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IMPROVING UNRESTRICTED LINE OFFICER COMMUNITY CORPS LOGISTICS KNOWLEDGE: KEY CONCEPTS AND PROCESSES

Miller, Sand D.; Vadala, Timothy P.

Monterey, CA; Naval Postgraduate School

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IMPROVING UNRESTRICTED LINE OFFICER COMMUNITY CORPS LOGISTICS KNOWLEDGE: KEY CONCEPTS AND PROCESSES

December 2022

By: Sand D. Miller
Timothy P. Vadala

Advisor: Bryan J. Hudgens
Co-Advisor: Aruna U. Apte
Second Reader: Chad W. Seagren

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Naval leadership has identified the lack of logistics experience as a critical force vulnerability in the Unrestricted Line (URL) community officer corps. They believe this gap will limit the Navy's ability to sustain operations in contested and constrained environments. As the United States enters a new era of strategic competition with near-peer competitors, increasing the logistical knowledge and educational experiences of the URL community is of paramount importance. Peacetime naval operations have dominated the operational landscape for several decades with logistical support mirroring that static and predictable environment. Strategic competition will challenge the established logistic concepts and those concepts must also change. This project develops case studies to equip URL officers with the necessary mindset to approach and analyze complex logistic concerns. Each case study touches on specific logistics topics, incorporates broader logistical implications, and uses various investigative and analytic tools to help solve real-world problems. Equally important, this study will build a stronger foundation that will make the warfighter more combat effective and further enhance his or her grasp of operational and tactical environments.

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Sand D. Miller, Lieutenant Commander, United States Navy
Timothy P. Vadala, Lieutenant Commander, United States Navy

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December 2022

Approved by: Bryan J. Hudgens
Advisor

Aruna U. Apte
Co-Advisor

Chad W. Seagren
Second Reader

Bryan J. Hudgens
Academic Associate
Department of Defense Management

Rene G. Rendon
Academic Associate
Department of Defense Management

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ABSTRACT

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LIST OF ACRONYMS AND ABBREVIATIONS

ACAT	Acquisition Category
AFB	Air Force Base
A_o	Operational Availability
AOR	Area of Responsibility
ASD	Aviation Support Detachment
ASEAN	Association of Southeast Asian Nations
CHENG	Chief Engineer
CLF	Combat Logistics Force
CNO	Chief of Naval Operations
COMNAVIRLANT	Commander, Naval Air Force Atlantic
DARPA	Defense Advanced Research Projects Agency
DMO	Distributed Maritime Operations
DOD	Department of Defense
DPRK	People's Republic of Korea
EABO	Expeditionary Advanced Basing Operations
EMD	Engineering and Manufacturing Development
FSV	Fast Supply Vessels
FY	Fiscal Year
INDOPACOM	United States Indo Pacific Command
JCS	Joint Chiefs of Staff
JLEnt	Joint Logistics Enterprise
LAW	Light Amphibious Warships
LCC	Life Cycle Costs
LOCE	Littoral Operations in a Contested Environment
LP	Linear Programming
MAIS	Major Automated Information System
MATCONOFF	Material Control Officer

MDAP	Major Defense Acquisition Program
MSA	Material Solution Analysis
NGLS	Next Generation Logistic Ships
OPNAV	Office of the Chief of Naval Operations
O&S	Operation and Support
PACFLT	United States Pacific Command
P&D	Production and Deployment
PEO	Program Executive Office
PERS-41	Surface Warfare Officer Assignments
PRC	People's Republic of China
PSV	Platform Support Vessels
PUK	Pack-up Kit
R&D	Research and Development
TAT	Turn Around Time
TMRR	Technology Maturation and Risk Reduction
TYCOM	Type Commander
UNREP	Underway Replenishment
URL	Unrestricted Line
USMC	United States Marine Corps
WIP	Work in Progress

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I. INTRODUCTION

"As it has been throughout history, logistics remains essential to deter and win great power competition, de-escalate crises to avoid conflict, and identify opportunities to build cooperation" (Fogg et al., 2021, para. 1). The United States and "by extension the Department of Navy" is situated in a renewed great power, or strategic competition, with China (O'Rourke, 2022, p. 3). As such, the Navy's logistical approach to yesterday's security environment is no longer sufficient or practicable. According to the former Vice Chairman of the Joint Chiefs of Staff, General John Hyten, "Contested logistics has been an area of rich study, rich conversation, and we're changing our entire logistics approach because of it" (Vergun, 2021, p. 2). Recently, Navy leadership identified the lack of logistics experience as a critical force vulnerability in the Unrestricted Line (URL) community officer corps. To address this concern, OPNAV N4 and PERS-41 policy makers are asking what the important gaps in knowledge and experience are for senior URL officers and how the Navy can incorporate experience and education into the URL career pathways (B. Hudgens, personal communication, March 31, 2022).

The Navy has a problem with new technologies and competitors: "Over the last century, the U.S. Navy has encountered critical moments when the emergence of new technologies and competitors cause paradigmatic shifts, undermining established operations and force structure" (Wirtz et al., 2022, p. 166). In today's strategic competition, the Navy must continue to evolve to counter our near peer competitor's strength, logistical reach, and geopolitical networks. As part of his executive summary in his logistics strategic document, Chief of Naval Operations Admiral Gilday stated, "Currently, the logistics enterprise is poorly positioned to rapidly remedy the situation. Multiple resource sponsors are responsible for stove-piped logistics investments with no senior logistics oversight to ensure the alignment of investments to a coordinated strategic plan – the result is systemic sub-optimization" (Gilday, 2021, p. i). Admiral Gilday (2021) continued to describe the challenge, "War games, exercises, experiments, and science & technology efforts have often overlooked or assumed away logistics problem sets for a decided focus on kinetic activities and capabilities" (p. 4).

Recently, the world and to a greater extent the United States experienced several instances that demonstrated the apparent vulnerabilities in the world's supply chains and more importantly in our overall logistics networks. A prime example (and one that mirrors a contested environment) is when the Ever Given ran aground inside the Suez Canal in 2020. "It's definitely going to continue to backlog ports and other delivery mechanisms as a result, and then of course the chaos that disrupts thereafter," said Douglas Kent in a CNBC article (Stevens, 2021, para. 3). This single event emphasized the importance of chokepoints in a supply chain and should be viewed as example of what could occur in a contested environment.

Another example of supply chain disruption happened as the world started to climb out of the COVID-19 pandemic. The Ports of Long Beach and Los Angeles experienced massive supply chain issues in 2021 resulting in catastrophic backlogs, increased lead times, workforce strain, and increased costs. As (Saraiva & Murray, 2021) stated in a recent Bloomberg article, "The bottleneck means companies that hire the shipping lines to move their goods have to place orders several months in advance, pay much higher rates and often order in larger quantities than they have in the past to ensure enough inventory is on hand" (para. 3)

In a contested environment, these real-world examples are not farfetched. In today's strategic competition, our status quo peacetime approach requires a "face lift." The Navy's supply chain is dependent on the world's chokepoints and can be disrupted easily. A common understanding of logistic concepts and processes is required to respond to today's challenges and strengthen the URL logistics decision making in a contested environment. As a result, the URL officer community must enhance their requisite logistics knowledge to make the best decisions possible.

Stemming from a focus on kinetic operations, logistics concerns were "downplayed" in planning and in wargaming scenarios. Consequently, the sustainment mechanisms are incapable of adapting to the changing and more contested operational conditions (Gilday, 2021, p. i). More specifically, Admiral Gilday (2021) expressed concern over the lack of "Big L" logistics understanding, which is "greater integration or expansion of logistics processes across all logistics core functions and functional capabilities" (p. 6). Since we are now operating in a contested maritime environment, the Navy and Marine Corps has been exploring different sustainment opportunities to excel in this challenging environment of operational concepts including Expeditionary Advanced Basing Operations (EABO), Distributed Maritime Operations (DMO) and Littoral Operations in a Contested Environment (LOCE) (p. 2). To achieve Admiral Gilday's desired end state of "logistics awareness and knowledge," the education and training of our force requires attention (p. 24). Therefore, the purpose of this qualitative study is to identify key logistical concepts that will enhance the URL officer Corps' logistical knowledge and experience using the case study method.

A goal of this study is to improve the logistics experience of the URL community officer corps which has been identified as a critical force vulnerability problem. This increased knowledge will help Navy leadership formulate how to incorporate key logistics processes, concepts, and knowledge most essential to perform at the tactical and operational levels. The findings will also increase understanding of the knowledge gaps for senior URL officers by elaborating on the pertinent skills and desired education experience that the Navy must incorporate into the development of its future leaders. Additionally, this study contributes to the manpower and personnel communities as they detail officers to appropriate billets (B. Hudgens, personal communication, March 31, 2022).

This capstone is organized into five chapters: I) Introduction, II) Background and Literature Review, III) Methodology and Approach, IV) Case Study Analysis, and V) Summary and Conclusions. In the next chapter, we will discuss the importance of understanding the different types of military concept of operations for logistics sustainment. Additionally, we will provide a review of previous contributions and concerns on today's military environment. In Chapter III, we detail the methods used to create and present key logistics concepts using the case study method. In Chapter IV, we present four separate case studies and their requisite answer keys. In the final chapter, we summarize the capstone project and provide conclusions on the importance of these logistical concepts and how they should be used to further develop the URL community's warfighting effectiveness.

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II. BACKGROUND

In this chapter, we study military operational concepts and its importance to logistics. Additionally, we provide previous work that identifies logistics concepts and the military theater environment.

“No force is immune to every threat; no force can operate with impunity in a heavily contested environment” (Martin, 2017, as cited in Halligan, 2020, p. 7). The landscape of military operations is constantly changing and expanding due to a variety of bad actors’ actions: “The current security environment will force the Navy to conduct distributed operations over a larger geographic area of responsibility. With units operating at extended distances in contested environments, their lifeline of sustainment becomes one of the top priorities” (Halligan, 2020, p. 1). The Navy is acknowledging this security environment by adopting a force laydown structure which allows more flexibility in planning operations: “Navy wants to begin shifting to a new more distributed fleet architecture that is to include a reduced proportion of larger ships and an increased proportion of smaller ships” (O’Rourke, 2022, p. 1) The following terms provide insight to understanding the decision-making process for this complex environment.

Distributed operations have been defined as “a concept of operations referred to as distributed lethality that entails more widely dispersing combatant ships to improve the Navy’s offensive and defensive capabilities” (Pendleton, 2017, p. 1). Since mobile forces are often tasked with multiple operations requiring them to remain in an operating area for extended periods, it is important to be aware of that area’s logistical resources and how to effectively respond to sustainment needs.

Distributed maritime operations (DMO) has been defined by Admiral Gilday as an “operations concept that leverages the principles of distribution, integration, and maneuver to mass overwhelming combat power and effects at the time and place of our choosing” (Gilday, 2021, p. 32). Today’s fight requires joint forces working together to achieve a desired effect at a particular time and place in a contested environment. As such, this is one of the three primary operational concepts Admiral Gilday has expressed sustainment concerns of when using the current logistics enterprise. (p. 2). This concept lends to forces potentially operating beyond normal logistics networks and infrastructure. Due to limited resources with competing requirements from other military components and allies, it is crucial to understand the friction points so all available resources can be leveraged for the best optimum results.

Expeditionary Advanced basing operations (EABO) has been defined as an operation concept which fully integrates “Fleet Marine Force and Navy capabilities to enable sea denial and sea control and power projection as well as sustainment of the fleet” (Gilday, 2021, p. 32). This is one of the newer operational concepts that uses the distributed fleet structure intended to counter adversarial forces. This concept is one of Admiral Gilday’s sustainment concerns when conducting operations in a contested maritime environment (p. 2). Additionally, EABO is an instrumental piece of the Marine Corps Force Design 2030. In fact, the Commandant of the Marine Corps engaged Congress to build a new concept ship because of the significant contributions that EABO would bring to the warfighter (Halligan, 2020, p. 13). Therefore, it is imperative to understand the limitations of operating in austere locations in which supporting that “last tactical mile” could be the difference between success or failure.

Littoral operations in a contested environment (LOCE) describes “naval operations in a littoral environment in light of emerging threats to provide a unified framework for Navy-Marine Corps innovation” (Gilday, 2021, p. 32). Again, this additional operational concept can be used in contested maritime environments; however, Admiral Gilday has concerns of sustainment support (Gilday, 2021, p. 2). LOCE also aligns with the Marine Corps Force Design 2030 for bringing a more adaptable and relevant capability to the warfighter (Feickert, 2022). Even though LOCE is still in development, it could prove beneficial in future planning efforts and wargame exercises.

A. LITERATURE REVIEW

Our literature review covers previous contributions and concerns into today’s challenge of sustaining forces in a dynamic environment. The research contributions include Government Accountability Office and Congressional Research Services Reports, and other relevant articles, publications, and peer work. In addition, we wanted to recognize areas where our research could aid in expanding efforts to educate and inform decision makers about applicable logistics concepts in the defined area.

1. Renewed Great Power Competition: Implications for Defense-Issues for Congress

The United States is engaged in a new fight or "strategic competition" with a near peer competitor in the People's Republic of China. Following the collapse of the Soviet Union, the United States has not gone toe-to-toe with another nation–either economically or militarily (O'Rourke, 2022, pp. 1–3). With the rise of China and the resurgence of Russia, O'Rourke (2022) states that the United States must "contend with the reality that the distribution of power across the world is changing, creating new threats" (p. 2). As a result, this strategic competition places added strain on today's military strategies and operating approaches. Further O'Rourke (2022) states in his Congressional Research Services report that, "the benefits, costs, and risks of forward-deploying U.S. forces to distant regions on a sustained basis rather than basing them in the United States and deploying them to distant regions in response to specific contingencies is a long-standing issue in U.S. defense planning" (p. 8). There must be a shift in military planning and, with that, a shift in how we view logistics and our current logistics environment.

In a specific sense, this report discusses the challenges facing military posture and the Navy as they respond to this strategic competition, global presence, and the sustainment of distributed operations. President Biden's March 2021 Interim National Security Guidance emphasizes grappling "with the reality that the distribution of power across the world is changing, creating new threats" (O'Rourke, 2022, p. 2). Those threats are being continually accessed to determine the impact to current policy, and strategy. The strategy further asserts the need to invest in its personnel by training and equipping them to maintain a ready defense posture for "deterring potential regional aggressors, reassuring allies and partners, and rapidly responding to crises" (O'Rourke, 2022, p. 8).

The old ways of fighting are insufficient for today's fight which is being fought across a spectrum of arenas. The article also details the various "DOD acquisition programs, exercises, warfighting experiments" which were "accelerated, increased in scope, given higher priority, or had their continuation justified as a consequence of the renewed U.S. emphasis on high-end conventional warfare" (O'Rourke, 2022, p. 18). Hence, O'Rourke poses several probable Congressional oversight questions such as 1) the rate of development for military operational concepts, 2) the benefits for those concepts and 3) the integration of those revised concepts for joint operations (O'Rourke, 2022, p. 27). The latter being a critical question to consider especially as it pertains to logistics.

2. New U.S. Marine Corps Force Design Initiative: Force Design 2030

This report discusses the U.S. Marine Corps announced plan to shift their forces within the next ten years in a new direction and position itself to respond adequately to China and Russia. This shift will move the Marines away from status quo ideals to embrace new operational concepts and capitalize on their force capability. The report also mentioned the Commandant's 2021 updates, which underscores their intent to remove "significant numbers" of fixed aircraft from future planning and "phasing out most legacy logistical capability, previously intended for sustained land operations, and modernizing the rest for distributed maritime operations" (Feickert, 2022, p. 3). This Congressional Research Services report addresses the potential Congressional concerns involving the Marines; for example, divesting themselves of various capabilities without adequate replacement and the ramifications for future taskings and planning. Since Marines bring a critical capability to the threat environment, it is important to be aware of any gaps in their capability for current and future operations.

3. Making DOD's Vast Logistics Enterprise More Resilient

The basis of this report argues that the Department of Defense (DOD's) Joint Logistics Enterprise (JLEnt) needs to adjust its current operating methods to excel within a contested environment (DARPA, 2019, para. 1). It also mentions the lack of understanding between the logistics systems and its parts, which expose the system to unintentional outcomes: "Local decisions are made without regard to the state of the global enterprise, causing catastrophic swings in inventory and readiness. Both failure modes are exacerbated by inadequate situational awareness driving operational decisions" (DARPA, 2019, para. 4). DARPA's answer to this challenging dilemma is the LOGX program, which is software based for "real-time logistics and supply chain system situational awareness" and takes advantage of "logistics information in digital format and the cloud" (DARPA, 2019, para. 2). Information is constantly changing and not having the latest information can be detrimental to supporting distributed forces. Thus, the awareness of LOGX capabilities would aid in having a holistic sustainment picture that supports theater operations.

4. Next Generation Logistics Ships: Supporting the Ammunition and Supply Demands of Distributed Maritime Operations

Apte et al. (2020), Halligan et al., (2020) and Loseke & Yarnell (2020) focused on the feasibility of an optimal type and quantity of Next Generation Logistics Ships (NGLS) required to act in complex contested environments based on given logistics sustainment scenarios. Their project focused on three types of vessels: Platform Supply Vessels (PSV), Fast Supply Vessels (FSV), and Light Amphibious Warships (LAW). The authors emphasized the adaptability of how the Navy's "innovation and capability advantage supplied new concepts such as distributed maritime operations (DMO), littoral operations in contested environments (LOCE), and expeditionary advanced base operation (EABO)" and also emphasized changing "how the U.S. Navy would employ and distribute its forces across contested environments" (Halligan et al., 2020, p. v). PSVs and FSVs have been in operation for quite some time; however, LAWs were a new warship class still in development at that time. The authors used linear programming (LP) for data analysis and as an optimization model for rendering solutions to the various scenarios. Their project provided a framework that could be utilized to support the given sustainment scenario of "rearm and resupply" using the DMO, LOCE and EABO operational concepts (p. v). Understanding the potential limitation of capabilities using the various operational concepts in a wartime scenario help illuminate available options that could be used in similar environments.

5. Navy Readiness: Actions Needed to Maintain Viable Surge Sealift and Combat Logistics Fleets

This Government Accountability Office report discusses the need for the aging surface fleet, which includes Combat Logistics Forces (CLFs), to support theater distributed operations and the impact of those operations on the forces and readiness. CLFs provide an essential capability that enables the warfighter to operate longer in a designated area: "the capability to rearm, refuel, and re-provision Navy ships at sea is critical to the Navy's ability to project warfighting power from the sea" (Pendleton, 2017, p. 9). Yet, the surface fleet has experienced severe material readiness challenges because of antiquated equipment and delays in required maintenance periods (Pendleton, 2017, p. 11). Similarly, the report noted that CLFs are facing the same obstacles, which resulted in its inability to execute or be available for tasking that supports major contingency operations (Pendleton, 2017, p. 11).

This report also stresses that the ramifications of conducting distributed maritime operations has not been determined: "The Navy has not assessed the effect that implementing widely distributed operations will have on the number and type of combat logistics ships required to support the fleet" (Pendleton, 2017, p. 22). Consequently, the report warns that deferring the analysis could hinder fleet support operations: "Given the fleet's dependence on the combat logistics force, waiting until 2019 or 2020 to conduct an assessment, as planned, could result in poor investment decisions as the Navy continues to build and modernize its fleet" (Pendleton, 2017, p. 28). The Navy has taken strides in recent years to address ship maintenance delays but having knowledge of this limiting factor is necessary to adequately support sustainment operations in a contested environment.

6. DOD Focus on Aspirational Challenges in Future Warfighting

This Department of Defense article focuses on the deterrence of future aggressions by China and Russia through the "expanded maneuver" concept (Vergun, 2021, para. 1). Former Vice Chairman of the Joint Chiefs of Staff, General Hyten, explained the concept as understanding and stopping each area our adversaries will respond while safeguarding "DOD and coalition forces" (Vergun, 2021, para. 2). The four core parts as expressed by

General Hyten were contested logistics, joint fires, joint all-domain command and control, and information advantage (Vergun, 2021, para. 3–13). The first core part is contested logistics, which is complex because various classes of supply like fuel and ammunition "doesn't just appear" (Vergun, 2021, para. 4). The second core part is joint fires, which is based on the idea of the adversary's inability to detect source of fires, thus preventing them from launching a defense (Vergun, 2021, para. 7). The third core part is joint all-domain command and control. This core helps bring clarity to the operating area: "the goal is to be fully connected to a combat cloud that has all the information that you can access at any time, any place … to be able to act quickly on that" (Vergun, 2021, para. 11).

In the event the information is inaccessible due hostile conditions, General Hyten states "you have to figure out how to operate once again with mission command — things that we learned as young lieutenants — how to operate with real centralized control but decentralized execution when you're disconnected" (Vergun, 2021, para. 12). The last core part is information advantage, which effortlessly joins people and systems together while "enabling interoperability across the joint force and with allies and partners" (Vergun, 2021, para. 13). This article is significant because it underlines the DOD's commitment level regarding requirements that addresses or support this concept, and its implementation among the military components. Additionally, it emphasizes the importance of having the knowledge and information to render autonomous decisions in face paced situations.

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III. METHODOLOGIES AND APPROACH

In this chapter, we formulate and describe our research approach and methodologies. As discussed in previous chapters, this project develops case studies to equip URL officers with the necessary mindset to approach and analyze complex logistic concerns. Each case study touches on specific logistics topics, incorporates broader logistical implications, and uses various investigative and analytic tools to help solve real world problems.

The Navy's logistics enterprise is vast, challenging, and at times complicated. Additionally, the logistic enterprise spans the Navy's global reach and all levels of strategic warfare. As a result, we must identify specific concepts and distill this information down to its purest and most critical form to include only those concepts that will maximize the URL logistics knowledge and those concepts that will enhance their warfighting capabilities.

To begin our analysis, we need to understand the overarching logistics concepts, which are outlined by the Joint Chiefs of Staff Joint Concepts for Logistics and the Joint Logistics Publication 4–0. Per Joint Concepts for Logistics, "the challenge for future joint logistics is to adequately support globally integrated operations given the combination of five ongoing trends: 1) the increasing logistics demand of U.S. joint forces and operations; 2) constrained resources, both overall and within the logistics force structure; 3) the growing complexity of logistics operations; 4) the proliferation of advanced anti-access/area-denial capabilities by adversaries that would degrade logistics capabilities and capacities; and 5) increasing cyber threats to joint and partner logistics networks and mission systems" (Joint Chiefs of Staff, 2015, p. 3). Further explained by Admiral Gilday (2021) and stated in our introduction, a common understanding of logistic concepts and processes are required to respond to today's challenges and ultimately strengthen URL decision making in a contested environment (p. 4).

As such, our case studies were built to capture specific logistics topics we believe will educate the URL community on real world logistic problems and applications to include spare parts, deployment and distribution, logistics in a contested environment, weapon system life cycle costs, demand signals, contracting elements, supply and transportation support functions and organizations, readiness, and sustainability to name a few. Each case study is broken down into four parts: 1) an introduction narrative, 2) a key concept knowledge check, 3) an application narrative, and 4) an application knowledge check.

The initial narrative introduces the reader or class to a potential real-world situation common to logisticians and planning staffs. The goal is to introduce the underlying problem and basic (key) logistic concepts. Following this narrative is a knowledge check designed to sharpen the reader's or class's understanding of foundational logistic concepts. Once these basic concepts are defined, the reader or class is provided an "application" of these concepts embedded in a second narrative.

As delineated by the CNO, the goal is to strengthen the URL decision making and understanding of logistics. We believe this application narrative/section meet that requirement as it challenges the reader or class to deepen their understanding of logistics thus strengthening their ability to not only grasp the concepts but make more effective and smarter decisions because of it. To help aid in this objective, the application narrative is followed by another knowledge check that builds upon the first knowledge check stretching the boundaries of understanding and application. Of note, these case studies were designed to stimulate conversation and analysis. The solutions provided in the answer key sections are subjective and open ended. Logistics is dynamic and complex, meaning the answers to some problems are clear but the answers to others are more fluid. As always, a goal of logistics is to support the mission and find a way to yes.

IV. CASE STUDY METHOD AND ANSWER KEYS

A. SPARE PART DETERMINATION

LCDR Smith has recently been assigned the maintenance officer position at Helicopter Sea Combat Squadron (HSC) 5 – “The Night Dippers.” His squadron is just one of several squadrons homeported at Helicopter Sea Combat Wing Atlantic in Norfolk, Virginia. After a stress-free weekend with a cookout and some yoga, LCDR Smith is well rested for what turns out to be a difficult week. Monday morning approaches quickly as he receives an email from his Type Commander (TYCOM), COMNAVAIRLANT, asking about monthly metrics and why his squadron is below an operational availability (A_o) of 92%. To add insult to injury, he owes a full report by the fifth of the next month and today is the thirty first.

LCDR Smith calls in his team, Chief Church and Aviation Petty Officer Scott, requesting they run down the maintenance report. After running through the report, the team notices the following issues:

- Longer than normal turnaround time (preventative maintenance TAT)
- Longer wait times for parts (affecting work-in-progress (WIP))
- Spare parts inventory below the service level of 85%

After his team leaves, LCDR Smith ponders other issues not in the report:

- Severe manning issues (80% manning)
- Service contracts: maintenance performed by the contractor has slowed maintenance down

Making sure he’s captured the entire story, LCDR Smith calls his supply counterpart, LCDR Gilmore at Aviation Support Detachment (ASD) Norfolk. LCDR Smith asks kindly why it was taking so long to get parts? Further, he asks LCDR Gilmore why we can’t just increase the inventory level for common parts on his aircraft. Sensing where this was going, LCDR Gilmore tells LCDR Smith that he needs to establish a demand signal. He also explains that service levels are determined prior to weapon system fielding, so it may be hard to change those now.

1. Knowledge Check: Key Logistics Concepts

1. Why do the metrics matter in the overall readiness scheme?
2. What is Operational Availability (A_o)? Why does the Navy care about weapon system A_o?
3. What is a service level? What is safety stock?

Several months later, LCDR Smith and his squadron are on a Sixth Fleet deployment onboard USS HARRY S TRUMAN. One month into deployment, a helicopter breaks down, a part is needed, and supply issued their last part a week ago. LCDR Smith gets slightly frustrated because he did his due diligence during workups and provided supply a proper demand signal for parts needed that were not in his pack-up-kit (PUK). Unfortunately, LCDR Smith finds his helicopter grounded for two weeks, his A_o below standards, and his helicopter is now a "hanger queen."

2. Knowledge Check: Readiness Application

1. How does the A_o of a squadron affect the A_o of the wing?
2. What is cannibalization? What is the impact of cannibalization on mission readiness?
3. What is form, fit, function? How does that affect the supply chain sustainability?
4. What are some of the performance metrics you would want in a contract?
5. Due to the current geopolitical situations, LCDR Smith's ship has been ordered to stay on station longer and operate in a dispersed manner. As a result, The Material Control Officer (MATCONOFF – Senior Supply Officer) on the TRUMAN notices a spike in the usage of parts within the strike group (increasing without replacement stock). What are a few hypothetical solutions to this problem?

6. There is always the quintessential supply problem: having parts but no money to order more OR having no parts but money to order more. What are a few impacts that these issues have on ships at homeport and deployed?

3. Key Concepts Answer Key

1. Metrics help establish performance parameters such as readiness, illustrate limitations or constraints, establish a baseline of acceptability, display service and protection levels, and help develop a holistic quantitative picture of the operation. More importantly, metrics help outline risks to the whole system and its individual parts. Seeing these risks help develop and implement mitigation factors into the operation. Targeting the metric thresholds helps ensure optimal mission readiness and capability. Finally, metrics show compliance with associated directives and procedures. What are we doing well? What are we not doing well?

2. Operational availability is the measure of the total operable state at the start of a mission when the mission is called for at an unknown random point in time (usually steady state readiness measure) under the actual operating environment.

   Mathematically, operational availability (A_o) is how often a weapon system is UP (uptime) divided by the TOTAL TIME (uptime plus downtime). This simple equation will tell the operator how "available" (i.e., ready, mission capable) the weapon system is at a given time. The A_o is a ratio that will be listed as a number between zero and one.

   The Navy cares about this number because the Ao shows leadership how many weapon systems are mission capable or ready (i.e., helicopters). So, if a squadron has ten helicopters and five are down for corrective or preventative maintenance the A_o is 0.5 or 50% mission capable for that unit. However, spread across all helicopters in Norfolk the overall A_o could be higher (or lower). In fact, the Navy preestablishes the

Ao prior to fielding the weapon system. This helps determine reliability, sustainability, and maintainability performance factors.

3. Service level measures how well you manage your inventory: percent of reorder cycles satisfied (i.e., no stock out). (G. Ferrer, class lecture notes, April 26, 2022). Mathematically:

$$Service\ Level = 1 - \frac{Number\ of\ cycles\ with\ shortage}{Total\ number\ of\ replenishment\ cycles}$$

Safety stock is the inventory calculated and added to on hand inventory levels to ensure stock does not run out (stock out).

4. Application Answer Key

1. First, you must know the total number of weapon systems (helicopters) within the wing and squadron. Next, the A_o of the squadron may be a different percentage than the A_o of the wing because one is for the individual unit and the other is for the total availability or capability. For example, if the squadron has five aircraft and two are down for maintenance or awaiting parts, then the squadron A_o is 0.60 or 60%. But the wing may have twenty total aircraft. If all other aircraft are mission capable and those two are still down, then the A_o of the wing is 18/20 which equals 0.90 or 90%. These numbers paint a very different picture at both the tactical and operational levels.

2. Cannibalization removes part(s) from a defective or downgraded system and places them in another asset with the goal of restoring that asset's capability. For example, LCDR Smith has a "hanger queen" which could be used as a source of parts to maintain other aircraft. Cannibalization will affect the true picture of reliability and repair times of a downgraded system. More importantly, demand signals and inventory levels for the parts are affected by this action. Reported Ao will be skewed since one aircraft is down not two.

3. Form, fit, function refers to identifying characteristics of a part which permits it to be a viable substitute that can perform the same when placed in the system. The substitute must meet the form (technical design of the part), fit (shape, connections, etc.) and function (required operability).

   How does that affect supply chain sustainability? Having viable substitutes increases the pool of available parts used to sustain mission readiness, which decreases the strain on the supply chain. We need the supply chain to be adaptable and flexible to respond to any and all variability in demand.

4. Reliability (how often something breaks), operational availability (mission capable), maintainability (repair capabilities – parts, tools, etc), or sustainability.

5. Solutions: 1) Pool available assets in the strike group which could assist in fulfilling the requisition (looking at the other ships in the strike group). 2) Increase stock level for the high usage parts to meet the increased demand within the strike group. This will allow more parts to flow to the ships to satisfy the increased demand. 3) Reach out to TYCOM to work a directive to push parts from other ships to you. 4) Last resort, cannibalize.

6. Open ended answer. 1) The readiness of the unit to respond to tasking or an increase in operational tempo will affect demand from a supply posture – not enough supply to meet demand. 2) lead time impacts. 3) Budget augments. 4) Frequency (demand) increases. 5) Budget prioritization of funding. 6) The degradation in the readiness of the strike group and their ability to stay on station when deployed.

B. PETROLEUM DISTRIBUTION IN A CONTESTED ENVIRONMENT

LCDR Smith is coming up on her one-year anniversary working at U.S. Pacific Fleet (PACFLT) in the Maritime Operations Center (MOC). Her job is simple – execute the fight. Her job, as simple as it may sound, is complex and vast. To this day, she still marvels at the fact she works at the world's largest fleet command, which encompasses

100 million square miles, nearly half the Earth's surface, from Antarctica to the Arctic circle and from the West Coast of the United States into the Indian Ocean. Additionally, PACFLT consists of hundreds of ships and submarines, a vast fleet of aircraft, and tens of thousands of Sailors and civilians!

Following the conclusion of a very hectic day, LCDR Smith finally gets to head home. Once home, she reads a news article stating that the Pentagon has ultimately decided to close the Red Hill Fuel Facility. This is a very interesting development because the facility houses gallons upon gallons of Defense Logistics Agency (DLA) capitalized fuel: F76, JP5, and JP8. Further, this facility is not inside or boarding the "second island chain" or within reasonable reach of China and even North Korea (DPRK) (Figures 1 and 2). Because of the vast area of responsibility tasked to PACFLT, she wonders where leadership will eventually place all that fuel and how that'll affect the sustainability of the fight.

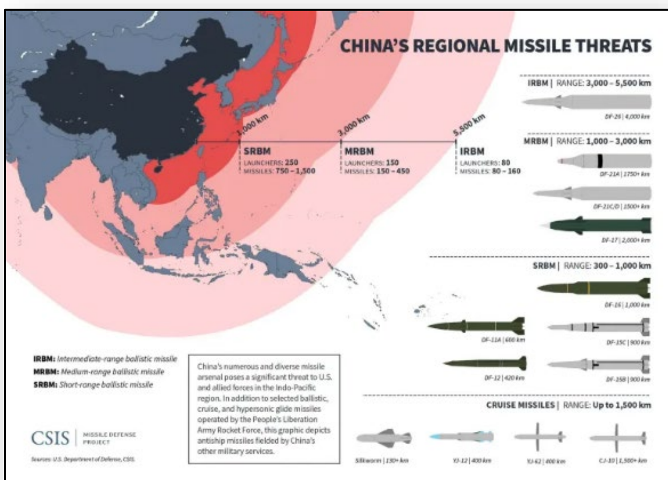

Figure 1. China's Regional Missile Threats. Source: Center for Strategic and International Studies (2021).

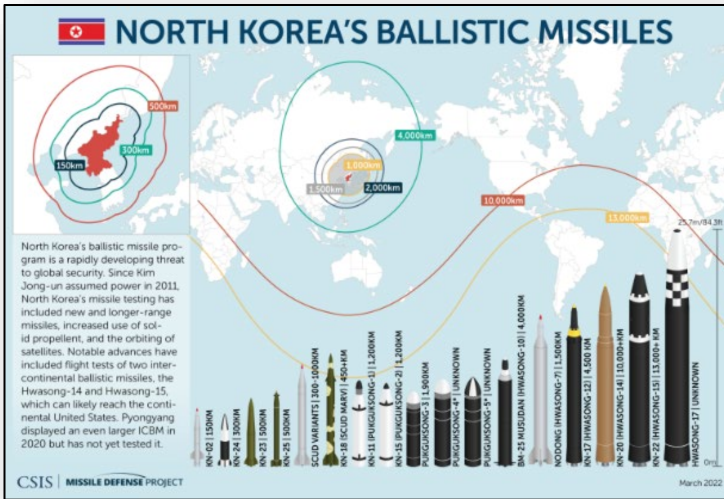

Figure 2. North Korea's Ballistic Missiles and Ranges. Source: Center for Strategic and International Studies (2022).

1. Knowledge Check: Key Logistical Concepts

1. What is the Defense Logistics Agency (DLA) and how does this organization help sustain U.S. military forces?
2. What does the concept, DLA capitalized fuel, mean?
3. Which military services use F76, JP5, and JP8? For the Navy, what are the logistical impacts of using two separate fuels during peacetime operations? In a contested environment?
4. Where are DLAs Indo-Pacific fuel offices? (Hint: Remember the vastness of the AOR)? Are these locations advantageous? If so, why? If not, why?

The next day, LCDR Smith opens her email and notices an email from an old Naval Academy classmate, LCDR Stevens, who is the Chief Engineer (CHENG) on a deployed cruiser. Word travels quickly and LCDR Stevens asks her how the closing of Red Hill affects him and his ability to sustain mission readiness. Her reply is "don't know yet" but they both know that the closing of this facility will have ripple effects throughout the AOR.

2. Knowledge Check: Supporting the Fleet

1. Weigh the pros and cons of redistributing the fuel from Red Hill and placing the fuel reserves in Australia, Indonesia, Vietnam, Philippines, or India. Your answer should include geopolitical factors, time/speed/ distance factors, chokepoint analysis, and adversary capabilities.
2. Redistributing the fuel to Australia, Indonesia, Vietnam, Philippines, or India may depend on more than the items listed in question A. The DOD has a budget and consideration should be given to travel distances. Using Linear Programming (LP) concept, what would the answer be for A? Constraints for this problem are budget and transit time.
3. A contested environment can be complex with continuously changing variables. Reviewing your answers to questions A and B, what would you recommend as the best solution? Explain your answer.

3. Key Concepts Answer Key

1. The Defense Logistics Agency (DLA) is the "Nation's Combat Logistics Agency that manages the end-to-end global defense supply chain – from raw materials to end user disposition – for the five Military Services, eleven Combatant Commands, other federal, state and local agencies and partner and allied nations" (Defense Logistics Agency, 2022). DLA provides distribution capabilities, provides food and clothing, contracts and parts for ground-based, aviation, and maritime weapon systems, buys and stores fuel, and disposes of old systems.
2. DLA manages the DOD's fuel inventory levels by owning, buying, and storing this fuel. Capitalization is simply the ownership of paid for fuel. This is important because this illustrates DOD's appetite to pay upfront for military grade fuel that it then stores at various locations globally. This is the primary way to refuel our aircraft and ships locally and aboard. Secondary means of refueling are managed differently through DLA's

SEA Card program or working with host nations and our allies and partners.

3. Air Force: JP-8 (aviation grade fuel/lower flash point than JP-5). Navy/ Marine: F-76 (diesel grade fuel used primarily in ships); JP-5 (aviation grade fuel/higher flash point than JP8). Army: JP-8 (aviation grade fuel/ lower flash point than JP-5).

   For the Navy, peacetime operations work well using two separate fuels (F-76 and JP-5). DLA stores both globally to help operating forces in each AOR. The supply chain impacts during peacetime are lower; however, during a contested environment using one type of fuel enhances and maximizes supply chain affects. The Navy would only have to worry about one "item" versus two separate "items." This could maximize time on station and decrease the frequencies of underway replenishments. This is an important question that plays into the importance of today's missions and global uncertainty.

4. Open ended answer. The locations are Japan, Singapore, Korea, Hawaii, and Guam. These locations are advantageous because they are dispersed ensuring the fleet can operate effectively throughout the AOR, while taking into consideration distributed maritime operations. The primary disadvantage is their proximity to China and the DPRK. Both nations have the capability to strike these locations and disrupt sea lines of communication and freedom of navigation.

4. Application Answer Key

1. Open ended answer. Diplomacy Partners: Japan, South Korea, Singapore, and Australia. Each nation adds value to the Navy's capabilities. However, all four of these countries exist within the first or second island chain. Although these nations typically support U.S. military requirements, they may not be the best locations for fuel used to support dispersed operations or a contested environment.

Other nations: Philippines, Malaysia, Association of Southeast Asian Nations (ASEAN), Indonesia, India, and Taiwan. These counties may or may not support U.S. diplomatic, economic, or military requirements. This is an important consideration because these countries dominate the geographic landscape of the Pacific as you near China.

Time/distance/speed: The pacific AOR is vast. It covers an area from India to the west coast of the United States and as far north as Alaska and as far south as Australia. Time/space/force becomes a factor in planning for force flow and replenishment. Indonesia and Philippines would be the best locations due to their centrality in the pacific.

Chokepoints: Straits of Malacca, Indonesia archipelago. These are important considerations for force flow, replenishments, and dispersed operations. Access denial due to chokepoints would disrupt fuel flowing from India or Australia.

Adversary capabilities: China and DPRK missile threat ranges, Chinese naval capabilities, cyberwarfare, space warfare. All five countries listed for this question would be in harm's way.

2. If Red Hill's fuel was redistributed, the answers in A must be considered. However, Linear programming (LP) is an excellent tool that can help illustrate the best solution to a problem. Remember, an LP model must have a decision variable, an objective function, and be subject to constraints. Below, is a step-by-step application, which seeks to minimize two separate criteria: days of travel (to redistribute the fuel) and budget. To begin, the locations and distances of the proposed fuel redistribution hubs must be determined as shown in Figure 3.

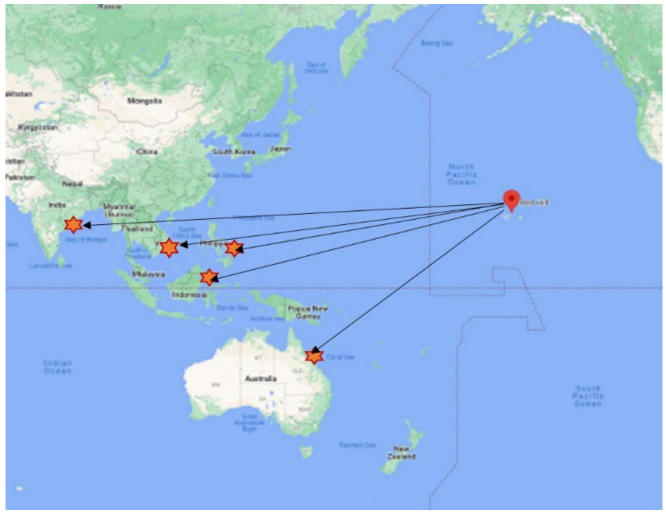

Figure 3. Map of Pacific AOR and Example Fuel Redistribution Location

The nautical mile (nm) distances from Red Hill, Honolulu, Hawaii to the five redistribution locations are:

- Brisbane, Australia: 4,085 nm (designated by the letter B)
- Chennai, India: 6,753 nm (designated by the letter C)
- Sorsogon, Philippines: 4,606 nm (designated by the letter S)
- Da Nang, Vietnam: 5,417 nm (designated by the letter D)
- Linköping, Indonesia: 4,643 nm from (designated by the letter L)

As such, Figure 3 can be easily redrawn to help visualize and outline the forthcoming decision variables and subsequent models as shown in Figure 4.

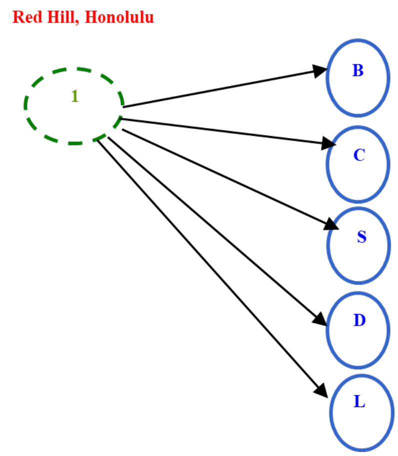

Figure 4. Illustration of the Decision Variables

Next, the distances traveled must be converted from nautical miles to days, as shown in Figure 5. For this problem we assume the travel speed is 15 knots.

Table 1. Formulating the LP Model: Travel Distances in Days

Red Hill, Honolulu	Distance in nm	Distance in hours	Distance in days
Brisbane, Australia	4085	272	11
Chennai, India	6753	450	19
Sorsogon, Philippines	4606	307	13
Da Nang, Vietnam	5417	361	15
Linköping, Indonesia	4643	310	13

The decision variable for each scenario (model) can be written such that i = 1 if warehouse A is required; 0 otherwise, for i = B, C, S, D, L.

a. *Model 1: Minimize Travel Days (Building Storage Tanks)*

- Objective Function: Minimize Travel Days: 11B + 19C + 13S + 15D + 13L (using the distance in days from Table 1)

Constraints:

- Budget: 15B + 10C + 20S + 13.5D + 14L ≤ 25

- Warehouses: B + C + S + D + L ≥ 2
- i binary (1 or 0)

The LP model is built using the criteria produced and as shown in Figure 5. As illustrated, minimizing travel days is dependent upon the overall budget and number of warehouses required to store the fuel. As a result, the model finds a feasible solution with Brisbane and Chennai satisfying the constraints. Even though Chennai is the greatest distance from Honolulu, this location proves feasible because of the low costs of storing the fuel. As noted, tradeoffs are critical.

Min Travel Days								
	B	C	S	D	L		sign	
Building Costs	15	10	20	14	14	25	<=	25
Warehouses	1	1	1	1	1	2	>=	2
Travel Days	11	19	13	15	13	30		
Decision Variable	1	1	0	0	0			

Figure 5. LP Model 1: Minimizing Travel Days as a Function of Budget (Building Storage Tanks)

b. Model 2: Minimize Budget (Building Storage Tanks)

- Objective Function: Minimize Budget: 15B + 10C + 20S + 14D + 14L

Constraints:

- Travel Days: 11B + 19C + 13S + 15D + 13L ≤ 35
- Warehouses: B + C + S + D + L ≥ 2
- i binary (1 or 0)

In this case, the LP model is reversed. Figure 6 shows the model built into excel. Here we are minimizing the budget as a function of travel days resulting in an entirely different solution: Chennai and Da Nang satisfy the model best. This particular model illustrates the importance our budgets have on decision making.

Min Budget								
	B	C	S	D	L		sign	
Travel Days	11	19	13	15	13	34	<=	35
Warehouses	1	1	1	1	1	2	>=	2
Building Costs	15	10	20	14	14	23.5		
Decision Variable	0	1	0	1	0			

Figure 6. LP Model 2: Minimizing Budget as a Function of Travel Days (Building Storage Tanks)

c. Model 3: Minimizing Travel Days (Leasing Storage Tanks)

- Objective Function: Minimize Travel Days: 11B + 19C + 13S + 15D + 13L

Constraints:

- Budget Rental: 9B + 5C + 6S + 7D + 11L ≤ 25
- Warehouses: B + C + S + D + L ≥ 2
- i binary (1 or 0)

The purpose of Model 3 is to illustrate budget effects on the travel days. Is there a difference in locations (feasible solutions) when the idea is to lease storage tanks vice build them? In Model 1, the total travel days were minimized to 30 days with a maximum budget of $25M and building storage tanks in Brisbane and Chennai. Here, the feasible solutions have changed slightly to Brisbane and now Sorsogon, as shown in Figure 7. Even though leasing storage tanks in Chennai is still the cheapest, the 19-day travel time is no longer desirable. This is an important consideration for warfighters, logisticians, and financial managers to understand and balance.

Min Travel Days								
	B	C	S	D	L		sign	
Leasing Costs	9	5	6	7	11	15	<=	25
Warehouses	1	1	1	1	1	2	>=	2
Travel Days	11	19	13	15	13	24		
Decision Variable	1	0	1	0	0			

Figure 7. LP Model 3: Minimizing Travel Days as a Function of Budget (Leasing Storage Tanks)

d. *Model 4: Minimizing Budget (Leasing Storage Tanks)*

- Objective Function: Minimize Rental Trucks: 9B + 5C + 6S + 7D + 11L

Constraints:

- Travel Days: 11B + 19C + 13S + 15D + 13L ≤ 35
- Warehouses: B + C + S + D + L ≥ 2
- i binary (1 or 0)

Finally, Model 4 minimizes the budget for leasing storage tanks as a function of travel time. As a result, Chennai and Sorsogon are the best answers, as shown in Figure 8. The costs to lease storage space now "overpowers" the farthest distances.

Min Leasing Cost								
	B	C	S	D	L		sign	
Travel Days	11	19	13	15	13	32	<=	35
Warehouses	1	1	1	1	1	2	>=	2
Leasing Costs	9	5	6	7	11	11		
Decision Variable	0	1	1	0	0			

Figure 8. LP Model 4: Minimizing Budget as a Function of Travel Days (Leasing Storage Tanks)

e. Summary: Linear Programming Application

Table 2 summarizes the feasible solutions determined in the four LP models above. How you build the model, what you minimize (or maximize), and what constraints you use will affect the outcome of the problem. Equally important is how you build (phrase) the problem. Is budget or travel days more important? Should we lease or build storage capabilities?

Table 2. Summary of Linear Programming Models to Redistribute Fuel

Solutions	Warehouses Location
Minimize Travel Days 30 within budget 25	Brisbane and Chennai
Minimize Budget 24 within Travel Days 34	Chennai and Da Nang
Minimize Travel Days 24 within Rental Budget 15	Brisbane and Sorsogon
Minimize Truck Rental 11 within Travel Days 32	Chennai and Sorsogon

3. Open ended answer. There may be no correct answer to this redistribution problem. The mathematical model is only as good as the information inputted. Can this model capture geopolitical situations? The model will optimize a budget or transit times but does not consider chokepoints or adversarial capabilities. Further, the DOD must consider their budget and how much it costs to redistribute the fuel. Should we lease storage tanks or build them? Further, this particular model does not optimize maritime operations in a dispersed or contested environment. Tradeoffs will exist and risk assessments will need to be performed.

C. CONTRACTING AND LOGISTICS

LCDR Smith has been working at Transportation Command (TRANSCOM) J35 at Scott AFB for several months and was just called into his boss's office. His boss, Col Adams, wants him to be a part of a command-wide logistics working group (LWG) to investigate TRANSCOM's logistics capabilities in a contested environment – specifically those capabilities in the INDOPACOM theater. The strategic competition with China (and Russia) demands TRANSCOM develop additional logistics options to aid U.S. forces in a contested environment. Over the next couple of weeks, LCDR Smith must familiarize himself with distributed operations and the importance of logistics in a contested environment. Upon exiting his boss's office, LCDR Smith becomes excited and anxious about the upcoming months. He quickly learns that logistics is more than going alongside for an Underway Replenishment (UNREP) or palletized parts delivered to airfields. Behind the logistics curtain, the field of supply is complex and at times complicated.

At the first logistics work group meeting, the group discusses their assumptions about logistics capabilities needed to support the deployed forces in a contested environment. As typical with most working groups, the group starts too specific. First, the group discusses types of sustainment (i.e., classes of supply) available at different overseas bases. Then, the group discusses their global carriers and various logistics networks. Sensing the working group speaking too specifically on logistics, LCDR Smith brings the group back to their underlying task – to discuss the concept of distributed operations in a contested environment. He explains to the group that the Navy has a requirement of Next-Generation Logistics Ships (NGLS) and mentions the Navy Light Amphibious Warship (LAW) Program. He explains that LAWs are designed to be the complement to the Combat Logistics Force (CLF) and augment existing amphibious type ships. With this information, the group addresses their assumptions and gets to work.

1. Knowledge Check: Key Logistical Concepts

1. What is logistics? Name a few core logistics functions.
2. What is TRANSCOM and what is it role as a functional command?
3. What are the ten classes of supply?
4. What is purpose of distributed operations? How does it impact the logistics network?
5. What is the CLF? Why is it important for sustainment of the forces?
6. Describe NGLS and LAWs and how they contribute to the concept of distributed operations?

As the working group nears the end of its assignment, LCDR Smith begins to draft an executive summary for Maj Gen Clarke (J3). LCDR Smith wants to incorporate concerns regarding funding, fielding, and contracting for the LAW program and the impact on distributed operational planning. Since the Navy delayed procurement of the first LAW from FY23 to FY25 at a cost of $247M, LCDR Smith believes TRANSCOM will be monitoring the LAW program closely for further developments because of its importance to joint operations and Marine Corps operational concepts. His executive summary will include information on the LAW program's budget request for $12.2M in FY23 for research and development, procurement costs and delays of the first LAW (noted above), procurement of the second LAW in FY26 for $203M, and procurement costs for the third and fourth vehicles in FY27 for a combined cost of $290M. LCDR Smith also notes that the Navy's FY23 submission mentioned that the construction contract would be for December 2024 with a delivery in July 2028.

2. Knowledge Check: Acquisition Application

1. Explain the importance of contracting in the acquisition life cycle?
2. When should contracting be involved in the requirements process?
3. What are the contracting steps?
4. Why to the costs for each LAW decrease with each subsequent procurement?
5. What are the different funding appropriations being used to purchase the LAWS and the period of availability?
6. What are possible implications or ramifications if the funds are not used during period of availability?

3. Key Concepts Answer Key

1. Joint Pub 4.0 defines logistics as planning and executing the movement and support of forces (JCS, 2019, p. GL-8). Some core logistics functions

include deployment and distribution, supply, maintenance, logistics services, and engineering (JCS, 2019, pp. x - xii).

2. United States Transportation Command (TRANSCOM) is one of the unified combatant commands of the United States Department of Defense which coordinates missions worldwide using both military and commercial transportation resources. Their mission is to provide full-spectrum global mobility solutions and enabling capabilities to our customers in peace and war. Their goal is to provide the United States with the most responsive and strategic mobility capability the world has ever seen. (USTRANSCOM, n.d.)

3. The ten classes of supply are 1) subsistence, 2) general support items (clothing and equipment), 3) petroleum, oil and lubricants, 4) construction materials, 5) ammunition, 6) personal demand (sundry, etc.), 7) major end items, 8) medical; 9) repair parts, 10) material to support military programs (contracting) (JCS, 2019, fig. II-2).

4. "Distributed operations have been defined as a concept of operations referred to as distributed lethality that entails more widely dispersing combatant ships to improve the Navy's offensive and defensive capabilities" (Pendleton, 2017, p. 1). How it impacts the logistic network is open ended. Ideas can include: 1) friction of common resources (supplies, services), 2) leveraging capabilities within theater (infrastructure, lines of communication, require thinking outside the box), and 3) limited or no logistics.

5. Combat Logistic Force is a "collective group of Military Sealift Command ships that provide underway replenishment, commercial helicopter services and other direct fleet support to Navy ships worldwide. These ships include fleet replenishment oilers, fleet ordnance and dry cargo ships, and fast combat support ships" (Gilday, 2022, p. 32). These ships

are important because it allows combat ships the ability to stay on station longer without impacting the assigned mission.

6. Next Generation Logistics Ships and Light Amphibious Warships are the next optimal type of logistic capability ships that can "augment the current CLF" and "can operate near a contested environment" depending on sustainment scenario (O'Rourke, 2022, pp. 1–2). Of note, this program is not fielded. They contribute to the concept of distributed operations by enabling the adaptability to address the last tactile mile in contested, constrained, or austere environment (O'Rourke, 2022, p. 2). Additional concepts, as defined by the CNO and Navy/Marine, include EABO, DMO, and LOCE (Gilday, 2021, p. 2).

4. Application Answer Key

1. Open ended answer. Contracting is important because it is the mechanism used to fund the investment strategy of today and future forces, which links suppliers within supply chain interactions with the industrial base. Contracting accounts for program associated costs and determines the best method for managing the life cycle and compliance of funding, budgeting, and acquisition execution.

2. Contracting should be involved from the beginning because the requirements process is constantly changing, and contracting is the vehicle used to fund the process. It ensures that industry experts, business leaders, and government representatives develop the appropriate business strategy which shapes and manages supplier relationships and associated risks inherent in the contracting requirement process.

3. The contracting steps are pre-award, award and post award. To encourage further discussion, response would be pre-award and solicitation, evaluation and award and contract admin.

4. Open ended answer. It could be part of the negotiated agreement of the awarded contract which address fair price to the government and contractors profit percentage. It could be a learning curve applied which reduces the cost overtime.

5. The funding appropriations and availability are procurement (three years) and research and development (two years for new obligations). Note: ship procurement is five years.

6. Open ended answer. The implication could be the risk to cost, schedule, or performance during the execution of the contract. One possible ramification could be that the program loses funding for the follow-on years of the build. Another ramification could be delays to the program can lead to readiness response concerns in dynamic operating environment.

D. SUSTAINABILITY

LCDR Smith has been assigned to the Program Executive Office (PEO) for the newest Weapon System X program. Over the course of her first several months, she quickly learns that life cycle costs (LCC) add up and that sustaining a weapon system throughout its life cycle requires tremendous amounts of planning, negotiating, and contracting. Her primary focus is keeping the Operation and Support (O&S) costs as low as possible without jeopardizing the overall readiness of the weapon system – no easy task.

To make matter worse, her Program Officer, CAPT Johnson, tells her group at the weekly staff meeting that the Navy is demanding they reduce the total LCC by fifteen percent. As a result, no part of the program can be ignored to maximize budget effects. CAPT Johnson turns to LCDR Smith and requests she reduce overall transportation costs for parts without risking mission readiness. In other words, make the necessary tradeoffs required to minimize transportation costs while maximizing sustainability.

After the meeting, LCDR Smith heads back to her cubicle and starts diligently working. First, she gathers the necessary data beginning with the major sustainability contract awards. She notices *Weapon Systems R Us* (WSRU) was awarded the largest contract providing 75% of the overall sustainability. Further, she notices that WSRU subcontracts all its warehousing, shipping, and delivering requirements to a single subprime contractor, *Support the Navy* (SN). Upon further investigation, LCDR Smith discovers that the SN warehouses are centrally located in the United States: Des Moines, Iowa; Oklahoma City, Oklahoma; and Houston, Texas. As she leans back in her chair, she thinks about the locations SN must support: Norfolk, Virginia; Puget Sound, Washington; and San Diego, California. She realizes this is a supply and demand problem and must have WSRU run the numbers.

1. Knowledge Check: Key Logistical Concepts

1. What are the five acquisition life cycle stages of a weapon system? What is/are the most expensive acquisition program?
2. What is sustainability? What sustainability factors impact readiness?
3. What are budget effects?
4. Can prime contractors subcontract responsibilities?

A week later, WSRU gets back to LCDR Smith with the transportation costs she requested. WSRU explains that SN can only provide a finite supply from each of its three warehouses and that total costs run about $9.95M. Knowing her budget is $7.5M, she requests the shipping costs and supply information from WSRU shown in Tables 3 and 4 respectively. LCDR Smith knows the required demand signals at each navy base to meet the readiness objectives and uses all the available information to build a linear program to minimize transportation costs.

Table 3. Shipping Costs from Supplier to Customer Locations

Shipping Costs			
From/To	Norfolk	San Diego	Puget Sound
Des Moines	$1,500.00	$2,500.00	$3,000.00
Oklahoma City	$2,000.00	$1,800.00	$2,500.00
Houston	$1,000.00	$3,500.00	$4,000.00

Table 4. Supply and Demand Data

Locations	Supply ≥ Demand	Supply ≤ Demand	Supply = Demand
Supply at Des Moines	1700	1800	2000
Supply at Oklahoma City	2750	2550	2750
Supply at Houston	1250	1050	950
Demand at Norfolk	2500	2500	2500
Demand at San Diego	2000	2000	2000
Demand at Puget Sound	1200	1200	1200

2. Knowledge Check: Sustainability

1. Explain the relationship between supply and demand in this problem. What must be greater than the other, supply or demand?

2. If transportation costs are fixed, what variables can LCDR Smith change to minimize the overall costs?

3. Key Concepts Answer Key

1. The five acquisition life cycle phases are: Material Solution Analysis (MSA), Technology Maturation and Risk Reduction (TMRR), Engineering and Manufacturing Development (EMD), Production and Deployment (P&D), and Operation and Support (O&S).

   The most expensive programs are known as Major Defense Acquisition Programs (MDAPs) or Major Automated Information System (MAIS). These programs have the most extensive statutory and regulatory reporting requirements. The Acquisition Category (ACAT) levels are as follows: ACAT I: R&D of more than $525M and total procurement of $3.065B; ACAT II: R&D of more than $200M and total procurement of $920M; and ACAT III: Less than ACAT II and do not meet the major system criteria (Defense Acquisition University, n.d.).

2. Sustainability can be defined as the ability to support a weapon system through maintenance, parts, funding, and personnel actions. Sustainability

is critically linked to mission readiness. How do you sustain or support a weapon system through its operational life cycle and disposal? PEO offices must ensure they account/plan for maintenance facilities, parts, trained personnel, and costs (funding). A deficiency in any one of these factors can decrease the readiness of the weapon system.

3. A budget effect can be viewed as something that could positively or negatively affect the outcome of a weapon system program or record (funding). Budget effects could be the risks to cost, scheduling, and performance of the weapon system. Another effect could be the inherent danger of insufficient or over expend of allotted funds for the program (reducing a program's spending by 15%).

4. They cannot because prime contractors are still responsible for the subcontractor's behavior and performance responsibilities. However, a prime contractor can subcontract contract requirements due to workload capacity, requirements of the contract (e.g., small businesses, veteran preference), etc.

4. Application Answer Key

1. Supply feeds demand. This process is cyclical and fluctuates based on the provided demand signals and supply lines. For LCDR Smith, she must understand what the demand signals are at all three navy bases. Next, she must understand SN's distribution capabilities and capacities to feed that demand. To further understand supply and demands relationship, Linear Programming is an excellent tool to determine which variable should be greater than the other (if any). The variables in this problem are inventory levels, demand signals, and transportation costs.

First, define the written problem mathematically:

- $Xij \geq 0$ where i = D, O, or H and j = N, S, or P

- Where D = Des Moines, O = Oklahoma City, H = Houston, N = Norfolk, S = San Diego, and P = Puget Sound

a. Supply is Greater Than Demand.

As shown in Figure 9, when supply is greater than demand, the residual (or remaining) supply must be held in an inventory. On one hand, holding inventory is not conducive to saving money. The more inventory held will increase holding costs. On the other hand, residual inventory could be labeled as safety stock used to support variability in demand (if required). Any operation would need to determine their own thresholds for holding extra inventory.

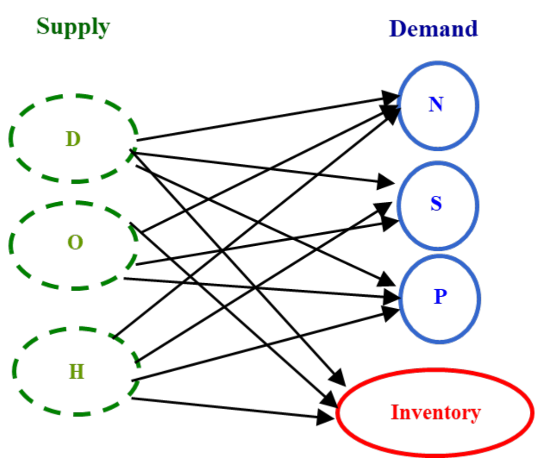

Figure 9. Illustration of Supply Greater Than Demand

Using this supply and demand relationship and the information in Table 3, the following objective function could be used to minimize total costs:

- Objective Function: Minimize (\$1500)XDN + (\$2500)XDS + (\$3000)XDP + …..+ (\$4000)XHP

The objective function is then subjected to the following constraints pulled from Table 4 and the supply is greater than demand column:

Supply:

- XDN + XDS + XDP ≤ 1700 at Des Moines
- XON + XOS + XOP ≤ 2750 at Oklahoma City
- XHN + XHS + XHP ≤ 1250 at Houston

Demand:

- XDN + XON + XHN ≥ 2500 at Norfolk
- XDS + XOS + XHS ≥ 2000 at San Diego
- XDP + XOP + XHP ≥ 1200 at Puget Sound

Figure 10 shows the model formulation as inputted into excel. This model's goal is to determine if a feasible solution exists as a function of supply, demand, and transportation costs. As shown, the total costs to meet the demand signals in N, S, and P is $9.95M with several distribution hubs not required to meet demand for the three customer locations.

Supply is Greater Than Demand												
	XDN	XDS	XDP	XON	XOS	XOP	XHN	XHS	XHP		Sign	
Supply at Des Moines	1	1	1							1700	<=	1700
Supply at Oklahoma City				1	1	1				2750	<=	2750
Supply at Houston							1	1	1	1250	<=	1250
Demand at Norfolk	1			1			1			2500	>=	2500
Demand at San Diego		1			1			1		2000	>=	2000
Demand at Puget Sound			1			1			1	1200	>=	1200
											Total	
Cost	$ 1,500	$ 2,500	$ 3,000	$ 2,000	$ 1,800	$ 2,500	$ 1,000	$ 3,500	$ 4,000		$ 9,950,000	
Decision Variable	1250	0	450	0	2000	750	1250	0	0			

Figure 10. LP Model: Minimizing Transportation Costs: Supply Greater Than Demand

b. Supply is Less Than Demand.

In this case, supply is less than demand as shown in Figure 11. Instead of having excess inventory, now the supplier cannot not meet the demand signal, which causes backorders. This scenario can be detrimental for various reasons i.e., increase in backorder costs and an increase in wait times for customers.

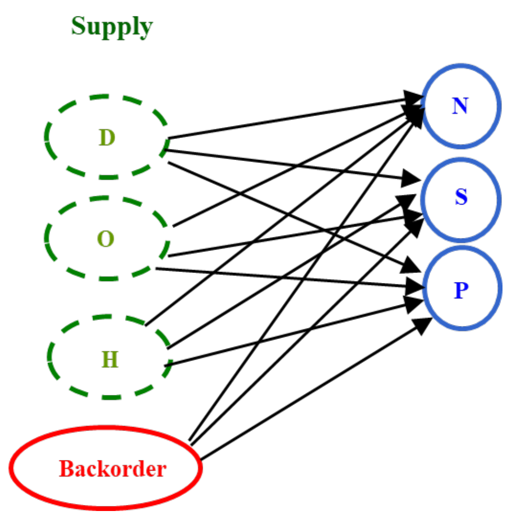

Figure 11. Illustration of Supply Less Than Demand

As seen in part a, the same objective function can be used to minimize transportation costs (no change):

- Objective Function: Minimize ($1500)XDN + ($2500)XDS + ($3000)XDP + …..+ ($4000)XHP

The above objective function is now subject to the constraints listed in Table 4 and the supply is less than demand column:

Supply:

- XDN + XDS + XDP ≤ 1800 at Des Moines
- XON + XOS + XOP ≤ 2550 at Oklahoma City
- XHN + XHS + XHP ≤ 1050 at Houston

Demand:

- XDN + XON + XHN ≥ 2500 at Norfolk

- XDS + XOS + XHS ≥ 2000 at San Diego
- XDP + XOP + XHP ≥ 1200 at Puget Sound

Per Figure 12, the total transportation costs have now increased to $13.79M. the demand at San Diego and Puget Sound can no longer be meet with the available supply resulting in backorders and subsequently an increase in back-order costs.

Supply is Less Than Demand												
	XDN	XDS	XDP	XON	XOS	XOP	XHN	XHS	XHP		Sign	
Supply at Des Moines	1	1	1							1800	<=	1800
Supply at Oklahoma City				1	1	1				2550	<=	2550
Supply at Houston							1	1	1	1050	<=	1050
Demand at Norfolk	1			1			1			2500	>=	2500
Demand at San Diego		1			1			1		1850	>=	2000
Demand at Puget Sound			1			1			1	1050	>=	1200
											Total	
Cost	$ 1,500	$2,500	$ 3,000	$2,000	$1,800	$2,500	$1,000	$3,500	$ 4,000		$ 13,790,000	
Decision Variable	0	1800	0	2500	50	0	0	0	1050			

Figure 12. LP Model: Minimizing Transportation Costs: Supply Less Than Demand

c. Supply is Equal to Demand.

Finally, supply is equal to demand as shown in Figure 13. In a perfect supply system, there is one unit of supply for every unit of demand, which can be difficult to achieve especially when there are thousands of items demanded as seen within the DOD’s supply chain.

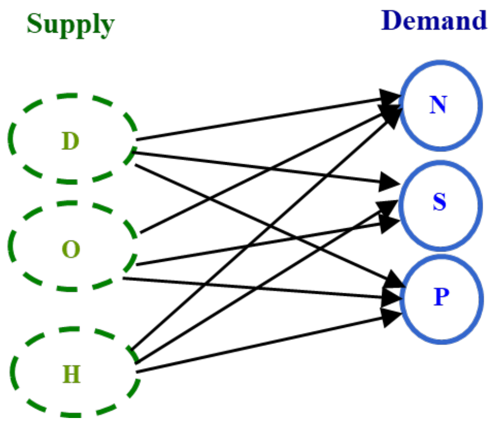

Figure 13. Illustration of Supply Equaling Demand

As seen in part a, the same objective function can be used to minimize transportation costs (no change):

- Objective Function: Minimize ($1500)XDN + ($2500)XDS + ($3000)XDP + …..+ ($4000)XHP

The above objective function is now subject to the constraints in Table 4 and the supply equals demand column:

Supply:

- XDN + XDS + XDP ≤ 2000 at Des Moines
- XON + XOS + XOP ≤ 2750 at Oklahoma City
- XHN + XHS + XHP ≤ 950 at Houston

Demand:

- XDN + XON + XHN ≥ 2500 at Norfolk
- XDS + XOS + XHS ≥ 2000 at San Diego
- XDP + XOP + XHP ≥ 1200 at Puget Sound

Figure 14 shows the results of the LP model when supply is equal to demand. The total transportation costs are $10.1M slightly higher than the results when supply was greater than demand.

Supply Equals Demand												
	XDN	XDS	XDP	XON	XOS	XOP	XHN	XHS	XHP		Sign	
Supply at Des Moines	1	1	1							2000	<=	2000
Supply at Oklahoma City				1	1	1				2750	<=	2750
Supply at Houston							1	1	1	950	<=	950
Demand at Norfolk	1			1			1			2500	>=	2500
Demand at San Diego		1			1			1		2000	>=	2000
Demand at Puget Sound			1			1			1	1200	>=	1200
											Total	
Cost	$1,500	$ 2,500	$ 3,000	$ 2,000	$1,800	$ 2,500	$ 1,000	$ 3,500	$ 4,000		$10,100,000	
Decision Variable	1550	0	450	0	2000	750	950	0	0			

Figure 14. LP Model: Minimizing Transportation Costs: Supply Equal to Demand

These three models illustrate the complexity of a supply chain. Minimizing transportation costs may be rudimentary but other costs (backorder and holding) may be incorporated and passed onto the customer. These are considerations LCDR Smith must consider.

2. Maximize transportation loads from supply to demand location. In other words, optimize transportation loads (one truck with ten pallets vice one truck with one pallet). Another area to consider is to reevaluate the weapon systems demand signal at each of the three navy bases. This could then decrease the supply inventory required to meet said demand and potentially limit backorder costs and/or holding costs. Another area to maybe consider is to work with WSRU to ensure SN has eliminated unnecessary processes that increase customer wait times or those processes that affect the customer's perceive value of the service being requested.

V. SUMMARY AND CONCLUSIONS

The primary objective of this project was to develop several case studies that maximize the URL's saturation in logistics to make them better warfighters. These case studies introduced foundational and several advanced logistic concepts we believe will strengthen the URL community. Of note, a goal of this project was not to make the URL officer corps logisticians by trade but for them to better understand logistic requirements, constraints, and to better utilize their logistic counterparts in peacetime, constrained, and contested environments. Army General John J. Pershing, commander of the American Expeditionary Forces during World War I, famously stated, "Infantry wins battles, logistics wins wars" (Lee, 2017, para. 1). With today's advanced technology and increased uncertainty driving the next set of conflicts, logistics may be more important now than ever and our URL community must be educated, equipped, and ready.

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