Tying Marines into a Common Operating Picture: lightening the load and decreasing uncertainty

Beginning in 1997, operational concepts of Operational Maneuver from the Sea and Ship to Objective Maneuver have matured to the point where U.S. Marine Corps infantry companies are conducting sustained, independent operations in a distributed environment. The result has been to increase the amount of equipment carried by Marines at the company level to assist the MAGTF in building a common operating picture. The increase in equipment has also resulted in Marines carrying weights that exceed acceptable standards. As the Marine Corps continues to advance the concept of distributed operations and enhanced company operations, the Marine Corps must look to technology that is multifunctional and reduces the overall weight Marines carry. Two technologies examined are Advanced Wireless Network for the Soldier and Epidermal Electronic Systems.
FUTURE WAR PAPER

TITLE:
Tying Marines into a Common Operating Picture: lightening the load and decreasing uncertainty

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EXECUTIVE SUMMARY

Beginning in 1997, operational concepts of Operational Maneuver from the Sea and Ship to Objective Maneuver have matured to the point where U.S. Marine Corps Companies are conducting sustained, independent operations in a distributed environment. The result has been to increase the amount of equipment carried by Marines at the company level to assist in building a MAGTF common operating picture. The increase in equipment has also resulted in Marines carrying weights that exceed acceptable standards. As the Marine Corps continues to advance the concept of distributed operations and enhanced company operations, the Marine Corps must look to technology that is multi-functional and reduces the overall weight Marines carry. Two technologies examined are Advanced Wireless Network for the Soldier and Epidermal Electronic Systems.
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Introduction

Marine Corps Doctrinal Publication 1, Warfighting, states that uncertainty is an attribute of war that one cannot eliminate from the battlefield. The continued development and employment of Position Location Information (PLI) technology, such as Global Positioning System and Blue Force Tracker, continue to reduce the uncertainty of “friendly force” location on the battlefield. As the Marine Corps continues to develop the Distributed Operations concept, leaders will increasingly rely on PLI to account for Marines in a MAGTF common operating picture. A common operating picture increases the responsiveness of fire support and reduces incidences of fratricide. Requiring Marines to carry more PLI equipment may decrease uncertainty, but it will also decrease dismounted mobility by increasing the amount of weight Marines must carry. Therefore, the next generation equipment to link Marines into a common operating picture must also assist in solving the problem of weight.

Two emerging technologies will increase the common operating picture while decreasing the amount of weight a Marine must carry: Advanced Wireless Network for the Soldier and Epidermal Electronic Systems. These emerging technologies decrease the operator’s load while increasing the MAGTF’s common operating picture in a distributed environment and therefore demand greater research and development.

Distributed Operations Defined

Operational Maneuver from the Sea (OMFTS) and Ship-to-Objective Maneuver, published by the U.S. Marine Corps in 1996 and 1997 respectively, advocate for a credible, forward deployed force capable of projecting power into the littorals to meet the threats to America’s interests and securities. OMFTS describes a future environment where the
breakdown of traditional societal order and the emergence of regional powers and/or the next superpower will challenge U.S. interests. Advances in weapon technologies that result in greater precision and lethality can increase the ability of nations to challenge U.S. military forces, potentially producing battlefield parity. To meet this challenge, OMFTS advocates operational level maneuver of Naval forces by reducing the logistical footprint ashore. Increased reliance on long-range precision weapons and naval fire support will aid in reducing the logistical footprint ashore. OMFTS combines greater speed and flexibility with a more robust command and control (C2) system that will increase the tempo of operations. A capabilities challenge presented in OMFTS is to have a communications system that provides “units with control over the information they need” to affect the mission – a common operating picture. Therefore, OMFTS argues C2 platforms must expand to meet this employment concept.

Ship-to-Objective Maneuver (STOM) focuses on the tactical issues within the OMFTS concept. The central idea in STOM is projecting power and influence ashore with a force employed over a wider geographic area and allowing operations to occur in a more decentralized manner. Key requirements to this idea included achieving a single-battle concept, tactical maneuver and fires integration, dispersion, and the Marine infantry company as the building block for operations ashore. In the execution of STOM, C2 systems must provide commanders at all echelons a common operational picture and the connectivity to monitor and influence events in real-time. However, by increasing the dispersion between units, there is an increase in uncertainty as to the exact location amongst maneuver units; this in turn reduces the responsiveness of fires. The underlying requirement in both OMFTS and STOM is that more equipment to support a common operating picture is required.
A Concept for Distributed Operations, published in 2005 by the U.S. Marine Corps, describes an operational approach that is an extension of the operational concepts in OMFTS and STOM. Distributed Operations (DO) calls for increased tactical unit dispersion in the battlespace in order to reduce unit vulnerability to enemy effects. DO also calls for increased access to fire support through an enhanced C2 network to ensure dispersed units have increased combat power. Because units are more reliant on non-organic fire support platforms, A Concept for Distributed Operations requires a common operating picture to ensure that units separated geographically are mutually supporting. Therefore, the small unit level requires additional equipment to perform target identification, location, and designation and to communicate with fire support elements and control fire support. The commonality between OMFTS, STOM, and A Concept for Distributed Operations is the requirement for additional equipment to support the MAGTF’s common operating picture.

Enhanced Company Operations (ECO), published by the U.S. Marine Corps in 2008, builds on the concepts in OMFTS, STOM, and DO. ECO states the Marine Company, not the battalion, is the smallest unit capable of sustained operations in a distributed environment. ECO calls for the development of innovative solutions to overcome problems associated with weight, casualty treatment, and communications. C2 systems for the company must be lightweight, designed for mounted or dismounted operations, simple to use for the average Marine, and compatible with the current Unit Operations Center Capability Set IV (battalion level). An enhanced common operating picture is inherent to ECO due to requirements for increasing fire-support response time, reducing fratricide, and aiding in casualty evacuation. Enhanced Company Operations is the extension of concepts articulated a decade earlier in OMFTS and
STOM; however, *Enhanced Company Operations* requires reduced equipment weight to ensure
dismounted Marines can operate effectively in a distributed environment.

**The Challenge of Weight**

At the individual level there are three categories of loads Marines carry: assault, march,
and existence loads. The assault load consists of the equipment required by an individual to
conduct combat operations over an indefinite time with minimal degradation to combat
effectiveness. Historical studies and analysis recommend that the assault load should not
exceed 30% of a Marine’s body weight. Loads exceeding 40% of body weight significantly
decrease physical performance in combat. The assault load carried by Marines serving in
today’s operational environment varies between 57% and 79% of a Marine’s body weight.

The total assault load carried by a dismounted Marine squad includes weapons and
ammunition, protective equipment, sustainment (clothing, food, and water), and communications
equipment. Although communications equipment currently comprises 2% of a squad’s total
assault load weight, predictions are that it will exceed 10% with predicted requirements for
intelligence, surveillance, reconnaissance (ISR) equipment, and communication enablers in the
distributed environment. The reliance on equipment to develop a common operating picture
and support fires is increasing the overall weight carried by the Marine squad. This increased
weight decreases operational effectiveness of the Marine and the squad – the exact opposite of
what is demanded in both *A Concept for Distributed Operations* and *Enhanced Company
Operations*. 
Position Location Information Challenges

The proliferation of un-manned aerial vehicles (UAVs) and other surveillance platforms results in unprecedented battlefield observation for U.S. military forces and enhances the ability of units to operate in a distributed environment. Systems such as the Ground-Based Observation Surveillance System (G-BOSS) and Aerostat provide persistent intelligence, surveillance, and reconnaissance (ISR) capability with day and night cameras as well as through radar to detect moving targets. This observation capability, coupled with precision guided munitions, increases a commander’s ability not only to account for his forces but also to strike enemy targets. However, in April 2011 the Department of Defense announced it was investigating the deaths of two U.S. service-members possibly killed by a US Air Force Predator Hellfire missile after they were mistaken as Taliban insurgents. Reports indicate that Marine leaders watching an infrared video-feed from a Predator authorized a drone strike against armed men moving towards their location. In this instance, leaders could not account for all their Marines in a common operating picture to inform decision.

Command and control (C2) is an interaction between people, information, and C2 support structure and the reporting of PLI within this framework is a procedural reporting requirement from small units to higher headquarters. Time, distance, space, and it effects on individuals and units must inform decisions; therefore, PLI is integral to the commander’s ability to exercise C2. Therefore, the greater information the commander has on the location of his people, the better informed his decisions should be. Uncertainty and time erode the commander’s ability to maintain effective C2 in this respect. Three means to counteract time and uncertainty are push-pull reporting, passive monitoring, or a combination of both.
The Marine Corps program of record for tracking friendly forces is the Data Automated Communications Terminal (DACT), which enables the MAGTF to maintain a common operating picture. The two variants of DACT are the Mounted-DACT (M-DACT) and the Dismounted-DACT (D-DACT). M-DACT uses a vehicle platform to link the commander down to the company-level through the Enhanced Position Location Radio System (EPLRS). The Single-Channel Ground and Airborne Radio System (SINCGARS) combined with the D-DACT links the commander down to the section level. For dismounted units, only sections equipped with the D-DACT tie into the MAGTF operating picture through an automatic data exchange of PLI. All other units are required to use a push-pull system of reporting over radios to inform higher headquarters of their location. Platoons can accurately report their location to within several meters with use of the Global Positioning System (GPS). However, there are two disadvantages within this system of reporting. First, unit location is no longer accurate once the platoon begins movement. It will only be accurate at the time of the next report. Second, the position only accounts for the location of the GPS and not for the entire unit. The actual footprint of the unit may extend over several hundred meters. The unit leader must provide additional information to inform a higher headquarters of the unit’s location when situations require. The Hellfire friendly fire narrative above describes a situation where that apparently did not happen.

In today’s operating environment, nearly every rifleman is equipped with a radio. Due to several factors, including cost and availability, three types of radios exist in a rifle platoon: Integrated Intra-Squad Radio (IISR) for intra-squad communications, the AN/PRC-148 (MBITR) for intra-platoon communications, and the AN/PRC-119G Single-Channel Ground and Airborne Radio System (SINCGARS) for company and battalion communications. Platoons require the
AN/PSN Defense Advanced GPS Receiver (DAGR) for synchronizing frequency hop and determining location. Radio and GPS are the means by which to report location. However, the recently fielded AN/PSC-13 D-DACT (Dismounted - Data Automated Computer Terminal) automates position location information (PLI) reporting into the MAGTF operating picture, increasing battle tempo and reducing the risk of fratricide. D-DACT, using SINCGARS as the communications pathway, is the lowest level of the digital C2 network for dismounted units. D-DACT is therefore limited to the number of SINCGARS available in a unit. If the number of D-DACTs carried in a unit increases to bring more Marines into the common operating picture, the amount of weight a Marine carries also increases.

**Advanced Wireless Network for the Soldier**

Wireless Data Networks (WDN) is the next step in tactical communications technology that will assist Marines with a common operating picture. WDN is a shift from voice-based, push-to-talk communications to Internet Protocol (IP) communications using wireless network technology. IP-based communication platforms provide voice communications, PLI, and data (video, digital photos, text, and chat) transfers across a network. Several defining features make WDN preferable to current voice-based communications. WDN employs mobile ad-hoc networking (MANET) characteristics. MANET is the capability of a mobile device to create new links with other mobile devices as its position changes. Two radios that are unable to communicate with one another because they are outside communications range use a re-trans radio to bridge the distance. The intermediary radio automatically receives and transmits the signal from radio one to radio two. This extends the distance message traffic can be transmitted. Second, wireless networks may possess dynamic spectrum access (DAS) technology, which allows the radio to detect the usable frequency spectrum and avoid transmission interference by
pushing data to open frequencies.\(^2\) That allows multiple units to operate on a frequency without them interfering with each other. Third, IP-based radio nets are scalable. The use of DAS does not limit the number of radios assigned to a net, allowing for scores of nodes to operate on the same network. Fourth, Disruption Tolerant Networking (DTN) technology is a safeguard against losing data transmissions when communication links are lost. DTN ensures that data remains at the last communications link until a network connection is re-established. Once the link is re-established the data transmits automatically. Finally, IP-based radios are capable of secure communications using the Advances Encryption Standard (AES) with an encryption key size of 256 bites, a US government standard for communications security.\(^23\)

Defense Advanced Research Projects Agency’s (DARPA) Advanced Wireless Network for the Soldier’s (AWNS) program tested and evaluated wireless technology’s ability to provide tactical communications for the individual soldier. AWNS used wireless technology “to deliver high-quality voice, imagery, video, chat, position location information, and data services on a network designed to be scalable to very large numbers of nodes.”\(^24\) The AWNS radio weighs no more than 2.5lbs with batteries; this is slightly heavier than the MBITR (1.9lbs).\(^25\) Field experiments conducted at Fort Devens, Massachusetts and Fort Benning, Georgia between June and November 2010 with the AWNS tested the capabilities and limitations of AWNS radios as a viable communications platform at the company level in both mounted and dismounted operations. Field-testing validated AWNS’s ability to provide voice, PLI, and data communications over multiple radio hops, as well as its ability to integrate with programs of record, to include the AN/PRC-117G and EPLRS.\(^26\) Thus, AWNS demonstrated its ability to provide secure tactical communications at the company level during field trials.
AWNS provides PLI by linking in with GPS; however, GPS jamming does not limit AWNS's ability to transmit voice or data communication as the radio is capable of operating without GPS.\(^{27}\) In a non-GPS degraded environment AWNS updates PLI every fifteen meters or thirty seconds.\(^{28}\) PLI updates allow company headquarters to track all soldiers carrying an AWNS in near-real time and allow all soldiers equipped with a Personal Data Assistant (PDA) type device to receive not only their location but also the location of all other AWNS equipped soldiers as well. A PDA will also allow soldiers to receive and transmit formatted messages, video, imagery, and other information. In effect, the AWNS combined with a PDA replace IISR, MBITR, GPS, and D-DACT at the company level.\(^{29}\) Field-testing has also validated AWNS's compatibility for use with vehicles and UAVs.\(^{30}\) In this respect, the versatility demonstrated by AWNS suggests that it is also fully compatible for use with persistent surveillance platforms currently employed by companies and battalions, such as the Ground-Based Observation Surveillance System and Aerostat.

Compatibility between AWNS and persistent ISR platforms offers commanders the opportunity to expand their command and control capability. It is completely conceivable, through software programming, that AWNS nodes can register on video feeds from ISR platforms. Coupled with nodal registration on a Blue Force Tracker this can greatly reduce the uncertainty with individual and unit location. In near-real time, AWNS will passively update a common operating picture thereby reducing the amount of time to request and generate location reports and reduce voice-transmitted data pushed over the radio. In essence, commanders watching UAV video feeds could see an icon identifying individual Marine locations amid the chaotic situation on the battlefield.
Epidermal Electronic Systems

IP-based radio systems can provide a platform to tie Marines into a common operating picture. Other electronic devices carried by Marines for ISR purposes can now interface with the communications network passively, alleviating Marines from many reporting requirements. However, the Lightening the Load study anticipated that weight attributed to ISR and communications equipment may grow to 10% of the total weight carried by a Marine. Therefore, the Marine Corps must seek technology that will prevent this from happening. One technology that may prevent this problem is Epidermal Electronic Systems.

Epidermal electronic systems (EES) represents a breakthrough in medical technology that could further assist in tying Marines into a common operating picture in a distributed environment. (Refer to figure 1 – 4, pp 14-15) The genesis of EES technology was the problem of “picking up the egg” associated with robotics. Robots and prosthetic devices require an ability to measure pressure to avoid breaking an egg when picking it up. EES also resulted from the desire to monitor a patient’s medical condition with the requirement to attach him to bulky wires and monitoring devices. The result was the creation of a small, stretchable, skin-like membrane that contains sensors and a power supply and is applied to a person much like a temporary tattoo.

EES is an electronic chip with the following characteristics: thinner than the width of a human hair, the approximate size of a postage stamp, flexible and stretchable, and self-adhering to the human skin. That allows built-in sensors to monitor and measure electrophysiological, temperature, and stress activity in the body. A limitation to EES is that it can currently function for approximately 24-hours before degrading to the point of interoperability. Many
advanced technological aspects of EES make it ideal for further development. EES does not require an external power source to operate due to its low rate of power consumption. This device may harvest energy through miniaturized solar cells or body generated thermal or movement energy from the wearer, all of which are renewable sources of energy. Furthermore, in addition to simply monitoring physiological status, EES demonstrated it is a versatile platform for other applications as it is compatible with light-emitting diodes, transistors, radio frequency capacitors, wireless antennas, and other components needed to turn it into a radio. In an experiment, EES developers placed EES on a man’s throat to measure muscle activity associated with mouthing the words “up,” “down,” “left,” and “right.” The purpose was to determine the ability of EES to control a strategy video game (Sokoban) and the experiment registered an accuracy rate of over 90%. Thus, EES technology possesses the basic components that can turn it into an enabling device for distributed operations: the ability to sense and transmit information.

With further technological development of the key components of radio and power source, it is probable that EES will become a more robust platform for collecting and transmitting information critical to developing a more complete common operating picture. Through EES commanders may receive information not only on the status of their Marines but also on environmental and enemy produced threats. EES may also integrate in fire support, reducing the amount of information transmitted to initiate a fire support mission. EES can report through IP-based communications medical status, threat detection, and location-direction for fire support.

EES has already proved its ability to monitor the physiological status of a patient and as a result can greatly assist with battlefield medicine. A commander can use this information to stay
abreast of the physical status of his Marines. Leaders are warned when a Marine’s physical status is about to change by measuring blood pressure, heart rate, electro-activity, etc. This can prevent environmental casualties before they occur. EES can assist medical staffs by providing information vital to triaging wounded Marines. Blast dosimetry is an example of how EES can assist in the triaging of Marines. By measuring the blast to which a Marine was exposed, medical authorities can determine the care that a Marine requires and the likelihood of traumatic brain injury. This aids in subsequent care and treatment. By updating the physiological status through EES, commanders can make better-informed decisions.

EES sensors can measure external occurrences such as temperature and passively monitor biological and chemical threats. Marines equipped with EES become sensor-detectors on the battlefield, assisting commanders with force protection. EES may not only replace monitor and survey equipment for chemical, biological, radiological, and nuclear (CBRN) teams but may also generate and promulgate an NBC-1 report over the wireless communications network. Another example of threat monitoring is the ability to range sound. By equipping EES with detection microphones, units can determine the location from which snipers fire. EES nodes distributed across the unit measure the sound and report it back to the unit’s command post. There it is processed and reported back to the unit for action. Passive monitoring devices on every individual can make the concept of “every Marine a sensor” a reality.

It is possible that EES could assist requests for fire support. In the future distributed operations environment, each Marine should have an IP-based radio. The radio links with the GPS network to determine location and orientation. This occurs automatically and continuously. Understanding that EES communicates with IP-based radios wirelessly, one can assume that the radio can measure the direction and distance between EES and the radio by measuring the time it
takes to interface between the two devices, the PLI of the radio and declination north, and EES transmission reception on the radio antenna. When a Marine with EES on is hand points, his location (PLI) and pointing direction (location of EES in relation to PLI) can be determined. This allows fire support requests initiation by simply pointing at the threat and giving a description and distance. A Concept for Distributed Operations requires small unit leaders to have equipment to assist with target location. EES may meet that requirement without increasing equipment weight.

Conclusion

Technological advances over the past twenty years have significantly expanded the amount of information to which people have access. Marine Corps command and control is dependent upon timely, accurate, and relevant information to inform the decision-making process in operating environment. Therefore, the Marine Corps needs to seek out and develop emerging technologies that give it a competitive edge in command and control.

Advanced Wireless Network for the Soldier and Epidermal Electronic Systems technologies are solutions that may decrease weight and increase the MAGTF’s common operating picture; therefore, these two systems require greater research and development. Distributed Operations requires additional equipment to ensure robust C2 networks, enhance ISR capabilities, and provide the information needed for accurate fire support. Although technology currently exists to support distributed operations, the technology also limits the ability to conduct distributed operations due to its weight and bulk. As the Marine Corps continues to advance the concept of distributed operations and enhanced company operations, the Marine Corps must look to technology that is multi-functional and reduces the overall weight Marines carry.
(Figure 1: EES Concept)\textsuperscript{38}

(Figure 2: EES circuit applied to human skin)\textsuperscript{39}
(Figure 3: EES on top of hand)\textsuperscript{40}

(Figure 3: Removing EES from the forehead)\textsuperscript{41}


Marine Corps Tactical Systems Support Activity. “Blue Forces SA Fact Sheet.”


9 Naval Research Advisory Committee. *Lightening the Load*, (Arlington, VA: Office of the Assistance Secretary of the Navy for Research, Development and Acquisition, September 2007), 13-14. Naval Research Advisory Committee defines the Approach March Load as the load for conducting a “20-mile march within 8 hours maintaining 90% combat effectiveness” and the Existence Load as a load associated with “limited movement within the confines of transportation platforms and limited marching from landing zone into secure area.” The recommended march load is 45% of body mass and the recommended existence load is 75% of body mass. Current operating environment for march and existence loads are 73% and 99% for a Marine weighing 169lbs.
22 Marine Corps Systems Command, “Ground-Bases Operational Surveillance System.”
22 DARPA Brief, Advanced Wireless Networks for the Soldiers (AWNS) With Wireless Network after Next (WNaN) Integration and Demonstration, dated 21 September 2011, slide 3 of PowerPoint brief by Dr. Bruce Fette.
23 DARPA Brief, Advanced Wireless Networks for the Soldiers (AWNS) With Wireless Network after Next (WNaN) Integration and Demonstration, dated 21 September 2011, slide 3 of PowerPoint brief by Dr. Bruce Fette.
24 DARPA, Broad Agency Announcement, Advanced Wireless Networks for the Soldiers (AWNS), Strategic Technology Officer, 3 November 2010, p 8.
26 DARPA Brief, Advanced Wireless Networks for the Soldiers (AWNS) With Wireless Network after Next (WNaN) Integration and Demonstration, dated 21 September 2011, slide 6 of PowerPoint brief by Dr. Bruce Fette.
27 DARPA Brief, Advanced Wireless Networks for the Soldiers (AWNS) With Wireless Network after Next (WNaN) Integration and Demonstration, dated 21 September 2011, slide 11 of PowerPoint brief by Dr. Bruce Fette.
28 John Flannigan (Contractor, Sage-Solutions, DARPA) interviewed by author 21 September 2011.
29 When viewed in conjunction with supported equipment required for distributed operations, D-DACT weighs 1.9lbs and the MBITR is another 1.9lbs for a total of 3.8lbs. The combination of AWNS and a PDA is just under 3lbs (2.5lbs and 4.9oz). A typical i-phone weighs nearly the same as an off-the-shelf (OTS) GPS (5.5oz); this, therefore is a one for one swap with the added ability of data communications.
30 DARPA Brief, Advanced Wireless Networks for the Soldiers (AWNS) With Wireless Network after Next (WNaN) Integration and Demonstration, dated 21 September 2011, slide 11 of PowerPoint brief by Dr. Bruce Fette.
36 John Rodgers, e-mail to author dated 20 October 2011. John Rodgers is the leader developer on EES sees inevitable use of this technology for both consumers and the military.
38 Sciencemag.org. http://www.google.com/imgres?imgurl=http://www.sciencemag.org/content/333/6044/838/F1.large.jpg&imgrefurl=http://www.sciencemag.org/content/333/6044/838/F1.expansion.html&usg= YlLni8ixNRSMu98H8ALQ1xDc YQ=&h=964&w=1049&sz=346&hl=en&start=19&zoom=1&tbm=isch&tbnh=138&tbnw=150&ei=ARZT4b A4e60AhjibHLDw&prev=/search%3Fq%3Depidermal%2Belectronic%2Bsystem%2B(eesl%2Bsciencemag%26um%3D1%26hl%3Den%26sa%3DN%26tbm%3Disch&um=1&itbs=1