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LOGISTICS INNOVATION FOR THE FUTURE OPERATING ENVIRONMENT: TRAIN LIKE YOU WILL FIGHT

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JCSP 45

Exercise Solo Flight

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TRAIN LIKE YOU WILL FIGHT**

Major Eric Henzler

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Logistics Innovation for the Future Operating Environment: Train Like You Will Fight

INTRODUCTION

Although the future is arguably, highly unpredictable, the United States of America and its allied partners consistently refine predictive assessments of the global security environment in efforts to maintain a competitive edge across all elements of the diplomatic, information, military, and economic (DIME) construct. In the military context, the U.S. Marine Corps (USMC) described the future operating environment (FOE) as one which is, “characterized by complex terrain, technology proliferation, information warfare, the need to shield and exploit signatures, and an increasingly non-permissive maritime domain.”¹ Consistent with the USMC assessment, the U.S. Navy cited increased competition within the maritime domain (oceans, littorals, and sea floor), the importance of data in decision making, and the rapid development and adoption of technology as key drivers of the future security landscape.² Similarly, the Canadian Armed Forces (CAF) recognized future engagements with adversaries will likely occur in dense urban areas (DUA), littorals, and mountainous regions; all amidst sophisticated and networked anti-access/area denial (A2/AD) capabilities employed by the enemy across all five domains (air, land, sea, space, and cyber).³

Among these popular assessments of the complex and contested FOE, the USMC describes logistics as, “the pacing function” by which readiness, agility, and lethality of

¹ United States Marine Corps. “The Marine Corps Operating Concept: How an Expeditionary Force Operates in the 21st Century.” (Washington, DC: Headquarters Marine Corps, Office of the Commandant, 2016), 8.

² John M. Richardson. “A Design for Maintaining Maritime Superiority (Version 2.0).” (Headquarters, U.S. Navy, Office of the Chief of Naval Operations, 2018), 3.

³ Canada. Department of National Defence. A-FD-005-001/AF-003, *The Future Security Environment 2013-2040*. (Winnipeg: Chief of Force Development, 2014), 110.

the Marine Air Ground Task Force (MAGTF) is maximized.⁴ Despite nearly two decades of land-based operations supported by robust theater-wide logistics hubs, and with virtual dominance of the air, land, and sea domains, the USMC logistics enterprise recognized it is no longer ideally postured to sustain combat power in a FOE contested by enemy A2/AD across all five domains. Consequently, the Deputy Commandant for Installations and Logistics (DC I&L) published a conceptual framework for expeditionary logistics which called for disruptive thinkers willing to challenge the status quo towards innovative logistics solutions across the following expeditionary logistics attributes:

- 1) Hybrid mix of legacy and evolving 21st Century logistics capabilities
- 2) From the sea, and naval in character
- 3) Flexible and expeditionary
- 4) Innovative, adaptive and versatile in thought-practice
- 5) Resilient and analog-capable C2
- 6) Data-driven⁵

Likewise, in a subsequent publication, the Vision and Strategy Branch from Headquarters Marine Corps (HQMC), I&L echoed the Deputy Commandant's sentiments when it described an operational concept for future logistics development whereby sustainment for the FOE must be organized across four lines of effort (LOE); enable global logistics awareness, diversify distribution, improve sustainment, and optimize installations to support sustained operations (see Figure 1).⁶

⁴ United States Marine Corps. "Sustaining the Force in the 21st Century: An Operational Concept for Future Logistics Development, Version 0.17." (Washington DC: Headquarters Marine Corps, Installations and Logistics, 2019), 2. *Note: At the time of this writing, this reference is still in DRAFT/Pre-decisional format awaiting signature and official release.

⁵ United States Marine Corps. "Marine Corps Hybrid Logistics: A Blend of Old and New." (Washington DC: Headquarters Marine Corps, Installations and Logistics, 2016), 7.

⁶ United States Marine Corps, Installations and Logistics, Vision and Strategy Branch. "An Operational Concept for Future Logistics Development." (*Marine Corps Gazette* 103, no. 3, 2019), 10.

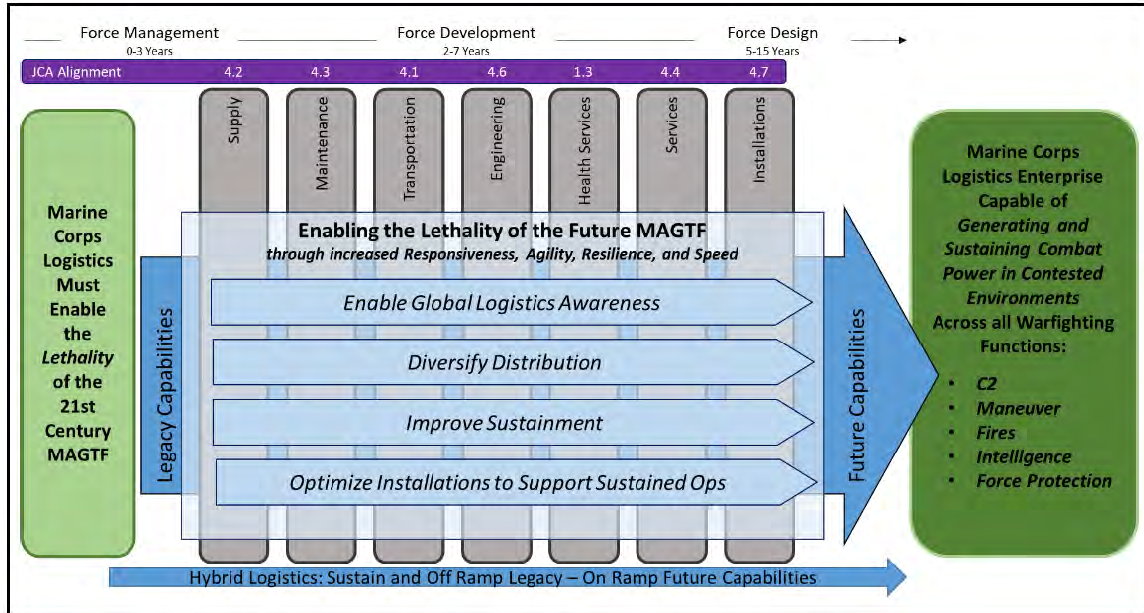


Figure 1: Sustaining the Force in the 21st Century

To that end, the Marine Corps writ large, and specifically, the broader logistics community has steadily come forward with ideas supporting each LOE and spanning multiple technologies including robotics, artificial intelligence (AI), autonomous systems, and big data analytics. However, even with the majority of the force on board the innovation train, and with functional prototypes under development and testing, there has been little evidence that the “disruptive” ideas and ensuing technologies have, in fact, bolstered the sustainment and lethality of the MAGTF *under the conditions expected to exist within the FOE*. The compelling question is – why not?

This essay challenges the efficacy of current logistics innovations and examines why they are falling short of institution-wide applicability, acceptance, and implementation. Furthermore, it argues that technology-based, network-reliant logistics capabilities must not undermine the USMC logistics enterprise’s competence in capacity-based sustainment afforded by existing global partnerships. Accordingly, the Marine

Corps' culture of logistics innovation is described through current initiatives spanning the doctrine, organization, training, materiel, leadership and education, personnel, facilities, and policy (DOTMLPF-P) spectrum. Secondly, the performance of some of the most recent hybrid logistics innovations as tested during Sea Dragon Integrated Training Exercise (ITX) 3-18 is analyzed to ascertain the utility of technology-based logistics solutions within the A2/AD environment. Finally, opportunities for further research and the exploration of alternative frameworks for deriving logistics solutions for the FOE are recommended.

USMC LOGISTICS INNOVATION ACROSS THE DOTMLPF-P SPECTRUM

Materiel Innovation

In June 2016, the DC I&L, Lieutenant General (LGen) Michael Dana, released Marine Administrative Message (MARADMIN) 304/16, announcing the first ever USMC Logistics Innovation Challenge. The challenge solicited creative ideas from across the enterprise, focused on a specific logistics challenge outlined as follows:

... Make Your Corps. Building off the international maker movement, imagine you have four weeks and unlimited resources to build a product to make your unit better using 3D printing or a similar technology. What would you make? Solutions can range from new rifle scopes to new radios to new vehicles. The purpose of this challenge is to expose Marines, Sailors and civilians to the tools, methods, and benefits of rapid prototyping, also known as "making." The making movement has been enabled by several recent technologies such as 3D printers, laser cutters, minicomputer numerical control (CNC) mills, easy-to-use computer aided design (CAD) software, simple sensors, and inexpensive micro-computers. With the right tools and instruction, what might a Marine make? Would these solutions improve warfighting capability, either while in garrison or forward deployed?⁷

⁷ Major General V. A. Coglianese. *Logistics Innovation Challenges*. Headquarters Marine Corps: Marine Administrative Message (MARADMIN) 304/16, 141455Z JUN 16.

The day after the message was published, LGen Dana followed it up with the release of a short YouTube video featuring him engaged in common USMC training scenarios, which underscored the applicability of the challenge across all trades and amplified the importance of total force participation.⁸

By the end of the 30-day challenge period, over 300 proposals were submitted from field grade officers all the way down to junior enlisted members. Seventeen winners were chosen and included additive manufacturing (AM) solutions for explosive ordnance disposal tools, terrain models, unmanned aerial vehicles (drones), and M777A2 (Howitzer) cables.⁹ Each proposal was born from “real-world” challenges the Marines experienced in their day-to-day operations and their innovative solutions promised a tangible and significant impact to bolstering the sustainability and lethality of the MAGTF. Most importantly, the magnitude and quality of submissions received was a strong indicator that the institution bought into the innovation movement and was eager to contribute solutions to existing and emergent problems. As a result, the Logistics Innovation Challenge is now a quarterly event, each targeting solutions across a specific theme (i.e. logistics apps, data-driven logistics, or unmanned systems), and each garnering more and more remarkable ideas.

Training Innovation

Perhaps the USMC’s most unique and coveted initiative is Innovation Boot Camp, a week long course provided by Building Momentum LLC, an Alexandria,

⁸ “Marine Corps Innovation Challenge.” YouTube video, 1:22. Posted by “Marines,” 15 June 2016. <https://www.youtube.com/watch?v=vECZ11Usny4>.

⁹ Lieutenant General Michael G. Dana. *Logistics Innovation Challenges Results Announcement, August 2016, Washington DC*. Headquarters Marine Corps: MARADMIN 492/16, 191828Z SEP 16.

Virginia based company who trains students to leverage technology, to solve problems.¹⁰ Since January 2017, more than 300 Marines including infantry, intelligence, communications, and mechanics have completed the course.¹¹ Proudly nicknamed “MacGyver Camp” by the Marines who attended, the course is deliberately fever-paced and educates Marines in critical prototyping skills such as welding, circuitry, computer aided drafting (CAD) software utilization, and plasma cutting; all of which are necessary for the curriculum’s culminating event – a simulated, real-world combat scenario.¹² While the Marines leave Innovation Boot Camp with a shift in mindset and a new found propensity for leveraging innovation and disruptive ideas to solve nearly any problem, the USMC logistics enterprise is not training enough Marines with these skills. Consequently, the USMC must find a way to expand the sphere of this training, perhaps by adding it to the curriculum of all formal logistics schools or by establishing pilot programs at each of the Marine Logistics Groups (MLGs). As a caution, the classic “train the trainer” methodology, although cost effective, is unlikely to cultivate true “disruptive” thinking with like-minded Marines training other like-minded Marines. Therefore, it is highly recommended that any training solution adopted by the USMC be solely instructed by personnel from private sector technology and innovation incubator firms.

Organization Innovation

Perhaps the most relevant, yet relatively under-the-radar example of the Marine Corps logistics enterprise organizing itself to foster innovation is the small team of

¹⁰ Josh Dean. “Making Marines Into MacGyvers,” (*Bloomberg Businessweek*, 20 September 2018), <https://www.bloomberg.com/news/features/2018-09-20/making-marines-into-macgyvers?srnd=premium-canada>.

¹¹ *Ibid.*

¹² *Ibid.*

professionals who make up the Next Generation Logistics (NEXLOG) Cell at the HQMC Installations and Logistics offices in the Pentagon. With a staff of less than ten people, NEXLOG's primary purpose is to serve as the logistics innovation advocate for the Marine Corps whereby identifying emerging technologies and enabling accelerated development and implementation to the operating forces.¹³ Although small in size, NEXLOG is strategically aligned with key organizations sharing a similar innovation mindset such as the Office of the Secretary of Defense (OSD) Innovation Unit, U.S. Special Operations Command (USSOCOM), the U.S. Army's Research Lab, the U.S. Navy's Office of Naval Research, and multiple commercial entities including drone developers from the United Kingdom.¹⁴

Most recently, NEXLOG has focused its innovation and exploitation efforts in three areas; additive manufacturing or "AM" (also known as 3D Printing), unmanned logistics systems (ULS), and data-driven logistics (D2L). Arguably, NEXLOG's most recognized success is in the AM realm, where among many advancements, they facilitated the 3D printing of a M1A1 tank engine impeller fan, the first ever ground weapon system successfully operated with a metal 3D printed replacement component. Within the ULS focus area, NEXLOG's most relevant project to date is the development of UH-1 "Huey" air delivery vehicles with a 2,000 pound cargo capacity, as well as several smaller cargo drones with lift capacities under 500 pounds. Data-driven logistics is the area where NEXLOG acknowledged it is lagging behind, but over the course of the

¹³ Dana, Michael G. "The Power of Disruption." (*Marine Corps Gazette* 102, no. 8, 2018), 8.

¹⁴ *Ibid.*, 8-9.

next year, it intends to explore D2L technologies including AI to further guide investments in big data analytics.¹⁵

Perhaps above all, NEXLOG's presence within the institution has enabled the establishment of standalone program offices for both AM and ULS (Air). Their continued advocacy for innovation and disruptive thinking has spread across the enterprise, even to combat forces that, with the help of NEXLOG, were equipped with deployable 3D printing capabilities and 3D printed quad-copter drones.¹⁶ Going forward, NEXLOG's persistence in soliciting ideas from the Fleet Marine Force (FMF) while diligently delivering executable solutions back to them will be critical to spreading the gospel of innovation and fostering total force buy-in. In order to achieve this reality, NEXLOG must scale its organizational structure into something much larger and more diverse than the current state. One way to accomplish this is to establish NEXLOG liaison officer (LO) positions at the Division, Group, and Squadron headquarters level to serve as the interface between operational units and the main NEXLOG office in the Pentagon. Additionally, the main NEXLOG office must be expanded to include billets for officers and senior enlisted Marines from trades outside of the logistics community in order to expand diversity of thought and experience. With this expansion, the NEXLOG "brand" will become more identifiable, relevant, and valued; a necessary shift from its current status across the broader USMC community which is, "what's NEXLOG?" and "what can they do for *me*?"

¹⁵ Ibid., 9-11.

¹⁶ Ibid., 8.

Facilities Innovation

Integrated with NEXLOG's AM focus area is the Expeditionary Manufacturing mobile testing facility, a rapidly deployable AM laboratory filled with cutting edge equipment and supplies capable of "making" nearly anything imaginable within the confines of a supply chain disrupted, semi-austere environment. More commonly known as the "EXMAN" among the logistics professionals who employ it, the debut version of the facility was introduced in 2016 at Camp Pendleton, CA as a partnership between the Marines of 1st Maintenance Battalion and Space and Naval Warfare Systems Command (SPAWAR).¹⁷

Since inception, the EXMAN has been perpetually tested and evaluated during training scenarios including the 1st Marine Division led exercise Steel Knight 2017 at Marine Corps Air Ground Combat Center (MCAGCC) Twentynine Palms, CA. Most notably during this exercise, EXMAN's 3D printing capabilities were employed to rapidly prototype a Logistics Vehicle System Replacement (LVSR) mounting bracket and return the vehicle to its full operational capability in far less time than would normally be required using the normal supply chain.¹⁸ Within a garrison environment, the EXMAN successfully prototyped and produced a wide array of components including the M1A1 impeller fan mentioned earlier, the power knob for the AN/PVS-17c night vision

¹⁷ Lieutenant Colonel Foster Ferguson, Commanding Officer, 1st Maintenance Battalion, 1st Marine Logistics Group, telephone conversation, 6 September 2018. Maria Kelly Murphy. "Expeditionary Manufacturing Mobile Test Bed (EXMAN)," last modified 03 May 2016. <http://www.secnav.navy.mil/innovation/Pages/2016/05/EXMAN.aspx>.

¹⁸ "Steel Knight: The Ex-Man Returns." DVIDS video, 1:41, posted by "First Marine Logistics Group," 12 December 2016, <https://www.dvidshub.net/video/499628/steel-knight-ex-man-returns>.

device, a camera mount for the MK-2 Explosive Ordnance Disposal (EOD) robot, and an Amphibious Assault Vehicle (AAV) engine connecting rod.¹⁹

Although the viability of the EXMAN to produce the same level of output from an expeditionary advanced base (EAB) or a sea-based platform within the A2/AD constrained FOE is unproven, the potential impact for Marine Corps logistics is undeniable. For example, when ordered through the supply system, the AAV engine connecting rod mentioned above costs \$561.38 (plus shipping) with a lead time of 152 days from the original equipment manufacturer (OEM).

Utilizing the 3D printing capability within the EXMAN, 1st Maintenance Battalion Marines produced a suitable replacement rod in 35 hours at a cost of \$98.00.²⁰ Most certainly, the 80% cost savings is desirable, but 98% reduction in customer wait time (CWT) and subsequent swift return of a critical asset to fight is the true indicator of USMC logistics sustaining the lethality of the MAGTF. However, the critical question remains – can the EXMAN produce the same results while forward deployed and contested by the A2/AD environment? The USMC must find the answer.

Since its initial proof of concept in 2016, EXMAN-like capabilities are visible across the enterprise in things like the Expeditionary Fabrication (XFAB) and Tactical Fabrication (TACFAB) suites recently tested during the 2018 Sea

¹⁹ Compilation from: Zach Daugherty and Andrew Heiple, “Additive Manufacturing Solutions in the United States Marine Corps,” (Naval Postgraduate School, 2017), 25-26, “3D Printing: The Future Of Warfare?” YouTube video, 5:01, posted by “Forces TV,” 07 September 2017. <https://www.youtube.com/watch?v=LKiESPbU6cQ>, “SoCal Ship-to-Shore Exercise: The Amazing Ex-Man.” Defense Visual Information Distribution Service (DVIDS) video, 1:30, posted by “First Marine Logistics Group,” 04 May 2017. <https://www.dvidshub.net/video/522465/socal-ship-shore-exercise-amazing-ex-man>, and Lieutenant Colonel Foster Ferguson, Commanding Officer, 1st Maintenance Battalion, 1st Marine Logistics Group, telephone conversation, 6 September 2018.

²⁰ Lieutenant Colonel Foster Ferguson, Commanding Officer, 1st Maintenance Battalion, 1st Marine Logistics Group, telephone conversation, 6 September 2018.

Dragon ITX, as well as AM mobile facilities forward deployed into combat zones. While the USMC is aggressively pursuing this revolutionary technology, more testing and evaluation is required to determine scalability, maneuverability, survivability, and sustainability amidst the rigors of an A2/AD environment. Continued investment in this area must remain a high priority.

Personnel Innovation

In general, the Marine Corps logistics enterprise has rarely been quick to implement innovations in the area of personnel either in terms of force structure or from a capabilities perspective. However, recent ideas emanating from the field grade officer level are making their way across the total force via the USMC's premier professional journal, the *Marine Corps Gazette*. Notably, Major Leo Spaeder proposed a Company Landing Team (CLT) concept which, in order to be effective, must be supported by Combat Logistics Integrators (CLIs) which, "fully embrace hybrid logistics, flatten the logistics concept of support, devolve the lowest echelon of logistics support to the company level, and combine tactical logistics-related military occupational specialties."²¹ Accordingly, Spaeder proposed each infantry battalion be embedded with a logistics platoon composed of specialized CLI's for sustainment, distribution, and maintenance functions, and each CLI trained with the specific skills required to operate the latest logistics technologies (i.e. unmanned logistics platforms). While conceptually, the idea has significant upside, cost constraints and the "horror" of organizational paradigm shifts often relegate these types of ideas to the "disruptive thinking" recycle bin.

²¹ Spaeder, Leo. "Flattened Logistics." *Marine Corps Gazette* 103, no. 3 (2019): 41.

For the sake of USMC sustainment viability in the FOE, it is recommended that Maj Spaeder's ideas be carefully considered for further testing and evaluation.

Analysis

It is quite clear the senior leadership of the USMC logistics community has fully embraced and is propagating the wave of innovation across the broader logistics community. Arguably, there is no shortage of technologically driven "disruptive" ideas, and the enterprise writ large is visibly enamored with the "shiny new toys". However, there is currently little evidence to validate the effectiveness of many of these innovations in a *training* environment, let alone the A2/AD FOE where failure to sustain the force results in mission failure at best and lives lost at absolute worst. Therefore, the USMC logistics community must continue to place the needs of their primary customers (i.e. the deployed MAGTF) at the forefront of all development and testing efforts, whereby ensuring the "shiny new toys" are actually meeting the requirements of the warfighter. This is possible, but requires diligent engagement across all stakeholders and demands realistic testing *outside* the friendly confines of home station training areas and *inside* of nasty, volatile, and access restricted landscapes only a Hollywood movie producer could fathom. The USMC is postured to do so, but there is much work to be done.

SEA DRAGON INTEGRATED TRAINING EXERCISE (ITX) 3-18

Background

Sea Dragon 2025 is a series of iterative experiments designed by the Marine Corps Warfighting Lab (MCWL) to address the Commandant of the

Marine Corps' (CMC) direction to evaluate the Table of Organization and Equipment (T/O&E) necessary for the USMC future force 2025.²² The series is also intended to examine DOTMLPF-P implications of the future MAGTF as outlined in the Marine Corps Operating Concept (MOC).²³ Sea Dragon ITX 3-18 was conducted from April-May 2018 using Combat Logistics Battalion 8 (CLB-8) as the experimentation force and was focused on hybrid logistics trials with unmanned logistics systems (ULS), AM capabilities, and D2L. Due to the limited scope of this essay, the following paragraphs outline some of the more significant results of ULS and AM testing only, and briefly assess key DOTMLPF-P implications for each in the FOE.

Unmanned Logistics Systems (ULS)

The experiment hypothesis for ULS-A (Air) during ITX 3-18 was, “employment of ULS-A will result in tailored resupply to a distributed force and simultaneously mitigate risk to ground-based resupply.”²⁴ One system used to test the hypothesis was the Tactical Resupply Vehicle 80 (TRV-80), a quad rotor drone with a max payload capacity of 80 pounds, flight duration of approximately 20 minutes, and an operational radius of 5-15 kilometers at an altitude below 1,000 feet (see figure 2).²⁵

²² United States Marine Corps. “Sea Dragon ITX 3-18 Final Report.” (Quantico, VA: Marine Corps Warfighting Laboratory, Futures Directorate, November 2018), 7.

²³ United States Marine Corps. “The Marine Corps Operating Concept: How an Expeditionary Force Operates in the 21st Century.” (Washington, DC: Headquarters Marine Corps, Office of the Commandant, September 2016), 8.

²⁴ United States Marine Corps. “Sea Dragon ITX 3-18 Final Report.” (Quantico, VA: Marine Corps Warfighting Laboratory, Futures Directorate, November 2018), 8.

²⁵ *Ibid.*, 21.



Figure 2: TRV-80 with cargo payload attached

During ITX 3-18, the TRV-80 was used for 14 resupply missions which resulted in reasonable success, but several areas which require refinement or further development. One significant finding was the TRV-80's inability to conduct dynamic re-tasking of the ULS beyond line of sight. Consequently, if enemy action necessitates rapid change in cargo delivery location, flight path, or final drone recovery position (which in an A2/AD environment, it will), the operator will have no way to reprogram the mission of the TRV-80, thus drastically reducing the likelihood of successful resupply.²⁶

Another noteworthy finding was the TRV-80's inability to fully deliver on the 80 pound payload capacity. Depending on weather conditions and designated altitude and flight path, the TRV-80 was able to deliver only 65% of its payload on average. Considering one 7-ton truck can carry 14,000 pounds of cargo over rough terrain, achieving the same sustainment impact to a combat unit would take approximately 280

²⁶ Ibid., 27.

TRV-80's.²⁷ In an A2/AD environment, the air space deconfliction requirements alone would make launching a “swarm” of TRV-80's extremely difficult, if not untenable. Consequently, the TRV-80 in its current state of development is incapable of mitigating the risk to ground-based resupply because it does not possess the delivery volume to significantly reduce sustainment via convoy operations.

From the DOTMLPF-P perspective, perhaps the most concerning issue is airspace deconfliction. If the TRV-80 is adopted into the USMC logistics arsenal and owned and operated by non-aviation units, the enterprise writ large must develop tactics, techniques, and procedures (TTPs) for air space deconfliction between other UAS and friendly manned aircraft, as well as defense against enemy air assets.²⁸ This will be a herculean effort spanning at least doctrine, training, personnel, and policy and will require measured input from nearly all stakeholders across the MAGTF. Despite the fact that, “the TRV displayed limited value to CLB-8 during ITX 3-18 based on the small payload of the system”²⁹, the USMC should still press forward with a comprehensive DOTMLPF-P analysis applicable to the employment of *any* ULS-A asset. Subsequently, as the TRV-80 is matured into a capability more suitable for battalion level resupply, the necessary infrastructure will be ready to support its employment.

Additive Manufacturing (AM)

The experiment hypothesis for AM was, “AM capabilities reduce repair and maintenance response times while reducing the quantity and volume of spare parts required to be carried forward by the MAGTF Logistics Combat Element.”³⁰ During ITX

²⁷ Ibid., 29.

²⁸ Ibid., 30-32.

²⁹ Ibid., 31.

³⁰ Ibid., 8.

3-18, both an XFAB and TACFAB capability were exercised. The major difference between the two capabilities is the TACFAB is more mobile, requires fewer resources to operate, but is limited to printing mostly plastic components. In contrast, the XFAB is a less mobile, more resource intensive, intermediate capability with “high-end” equipment capable of printing in metal and advanced polymers, as well as the ability to test parts for suitability and compliance.³¹ Due to the space constraints of this essay, only the TACFAB is reviewed in this section; however, many of the observations provided apply to both systems.

The operational concept for the TACFAB is to push AM capability as close to the forward edge of the battlefield as possible through the deployment of “low-end” 3D printers, 3D scanners, and a “high end” laptop loaded with advanced modeling software and the Marine Corps Systems Command (MARCORSYSCOM) database of pre-approved components for AM production.³² During ITX 3-18, CLB-8 employed the TACFAB for 73 print jobs with a 59% success rate. Failures were most commonly attributed to printer malfunction and errors during design which rendered prototypes unusable. Environmental conditions such as temperature and humidity were also observed to have an adverse effect on certain printing materials such as high impact polystyrene (HIPS) and polylactic acid (PLA), causing warping and preventing first layer bonding.³³

Although TACFAB enabled the 3D printing of plastic components with some success, the operators noted the lack of metal printing, welding, and stress engineering analysis capacity of TACFAB as a major limiting factor. Additionally, the time required

³¹ Ibid., 48-50.

³² Ibid., 48.

³³ Ibid., 53.

to design a part which was not already resident in the approved database, coupled with consistently long print times hindered CLB-8's ability to provide "on-demand" sustainment support to emergent parts requirements.³⁴

The implications of AM and its potential value to USMC operations will undoubtedly impact all areas of the DOTMLPF-P spectrum. However, within an A2/AD environment, communication and integration between the TACFAB at the forward edge, the XFAB in the rear echelon, and the depot-level AM capacity outside the theater of operations will be problematic. Disrupted C2 between systems will delay or even negate the ability of tactical units to gain design/print authorization for parts not already resident in the MARCORSSCOM approved database. Similarly, approved design and cataloguing update "pushes" from higher echelon AM labs down to the TACFAB may be at risk of cyber attack and the manipulation of design specifications to maliciously alter part performance and reliability. Although AM has the potential to reduce maintenance cycle time, shorten the supply chain, and diminish the proverbial "iron mountain" of materiel, the requirement to sustain the AM capability itself (with material, power, maintenance, etc.) will be significant and must not be overlooked. Consequently, the USMC must continue to exercise AM capability at every opportunity - with a particular focus on mitigating the multiple risks inherent in the contested FOE.

ALTERNATIVE (NOT NEW) APPROACH FOR THE A2/AD ENVIRONMENT

In the *National Security Strategy of the United States of America*, President Trump aptly stated, "We also incorrectly believed that technology could compensate for our reduced capacity . . . we convinced ourselves that all wars would be fought and won

³⁴ Ibid., 51-53.

quickly, from stand-off distances and with minimal casualties.”³⁵ When viewed through a logistics lens, President Trump’s comment serves as a cautionary tale and is a stark reminder that while innovation and technology-based logistics solutions may be quite valuable, over-reliance on them, especially in an A2/AD environment, can have dire consequences. Therefore, it is important to consider alternate frameworks from which to anchor our collective thought regarding effective sustainment amidst the friction and uncertainty of the FOE. One such framework was proposed by U.S. Air Force Captain Philip Lere who believes current logistics doctrine within the joint logistics environment (JLEnt) dramatizes the superiority of technology and downplays its weaknesses. Consequently, his framework as displayed in *Figure 3*, reinvigorates the relevance of capacity-centric logistics through the acknowledgement of vulnerabilities within the JLEnt across both information and physical lines of communication (LOCs).³⁶

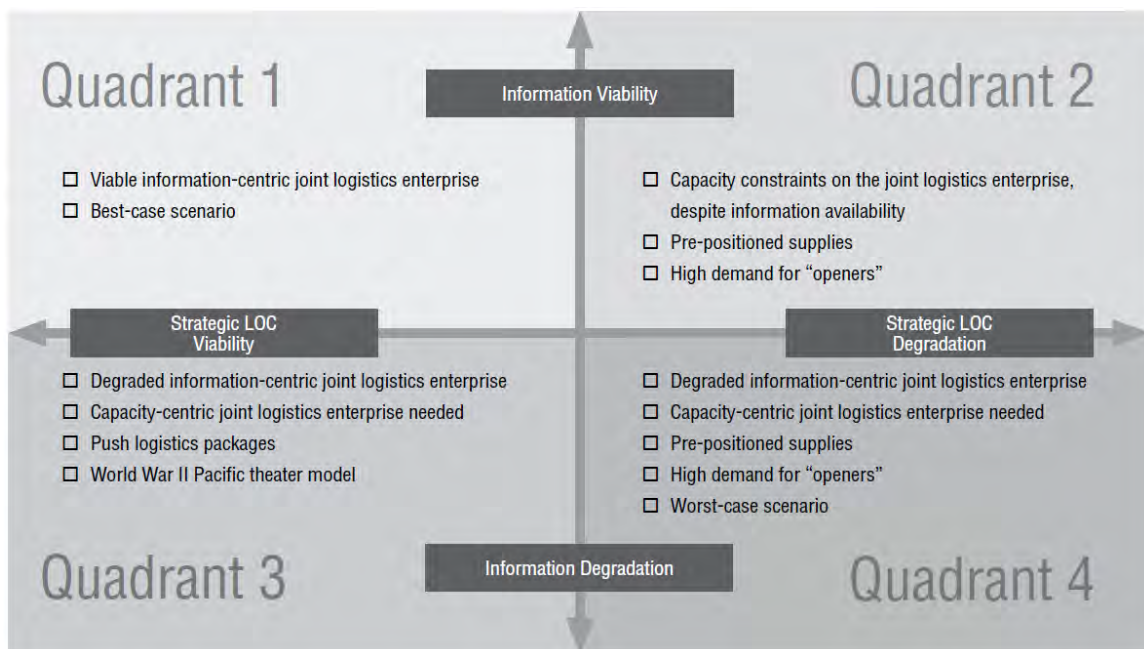


Figure 3: Captain Philip Lere’s JLEnt Vulnerabilities Framework

³⁵ Donald J. Trump. *The National Security Strategy of the United States of America* (2017), 27.

³⁶ Philip Lere. "Fog, Friction, and Logistics." *Army Sustainment* 49, no. 3 (2017), 11.

Captain Lere's central point is within the FOE, multi-domain attacks by our adversaries will disrupt web-based networks and the critical information-dependent logistics systems which rely on them; yet, information-based logistics still endures as the central priority of current training and future sustainment capability development. To this, he implores JLEnt professionals to use his framework as a means to analyze potential levels of friction within the A2/AD environment, and understand where technology reliance vulnerabilities exist. Furthermore, if and when the vulnerabilities are exploited, Lere argues the JLEnt must be prepared and proficient enough to revert back to some form of capacity-centric, analog sustainment methods of the past – which are still highly relevant in the future battlespace.³⁷

For the USMC logistics community, Captain Lere's framework offers valuable insight, specifically with regard to how we are exercising our developing logistics capabilities and informing DOTMLPF-P decision making. For example, the Sea Dragon ITX 3-18 exercise referenced earlier was conducted at MCAGCC, Twentynine Palms, California. Although this is arguably the USMC's premier combined arms training facility, the logistics testing conducted during ITX 3-18 was done largely (if not solely) in quadrant one of Lere's framework. As noted above, there were multiple challenges observed with the logistics innovations tested during the ITX, despite the fact that it was conducted under the "best case scenario". Placing the same innovations into an exercise scenario consistent with the frictions outlined in quadrants two or three of Lere's framework would likely have resulted in much more pessimistic results. However, this is exactly the space where the USMC must test the capabilities of its logistics innovations.

³⁷ Ibid., 10-12.

Understandably, the USMC logistics community, like many other military organizations adopted the “crawl, walk, run” methodology for developing and introducing technology-based sustainment platforms into service. However, with at least a few of our adversaries already “running”, this begs the question – how much longer can the USMC logistics enterprise afford to be crawling its way into the information and technology dominant FOE? The answer is – no longer. To that end, the USMC must first aggressively seek out ways to exercise logistics capabilities amidst the vulnerabilities resident in quadrants two, three, and (to the extent possible) four of Lere’s framework. Acknowledging the shrinking training budgets of today’s fiscally constrained environment, finding these opportunities will be challenging, but not impossible. Every major joint, coalition, or multi-national exercise (such as Trident Juncture and RIMPAC) is an opportunity to test selected capabilities and should be leveraged accordingly. Even day-to-day operations within a garrison environment provides a low-cost, low-risk venue to test capabilities - if commanders force their Marines and Sailors into a degraded information space. With the majority of the USMC preaching from the innovation pulpit, there absolutely must be room for this same type of disruptive thinking in the training development sphere. The time to act is now.

A second area worthy of careful consideration is to figure out where the USMC logistics enterprise can practice and refine its skills which are already “running”. Arguably, this expertise lies in capacity-centric logistics which Lere suggests will be critical to “opener” capabilities demanded in the A2/AD environment.³⁸ As the CMC outlined in the MOC, Marine logisticians must heavily consider “outside the MAGTF” (i.e. Naval, Joint, multi-national, and commercial industry) options for a distribution

³⁸ Ibid.

pipeline that delivers sea-based supplies to smaller, dispersed units ashore.³⁹ Sea-based delivery is essentially the “opener” which Lere deems critical in the FOE. Since current USMC doctrine is predicated on the imperative that the 21st Century MAGTF, “operates and fights at sea, from the sea, and ashore”⁴⁰ it is therefore prudent to pursue training opportunities to exercise capacity-centric capabilities already managed and maintained by “outside the MAGTF” agencies.

The U.S. Navy (USN) is one such agency, and has been the USMC’s stalwart teammate for more than a hundred years. As such, the USN also understands the potential benefits of information-based logistics support and the need to leverage afloat forward staging bases (AFSB) and mobile landing platforms to facilitate, “supply, ordnance, and fuel delivery mechanisms that are responsive, nimble, and less detectable than their predecessors.”⁴¹ At the same time, the USN is cognizant that there is a limit to technology-centric logistics capabilities, and within an A2/AD environment, “traditional networks of shore-based “hub and spoke” support systems must be updated and augmented” to achieve the necessary level of sustainment to the total force.⁴²

Appropriately then, the USMC and USN must seek out opportunities to practice ship-to-shore sustainment operations, under the harshest A2/AD conditions possible. In current training scenarios, capacity-based logistics infrastructure owned and operated by the Defense Logistics Agency (DLA), U.S. Transportation Command (USTRANSCOM), partner nations, and the private sector are leveraged in order to deliver sustainment to the

³⁹ United States Marine Corps. “The Marine Corps Operating Concept: How an Expeditionary Force Operates in the 21st Century.” (Washington, DC: Headquarters Marine Corps, Office of the Commandant, September 2016), 23.

⁴⁰ *Ibid.*, 8.

⁴¹ Peter G. Stamatopoulos. *Maritime Logistics in a Changing Strategic Environment* (U.S. Department of the Navy, Supply Systems Command, 2018), 34.

⁴² *Ibid.*

AFSBs or EABs. This process has become so network and information dependent for Marines, Sailors, and the logistics providers that the normalcy of unfettered access to both physical and information LOCs has seemingly caused an atrophy of once necessarily critical analog C2 integration and procedural discipline. But - what would the implications be if the enemy disrupted the LOCs and the capacity-based logistics providers could no longer respond to information dependent demand signals to sustain the sea based platforms? The USMC and USN should not only examine this problem set, they must begin *training* against it.

Admittedly, this type of testing will be difficult to achieve across all stakeholder's, as the willingness of DLA, USTRANSCOM, and industry partners to consciously "disrupt" their information-based logistics systems for the sake of training for the A2/AD environment is likely not very palatable. At worst, the USMC and USN must internally make every effort to simulate this type of disruption and pursue viable mitigation strategies. At best, they must start a dialogue across all stakeholder agencies and begin socializing potential training options to address A2/AD disruptions not if, but *when* they occur.

CAN'T WE JUST ACCEPT DIGITAL DEPENDENCE AS OUR TOP PRIORITY?

While this essay has argued in favor of avoiding over-reliance on technology-based logistics systems' dependence on the cyber domain for viability, there are some professionals who believe the United States' advantages against near-peer competitors exist *solely because of* the enabling capacity cyberspace provides. As such, advocates of this line of thinking consider the protection of cyber networks as the critical element to U.S. power projection. In his Air & Space Power Journal article, "The New Matrix of

War”, USAF Captain Keith B. Nordquist cautions, “an adversary does not need to compete with the DOD’s superior capacity, capability, or availability – they need to only degrade the ability to employ its advantages to produce strategic effects.”⁴³ As such, the military must first embrace its dependence on digitally enabled capabilities, and then ferociously develop solutions to defend, deter, and defeat cyber threats. Nordquist also asserts that within an A2/AD environment, “the end-to-end functionality of the [global distribution network] system, from combatant commander request to sourcing and delivery, relies almost completely on digital tools.”⁴⁴ Therefore, the primacy of logistics success in the FOE must be embedded in the protection of cyberspace capacity – right?

Although it is undeniable that the protection of cyber networks is highly important, if not critical, it may not be the most important factor for logistics success in the FOE. The U.S. Joint Concept For Logistics (JCL) contends success for the JLEnt within the FOE lies in Globally Integrated Logistics (GLI), which is, “the capability to allocate and adjudicate logistics support on a global scale to maximize effectiveness and responsiveness.”⁴⁵ While the JCL does identify the protection of logistics information as a key requirement, it also acknowledges, “heavy dependence on a resilient and comprehensive information environment is the single greatest vulnerability of the [GLI] concept, and mitigating this risk would be a major challenge.”⁴⁶ Without question, mitigating the risk of disrupted logistics LOCs is a challenge, but as this essay has proclaimed, a worthwhile strategy to exercise logistics capabilities in an A2/AD

⁴³ Keith B. Nordquist. "The New Matrix of War: Digital Dependence in Contested Environments." *Air & Space Power Journal* 32, no. 1 (2018): 110.

⁴⁴ *Ibid.*, 111.

⁴⁵ “Joint Concept for Logistics” Version 2.0. Washington, DC: The Joint Staff, (2015), vi.

⁴⁶ *Ibid.*, 18.

environment when cyber defensive measures fail (which they will), is the more critical priority.

CONCLUSION

Unfortunately, it seems the USMC logistics enterprise has become so adept and laser focused on developing innovative technologies and their means to sustain combat forces with “on-demand” support, they are failing to lend appropriate credence to understanding the potentially severe implications of the A2/AD environment on these capabilities. In order to fully comprehend the capacity limitations of technology-based logistics assets, the USMC must actively engage in training *within conditions which closely mirror the volatility and uncertainty of the contested FOE*. At this point in time, there is little evidence to suggest this magnitude of training is occurring at a level necessary to elicit comprehensive and employable risk mitigation measures. This must rapidly change.

In addition to adequately testing logistics innovations within the A2/AD environment, USMC logistics professionals must also remain focused on maintaining proficiency in leveraging capacity-based logistics resources via proven analog methods of the past. Consequently, every effort must be made to engage partners within the JLEnt to determine feasible training opportunities to exercise sustainment throughput without the luxury of unbridled information and physical LOCs. Practice in this arena is critical; and right now, the JLEnt is not ready for game time on the field of A2/AD. This must also rapidly change, and the USMC logistics community is the perfect organization to lead the charge.

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