SYM-AM-25-349

Excerpt from the Proceedings

of the

Twenty-Second Annual Acquisition Research Symposium and Innovation Summit

Thursday, May 8, 2025 Sessions
Volume II

Collaborating With Universities and Small Business Innovation Research to Address the USMC's Critical Needs

Published: May 5, 2025

The research presented in this report was supported by the Acquisition Research Program at the Naval Postgraduate School.

To request defense acquisition research, to become a research sponsor, or to print additional copies of reports, please contact any of the staff listed on the Acquisition Research Program website (www.acquisitionresearch.net).

ACQUISITION RESEARCH PROGRAM
DEPARTMENT OF DEFENSE MANAGEMENT
NAVAL POSTGRADUATE SCHOOL

Collaborating With Universities and Small Business Innovation Research to Address the USMC's Critical Needs

Lt Col. Gabe E. Mata—1st Marine Logistics Group [gabino.mata@usmc.mil]

Dr. Ying Zhao—Naval Postgraduate School [yzhao@nps.edu]

Mr. Rory Polera—Tagup Inc. [rory@tagup.io]

Abstract

The U.S. Marine Corps (USMC) faces significant challenges in adapting its logistics framework to embrace modern technologies, notably in the integration of Artificial Intelligence (AI) and Machine Learning (ML) into its operational frameworks. The USMC needs holistic AI/ML integration strategies as well as organizations, technologies, and modern doctrines to facilitate AI/ML integration and pace with the state-of-the-art. We show how the USMC's 1st Marine Logistics Group (MLG) work with as technology transition partners in AI/ML applications with academia and industry. The focus is on material readiness and personnel readiness, therefore ensuring sustained future combat power.

The opportunities for such partnership and collaboration between defense, industry and academia would create an environment where not only the USMC acquisition professionals, policymakers, and/or end users can quickly adapt to emerging and relevant technologies, but also innovative ideas and solutions from academia and industries can be rapidly developed into the USMC operational needs. We show SBIR companies can start with small scale innovations and collaborate with the USMC to develop, test, and transit technologies truly useful for the warfighters. The process creates the momentum for SBIR companies and long-term plans to scale up the technology and maintain innovation cutting edges.

We present a couple of case studies. We discuss success stories and lessons learned from these efforts so far, what coordination is required in the future, and what capabilities and challenges USMC and SBIR collaborations present for the operational and acquisition communities.

Keywords: Small Business Innovation Research, SBIR, Marine Logistics Group, Artificial Intelligence, Machine Learning, Automation

Research Problems

The ongoing conflicts in the world vividly demonstrate how unmanned aerial vehicles (UAVs) and AI have revolutionized modern warfare. Furthermore, China's strategic military expansion in the South China Sea includes sophisticated surveillance systems and a rapidly growing naval presence, necessitating an advanced logistical framework to support these remote bases effectively.

The logistical demands of maintaining and operating advanced technological equipment in real-time conflicts are critically important. The conflict emphasizes the necessity for rapid resupply, repair, and maintenance to sustain operational capabilities. The USMC faces significant challenges in adapting its logistics framework to embrace modern technologies, notably in the integration of AI/ML into its operational frameworks as following needs (Mata, 2024):

- Need a holistic strategy: The USMC needs to integrate data science and AI/ML into the Marine Corps' logistical and operational frameworks. There is a critical gap to establish necessary doctrines and strategies to pace with the full utilization of emerging AI/ML technologies to assist decision-making and operational efficiency for the USMC. For example, China has made significant strides in integrating AI/ML into its military capabilities using coherent strategies such as "Military-Civil Fusion." This holistic

approach could potentially give China an edge in optimizing the use of AI in military logistics and operations. The United States must prioritize the seamless integration of AI/ML technologies into operational doctrines and logistics frameworks.

- Need to align organizations, technologies, and modern doctrines in a manner that enhances the USMC's capability to conduct posture and deterrence-focused operations (e.g., Global Position Network): It is a necessity for the USMC to align with technological and operational changes, advocating for a complete overhaul of logistical approaches to support modern military operations (Palmer, 1997; Deputy Commandant for Information, 2024).

Different roles in the acquisition community, such as contracting officers, program managers, senior leaders, and engineers can all contribute to the success and agility of the technology transfer. While military organizations such as the 1st MLG may provide critical needs, universities such as the Naval Postgraduate School can provide research and publish papers for innovative ideas, and small business innovation research (SBIR) companies such as Quantum Intelligence and Tagup can provide innovative ideas, implementation, and technology transformation of many innovation ideas.

SBIR is a bottom-up approach to innovation. Scope specifications do provide adequate bridging for industry partners to meet the resource sponsors requirements. The RFP process (e.g., length restrictions, demonstration requirements, contract structure) ensure that awarded SBIR contracts are mission oriented and outcomes-driven to drive competition and innovation opportunities. This process also maximizes utility of the product or system to the end-user and mitigates risk to the DoD.

Innovation with SBIR companies starts with a small scale. The USMC applications can bring momentum for the SBIR companies; however, it is critical for the SBIR companies to have a long-term effort up across the DoD and commercialization plan so the technology can be validated and achieve large-scale results.

The SBIR companies collaborating with DoD organizations such as the 1st MLG in Phase II product development, testing, production, and sustainment can promote innovation while preserving the efficiency and creativity of small teams. It is critical for SBIR companies to engage the end users in the early stage of Phase II. The 1st MLG provides the critical infrastructure, data, needs, and end users' requirements to train AI/ML models and validate the discovered insights.

Case Studies

One of the holistic strategies of the USMC's 1st MLG to integrate AI/ML technologies into the operations is to work as technology transition partners with academia and industry, specifically, the Naval Postgraduate School and small business innovation research companies such as Quantum Intelligence and Tagup, to not only ensure material readiness but also personnel readiness, therefore ensuring sustained combat power for the USMC.

The opportunities for such partnership and collaboration between defense, industry, and academia would create an environment where not only the USMC acquisition professionals, policymakers, and/or end users can quickly learn about emerging and relevant technologies, but also ideas and solutions can be rapidly developed, tested, and transitioned into the USMC operational needs.

A few initiatives are shown will be detailed as the research results:

1. Leveraging Artificial Intelligence to Learn, Optimize, and Wargame (LAILOW) framework by the Naval Postgraduate School: LAILOW was funded by the Office of Naval

Research (ONR) Naval Enterprise Partnership Teaming with Universities for National Excellence (NEPTUNE) program. LAILOW is a framework used for the USMC to machine-learn operation and collaboration patterns from historical data that can be used to predict future needs. The LAILOW framework uses historical data to predict future logistical needs and prepare for unforeseen circumstances through predictive modeling and data analytics. The LAILOW framework is also an optimization framework of logistical operations to maximize efficiency, readiness, and responsiveness by modifying logistical and business decisions and actions within the feasibility constraints. The LAILOW framework can leverage coevolutionary algorithms (Zhao et al., 2021) to explore "what-if" scenarios where logistics challenges that do not exist in the historical data, providing simulations and wargames to discover vulnerability, emerging scenarios that are not seen in the historical databases, and more importantly discover resilient solutions.

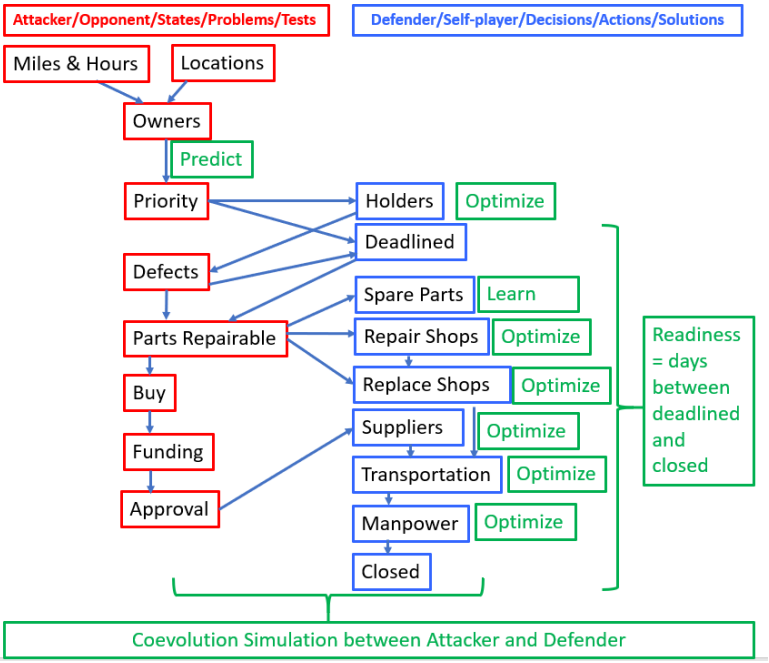

Figure 1. An Example of USMC Logistic Enterprise Equipment Maintenance and Logistics Process Using the LAILOW Framework
(Zhao et al., 2021)

2. Collaborative Learning Agents (CLAs) and risk management framework from Quantum Intelligence, Inc. (Quantum): CLAs were originally developed under a NAVSEA-funded SBIR Phase I/II. Currently, the 1st MLG will work with Quantum to customize the CLA system (Zhao & Zhou, 2019) developed by Quantum to address the USMC's challenges and needs, specifically the needs for the Warfighting Systems & Human Factors Integration (WHI) capabilities of integrating maintenance logistics with human elements for optimal return in minimum time, minimum injury, optimal safety, and minimum cost.

The technology addresses the gap in WHI to integrate AI/ML strategies and models into existing WHI databases and business processes that can significantly enhance the efficiency, effectiveness, adaptability of systems, and quality of tactical decision making.

The result would be a risk management framework with distributed AI agents. In the context of WHI, different end users may not have the rights to share data directly because of sensitive data of human elements such as personal identification information (PII). Quantum's innovative CLAs allow AI/ML models to be fused without the raw data. In addition, the risk

management framework would apply data-driven AI/ML to predict future risks based on fused AI/ML models and discover root causes of risks and generate actionable insights in strategic, operational, and tactical levels.

Figure 2 shows an example to demonstrate the CLAs using the data sets of the mishap and incident reports of a marine transportation equipment and related data resources from the I Marine Expeditionary Force (IMEF). The 1st MLG is one of IMEF's organizations.

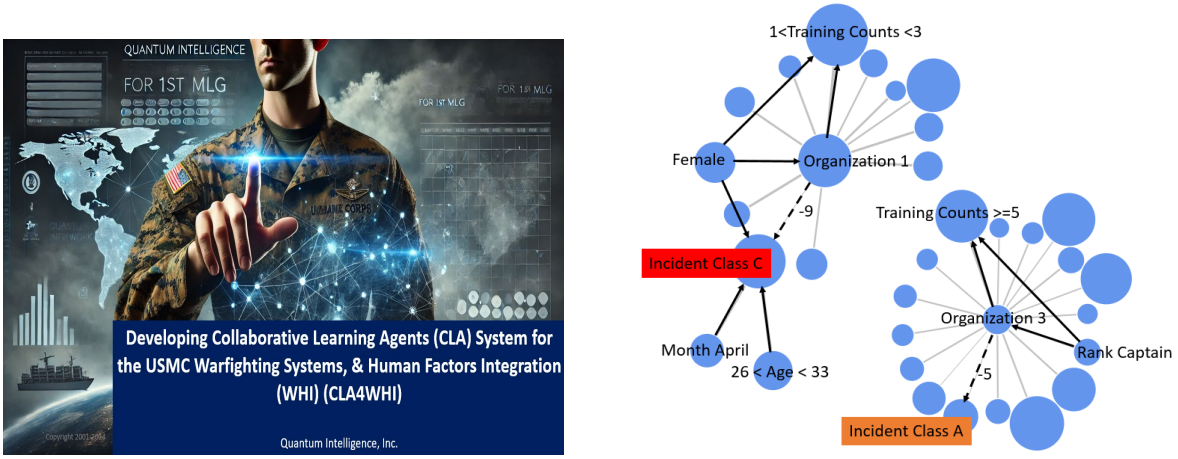

Figure 2. Counterfactual Knowledge Graphs From the Fused Patterns Using Collaborative Learning Agents From Quantum
(Zhao et al., 2025)

3. Manifest for logistics optimization using ML by Tagup Inc.: Tagup offers a commercially available logistics modeling and simulation (M&S) technology capable of improving contested logistics planning and decision-making as measured by total combat readiness. The software is currently deployed in production for the Marine Corps but is relevant to any branch of service, like the Navy, Air Force or Army. Manifest consists of a suite of software applications and service infrastructure that leverage the wealth of historical equipment operations, maintenance and supply data using AI/ML. Commanders and logisticians use Manifest to determine the optimal stocking policies by National Stocking Number (NSN) and location that maximize equipment readiness and combat power given cost, space, and manpower constraints.

Manifest is used to close the gap between dated logistics automated information systems and planning processes. Manifest was initially developed under a NAVAIR-funded SBIR Phase I/II and underwent testing for a subset of Marine Corps Class VII and IX ground equipment, including 880 Light Armored Vehicles (LAVs) and over 8,200 Medium Tactical Vehicle Replacements (MTVRs; Tagup, 2021). Manifest has since been generalized and operationalized for medical equipment and supplies (Class VIII). It is currently used by 1st Medical Logistics Company (1st MEDLOG), supporting their INDOPACOM Area of Responsibility (AOR) via three distinct supply nodes (Camp Pendleton, Marine Rotational Force-Darwin, and the Philippines). Ultimately, Manifest enables logisticians the ability to dynamically adjust their stocking policy/criteria (quarterly) by synchronizing many complex supply decisions and their relationship with time, so the warfighter has what they need when they need it. The AI/ML models and simulations dynamically inform logisticians on the optimal timing to replenish inventory by location based on lead times from their suppliers, expiration of perishable items, budget, and operating tempo (OPTEMPO).

For example, simulations of Class VIII materiel for 1st MEDLOG are used to quantify the tradeoff between readiness and cost, resulting in a potential increase in readiness and fill rate

for a fixed cost, or a reduction in surplus stock without compromising readiness or fill rate. This allows the USMC to effectively wargame/evaluate cause-effect relationships, ensuring the best equipment sets and supplies are available downrange for our operating forces.

Manifest has revolutionized the mobilization planning process by identifying the optimal equipment sets for deployment within seconds—a task that previously required hours or days. It also offers data-driven insights for replenishing medical equipment sets that consider current and incoming inventory to enhance readiness posture. Furthermore, it recommends the optimal inventory stocking policy by location, maximizing readiness, and fill rate while minimizing surplus stock. Using 2 years of historical transaction data (captured in DMLSS), Manifest has reduced operating costs by over 20%, all while maintaining readiness. Additionally, Manifest has right sized intermediate supply points. The same tools could be used to increase readiness by up to 13%; however, the unit decided to address budget cuts first.

More details of Manifest, its applicability to Class VIII, and results can be found in a March 2024 *Marine Corps Gazette* article titled "Machine Learning for Medical Logistics" (Fowler & Polera, 2024) or in a video published by 1st Marine Logistics Group (The 1st MLG, 2024).

Additional information from the original SBIR Phase II on Class VII and IX are available on request. References from users are also available upon request.

Figure 3 shows Manifest in action at 1st MEDLOG (when compared to the status quo). Manifest is used to enable more efficient inventory replenishment and mobilization planning operations, given the inventory on hand, budget available and upcoming planned exercises/deployments. More details on the use of the tools can be found at the following video on 1st MLG's website: https://www.1stmlg.marines.mil/News/Videos/videoid/926019/.

Figure 3. Manifest in Action at 1st MEDLOG

References

Deputy Commandant for Information. (2024). *Marine Corps guidance on generative artificial intelligence* (NAVMC 5239.1). https://www.marines.mil/News/Publications/MCPEL/Electronic-Library-Display/Article/4013464/navmc-52391/

Fowler, J., & Polera, R. (2024, March). Machine learning for medical logistics. *Marine Corps Gazette*, *108*(3), 36–40. www.mca-marines.org/gazette

Mata, G. (2024). *Essay for AMCL*.

Palmer, H. T. (1997). *Miles wide, inches deep: Army logistics on the 21st-century battlefield*. U.S. Army War College.

Tagup Inc. (2021, November). *LAV25 logistics optimization using machine learning*. Small Business Innovation Research Award Details. https://legacy.www.sbir.gov/sbirsearch/detail/1928459

The 1st MLG (2024). *Medical logistics company utilizes artificial intelligence*. 1st MLG – news - videos. https://www.1stmlg.marines.mil/News/Videos/videoid/926019/dvpcc/false/#DVIDSVideoPlayer24477

Zhao, Y., Hemberg, E., Derbinsky, N., Mata, G., & O'Reilly, U. (2021). Simulating a logistics enterprise using an asymmetrical wargame simulation with Soar reinforcement learning and coevolutionary algorithms. *2021 Genetic and Evolutionary Computation Conference Companion (GECCO '21 Companion)*. https://dl.acm.org/doi/10.1145/3449726.3463172

Zhao Y., & Zhou C. C. (2019). Collaborative learning agents (CLA) for swarm intelligence and applications to health monitoring of system of systems. In J. Rodrigues et al. (Eds.), *Computational Science – ICCS 2019. ICCS 2019. Lecture Notes in Computer Science, Vol. 11538* (pp. 706–718). https://link.springer.com/chapter/10.1007/978-3-030-22744-9_55

Zhao, Y., Mata, G., & Zhou, J. (2025). *Discovering root causes of risks for warfighting systems & human factors integration (WHI)* [Poster presentation]. 9th the Annual Conference for Naval Applications of Machine Learning, San Diego, CA.

Acquisition Research Program
Department of Defense Management
Naval Postgraduate School
555 Dyer Road, Ingersoll Hall
Monterey, CA 93943

www.acquisitionresearch.net