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Contested Logistics: Overcoming Army Medical Supply Challenges in the Indo-Pacific

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Author Note: The authors are a team of cadets and instructors at the United States Military Academy at West Point. With the support of the United States Army Medical Capability Development Integration Directorate (MED CDID), the authors researched and offered recommendations on the Army Medical System in a contested environment. The views expressed herein are those of the authors and do not reflect the position of the United States Military Academy, the Department of the Army, or the Department of Defense.

Abstract: Considering potential large scale combat operations in the Indo-Pacific, the authors determined that the United States Army medical sustainment structure is insufficient in capacity and transportation to enable timely supply of medical materiel. The Army sustainment structure must overcome logistical challenges and disruptions created by adversaries during conflict. The team's recommendation incorporates current Combined Joint All-Domain Command and Control (CJADC2) and Multi-Domain Operations (MDO) perspectives while leveraging U.S. regional allies and partners and technology to promote predictive logistics for future U.S. Army medical efforts. The project focused on the delivery of Class VIIIA (medical consumable supplies) materiel to the joint force at the brigade-level and above. To maintain a manageable project scope, the researchers omitted supply chain competition, materiel production disruptions, asymmetric threats, and Class VIIIB (blood products). The final recommendations support MED CDID's mission to deliver medical capabilities and meet the needs of the future Army and Joint Force.

Keywords: Large Scale Combat Operations (LSCO), Indo-Pacific, Anti-Access Area Denial (A2/AD), Predictive Logistics, Medical Logistics, Combined Joint All-Domain Command and Control (CJADC2)

1. Introduction

Global instability in the modern world stems largely from increasing economic, technological, and military competition between major powers, causing regional conflicts and escalating tension. According to the U.S. National Security Strategy (2022), the U.S. views China as its greatest long-term adversary, leading to a military focus on the Indo-Pacific as a potential battlefield (Biden, 2022). The U.S. Military is continuously working to modernize and prepare its forces for the unique challenges of modern warfare. The U.S. Army Medical Capability Development Integration Directorate (MED CDID) requested the authors provide a solution for the delivery and resupply of Class VIIIA medical materiel in U.S. Indo-Pacific Command (INDOPACOM) within a contested environment. This project carries real-world relevance with the rising friction between the U.S. and the People's Republic of China resulting from great power competition (Cordesman, 2021). As multi-domain warfare presents a new era of conflict, this initiative focuses on generating and optimizing viable solutions and defining areas for future research, improvement, and redesign. The following report reviews the methodology, provides a redefined problem statement, mitigates candidate solutions, and offers final recommendations to MED CDID.

1.1 Methodology

The Systems Decision Process (SDP) visualizes how developing, assessing, and integrating a system collectively drives the progression of its engineering (Driscoll, 2022). This framework combines an assessment of the true problem, the design of a solution, the analysis of alternatives, and the implementation of an optimal solution. To combat the qualitative gaps of the SDP in relation to this project, the team incorporated the Marine Corps War College Strategy Development Model (MCWAR), which describes a cyclical process that begins and ends with an appraisal of the strategic environment (Marion, 2022). Analysis of the environment influences the creation of policy, which in turn impacts the environment. The SDP is focused on quantitative data, such as value measures and monetary cost, while the MCWAR neglects the concept of value-focused thinking. Therefore, the authors combined the two models to create a framework, as shown in the Modified Systems Decision Process in Figure 1 below. There are four main phases: Problem Definition, Solution Design, Decision Making, and Validation and Recommendation. This new framework maintains the structural design of the original SDP, with elements modified within to better encapsulate the qualitative MCWAR components.

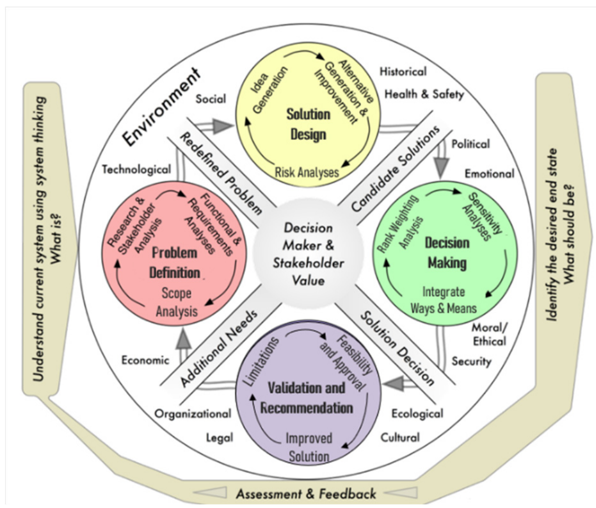

Figure 1. The Modified Systems Decision Process

2. Problem Definition

The problem definition phase helps to build an actionable policy recommendation because it identifies the specific problem that each subsequent part works to solve. A functional hierarchy organized overarching, embedded, and detailed issues in the problem statement and established the major subject areas for research to facilitate effective analysis. From this, a redefined problem statement enabled targeted research into the subjects affecting potential policy solutions.

2.1 Stakeholder Analysis

Stakeholders provide their wants, needs, and desires to guide the project scope, research, resource allocation, and outputs. The project's stakeholders included MED CDID and INDOPACOM. The latter is a beneficiary of the researchers' recommendations, while the former is the primary stakeholder. MED CDID develops and integrates medical concepts for future Army operations, aligning these concepts with broader military strategies. Their primary objectives include concept development, support for Joint concepts, and prioritization of operational risks and capability gaps with force modernization through research and technology initiatives. MED CDID required an analysis of capability gaps in existing strategies and the generation of policy recommendations in the event of contested logistics in INDOPACOM (USA MEDCOM, 2022).

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2.2 Functional and Requirements Analysis

The research team created a functional hierarchy to define the project's scope while incorporating the results of initial research and stakeholder input. The deliberate categorization identified three main areas of study for the literature review. From the literature reviews, each member of the research team was considered an expert in their category and contributed literature-backed input in the Idea Generation and Rank Weighting Analysis phases. The first category was military strategy, which was separated into enemy regional A2/AD capabilities and friendly Large Scale Combat Operations (LSCO) and Combined Joint All-Domain Command and Control (CJADC2) doctrine. Second, the researchers analyzed U.S. Army sustainment, split between research on predictive logistics and the delivery and resupply of Class VIIIA. Finally, the Indo-Pacific geopolitical environment category focused on allies, partners, and geographic factors or constraints. By integrating these domains of in-depth research, the team generated the scope and requirements of this contested logistics problem.

2.3 Redefined Problem Statement

The authors' literature review findings engendered a redefined problem statement of "Provide a recommendation on how to improve current medical logistic capabilities from a CJADC2 perspective in a LSCO environment in INDOPACOM, specifically focusing on optimizing supply and delivery of Class VIIIA medical materiel through predictive logistics."

3. Solution Design

3.1 Risk Analysis

The team utilized Risk Analysis in the modified SDP instead of **Solution Enhancement**. This method best accounts for the environmental factors of contested logistics to include probable actions of adversaries. A Failure Mode and Effects Analysis (FMEA) captures projected risks' likelihood, severity, and detectability to calculate their expected impact. Through extensive literature review and consulting key stakeholders, the team identified the areas of highest risk as: improved and extended enemy A2/AD capabilities, Artificial Intelligence (AI) inaccuracies, compromised cyber security, and the lack of sensory data collection tools. Next, the authors emphasized mitigating the following risks due to their assessed potential impact on project outcome: optimizing joint training and combined operations with current allies while enhancing priority partnerships; combining AI and human interfaces for systemwide flexibility and multifaceted inputs; and employing encrypted and cloud-based data subsystems integrated with AI and refined communication networks.

3.2 Idea Generation

The Decision Analysis Diagram, shown in Figure 2, categorizes the primary causes and effects of systematic failure. The team used the diagram to communicate noteworthy trends within theater-level contested logistics to stakeholders. Next, the researchers assessed the most critical forecasted trends limiting system functionality to be: limited operating picture for

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medical materiel; insufficient integration with Army sustainment; geopolitical constraints; transportation lead time behind schedule; and high priority targets.

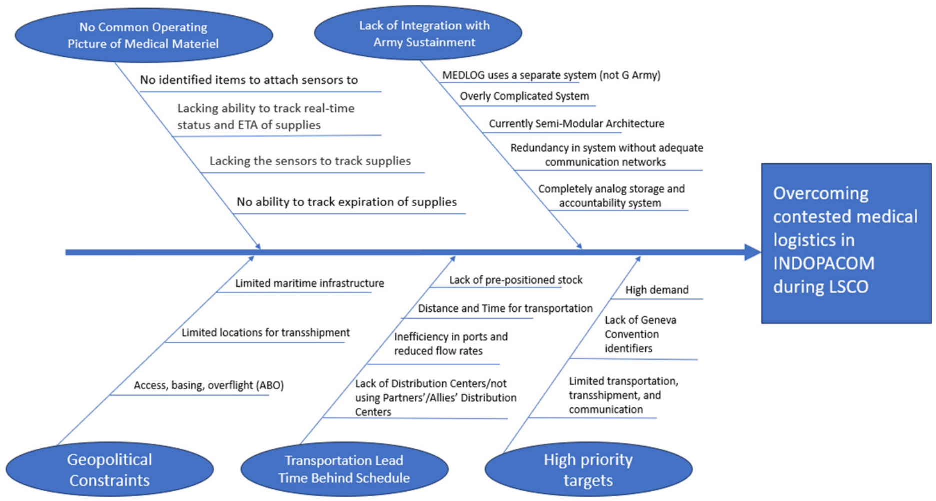

Figure 2. Decision Analysis Diagram

3.3 Alternative Generation

After a brainstorming process in which the team suggested as many plausible solutions as possible, they began alternative generation. The focus shifted to practicality and feasibility, given the means available. Subsequently, the authors filtered many of the generated ideas. The categories for alternative generation followed the same organizational theme as the problem definition and resulted in a Decision Analysis Diagram (Figure 2). After establishing this structure, the authors transitioned sequentially from one category to the next, generating alternatives for each. The alternatives represent specialized solution proposals that address the highest-priority risks to mission success. As the last step in the solution design process, the group subsequently transitioned to the decision-making phase, where they generated options for their final recommendations.

4. Decision Making

4.1 Rank Weighting Analysis

To determine the most effective alternatives, the team utilized Rank Weighting Analysis to rank the alternatives against each other using an ordinal scale. Based on previous literature review and additional input from subject matter experts, each team member ranked the factors within the overarching problem and subproblems on a scale from 1 to n, with n being the number of alternatives in each problem. Additionally, the research team sent a client version of the Rank Weight Analysis to the stakeholders with instructions to rank each alternative from highest priority to lowest priority; however, because of a lack of response, the research team was unable to utilize stakeholder input for the prioritization of alternatives. Because of this, the research team relied on the team-internal analysis and ranking to determine the solutions. Once the scores were collected and the modes of the data were noted, the team generated final solutions, as shown in Table 1.

Table 1. A Consolidated Table of Recommended Decisions

Recommendation	
Problem	**Selected Alternative**
Type of Sensor	GPS (Shipping Vehicle)
How Small of a Unit	Pallet
Data Bandwidth in Tracker	High Bandwidth (Higher Cost, More Value)
Allies and Partners Preferred	Japan
Number of Supply/Intermediate Nodes	Leverage Allies'/Partners' Land Space
Risk Tradeoff for Transportation	Small Dispersed Vehicles (Low Risk, Higher Cost)
Priority Target Risk Mitigation	Distinguish between Class VIIIA Supply Vehicles (Commercial vs Red Cross vs Non-Red Cross Military)
Increase Positioned Supply Capacity	Policy Change to allow non-FDA Approved Class VIIIA Supply
Increase Security of Supply/Transshipment Nodes	Communication and AI triggers for upstream activity and needs

4.2 Sensitivity Analysis

Sensitivity analysis determines the potential impact of the input variables in a model by varying their values. With a wide range of background knowledge guided by focus areas, the researchers unavoidably brought biases into the decision-making process. Within the model, the authors used the outlier method to conduct a sensitivity analysis between team member responses. The authors then calculated the outlier limit by multiplying the number of factors within the broader problem and each subproblem by 0.25 and then rounded up to the nearest whole number. Because the data for this step was ordinal rather than numerical, the authors could not use standard deviation to measure distribution as the rankings would produce a flat histogram with each factor only being ranked once. The authors agreed that 0.25 was a reasonable threshold given the range of numbers used for ranking. Next, the authors calculated the outlier range by subtracting and adding the outlier limit to the mode. If a group member's ranking of a certain factor fell outside the outlier range, it became an outlier requiring further analysis. This process allowed the team to consider each team member's difference in specific knowledge areas and identify other considerations not known to the entire group before assessing whether the outliers were more correct than the group mode.

Considering the outliers, the most important appears to be increasing the security of supply or transshipment nodes, specifically when AI is utilized at the node. Since AI unreliability is highly probable, the team suggests another alternative may be more reliable in an operational environment. Also, another concern is that Army Prepositioned Stock (APS) and outsourcing are under-utilized and less risky. Given that APS has been a recent initiative, the current U.S. capacity is insufficient to satisfy the demands of a LSCO environment. Overall, these are the two main areas for the stakeholders to consider further based on the situation, given that the researchers do not have access to accurate information on the reliability of AI and the quantity of Class VIIIA supply the Army currently possesses.

4.3 Integrate Ways and Means

To achieve the ends being pursued of overcoming contested logistics in INDOPACOM, the team utilized the MCWAR model to analyze the integration of ways and means. The team analyzed five key problems that must be addressed. The solutions to the problems are the *ways* in which concepts can be pursued to achieve the *ends*, while the technologies and ideas implemented will be the *means* for the resources used to integrate these solutions.

1. Overcoming the limited common operating picture of medical materiel is accomplished by selecting appropriate types of sensors, the level at which to track supplies, and the bandwidth of trackers. The means to integrate this concept are technologies currently being developed that streamline medical logistic operations by automating inventory counts, orders, and resupply, reducing consumables, and connecting the information to army C2 systems.
2. Issues regarding the transportation lead time schedule are addressed by recognizing the utility of U.S. allies and partners and incorporating allied and partner nations' locally procured medical supplies and existing supply chain networks into the military's supply chain.
3. The potential high prioritization of supply transportation vehicles can be addressed by leveraging smaller, dispersed, autonomous vehicles that utilize hydrofoil technology. These vehicles take advantage of ground-effect aerodynamics for greater speed and survivability in transshipment.
4. Geopolitical constraints pose challenges due to allies and partners having different standards in medical equipment for their militaries. At the onset of LSCO, the joint force may not have the choice to wait for supplies to arrive, but this can be addressed through a policy change to allow non-FDA approved Class VIIIA supplies from allies and partners, increasing the number of APS nodes, and focusing on AI that upstream ordering and shipment.

5. Medical Logistics has limited integration with GCSS-Army. MED CDID is currently addressing this by testing the use of GCSS-Army in selected units with plans to fully integrate by 2028. No further action is required or recommended until the current integration period is completed.

In conclusion, the team identified five alternative solutions that contribute to solving the problem of overcoming contested logistics in the Indo-Pacific. The authors specifically discussed how these solutions can be implemented and what means to use to integrate them.

5. Validation and Recommendation

5.1 Limitations, Feasibility, and Approval

In the modified SDP model, the research team selected Validation and Recommendation as the final phase to assess the limitations and solution feasibility of the policy recommendation. Rather than focus on how a system is implemented over its lifespan, the team decided to emphasize the recommended solution's soundness regarding client needs, wants, and desires. To scope their research, the team assumed that LSCO would only occur within the Indo-Pacific. Additionally, they assumed the U.S. would continue its current relationship with regional allies and partners during LSCO, specifically utilizing their supply nodes and medical materiel. Future conflict may require a decision on whether to use non-FDA approved items from allied and partner nations, depending on the current risk to the force. Lastly, the team assumed that cost was not a crucial variable. The recommendation is not yet operationally capable concerning current Technology Readiness Levels (TRLs). The small marine crafts, transcontinental maritime and air defense capabilities, and integrated networks to sustain AI, communication, and cybersecurity are still in development and are not currently deployable in the event of LSCO today. This contested environment requires major defensive asset mobility by adjusting enemy A2/AD bubbles, automated packaging, tracking, and distribution, and communication encryption and availability. Ultimately, the feasibility and approval authority depend on the information at the time of decision along with the commander's decision-making process.

5.2 Improvement and Future Research

For future research, the team recommends exploring the adversary's A2/AD capabilities for effective route planning. Due to A2/AD being a national defense matter for the adversary, such data is highly classified. However, a detailed analysis of the adversary's force disposition would be crucial for decision-makers to determine the best axis of advance from the storage nodes to the line combat units. Moreover, future research should investigate technological methods to enhance the integration of automated collection, sharing, and synchronization of dispersed source data collection and storage for Class VIIIA to provide a common operating picture of medical supply to commanders. In addition, the use of AI models in maritime logistics can "prioritize routing tasking while in transit and optimize staging locations and transit routes" for the deployment and distribution of supply to increase the organization's overall effectiveness (Hoekstra, 2021, p. 22). Currently, systemwide compatibility is broadly inadequate among allied nations, vehicles, and geography. MEDLOG needs an AI interface and the necessary architecture along designated supply routes and production lines to improve logistical operations with CJADC2. These developments could generally address the expansive, multifaceted innovation that multi-domain warfare requires, further bolstering the functionality of MED CDID within and well beyond Army 2040 (AFC Concept for Medical 2028, 2022).

New Indo-Pacific alliances will be critical, particularly to contested areas like Taiwan (Biden, 2022). Technological integration will shape this undertaking, as seen with Japan, South Korea, Canada, and Australia as the Pacific countries commitment to support the 6G network (Edwards, 2024). Ultimately, the team identified Japan, South Korea, and Australia as the most crucial allies to this project; new treaties can optimize a multinational strategy (Ayson, 2021) (Colombia, 2023).

6. Conclusion

The project provides realistic recommendations to improve the resilience of U.S. Army medical logistics in the Indo-Pacific within a LSCO environment. Using systems thinking and the defense and strategic studies policy formulation process, the team concludes that leveraging allies, embracing technology, and adapting policies are required to address challenges in the delivery of Class VIIIA supplies in a contested environment. Furthermore, ongoing validation and integration of emerging technologies are crucial for long-term sustainability.

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