high-quality, trustable decision guidance that is truly "computationally informed."

The distributed nature of military operations also presents a challenge. The battlefield is no longer in one isolated location, but is spread out, sometimes with global distribution. Decision-makers at various levels of the operational chain of command are now geographically disbursed. Given the large computational system requirements for running the more powerful and sophisticated AI tools, this creates challenges. The advent of 5G technologies and edge computing may alleviate these challenges to a degree; however, this is still in development.

The final area addressed by this paper is Realistic Representations of Decision Spaces. This refers to the need to develop "new visualization approaches" which are appropriate for "dynamic environments characterized by changing rules, cognitive states, uncertainty, and individual biases and heuristics" (Kase et al., 2022, p. 5). The paper argues that providing a "combined perspective" – one that augments the human decision-maker's point of view by pairing it with AI to provide a "navigable AI-augmented decision space" – will more effectively contend with all of the uncertainties inherent in the complexity of modern decision-making (Kase et al., 2022, p. 5). The paper then goes on to predict that AI will eventually become adept at predicting and recommending Courses of Action, using reasoning that is "both abstracted and relatable…to enable transparency and trust without imposing undue cognitive burden" (Kase et al., 2022, p. 6).

Questions and Implications: This paper talks a great deal about "the AI's reasoning." Can it even be said, at this point, that AIs "reason"? We will discuss this question a bit further in the discussion of the next paper, which focuses on the difference between language and thought. Additionally, the distinction between "data-driven decision-making" and "computationally informed decision-making" seems non-trivial. Which is the better mental model? Military leaders have, for the past several years, been speaking at length about “data-driven” decisions. Data is good, but does this mindset in some ways abdicate the responsibility of commanders to employ human judgment in all decisions? At the end of the day, all data is imperfect, as is our understanding of it. Much of the growing confidence in emerging AI technologies seems to be based on successes which may or may not end up translating or scaling to defense use cases. As the paper points out, this success “in games such as Go, Chess…are based on games with complete knowledge of the…state of the world…whereas wargaming typically involves incomplete…uncertain, and /or deceptive information about the operational environment” (Kase et al., 2022, p. 3). Using the term “informed” instead of “driven” may be a healthier approach.

The third paper, “Dissociating Language and Thought in Large Language Models” by Kyle Mahowald, Anna Ivanova, Idan Blank, Nancy Kanwisher, Joshua Tenenbaum, and Evelina Fedorenko, highlights a critical characteristic of Large Language Models (LLMs) that seems to be often overlooked by senior leaders who push aggressively for the use of generative AI everywhere possible. This characteristic is related to the similarity between the neural networks used to power LLMs, and the modules within the human brain that those networks are (loosely) modeled after. First, it is important to note that the “neurons” within the “neural network” of AI systems do not correspond physically or functionally to the actual neurons within the human brain. However, for functional purposes, they “exhibit non-trivial similarities” (Mahowald et al., 2024, p. 9), especially regarding the neural network module within the human brain with controls the formation of human language.

This is the critical distinction highlighted in this paper: the difference between what the authors call “Formal Linguistic Competence – knowledge of linguistic rules and patterns – and Functional Linguistic Competence – understanding and using language in the world” (Mahowald et al., 2024, p. 1). Put another way, there is a distinction between the ability to construct language in the correct grammatical form and the ability to use language to accomplish goals. This is the difference between forming good sentences and actually thinking good thoughts. The reason this distinction is so critical, according to the authors, is that these two functions within the human brain are controlled by modules that are entirely separate from one another (Mahowald et al., 2024).

This raises another question: Can a technology like a LLM – based loosely upon the brain's ability to *form* language but not necessarily modeled on the capacity to cognate or to "perform arithmetic tasks, engage in logical reasoning, understand computer programs, listen to music, categorize objects or events, [or] reason about people's mental states" (Mahowald et al., 2024, p. 5) – be realistically expected to advance to the point of being able to truly "reason" to any degree of realistic abstraction, as described in the previous paper?

The paper does make a good point about the fact that while spoken language is not the same as thought, there is so much of what constitutes thought that is in fact communicated through language, within the "linguistic signal," and therefore it may be feasible that the current approach to LLMs may see systems which get much closer to something approximating actual reasoning ability, rather than just high-level language formation – but, as the authors are quick to point out, there are still "open questions" about this (Mahowald et al., 2024, p. 2).

It is telling that there are still open questions about how much reasoning ability can ever be achieved by a system modeled after the "formal" module within the brain, especially since LLMs still fall short on many of the "functional" skills that rely on cognitive capabilities "that go beyond formal competence" and the fact that "real-life language use is impossible without non-linguistic cognitive skills" (Mahowald et al., 2024, p. 9). According to the paper, these critical non-language specific functions are formal reasoning, world knowledge, situation modeling, and social reasoning, as listed below (Mahowald et al., 2024, pp. 9–11):

- "<u>formal reasoning</u>—a host of abilities including logical and mathematical reasoning, computational thinking, and novel problem solving" (p. 9).
- "<u>world knowledge</u>—factual and commonsense knowledge about agents, objects, properties, actions, events, and ideas" (p. 9).
- "<u>situation modeling</u>—the dynamic tracking of objects, agents, and events as a narrative/conversation unfolds over time" (p. 9).
- "<u>social reasoning</u>—understanding the social context of linguistic exchanges" (p. 11).

The authors make the point that "an average conversation requires the use of all these capacities, yet none of them are specific to language use" (Mahowald et al., 2024,

p. 11). This insight is sobering when we consider that LLMs are based primarily on language use, rather than on cognition. This insight is related to another issue highlighted by the authors: the conflation of language and thought. The authors claim this is a logical fallacy, which they call the "good-at-language → good-at-thought" fallacy (Mahowald et al., 2024, p. 2). This fallacy actually has its origins in Alan Turing's famous "Turing Test" from the 1950s, in which a computer system is determined to be intelligent or alive if it can make a human user not be able to distinguish whether or not he or she is interacting with a human or a computer (Mahowald et al., 2024, p. 2). This is itself based on the fact that "when we hear a sentence, we typically assume that it was produced by a rational, thinking agent (another person)" (Mahowald et al., 2024, p. 1).

Implications: The human tendency to conflate language and thought has led to a focus on creating systems that appear to interact with humans in an intelligent way by mimicking the formation of complex language. The progress of these systems in recent years is breathtaking, and the impacts will be both profound and long-lasting. It is therefore essential to fully understand those impacts, so that they do not become profoundly *negative*. A clear-eyed understanding of what these systems are, how they are built, and what they do (form and manipulate complex language) and do not do (actually think and reason), is critical to guiding their development and adoption.

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Acquisition Research Program
Naval Postgraduate School
555 Dyer Road, Ingersoll Hall
Monterey, CA 93943

www.acquisitionresearch.net