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MASTER OF MILITARY STUDIES

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**TITLE:**

**Modernization of Tactical Logistics**

SUBMITTED IN PARTIAL FULFILLMENT  
OF THE REQUIREMENTS FOR THE DEGREE OF  
MASTER OF MILITARY STUDIES

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## Executive Summary

**Title:** Modernization of Tactical Logistics

**Author:** Major Joussef J. Abchi Donado, United States Marine Corps

**Thesis:** The current logistics architecture, manpower structure, and equipment footprint are ill prepared for future operating environment—LOCE/A2AD—at the tactical level.

**Discussion:** Littoral Operations in a Contested Environment (LOCE) will present unique challenges that traverse all warfighting functions. In tandem with the Commandant's Planning Guidance (CPG) from 2019, the current methodology by which tactical logistics is manned, equipped, and executed requires significant revision to improve efficiency and effectiveness given the limitations of future war. The Department of the Navy (DoN) continues to battle with the financial austerity of today's economy but needs to change in order to meet the demands LOCE/A2AD presents.

This paper explores the current logistical structure and equipment organically aligned to the infantry battalion and their associated limitations as it relates to the concepts of Littoral Operations in a Contested Environment (LOCE) and Anti Area Access Denial (A2AD). More specifically, it highlights alternative approaches to the organization, training, and equipment density of logistics in an infantry battalion.

**Conclusion:** In an ideal conflict, combat elements would not require logistics support and would be able to self-sustain. By leveraging alternative approaches to the fulfillment of combat element logistics requirements significant efficiencies can be achieved. Providing logistics Marines with a broader scope of skills can have a positive impact on manpower requirements and provide commanders with flexibility. Restructuring how logistics is conducted within the infantry battalion can create more options for commanders operating in austere environments. Distributing newer technologies, that decrease sustainment requirements increases the overall reach of unit and by extension its operational ability. The combination of these aspects would create a more modern force capable of conducting operations within a LOCE/A2AD environment. Ultimately, the current design of tactical logistics is ripe for change. If its composition is corrected, it would provide battalion commanders with the ability to operate and support distributed operations in such a way where speed will be improved and the unit's physical footprint would shrink. The combination of these changes would improve the resiliency of the unit and enable a larger breadth of autonomy at the company level.

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## *Preface*

After significant dialogue regarding Littoral Operations in a Contested Environment (LOCE) and Anti Area Access Denial (A2AD) concepts it became evident that there is a significant gap between what our current capabilities allow US forces to accomplish in future conflict. Much investment has been made in the development of newer, more lethal weapons platforms but little has really changed in the world of logistics capabilities. I believe the paradigm needs changing and as an institution there is significant room for improvement and modernization.

As I approached the problem of how to modernize tactical logistics, I started from the perspective of the infantry company and their growing need for operational autonomy. Specifically, the ability to operate for extended periods of time away from a logistics hub and under the LOCE/A2AD threat. I coupled my perspective on existing logistics requirements and considered alternative approaches that are either already in use or on the bleeding edge of technology to meet those needs. Given these observations and my experience as a Marine ground supply officer, I believe that there are efficiencies we can leverage to develop more versatile logistics Marines with modern equipment and programs to control tempo and create confusion for our adversaries.

Though logistics in its own right does not win conflicts, the inability to provide it will guarantee failure. In an era where information is readily accessible, technology is in a constant state of evolution, and commercial business practices are becoming more impactful, the Marine Corps will need to embrace change to thrive in the LOCE/A2AD environment. We can no longer define MOSs along platforms/systems or limit responsibilities to such. Employment methodologies must embrace a distributed operations model which means providing logistics

support to smaller combat echelons. New technologies should leverage local resources, minimize combat load and footprint, and capitalize on adjacent forces for sustainment as needed. The combination of these factors would create a more agile logistics capability and potentially redefine how the advancement of logistics Marines is conducted. Ultimately, a logistics Marine should be capable of providing an array of capabilities because their training and equipment set enables such.

## INTRODUCTION

The current logistics architecture, manpower structure and equipment footprint are ill prepared for the future operating environment at the tactical level. Littoral Operations in a Contested Environment (LOCE) present unique challenges that traverse all warfighting functions. In tandem with the Commandant's Planning Guidance (CPG) from 2019, the current methodology by which tactical logistics is manned, equipped, and executed requires significant revision to improve efficiency and effectiveness given the limitations of future war. The Department of the Navy (DoN) continues to battle the financial austerity of today's economy but needs to change in order to meet the demands LOCE presents. The organizations within the Marine Corps need to rebalance the force in terms of the distribution of unique specialties, equipment composition, procurement/sourcing strategies, and distribution practices to create a logistics model that is resilient and effective when operating within the Anti-Area Access Denial (A2AD) environment. Ultimately, the current design of tactical logistics is ripe for change. If its composition is corrected, it would provide battalion commanders with the ability to operate and support distributed operations in such a way where speed will be improved and the unit's physical footprint would shrink. The combination of these changes would improve the resiliency of the unit and enable a larger breadth of autonomy at the company level.

From a manpower perspective, the logistics section of an infantry battalion staff lacks variety in capabilities. The equipment base for an infantry battalion only supports ground transport and does not leverage the use of emergent commercial options to facilitate distribution. The paradigm of the "iron mountain" must change to make room for true "just in time" logistics. In order to do so the DoN needs to do more to align military application of supply with its civilian counterparts, leverage technological advancement sooner, procure operationally and

cost-effective equipment, and ensure those assets are commercially sustainable. Though the scope of this paper focuses heavily on the infantry battalion logistics section, there are other aspects of logistics that may receive benefit from this proposal as well.

## BACKGROUND

The DoN recognizes the LOCE concept as the future operational environment and will force changes to logistics.<sup>1</sup> With a growing adversarial capability to contest U.S. force projection across multiple domains, the concept of domain superiority has started to fade.<sup>2</sup> Future conflict presents a scenario where U.S. forces will have to embrace operating within the A2AD threat posed by adversaries.<sup>3</sup> These challenges present unique hurdles for the ground logistics community. It can challenge the logistical need for communications, elevates the target value of high demand, low density logistics equipment, and makes the “iron mountain” approach to military supply a significant vulnerability. This scenario is considerably different from what U.S. forces have been exposed to in the last 15 years and has highlighted various areas of vulnerability in the current construct.

With the compounding threat A2AD presents to the existing paradigm, the Commandant of the Marine Corps (CMC), recognizes a need to emphasize Distributed Operations (DO) but looks to the force in order to drive that innovation.<sup>4</sup> The intent is to enable squad sized units with the ability to effect combined arms on adversarial threats, but logistics has been largely confined to the battalion level of command. If dispersion is the primary method of generating security to U.S. forces while operating under the A2AD threat, logistics will need to elevate its own capabilities in such a fashion that will enable it. The CMC notes his five reasons for dispersion as: better mission accomplishment, improve maneuver options/positional advantage, reduce the effects of enemy fires, impose costs and induce uncertainty, and reduce friendly signatures.<sup>5</sup> The

requirements LOCE/A2AD present for dispersion and mobility creates challenges to existing logistics capabilities.

LOCE and DO introduce new paradigms that have become the focus of military reform, but this does not change the logistical realities of kinetic operations. Logistics sets the boundaries for what a military force is operationally capable of.<sup>6</sup> By further distributing forces, logistics practices need modernization to crest growing distances between supporting and supported forces.<sup>7</sup> The timing and depth of logistics support also presents additional challenges when viewed in relation to reaction time and tempo.<sup>8</sup> The variety of logistics missions will require forces that are more adaptable, easily dispersed, and have proficiency in varying domains improving efficiency. Organizational investments have to focus on emerging technologies that are effective, resilient, cost-effective, and replaceable. Lastly, strategic partnerships with growing technological firms will serve to keep military advancement in step with commercial entities and allow US forces to influence future technologies.<sup>9</sup>

Headquarters, Marine Corps (HQMC), Installations and Logistics (I&L) has also recognized the need for logistics modernization and developed their *Sustaining the Force in the 21st Century* concept.<sup>10</sup> In this concept, 4 major lines of effort are presented to articulate how the force intends approach the necessary changes to meet the CMC's intent. By enabling global logistics, diversifying distribution, improving sustainment, and optimizing installations to support sustained operations, I&L intends to modernize logistics current capabilities.<sup>11</sup> For the purposes of this thesis the first three are most important. The existing logistics footprint is better tailored for counter insurgency/stability operations than it is for LOCE and DO. Conventional force logistics needs reformation to meet the requirements LOCE and DO present. By making specific changes to existing organizational constructs, training requirements, personnel, and

equipment, the logistics community can find efficiency, improve customer support in a distributed environment, and provide additional support to the maneuver force while operating within the current strategic limitations.

ORGANIZATION

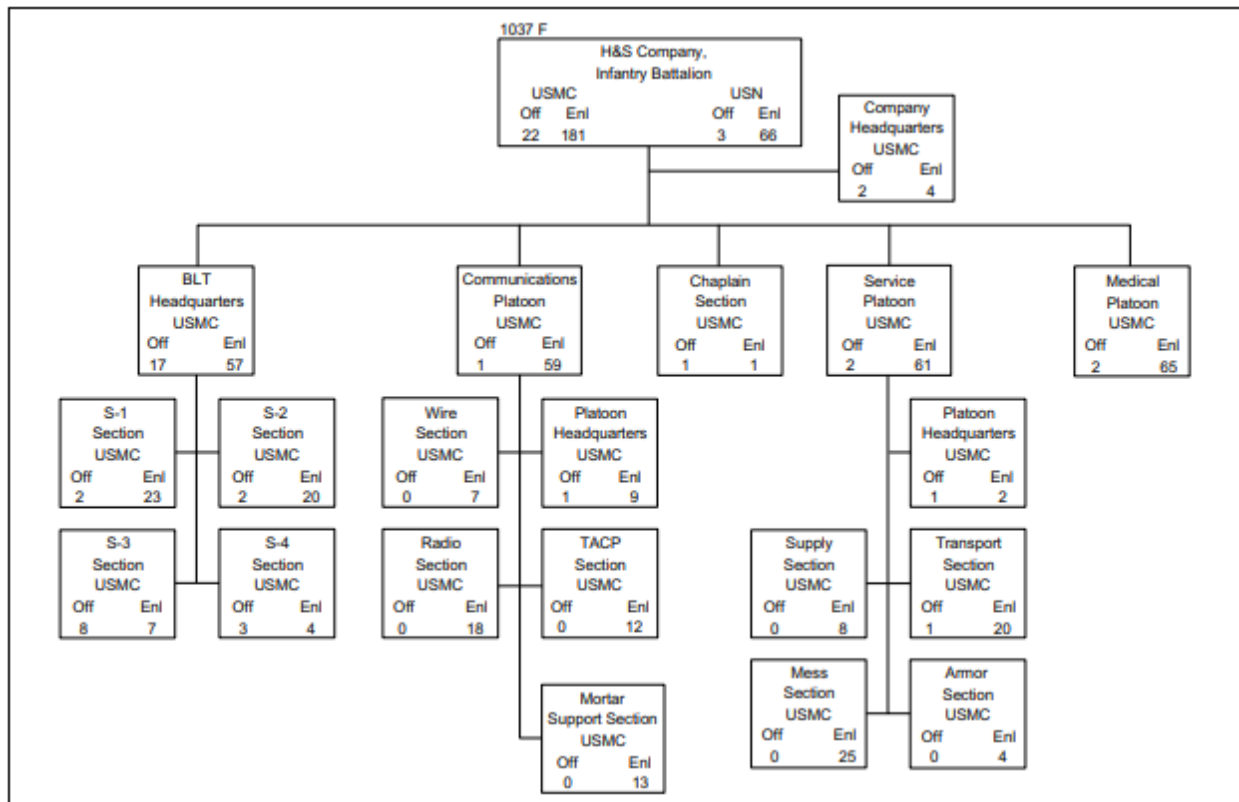


Figure 1: H&S Company, Infantry Battalion<sup>12</sup>

As noted in figure 1, a USMC infantry battalion has a service platoon sized element consisting of a very limited logistics capability. According to doctrine, this logistics capability complements the combat power of the unit but is not as robust as an infantry unit is intended to be foot mobile.<sup>13</sup> The infantry battalion is currently the first level of command with a dedicated logistics capability where by the S-4 Officer and Supply Officer serve as staff officers to the Battalion Commander. This construct places logistics largely centralized at the top of the unit with minimal ability to disperse and does not place any logistics capability at the infantry

company level or below. Due to the limited amount of resources provided for transportation and services, logistics sections tend to find themselves conflicted when balancing capacity and capability. For example, assets used to mobilize forces limit their ability to be leveraged for other logistics purposes. Maintenance capability, supply inventory, and distribution capacity become isolated limiting the dispersion of forces and confining resupply to major lines of communication.

The LOCE and CPG concepts express the need to develop the ability to support forces along a larger environment and as noted earlier, logistics is usually the largest limiting factor. The intent to further leverage mission tactics and increase the degree to which forces can displace requires a different approach to logistics.

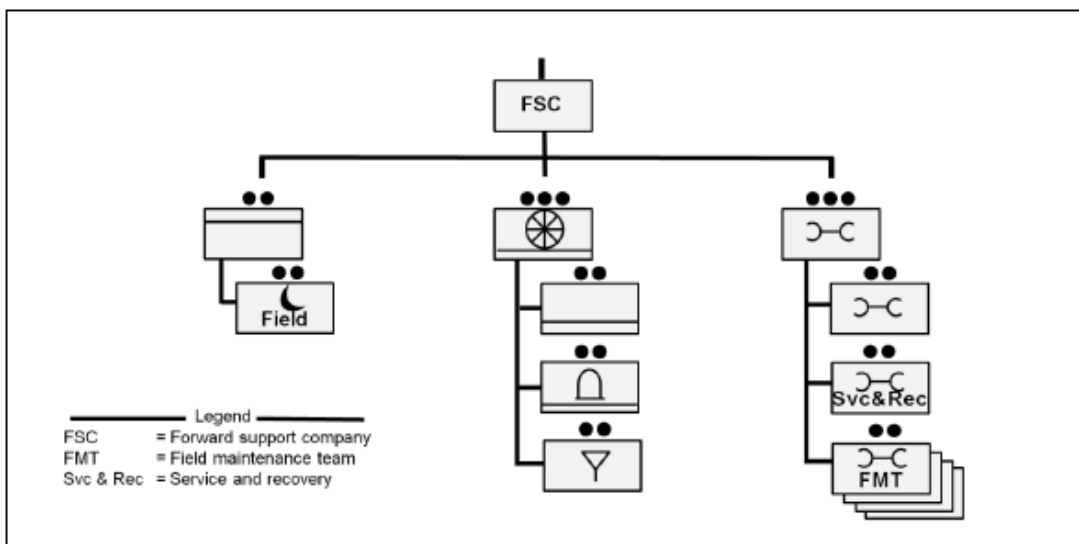


Figure 2: Forward Support Company (FSC) supporting a combined arms battalion<sup>14</sup>

If the squad is to leverage combined arms capabilities, then logistics needs to enable that autonomy and dispersion by employing capabilities at greater distances. The U.S. Army's approach to battalion level logistics differs from the Marine variant, as it places a company size logistics element within the organic construct of the battalion (see figure 2). Though the Forward Support Company (FSC) presents a standardized construct, these forces are tailored to meet the

requirements of the supported unit (i.e. infantry vs. tank, etc.). This FSC provides a direct logistics support capability to the battalion commander, placing a logistician at a company command level on par with his/her infantry counterparts, and specializes in the requirements of that unit type.<sup>15</sup> Due to the technical nature of logistics, the FSC serves as the critical link to the Brigade Support Battalion (BSB) and comprises of already established Field Maintenance Teams (FMTs) that can effectively operate in forward environments.<sup>16</sup> The FSC provides sustainment, distribution, and maintenance capabilities that enable the maneuver elements to stay focused on their requirements and minimizing reach back requirements. This model may not be completely applicable to all Marine Corps combat units but it does present a different approach to the employment methodology of logistics forces.

The forces most familiar with distributed operations are Marine Special Operations Command (MARSOC) units. The main maneuver element is the Marine Special Operations Company (MSOC), which comprises of four Marine Special Operations Teams (MSOTs). The nature of Special Operations (SO) parallels closely what LOCE/A2AD is theorized to present.<sup>17</sup> When originally constructed, MARSOC forces were designed to utilize conventional force logistics capabilities to garner sustainment.<sup>18</sup> Due to emerging requirements and employment models, conventional force logistics footprints were too large to meet the signature requirements Special Operation Forces (SOF) needed.<sup>19</sup> As MARSOC struggled to create a SOF logistics capability—later named Logistics Support Teams (LSTs)—various studies noted the financial and operational impacts presented by the lack thereof.<sup>20</sup> Various points were highlighted in these studies: MARSOC will continue to operate in a distributed fashion that suffers from limitations to transportation and other mobility challenges, force restrictions demand cross-functionality, U.S. Special Operations Command (USSOCOM) provided equipment bridges gaps in service

provided equipment, and locally procured equipment, transportation, and supplies were easier to source and maintain.<sup>21</sup> MARSOC LSTs have a unique composition of supply, maintenance, and embarkation personnel that are trained for the environment of employment. These teams provide MSOTs the ability to subsist while maintaining a low signature and minimizing the need to have an “iron mountain” nearby.

A combination of the Army’s FSC and MARSOC’s LSTs present a needed revision to existing practices and introduce unique capabilities to the maneuver element that enhances operability in the LOCE/A2AD environment. The nature of the LOCE/A2AD environment is one most akin to the operating environment of the SOF community and shares many logistics parallels with it. The need to maintain a low-level signature, the ability to leverage existing infrastructure, use of host nation support and other unique procurement methods, and the implicit dispersion has created the need for a logistics capability below the MSOC level. The Army recognized that having a logistics organization that is nested within the maneuver element enhanced support to it and created a better feedback loop to the Army Brigade Support Battalion (BSB) for additional support. When compared to the existing USMC model, the combination of the Army FSC and MARSOC LST, in tandem with the development of other training and inclusion of newer equipment can create the necessary change to enable logistics at the infantry company level.

By constituting a logistics company (figure 3) comprised of a distribution, sustainment, and maintenance platoons one can create the requisite structure to sustain the battalion headquarters. However, by creating LSTs that are nested in the aforementioned logistics company, logistics capabilities can be placed at lower levels enabling autonomy and enhancing dispersion. These LSTs would be designed to support the minimum logistics requirements

needed at the company level, given a complimenting equipment set, and prerequisite training. The goal of this pairing would be to enable conventional forces to self-sustain when needed and operate in a degraded communications environment. The structure of the LSTs created for an infantry battalion does not need to match the MARSOC model perfectly, but some of the skills taught in their curriculum may serve useful in the conventional forces. This model, noted in figure 3, serves as a starting point to highlight additional changes noted through the remaining portions of this document.

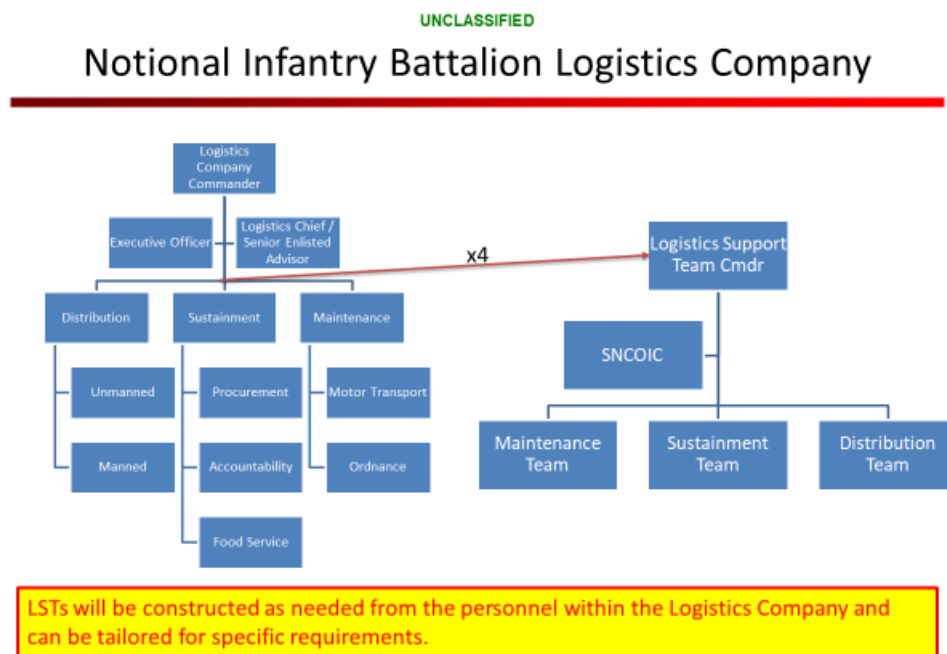


Figure 3: Notional Infantry Battalion Logistics Company

TRAINING AND MANPOWER COMPOSITION

The current congressional limitations on service manpower sizes, fiscal austerity, and a growing threat to national interests produces a forcing function driving a reassessment of what the future fight will present and how U.S. forces will be employed. The adage of “doing more with less” serves as a good analogy to describe the compounding effect of these factors. The

CMC has made note of the various changes necessary to support the future LOCE/A2AD environment while balancing the limitations noted earlier: “The complexity of the modern battlefield and increasing rate of change requires a highly educated force.”<sup>22</sup> Comparable military specialties need to be consolidated or cross trained to highest extent possible to maximize manpower efficiency, add redundancy, and increase “lethality” when operating in forward environments.

The advent of MARSOC presented many logistical concerns that took a significant amount of time and institutional inertia to overcome. It also highlighted the variety of skills that needed to be resident within the LSTs to ensure mission success. At its inception the MARSOC operational model depended heavily on conventional forces for logistical support but given the various changes in operational requirements, special operations logistics needed to develop a more compact and flexible support element.<sup>23</sup> Beyond the organizational changes with having an LST providing the logistical support base for a MSOC, the composition and capabilities of the LST were also of concern. The entry level logistics training pipelines do little to create overlapping expertise and are defined by very isolated technical fields. In the 30XX occupational field (OCCFLD) there are two major enlisted military occupational specialties (MOSs): 3043 (Supply Admin) and 3051 (Warehouseman). Both are listed as required personnel for a battalion supply section but the cadre of skills needed could be effectively managed under one MOS. Similar scenarios exist within motor transport, communications, engineering, etc. Given these examples, there is room to merge MOSs or cross train Marines sharing comparable disciplines to develop a more streamlined and interchangeable personnel model. To arrive at this model significant changes to the existing training and education model need to be addressed.

The current MOS alignment model isolates Marines into equipment centric domains. When compared to a different model that aligns more closely with functionality or capabilities, it becomes evident that the existing paradigm creates excessive manpower requirements both for the institution writ large and for the fulfillment of contingency requirements. The LOCE/A2AD environment will still present logistics requirements that need to be organically produced, but the era of large Forward Operating Bases (FOBs) will only present lucrative targets for U.S. adversaries making it counterproductive. LST composition must consist of personnel who have a broader scope of experience and are equipped to meet various requirements in austere locations while supporting maneuver forces. These requirements led to the establishment of a MARSOC combat service support training pipeline that generalized skill sets into LSTs comprised of approximately 17 Marines to support an entire MSOC. These LSTs use these Marines to build “contact teams” as necessary to provide additional support when needed to MSOTs operating in regions more geographically dispersed and has become the go to model for future logistics support requirements.

The MARSOC logistics training regimen is unique in that it requires all logistics personnel to have proficiency in adjacent skill sets and provides foundational instruction in “non-traditional” aspects that provide logisticians with enough information to exercise adaptability within their operating environment. In comparison, the current standardized pipeline is limited to a specific platform with little room for expansion. Coupled with the distributed and sensitive nature of special operations, MARSOC logisticians are funneled through a training pipeline that is designed to educate a small contingent of Marines in all of the critical logistics skills necessary to operate in the target environment.<sup>24</sup> Because of the limited density of these teams there would

not be any redundancy in skills without the creation of the Multi-Domain Logistics Operations Course (MDLOC).<sup>25</sup>

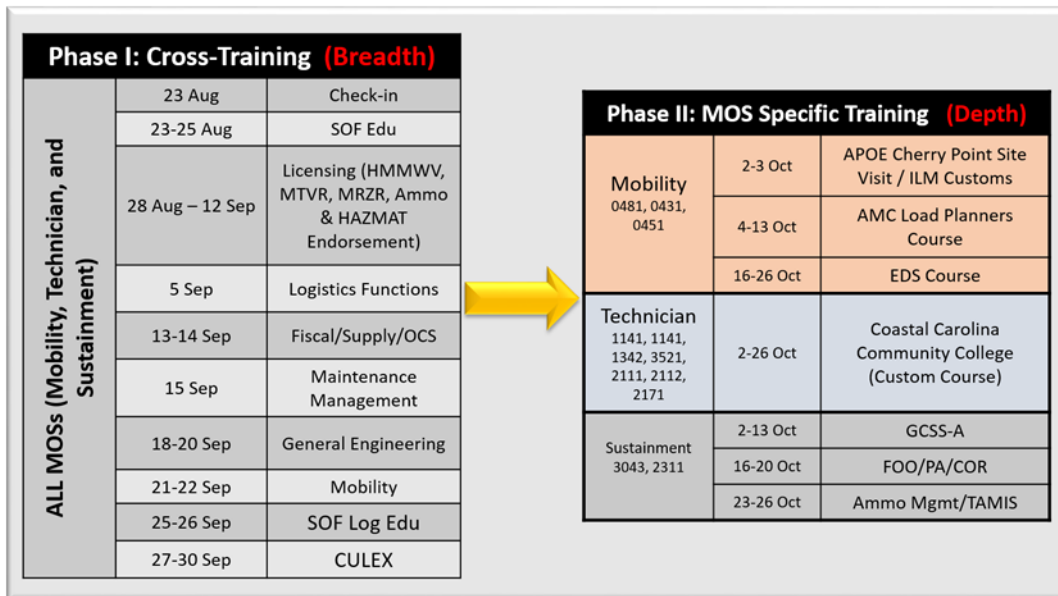


Figure 4: MDLOC 17-2 Concept of Operations<sup>26</sup>

As noted in figure 4, the MDLOC curriculum enhances the “breadth” and “depth” of all logisticians by guiding students through two distinct phases. The cross-training phase provides foundational information in all aspects of logistics, unique vehicle licensing, and the special forces logistics architecture.<sup>27</sup> The second phase enhances the existing skillsets resident in the current class by placing specific MOSs into “mobility, technician, or sustainment” pipelines that develop unique skills needed to sustain MSOCs.<sup>28</sup> “Mobility” focuses on enhancing embarkation skills. “Technicians” receive commercial training on automotive mechanics. “Sustainment” provides instruction on unique supply and procurement procedures. The combination of these skills and equipment enables the use of “hybrid logistics,” creates small effective logistics teams that can support distributed maneuver elements, and provides redundancy improving survivability.

Current conventional logistics forces have a limited breath of adjacent logistics skills, hindering their ability to best serve maneuver elements. With logistics largely isolated at the battalion level, company maneuver elements are largely supported via “push” logistics to established FOBs and do not enhance dispersion. By creating multifaceted logisticians that are empowered by current commercial technology, greater logistics capabilities can be placed at lower echelons and improve sustainability and survivability. A tailorable curriculum for logistics training and education would serve beneficial in the development of young logisticians and should look to bridge common skillsets by focusing on the improvement of the capabilities that Marines can bring to the fight. Limiting knowledge requirements to MOSs and then MOSs to organizational constructs creates waste in the form of underutilization. The MARSOC LST model proves that young Marines can be effective in supporting distributed teams but, this model needs to be echoed through conventional forces. If comprised of more well-rounded logisticians, these LSTs can further disaggregate into “contact teams” to provide more focused support to platoons and squad sized maneuver elements.

#### EQUIPMENT AND EMPLOYMENT

LSTs for conventional forces need to contain the right mix of sustainment, distribution, and maintenance capability for the mission at hand. When the adversarial threat can hinder communications and maneuver, distributed teams need to be able to leverage all options to ensure survivability and continue operations in lieu of contest. An infantry company commander must be able to disperse and while still maintaining command and control to the platoon level but its current tether to the battalion command post for logistics is counterproductive. Future LSTs need to be able to leverage new technologies and employment practices in future conflict to properly sustain the forces they support.

Throughout the execution of Operations ENDURING FREEDOM (OEF) and IRAQI FREEDOM (OIF), logistics became a consistent point of friction.<sup>29</sup> A U.S. Army (USA) study noted the significant requirements for Classes I (water and rations), III (fuel), and V (ammunition) for sustained combat operations and recognized that the A2AD environment would challenge the existing ability to provide such support.<sup>30</sup> More importantly, the same study noted that logistics operations do not normally see the same level of attention as combat arms specific platforms and thus, remain behind the power curve regarding modernization.<sup>31</sup> Water production and consumption, fuel and energy, ammunition, soldier systems, and mobility, all present considerable concerns.<sup>32</sup> The USA is actively looking to “reduce bulk and weight” of existing logistics capabilities and enhance the visibility of current inventory and allow for further dispersion on the battlefield.<sup>33</sup> By leveraging new technologies US forces will be able to operate in more austere environments and survive.

### *Water*

Throughout recent history, US forces were very reliant on the use of contractor provided bottled water for sustainment.<sup>34</sup> This has led to a degradation in water generation capabilities with the military limiting sustainment capability. This dependency on host nation water production will not be feasible going forward. Additionally, the ability to move water production capabilities to lowest maneuver echelon would enhance survivability. Current water production capabilities are large and bulky limiting maneuver.<sup>35</sup> Research on the production of water through rain collection/atmospheric water and the use of distillation/nanotechnology to purify existing water sources shows significant promise for use at the company and larger echelons.<sup>36</sup> However, there are still limitations on water production at the platoon and squad levels. Additionally, a water testing capability at the squad level would enable forces to better leverage

the MIOX filtration system.<sup>37</sup> The current MIOX filtration system can remove viruses and bacteria via the use of chlorine but cannot remove chemicals.<sup>38</sup> The ability to produce water at the individual level would subsequently minimize the need to transport water.<sup>39</sup> Future LSTs can utilize larger water sourcing technologies to produce water for forward elements by managing and maintaining a compact distillation and testing capability within the company level.

### *Fuel and Energy*

The need for fuel and energy production largely serve two requirements: equipment usage and power generation.<sup>40</sup> During OIF and OEF large forward operating bases had massive fuel consumption requirements making petroleum-based requirements outweigh water.<sup>41</sup> Almost all power generation was fossil fuel based and did little to leverage other forms of energy production.<sup>42</sup> Additionally, the use of this type of power generation did little to minimize the footprint of friendly forces and presented significant challenges pertaining to fuel distribution. The ability to leverage alternative sources of energy could be helpful in decoupling maneuver force power requirements and facilitating autonomy. Additionally, use of locally available power sources can better minimize US force footprints and enable better signature management.

There are currently no ground transportation systems that can serve a dual purpose in both transportation and power generation. Also, there are no “hybrid” ground transportation systems that parallel technology seen employed by Honda, Toyota, etc. Above and beyond the need for better integration of “hybrid” technology, is the ability for units to be able to power necessary equipment that supports command and control. Complex and differing battery requirements per platform and the inability to tap into alternative energy sources (solar, hydrogen, etc.) make fossil fuel management a critical and challenging requirement for

logisticians.<sup>43</sup> The current dependency on bulk fuel is too great and presents another restriction to greater autonomy and dispersion.

There are no power generation capabilities currently employed below the company level. Fully electric vehicle technology is advancing but cannot currently meet the rigors presented in expeditionary environments. The use of new advancements in battery storage and alternative energy sources can offset a considerable amount of demand for fossil fuels.<sup>44</sup> The use of fuel cells has shown a significant growth in efficiency. When viewed in comparison to the use of conventional generators, fuel cells are lighter and are more easily displaced. Various commercial organizations are producing hydrogen-based alternatives for energy sourcing. Use of portable solar systems have a significant amount of promise. Flexible photovoltaic systems are more rugged and can be placed on existing tenting or tarping creating efficiencies in both power generation and billeting.<sup>45</sup> Coupled with advancements in energy storage and efficient energy consumption, fossil fuel consumption rates can be significantly reduced and, in some cases, eliminated.

### *Ammunition*

Ammunition is the third largest logistics burden after fuel and water.<sup>46</sup> Due to the volatile nature of ammunition there are significant regulations governing the transportation and storage of it.<sup>47</sup> The composition of ammunition is largely based in heavy metals and when coupled with dense packaging makes its distribution burdensome.<sup>48</sup> Changes to the composition of small caliber ammunition and its associated packaging should be explored with in the intent to develop lightweight ammunition that either retains or improves its current performance with reductions in weight.<sup>49</sup> Ultimately, ammunition requirements will still need to be sourced through the existing supply chain but advancements in ammunition would reduce the logistics burden that comes with

its usage and transportation. LSTs would be able to source more ammunition and manage longer distribution lines if successful.

### *Distribution Capabilities*

The current equipment base of an infantry battalion is largely comprised of wheeled vehicle assets to support distribution of personnel and equipment. Any distribution activity that needs to be executed over air or sea methods currently requires coordination with the aviation component or U.S. Navy. An additional limitation of wheeled vehicle assets is their limitation to use on roads or other permissive terrain. This limitation forces the need to resupply to be conducted on near a road if done organically. These areas are normally open to surveillance and can create unnecessary risk and create additional burden for supported forces. Autonomous technologies have allowed for commercial organizations to offer their customers new and timely distribution options.

In order to appropriately employ wheeled vehicles in an expeditionary environment, three Marines need to be in one vehicle. Traditionally, a driver, assistant driver, and a gunner to provide security. Autonomous ground vehicles would replace operators in lower scale missions and enable human capital to be used elsewhere. Also, autonomous vehicle technology can be employed in the existing variants of ground transportation providing the advantages noted earlier but also adding a layer of complexity for the enemy.<sup>50</sup> These kits can add varying degrees of autonomy and can employed in convoy applications to deliver greater loads.<sup>51</sup> The “last tactical mile” is a phrase used to denote movement from the point of final debarkation to the end user. This aspect of logistics is what would largely connect the LST to the end user and should consist of varying types “connectors” that have recently come to fruition.

The implementation of unmanned/autonomous technologies can have varying degrees of impact but provide LSTs with the capability to conduct resupply in more austere environments improving responsiveness. As drone technology continues to support larger payloads the requirements for ground distribution will likely diminish. Given the advent of commercial multirotor style drone platforms, Amazon is currently developing a service known as “Prime Air” to make deliveries to their customers within minutes.<sup>52</sup> The current drone variant being tested can support a payload of approximately 5 lbs. depending on conditions.<sup>53</sup> Newer variants of Amazon drones are capable of going 50 miles through the employment of a new design that combines the advantages of a quadcopter and a fixed wing air craft.<sup>54</sup> There is an assortment of commercial drones that can carry up to 11 kg (~24 lbs.) offered by DJI.<sup>55</sup>

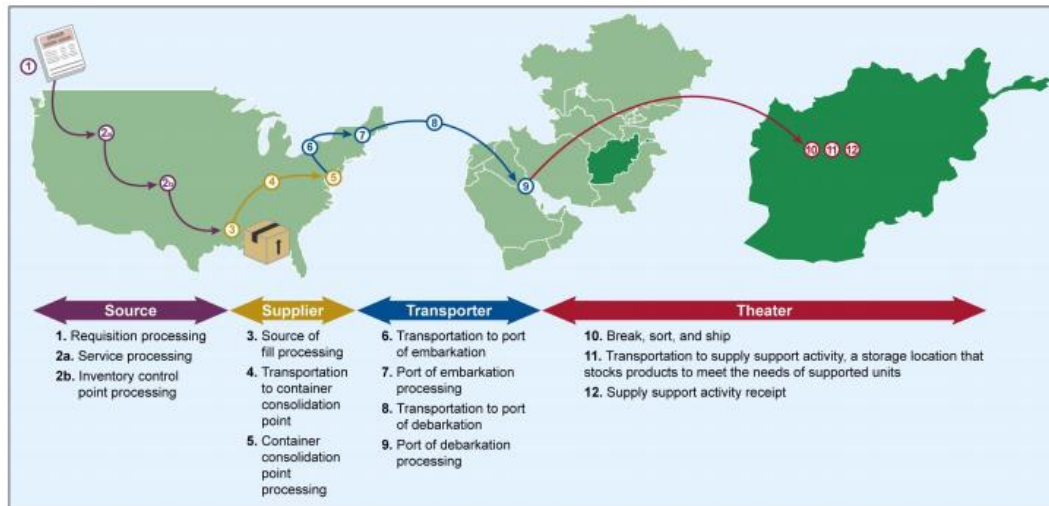
From a ground transportation perspective, Oshkosh, MILREM, and QinetiQ are developing tactical level autonomous ground vehicles. The Titan Unmanned Ground Vehicle (UGV) is a tandem project between QinetiQ and MILREM that provides an autonomous, tracked, electric-diesel hybrid platform capable of carrying a 1,500 lbs. payload and pull force of 2,000 lbs.<sup>56</sup> The Titan’s range of autonomous capabilities range from manned to unmanned, its physical range is 20 km in an all-electric mode or 100 km in hybrid mode, and is capable of operating in day and night.<sup>57</sup> Oshkosh has taken a different approach by leveraging the existing Medium Tactical Vehicle Replacement platform and integrating autonomous capabilities, it has developed the “TerraMax” platform.<sup>58</sup> Notably, the modular kit of the “TerraMax” is designed to be integrated into any tactical vehicle, has the capability to assess terrain and traffic, and can operate without GPS.<sup>59</sup>

Both mediums of transportation—surface and aerial—are seeing significant technological growth presenting various options for U.S. forces to leverage in the A2AD environment. Marine

LSTs could leverage a combination of these technologies to support all logistics missions and provide options to the infantry company while operating in more dispersed operating areas.

Having transportation assets that can operate autonomously provides commanders with flexibility and reach while maintaining operational tempo and safeguarding military personnel.

*Tactical Supply Chain*



Source: GAO analysis of Department of Defense (DOD) information. | GAO-15-226

Figure 5: The Department of Defense Global Distribution Pipeline<sup>60</sup>

LOCE/A2AD environment will present significant challenges to the existing supply chain management practices and will require revision to avoid adversarial focus, divest risk, and provide redundancy. Figure 5 denotes the current process sourcing equipment from the industrial base, via the use of coordinated military and civilian transportation routes, to a MAGTF (Marine Air-Ground Task Force) at a specific location. The responsibility for distribution then shifts to the MAGTF Materiel Distribution Center (MMDC) for the subsequent coordination for distribution to the end user's supply section.<sup>61</sup> Current publications note the differences in push and pull logistics, and the associated supply point and unit distribution methods for the execution of resupply. This isolated flow creates a large logistics hub that is normally collocated with the command element in the rear area of the area of operations thus, creating a lucrative target for

the adversary. Supplies are then subsequently distributed through the operating environment through isolated logistics nodes that stovepipes logistics as a top-down sourcing model where units seldom leverage excess inventory adjacent to them.

The future operating environment will further pit efficiency against effectiveness as it relates to logistics. Given the constraints noted above, it will become more prudent to create additional theater distribution nodes with the ability to conduct resupply directly to the company or platoon level from an area outside of the A2AD threat. Due to the increasing range of weapons, the ability to distribute equipment becomes more contested and requires tactical units to be able to leverage air as a via avenue for distribution. The anticipated operating environment will require “just in time” logistics to provide the correct amount of supplies at the right time to avoid exposure, minimize load, while enabling mobility and tempo. The use of unmanned aviation and ground systems can support the physical transportation requirement, however, significant improvements to how requisition management is executed are needed.

There is no current ability to fulfill logistics requirements in stride with tactical movement. In the aviation community, a “coronet” mission is when a tanker is assigned to formation in order to provide inflight refueling enabling greater range.<sup>62</sup> The use of emergent technologies—UAS/UGS—could be effectively employed in “coronet” fashion to provide sustainment if enabled with swarm capabilities. Defense Advanced Research Projects Agency (DARPA) has already developed technology—Collaborative Operations in Denied Environment (CODE)—enabling UAVs to complete missions without communications or GPS access (Ball, USN).<sup>63</sup> Though this technology was largely for offensive operations, the ability to leverage multiple UAS platforms simultaneously can significantly improve distribution capability especially when combined platforms that can sustain large payload capacity.

Another area for improvement is the cross-service supply accessibility. Though all services utilize MILSTRIP (Military Standard Requisitioning and Issue Procedures) standards to submit requisitions to wholesale supply agencies, there is no process by which a Marine Corps unit can requisition equipment from an adjacent service without significant coordination to deconflict payment process and shipping. Each military service maintains different protocols for the accountability of its equipment, its associated maintenance management, and its fiscal accounting and execution which perpetuates this dissonance. Procurement capability largely rests within the battalion supply section and should also be placed closer to the tactical level. This practice denies access to available inventory from adjacent units and should be corrected. If rectified, it would enable supply availability to all services and create redundancy for parts and supplies that are common to all services.

#### CONCLUSION

The future of LOCE/A2AD fight will inject varying degrees of friction on U.S. forces operating in adversarial terrain. These challenges will require logistics capabilities that transcend limitations to mobility, communications, and sustainment. Additionally, friendly forces will need to continue operations while having limited communications capabilities and logistics support. The combination of these problems directly challenges the effectiveness of existing organic logistics structure of the infantry battalion and its ability to operate effectively. In order to remedy these issues, significant changes to the structure of the infantry battalion's logistics capabilities, the training and employment of its logistics personnel, and its equipment composition will require modernization and reform to meet demands most commonly seen in special operations missions.

With most logistics capabilities largely residing at the battalion level, company level units must constantly receive resupply from the battalion command post for sustainment. Additionally, the organic distribution capability of the infantry battalion is purely vehicular based, forcing maneuver elements to constantly gravitate to roads for sustainment. This form of resupply creates pauses in operational tempo and choke points that can be leveraged by adversaries. An alternative is to create a logistics company that is organic to the infantry battalion and provide LSTs (logistics support teams) to the company maneuver elements which consist of a combination of sustainment, maintenance, and distribution personnel to provide more robust capabilities to smaller maneuver elements creating logistics redundancy and enhanced visibility at the point of need.

The composition and training of personnel also would benefit from a substantial revision to adopt a model commensurate with the expectations placed on MARSOC MDLOC graduates. Current training requirements for MOS awarding largely revolves around either a subset of equipment or computer platforms that are in many cases segregated into operators and maintenance technicians (ex. motor transport). This is an inefficient use of manpower and creates duplicative requirements for personnel that could be halved in favor of personnel who can perform a range of skills that would overlap more than one MOS. This new approach would enable the service to leverage efficiencies elsewhere while generating specialists that are able to do more tactically. This paradigm shift would force services to consider training that more closely aligns to commonalities across platforms and programs. This overlap in skills would enable greater employment opportunities for personnel and create redundancy within the logistics sections.

The logistics equipment base of the infantry battalion is largely dated and is designed primarily for ground-based transportation. There is a limited amount of equipment dedicated to the sustainment of other requirements. As experienced through OEF and OIF, subsistence, fuel/energy, and ammunition create the largest logistics burden in kinetic operations and will continue to be the norm going forward. Newer technologies have come to help create solutions to these hurdles.

There is no organic water production capability within the infantry battalion and the historical leveraging of host nation support may prove challenging in a LOCE/A2AD environment. There is a growing need for a capability to quickly test locally available sources of water, sanitize it, and distribute it. The commercial sector is actively working to create a solution for this but they are too large. Ideally, the ability to source water at the individual level would quell the largest logistics requirement.

The requirement for fuel has a similar effect as does water when viewed in relation to the burden it places on logisticians. Energy is still largely sourced using fossil fuels and the associated combustion engines to produce electricity. These large electrical networks do little for deception and only exacerbate maintenance and logistics requirements. Significant effort has been placed in the research of alternative energy sources to include the use of fuel cells, solar, and hybrid power to divest a significant portion of the bulk fuel requirements. There are many opportunities to update existing platforms to leverage these alternative sources and extend their operational range.

Ammunition requirements present the third largest requirement during kinetic operations and due to its volatility is closely managed. Its composition makes it dense and heavy creating

additional burden for transportation. Coupled with the existing packaging requirements, this supply has significant potential for advancement.

The distribution options of the average infantry battalion are entirely ground based. The proliferation of autonomous vehicles presents a plethora of options that can be trained to and employed at some of the lowest tactical levels providing a reach back capability that would otherwise do not exist. Unmanned ground systems can move the heavier items while unmanned aerial systems can provide “just in time” supplies to maneuver elements. Implementation would successfully limit unnecessary troop exposure while meeting end user demands. Use of “swarm” technology can multiply payload per mission capacity while operating within a limited communications environment. Lastly, a better integration of cross-service requisition fulfillment would better synchronize inventory management, enable closer relationships, and create efficiencies in the supply chain.

The LOCE/A2AD environment will be significantly different from what was seen during OIF and OEF presenting a different problem set in need of solutions. If the lowest tactical unit can learn to meet their own logistics requirements and leverage the resources around them there will be a corollary effect on the theater level requirements, an increase in range and dispersion, and an improvement to survivability. Multifaceted forces enabled with emergent technologies will present new approaches to age old problems and bring us closer to the closing the challenges presented in future conflict.

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