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14. ABSTRACT
It is obvious that challenges face the logisticians of 2025, and while a hybrid logistics concept does exist, it fails to recognize that we face many of the challenges of 2025 today. Currently available unmanned logistics systems (ULS) have capability gaps and weaknesses; however, they still have an important role to play as a bridge solution that is being ignored. The Marine Corps needs to think beyond what is possible now, but it also has an opportunity to take advantage of currently available solutions to enable future logistics concepts.
The Marine Corps has been aggressively pursuing unmanned systems for the past several years in order to meet the demands of the future operating environment. While pursuing future platforms is a must for any force to remain relevant in future conflicts, the Marine Corps has missed an opportunity to adapt existing platforms to leverage the dynamic capabilities that they offer. Current ULS already have significant capabilities, and while they have been utilized to a small degree they have not taken advantage of the uniqueness that these systems offer. Additionally, little thought has been given as to the type of unit or where the manpower to man such a unit will come from to support these new technologies.
The Marine Corps needs to begin utilizing the existing ULS now with a dynamic concept of employment and with new unit

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MASTER OF MILITARY STUDIES

LOGISTICS TO THE MAX: FUTURE FORCE STRUCTURE AND CONCEPT OF EMPLOYMENT FOR UNMANNED LOGISTICS SYSTEMS

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

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Executive Summary

Title: Logistics to The Max: Future Force Structure and Concept of Employment for Unmanned Logistics Systems

Author: Major Travis Tufte

Thesis: It is obvious that challenges face the logisticians of 2025, and while a hybrid logistics concept does exist, it fails to recognize that we face many of the challenges of 2025 today. Currently available unmanned logistics systems (ULS) have capability gaps and weaknesses; however, they still have an important role to play as a bridge solution that is being ignored. The Marine Corps needs to think beyond what is possible now, but it also has an opportunity to take advantage of currently available solutions to enable future logistics concepts.

Discussion: The Marine Corps has been aggressively pursuing unmanned systems for the past several years in order to meet the demands of the future operating environment. While pursuing future platforms is a must for any force to remain relevant in future conflicts, the Marine Corps has missed an opportunity to adapt existing platforms to leverage the dynamic capabilities that they offer. Current ULS already have significant capabilities, and while they have been utilized to a small degree they have not taken advantage of the uniqueness that these systems offer. Additionally, little thought has been given as to the type of unit or where the manpower to man such a unit will come from to support these new technologies.

Conclusion: The Marine Corps needs to begin utilizing the existing ULS now with a dynamic concept of employment and with new unit structure in order to maintain our warfighting advantage as the future conflict environment changes through 2025.

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Introduction

The latest buzz phrase in the world of tactical logistics support is unmanned logistics systems (ULS). The promise of swarms of unmanned aerial systems pushing all classes of supply throughout a highly distributed battlespace in support of the Marine Corps force of 2025 is a significant portion of the logistics plan in support of the Marine Corps Operating Concept (MOC).[1] These lofty ambitions are not entirely misplaced given the concepts espoused within the MOC as well as the recently released National Defense Strategy.[2] Small units, likely company or less, will be dispersed throughout the battlespace. The near peer enemy will have anti-access and area denial capabilities which will present new challenges as well. These challenges will undoubtedly require new and creative ways of providing all functions of combat service support across the range of military operations.

It is very likely that unmanned systems will have a role to play in the future style of warfare, however, the method of employment, the unmanned systems that could and should be employed, and the structure changes that the Marine Logistics Group (MLG) and other major subordinate commands would have to undergo are far from clear. It is obvious that challenges face the logisticians of 2025 and, while a hybrid logistics concept does exist, it fails to recognize that we face many of the challenges of 2025 today. Currently available ULS have capability gaps and weaknesses; however, they still have an important role to play as a bridge solution that is being ignored. The Marine Corps needs to think beyond what is possible now, but it also has an opportunity to take advantage of currently available solutions to enable future logistics concepts today and the integration of ULS today. To date, employment of ULS has largely been centered on aerial unmanned vehicles.[3] While this is all well and good as they will be important in supporting small distributed units, the Marine Corps cannot wish away heavy logistics support such as bulk liquids. What this means is heavy logistics, and for the sake of this paper, heavy ULS. The Marine Corps as a fighting force is a heavy force despite arguments that it is meant as a middleweight. A heavy force, or any conventional force for that matter, requires significant logistical capability. To quote the British military scholar Sir Robert Thompson in his observations of the stall of North Vietnam's conventional attack during the Easter Offensive of 1972, "you cannot refuel T-54 tanks with gasoline out of water bottles carried on bicycles."[4] The T-54, a tank, which he references burns approximately a gallon per hour.[5] Comparatively, the Joint Light Tactical Vehicle (JLTV) which is to be the future primary light tactical vehicle of both the Army and Marine Corps burns 1.6 gallons per operating hour.[6] To further quote Sir Robert Thompson, "It has got to come down in trucks, and trucks in large numbers."[7]

This paper will cover several topics to illustrate the utility of ULS for the Marine Corps, the requisite structural changes needed to accommodate ULS, and a concept for their employment. First, it will cover the recent operational and logistical concepts that the Marine Corps has published that address what future conflicts will be and the Corps' eventual plan for supporting and sustaining operations in that environment which builds the context for the shift to ULS. Next, it will cover current ULS systems that could make a near immediate impact on the operating forces. Third, it will review the current Logistics Combat Element (LCE) structure and make recommendations on how the units that would operate ULS would fit into the Marine Air Ground Task Force (MAGTF). Finally, this paper will present a concept for the currently available ground and air ULS in a single system and the risks associated with their use.

Background

In order to understand where the future of logistics in the Marine Corps may be headed, one must first understand where the future of warfare, or at least as the Marine Corps sees it, is predicted to be as explained in the MOC. The document is very broad in scope and meant to do two things: to describe how the Marine Corps will operate in 2025 and beyond; and second, to shape actions as the capabilities and capacity of the future force is designed and developed. The MOC 2025 also outlines what future conflicts will be. As the writers of the MOC have presented, the Marine Corps is not currently organized, trained, or equipped to meet the demands of the future operating environment characterized by complex terrain, technology proliferation, information warfare and the need to shield and exploit signatures, and an increasingly non-permissive maritime domain.[8] The MOC is intended to be a roadmap to be successful in such an environment.

The MOC identifies five drivers of the future security environment, which is important for two reasons: first, it shows how the force will fight. Second, by identifying how the force will fight and the challenges it will face it provides significant insight into the way in which tactical logistics support will be provided. The five key drivers are: 1) highly complex terrain comprised of dense, urban populations with sometimes poor or little governance, 2) technology proliferation – widely available to both near peer and non-state actors, 3) the use of information as a weapon, 4) battle of signatures – "to be detected is to be targeted is to be killed", and 5) an increasingly contested maritime domain.[9] Unmanned logistics systems can address and mitigate three of the five drivers. A highlight of significance to the Marine Corps is that many of today's and likely the futures, most troubled areas, as well as significant amounts of global commerce, will continue to lie within or pass though the littoral regions of the world.

The MOC addresses what logistics support will potentially look like as well with a focus on being operationally lighter in a logistical sense, trying to avoid building the infamous "iron mountain." Possibilities for doing this are presented as making use of automation and unmanned systems as well as additive manufacturing to both lighten the load and minimize logistics burden while operating distributed. The MOC goes on to suggest that the contested environment will require reflexive and responsive support to a dispersed force via the use of distributed expeditionary advanced bases (EAB) and unmanned systems. While not intended as the sole means of changing the way tactical logistic support is conducted, it is quite apparent that unmanned systems feature prominently in the MOC.

Overview of Current Unmanned Logistics (ULS) Platforms

This paper will primarily explore two types of ULS: ground and air.[1] By looking at currently available systems for ground and air ULS, a concept of employment becomes possible. In order to figure out the best employment within the current MAGTF logistics framework, it is first necessary to understand how they will be utilized.

Ground unmanned logistics systems technology already exists. The TerraMax Unmanned Ground Vehicle technology is essentially a bolt on kit that can be applied to any tactical wheeled vehicle from any manufacturer.[10] This technology allows a single operator to control multiple unmanned vehicles from beyond line of sight.[11] The implications of this are tremendous for a multitude of reasons. First, from the perspective of maintenance and maintainers, this is an outstanding solution. There is no need for new training or additional parts procurement for the vehicles themselves, as the system can be applied to the existing inventory of rolling stock, most of which is already procured from Oshkosh Defense. This would generate significant cost savings over a completely new system which would require both retraining all

[1] While the MOC makes mention of unmanned maritime surface systems, unmanned surface vehicles seem to be lagging the furthest behind at present. Given the lag in development of unmanned maritime surface systems, no potential employment concept exists at present lacking both the systems on the force structure to support it.

maintainers on new vehicles and integrating new parts into the supply system. Additionally, the timeline for implementing such a system should be shorter for the same reasons. TerraMax also could simplify the concept of employment by a significant degree by, utilizing a very simple concept of employment, facilitating a one for one swap of manned cargo vehicles within logistic and combat trains. It should be noted, however, that doing so would be overly simplistic and not make the best use of the capabilities or address the shortfalls adequately; potential concepts for employment will be covered later in this paper. And of course, there are the benefits that come with any unmanned system such as removing humans from life threatening situations, reduced manpower requirements, and reduced issues with crew or operator fatigue.

The TerraMax system is capable of running in three different modes of operation depending on what the situation requires: semi-autonomous, follower, or remote operation.[12] The mode selection for each vehicle is controlled from the primary operator control unit (OCU). The OCU can be installed in any other tactical vehicle along with a GPS receiver and radio data link that allows communication with the other TerraMax vehicles in the convoy. With a range of one kilometer, a single operator can effect command and control over a mixed manned and unmanned convoy. The system is controlled using a touch screen and video game style controller in the event the human operator wishes to have hands on control. In semi-autonomous mode, basic waypoint navigation via GPS coordinates is supported. The OCU allows the operator to create mission plans with movement control measures such as check-points, intended vehicle separation distances, speed limits by region, and exclusion zones. Missions are planned from the OCU on a route map that is produced from geospatial vector data and pre-defines the roads on which the UGVs may travel. The system is easy to train current motor transport operators, military occupational specialty (MOS) 3531, on as evidenced by a Marine Corps

Warfighting Laboratory experiment in which operators were given only three days of training and then proven to be capable of operating the system. At the conclusion of the experiments the operators felt comfortable operating three to five of the unmanned vehicles at once.[13]

At present the cost of the system compared to a manned option is hard to ascertain as procurement has not evolved to the point at which a unit cost could be provided by Oshkosh Defense.[14] Despite the lack of specific information there is still likely to be a cost benefit associated with an unmanned asset based solely on the removal of the human operator of the vehicle. Based upon a study conducted by Naval Postgraduate School students, the cost of a human life was six million dollars based upon life insurance, survivor benefits, loss of earnings, lost human capital, and welfare lost to society.[15] By removing a human driver and assistant driver from the manned vehicle and replacing it with an unmanned vehicle, 12 million dollars in human capital have been eliminated from a dangerous duty. While the specific cost of a single TerraMax vehicle is not yet known, it seems likely that it would not exceed the 12 million given that the cost of the manned variant is approximately 230,000 dollars.[16]

Aerial ULS (ULS-A) has already been used successfully by the Marine Corps. In Operation Enduring Freedom, the K-MAX unmanned helicopter was used with substantial success and proof of concept in Afghanistan.[17] The K-MAX was procured in 2009 in response to a Joint Urgent Operational Needs Statement (JOUNS) and the ULS-A was operated by a Marine Unmanned Aerial Vehicle Squadron (VMU) detachment and used primarily as a platform for external lifts in conjunction with MLG helicopter support teams.[18] The aircraft is capable of lifting loads up to 6,000 pounds at sea level and 4,000 at elevations of up to 15,000 feet and has a range of 84 miles. This is a considerable lift capacity and has proven capable in combat of filling a niche within tactical resupply while flying over 2000 sorties delivering approximately

4.4 million pounds of cargo from December 2011 to May of 2014.[19] The operational analysis study conducted by Naval Postgraduate School students went so far as to show that it was capable of eliminating significant numbers of ground convoys and freeing up manned aircraft based upon its payload capacity and proved cost effective when accounting for the value of human lives saved.[20] The K-MAX continues to undergo testing by the Marine Corps at Marine Operational Test and Evaluation Squadron 1 (VMX-1) in Yuma, Arizona.

The large-scale implementation of ULS-A to tactical logistics brings with it multiple potential concepts of employment. The first, which has already been demonstrated as a capability on the battlefield, is that ULS simply replaces the helicopter with an unmanned variant and then uses a sling load to transport supplies. During Operation Enduring Freedom, the K-MAX unmanned helicopter was successfully deployed to Afghanistan and proved capable of performing sling load resupply to outlying forward operating bases. The benefit of this system is that it required no change to the MLG structure or manning to accomplish. The external lifts were conducted using MOS 0481 landing support Marines, fulfilling one of their mission sets of a helicopter support team. The burden for this particular type of ULS falls on the Marine Air Wing (MAW) to integrate, at least at the scale for the K-MAX program. The greater question for the future may be, at what point does the MAW not want to adjust its structure to accommodate ULS-A to the detriment of their other missions? At some point in time, it is reasonable to expect that with the given mission set of ULS-A as primarily logistical support, the MAW would not want to give up valuable manning and equipment for the sake of the MLG's mission. A solution will have to be found where either the MAW accommodates this additional unit, likely a squadron or detachment, within its own structure or the MLG adds it to its structure. For an idea of what this addition will look like there is no current template from which to draw.

The best example would be the manning and equipping of a current VMU squadron, which has the mission of operating unmanned reconnaissance aircraft.[21] The VMU squadrons were highly effective in employing the K-MAX system during OEF and it stands to reason that this is what should be used as the planning factor for structure addition to either the MLG or the MAW.[22] The next question that must be asked is the following: absent an increase in the authorized manning levels of the Marine Corps, where do these numbers come from?

Current MLG Structure

In order to incorporate and employ ULS, the MLG must undergo some type of structural change. While the exact makeup of the future MLG is beyond the scope of this paper, there are conceptual considerations and predictions that can be made by looking at the current structure, what it does, and how the structure may need to change to support the inevitable influx of unmanned systems. Through an examination of the current structure of the MLG, the makeup and missions of the various units will be explained and suggestions to structural changes to support the introduction of ULS will be made. Specific changes to military occupational specialty (MOS) makeup and proposed tables of organization and equipment (TO&E) will not be made. However, general capability gaps and potential solutions will be discussed and proposed. The LCE of the MAGTF is the MLG. It is tasked with providing general and direct logistics support along the lines of the six functions of tactical logistics to their supported units. The six functions are as follows: transportation, general engineering, supply, maintenance, services, and health services.[23] While the current structure works for today's technologies and doctrine, changes will need to be made in order to support future logistics concepts. Quite simply, the current structure of the logistics element of the MAGTF is not currently organized to support the integration of large numbers of unmanned vehicles whether they are aerial, ground, or maritime surface ULS. The existing structure of 1st MLG will be used as an example to lay out the current makeup of an MLG and the capabilities that the units within provide to the MEF.

While the MLG structure has changed repeatedly over the past two decades and undergone name changes but in each form and under either name it has remained the primary provider of combat service support to the Ground Combat Element (GCE) and the 1st Marine Expeditionary Force (MEF) within the MAGTF structure.[2] The current task organization of the 1st MLG can be seen below in Figure 1.

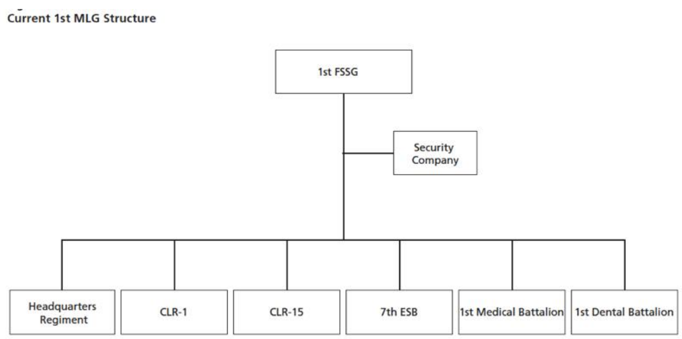

Figure 1

The current structure is made up of Combat Logistics Regiment 1 (CLR), CLR 15, Headquarters Regiment, 7th Engineer Support Battalion (ESB), 1st Medical Battalion, and 1st Dental Battalion. Combat Logistics Regiment 1 is the direct support regiment within 1st MLG. Within CLR 1 there are three direct support Combat Logistics Battalions (CLB), 1, 5, and 7, and 1st Transportation Support Battalion (TSB).[24] The CLBs (not pictured) are tasked with providing task organized direct support logistics beyond the organic capability to their corresponding infantry regiments within 1st Marine Division. The focus of these units is primarily on providing support to the GCE. Transportation Support Battalion has a different mission from the direct support CLBs which is to "Provide transportation and throughput support for the Marine

[2] The MLG was previously known as the Force Service Support Group, or FSSG.

Expeditionary Force (MEF) to facilitate the distribution of personnel, equipment, and supplies by air, ground, and sea" and consists of the following five companies: landing support, headquarters and service, motor transport "A," motor transport "B," and support.[25] The preponderance of general support logistics capability falls under CLR 15. The mission of CLR-15 is to provide intermediate-level supply, field-level maintenance, materiel distribution support, procurement management, equipment fielding support and forward resuscitative health care to the MEF.[26]

The current structure of the MLG comprises substantial capabilities that encompasses all defined functions of logistics. However, this structure does not currently account for ULS, a mainstay of the MOC and hybrid logistics concept. Within the existing MLG structure, certain elements of ULS can be added in a one for one exchange with manned systems. This works most easily with TerraMax as manned vehicles can be exchanged for unmanned. While MOSs may need to be added or created, the general idea of logistics trains consisting of heavy trucks to move, at the very least bulk liquids and fuels will withstand the introduction of unmanned systems. A more challenging issue presently is how to accommodate maritime surface and air ULS units within the existing manpower constraints.

The lack of a unit specifically for ULS-A systems highlights an important problem that will come to a head at some point in the future as the service moves towards unmanned systems. Where does the manpower and structure come from and where does it reside to be best employed? While the implementation of the TerraMax system seems to be fairly simple, ULS-A is a unique capability that will require reorganization of units within the MLG to achieve.

Adapting VMU Structure for ULS-A

No base model currently exists for what an a ULS-A squadron would look like as it is in the concept stage and has not yet become a fully operational capability. For this reason, the VMU model will be the base concept for a future detachment for ULS-A as a part of a VMU squadron. A fully manned and staffed VMU has the capability to operate three RQ-7B Shadow systems and nine RQ-21A Blackjack systems.[27] Like many units, unmanned aircraft squadrons typically task organize to support operational requirements of whichever MAGTF they have been assigned to support. For ULS-A employment, we will make the same assumption, that typically the unit will deploy piece-meal in task organized detachments. The breakdown for a VMU detachment in support of MEF through MEB sized MAGTFs is in the below figure taken from Marine Corps Warfighting Publication (MCWP) 3-42.1.[3]

Supported Unit	Supporting VMU Detachment
MEF	3 RQ-7B Shadow Detachments 9 RQ-21A Blackjack Detachments
MEB	1 RQ-7B Shadow Detachment 3 RQ-21A Blackjack Detachments
MEU	1+ RQ-21A Blackjack Detachment

Figure 2

Assuming that ULS-A require a comparable number of personnel to operate, maintain, and support, then a ULS-A detachment would look very similar in size and scope to VMU. See below figure developed by the author.

Supported Unit	Supporting ULS-A VMU Detachment
MEF	12 K-MAX Detachments
MEB	4 K-MAX Detachments
MEU	1+ K-MAX Detachment

Figure 3

[3] The figure implies that the total number of both systems and the associated personnel to support the aircraft would support each size MAGTF.

By aligning the detachments as depicted in the table, each infantry battalion and CLB could be provided with one K-MAX and its associated operator, enlisted MOS 7314, and maintenance detachments.

Now that a model for a ULS-A squadron has been identified, the question of what major subordinate command should have ownership comes back to the fore.

There are conflicting arguments for where a ULS-A squadron would best reside. One could argue that given its primary mission of logistics that the MLG should have ownership and responsibility for this mission. The other argument would be that as a unit that will be sharing airspace with the MAW and other aircraft, it is better off being controlled by the MAW. The most logical argument, however, is to put the squadron in the MAW. Given the complexities of air operations it would be exceedingly difficult and cumbersome to incorporate this unit into the MLG without devoting significant additional personnel to the MLG capable of working through the issues of airspace deconfliction and daily tasking cycles, both of which are an absolute necessity for ULS-A as shown by the current operating procedures in place for VMU. To do so would create inefficiencies in manpower management by creating duplicate structures that do the same thing. The MAW, or whatever size aviation unit makes up the ACE of the MAGTF, already has these personnel and procedures in place and furthermore, VMU has demonstrated that they can manage currently existing cargo ULS-A platforms based upon their employment of the K-MAX system during OEF.[28]

Now that the issue of where to put the ULS-A unit has been resolved, the next question is where do the Marines to fill the requisite billets in the T/O of this unit come from? Using the numbers from VMU, the requirement for manning of a full squadron would be 27 officers and 158 enlisted; however, this is only if an entire additional squadron was created using the exact

VMU table of organization (T/O).[29] By creating a ULS-A detachment within an existing VMU squadron, the actual T/O of the ULS-A unit could be reduced down to 20 officers and 85 enlisted by removing the need for additional command structure and headquarters and service type personnel.[30] These numbers include all the requisite detachment officers in charge (OIC), unmanned aircraft control officers, operators, and support personnel required to man VMU detachments in support of a MAGTF all the way to MEF size. Based upon the review of the MLG, there exists a logical unit from which to pull many of the requisite manpower for a ULS-A unit: TSB. In order to find the requisite manpower to fill out a unit to operate ULS-A, the headquarters company of TSB would need to be eliminated and the companies shifted into the Headquarters Regiments of the MLG. The battalion is made of functionally aligned units that rarely work together as a whole command in support of a specific mission but are instead task organized to logistically support an operation or other functions. In the past, this organization did not exist as a complete command but rather as separate companies underneath other battalions.[31] The unit was reformed in 2014 year under the auspices of aligning units functionally.[32] There are, and have been, arguments to support the functional alignment of units in the MLG which are valid; however, given the fact that the MLG was previously successful in completing its assigned missions without the TSB structure, it stands to reason that it could do so again. The priority in the ULS scenario is finding the structure and manpower that does not currently exist and without an increase in manning for the MAW to support a ULS squadron; those bodies must come from somewhere.

By examining the Table of Organization and Equipment (TO&E) one can see that the manning level of TSB Headquarters and Service Company is 78 personnel.[33] By rolling the companies from TSB into the Headquarters Regiment of the MLG, redundant headquarters and administrative capabilities within the MLG can be reduced while maintaining the functional elements of the battalion. This would free up 78 personnel slots from the deactivated TSB Headquarters Company for the ULS detachment that will be formed underneath VMU within the MAW. The billets and manning requirements would be eliminated from the MLG and MAW would get the additional manning allocated in the appropriate MOSs for unmanned aircraft operations. While it is far from an optimal solution to deactivate TSB as a unit within the MLG, there is a precedent for this to happen and have the MLG still be able to accomplish its mission, as TSB was only recently reactivated, making it the most logical solution. It would be hoped that the efficiencies gained from the introduction of ULS would eventually lead to reduced manpower requirements elsewhere, which would facilitate the reemergence of TSB.

A Concept of Employment for K-MAX

Without question, ULS has a significant role to play in the future operating environment. It has already been proven to have utility in ongoing conflicts as the operation of the K-MAX in Afghanistan has shown. Having established the current capabilities of two of the existing unmanned platforms, how are they integrated into the Marine Corps and what does employment look like? Having discussed the integration of the existing platforms, K-MAX and TerraMax, into the force structure, it is now possible to frame a scenario in which these systems would be employed. In order to envision a scenario to which ULS is a potential solution, there must be a problem that needs to be solved. Two problems that often plague combat service support entities are the "iron mountain," referring to the massing of supplies at one location as they await being pushed forward to where they are needed by combat units, and maintaining lines of communication.[34] Additionally, logisticians must strive to eliminate backtracking and unnecessary distribution traffic by maximizing throughput methods through the ground and air.[35] Unmanned systems present an opportunity to minimize and mitigate these problems.

In this scenario we will use the assumption that there are two key advantages to the use of unmanned systems and explore how they could be employed with max effectiveness in a conflict. The first, and most obvious, is the removal of Marines or soldiers from the path of harm and replacing them with said unmanned systems. The second is that an unmanned system creates many efficiencies that manned platforms cannot duplicate. Each platform has its own unique efficiencies that it provides the force. For the K-MAX, even with a lesser lift capability when compared to the manned alternative, we have increased operating hours, improved reliability, and reduced the overall footprint required to operate. How best, then, are these systems employed? The answer is by exploiting these advantages rather than employing the systems in the exact same manner in which the manned variant is used.

While the K-MAX was used with a degree of success in OEF, it was employed in the exact same manner in which we would use the CH-53, that is, by conducting external lifts from a large, secure, forward operating base.[36] While this was effective in removing some manned convoys from the roads and manned aircraft from the skies, it didn't leverage many of the K-MAX's advantages over the most similar manned alternative, the CH-53. The K-MAX should be employed by spreading the operational sites out from the main forward operating base (FOB) and operating from forward sites, a concept highlighted within the MOC several times and referred to as EABs.[37] The Marine Corps should take advantage of the smaller footprint and ease of operation advantages over a CH-53 to push the K-MAX to smaller FOBs enabling greater decentralization of the distribution network. This capability should be pushed out to a CLB acting in direct support to an infantry regiment or, going a step further, pushed out to an infantry battalion for use in supporting their dispersed companies and platoons. By utilizing the resident 0481 Landing Support MOS expertise to conduct an HST, coupled with the simplicity of operating the K-MAX, it is entirely feasible to have this capability at the infantry battalion level. Imagine the flexibility that would be provided to a battalion with the capability to conduct aerial resupply attached to it. While the cost of providing an 11,000,000 million dollar K-MAX to every infantry battalion in the Marine Corps may not be an entirely feasible option, providing a detachment to each in theater battalion from the ULS VMU squadron that is also stationed in theater would make this a more realistic proposal. This capability will be increasingly important in both the current and future operating environments. One of the five drivers of change referenced in the MOC is an increasingly contested maritime domain. By spreading resupply capabilities out with smaller footprint ULS-A, it allows for the exploitation of gaps within the enemy's defense coverage.

The Marine Corps Warfighting Lab (MCWL) has done extensive modeling on the prospect of pervasive ULS-A use and has found that there are significant and tangible benefits.[38] Namely, that the use of ULS-A can significantly cut down on the burden on the manned alternative for external or internal lifts, the CH-53 or MV-22, reducing their operating hours and freeing them for other missions.[39] Additionally, not included in the MCWL study but available via open source, is the reliability and cost effectiveness of ULS, specifically the K-MAX, when compared to that of a CH-53E. The K-MAX requires approximately 1.3 man-hours of maintenance per every hour of flight at a cost of $1,300 per hour to operate compared to the CH-53E at 23 man-hours of maintenance for an hour of flight at a cost of $11,000 an hour to operate.[40] While the payload of the K-MAX is substantially less, it is more than made up for by its cost savings and reduced maintenance requirements. By leveraging the tangible benefits of the existing ULS system, K-MAX, and operating it from EABs, the Marine Corps can take a significant step forward in realizing the goal of the MOC without having to wait until 2025.

A Concept of Employment for TerraMax

Integrating the TerraMax system presents significant opportunities within the current construct of combat service support units. The importance of the capability to move heavy logistical support is never going away. There will always be a requirement to move mass quantities of bulk fluids both water and fuel. While ULS-A provides its own unique and force multiplying capabilities there are classes of supply that will always require heavy lift to move in any significant quantity. Earlier this paper referenced a quote from Sir Robert Thompson regarding trucks in large quantities, that has not, and will not change given the vehicle-centric nature of the Marine Corps. The TerraMax system affords the Marine Corps an opportunity to address this ever-present need for heavy lift with an unmanned option.

There are two likely scenarios for the employment of TerraMax, both of which will be discussed here. As previously mentioned, a straightforward and relatively seamless integration solution exists by conducting swaps of manned vehicles for unmanned vehicles and integrating them together within convoys. With the TerraMax there is a significant manpower reduction brought about while providing the exact same capability as the manned variant. The second scenario, which fully embraces the unmanned system, would be completely unmanned convoys operating on pre-planned routes. Both scenarios have advantages and drawbacks, yet both are also plausible given the right situation.

The first scenario would be fairly straightforward yet highly effective: integrate both manned and unmanned vehicles within a convoy. The operators of the unmanned vehicles could ride in a command and control truck within the convoy and control multiple trucks from there.

This is more efficient than running a traditional manned convoy as fewer overall Marines would be required yet it also serves to ensure that the risks associated with an unmanned vehicle are addressed. Based upon MCTP 3-40B, a resupply such as that provided by a unit combat train requires flexibility and maximum firepower for survivability while delivering critically needed classes of supply.[41] What this entails is vehicle recovery, security, and the ability to respond to a changing and chaotic environment. Vehicles, both manned and unmanned, will ultimately break down through either mechanical failures or battle damage. In order to recover these vehicles Marines manning a wrecker vehicle will need to be present to deal with vehicles that need to be recovered. The second risk is security. Vehicles operating in a combat situation will require security to complete their mission. Marines will need to man weapons systems and provide that security to protect the vehicles and supplies they carry and ensure the mission is completed. The third risk is the ability to rapidly respond to a changing and chaotic environment. The MOC specifically calls out highly complex terrain as being a driver of the future operating environment. By having unmanned vehicles yet keeping the operator within the convoy in a command and control vehicle, they would be able to adapt immediately to the situation with the expertise that only comes from being in the middle of it all.

The second scenario in which we could best leverage this asset is to make them do things that the manned variants cannot: run 24 hour, or as close as maintenance allows, operations. By setting the trucks on a pre-planned route that is surveilled around the clock by persistent, armed, intelligence surveillance reconnaissance (ISR) UAV overhead and have recovery teams operating in shifts to go recover downed vehicles when the time arises, substantial amounts of supplies could be moved around the clock. The best scenario for this would be on LCE trains or unit supply trains moving supplies from a combat service support area (CSSA) forward to combat units as illustrated in the figure on the following page taken from Marine Corps Tactical Publication (MCTP) 3-40.

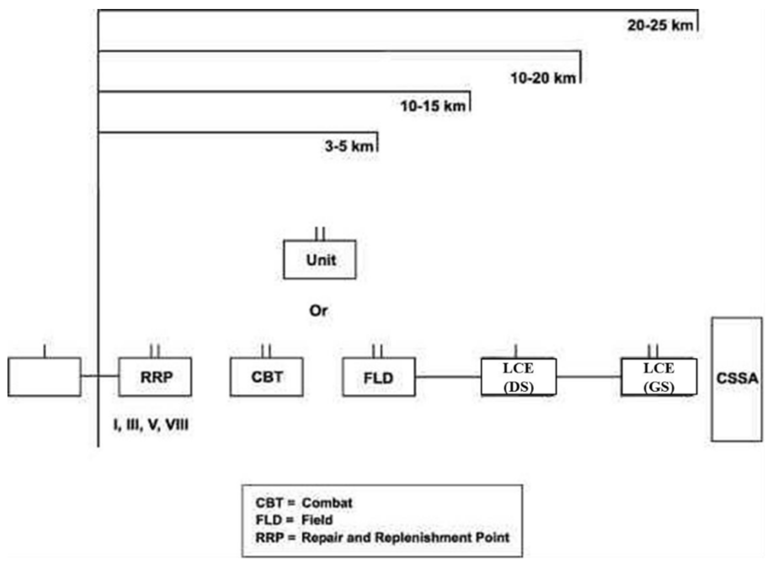

Figure 4

Typically, when executing long distance direct haul operations, the limiting factor is the personnel operating the vehicles, primarily driver fatigue.[42] By removing that limitation, throughput would increase, thereby decreasing response times for supplies coming from the CSSA and mitigating long or extended supply lines.

Both scenarios represent significant capabilities over purely manned operations. The first would be most applicable in situations where vehicle recovery and enemy contact is highly likely, i.e. combat trains heading from battalions to their companies. While the second scenario would require a highly permissive environment, if able to be instituted, the throughput would be substantial. With the TerraMax logisticians would have a distinct opportunity to employ ULS while still retaining a heavy lift capability.

Integrating K-MAX and TerraMax

The scenarios for both K-MAX and TerraMax separately represent unique capabilities for each; however, it is only through the integration of both systems that the advantages of one can address the other. The K-MAX is capable of operating from a smaller footprint and moving supplies regardless of the terrain or enemy situation on the ground. The TerraMax has the heavy lift capability, particularly for bulk liquids, that the K-MAX does not. By pushing K-MAX out to the battalion level, or operating them from EABs, they would be able to resupply smaller, distributed units that are either unreachable by ground or don't require as much support. The TerraMax could maximize throughput in permissive environments to an extent not possible with manned vehicles and also be utilized in a more traditional unit combat train role. Regardless of the particular situation or platform, the opportunity is clear that they are complementary systems best employed together. The weakness of one is offset by the strength of the other.

Current Issues with the Employment of ULS-A

While ULS does, even at present, represent a new and emerging capability for logistical support, there are drawbacks and capability gaps that must be discussed. The TerraMax, being ground based, does not have many of the issues associated with ULS-A. The K-MAX, while very capable, does have its drawbacks. First and foremost is the current cargo carrying capacity or rather the lack thereof for heavy classes of supply. Second, is the problem of electronic signatures that drones could potentially be putting off, to quote the MOC "to be detected is to be targeted is to be killed."[43] Finally, there is the airspace congestion that could potentially be generated by swarms of unmanned aircraft heading throughout the battlespace.

At present, the cargo carrying capacity of ULS-A is limited. Even if the best-case scenario is used, for example the K-MAX helicopter, it only has an external payload of 6,000 pounds at sea level and 4,000 at elevations of up to 15,000 feet. To compare, the manned equivalent, a CH-53K, can lift up to 27,000 pounds externally for up to 110 nautical miles.[44] That is a significant disparity in capability. While multiple K-MAX units could be used to match the CH-53's capability, there will be many missions that a ULS-A is not capable of completing. In a distributed fight, it stands to reason that external lift of artillery pieces would be necessary. One can look to the past and the jungle firebases of the Vietnam War, as just one example. These firebases were setup in terrain that was impassible to vehicle movement and required the external lift in of howitzers to establish. One M777, the standard artillery piece of the Marine Corps, weighs 10,000 pounds.[45] A CH-53E would be capable of lifting both the piece and the crew for it in a single lift whereas the K-MAX is not capable of either. While certainly lifting artillery pieces into impassible terrain could be described as a very situationally dependent mission, the ammunition resupply of an artillery unit is not. A pallet of projectiles for a 155mm artillery piece weighs approximately 850 pounds for 8 rounds, the pallet of propellant an additional 1300 pounds.[46] The sustained rate for a battery of six guns is two rounds per minute per gun.[47] The K-MAX would only be capable of providing enough ammo and propellant for two minutes with a single lift whereas the CH-53K has the potential to carry enough rounds for 20 minutes of firing by a battery at the sustained rate, a substantial difference. While the K-MAX is suitable for may suitable for many resupply missions, it clearly has limitations.

The next serious pitfall of drones or unmanned systems is, potentially, the biggest and is something that is a critical capability for either a near peer opponent or an asymmetrical opponent in the security environment of 2025. First, the MOC makes it clear that the battle of electronic signatures will be substantial in the security environment of 2025. There have also been repeated instances of General Officers stating that the Marine Corps needs to get back to the basics of navigation using compasses, the way the Corps used to train and reduce our reliance on GPS, which generates a signal.[48] This point has been hammered by senior leadership as they discuss limiting items such as cell phones and other personal electronics as they, collectively, give off a large electronic signature.[49] Very recently such devices linked to the fitness website, Strava, have collected data which was then inadvertently made public and showed the usage location of electronic personal fitness tracking devices.[50] While the data release was not intended as harmful, it did show what electronic or GPS signatures could do. Additionally, it stands to reason that a ULS, receiving and sending signals back to either a human controller, GPS satellite, or both will emit an electronic signature or be susceptible if GPS is targeted and degraded.

While the emission of electronic signatures that could be used for targeting is, of course, an issue, there is another issue brought on by the technology that is used to control an unmanned system. There is the potential for hacking by either a near peer competitor or by an asymmetrical opponent that is trying to leverage against a perceived weakness of American technical superiority. There are already instances of both of these examples coming to fruition in recent conflicts involving modern armed forces utilizing unmanned systems. In 2012 a Palestinian terrorist was able to hack into an Israeli drone and steal the feeds beaming back to a military ground station.[51] In another instance in 2009, the US admitted that Iranian-backed insurgents in Iraq had used consumer-grade hardware and software to steal and record video feeds from U.S drones. Additionally, in 2011, the U.S. lost a drone that somehow ended up landing safely in Iran.[52] While the U.S. claimed that it lost control and the drone crashed, the Iranians later showed the intact drone and claimed that their cyberwarfare division had been able to hack into the GPS and force the aircraft to land where they wanted it to. This is not the only example of issues with the security of navigation systems of drones. In 2012, at a cost of only $1000, a team of Texas college students were able to "spoof" the US Government controlled guidance system and seize control.[53] Given the ease and low cost with which the hack was accomplished, it is clear that this is a legitimate issue that presents a serious risk when employing unmanned systems.

The current airspace over a theater of conflict has a myriad of aircraft, both manned and unmanned, filling the skies. This is another potential trouble area for any argument in favor of increasing the number of unmanned platforms taking to the skies. In a 2014 database compiled by the *Washington Post*, over 400 large U.S. military drones crashed in major accidents worldwide of which 194 fell into the category of most severe Class A mishaps causing at least 2 million dollars in damage.[54] The data shows that as the usage of drones increases, there is a corresponding increase in the number of accidents. However, it should be noted that despite the increase in crashes, the Pentagon has said that the number of crashes per flight hour has steadily been decreasing denoting an increase in reliability. While many of the crashes do not involve other aircraft, some have. For example, in 2011 an Air Force C-130 collided with an unmanned aircraft over Afghanistan. During the C-130's descent into Forward Operating Base Sharana, the aircraft was suddenly hit by an ISR unmanned aerial vehicle (UAV) later identified as an RQ-7B Shadow. The UAV weighs in at around 375 pounds and left a large, gas spewing hole, in the left wing of the C-130 and was completely destroyed. The drone operator was unaware of the crash until the air-traffic controller informed him that they had a C-130 hit a UAV.[55] The resultant investigation from the incident was not released to the public. It should be noted that this particular accident took place in a remote province in Afghanistan and not in a highly complex urban environment, which the MOC identifies as one of the five key indicators of the future security environment of 2025. It stands to reason that in a highly complex environment there will be substantially more air traffic or obstacles to avoid. Further evidence collected by the U.S. Department of Transportation (DOT) backs up the theory that airspace congestion from unmanned aerial systems (UAS) will be problematic in the future. In 2014 in Florida, there was another near disaster when a regional jet carrying 23 passengers and crew nearly collided with a drone at 2,300 feet even though type of UAS it nearly hit was supposed to remain at 400 feet.[56] Based upon a 2012 study by the DOT, which simulated UAS operations at small to medium sized airports, the introduction of only four unmanned aircraft into a simulated airspace had significance impacts on safety, efficiency, and controller workload.[57] A lack of understanding of UAS and the issues associated with lost links to aircraft resulted in increases in aborted aircraft landings and a reduction in the situational awareness of flight controllers. For context in how busy airspace can be in the middle of a military operation, at one point, during OEF, in 2009, the airfield at Camp Bastion, Afghanistan, was the fifth busiest in operation by the United Kingdom.[58]

In addition to the physical airspace congestion, there are other concerns regarding frequency spectrum congestion and spectrum management for drones. This is considered a fundamental problem in modern wireless communications.[59] Per a 2017 study, at present in the U.S., commercial long-term evolution (LTE) systems are having to coexist with military UAS systems.[60] While research is currently underway for harmonious coexistence, it is not yet complete. High quality streaming video and rich content data requires significant amounts of spectrum proportional to the throughput and quality desired.[61] While likely not as much of an issue for an ULS-A as it probably won’t be returning high quality feeds, it is still an issue. Per the study, as the air becomes more congested with UAVs and the airwaves are saturated with radio frequency (RF) signals, significant amounts of bandwidth will need to be provided to accommodate the desired communications.[62] While this may not be as much an issue in some of the current theaters of operations, we can again go back to the MOC and two of the five drivers of the future security environment: highly complex urban terrain and technology proliferation. One would assume that any significant population center is now dominated by electronic signal emitting devices. Couple this with the military's rapid increase in drone usage and there becomes many competing systems for limited bandwidth. In a non-permissive environment, the U.S. may not be able to control and parse out the requisite amount bandwidth to meet all UAV needs.

Conclusion

While not possible to perfectly predict the future of warfare, and by extension, the logistical support to the future concept, it is important to be constantly be working towards better solutions to both existing and anticipated future logistical problems. Certain actions will need to be taken in order to start moving the force towards the future. The currently available ULS for both air and ground present capabilities which, when employed correctly within the correct unit construct, leverage their advantages and serve to address several shortcomings of existing manned options. While there are suitable ULS presently available, there are changes that must be made and risks that must be assumed. Absent an increase in manpower end strength, the Marine Corps and the LCE the MLG, will need to decrease manning in certain units in order to provide the Marines needed to operate ULS-A. The best way to do so at this time is, unfortunately, by folding the colors of the TSBs and utilizing those manpower gains elsewhere.

This paper has outlined how those manpower gains could be shifted over to a VMU squadron within the MAW, which is where they are best suited, and then pushed out as detachments for operations. In addition to structure changes, a new concept of employment for manned teaming with ULS needs to be implemented and operationalized. Both the MOC 2025 and Hybrid Logistics Concept point towards a future in which unmanned systems play a significant role in the support of the force. As the Marine Corps moves towards the eventual future that those concepts espouse, it needs to begin employing the existing solutions to bring that end state closer to reality. The capabilities that have been proven by both the K-MAX and TerraMax systems clearly illustrate an opportunity to act as the bridge towards 2025 realities. By embracing existing ULS now, the fighting force will be better supported, put in harms' way less frequently, and positioned exploit emerging technologies in ULS.

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