Contested Logistics as an evolution of military logistics using technological tools

La Logística en Disputa como evolución de la logística militar usando herramientas tecnológicas

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Abstract

This study addresses the importance of logistics in military strategy, the complex dynamics between the science and art of logistics during conflicts, and the elements of Information and Communication Technologies (ICTs). Logistics plays a crucial role in ensuring the success of military operations, especially in contexts where supply lines are vulnerable to interference. This analysis focuses on "Contested Logistics," exploring how effective coordination and resilience can overcome the challenges of contested environments. This work used an exploratory and descriptive methodology combining qualitative and quantitative analyses. The study includes a comprehensive bibliometric analysis using the VoSviewer technology tool, which analyzes the existing literature on logistics and identifies recent trends and key terms. The results highlight the main logistics challenges in contested environments: supply line interference, multi-domain threats, logistics, and ICT application-related vulnerabilities. In addition, they propose technological solutions, collaborative strategies, and autonomous systems. The results provide a basis for future research, suggest the need for a joint concept for Disputed Logistics within military strategic frameworks, and address the importance of logistics in military strategy, the dynamics between the science and art of logistics, and the relationship of the role of ICTs in the implementation of new solutions.

Keywords--- Contested Logistics, Military Strategy, Multidomain Threats, Logistical Vulnerability, ICTs

Resumen

Este estudio aborda la importancia de la logística en la estrategia militar y la compleja dinámica entre la ciencia y el arte de la logística durante los conflictos y los elementos de las Tecnologías de la Información y la Comunicación (TICs). La logística desempeña un papel crucial para garantizar el éxito de las operaciones militares, especialmente en contextos en los que las líneas de suministro son vulnerables a las interferencias. Este análisis se centra en el concepto de «logística disputada», explorando cómo una coordinación eficaz y la capacidad de recuperación pueden superar los retos que plantean los entornos conflictivos. Este trabajo usó una metodología exploratoria y descriptiva combina análisis cualitativos y cuantitativos. El estudio incluye un exhaustivo análisis bibliométrico mediante la herramienta tecnológica VoSviewer, que analiza la literatura que existe sobre logística e identifica tendencias recientes y términos clave. Los resultados ponen de relieve los principales retos de la logística en entornos disputados, como las interferencias en las líneas de suministro, las amenazas multidominio y las vulnerabilidades logísticas y las relacionadas con aplicaciones TICs. Además, proponen soluciones tecnológicas, estrategias de colaboración y el uso de sistemas autónomos. Los resultados proporcionan una base para futuras investigaciones, sugieren la necesidad de un concepto conjunto para la Logística en Disputa dentro de los marcos estratégicos militares, y abordan la importancia de la logística en la estrategia militar y la dinámica entre la ciencia y el arte de la logística, y la relación del papel de las TICs en la implementación de nuevas soluciones.

Palabras clave--- Logística en Disputa, Estrategia Militar, Amenazas Multidominio, Vulnerabilidad Logística, TICs

I. INTRODUCTION

Military logistics has played a crucial role in warfare development since the dawn of humanity [1], [2]. From a historical and strategic perspective, its significance has emerged as a decisive factor in the ability of armies to project power, sustain campaigns, and secure victory on the battlefield [3], [4]. Each military revolution has been accompanied by logistical advancements that have enabled the movement of troops and the supply of resources and facilitated the integration of new technologies and innovations, shaping the course of wars [5], [6]. In this context, military logistics emerges as a discipline that combines strategic, operational, and tactical aspects, reflecting the decisions of both commanders and adversaries in the theater of operations [2], [7].

Despite its critical importance, the systematic study of scientific literature on the relationship between logistics and military strategy has been limited to [2], [5], [6]. Researchers who have examined this topic emphasize the interaction between the art of logistics—characterized by the commander's intuition and experience—and its scientific dimension, which includes the use of mathematical models, statistics, and projections to optimize resources and reduce uncertainty [5], [8], [9], [10]. This interrelationship suggests that logistical effectiveness in contemporary conflicts depends not only on technological advancements but also on the capability to model complex scenarios using advanced analytical tools [11], [12], [13], [14].

Military logistics, however, does not operate in isolation, as it must assess its partners, environment, and surroundings [14]. It is deeply influenced by the operational environment, where the decisions of allies, partners, and adversaries shape a dynamic and often contested setting [3], [7], [13], [15], [16], [17], [18], [19]. Joint logistical planning, by military doctrine, aims to achieve unity of effort and resource synchronization to prevent miscoordination that could compromise strategic objectives [13], [15], [20]. In this environment, the actions of the adversary play a crucial role by continually modifying the logistical landscape, creating challenges that transcend the simple administration of supplies and transportation, and demanding an integrated approach to manage competition for resources [7], [10], [21].

This article analyzes contested logistics from an analytical perspective, delving into the factors that define this concept. The proposed approach seeks to go beyond traditional supply logistics to explore the influence of adversary actions on the military supply chain and how these actions generate uncertainty across all operations domains [20], [22]. Finally, the study intends to expand existing doctrinal definitions by developing a conceptual framework that captures the complexity of the contemporary logistical environment and the demands imposed by modern warfare, proposing some software-based solutions.

II. RELATED WORKS

Examining the evolution and significance of logistics over the last few decades reveals a transformation process that spans from its initial military conception to its subsequent application in the global economy. Early logistics studies focused almost exclusively on the military domain; early investigations underscored the importance of "deceptive logistics" for gaining operational advantages [23]. While a work, it highlights the historical continuity in the provisioning and maintenance of troops, illustrating the mechanisms needed to sustain military campaigns of varying scales [4], [7], [24].

Subsequently, the field began to adopt quantitative methodologies and mathematical models to support decision-making. Beginning with Partridge and Rickman, Computable General Equilibrium (CGE) models were introduced in regional management, opening the door to more systemic approaches in infrastructure planning and public policy [25]. Studies demonstrated how simulation and Value Stream Mapping can optimize industrial production and minimize costs and inefficiencies [26], [27].

The military realm was not left behind: researchers such as Krepinevich and colleagues delved into the challenges of Anti-Access/Area Denial (A2/AD) environments, which demand increasingly versatile and technologically sophisticated logistics strategies [28]. Meanwhile, other authors underscored the need to reduce the logistics footprint through technological innovations and adopt more agile and reliable systems [29], [30]. Also, the potential of optimization in maritime prepositioning operations and the relevance of cargo planning to

expedite tactical responses [31], [32]. Another key aspect has been the academic and corporate dimension of logistics conducted studies on the dynamic location of logistics nodes and the use of genetic algorithms, demonstrating the applicability of these tools [33], [34], [35], [36], [37] in complex decision-making scenarios. Likewise, in separate works, logistics is defined as a "science of networks and flows," placing it at a convergence point among economics, engineering, and geography [2].

With digitization and the rise of technology, new challenges have emerged, including cybersecurity, process automation, and the adoption of autonomous weapons [38], [39]. Furthermore, it illustrates how workers can disrupt critical points in the global supply chain, revealing systemic vulnerabilities [19]. Thus, logistics has been consolidated as a central discipline in both military and civilian spheres in the pursuit of efficiency and resilience. Its tools—from computational simulation to operational modeling and the incorporation of artificial intelligence—enable governments and companies to anticipate complex scenarios, optimize resources, and enhance competitiveness, underscoring its undeniable relevance in today's world.

"Logistics in contested environments" has become a focal point for the military and academic communities, given the growing complexity of operations in scenarios where access to resources and freedom of maneuver may be constrained. Another work highlights that logistics is now a vulnerable target and, therefore, a priority for adversaries seeking to slow or disrupt the pace of deployed forces [8], [10]. Along the same lines, it emphasizes that logistics management in contested zones is a decisive factor in ensuring operational success [21].

Various studies have focused on adapting supply chains to contexts marked by high uncertainty. For example, [40] proposes a methodology to determine optimal resource prepositioning sites, while another work develops commodity flow models encompassing multiple resource types and routes [11]. Likewise, [41] presents a linear programming approach to maximize efficiency in storage capacity allocation, stressing the need to integrate quantitative analyses in military planning.

Innovation and technology play a central role in current debates. In [42], data analysis and system interoperability are critical factors in overcoming logistical challenges in hostile environments. The concept promotes multiservice collaboration [43]. In contrast, this work [13] proposes incorporating commercial assets to reinforce the military fleet, facilitating sustainability in high-risk areas. Surrey supplements this view by advocating for establishing an expeditionary civilian air fleet, highlighting the capacity for rapid response to contingencies [44].

Cyber defense and logistical deception measures are also subjects of analysis. They examine deception tactics that conceal true capabilities or resource locations, hindering adversarial intelligence efforts [18]. Likewise, they underscore the relevance of electronic warfare in communications and command-and-control systems, with direct implications for planning and executing supply operations [45].

Strategically, the need to integrate logistical contingencies into formulating doctrines and joint operational concepts is emphasized [16], [46]. The rivalry between China and the United States suggests that a prolonged conflict would have enormous logistical implications [47]. In [12], [48] evaluates the efficacy of heuristic and approximate dynamic methods for generating routing and simulation solutions, respectively, reinforcing the multidisciplinary nature of modern logistics.

Socioenvironmental factors arise in studies of the interconnection between territories, resources, and equity [49], [50]. These contributions and reflections on the sustainability of logistical support point toward a consensus: logistics in contested environments require an integrated vision, advanced tools, and strategic coordination to address current and future threats [17], [51].

Recent literature on logistics in contested environments continues to expand and deepen its exploration of resource optimization, the integration of emerging technologies, and doctrinal adaptation under increasingly complex scenarios. A cutting-edge approach is the application of game theory to logistics planning, where strategic interactions among stakeholders are modeled to understand and anticipate adversary behaviors concerning the distribution and

protection of supplies [9]. This analytical framework complements a work emphasizing how digital support and simulation tools can enhance decision-making in hostile scenarios [52].

The importance of technological innovation is evident in numerous studies. Analyze the implications of next-generation aviation systems for logistic sustainment and missions, highlighting the need to integrate reliability and maintainability analyses in early design stages [53]. The role of autonomous vehicles in ocean engineering demonstrates how their deployment could revolutionize naval logistics [54]. Similarly, [56] examines how autonomous capabilities support naval operations [55]. In contrast, Sierra addresses low-profile uncrewed vessels for covert activities, spurring discussion of their potential applications in military and illicit operations.

In the naval sector, safeguarding strategic stockpiles and maintaining a strong industrial base is important to uphold response capabilities during conflicts [57]. This study provides an integrated overview of logistical challenges in contested maritime theaters, highlighting the critical link between supply availability and operational superiority [22]. Complementarily, the naval operational-level doctrine and the evolution of Colombian naval logistics reinforce the notion that doctrinal updates and interstate coordination are imperative to confront increasingly competitive environments [6], [58], [59].

Regarding health management and medical support in operations theaters, [60], [61] propose the use of digital twins and autonomous care to improve casualty survival rates, anticipating that passive data collection and artificial intelligence will optimize battlefield care in the future Irwin et al. continue in this vein, outlining the medical supply challenges in the Indo-Pacific region and underscoring the importance of interoperability and resource decentralization [62].

Collectively, these investigations reinforce the understanding that logistics in contested environments is not merely a technical challenge but a strategic component requiring an integrated approach, from planning and doctrine to technological innovation and international cooperation, as well as the consideration of social and economic factors that can redefine the power balance and the effectiveness of deployed forces.

III. METHODOLOGY

This research is framed within an exploratory and descriptive approach [66], employing a qualitative methodology [67] complemented by quantitative tools for bibliometric analysis. The exploratory nature of the study is justified by the interest in investigating and systematizing an area of knowledge—contested logistics—that, although it has been addressed in various studies from the perspectives of science and probability [68], still lacks a comprehensive analysis that considers both its challenges and solutions in multidomain operational contexts [5].

From a descriptive perspective, the research aims to detail and categorize the concepts, approaches, and logistical solutions identified in the existing literature, providing a structured view of the topic. The qualitative component focuses on interpreting and analyzing key concepts using quantitative tools, such as bibliometric analysis through VOSviewer. This enables the measurement and visualization of recurring patterns in the reviewed texts, thereby enhancing understanding trends in contested logistics. In this way, the study is characterized by a combination of external manifestations and certain shared intrinsic conceptual links [69].

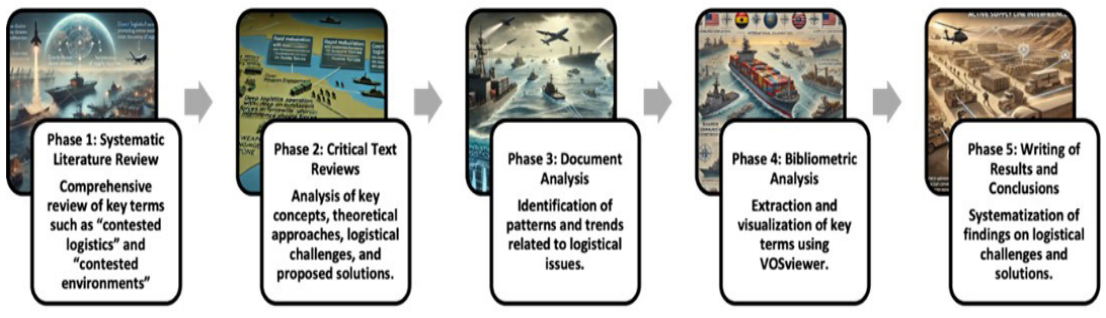

Figure 1. Phase-based Methodology (Source: Own work with AI-generated images based on study design)

This methodological combination enables conceptual deepening and empirical validation by analyzing term networks and co-occurrences, ensuring a comprehensive view of the phenomenon under study.

A. First Phase

In the first phase, a systematic review of the existing literature was conducted, focused on identifying relevant studies in academic databases and articles published online, both in conference proceedings and specialized scientific journals. This review included a thorough search for key terms such as "contested logistics" and "contested environments," enabling the compilation of a significant set of documents. Following this process, 47 sources were identified as pertinent for analysis and selected based on their relevance and contribution to the study topic.

B.Second Phase

The second phase involved the development of critical reviews for each of the selected texts. In this stage, special attention was given to the following aspects of each document: the concept of contested logistics, the primary theoretical and methodological approach, identified logistical challenges, solutions proposed by the authors, and key elements of premises and conclusions. This process allowed for the extraction of crucial information to understand the multidimensional nature of contested logistics in current operational environments.

C. Third Phase

In the third phase, an exhaustive document analysis of the texts was conducted, focusing on identifying patterns and trends related to the logistical challenges and solutions presented. This analysis aimed to determine how each document addresses logistical issues in conflict environments and the strategies proposed to mitigate associated risks, enabling a systematization of knowledge.

D.Fourth Phase

In the fourth phase, bibliometric verification and analysis of the selected literature was carried out using the VOSviewer platform, a specialized software for creating maps based on textual data and analyzing co-occurrence networks of terms. This analysis included the following methodological steps:

- Creation of a textual data map from the reference files managed.
- Data reading and extracting terms from each document's title and abstract fields.
- Binary counting is used to record the frequency of term occurrences.
- Establishment of a minimum occurrence threshold for each term, which allowed the identification of a total of 893 terms, of which 64 met the established relevance criteria.
- From this set, a final selection of 38 key terms was made based on their interactions and co-occurrences within the reviewed literature. This allows visualization of the main thematic areas related to contested logistics.

E. Fifth Phase

The fifth phase involved writing the results and formulating conclusions based on the text analysis and the generated bibliometric map. During this stage, the main findings regarding logistical challenges and solutions in contested contexts were systematized, integrating the theoretical and methodological contributions of the reviewed authors.

This study adopts an exploratory, descriptive, and bibliometric approach. It aims to analyze logistical dynamics in conflict or strategic competition scenarios, proposing a synthesis of existing knowledge and identifying the most relevant trends and challenges that logistics faces in contested environments.

IV. RESULTS

A. Bibliometric Analysis of Articles Related to Contested Logistics

The bibliometric analysis conducted through the VOSviewer platform allowed for a detailed structuring of the documents investigated, providing a comprehensive view of the

primary sources used (Figure 2). In this context, correlations between keywords and the main research topic were identified and analyzed, revealing interrelationships to understand thematic evolution within the field. An overlay visualization presented a graph, marking a starting point to trace the temporal and conceptual development of the research topics.

During the analysis, 1,616 unique terms were identified. By setting a minimum occurrence threshold of five mentions per term, 39 terms met this criterion, representing a significant set for further analysis. From there, the system selected 60% of the most relevant terms, resulting in 26 terms. After a critical review, 12 terms that were not directly related to the central research theme were excluded, leaving a final graph with 14 key terms.

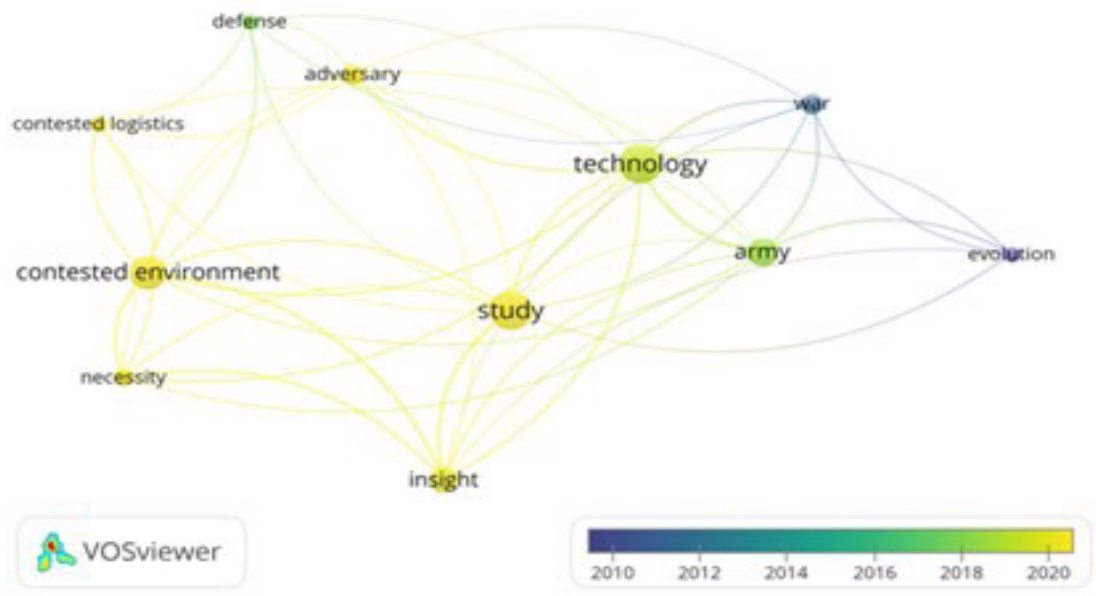

Figure 2. Highlighted Topics in the VOSviewer Bibliographic Analysis

The results indicate that the topics investigated are relatively recent, forming an emerging cluster connecting to contested environment studies. From this context, the concept of "contested logistics" emerges, marking a particular area of interest and opening new research avenues to understand how logistics has played a critical role in conflict or competition scenarios since 2018. This suggests that the field of study is expanding, with significant implications for logistics in strategic, tactical, operational, and technological contexts, which can be addressed through software development.

The importance of these results lies in their ability to identify emerging and key areas in the study of "Contested Logistics." The analysis shows that this topic is scarce, recent, and growing, underscoring the relevance of its research for planning new strategies in competitive contexts. The selected terms reflect the conceptual evolution of the field, providing a solid foundation for future research and practical applications in logistics management within conflict environments.

B. Definition of Contested Logistics: Adaptation and Resilience Against Active Interference in Strategic Conflicts

Contested logistics is a broad concept referring to logistical operations that face active interference from adversaries in conflict or strategic competition scenarios [8], [16], [19], [20], [44]. Such interference can manifest as direct attacks on supply lines, logistical facilities, and distribution networks aimed at disrupting or impeding the flow of critical resources [11], [13], [19], [51], [62], [70].

This type of logistics is characteristic of anti-access/area-denial (A2/AD) environments, where adversaries employ advanced capabilities to restrict access to operational zones, target key logistical routes, or sabotage sustainment capabilities through multidomain threats, such as cyberattacks, long-range missiles, and jamming systems [12], [13], [28], [39], [42], [47], [56], [71], [72].

Contested logistics demand resilience, technological innovations, and deception tactics to ensure supply continuity under constant threat, whether in asymmetric warfare, maritime scenarios, or large-scale conflicts such as those in the Indo-Pacific [13], [40], [63], [70], [73], [74]. Through advanced planning, multinational cooperation, and the use of autonomous systems, risks can be mitigated to ensure that military forces maintain operational effectiveness even under adverse conditions [18], [20], [22], [43].

To achieve this, it is essential to implement concealment and deception technologies along logistical routes [18], as well as strengthen the survivability of logistical assets against direct threats such as missiles and hostile submarines [44], [75]. Additionally, logistics must be prepared to overcome blockades in enemy-controlled territories and address mobility challenges in contested geographic areas [10], [57], [76].

Contested logistics also face unique challenges in modern multidomain warfare contexts, where supply chains are exposed not only to physical attacks but also to cyber threats and communication disruptions [17], [45], [47]. In response to these threats, proposed solutions include the integration of regional allies, the use of simulations, and the optimization of logistical planning to maneuver from more distant locations [9], [12], [77].

Focus of Contested Logistics: Adaptation, Resilience, and Technologies to Overcome Multidomain Threats

The primary focus of contested logistics centers on the need to modernize military logistical capabilities to operate effectively in highly volatile, vulnerable environments and under constant threat [13], [60], [61], [65]. This requires implementing advanced technologies and agile strategies that optimize operations in hostile contexts [29], alongside employing deception strategies, such as falsification and concealment, to protect logistical resources and minimize the risk of interdiction by adversaries [18], [28]. Adapting traditional logistical systems with agent-based adaptive systems is crucial for ensuring efficient decision-making under pressure in asymmetric warfare. In contrast, logistical innovations are necessary to maintain supply in conflict zones where vulnerability to direct attacks is high [73].

Evaluating the survivability of logistical assets in hostile environments is essential, as they face direct threats such as missiles and submarines, requiring logistics to withstand attacks while ensuring the flow of supplies [13], [75]. Additionally, supply chains must be safeguarded against adversarial offensive capabilities aimed at disrupting resupply [39], [71]. In this context, it is vital to ensure that logistical operations can maintain supply across multiple fronts, operating in global and contested scenarios [16], [17] and that technological innovations, such as uncrewed vehicles and other advancements, are adopted to counter threats [51], [56]. For this reason, it is necessary to study how prolonged conflicts between major powers, such as the United States and China, rely not only on direct military confrontation but also on the ability to sustain a protracted war through logistics and the maintenance of key resources [47].

Figure 3. Focus of Contested Logistics (Generated by AI-generated images based on study design)

In maritime environments, assessing logistical threats and the ability to operate under high-vulnerability conditions is essential to ensure operational continuity [60], [61], [74]. In-depth logistical planning is necessary to sustain forces within critical zones, such as the weapons engagement zone (WEZ), in the face of direct enemy interference [77]. Interference in command and control (C2) capabilities must also be addressed, as it compromises force maneuverability [45]. Thus, resilient logistics is key to maintaining continuity of operations under constant pressure and multidomain threats [17], [43].

Contested logistics also face logistical blockades in enemy-controlled territories [13], [76], as well as restricted access to logistical resources in A2/AD environments, affecting both bases and transit lines [12]. Adapting to the challenges of multidomain warfare is essential, incorporating emerging technologies and optimizing logistical vulnerability to reduce the impact of direct attacks on supply chains [5], [11]. This includes collaborating with allies to operate in environments where supply lines are compromised [19], [40] and developing new technologies to ensure supply flow despite persistent threats [8], [10].

Logistical capacity under communication congestion and denial conditions also represents a significant challenge, and it is crucial to evaluate this to avoid bottlenecks in logistical management across broad geographical areas [21], [42]. Additionally, the inadequacy of current logistical processes in the face of active threats must be addressed through review and optimization of the supply chain [13], [57]. On a multinational level, logistical challenges must be met with collaborative and technological solutions, especially against cyberattacks and advanced technological threats [70].

The focus of contested logistics also includes a deep understanding of strategic interactions between logistical forces and their adversaries, which can be modeled through game theory to anticipate disruptions and adapt operations [9], [65]. Finally, logistics must address three fundamental challenges: threat, environment, and inherent limitations, necessitating the adoption of autonomous and resilient capabilities to ensure logistical flow under constant threats [22]. These challenges are especially critical in environments such as the Indo-Pacific, where A2/AD capabilities complicate medical logistics and the distribution of other essential resources [62]. Furthermore, contested logistics can extend to health crises and labor mobility areas, as observed during the COVID-19 pandemic [63].

D. Challenges in Contested Logistics: Multi-Domain Risks and Resilience Strategies

Supply Line Interference: Active interference in supply lines is one of the most critical challenges contested logistics face. This encompasses the interdiction of logistical routes by adversaries seeking to disrupt the flow of goods and resources [18], [28]. Direct interference and attacks on logistical convoys in asymmetric combat environments necessitate continuous innovations to sustain logistical operations [73]. Attacks on logistical routes and nodes compromise the ability to maintain military operations and sustainment [8], [44], affecting both lines of communication and resource distribution [21], [42]. Furthermore, logistical blockades imposed by enemy forces create further friction that complicates operations [76]. These logistical blockades can be detrimental to military operations, as they interfere with the last-mile logistics [57] and limit medical logistical capacity in Anti-Access/Area Denial (A2/AD) environments [62].

Multi-Domain Threats: Logistical operations are exposed to threats across multiple domains, including air, sea, land, cyberspace, and space [17], [45]. The vulnerability of supply chains spans these domains, as adversaries may employ offensive strategies to target key nodes within the supply chain [5], [19], [39], [71]. Logistics in maritime environments is also constantly threatened by anti-ship missiles and submarines, which jeopardize logistical operations at sea [44], [74]. Additionally, cyberattacks and diplomatic restrictions hinder access to strategic zones, increasing pressure on logistical lines [16], [70]. In a multi-domain scenario, adversarial offensive capabilities can disrupt supply chains in a coordinated manner across various areas, thus amplifying operational complexity [22], [40].

Lack of Logistics Planning and Management: Comprehensive logistics planning is essential to sustain forces within weapon engagement zones (WEZ), where hostile forces actively interfere with operations [77]. The rapid and resilient mobilization of personnel and equipment under logistical attack requires efficient resource coordination and supply lines [43]. However, multinational logistical challenges, such as the need for international support networks, further complicate operational planning in strategic regions like the Indo-Pacific [70]. Logistical management over extensive geographical areas is critical, as distance and limited resource access in conflict scenarios increase logistical vulnerability [21], [56]. Planning efforts are also needed to ensure that decisions by non-military actors do not interfere with military operations, as these actions could create uncertainty and delays [20].

Figure 4. Challenges in Contested Logistics (Generated by AI-generated images based on study design)

Logistical Vulnerability and Survivability: Logistical assets are constantly threatened by direct and persistent attacks, making logistical survivability a crucial factor in conflict zones [13], [75]. Logistics remains at risk at any point along the supply chain, particularly during large-scale deployments where forces must sustain supplies under active attacks [11], [44]. Operations under enemy control generate friction and hinder supply continuity [76], rendering communication and supply lines highly vulnerable, significantly compromising sustainment capability [40]. Logistical forces must also be prepared to face active interference at logistical facilities, jeopardizing maneuverability and operational effectiveness [19], [45].

Geographic and Operational Contexts: Military logistics is profoundly influenced by geographic contexts and varied operational areas. The geographic distance between operational theaters and logistical bases presents a significant challenge for sustaining forces, especially in strategic regions such as those examined by the United States in the Indo-Pacific [13], [70]. Military forces must efficiently manage their logistical resources in areas where adversary A2/AD capabilities restrict supply access and freedom of movement [18]. The dynamic environment of these operational theaters demands innovative solutions to keep logistics both operational and adaptable [22], [44], [78]. As adversaries target logistical lines and critical transport points before the conflict phase, forces must handle competition for limited resources [20]. Diplomatic restrictions and economic pressures also impact military logistics, limiting access to strategic bases [12].

Technological Innovation and Protection: Technological innovation is essential for securing supply lines and ensuring operational continuity in contested environments. Military forces must reduce their logistical footprint [30], [31], [79] and adopt new technologies to operate in modern, challenging settings with limited resource access [29], [53], [78]. Deception strategies are vital for safeguarding logistical routes, including concealing routes or deploying decoy convoys to mislead the enemy [9], [18]. Additionally, the development of autonomous platforms and the use of low-profile uncrewed logistics vehicles (ULPVs) are crucial for overcoming logistical threats in contested areas [13], [44], [55], [56]. Forces must also be prepared to implement machine learning technologies and autonomous networks, enabling enhanced logistical planning and management under high-pressure conditions [16], [41], [52], [55].

Premises of Disputed Logistics: Starting Point for Reasoning, Modernization, Resilience, and Coordination with Other Actors in Multidomain Environments

Optimization and Logistics Modernization: Logistics modernization is essential for the armed forces to address challenges in highly contested, modern environments by minimizing vulnerability. This involves reducing the logistical footprint [30], [31], [79], adapting to agile logistical systems suited for asymmetric combat scenarios, and implementing deception strategies such as falsification and concealment to protect logistical routes from direct threats, cyberattacks and Anti-Access/Area Denial (A2/AD) environments [13], [16], [17], [18], [28], [29], [44], [73]. Additionally, forces must adopt resilient technologies and advanced platforms to sustain supplies in restricted-access areas [41], [51], [52], [74], [78].

Figure 5. Premises of Disputed Logistics (Generated by AI-generated images based on study design)

Resilience in High-Threat Environments: In scenarios where logistical assets face constant attacks or disruptions, ensuring their survival is critical. Supply chains must remain operational under direct attacks in conflict zones, and interference along supply lines must be mitigated through logistical innovations [43], [75], [76]. The adversaries' Anti-Access/Area Denial (A2/AD) capabilities restrict logistical movement, making it imperative for logistical assets to be resilient and capable of withstanding such threats to sustain operations [8], [44], [53], [71], [80]. Adaptive systems in uncertain situations enhance decision-making under pressure, ensuring logistical supply continuity despite adversarial blockades or attacks [73].

Coordination with Other Actors and Strategic Planning: In operational environments where A2/AD capabilities limit access, logistics demand comprehensive planning and multi-organizational cooperation to ensure force sustainment. Large-scale deployments increase logistical vulnerability, necessitating advanced solutions and strategic partnerships to address economic, social, cultural, and diplomatic constraints, as well as geopolitical risks and attacks on intermediate bases and supply routes [11], [12], [13], [20], [29], [40], [70]. Logistical blockades and active enemy interference require forces to coordinate through strategic alliances and adopt technologies to overcome supply access limitations [21], [56], [62], [78].

Protecting Supply Chains Across Multiple Domains: Multi-domain threats—including air, sea, land, cyberspace, and outer space—jeopardize logistical supply chains, demanding strategic planning and advanced technological adoption. In these settings, forces confront persistent threats such as cyberattacks, direct assaults on supply lines, congestion, and loss of logistical, operational capacity [21], [22], [42], [70]. Deceptive strategies like falsification and concealment, along with autonomous systems and unmanned platforms (ULPVs), are essential to counter interdiction threats and maintain logistical flow [9], [18], [56].

V. DISCUSSION

A. Comparative Analysis of Disputed Logistics

From a commercial perspective, secured logistics means that the industry can meet market demands, indicating that the central issue is movement [22], [44]. In the military sphere, however, forces must ensure the continuity of logistics across different theaters of operations, maintaining the flow through air, land, and sea routes [13], [53], [75]. Within the context of conflict, the secured movement represents the capability to mobilize at both operational and tactical levels, always relying on established logistical routes within these domains [20], [22], [44], [74].

The Joint Publication from the General Command of the Armed Forces [15] emphasizes the need for Unified Action to achieve secured logistics. Unified Action is essential for ensuring coordinated decision-making among military units, the government [58], [81], and non-state actors [64]. These coordination processes introduce new logistical dilemmas arising from newly synchronized plans [17], [43].

While the decisions and plans of these non-military and non-governmental actors may not always seem crucial, they can create conditions that characterize a disputed logistical environment [20], [49], [70], [80]. Such plans may conflict with the state's objectives concerning movement and supplies. Therefore, armed forces must incorporate these actors into their planning, especially those pursuing similar goals or potentially benefiting from adversarial plans, as they may act as triggers or prerequisites defining a disputed logistical environment [19], [20], [45], [49].

Additionally, studies on logistics in contested environments have explored adversaries' active interference in supply chain operations, particularly within military logistics [9], [18], [74], [80]. This concept entails confrontation between adversaries with similar or superior capabilities, extending across multiple domains and potentially covering vast, non-contiguous areas [10], [20]. It presumes that all realms will face threats, eliminating the nation as a sanctuary and exposing logistics to direct attacks [17].

Given these circumstances, military forces must explore, develop, and implement cutting-edge strategies and next-generation technologies within strategic, operational, and tactical logistics [3]. The adoption of emerging technologies, such as machine learning, man-machine combat teams, and networked autonomous platforms, will be essential to establish dominance in a world where domains are in constant dispute [16], [55].

B. Considerations in the Study of Contested Logistics

Contested logistics describes a set of problems that include increased threats to supply chains, reduced mobility, and the need to operate in a resource-limited environment [17], [29], [82]. Logistics in a conflict environment incorporates many factors, but the key issue is the ability to deliver supplies to the combatant—end users who are inherently located within a hostile Area of Operations (AO) [21], [74], [82]. Therefore, to evaluate the assets of a

delivery, one must start from the ability to penetrate the threat layers of the enemy force in a simple campaign model [83, p. 104].

Generally, authors only articulate and focus on the challenges and complexities of contested logistics. However, this method of concentrating on the conditions generates two problems. First, it is indistinguishable from most forms of logistic operations; second, there is no method that defines the root cause of what makes the environment contested [20]. Being strict with the concept, the non-ideal conditions indicated in the definition can be a byproduct of anything within the operational environment and, therefore, do not help differentiate the moment or conditions that establish the existence of contested logistics [5], [22], [73], [84].

In this sense, contested logistics is not solely a matter of operating in adverse conditions but of adapting to an environment where the adversary actively seeks to disrupt logistic operations through direct fire, sabotage, conventional and unconventional warfare tactics, electronic warfare, hybrid warfare, etc . [28], [62]. For this reason, it was evidenced in most studies that for a contested military logistics scenario to occur, two essential conditions must be met: The first is that activities take place within those considered within the theater of war; the second is that, in terms of modes of operation for its development, movements in contested environments require reconnaissance, deception, and interference [1], [13], [23], [29], [44], [47], [52], [70], [72], [82].

Strategies to mitigate these threats require exhaustive planning that considers not only the protection of logistic assets but also the ability to project power in an active and dynamic theater of operations [17], [40].

Additionally, technological evolution has transformed the way contested logistics operations are executed [23], [28], [51]. Reconnaissance units and deception tactics, fundamental in ancient times, must now face advanced sensor networks and highly sophisticated defense systems, which demand new tools and methodologies, such as the use of artificial intelligence and cybersecurity technologies to protect logistic networks [16], [22].

Contested logistics implies a comprehensive and flexible approach that goes beyond traditional logistic limitations, adapting to the complexities of a multidomain conflict environment [17], [20]. The key elements of this strategy include operational resilience, rapid response capability, and the use of emerging technologies to maintain the flow of supplies even in the most adverse scenarios—elements that will be reviewed below [56], [70].

C. Interaction of Actors in Contested Logistics

In the commercial context of contested logistics, users, competitors, and adversaries alike seek to gain an advantage by positioning resources strategically and denying access to their opponents. Evidence shows that methods range from employing strategies such as securing exclusive rights to disrupting supply flows and compromising competitor operations [71], [75].

Military adversaries, unlike market competitors, employ additional techniques, such as disrupting operations through direct and indirect fire, terrain alteration, and obstacles, and may even destroy enemy assets—an action beyond the reach of commercial competitors [18], [20], [28], [74]. These last two methods—disrupt and destroy—are what most military professionals envision when considering a contested logistics environment and developing strategies from a kinetic approach [20].

However, preventive strategies before the conflict, aiming to disrupt sustainment networks through non-kinetic efforts like cyber-attacks or restrictions on key logistic infrastructures, are seldom utilized or considered in planning [62], [76]. Similarly, efforts to optimize logistics through planning are influenced by these adversarial challenges and the cooperation and coordination among strategic partners, which must be incorporated into planning. Strengthening coordination between allies is essential, as a lack of communication, resources, and shared interests can lead to delays and inefficiencies [43], highlighting the need for unified logistic planning to ensure operational continuity under adverse conditions [5], [85], [86] an endeavor that demands an extensive organizational process within temporal and spatial constraints.

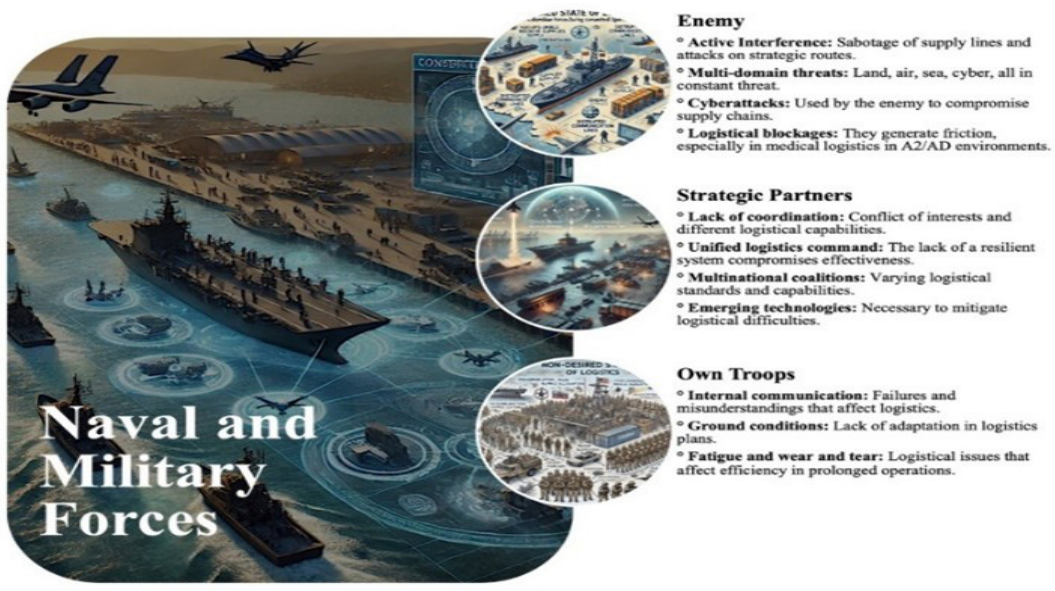

Figure 6. Interactions Among Actors (Generated by AI-generated images based on study design)

For this reason, the planning process for Contested Logistics must consider interactions between military forces and different actors, which can be classified into three main dimensions: Military Forces vs. Enemy, Military Forces vs. Strategic Partners, and Military Forces vs. Own Troops.

In this way, it becomes evident that contested logistics presents external risks (enemy interference) and internal risks (coordination among allies and internal management), as represented in Figure 6. This underscores the need for planned, agile, integrated, and resilient logistics to ensure operational continuity [43], [55]. Solutions should include the adoption of advanced technologies [29], [51] and the strengthening of logistic command and control to address threats across all domains [9], [16], [70].

D. Operational Strategies and Tangible Components for Resilience in Conflict Environments

It is essential to understand that contested logistics is not a novelty in modern warfare but rather a persistent issue that planners, strategists, and industry have faced throughout armed conflicts. The only significant difference today, compared to when German submarines roamed the Atlantic Ocean, for example, is the technology available to detect logistic movements and, consequently, the technology available to strike a state's logistic network from an extended range [22].

The Liberty Ship program during World War II was pivotal to the war's outcome [88]. Liberty Ships overcame the attrition caused by German submarines in the contested waters of the Atlantic. Many of the lessons learned from the design and production of Liberty Ships can similarly inform the design and production of ULPVs to counter threats in the contested waters of the Indo-Pacific [56].

The United States Navy has developed concepts for Distributed Maritime Operations (DMO), leveraging naval forces' inherent mobility and firepower to generate multi-axis attacks, complicate enemy targeting, and project power across a wide battlespace. Supporting this concept will require new logistics and maintenance approaches. Current supply chain processes do not adequately address these requirements. The need for a more precise understanding extends from the industrial base, where the supply chain originates, to the "last tactical mile" at the end of the distribution chain. This report evaluates logistic requirements and identifies improvements, both in terms of capabilities and within supply chain processes, to support DMO in contested environments [57].

Figure 7. Operational Strategies and Tangible Components (Generated by AI-generated images based on study design)

For detailed planning of contested logistics, several key elements are proposed, organized into five main categories, divided into two dimensions: Tangible Components (Groups 1 and 2) and Operational Strategies (Groups 3, 4, and 5). Tangible Components include advanced logistic infrastructures, autonomous vehicles, and security technologies to secure critical routes. Operational Strategies encompass the tactics, collaborations, and methodologies needed to ensure the efficiency and resilience of logistic operations in adverse or multidomain environments, where adaptability is crucial for operational sustainability, as shown in Figure 7.

Group 1: Resilient Infrastructure and Operational Means refers to the material and physical tools employed to safeguard and optimize logistics operations.

Group 2: Intelligent Logistics Operations: This group encompasses technological and tactical solutions to optimize logistics under risk conditions.

Group 3: Sustainment and Continuity Strategies: This group includes tools for projecting and maintaining supply flows.

Group 4: Adaptability and Resilience Strategies: This group contains tools that aid operational flexibility and adaptation to changing or adverse conditions.

Group 5: Collaboration and International Networks Strategies: This final group refers to tools and strategies relying on collaboration among allies and strategic partners to ensure logistical sustainment.

These tools combine the material (infrastructure and technologies) with the existential (operational strategies) to ensure logistics operations can withstand and adapt to threats in contested environments.

E. Approach to the Disputed Logistics Planning Process

Following the conceptualization of the term “Disputed Logistics,” a conceptual review was conducted to define its focus, the challenges it must overcome, and the premises upon which its study should be established.

This foundation generates the study discussion, comparing commercial and military disputed logistics. This includes essential considerations for the study, the actors involved, and their possible interactions. Finally, several operational strategies and tangible components are proposed, which should be considered to initiate the planning process.

The results presented on May 2, 2024, during the Regional Conference of the Industrial and Systems Engineering Society [62] will be considered to begin analyzing a potential methodology to address disputed logistics challenges systematically. This study’s recommendation is to incorporate current perspectives from Joint All-Domain Command and Control (CJADC2) and Multidomain Operations (MDO) while leveraging regional allies, partners, and technology to advance predictive logistics for future efforts [62].

The systems decision process (SDP) illustrates how a system’s development, evaluation, and integration contribute to its engineering [90]. This framework encompasses problem identification, solution design, alternative analysis, and implementation of the best option. To address the qualitative limitations of the SDP in this project, the Marine Corps War College

(MCWAR) strategy development model was incorporated, which describes a cyclical process focused on assessing the strategic environment [46]. While the SDP focuses on quantitative data, such as value and cost, the MCWAR considers qualitative aspects. Therefore, both models were merged into a new framework, as shown in Figure 8. This modified framework retains the structure of the SDP. Still, it integrates qualitative elements from the MCWAR into the four main phases: Problem Definition, Solution Design, Decision Making, and Validation and Recommendation [26], [62], [91].

This procedure offers realistic recommendations to enhance the resilience of contested logistics by utilizing systems thinking and the policy formulation process from strategic and defense studies [12], [27], [32]. However, it is also necessary to consider that efforts should be continuously aimed at reducing the OODA loop (Observe, Orient/Decide, Act), significantly increasing the speed to overwhelm the opponent, create security in the theater of operations, and turn, break the A2/AD (Anti-Access/Area Denial) capabilities of adversaries [56].

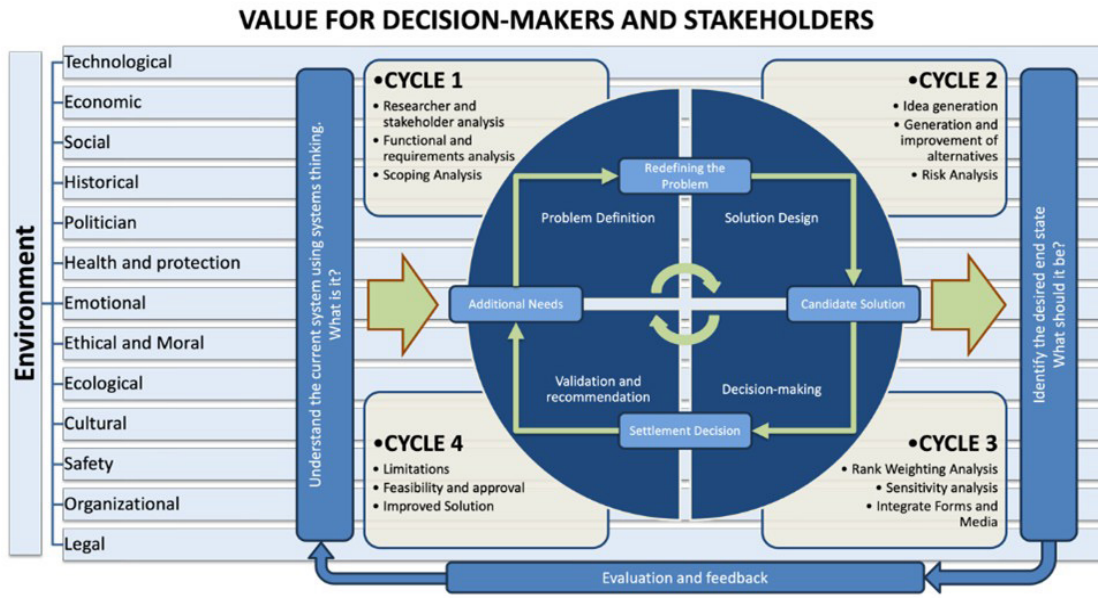

Figure 8. Valuation Process for Decision Makers [28]

Anti-access (A2) operations are defined as geographical, military, or diplomatic challenges that restrict the ability to enter an operational area of interest. Area denial (AD) is defined as the potential and actual threats within that operational area [18], [28]. It is also prudent to consider the Joint Concept for Contested Logistics (JCCL), which proposes three lines of effort: a) integrated and resilient logistics command and control; b) assured joint power projection; and c) sustainment of distributed operations [17].

On the other hand, it is essential to consider deception. Deception in a logistics environment has been studied, particularly in warfare, to provide a list of illustrative logistical deception strategies at both warfare's operational and tactical levels. These tactics are executed through a combination of five options: location, timing, scale, method, and intent [23].

It is also necessary to conduct exercises in a simulated logistics environment, allowing decision-makers to select optimal locations for airports, transportation methods, and resupply operations while considering constraints such as costs, distances, and vulnerabilities, such as migrant labor1 and uncrewed, low-profile vehicles and units. Complexity arises from the range of assessment options and factors [12]. Similarly, it should be noted that every movement made is potential information perceived by the enemy, who can gather data at any stage of the process, thus enabling the identification of strategic targets [22].

VI. RECOMMENDATIONS

The military forces should prioritize research and development of new logistical solutions to produce or source critical supplies in remote areas. Implementing a systems-thinking approach to managing logistical complexity is also vital. Training personnel in emerging technologies and fostering participation in multi-jurisdictional exercises will enhance coordination and interoperability, ensuring that military forces are prepared to operate efficiently in complex and contested environments.

To address challenges in contested environments, military forces must invest in autonomous systems such as drones and unmanned vehicles and machine learning algorithms to optimize

routes and predict threats. Strengthening cybersecurity and employing deceptive tactics to protect logistical operations from potential attacks is essential. Additionally, adopting real-time inventory management systems and reducing the logistical footprint in operational areas are recommended to increase efficiency and minimize vulnerability.

To ensure logistical continuity under pressure, it is fundamental to establish alternative supply routes and optimize transportation across different domains. Multinational cooperation and the integration of non-governmental and commercial actors in logistical planning are essential for resource and capability sharing. Moreover, strengthening the resilience of logistical command and control systems and conducting simulated exercises are crucial to assess and improve responsiveness to adverse situations.

Research on "contested logistics" in military operations emphasizes the need to develop advanced technological solutions to strengthen logistical resilience in conflict environments. Several innovations are proposed, including machine learning algorithms and neural networks in autonomous systems to optimize routes and efficiently manage resources. Additionally, improving cybersecurity by using blockchain and decentralized networks to protect critical communication infrastructures is suggested. Implementing advanced software for simulations, tactical deception, and personnel training through virtual and augmented reality is also essential to preparing the armed forces for adverse situations.

Information and Communication Technologies (ICTs) are essential for strengthening military logistics in contested environments, offering critical solutions against multi-domain threats. Automation with autonomous systems enhances operational efficiency in high-risk areas, allowing supply without direct human intervention. Cybersecurity, in turn, protects the supply chain against cyber-attacks, ensuring the integrity of communications and sensitive information. Artificial Intelligence (AI) and data analysis enable the anticipation of threats and real-time route optimization, facilitating the adaptation of logistical strategies to changing conditions. These capabilities include deception tactics, such as alternate routes and decoy convoys, which increase operational resilience and flexibility. Together, ICTs drive more robust and adaptable logistics, essential to maintain the effectiveness of military operations in highly complex and high-risk scenarios.

For the National Navy, adopting a comprehensive approach incorporating these advanced technologies is crucial. This will promote the reduction of logistical footprints and resource optimization for greater sustainability. Predictive analysis for managing vulnerable infrastructures is also recommended, combining systems thinking and modeling of logistical interdependencies. These technological strategies will not only improve responsiveness to complex threats. Still, they will also ensure more integrated, flexible, and resilient military logistics in dynamic conflict environments, ensuring operational continuity and mission effectiveness.

VII. CONCLUSIONS

Modernizing military logistics is essential to confront challenges in modern and conflicting environments. Adopting advanced technologies and reducing the logistical footprint enable forces to operate more efficiently, even when access to resources is limited [29]. In A2/AD scenarios, deception strategies such as falsification and concealment are fundamental to protecting logistical resources and minimizing interdictions [18], [28]. These advances allow logistical systems to adapt to asymmetric combat scenarios, optimizing decision-making and maintaining supply under attack [73], [75].

Various advanced technological tools are utilized in contested logistics to increase resilience and operational efficiency. Notable among these are machine learning algorithms and neural networks, which optimize logistical routes and manage resources effectively [69], [74], [92], [93], [94]. Using blockchain and decentralized networks strengthens cybersecurity, protecting critical communication infrastructures against potential cyberattacks [38]. Additionally, autonomous systems like drones and uncrewed vehicles are implemented to perform resupply and surveillance tasks in high-risk areas [54], [55]. Virtual and augmented reality are employed for training and simulation of complex scenarios, improving personnel preparedness; predictive analysis tools and modeling of logistical interdependencies allow for

anticipating and managing vulnerabilities, ensuring the continuity of operations in volatile and conflictive environments [25], [32], [95], [96], [97].

Contested logistics require significant resilience to withstand constant threats across multiple domains. Logistical assets must be capable of surviving direct attacks while maintaining the continuity of supply in hostile territories [65], [71], [75]. Logistical planning should include technological innovations that guarantee the protection of supply chains and allow operation in highly contested environments, such as A2/AD scenarios [40], [51], [74]. Advanced countermeasures are key to protecting command and control capabilities in environments where active enemy interferences are frequent [45].

Multinational coordination and thorough logistical planning are indispensable to sustain operations in environments like the Indo-Pacific, where adversaries' A2/AD capabilities limit access to resources and strategic areas [12], [70]. International collaboration helps mitigate logistical challenges, ensuring supply through strategic alliances [20], [43]. Additionally, armed forces must develop capabilities to maneuver under continuous threats, confronting blockades and direct attacks on supply routes during large-scale deployments [11], [56].

Implementing autonomous systems and unmanned platforms (ULPVs) is crucial to overcoming logistical threats in contested environments. These technologies reduce detection and ensure supply in restricted-access areas [9], [55], [56]. Additionally, deception strategies, such as convoy falsification and route concealment, help disorient the enemy and protect logistical lines under constant attack [18], [48]. Developing autonomous capabilities and establishing redundant protection of logistical routes are essential to ensure operational continuity [22], [54], [55], [65].

Large military deployments face high logistical vulnerability due to constant external threats. Optimizing logistical and transportation models is essential to minimize losses and maintain supply in hostile environments [11], [57]. A2/AD capabilities and direct attacks on supply routes demand technological innovations that ensure the survival of logistical assets in maritime and terrestrial scenarios [74]. Integrating regional allies also plays a crucial role in addressing these logistical challenges and enhancing sustainment [62].

Cybersecurity is a critical component of contested logistics, as cyberattacks can compromise logistical lines and communication networks, impacting the distribution of military resources [21], [42]. Strengthening cyber defenses is essential to ensure operational continuity in environments where cyber threats are increasingly prevalent. Additionally, the constant reconfiguration of supply chains is vital to mitigate disruptions caused by simultaneous crises, such as those observed during the COVID-19 pandemic [63]. Responding to these challenges requires rapid adaptation and the use of emerging technologies in multinational logistics [16], [70].

For these reasons, it is important that the Joint Concept for Contested Logistics be defined as part of the Joint Warfare Concept (MFC 5-0, 2024), aiming to create agile and resilient military logistics.

This can be achieved through the development of cutting-edge software, which is crucial for optimizing military logistics in contested environments. This software enables the integration of advanced technological solutions, collaborative strategies, and innovative approaches to strengthen logistical capabilities, especially in maritime settings, and ensure operational continuity against multifaceted threats [54], [55]. Implementing software with machine learning algorithms and neural networks in autonomous systems and uncrewed vehicles optimizes supply routes and enhances resource management [33], [34], [89].

Cybersecurity is enhanced through programs that detect and mitigate cyberattacks, while integrated secure communication platforms, utilizing blockchain and decentralized networks, ensure efficient coordination free from adversarial interference [12], [73]. The software also enables deception tactics through simulations and fictitious scenarios that protect logistical operations [50].

The reduction of the logistical footprint is achieved through simulations and management software that optimize supply usage and minimize waste, promoting sustainable logistics and independence from external supplies. Additionally, predictive analytics software strengthens critical infrastructure management by identifying vulnerabilities and proposing proactive solutions [98].

Integrated with software simulations, personnel training through virtual and augmented reality platforms prepares forces to operate under adversarial conditions. At the same time, programs that model the interdependence of logistical factors facilitate a focus on systems thinking [12], [32], [73], [91].

In summary, cutting-edge software acts as an integrative axis, bringing together diverse solutions to enhance military logistics' efficiency, resilience, and adaptability, ensuring operational continuity in contested and challenging environments. This technological integration is essential to facing the complex contemporary logistical challenges and guaranteeing effective and sustained military operations in multidimensional conflict scenarios.

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AUTHORS' CONTRIBUTION

The author's contributions to this article are as follows:

Gustavo Andrés Guerra La Rotta: Research, data analysis, visualization, writing, review, and editing.

The author participated in the review of all results and gave their approval to the final version of the manuscript.

CONFLICT OF INTERESTS

The author declares that there are no conflicts of interest about the reporting of this study.

REFERENCES

[1] N. R. Southern, "Historical perspective of the logistics and supply chain management discipline," *Transportation Journal*, vol. 50, no. 1, pp. 53–64, Dec. 2011, doi: 10.5325/transportationj.50.1.0053.

[2] P. Klaus and S. Müller, "Towards a Science of Logistics: Milestones along Converging Paths," in *The Roots of Logistics*, Springer Berlin Heidelberg, 2012, pp. 3–26. doi: 10.1007/978-3-642-27922-5_1.

[3] B. R. . Schneider and L. E. . Grinter, *Battle of the Future : 21st Century Warfare* Issues, Revised. Maxwell Air Force Base: Air University Press, 1998. Accessed: Sep. 03, 2024. [Online]. Available: https://www.airuniversity.af.edu/Portals/10/AUPress/Books/B_0064_SCHNEIDER_GRINTER_BATTLEFIELD_FUTURE.pdf

[4] C. R. Shrader, *United States Army Logistics, 1775-1992: An Anthology, Vol. 1*, First., vol. 1. Washington D.C.: Center Of Military History United States Army, 1997. Accessed: Sep. 03, 2024. [Online]. Available: https://history.army.mil/html/books/068/68-1/cmhPub_68-1.pdf

[5] A. Serrano, D. Kalenatic, C. López, and J. R. Montoya-Torres, "Evolution of Military Logistics," *Logistics*, vol. 7, no. 2, pp. 7–22, Jun. 2023, doi: 10.3390/logistics7020022.

[6] G. A. L. R. Guerra, A. Alejo Aguilar, and W. M. Cuadros Pineda, "Evolución de la Logística Naval para la Armada de Colombia (Parte I)," *Derrotero*, vol. 18, no. 01, pp. 1–17, Jun. 2024, doi: 10.70554/Derrotero2023.v18n01.05.

[7] J. L. Kent and D. J. Flint, "Perspectives on the evolution of logistics thought," *Journal of Business Logistics*, vol. 18, no. II, pp. 15–29, Apr. 1997, [Online]. Available: https://api.semanticscholar.org/CorpusID:166361057

[8] M. Accardi, "*Army Futures Command exploring contested logistics*," https://www.theredstonerocket.com. Accessed: Sep. 02, 2024. [Online]. Available: https://www.theredstonerocket.com/military_scene/article_7b2fffdc-3bed-11ee-a2b8-5f7ceee563ff.html

[9] J. Cerny et al., "*Contested Logistics: A Game-Theoretic Approach*," New York, Aug. 2024, p. 23. Accessed: Sep. 02, 2024. [Online]. Available: http://arxiv.org/abs/2408.13057

[10] B. Megan, "*Army focuses on contested logistics-a threat to enemy*," https://www.theredstonerocket.com. Accessed: Sep. 02, 2024. [Online]. Available: https://www.theredstonerocket.com/military_scene/article_064db93e-d36f-11ed-b168-176f7bf45396.html

[11] I. Strinsky, "*Multi-Commodity Flow Models for Logistic Operations within a Contested Environment*," Master of Science, School of Clemson University, South Carolina, 2023. Accessed: Sep. 02, 2024. [Online]. Available: https://tigerprints.clemson.edu/all_theses

[12] M. Powers and B. O'Flynn, "Contested logistics simulation output analysis with approximate dynamic programming: a proposed methodology," *Journal of Defense Analytics and Logistics*, vol. 6, no. 2, pp. 120–133, Dec. 2022, doi: 10.1108/jdal-07-2022-0004.

[13] A. Apte, K. Doerr, and U. Apte, "*Framework for Augmenting Current Fleet with Commercially Available Assets for Logistics Support in Contested Environment,*" Monterey, Sep. 2020. Accessed: Sep. 06, 2024. [Online]. Available: www.acquisitionresearch.net

[14] R. B. Neller and J. M. Richardson, "*Littoral Operations in a Contested Environment*," Estados Unidos, 2017. Accessed: Sep. 06, 2024. [Online]. Available: https://www.mca-marines.org/wp-content/uploads/Littoral-Operations-in-a-Contested-Environment.pdf

[15] CGFFMM and H. F. B. Giraldo, MFC 5-0. Colombia: "*Manual Fundamental Conjunto MFC 5-0 Planeamiento Conjunto*" (Público), 2024, p. 536.

[16] P. Benfield and G. Grant, "*Improving Joint Operational Concept Development within the U.S. Department of Defense*," WashingtonD.C., 2021. Accessed: Sep. 03, 2024. [Online]. Available: https://s3.us-east-1.amazonaws.com/files.cnas.org/documents/CNAS-Report-Defense-Joint-Warfighting-Oct-2021-FINAL.pdf

[17] F. Wolfe, "Joint Warfighting Concept Assumes '*Contested Logistics*' - Defense Daily," https://www.defensedaily.com. Accessed: Sep. 03, 2024. [Online]. Available: https://www.defensedaily.com/joint-warfighting-concept-assumes-contested-logistics/pentagon/

[18] R. Ausseil, R. Gedik, A. Bednar, and M. Cowan, "Identifying sufficient deception in military logistics," *Expert Syst Appl,* vol. 141, p. 20, Mar. 2020, doi: 10.1016/j.eswa.2019.112974.

[19] J. Alimahomed-Wilson and I. Ness, "*Choke points. Logistics workers disrupting the global supply chain*," 2018, doi: 10.1111/lands.12370.

[20] J. M. King, "*Contested Logistics Environment Defined*," https://www.army.mil. Accessed: Sep. 02, 2024. [Online]. Available: https://www.army.mil/article/272922/contested_logistics_environment_defined

[21] B. Reece, "*Managing Logistics in Contested Areas Is Key to Military Success*," https://www.defense.gov. Accessed: Sep. 02, 2024. [Online]. Available: https://www.defense.gov/News/News-Stories/Article/Article/3513936/managing-logistics-in-contested-areas-is-key-to-military-success/

[22] A. C. Fox, "Contested Logistics - A Primer," *Land power Essay*, vol. 1, no. 24, p. 8, Feb. 2024, Accessed: Sep. 02, 2024. [Online]. Available: https://www.ausa.org/sites/default/files/publications/LPE-24-1-Contested-Logistics-A-Primer.pdf

[23] L. D. Harman, "*Deceptive Logistics at the Operational Level of War*," Fort Leavenworth, May 1987. Accessed: Sep. 04, 2024. [Online]. Available: https://apps.dtic.mil/sti/tr/pdf/ADA192494.pdf

[24] C. R. Shrader, *The first helicopter war: logistics and mobility in Algeria*, 1954-1962. Westport, CT: Praeger, 1999. [Online]. Available: https://search.ebscohost.com/login.aspx?direct=true&scope=site&db=nlebk&db=nlabk&AN=300018

[25] M. D. Partridge and D. S. Rickman, "Regional Computable General Equilibrium Modeling: A Survey and Critical Appraisal," *Int Reg Sci Rev*, vol. 21, no. 3, pp. 205–248, Jan. 1998.

[26] T. Mcdonald and E. M. Van Aken, "International Journal of Applications : A Leading Journal of Supply Chain Utilising Simulation to Enhance Value Stream Mapping : A Manufacturing Case Application," *International Journal of Logistics Research and Applications*, vol. 5, no. 2, pp. 213–232, 2002, doi: 10.1080/13675560210148696.

[27] F. A. Abdulmalek and J. Rajgopal, "Analyzing the benefits of lean manufacturing and value stream mapping via simulation: A process sector case study," *Int J Prod Econ*, vol. 107, no. 1, pp. 223–236, May 2007, doi: 10.1016/j.ijpe.2006.09.009.

[28] A. Krepinevich, B. Watts, and R. Work, "*Meeting the Anti-Access and Area-Denial Challenge*," Washington, DC, 2003. Accessed: Sep. 06, 2024. [Online]. Available: https://csbaonline.org/uploads/documents/2003.05.20-Anti-Access-Area-Denial-A2-AD.pdf

[29] A. F. Piggee, "*Transformation - Revolution in Military Logistics*," Pennsylvania, Apr. 2002. Accessed: Sep. 06, 2024. [Online]. Available: https://apps.dtic.mil/sti/tr/pdf/ADA401039.pdf

[30] M. Schaeffer, J. Beck, D. Verma, and T. Parry, "*Designing and Assessing Supportability in DOD Weapon Systems: A Guide to Increased Reliability and Reduced Logistics Footprint*," Washington, Oct. 2003. Accessed: Sep. 10, 2024. [Online]. Available: https://apps.dtic.mil/sti/pdfs/ADA606329.pdf

[31] R. T. Alvarez, D. F. Matthews, R. Nalwasky, K. Alvarez, and B. R. Naegle, "*Reducing the Logistics Footprint in Naval Ships Through the Optimization of Allowance Equipage Lists (AELs)*," Master of Science, Naval Portgraduate School, Monterey, 2010. Accessed: Sep. 10, 2024. [Online]. Available: https://core.ac.uk/download/pdf/36703889.pdf

[32] T. Brandon K., "*Improving Maritime Prepositioning Force (MPF) offloads using modeling and simulation*," Master, Naval Postgraduate School, Monterey, California, 2008. Accessed: Jan. 12, 2025. [Online]. Available: https://apps.dtic.mil/sti/tr/pdf/ADA493791.pdf

[33] J. C. Figueroa García, D. Kalenatic, and C. A. Lopez Bello, "Missing data imputation in multivariate data by evolutionary algorithms," in *Computers in Human Behavior*, 2011, pp. 1468–1474. doi: 10.1016/j.chb.2010.06.026.

[34] J. C. Figueroa-García, D. Kalenatic, and C. A. López, "Incomplete Time Series: Imputation through Genetic Algorithms," *Intelligent Systems Reference Library*, vol. 47, pp. 31–52, 2013, doi: 10.1007/1007/978-3-642-33439-9_2.

[35] D. Kalenatic, J. C. Figueroa-García, and C. A. Lopez, "A neuro-evolutive interval type-2 TSK fuzzy system for volatile weather forecasting," in *Lecture Notes in Computer Science* (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 2010, pp. 142–149. doi: 10.1007/978-3-642-14922-1_19.

[36] J. C. Figueroa-García, D. Kalenatic, and C. A. Lopez, "Interval type-2 fuzzy Markov chains: Type reduction," in *Lecture Notes in Computer Science* (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 2011, pp. 211–218. doi: 10.1007/978-3-642-25944-9_28.

[37] D. Kalenatic, J. C. Figueroa-García, and C. A. Lopez, "Scalarization of type-1 fuzzy markov chains," in *Lecture Notes in Computer Science* (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 2010, pp. 110–117. doi: 10.1007/978-3-642-14922-1_15.

[38] J. Andress and S. Winterfeld, "*What is Cyber Warfare?*," in Cyber Warfare, J. Andress and S. Winterfeld, Eds., Syngress, 2011, pp. 1–18. doi: 10.1016/B978-1-59749-637-7.00001-0.

[39] P. Scharre, *Army of None: Autonomous Weapons and the Future of War*, First. NewYork: W.W. Norton & Company., 2018. Accessed: Sep. 06, 2024. [Online]. Available: https://is.muni.cz/el/fss/podzim2020/BSSn4411/um/Army_of_None__Autonomous_Weapons_and_the_Future_of_War_p1-245.pdf

[40] T. Beebe, "*Optimal prepositioning sites in the contested environment*," Master's thesis, Naval Postgraduate School, Monterey, 2023. Accessed: Sep. 06, 2024. [Online]. Available: https://apps.dtic.mil/sti/trecms/pdf/AD1212884.pdf

[41] C. Gupta, V. Kumar, and K. Kumar, "A Linear Programming Approach to Optimize the Storage Capacity," in *Proceedings of the 2023 12th International Conference on System Modeling and Advancement in Research Trends, SMART 2023*, 2023, pp. 508–511. doi: 10.1109/SMART59791.2023.10428501.

[42] A. Obis, "*Army Leaders Say Data is Key to Tackling Contested Logistics*," https://govciomedia.com. Accessed: Sep. 02, 2024. [Online]. Available: https://govciomedia.com/army-leaders-say-data-is-key-to-tackling-contested-logistics/

[43] T. A. Walsh and A. L. Huber, "*A Symphony of Capabilities: How the Joint Warfighting Concept Guides Service Force Design and Development*," National Defense University Press, vol. 111, no. 4, Oct. 2023, Accessed: Sep. 03, 2024. [Online]. Available: https://ndupress.ndu.edu/Media/News/News-Article-View/Article/3568312/a-symphony-of-capabilities-how-the-joint-warfighting-concept-guides-service-for/

[44] P. A. Surrey, "*An Expeditionary Civil Reserve Air Fleet for the Contested Environment*," Master of Military Studies (MMS) thesis, Marine Corps University, Quantico, 2021. Accessed: Sep. 07, 2024. [Online]. Available: https://apps.dtic.mil/sti/trecms/pdf/AD1178321.pdf

[45] C. S. Tsirlis, "*Spectrum Contested Environments - Maneuver warfare and command and control in an EMS environment*," Marine Corps Gazette, no. Ideas & Issues (C4/OIE), pp. 71–81, Apr. 2020, Accessed: Sep. 02, 2024. [Online]. Available: https://www.mca-marines.org/wp-content/uploads/0420-Spectrum-Contested-Environments.pdf

[46] D. R. Marion, *Strategy Primer*, Expanded edition. Quantico, Virginia: The Marine Corps War College, 2022. Accessed: Sep. 10, 2024. [Online]. Available: https://www.usmcu.edu/Portals/218/TheMCWARStrategyPrimer_exp%20ed_web.pdf

[47] I. Rehman, "China, the US and protracted war: a comparative evaluation," *Adelphi series*, vol. 62, no. 496–497, pp. 73–132, Mar. 2022, doi: 10.1080/19445571.2022.2274679.

[48] J. D. Mantilla Mejía, "Uso del operador swap genera soluciones eficientes computacionales en un caso de enrutamiento de vehículos con enfoque de ventanas de tiempo," *Computer and Electronic Sciences: Theory and Applications*, vol. 2, no. 1, pp. 51–60, Aug. 2021, doi: 10.17981/cesta.02.01.2021.05.

[49] H. C. Valenzuela, J. B. Sáez, and C. C. Becker, "Neoliberal economic, social, and spatial restructuring: Valparaíso and its agricultural hinterland," *Urban Plan*, vol. 6, no. 3, pp. 69–89, 2021, doi: 10.17645/up.v6i3.4242.

[50] P. Howson, "Building trust and equity in marine conservation and fisheries supply chain management with blockchain," *Mar Policy*, vol. 115, no. September 2019, p. 103873, 2020, doi: 10.1016/j.marpol.2020.103873.

[51] W. D. Mills and E. Limpaecher, "Sustainment will be Contested," *Proceedings - Calhoun: The NPS Institutional Archive*, vol. 146, no. 11, pp. 30–35, Nov. 2020, [Online]. Available: https://hdl.handle.net/10945/66167

[52] A. V. Reddy et al., "Contested Logistics Operations Using Digital Support," in *AIAA SciTech Forum and Exposition*, 2024, 2024. doi: 10.2514/6.2024-0481.

[53] G. V. Chary, S. P. Brady, M. R. Wayne, and D. E. Mortin, "Assessing Sustainment and Mission Impacts Associated with Next Generation Aviation Systems," in *Proceedings - Annual Reliability and Maintainability Symposium*, 2024. doi: 10.1109/RAMS51492.2024.10457829.

[54] N. S. Pessanha, "Revolutionizing ocean engineering: the impact of autonomous vehicles," Academia Engineering, p. 10, Sep. 2024, doi: 10.20935/AcadEng7339.

[55] G. A. L. R. Guerra, K. L. L. Urrea, and J. C. M. Acevedo, "Autonomous Vehicles as a new capability and Support of Naval Operations," *Journal Of Computer and Electronic Sciences Theory and Applications*, vol. 4, no. 2, pp. 49–65, 2024, doi: 10.17981/cesta.04.02.2023.04.

[56] S. Sierra, "*Unmanned Low Profile Vessels (ULPVs): 'Narco Subs' for Contested Logistics*," Monterey, May 2024, p. 20. Accessed: Sep. 06, 2024. [Online]. Available: www.acquisitionresearch.net

[57] J. Fleming, B. Martin, F. Villalobos, and E. Yoder, "*Naval Logistics in Contested Environments: Examination of Stockpiles and Industrial Base Issues*," RAND CORPORATION, Santa Monica, 2024. Accessed: Sep. 02, 2024. [Online]. Available: www.rand.org/t/RRA1921-1.

[58] A. N. de C. ARC, G. A. L. R. Guerra, G. A. G. Velandia, R. S. F. Sarria, and H. L. Rondon, OP 3-4.1. Colombia: Jefatura de Acción Integral y Desarrollo, 2024, pp. 1–140.

[59] A. N. de C. ARC, L. D. Vallejo Polanco, J. A. Pitta Vargas, M. Castellanos Álvarez, and M. Ramos Hernández, OP 4-1.1. Bogotá D.C., Colombia: Jefatura de Operaciones Logísticas, 2021, p. 184.

[60] J. C. Pamplin, M. H. Remondelli, N. Fisher, and M. T. Quinn, "Fully Autonomous Casualty Care on the Future Battlefield," *Mil Med*, Aug. 2024, doi: 10.1093/milmed/usae377.

[61] J. C. Pamplin et al., "Revolutionizing Combat Casualty Care: The Power of Digital Twins in Optimizing Casualty Care Through Passive Data Collection," *Mil Med*, May 2024, doi: 10.1093/milmed/usae249.

[62] C. Irwin et al., "Contested Logistics: Overcoming Army Medical Supply Challenges in the Indo-Pacific," in *Proceedings of the Annual General Donald R. Keith Memorial Conference, New York: A Regional Conference of the Society for Industrial and Systems Engineering*, May 2024. Accessed: Sep. 06, 2024. [Online]. Available: https://www.ieworldconference.org/content/WP2024/Papers/GDRKMCC24_14.pdf

[63] S. Scheel, S. Álvarez Velasco, and N. De Genova, "COVID capitalism: The contested logistics of migrant labour supply chains in the double crisis," *Politics*, vol. 44, no. 2, pp. 175–187, May 2024, doi: 10.1177/02633957241229377.

[64] N. I. C. NIC, "*Non-State Actors Playing Greater Roles in Governance and International Affairs*," Washintong D.C., Jun. 2024. Accessed: Jul. 22, 2024. [Online]. Available: https://www.dni.gov/files/ODNI/documents/assessments/NICM-Non-State-Actors_23-01637_05-18-24_.pdf

[65] C. Wisdom, N. Chartrain, K. Blaize-Wise, G. J. Klarmann, K. H. Gilchrist, and V. B. Ho, "Point-of-Need Additive Manufacturing in Austere Arctic Environments: An Evaluation of Medical Logistics Requirements and Capabilities Demonstration," *Bioengineering*, vol. 11, no. 3, Mar. 2024, doi: 10.3390/bioengineering11030232.

[66] R. Hernández-Sampieri, C. Fernández-Collado, and P. Baptista-Lucio, *Metodología de la Investigación*. 2004. Accessed: Feb. 28, 2018. [Online]. Available: http://observatorio.epacartagena.gov.co/wp-content/uploads/2017/08/metodologia-de-la-investigacion-sexta-edicion.compressed.pdf

[67] R. Hernández-Sampieri and C. P. Mendoza-Torres, *Metodología de la investigación: las rutas cuantitativa, cualitativa y mixta*, First. Mexico D.F.: McGraw Hill, 2018.

[68] I. M. Copi and C. Cohen, Introduction to Logic, Second., vol. 1. Mexico: Pearson Education Inc, 2013.

[69] P. Klaus, "Logistics as a science of networks and flows," *Logistics Research*, vol. 2, no. 2, pp. 55–56, Jun. 2010, doi: 10.1007/s12159-010-0033-6.

[70] L. Tanya, "*Keys to Contested Logistics in the Indo-Pacific: Access, Presence, Posture, and Interoperability*," https://api.army.mil. [Online]. Available: https://api.army.mil/e2/c/images/2024/01/29/93622382/original.jpg]

[71] S. Joshi, "*Demystifying the Anti-Access / Area Denial (A2 / AD) Threat*," Medium. Accessed: Sep. 04, 2024. [Online]. Available: https://sameerjoshi73.medium.com/demystifying-the-anti-access-area-denial-a2-ad-threat-d0ed26ae8b9e

[72] J. M. Voth, E. G. Pence, V. Sorrentino, and G. H. Sturtevant, "A moment of maritime opportunity? The U.S. Navy operational energy challenge," *Journal of Marine Engineering and Technology*, vol. 23, no. 3, pp. 196–208, 2024, doi: 10.1080/20464177.2024.2315648.

[73] I. Cil and M. Mala, "A multi-agent architecture for modelling and simulation of small military unit combat in asymmetric warfare," *Expert Syst Appl*, vol. 37, no. 2, pp. 1331–1343, Mar. 2010, doi: 10.1016/j.eswa.2009.06.024.

[74] C. A. Sorenson, "*Logistics in a contested environment: network analysis and flow optimization*," Master of Science, Naval Postgraduate School, Monterey, 2020. Accessed: Sep. 06, 2024. [Online]. Available: https://apps.dtic.mil/sti/trecms/pdf/AD1114716.pdf

[75] T. J. Lundberg, "*Logistical Maneuverability: Tactics Wins Battles, Logistics Wins Wars.*," Master's Thesis, Marine Corps University, Quantico, 2017. Accessed: Sep. 02, 2024. [Online]. Available: https://apps.dtic.mil/sti/citations/AD1176532

[76] D. Vendel, "*Sustaining shadows: a theory of special operations logistics for unconventional warfare*," Självständigt arbete mastersuppsats, krigsvetenskap, Försvarshögskolan, Stockholm, 2021. Accessed: Sep. 02, 2024. [Online]. Available: https://www.diva-portal.org/smash/get/diva2:1571682/FULLTEXT02.pdf

[77] A. M. Ansley, "*The Challenges of Logistically Sustaining and Supporting an Operational Force in a Contested Environment*," Master of Military Studies (MMS), Marine Corps University, Quantico, 2020. Accessed: Sep. 02, 2024. [Online]. Available: https://apps.dtic.mil/sti/trecms/pdf/AD1177441.pdf

[78] D. Juling, "Truck Platooning: Great Prospect or Unrealistic Concept for Military Logistics in Europe?," *RUSI Journal*, vol. 168, no. 1–2, pp. 108–115, 2023, doi: 10.1080/03071847.2023.2195897.

[79] M. Manning and C. Daniels, "Conquering the Iron Mountain: Reducing the Marine Expeditionary Unit's Logistics Footprint Within the Amphibious Readiness Group," Monterey, Nov. 2011. [Online]. Available: www.acquisitionresearch.net

[80] M. Arboleda, "Extracción en movimiento: circulación del capital, poder estatal y urbanización logística en el norte minero de Chile," *Investigaciones Geográficas*, p. 3, Dec. 2018, doi: 10.5354/0719-5370.2018.48475.

[81] G. A. L. R. Guerra, D. Pulido, and J. E. Herrera, "*Informe de Gestión proceso de Acción Integral Vigencia 2023.*," Bogotá, Jan. 2024. [Online]. Available: www.armada.mil.co

[82] A. R. Shaffer and W. Miles, "Enabling Logistics in Contested Environments Share Tweet," https://www.nationaldefensemagazine.org/. Accessed: Sep. 09, 2024. [Online]. Available: https://www.nationaldefensemagazine.org/articles/2024/1/5/emerging-technology-horizons-enabling-logistics-in-contested-environments

[83] E. Bengigi et al., "*Logistics in Contested Environments*," Monterey, Jun. 2020. [Online]. Available: http://hdl.handle.net/10945/65507

[84] D. Kalenatic, C. A. L. Bello, and L. J. G. Rodríguez, "Modelo de Medición, Análisis, Planeación y Programación de Capacidades en un Contexto de Múltiples Criterios de Desición," 2004. [Online]. Available: http://revistas.udistrital.edu.co/ojs/index.php/reving/article/view/2718/3929

[85] D. Kalenatic, L. González, C. López, and L. Arias., "El sistema de gestión tecnológica como parte del sistema logístico en la era del conocimiento.," Cuadernos de Administración, vol. 22, no. 39, pp. 257–286, 2009, [Online]. Available: http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=49813810&lang=es&site=ehost-live

[86] D. Kalenatic, C. A. L. Bello, L. J. González, and F. J. R. Velasco, "Modelo de Localización dinámica de nodos logísticos intermedios dentro de zonas seguras en el contexto de logística focalizada," *Revista Facultad de Ingenieria*, no. 59, pp. 133–144, 2011.

[87] G. A. L. R. Guerra and H. Rondón López, "Historical evolution of the integral action of the National Navy of Colombia," *Revista Rices*, vol. 2, no. 1, Jun. 2024, Accessed: Aug. 20, 2024. [Online]. Available: https://revistas.universu.com.co/index.php/rices

[88] A. Herman, Freedom's Forge: How American Business Produced Victory in World War II, First. NewYork: Random House, 2012. Accessed: Sep. 06, 2024. [Online]. Available: https://books.google.com.co/books?id=nKcFfGk-WH4C

[89] P. Venkateshan and K. Mathur, "An efficient column-generation-based algorithm for solving a pickup-and-delivery problem," *Comput Oper Res*, vol. 38, no. 12, pp. 1647–1655, 2011, doi: 10.1016/j.cor.2011.02.009.

[90] P. J. Driscoll, G. S. Parnell, and D. L. Henderson, Decision Making in Systems Engineering and Management, Third., vol. 1. in Wiley Series in Systems Engineering and Management, vol. 1. Wiley, 2011. [Online]. Available: https://books.google.com.co/books?id=33vO3gnwv4wC

[91] C. H. Kääriä, Y. Wang, M. D. White, I. Owen, J. S. Forrest, and I. Owen, "The virtual AirDyn: A simulation technique for evaluating the aerodynamic impact of ship superstructures on helicopter operations," *Aeronautical Journal*, vol. 117, no. 1198, pp. 1233–1248, 2013, doi: 10.1016/j.oceaneng.2012.12.052.

[92] A. Gunasekaran, K. hung Lai, and T. C. Edwin Cheng, "Responsive supply chain: A competitive strategy in a networked economy," *Omega* (Westport), vol. 36, no. 4, pp. 549–564, 2008, doi: 10.1016/j.omega.2006.12.002.

[93] E. Salcedo-Albarán, "Minds and systems View project Illicit networks, corruption and states View project," 2007. [Online]. Available: https://www.researchgate.net/publication/4829585

[94] J. C. Figueroa-García, D. Kalenatic, and C. A. López-Bello, "Multiple experts knowledge in fuzzy optimization of logistic networks," *Intelligent Systems Reference Library*, vol. 87, pp. 623–643, 2015, doi: 10.1007/978-3-319-17906-3_24.

[95] M. Fortuna and S. Rege, "*Computable General Equilibrium Models: Theory and Applications*," p. 229, Jun. 2010, Accessed: Nov. 04, 2023. [Online]. Available: http://www.uac.pt/~ceeapla/

[96] D. Kalenatic, C. López, and L. J. González, "Modelo de ampliación de la capacidad productiva," *Ingeniería*, vol. 14, no. 021-750X, pp. 66–77, 2009, [Online]. Available: file:///C:/Users/Joha/Documents/Asistencia/Modelo de ampliación de la capacidad Productiva.pdf

[97] L. J. González, D. Kalenatic, F. Rueda, and A. Sarmiento, "Caracterización del sistema logístico de ayuda humanitaria y de los modelos matemáticos asociados," 2013.

[98] G. Cipoletta. Tomassian, Gabriel. Pérez Salas, R. J. (Ricardo J. Sánchez, and United Nations. Economic Commission for Latin America and the Caribbean. División de Recursos Naturales e Infraestructura., Políticas integradas de infraestructura, transporte y logística : experiencias internacionales y propuestas iniciales. CEPAL, 2010.

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