Strategy Research Project

Overcoming Multi-Domain Battle Sustainment Challenges through Demand Reduction Initiatives

by

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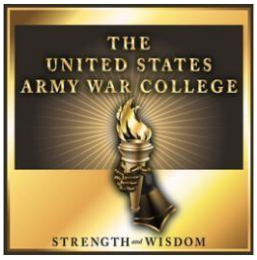

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In 1973, the Army recognized a need to change and implement AirLand Battle doctrine to defeat the Soviet Union. Today, the U.S. faces a complex world consisting of trans-regional, multi-domain, and multifunctional threats. Similar to the actions taken by the Army in 1973, Army senior leaders recognized the new changing character of war and introduced the Multi-Domain Battle concept. This concept stresses the idea of gaining a position of advantage by creating and exploiting temporary windows of advantage, restoring capability balance, building resilient Joint Force battle formations, and altering force posture to enhance deterrence by challenging the U.S.power projection, entry, and freedom of action capabilities. This concept generates a myriad of sustainment challenges. This paper specifically addresses the challenges posed by the dispersion of sustainment operations resulting in semi-independent sustainment operations across a wider area, the size of sustainment nodes, and the critical transition point from movement to maneuver. To overcome these sustainment challenges, the Army must continue to focus on demand reduction initiatives through the use of increased technology in three areas water, fuel, and operational energy to maintain the competitive advantage and win in the future against great-power

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Overcoming Multi-Domain Battle Sustainment Challenges through Demand Reduction Initiatives

> …the idea of the future being different from the present is so repugnant to our conventional modes of thought and behavior that we, most of us, offer a great resistance to acting on it in practice.
>
> —John Maynard Keynes[1]

Army Chief of Staff General Mark A Miley at the 2017 Association of the United States Army Annual Meeting and Exposition stated that "we are at an inflection point in our history where we must reform how we modernize our Army—the role, responsibilities, structure, and organization."[2] Executing a new Afghanistan strategy, continuing the efforts in Iraq and Syria, contending with nuclear threats from North Korea, and defeating violent extremist organizations are but a few threats that the United States faces today. These global threats coupled with the volatile, uncertain, complex and ambiguous environment and the current political state make readiness and preparedness for war paramount. Given the complexity of these issues and the uncertainty of the situation, the Army Senior leaders, led by General Milley and the Training and Doctrine Commander (TRADOC), General David G. Perkins, introduced a new operating concept called Multi-Domain Battle as a means to defeat future threats against near-peer competitors. The purpose of this paper is to explain the origin and framework of Multi-Domain Battle, the differences between AirLand Battle and Multi-Domain Battle, and examine sustainment challenges and the associated implications presented during Multi-Domain Battle. Finally, we will explore demand reduction initiatives, in three key areas: water, fuel, and operational energy, as a possible solution and or mitigation to overcome sustainment challenges and to maintain a competitive advantage in the future.

Background

General William DePuy, the TRADOC Commander in 1973, along with other Army leaders created the AirLand Battle concept as a result of observation and lessons learned from the Arab-Israeli War of 1973. American Army leaders quickly learned that the United States must transform the Army to defeat the Soviet Union in a large-scale conflict in Europe.[3] Due to heightened tensions around the world from the Vietnam War, the Arab-Israelis War, and the Cold War, the Army leadership experienced "'reactive innovation' or a change in thinking about, and preparing for a future war."[4] The Soviet Union posed a major threat to the United States. As a result, Army leaders collaborated with the Air Force leaders and transition in less than a decade, from an "Active Defense" concept focusing on battalion size counterinsurgency operations, into AirLand Battle concept. Referred to as "the Cold War doctrine," AirLand Battle focuses on large-scale synchronized ground operations through the integrated battle concept against peer threats concentrating primarily on the air and land domains emphasizing the battlefield framework and the concepts of deep, close, and rear areas.[5]

The principal characteristics and tenets of AirLand Battle were the catalyst to ensuring success against the Soviet Union. These principal characteristics consist of Corps perspective, operational art and maneuver warfare, decentralized execution of mission orders, integrated battle, extended battlefield, and reliance on technology. The Corps organizational structure was the focal point at the operational level. The Corps Commander is responsible for fighting the battle and implements integrated battle as a unified approach, using all the tools necessary to win including joint operations, the unity of effort, and the possible use of tactical nuclear, chemical, and biological weapons. The key elements to ensure success under AirLand Battle reside in four

tenets: initiative, depth, agility, and synchronization. Embedded in these four tenets was the renewed emphasis on communication, engaging the enemy in a tiered approach, and retaining initiative through the employment of the operational reserve.[6]

Simultaneously, during the early 1980s, the Army's modernization and reorganization effort transformed the Army. The Army sought ways to leverage that latest technology, and as a result, invested in several new warfighting platforms, which came to be known as "the Big 5" consisting of the M1 Abrams tank, M2 Bradley Fighting Vehicle, the Patriot Air Defense System, the Blackhawk helicopter, and the Apache. The Army's reorganization plan called the Army 86 structure focused primarily on the Division, ultimately resulting in the Army of Excellence (AOE) consisting of five Active Army Corps and sixteen Active Army Divisions.[7] The emergence of the new doctrine, equipment, and an Army organization were vital aspects in establishing the United States Army's dominance.

AirLand Battle and AOE Sustainment and Sustainment Challenges

Similar to the AirLand Battle doctrine, the Army's sustainment structure focused on sustaining both the Corps and the Division in a large-scale force on force war in Europe. Sustainment forces, referred to as combat service support forces, were large units mainly consisting of functional specified logistics components. Some examples of these units include the various types of transportation truck companies and the specified quartermaster companies like general support petroleum supply companies, Heavy Equipment Transport Companies, and laundry and bath companies. These specified companies provided redundancies at each echelon above Division. Figure 1 depicts the doctrinal concept for support structures from the theater level down to the

battalion with an emphasis on the linear support structure, echeloning commodities down to the end user, and having redundant resupply capabilities.

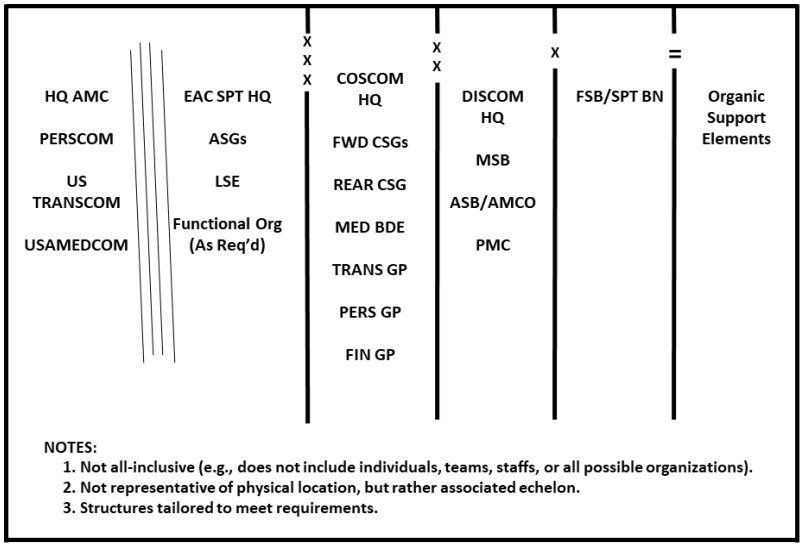

Figure 1. Army Support Structure in Fully Developed Theater[8]

Focusing on Corps operations, AirLand Battle presented several sustainment challenges. The new reality was when a Division, consisting of 16,000 troops, deploy it cannot accomplish the mission without being accompanied by 32,000 support troops from the Corps to act as enablers. Under AirLand Battle, the rear area was considered secure and provided sustainment units freedom of movement. Supplies and equipment would traverse long distances and be doubled and sometimes tripled-handled before the supplies and equipment reach the end-user. Additionally, units at this echelon may or may not have a habitual relationship with each other, thus complicating an already cumbersome time-consuming process. Furthermore, this trans-load, upload, and download process presents several challenges in planning and executing a theater concept of support over extended distances.

The next challenge of creating super-large logistics bases come as a result of echeloning supplies and equipment. To reduce the lines of communication, the units at each echelon would create a supply point and distribute equipment and supplies via supply point distribution, distribution method where customers pick up equipment and supplies from their designated source of supply. An example of this concept occurred during Operation Desert Storm when the Army created two super-large logistical bases named Logbase Charlie and Logbase Echo. Each of these logistics bases supported a corps, and during the charge from Saudi Arabia to Kuwait, one company commander describes the logistics base as the “Iron Mountains of supplies” where units would have to sift through supplies to get what was required.[9] Lastly and equally important was the challenge of the maneuver element outrunning their resupply. This resupply could be a direct support unit inside the brigade combat team (BCT) or a unit from the corps using throughput, a distribution method where supplies and equipment bypass intermediate supply points and go directly to the end user and eliminated the need for double handling, as a means of resupply.[10] A recent example of when a unit outran its resupply occurred in the first ten days of decisive ground operations during Operation Iraqi Freedom when the media reported that several forward combat units were severely low on food and water.[11]

The Between Years 1993-2014

After the implementation of the AirLand Battle doctrine, the Army experienced several changes in the operational environment, which resulted in specialized changes in the Army Operating Concept. For example, after the fall of the Berlin Wall and the collapse of the Soviet Union, the United States became the lone superpower, and as the lone superpower, the focus was on operations other than war. Therefore, the Army

Operating Concept in 1993 shifted to Military Operations Other Than War. Nonetheless, AirLand Battle doctrine and tenants continued to be the centerpiece as the Army Operating Concepts evolve between the years 1993 and 2012 to meet the current evolving threat. To overcome these emerging threats, the Army after the invasion during Operation Iraqi Freedom transitioned from AOE to a modular force structure. Under the modular force structure, the Army made some units that were organic to the Division now organic to the BCT and standardized all BCTs into three different types of BCTs.[12] These new organic units made the BCT self-sufficient as it became the Army's primary fighting force. Other significant changes in Army's structure included the introduction of five standardized support brigades: the aviation brigade, maneuver enhanced brigade, the battlefield surveillance brigade, the fires brigade, and the sustainment brigade.

The Between Years Sustainment and Sustainment Challenges

As the Army transformed into the modular force, the sustainment echelons were drastically cut. The Army deactivated the Theater Army Area Command, Corps Support Command (COSCOMs), Division Support Command (DISCOM), Main Support Battalion, and Forward Support Battalions and introduced the Theater Sustainment Command (TSC), Expeditionary Sustainment Command (ESC), the Sustainment Brigade, the Combat Sustainment Support Battalions, the Brigade Support Battalion (BSB), and the Forward Support Companies. Under this new structure, TSCs and ESCs "generally support the sustainment brigades located throughout the theater which delivers logistics to the divisions. [In turn], the sustainment brigades will use combat sustainment support battalions to deliver supplies and equipment to the BCT through their BSB and then to the FSC [Forward Support Company], which provide support as far forward as possible on the battlefield."[13]

During this period, the Army reduced in size, and consequently, the sustainment community absorbed a large majority of the cuts. With the deactivation of the COSCOM and the DISCOM, distribution and materiel management inside a Division would be significantly reduced creating a more throughput-based system.[14] Additionally, approximately 80 percent of the logistics capability, which was in the active component under AOE, is now in the reserve component. Under the new modular concept, sustainment units above brigade became “plug and play” based organizations and would deploy as a company, platoon, and section entities. Habitual support relationships were no longer, and assessed strengths and weaknesses of units for employment on the battlefield were no longer factors considered when these entities were task organized.

Foreseeable Change: Multi-Domain Battle

Undeniably, the success of AirLand Battle in Operation Desert Storm caused the opposition to seek asymmetric means to counter AirLand Battle. Similar to General DePuy, on April 8, 2015, Deputy Secretary of Defense Bob Work spoke to the US Army War College. Deputy Secretary Work experienced reactive innovation by charging the Army to develop AirLand Battle 2.0, given that the enemy will have “lots of guided rockets, artillery, mortars and missiles, and [will use] informationalized warfare to completely disrupt our heavily netted force.”[15] From this AirLand Battle 2.0 task given by Secretary Work, the Army started the initial steps in developing what is now called Multi-Domain Battle. General Perkins explained the origins of Multi-Domain Battle as a concept “driven by proactive choice and informed by the threat of failure…using recent events in the South China Sea, Russia’s New Generation Warfare, and the ongoing challenges in the Middle East” as evidence of the Army’s need to evolve and change.[16]

Multi-Domain Battle addresses the challenges posed by near-peer competitors capable of restricting and denying access across all five domains including air, land, sea, space, and cyberspace. Multi-Domain Battle stresses three main concepts: the idea of gaining a position of advantage by creating and exploiting temporary windows of advantage, restoring capability balance and building resilient Joint Force battle formations and altering force posture to enhance deterrence by challenging the United States power projection, entry, and freedom of action capabilities.[17] The key drivers of Multi-Domain Battle are essential in ensuring success. These drivers include the employment of resilient cross-domain capable formations with the ability to fight without continuous supply lines, avoid detection, survive enemy contact, and execute mission command in degraded conditions while maintaining temporary "touch points" to allow the higher command to converge capabilities across domains to achieve successful effects.[18]

AirLand Battle versus Multi-Domain Battle

"Change from cultural self-selection is a proactive change, and in proactive changes, leaders have the time and opportunity to focus change reflective of their culture and organizational strengths."[19] AirLand Battle and Multi-Domain Battle are the best examples of change by choice; however, each concept possesses unique similarities and distinct differences.

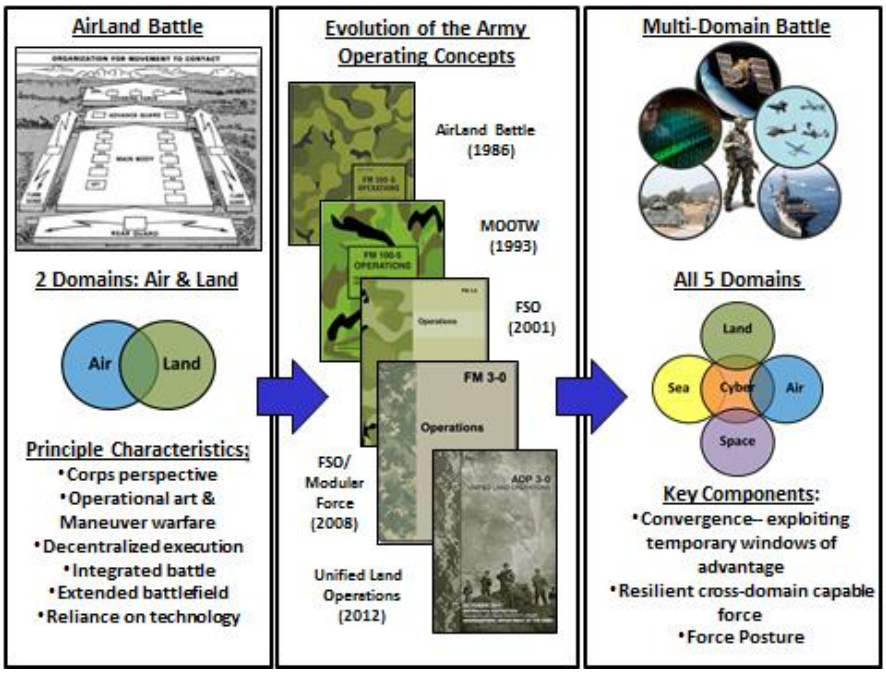

Figure 2. AirLand Battle versus Multi-Domain Battle[20]

Figure 2 shows the similarities and differences between AirLand Battle and Multi-Domain Battle. Both concepts are great examples of change by choice; however, each concept possesses unique similarities and distinct differences. Some of these similarities originate from the principle characteristics of AirLand Battle, specifically decentralized execution of mission orders, integrated battle, and reliance on technology. One of the main similarities is that both concepts call for decentralized execution using mission orders with a shared common understanding of the commander's intent down to the lowest level possible. Additionally, Joint Force integration and synchronization are crucial elements of both concepts to leverage the total force capability to defeat the enemy. Another important aspect of both concepts is the requirement for an increase in technology or modernization to ensure overmatch. In AirLand Battle, the Army instituted the Big 5 as the technological leap needed to defeat the Soviet Union threat. The Big 5 consist of the Abrams main battle tank, the Bradley Fighting Vehicle, the Apache attack

helicopter, the Black Hawk utility helicopter, and the Patriot air defense missile system.[21] Likewise, in October 2017, General Milley introduced the Army's new six modernization priorities needed to compete and win in a Multi-Domain Battle environment. These priorities include "long-range precision fires, the next generation combat vehicle, future vertical lift, a mobile and expeditionary network, air and missile defense capabilities, and Soldier lethality."[22]

Shmuel Shmuel, an author, critic, and Military Analyst at the Israeli Defense Force Dado Center for Military Studies, said, "Multi-Domain Battle seems similar to what the Army is already doing…and [the concept] is not unprecedented, rather it is about using capabilities in more innovative ways to overcome new challenges."[23] Although this statement has some validity, there are indeed some very distinct differences between AirLand Battle and Multi-Domain Battle. The obvious and most glaring difference is that AirLand Battle focuses on two domains against a large known specific threat "with the assumption that maritime and air would create windows of opportunity for land forces." Meanwhile, Multi-Domain Battle focuses on the enemies ability to challenge or deny access across all five domains and stresses the importance of fully integrating the joint force and massing effects to deter or defeat the enemy across the spectrum of threats.[24] Besides the difference in domains, the idea of "anti-access/area-denial, where the enemy will employ high-tech weapon systems in and against all domains," is a monumental difference from the past several decades when the United States always achieved and maintained superiority in both the air and sea domains.[25] Anti-access/area-denial across all domains transforms how the United States will conduct

war, and the idea implies that “many small forces will conduct land maneuver, dispersed throughout the area of operations sometimes outside of mutual support ranges.”[26]

Multi-Domain Sustainment and Sustainment Challenges

From these drastic changes made in the sustainment structures leading up to the modular concept and the distinct similarities and differences between AirLand Battle and Multi-Domain Battle, there is a myriad of sustainment challenges that can hinder the commander from achieving success during those limited windows of advantage. As mentioned previously, in Multi-Domain Battle, the enemy will attempt to prevent and fracture sustainment operations across all domains to cut off sustainment support to the warfighter.[27] Acknowledging the multitude of sustainment challenges presented by Multi-Domain Battle, this paper will focus only on three sustainment challenges. The first challenge is the dispersion of sustainment operations resulting in semi-independent sustainment operations across a wider area. However, with every domain contested and the concept of fighting in dispersed small groups, the concept of sustainment support must account for these scattered formations by either decreasing the requirements at the point of need or use multiple modes of delivery (i.e., aerial resupply, autonomous vehicle, robots).

The second challenge is the size of sustainment nodes. During the most recent conflicts in Iraq and Afghanistan, sustainment nodes or forward operating bases were large in size and scope and were expected to have at least a minimum of thirty days of supply on hand, which has become the new norm. Consequently, at an Atlantic Council event, General Milley said, “We will not have the luxury of having this massive amount of logistics behind us in the future higher end, higher intensity conflict.”[28] According to the Army Functional Concept for Movement and Maneuver 2020-2040, “Armored,

Infantry, and Stryker Brigade Combat Teams will remain the Army's primary tactical fighting formations."[29] Given these considerations, leaders typically err on the side of having excess supplies on-hand; however, and the question remains what is the appropriate size of the sustainment node size, and how much risk to the mission does the commander want to undertake?

Lastly is the challenge of the transition from movement to maneuver. "In the future, the Army requires the ability to rapidly transition from movement to maneuver and minimize the time required to conduct Reception, Staging, Onward Movement and Integration (RSOI) activities within an Area of Operations."[30] The Army continues to conduct exercises to streamline the process and gain efficiencies. Without a major deployment innovation, RSOI will continue to be an obstacle during Multi-Domain Battle. Think-tank experts predict that establishing a "scalable global sustainment architecture consisting of multiple modes, nodes, routes, and suppliers integrating with security and protection are the answers to solve these future challenges."[31] Due to the increase in Operation tempo, extended lines of communication, and reduction of sustainment forces, requirements for sustainment must be reduced.

Demand Reduction Initiatives

To overcome the sustainment challenges presented by Multi-Domain Battle, the Army must continue to focus its energy on demand reduction initiatives in three areas water, fuel, and operational energy to maintain the competitive advantage in the future against a near-peer competitor. "Demand is the operational requirement for services or commodities beyond a unit's ability to produce or acquire independently that enables freedom of action, extends operational reach, or prolongs endurance."[32] Water makes up over 60 percent of the human adult body and is one of the most vital elements

needed for survival.[33] The consumption of water and fuel accounts for a large percentage of the substantial demand requirements from a deployed force. For example, during the initial phases of Operations Iraqi Freedom, water, and bulk fuel account for over 51 percent of the cargo transported. “In Iraq, 50 percent of the convoy trucks transported bottled water.”[34] Water is the one area where the Army can initiate changes in the short term to have an immediate impact on reducing future sustainment requirements. Due to the enormous transportation burden on the battlefield, the Army must explore distillation, nanotechnology, and ship-based water production initiatives as ways to overcome the transportation challenges and produce water at the point of need.

While the Army has attempted to implement some of these demand reduction initiatives, funding continues to remain a constraint and keeps most of these initiatives in the exploratory phase. Instituting these initiatives, particularly in water, will result in a significant decrease in demand, thereby allowing the commander more flexibility and freedom of movement. Distillation is a process of purifying a liquid by successive evaporation and condensation.[35] Over the past decade, there has been a tremendous amount of work and innovation in refining water production and palatability through distillation. Several companies have developed novel ideas that could have game-changing global effects. The Department of Defense through the Defense Advanced Research Projects Agency was the original innovator of the concept of water-harvesting technology. There will be several examples presented throughout this paper as a means to illustrate the availability of this technology and is not an endorsement for a specific company more of a means to demonstrate the capability.

The first company to develop and highlight water-harvesting technology was Aqua Sciences. Aqua Sciences developed the technology to make water from air by "using a patented salty solution whose molecules attracts and plucks the water vapor atoms out of the air."[36] The company developed a 40-foot water-producing unit called the Emergency Water Station. The Emergency Water Station produces 2,600 gallons per day and is powered by a self-contained electrical generator unit at the cost of 17 cents per gallon, which is considerably less than bottled water. The Emergency Water Station is tailorable and configurable into 20-foot units capable of transport by air, land or sea in an International Standards Organization marine container package to maximize military transport efficiency. In the recent past, Federal Emergency Management Agency purchased several systems from Aqua Sciences to use for humanitarian support during the Haiti crisis and produce outstanding results. The Emergency Water Station is a viable alternative to significantly reduce bottled water on the battlefield and produce water at the point of need.[37]

Another alternative to the Emergency Water Station but on a smaller scale is a device called the Slingshot. The Slingshot is an efficient, clean water solution using a closed loop designed that preserves energy through heat exchange. The Slingshot runs on electricity and is the size of a small refrigerator with the capacity to purify over 264 gallons of water per day to include purifying sewage water. Additionally, the Slingshot cost approximately $2000 per unit with minimal maintenance cost. Considering the size, cost, and the requirements of the future force, procurement of the Slingshot becomes an appropriate selection as an alternative solution for smaller units with a temporary mission.[38]

Another innovative way to purifying water is through the use of nanotechnology. Puralytics, a water purifying company, “Has developed a patented photochemical water purification process using only light energy from LEDs or sunlight to activate an advanced nanotechnology coated mess.”[39] Once this process is complete, the water will be free of any heavy metals, viruses, bacteria and harmful pathogens. Puralytics introduced in July 2017 the latest water purification unit using nanotechnology called the New Shield 1500. The New Shield 1500 is highly mobile and easy to operate and maintain. The New Shield 1500 has several configurations and is capable of producing up to 1500 gallons of water per day without chemical additives. To date, the New Shield 1500 has been employed during natural disasters internationally, to remote locations in South America, and the Middle East, yielding great results in all locations.[40]

Fuel is Critical

Just as important as water, fuel is one of the most critical commodities on the battlefield and will remain a critical component to winning the competitive advantage during Multi-Domain Battle. The Army Materiel Systems Analysis Activity “estimated that about 50 percent of the fuel transported to forwarding operating bases, during the initial phase of Operation Iraq Freedom, was for generating power and fueling logistics convoy trucks.” Taken together, these convoys accounted for over tens of millions of gallons of fuel lead by tens of thousands of Soldiers and contractors. Even more alarming is that on average there was “one casualty per 50 supply convoys in operations in Iraq and Afghanistan.” To reduce the sustainment burden during Multi-Domain Battle, the Army must reduce the fuel demand by acquiring more fuel-efficient aviation and ground engines and add auxiliary power units to offset the fuel demand.[41]

The Army continues extensive research to improve energy efficiency to reduce fuel demand. Fuel is used for two primary purposes: powering engines and generating power. This portion of the paper will focus on powering both aviation and ground engines. Ensuring aviation engines are fuel efficient, maintainable, durable, and can conduct continuous flight operations is an absolute must. In March 2017, Army senior leaders reaffirmed to lawmakers that the Improved Turbine Engine Program (ITEP) for Blackhawk and Apache helicopters remains one of the Army's top modernization priorities. The ITEP is an on-going program with the overarching task of replacing the 1970s era T700 family of engines in 2,135 Blackhawks and 684 Apaches.[42]

In August 2016, the Army issued preliminary design review agreements with General Electric Company (GE) and Advanced Turbine Engine Company (ATEC), a joint venture group formed by Pratt & Whitney and Honeywell. ITEP's goals were to

> build an engine that can 'plug and play,' double the carrying capacity of the Blackhawk, supply 3000 shaft horsepower instead of the T700's maximum 2000 shaft horsepower…offer 65 percent improvement in power-to-weight ratio, a 20 percent longer engine life, a 25 percent [decrease in] fuel consumption, and 20 to 25 percent [decrease in] production and maintenance cost.[43]

To date, both companies have seen tremendous success. On October 9, 2017, GE completed the test of the T901 turboshaft engine prototype confirming that the engine met all of ITEP's goals while maintaining the single spool engine design of the T700.[44] Similarly, in December 2017, ATEC successfully installed the engine prototypes and met ITEP's goal using a T900 duel-spool engine design. Both companies will continue to compete for the contract.[45] The Army senior leaders must continue to ask for the appropriate levels of funding to ensure that this advancement in engine technology is incorporated into the force before 2027.

Equally as important as the development of a more fuel-efficient aviation engine is the development of more fuel-efficient ground engines, specifically for the M3 Bradley Fighting Vehicle and the M1 Abrams tank. As mentioned earlier, the Army through U.S. Army Tank Automotive Research, Development, and Engineering Center continues to explore advanced engines options with specifications of achieving a 25 percent decrease in fuel consumption. In a joint venture with Achates Power, an engine design company focusing on improving internal combustion engines, Cummins Incorporated instituted the Advanced Combat Engine project which will replace the Bradley Fighting Vehicle (BFV), the 600 horsepower Cummins VTA-903T the engine. In October 2017, Cummins and Achates announced a revolutionary new diesel engine "designed as an opposed-piston engine that works on a two-stroke combustion cycle and eliminates the need for a valve-train…with a 21 percent reduction in thermal rejection, a 50 percent increase in power density, and a 13 percent [increase] in fuel efficiency." The engine has promising design features and is projected to begin testing in 2019. This project must continue to receive visibility and consistent funding to remain on schedule. This advanced engine technology can revolutionize how we operate and employ BFVs during Multi-Domain Battle because of the extended range and fuel efficiency.[46]

Besides the BFV, the M1 Abrams tank is the primary consumer of fuel on the battlefield and gaining fuel efficiency would have exponential effects similar to those of the BFVs. The M1 Abrams tank consumes approximately 300 gallons every eight hours depending on the mission, 60 gallons per hour when traveling cross-country, and 30 gallons per hour while operating at a tactical ideal.[47] In its efforts to modernize, the Army in 2017 received the first of six M1A2 System Enhancement Package Version 3

(SEPv3) Abrams tanks. These upgraded tanks built by General Dynamics Land Systems will undergo field-testing with selected armored units with a goal to begin total Army fielding in the fiscal year 2020. So far, these upgraded tanks are being praised as "a great step forward in reliability, sustainability, protection, and onboard power."[48] Some of the new features of the M1A2 SEPv3 include a Joint Tactical Radio System allowing for better communications with advanced network capabilities, increased power generation and distribution capacity, improved survivability and lethality compared to older Abrams models, a new Vehicle Health Management System that supports off vehicle reporting of maintenance status, and the addition of a new under-armor Auxiliary Power Unit which helps significantly reduce fuel consumption.[49] Major General David Bassett, Program Executive Officer for Ground Combat Systems, highlighted the fact that "these vehicles are not just about assuring our allies or deterring or coercing potential adversaries…they are about compelling our enemies and winning the Multi-Domain Battle."[50]

Unlike the BFV, General Dynamics did not design a more fuel-efficient tank engine; instead, General Dynamics decided to add an auxiliary power unit, which is another method used to reduce the fuel demand. Auxiliary power units, in the Army's large vehicle fleet, can have a significant impact on extending the operational reach and allowing the maneuver commander to have more freedom of action on the battlefield. Engineers from the U.S. Army Research, Development, and Engineering Command's communications-electronics center demonstrated the Tactical Idle Reduction (TIR) for heavy tactical vehicles using a 5-kilowatt auxiliary power unit. In the demonstration, an M915A line haul truck installed with the TIR was used. "Based on operational data of

power consumption and idling times from Iraq and Afghanistan, the M915A truck consumes 1 gallon of fuel per hour while idling. [Additionally], the TIR consumes 0.6 gallons per hour under full load when the environmental control unit is running on high, and all electrical loads in the truck's cab are powered." The results were noteworthy, yielding a saving of 870 gallons per year per M915 vehicle and at least 700,000 gallons a year for the entire fleet of M915s. This demonstration validates the use of auxiliary power units as another measure to reduce the overall fuel demand and can be implemented in all of the Army's line-haul trucks across the total force over the course of ten years.[51]

Operational Energy is necessary

Another area of demand reduction initiatives from lessons learned in the Army's most recent campaigns in Iraq and Afghanistan is operational energy. Operational energy is "the energy required for training, moving, and sustaining military forces and weapons platforms for military operations."[52] According to Secretary of the Army John McHugh, "Army operational energy is a critical enabler for the range of military operational capabilities from the individual Soldier to the strategic levels."[53] To stress the importance, Secretary McHugh signed a policy memorandum on April 30, 2013, directing the Army to find ways to improve energy performance through techniques, behaviors, and organizational culture.[54] This portion of the paper will address the second purpose of fuel: generating power. The Army has accomplished a lot since the enactment of 2013 policy memorandum. However, with the complexity of Multi-Domain Battle, the Army must continue to focus on energy-related technologies such as solar energy, micro/smart-grids, and fuel cells to help sustain forces during semi-independent operations while exploiting the limited windows of opportunity.

Solar energy is not a new idea or concept. The Army has made tremendous use of harvesting solar energy to use as an effective alternative to traditional energy sources. Some of these solar energy projects consist of using “large centralized utility-scale power bases, smaller distributed-generation systems to power buildings and homes, and portable solar systems to provide energy in the field for the Soldiers.”[55] One revolutionary project, still under testing is the Solar Power Shelter System. “The Solar Power Shelter System is an integrated hybrid system that combines solar power with a standard military diesel generator to provide a continuous energy loop” with the goal of “minimizing battlefield logistics footprints and decreasing fuel-consumption costs.”[56] In addition, the Solar Power Shelter System does not consume space as it sits on top of a military shelter or shipping container. Some of the other added advantages include replaceable solar panels, which significantly reduce maintenance cost, and the ballistic capability provided in each solar panel providing additional protection to the people inside the container.[57]

To maximize the use of generators, solar power, and reduce the fuel demand at the point of need, the Army must continue to promote the use of microgrids and pursue smart-grid technology. “A microgrid is a locally confined and independently controlled electric power network in which distributed energy resources, and loads are integrated. A microgrid has a stand-alone power generation source and reduces the number of generators required to provide power.” A 1-megawatt microgrid was installed during contingency operations in Afghanistan, yielding a 17 percent reduction in fuel consumption and an 85 percent reduction in generator operating hours with 67 percent lower maintenance costs.[58]

Microgrid use on the battlefield is proven. Conversely, “a smart grid is a modernized electrical grid that uses information and communications to enhance its efficiency, reliability, and economy and the sustainability of the production and distribution of electricity.”[59] However, for Multi-Domain Battle microgrid technology coupled with smart grid technology will be the key to ensuring units have an adequate uninterrupted power source, which requires less fuel, less oversight, and less contract support. The Army’s Research, Development and Engineering Command’s Communications-Electronics Research Development and Engineering Center continues to test smart grid technology using a device called the tactical microgrid system. The tactical smart grid system is “a computer-based controller that makes moment-by-moment decisions on how much power is required by the equipment Army warfighters take into the field during tactical operations and matches it with the power generating capability from the sources at hand.”[60] In addition, this system can provide information that helps reduce and prevent future operational problems while reducing the fuel demand by 15 to 30 percent.[61]

Out of all the technologies for power generation, fuel cells may be the most promising for future military application in 20-30 years. Fuel cell technology is already being touted by experts as the future of energy with the potential to provide groundbreaking technology to the modern battlefield. “Fuel cells undergo a chemical process to convert hydrogen-rich fuel into electricity. Fuel cells do not need to be periodically recharged like batteries, but instead, continue to produce electricity as long as a fuel source is provided.”[62] Fuel cells have multiple military applications ranging from providing power for the individual handheld items for Soldiers to operating tactical

vehicles of all sizes, and even running small base camp equivalent to the size of a small city. Recognizing fuel cell technology potential, the Army in conjunction up with General Motors developed the Chevrolet Colorado ZH2, a hydrogen-fuel-cell-powered pickup truck. The ZH2 is not your typical truck. The ZH2 has a "reinforced body that is six-and-a-half feet tall and seven feet wide with 37-inch tires and a special suspension built for off-road handling."[63] The truck comes equipped with "a single motor powered by a hydrogen fuel cell, a battery, [and] the electricity-powered engine that is quieter than a traditional combustion engine."[64] Despite the fact that hydrogen can be challenging to store, the ZH2 continues to provide impressive test results, and with further innovation and exploration, the Army can capitalize on this untapped potential.[65]

Other Sustainment Considerations

Indeed, instituting key demand reduction initiatives will have a tremendous impact on reducing the logistics footprint and will help overcome the multitude of sustainment challenges presented by Multi-Domain Battle. However, other considerations must be addressed to create a comprehensive sustainment strategy for tackling the future battlefield environment. Some of the critical factors include mission command and empowering leaders, maintaining a responsive, resilient industrial base, and maximizing the Joint Logistics Enterprise, inter-organizational logistics capabilities, and multinational partners' logistics capabilities. One of the most important factors in the military is our people. Training our young men and women to think critically and understand the challenges presented during Multi-Domain Battle will weigh heavily on how the Army overcomes sustainment challenges in the future. This educational process should not only focus on the basics fundamental building blocks of leadership and sustainment but must also elaborate on problem-solving techniques and provide

innovative solutions to problems using well-documented lessons learned and vignettes from history. Next, the Army senior leaders must ensure that the industrial base receives the adequate facility and technological upgrades to remain responsive and resilient and continue to meet and anticipate future operational requirements. Lastly and most importantly, the Army because of the complexity of Multi-Domain Battle will have to leverage the Joint Logistics Enterprise, inter-organizational logistics capabilities, and potentially even multinational partners' logistics capabilities. As a result of the operations in Iraq and Afghanistan, the Army has increased its interaction with other Services and multinational partners; however, this interaction will not be enough to overcome the potential challenges. Without a doubt, the Army will have to truly become one of the major contributors to the Joint force to ensure uninterrupted sustainment support throughout each critical phase of Multi-Domain Battle.[66]

Conclusion

As the Army prepares for the future, there is only one thing that experts know for sure, and that is change is unavoidable. Multi-Domain Battle offers the Army a new way to compete and win in the future against near-peer competitors. Under this concept, sustainment operations may be hindered, stalled, and will require innovation and ingenuity to overcome. The Army can no longer assume the risk of failing to investing in water, fuel and operational energy demand reduction initiatives if the United States is to maintain the competitive advantage against a near-peer threat. Investing now in water initiatives with a more incremental approach to fuel and operational energy will allow enough time to adequately resource each initiative and ensure that sustainment enables the Commander to gain a competitive advantage during these limited windows of opportunity to win in a Multi-Domain Battle environment.

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