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Naval Research Advisory
Committee Report



SHIP-TO-WARFIGHTER LOGISTICS FOR SMALL UNIT OPERATIONS

MARCH 1998

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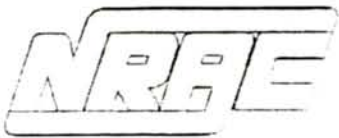
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13. ABSTRACT (Maximum 200 words) NRAC assessed ship-to-warfighter logistics for Small Unit Operations, focusing on rapid response expeditionary operations. Recommendations are: <u>Information Systems/Training</u> : Modify the military structure and training standards for today's computer literate, cross-trainable recruits. Combat-specific training must include systems limitations; realistic threat and electronic/information warfare environments; open systems standards; and commercial technology. The Combat Support Services-Enterprise experiment should grow into a logistics test bed with the 15th Marine Expeditionary Unit. <u>Delivery systems</u> : Use unmanned vehicles in training exercises, and reduce the Marine's equipment load. <u>Power/Energy conversion consumption</u> : Radios and batteries are major drivers for a Marine's equipment load. Significant energy savings is available immediately through communications protocols focused on reducing energy consumption. Both fuel cells and micro-machined power modules (engines/generators) offer future potential for high density power supplies. <u>Communications/navigation</u> : Recognize the vulnerability of GPS signals to lower power jamming. <u>Consumables</u> : The Marine and his equipment load (dominated by consumables, e.g. ammunition, water) should be viewed as an integrated weapon system. <u>Health services</u> : Recommendations include: revised trauma model that supports operational concepts; casualty stabilization/intervention including new hemorrhage control techniques, telemedicine and remote protocols development; stealthy unmanned evacuation systems; and improved readiness via vaccines, chemoprophylaxis and repellents. <u>Improved chemical/biological capability</u> : Joint requirements should support emerging operational concepts. Develop portable sensors for early, sub-lethal detection; portable, waterless chemical decontamination approaches; and improved protective clothing.					
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SHIP-TO-WARFIGHTER LOGISTICS FOR SMALL UNIT OPERATIONS

Table of Contents

Report Documentation Page	i
Title Page	iii
Table of Contents	1
Executive Summary	3
Outline	7
Terms of Reference	9
Panel	11
Briefing Organizations	13
Framework and Approach	17
Overarching Issues	31
Technology Windows of Opportunity	39
Information Systems	41
Delivery Systems	51
Power/Energy	63
Communication/Navigation	73
Consumables	81
Health Services	91
Chemical/Biological Detection	101
"Take Aways"	107
Appendix A: Acronym List	A-1
Appendix B: Bibliography	B-1

Naval Research Advisory Committee

Ship to Warfighter Logistics for Small Unit Operations Executive Summary

The Naval Research Advisory Committee (NRAC) was tasked by the Honorable John Douglass, Assistant Secretary of the Navy for Research, Development and Acquisition [ASN(RDA)], to conduct a study of ship-to-warfighter logistics for Small Unit Operations (SUOs), with particular attention to the challenges involved in supporting rapid response expeditionary operations in the littorals.

The NRAC Panel decided to approach the complex problems involved in logistics for SUOs by addressing needs and formulating recommendations in seven areas: information systems, delivery systems, power/energy, communications/navigation, consumables, health services (including combat casualty care), and chemical/biological (C/B) capability.

During the course of addressing needs and formulating recommendations, the Panel drew upon operational concepts, advanced warfighting experiments, Advanced Concept Technology Demonstrations (ACTDs), and operations fortuitously witnessed aboard the USS LaSalle (Joint Task Force Command Ship) during the Albanian American Citizen Non-combatant Evacuation Operation (NEO). From all these, the Panel singled out for attention those concepts and technologies that it felt could significantly reduce logistics footprint, minimize exposure time, and increase SUO efficacy.

The Panel believes that the consequent recommendations laid out in this report provide the foundation for an affordable DON technology investment strategy leading to substantially more effective and efficient ship-to-warfighter logistics for SUOs.

Overarching Problems and Opportunities

Nearly thirty detailed recommendations emerged from the work of the Panel on the seven subareas---information systems, delivery systems, power/energy, communications/navigation, consumables, health services, and C/B capability.

As the work on these detailed recommendations progressed, three overarching collections of problems and coupled opportunities emerged that the Panel believes merit the attention and action of DON senior leadership:

Training problems and opportunities: Assumptions should be adjusted to recognize the skills of today's recruits, who are increasingly computer literate and cross-trainable. The Military Occupation Specialty (MOS) structure and Individual Training Standards (ITS) should be modified to reflect these capabilities. Combat-specific training must include systems limitations, uncertainties, and

unavailabilities. Training should be conducted within an appropriate electronic/information warfare environment because of the increasing dependence on electronics and communications technology.

Potentially war-winning systems, such as unmanned vehicles of various sorts, should be incorporated in surrogate form into training exercises to determine where technology investments would have the greatest impact. The Marine's equipment load, increasing as technology progresses, should be reduced by viewing the Marine and his load as an integrated weapons system, adjusted according to results obtained in experimenting in training exercises with alternative load levels and load distributions.

Finally, modern commercial technology needs to be tried in a realistic military environment to explore the effectiveness of alternative operational concepts.

Energy conversion/consumption problems and opportunities: Increasing dependence upon information flow and communications ensures that radios and batteries will continue to be significant drivers for a Marine's equipment load and for the resupply of SUOs. Fortunately, significant energy savings can be attained through radio, signal-processing, and communications-protocol designs that are focused on reducing energy consumption. The potential exists to provide as much as a 30-to-1 increase in battery life. Training is also warranted to provide improved communications discipline leading to reduced transmissions.

Transition from AWEs: AWEs are excellent vehicles for evaluating and establishing the merits of new operational concepts designed to exploit emerging technology. For example, the Panel was impressed by the Combat Support Services-Enterprise (CSS-E) experiment, and recommends that the experiment should grow into a logistics test-bed with the 15th Marine Expeditionary Unit (MEU).

In general, however, the Panel recommends caution in transition to acquisition for two reasons: First, AWEs need to be exposed to additional threats in an operational assessment to evaluate limited degradation or denial, new concept training inadequacies, and environmental extremes. Second, information technology is moving faster than the acquisition cycle; thus, commercial technology must be leveraged to the maximum extent feasible.

Specific Recommendations

Information systems: The Panel compared deployed USMC logistics services with those offered by the CSS-E experiment conducted as an adjunct to the Hunter Warrior AWE. CSS-E after action reports indicate that the assembled hardware and software provide a potentially low risk, low cost, "80-90" percent solution to requirements for situation awareness, asset visibility, customer confidence, logistics command and control, inventory and footprint, effective asset allocation and logistics

anticipation. The Panel recommends CSS-E be deployed, with proper consideration of military communications and information systems safeguards. The Panel also recommends that future logistics systems applications development use "open systems" standards.

Delivery systems: The introduction of jungle or urban warfare environments necessitates considering Unmanned Air Vehicles (UAV) and Unmanned Ground Vehicles (UGV), while riverine or littoral operations suggest use of Unmanned Surface Vehicles (USV). Fortunately, a number of manned and unmanned systems show great promise, especially when equipped with beacon or Global Positioning System/Inertial Navigation System (GPS/INS) capabilities. With appropriate development, such systems could deliver consumables, supply just-in-time ammunition, evacuate casualties, and provide many types of surveillance operations. The Panel recommends the use of manned vehicles or unmanned prototypes as surrogates in the upcoming AWEs so as to determine the potential operational impact of various AWE capabilities and to help guide technology investments.

Power/Energy: Today's radio and battery systems add enormously to the weight carried by SUO personnel. In the future, both fuel cells and micro-machined power modules (engines/generators) offer potential for high density power supplies, but there are no near-term alternatives for general purpose applications. Accordingly, the Panel recommends strong efforts in the direction of improved operator training, better radio and signal processing designs, and carefully selected communications protocols, all with a view toward increasing energy efficiency by at least an order of magnitude.

Communications/Navigation: The Panel found that the vulnerability of GPS signals to low power jamming, particularly for the ground force and aerial resupply techniques, was not widely appreciated. Solutions can be very costly and may require the introduction of "psuedolites" as airborne, high-power GPS repeaters in an integrated expeditionary communications/navigation infrastructure. The Panel recommends careful attention to these issues, with the immediate introduction of training in a realistic communications/navigation threat environment.

Consumables: Today's Marine either carries an enormous load or leaves something important behind. Consumables--such as ammunition, rations, water, and repair parts--dominate that load and drive SUO replenishment requirements for missions longer than 4 days and SUO size greater than 10 Marines. The Panel recommends the pursuit of a number of promising load-reducing technologies and further recommends an approach to tailoring loads that views the Marine and his equipment load as an integrated weapon system.

Health services: The Panel recommends: a revised trauma model that supports operational concepts (not based on the civilian EMS model); improved battlefield casualty stabilization and intervention that includes new hemorrhage control techniques, telemedicine and remote

protocols development; stealthy unmanned evacuation systems; improved pre- and post-deployment medical readiness via vaccines, chemoprophylactics and repellents; and continued microbial and chemical research to address new threats.

Improved C/B capability: The Panel recommends that the DON ensure that joint requirements support emerging operational concepts. The array of sensor technology development for C/B detection is impressive, improving markedly upon fielded systems. Development recommendations include: portable sensors for early, sub-lethal detection; portable, waterless chemical decontamination approaches; and improved protective clothing.



Outline

- Terms of Reference/Specific Tasking
- Panel
- Briefings
- Operational Framework
- Study Approach
- Overarching Issues
- Technology Windows of Opportunity
 - Information
 - Communications/Navigation
 - Delivery
 - Consumables
 - Power/Energy
 - Health Services
 - Chemical/Biological Detection and Decontamination
- "Take Aways"

This NRAC Ship-to-Warfighter Logistics for Small Unit Operations Report is organized into five basic areas. The report begins with administrative topics such as study tasking, participants, and sources of information. The report next addresses conceptual and operational frameworks for the study and the specific study approach. These are followed by identification of a set of overarching issues which were found to be pervasive throughout both the operational logistics and the technology elements of the study. The report then addresses seven technology "products," or windows of opportunity, with specific recommendations in each of these areas. Finally, there is a summary of key points and recommendations, called "Take Aways" for DON senior leadership consideration.



Terms of Reference - Specific Tasking

- Identify resupply requirements and unique challenges of SUO
- Review existing technologies for fast, precise delivery and distribution
- Recommend new technologies or innovative use of existing technologies to have an impact
- Specifically address medical, medevac and CBW needs

In March 1997, NRAC was charged with an assessment of the DON logistics support for SUOs. The general study objective called for a technology assessment related to logistics initiatives to support emerging field concepts dominated by SUOs. The Panel also was asked to specifically address medical, medevac, and chemical/biological warfare (CBW) needs.

For the purpose of this study, the Panel looked at a range of issues surrounding the resupply of small units, including natural environment (desert, jungle, urban), levels of technology maturity, and the methods of resupply. Combat casualty care was addressed with and without the availability of medevac.

The specific Terms of Reference for the NRAC Summer Study Panel on Ship-to-Warfighter Logistics for SUOs are included here in their entirety.

Terms of Reference for NRAC Panel on Ship-to-Warfighter Logistics for Small Unit Operations

General Objective: Identify future science and technology opportunities, and assess technologies associated with current DON logistics initiatives in order to resupply forward-deployed SUOs with food, ammunition, water, fuel, batteries, medical supplies, etc., with minimum footprint and exposure time, and maintain communications for a period of several days to several weeks.

Background: For most of the 20th century the usefulness of seabased logistics has been limited by the voracious appetite of modern landing forces for such items as fuel, large caliber ammunition, and

aviation ordnance. In the future, the United States is likely to face a number of very different threats to its security, interests, and way of life. Many of these threats will originate from within the littorals (those areas along the coastline), forming the basis for operational concepts embodied in Naval doctrine such as "From The Sea" and "Operational Maneuver From The Sea," and some new operational concepts such as those exemplified in the DON Extended Littoral Battlefield ACTD, or USMC "Sea Dragon."

Improvements in the precision of long-range weapons, greater reliance on sea-based fire support, departure from traditional expeditionary landing operations, greater maneuver potential and effectiveness of small units, and possibly less reliance on mechanized armor, promises to significantly alter the manner in which supply facilities are established ashore. Emphasis will be on speed, reduced footprint, and, in some cases, covert resupply.

Specific Tasking:

- a. Provide a matrix of resupply requirements and unique challenges for SUOs, ranging from MEU needs to support of small team(s) based on natural environment, communications, types of supplies and rates of consumption.
- b. Review existing technologies applicable to fast, precision delivery and distribution of supplies (e.g., GPS, Remotely Piloted Vehicle (RPV)/UAV, parafoils, and information/communication).
- c. Recommend new technologies and innovative use of existing technologies that affect resupply needs or consumption (e.g., alternate fuel sources, solar or alternate source battery charging and power generation, and remote diagnostics) rates.
- d. Specifically address disease prevention, mitigation, and medevac needs and approaches, including recommendations for chemical/biological warning and prophylaxis.

Sponsor: MAJ GEN Edward Hanlon, Jr., USMC, Director, Expeditionary Warfare (N85), OPNAV.

Executive Secretaries: CAPT Chris Daly, SC, USNR, CINCPACFLT, (808) 417-3984 and LtCol. Joe Kusior, USMC, Commander, USMC Forces Pacific, (808) 477-8323.



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Panel formed in January 1997

The Panel was composed of representatives from industry, academia, and the DON science and technology community. Seven NRAC members were complemented with a cadre of subject matter experts to address this issue.

The sponsor of the study was MGEN Edward Hanlon, Jr., Director of Expeditionary Warfare (N85), Office of the Chief of Naval Operations.

The study topic was proposed in the fourth quarter of 1996, and the NRAC Panel began its deliberations in March 1997.



Briefing Organizations

N85 (Expeditionary Warfare)	Naval Special Warfare Group One
Marine Corps Warfighting Lab	Naval Special Boat Unit Twelve
HQ, USMC (Installations and Logistics)	Caterpillar, Inc.
1st FSSG	Defense Science Board
ELB ACTD	DASN (C4I)
USA Force XXI Integration Div.	Former ASD (International Affairs)
US Army Land Warrior/PM Soldier	
Naval Special Warfare Command	

In the three months prior to the final two-week report preparation period, the Panel hosted briefings from more than 30 organizations; some discussing a variety of topics relevant to future logistics deployment and small unit operational concepts. Briefers represented a large cross-section of Department of Defense (DOD), DON, Army, and university research and technology centers, in addition to private industry. The Marine Corps provided extensive insight into their Advanced Warfighting Experiment (AWE), especially the Sea Dragon Program, and the Marine Corps Warfighting Laboratory. The Army and DON provided insight into their battle lab concepts as well, including an assessment of current operational concepts by the Naval Special Warfare Command and briefings on the Extended Littoral Battlefield (ELB) ACTD.

NRAC members who participated on the Panel also had the benefit of three additional relevant visits: (1) a full-day visit to the USMC Warfighting Laboratory at Quantico in the fall of 1996; (2) a visit to observe the Hunter Warrior AWE at 29 Palms in March 1997; and (3) a visit to the Joint Task Force Command Ship, USS LaSalle, during a NEO in Albania, involving the 26th MEU from the NASSAU Amphibious Ready Group (ARG) in March 1997.



Briefing Organizations

DARPA Defense Sciences Office

DARPA Tactical Technology Office

Naval Research Laboratory

OUSD Land Warfare UGV PM

Naval Medical Research
and Development Command

Delta Defense/Delta Frangible Ammunition

Naval Health Research Center

US Army Medical Research Institute
of Infectious Diseases

Department of EECS
University of California, Berkeley

Telemedicine Research Laboratory, US Army
Medical Research and Materiel Command

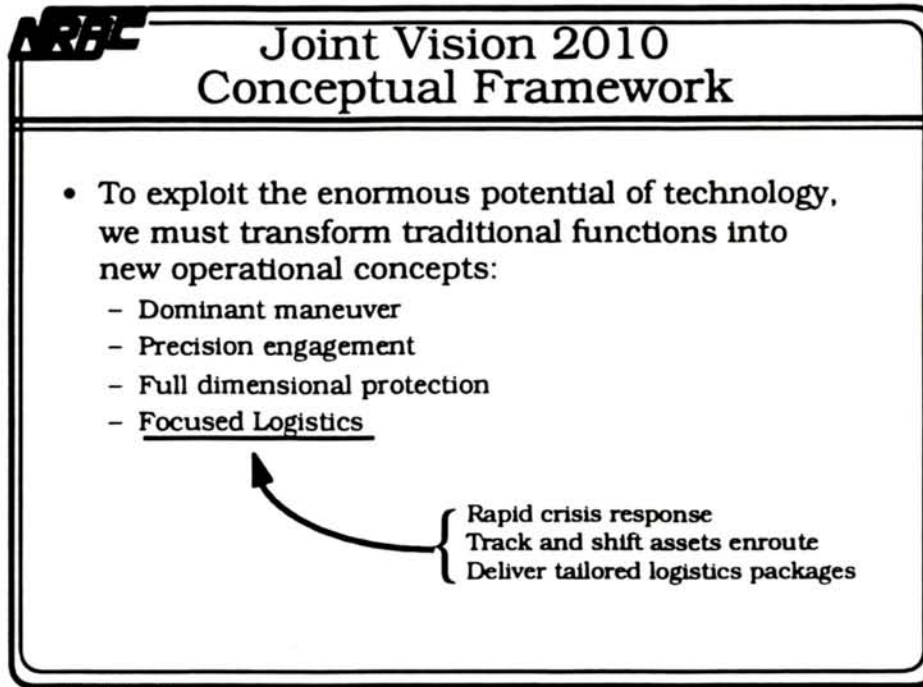
USN SPAWAR GPS Program Manager

Telemedicine Program Office
ASD (Health Affairs)

NRaD, Unmanned Vehicles Division

The Panel gained a solid understanding of logistics needs for a variety of SUOs and variations in unit size, tasking, and environment. The Panel was divided into four sub-panels, two addressing different aspects of technology maturity, and one each to address operational requirements and medical services.

In the final days of deliberations, the Panel arrived at specific recommendations for seven different technology areas and for a small set of overarching issues which span all elements of the study.



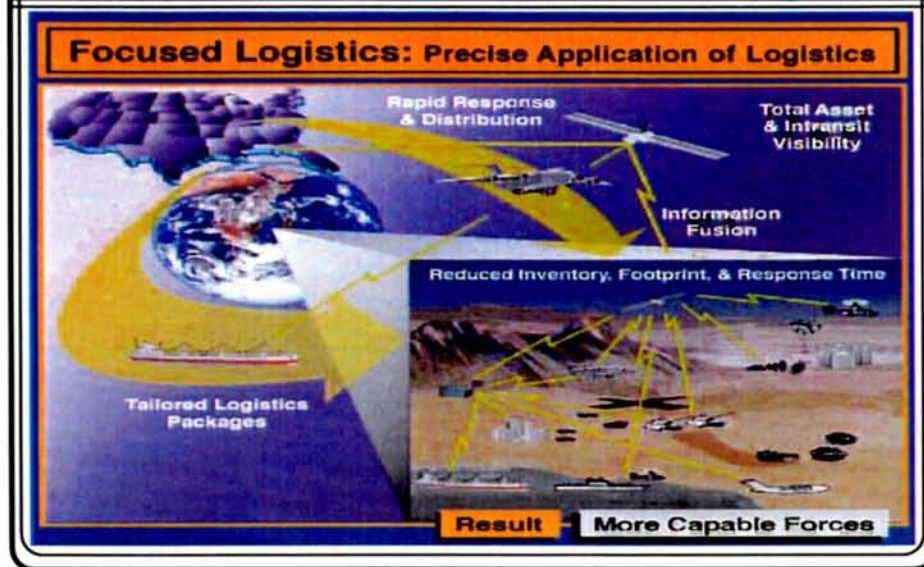
The Panel selected Joint Vision 2010 to establish a conceptual framework for the study. Joint Vision 2010 draws upon dramatic advances in information technology that greatly enhance intelligence, and command and control to develop four operational concepts:

- dominant maneuver
- precision engagement
- full dimensional protection, and
- focused logistics.

The focused logistics element was used to provide a more specific framework. In this context, focused logistics, as subsequently defined, is based upon integration of information, logistics and transportation technologies to provide rapid crisis response, to track and shift assets even while en route, and to deliver tailored logistics packages directly to the strategic, operational, and tactical levels of operations.

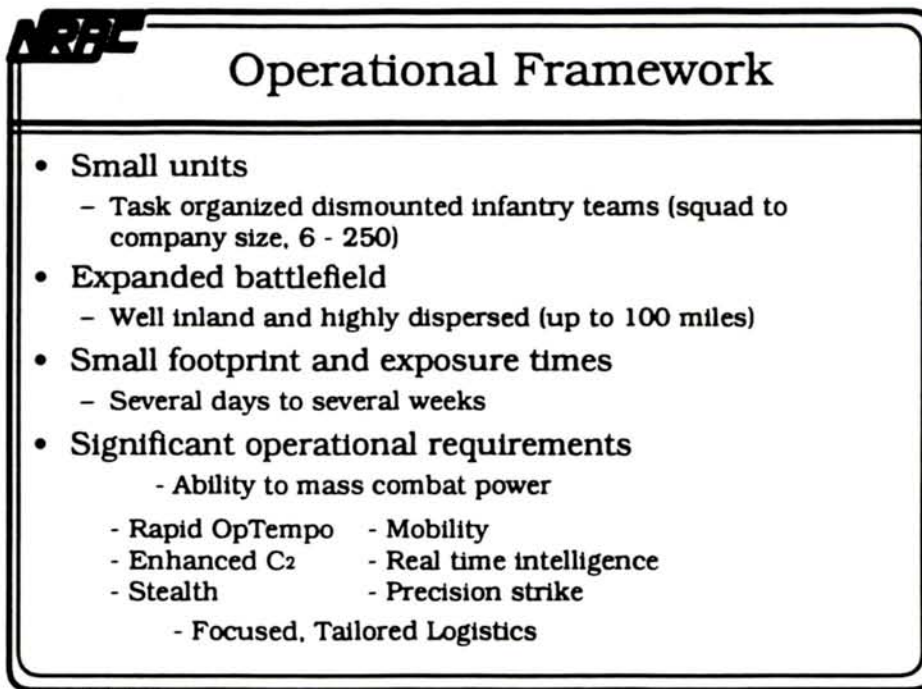


Focused Logistics from Joint Vision 2010



A quick, simple definition for focused logistics is precise application of logistics. Elements include logistics packages specifically tailored to the user's needs, total asset and intransit visibility to provide rapid response, and timely and precise distribution to the user. A keystone for the process is the fusion of information throughout the operational request, supply, and delivery chain.

Rapid response and timely precision delivery facilitate resupply with minimum footprint and exposure time, and allow for reduced inventory at intermediate stages and the final use point. The result of this process provides for warfighting leverage and more capable forces.

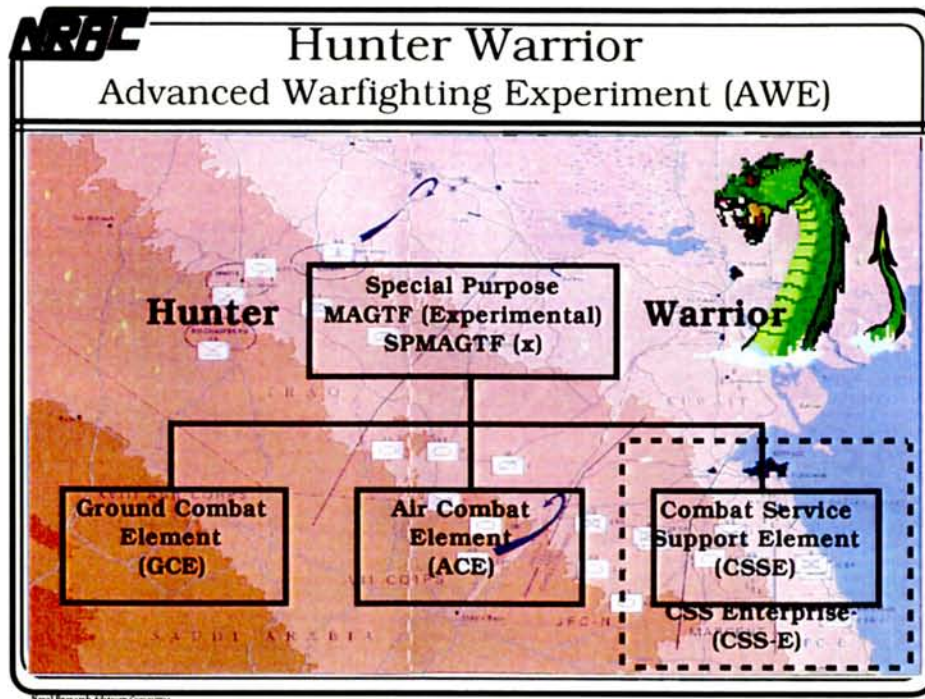


Building upon the conceptual framework, the Panel thought it was important to establish an operational framework and environmental and operational conditions in which SUOs might take place. Such a framework provides a basis from which to identify and exploit future technology opportunities, as well as to assess current technologies required to support SUOs with combat service support.

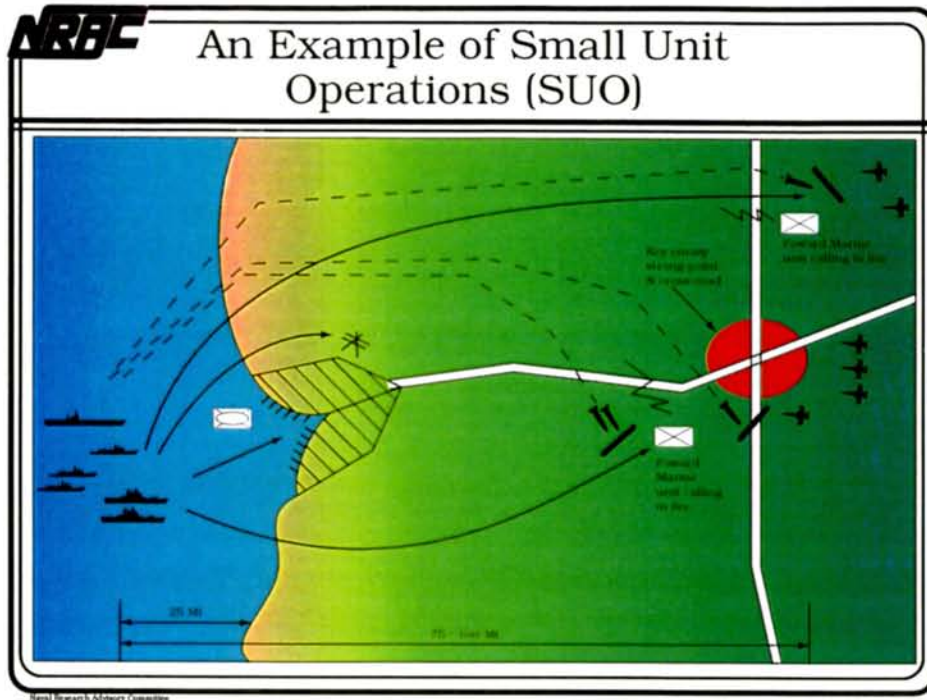
"Small Units" were defined as task organized teams, from squad to company size, capable of deploying over an expanded battlefield, well inland and widely dispersed (up to 100 miles), or within urban areas. They must present a minimum footprint and limited exposure time, while maintaining command and control (C²) for a period of several days to several weeks.

The operational environment and conditions these small units will operate within will require the ability to mass through rapid concentration of combat power, rapid operational tempo, enhanced C², real time intelligence, precision strike capabilities, and stealth, mobility, and focused, tailored logistics.

The Panel evaluated the resulting SUO resupply needs in the context of maintaining adequate and secure communications for resupply information, flexible and timely precision resupply, self-sufficiency, and reduced mass and volume for the resupply needs.



Emerging concepts and technologies attendant to the operational framework previously described are currently being evaluated by the Marine Corps Warfighting Laboratory. A Special Purpose Marine Air-Ground Task Force (SPMAGTF), with ground, air, and combat services support elements, has been formed for concept and technology evaluation. The Combat Service Support Element is designated CSS Enterprise. During Exercise Hunter Warrior, the first in a series of experimental exercises, CSS Enterprise employed new logistical concepts. These provided an important baseline for this study.



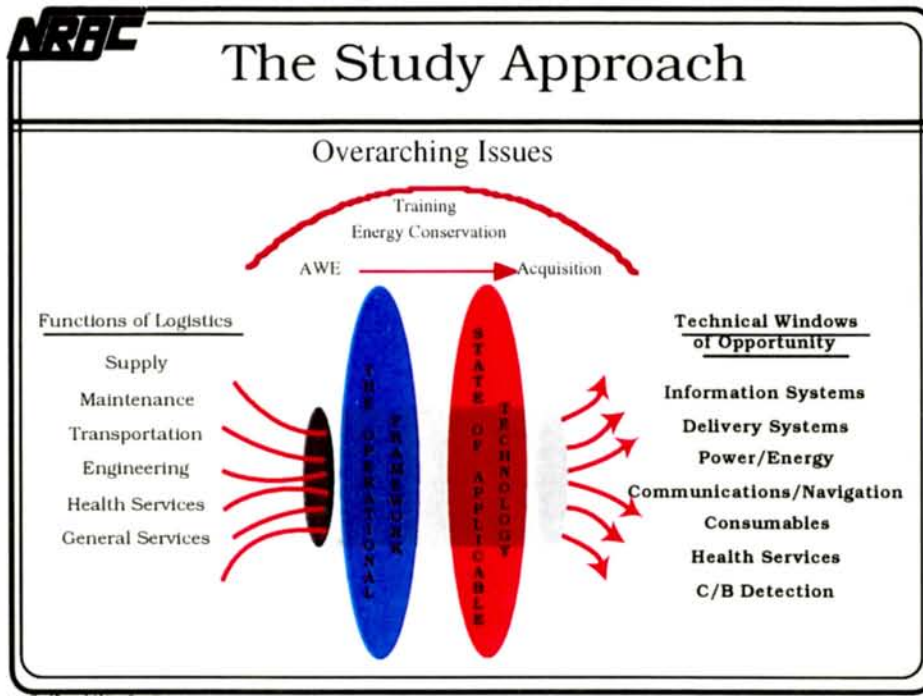
This chart illustrates one type of SUO at the upper limits of such operations.

The opponents are rebel forces in a Third World country in the throes of revolution. The objective is to secure possession of the airfield just inland from the country's primary port city. This is needed to evacuate American citizens and other foreign nationals, and possibly to bring in supplies in support of the national government.

The opponent forces basically are irregular light infantry and are positioned around a critical road junction located approximately 75 miles inland from the port. The road network is limited in extent and critical to the movement of ground forces lacking the airlift capabilities of US forces.

In this operation, a reinforced, battalion-sized MEU has been positioned off the port, supported by accompanying US Naval forces. The MEU commander begins his attack to secure and hold the airfield and port with two simultaneous, coordinated SUOs against the rebel forces located around the key road junction. In these two operations, Marine dismounted infantry companies are airlifted into positions straddling the road junction where they can observe the opponent's main positions and call in heavy missile and aircraft-launched fires on those positions. Their first objective is the maximum destruction and disruption of those forces. Following that, they will secure the road junction and block any attempt to interfere with US operations at the airfield and elsewhere in the port area. Depending on how US political objectives evolve following these initial SUOs, the units involved will either fall back to the port area and be withdrawn as the evacuation mission is completed, or be relieved by larger reinforcing units as a

longer in-country restoration mission develops. In either case, a SUO such as this normally will be completed in a few days to, at most, a few weeks.



Once the conceptual and operational framework for SUOs was established, the Panel considered the impact of logistics support as affected by unit size, dispersion, and environmental extremes. SUO size was considered to increase in multiples (i.e., by increasing the number of squads until the desired force size is achieved), with support and special services scaled to accommodate. Dispersal was affected primarily by mobility organic to the unit and insertion/extraction alternatives. Operational and natural environments were examined to determine where unique requirements may be imposed. Special services issues (e.g., medical and CBW) were considered as separate elements. It became evident that the most taxing requirements were associated with the dismounted squad size units.

The logistics functions (supply, maintenance, transportation, engineering, health services, and general services) were examined from two aspects: (1) operational framework; and (2) an assessment of existing and future technologies applicable to these functions as related to SUOs.

Specific technology areas were identified to improve the DON's ability to resupply rapidly (speed), reduce the needed volume of resupply (footprint), and minimize vulnerability during the resupply process (exposure). The technology "windows of opportunity" were in the following areas: information systems, delivery systems, power/energy, communication/navigation, consumables, health services, and C/B detection. These "windows of opportunity" form the basis for this report.

During the course of the study there were three issues which were pervasive. The Panel considered these as "overarching issues" for the

study, and they are treated separately in summary terms. They are training, energy conversion, and transition from AWE to acquisition.

Take Aways

- **Keep CSS-E going . . . grow into deployed logistics testbed**
- **It's not the batteries . . . fix the radios and communication protocols**
- **Need training and technology discipline across the board . . . tested in operational environments**
 - Disciplined communications/degraded environment
 - Wider use of surrogates
 - Integration of individual equipment load and the Marine as a weapon system

This study was unusually broad because of the number of logistics functions associated with maintaining operations and the resulting number of specific technology product areas which impact logistics and small unit operations on a day-to-day basis. Therefore, the Panel chose to develop a set of three main issues and recommendations as "take-aways" for senior DON leadership consideration which reflect a total of 29 detailed recommendations that have been developed across the span of seven technology areas which are described in those sections of the report and tied back to this chart.

The CSS-E experiment was a success and provides a low cost, low risk 80-90% solution to logistics information management. It should be grown into a deployed logistics testbed with the 15th MEU in 1998.

Batteries (and radios) heavily influence the load for the individual Marine and present a significant resupply problem. Unfortunately, battery technology is relatively mature, and significant gains in output power per unit size are not forecast. However, it is clear that today's commercial electronic technology, if applied and adapted to military radios and signal processing, can provide a significant improvement in energy use as can new communication protocols which focus on reduced transmissions.

It became clear to the Panel that training and technology discipline are needed across the board, including testing in operational environments. Elements include disciplined communications use in a degraded environment and wider use of surrogates to test operational concepts (e.g., unmanned ground or air vehicles) in order to define a proper set of operational requirements relevant to SUOs. In addition, the Panel believes that the individual Marine and his equipment load

should be treated as an integrated weapon system, with a focus on reducing the load. Finally, technology is seductive. The Panel cautions that off-the-shelf technology, untried in a military environment, may be vulnerable to exploitation. The Panel believes this underscores the importance of the operational testing/requirements definition process. The Panel also believes that it is mandatory to leverage commercial technology, while at the same time shorten the acquisition process.



Overarching Issues

- Training
- Energy Conservation
- AWE → Acquisition

Three issues emerged that appeared in virtually all aspects of the study. They are training, energy conservation and transition from AWEs to the acquisition process.

Training needs to reflect the background and skills of today's recruits (e.g. computer literate), who are much more amenable to and capable of cross-training than in the past. MOS structure and ITS should be upgraded to reflect this. In addition, combat specific training must account (and prepare) for systems limitations, uncertainties, or lack of availability by incorporating alternatives. Finally, due to an increasing dependence on electronics and communications technology, the training should be conducted within an appropriate electronic/information warfare environment.

The Panel observed that, with a greater dependence upon information flow and communication, there is greater use of radios...hence power supplies. For SUOs this is typically thought to be "batteries." Radios and batteries are significant drivers for the individual Marine's equipment load and for resupply of SUO. However, significant savings in energy requirements can be attained through radio and signal processing design focused upon energy reduction. The potential exists to provide as much as a 30-to-1 increase in battery life. This issue goes hand-in-hand with training to reduce the number of transmissions necessary, streamline transmission protocols, and provide essential communications discipline.

The AWEs make excellent use of surrogates, based upon commercial technology in many cases, to evaluate and even establish new operational concepts and their merits. The AWEs are properly designed to exploit the available technology and are success oriented.

The Panel discussed two specific issues in the context of transition to acquisition which may produce unintended results. First, the Panel believes that the AWEs need to be subjected to additional threats in an operational assessment to evaluate limited degradation or denial, training inadequacies for the new concepts, and environmental extremes. Second, the Panel notes that technology, specifically commercial information technology and processes, is moving faster than the acquisition cycles. It is clear that commercial technology must be leveraged to the maximum extent which includes both a need to remove traditional impediments on protection of emerging commercial intellectual property (relating to technology advances) and a need to dramatically reduce acquisition/deployment time.



Training: The Ultimate Key to Success on the Battlefield!

- Small Unit Operations (SUOs) tax skills proficiency and fitness
- Today's Marine can master far more skills than required by current Military Occupation Specialty (MOS) structure and Individual Training Standards (ITS)
- Skill cross-training is not only desirable, but highly feasible to enhance the conduct of SUOs
- We must train to systems limitations and within an Electronic/Information Warfare environment

As the Defense Science Board Task Force on Tactics and Technology for the 21st Century stated in their report: "Training is critical and near (or at) the top of the determinants of victory." In the case of emerging operational concepts which call for small units deployed over an expanded battlefield, well inland and widely dispersed, or within urban areas, the individual Marine must be more highly trained, proficient in numerous military skills, and exceptionally physically fit. Current day Marines have the capability of mastering far more combat and technical skills than MOS structure or current ITS call for them to maintain. Preparation of the SPMAGTF for Hunter Warrior clearly demonstrated this. Individual Marines of junior rank (Private to Sergeant) were trained to senior staff noncommissioned officer (Gunnery Sergeant) standards with little difficulty. This fact is critical to success on the future battlefield. Equally, it supports a much needed skill cross-training requirement for members of small units operating independently. Two experiments conducted during Hunter Warrior -- Mechanic/Operator Integration and Medical Readiness Learning Interactive Triage Trainer (MERLIN) training of medical and non-medical personnel -- are positive examples that logistics MOS personnel cross-training is not only desirable, but highly feasible. Skill cross-training throughout the MEU Special Operations Capable (SOC) sized force will enhance its ability to conduct SUOs.

Training to systems limitations is also critical to success on the future battlefield. Systems dependence can lead to defeat. Individuals and units must train for systems failure, the uncertainty which results, and the actions required to find alternatives to non-availability. Equally important, employing degraded or denied systems should be incorporated into exercises. Where safety is a concern, controlled demonstrations should be used so that the trainees respond

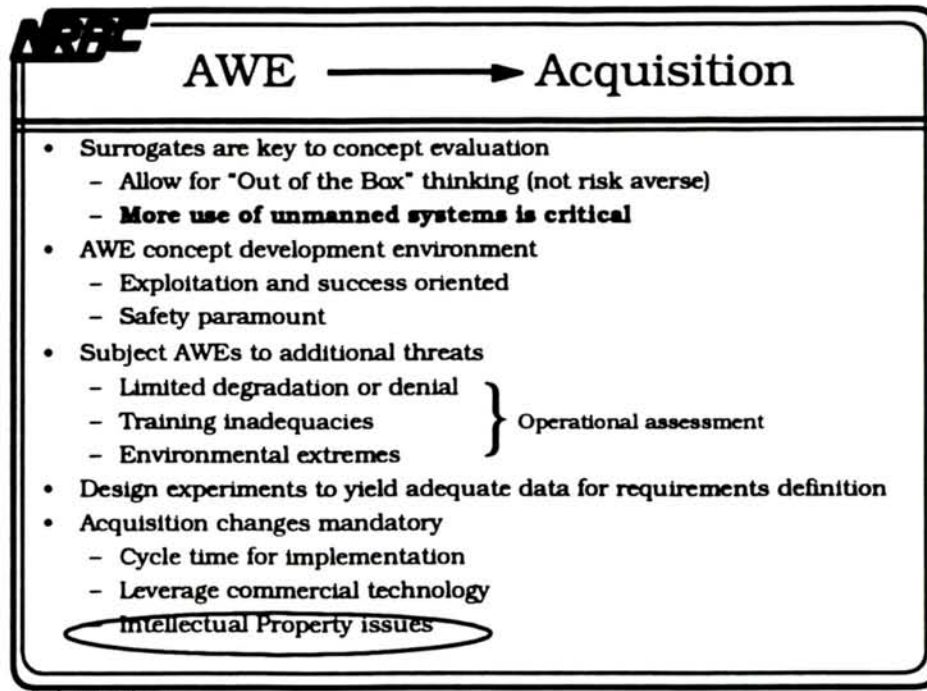
appropriately. As an example, GPS can be easily jammed or otherwise interfered with by relatively unsophisticated means. Because of this, Marines should be trained to recognize when GPS is being interfered with, seek alternatives or corrective measures for precision resupply/location, or revert to the basics of map and compass reading skills. Simply stated, training must reinforce basic skills and prevent an over dependence on sophisticated systems.



Focus on Energy Conservation/Reduction

- Radios and batteries are significant drivers of individual loads and resupply
- Significant energy reduction potential through radio and processor design
- Significant energy savings through disciplined reduction in transmissions
 - Transmissions are principle driver (Number, Range, Environment)
 - Communication protocols to minimize transmissions
 - Communication training and discipline essential

Current operational radios and batteries impose a significant weight and resupply burden on SUOs. Within a typical squad size unit, the radios and batteries for one week's operation can constitute up to 15% of the total backpack weight, comparable to the ammunition weight. Although batteries are a mature technology with limited growth potential, emerging technologies, including low voltage circuitry, power management control, and advanced signal processing architecture, will improve the power efficiency of radios and other electronic devices by more than an order of magnitude. With such innovation, a current 12-hour duration battery would last for a two-week period. Additional energy efficiencies in SUO communication can be realized immediately by employing energy saving protocols which minimize transmissions and maintain user discipline. An important first step in the development of such protocols is to develop benchmark data on communication traffic and energy usage requirements from future AWEs, such as Urban Warrior and Capable Warrior.



One of the most significant issues the Panel highlighted is the need for rapid transition of the technologies exploited effectively in the AWEs to acquisition for use by deployed forces on a regular and sustained basis.

Surrogates are used in the AWEs as a mechanism to provide for "out of the box" thinking, or how to conduct operations and to deploy technology products different than the norm. This is accomplished in a concept development environment geared toward exploitation of commercially available technology in many cases (particularly information, computational, and communication related technologies) and, in other cases, use of technology products in new ways.

The Panel expresses some concern, however, that the evaluation of these technologies be further disciplined as a part of the evaluations to examine potential degradation or denial of use (e.g., GPS), training inadequacies (unknowns), and environmental extremes (e.g., jungle, urban, coastal, desert) to round out the assessment in representative operational conditions. The Panel feels that such an opportunity provides a valuable mechanism for delineation of operational requirements associated with new concepts, equipment, and training.

The Panel was concerned as a result of some technology briefings that even though substantial progress has been made in Acquisition Reform by the DON, the issue of intellectual property safeguards for private (commercial) industry remains an impediment. Acquisition issues of this kind need to be resolved to ensure that our forces can benefit from the significant technology and cost leverage available through use or adaptation of commercial technology in the shortest possible time.

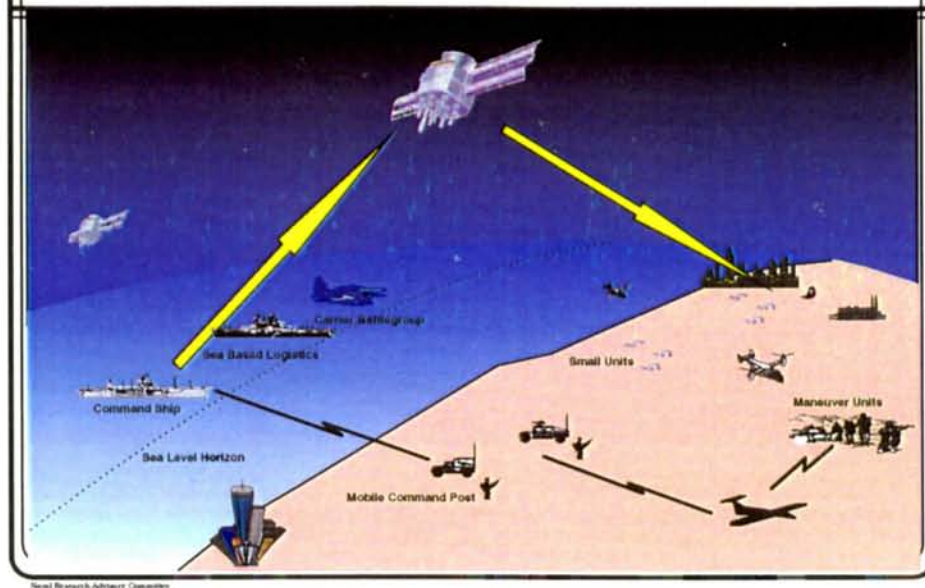


Technical Windows of Opportunity

- Information Systems
- Delivery Systems
- Power/Energy
- Communications/Navigation
- Consumables
- Health Services
- C/B Detection

As noted earlier, the study approach used a conceptual and operational framework, coupled with a technology assessment to explore the traditional logistics functions. This process resulted in a grouping of technologies into seven "areas" which the Panel identified as "Technical Windows of Opportunity." These form the basis for the remainder of the report, with specific recommendations provided for each. The seven areas are: information systems, delivery systems, power/energy, communications/navigation, consumables, health services, and C/B Detection.

Information Systems

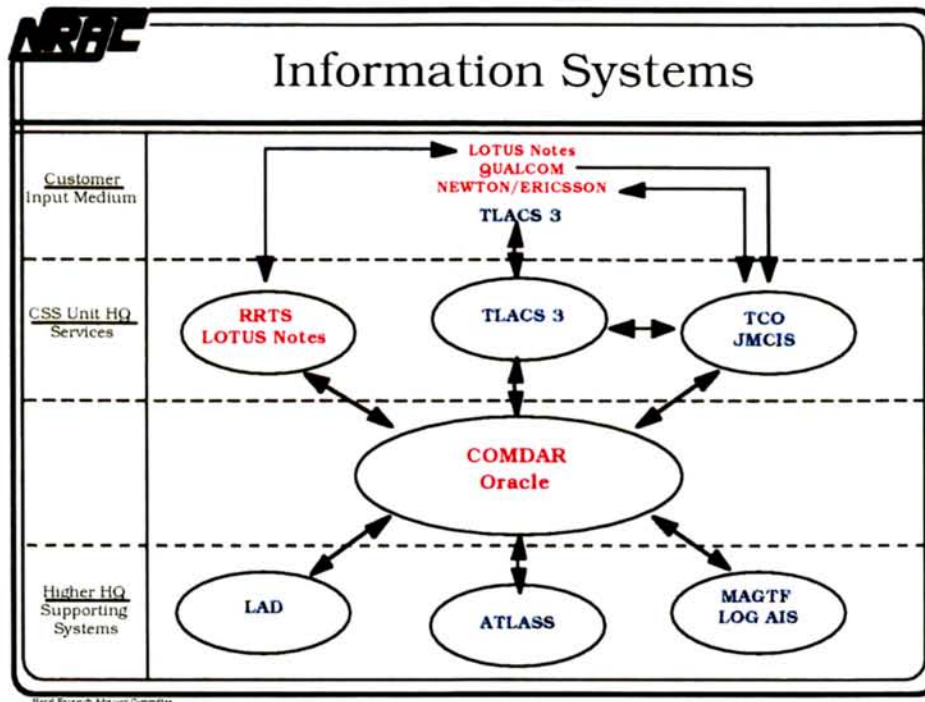


Perhaps the most dramatic technology area, in terms of expanded capability and impact on the entire battlespace, is information systems. Networking can provide vital command and infrastructure knowledge across the board. For the purposes of this study, the Panel concentrated on the application of information systems to enable "Focused Logistics" in the context of Joint Vision 2010, fusing information to provide rapid response and distribution, total asset and in-transit visibility, and precision distribution to reduce inventory and footprint.

USMC Logistics Information Systems		
<u>Requirements</u>	<u>Current Systems</u>	<u>CSS Enterprise</u>
Situational awareness	No	Yes
Asset visibility		
Dump status	Partial	Yes
Intransit visibility	No	Yes
Customer confidence	No	Yes
Logistics command and control	Partial	Yes
Inventory and footprint	No	Yes
Effective asset allocation	Partial	Partial
Logistics prediction/anticipation	No	Partial
CSS Enterprise provides a low risk, low cost, 80-90% solution		

Information systems are the backbone of an effective logistics support system. Elements of information are required at every echelon, from the customer to national level supplies. When examining the requirements for focused logistics imposed by the conceptual and operational framework of this study, several significant deficiencies exist for current systems. These are in contrast with the results of the CSS-E experiment conducted in conjunction with the Hunter Warrior AWE.

A detailed review of the after action report for the information systems portion of CSS-E led the Panel to the following conclusions and observations: 1) All required technology is available now; 2) while excellent success in correcting the deficiencies is anticipated, a degree of cultural change is required; 3) confidence in information and responsiveness must replace reliance on costly inventory; and 4) integration of the technology utilized is low risk and is essential in order to move toward the logistics vision of Joint Vision 2010. Because of the short life cycle of technology in this area and the need to acquire, introduce, and exploit far quicker than traditional acquisition procedures support, evolutionary changes (as opposed to revolutionary changes) in the logistics information system will leave a rolling succession of missed opportunities and fall far short of the goal.



CSS-E laced together both Government Off-the-Shelf Technology (GOTS) and Commercial-Off-the-Shelf Technology (COTS) in an operational framework compatible with today's protocols and command system infrastructure.

The following list relates to those principal systems used in the exercise.

Government Off-the-Shelf (GOTS)

Tactical Level Combat Service Support System (TLACS³)
 Tactical Combat Operations (TCO)
 Joint Maritime Command Information System (JMCIS)
 Logistics Anchor Desk (LAD)
 Marine Air Ground Task Force Logistics Automated Information Systems (MAGTF LOGAIS)
 Asset Tracking for Logistics and Supply System (ATLASS)

Commercial Off-the-Shelf (COTS)

Rapid request Tracking System/Lotus Notes (RRTS)
 Common Data Repository/Oracle (COMDAR)
 Newton-Ericsson hand held computer/Apple computer
 QUALCOMM OmniTRACS/QUALCOMM

The basic system architecture is shown above. The heart of the system is the common logistics database or COMDAR. COMDAR also represents a quantum leap forward from existing logistics common data base systems by providing an integrated network that serves all customers, services and supporting systems in the field and at Headquarters. The majority of systems integration work centered around the Oracle programming effort to produce COMDAR. Resolution

of those deficiencies identified in the previous chart, and the CSS-E elements involved are:

Situational Awareness:

- NEWTON-ERICSSON
- QUALCOMM OmniTRACS
- TCO/JMCIS
- TLACS³

Asset Visibility:

- RRTS
- QUALCOMM OmniTRACS
- NEWTON/ERICSSON
- TLACS3
- ATLAS

Customer Confidence:

- RRTS
- NEWTON/ERICSSON
- TLACS³

Logistics Command and Control:

- RRTS
- TLACS³
- TCO/JMCIS

Inventory and Footprint:

- All System Components

Effective Asset Allocation:

- TLACS³
- LAD
- MAGTF LOGAIS

Logistics Anticipation:

- TLACS³
- LAD
- RRTS



One example of the integration and incorporation of COTS-based hardware and software is found in the OmniTRACS system used with CSS-E. The upper left-hand photo illustrates the antenna mounted atop a delivery truck. The lower right-hand photo depicts the display for an integrating tracking system to facilitate asset awareness with input fed by various sources integral with en route delivery platforms.



Information Systems Recommendations

Near Term (0 - 5 Years)

- **Designate 15 MEU as operational testbed for CSS-E system/integrate training into workup**
 - **Deploy as redundant to current system/inventory**
 - **Encourage improvement/ownership**
- **Establish at high level champion of CSS-E at HQMC and assign a MARCORSYSCOM PM**

Mid Term (5 - 10 Years)

- Develop logistics systems applications to open system architecture standards to support a "Plug and Play" approach
 - Maintain compatibility with operational command systems
 - Provide for system expansion
 - Maintain technology currency

The Panel's near-term recommendation captures the urgency that this window of opportunity demands. The 15th MEU appears to be the best positioned unit to serve as a deployment test bed for the information systems and requisite communications upgrades because it will deploy in the fall of 1998. Operational capabilities of the MEU should not be impacted by maintenance of parallel systems, predeployment training and a resource increment. Within the constraints of operational requirements, system enhancement should be encouraged and a well considered testing architecture should be developed.

The Panel believes that integration of CSS-E with the 15th MEU will illustrate the predicted high payoff for the Marine Corps; and the Commandant and his staff should champion the initiative, recognize the urgency, and commit the relatively small incremental resources involved. This appears to be a very timely and lucrative opportunity to realize significant near-term benefits from the Marine Corps Warfighting Laboratory.

Finally, the system should be assigned to a Marine Corps Program Manager for oversight, operational evaluation and implementation from a total systems approach.

The Panel believes the mid-term recommendation is necessary to ensure the incorporation of open system architecture standards in logistics systems within the DON.

The Panel believes that the experiences of the CSS-E and the follow-up testbed with the 15th MEU will fully demonstrate the viability of the concept. However, the design of an open system architecture

standard for logistics system applications is necessary to ensure the "plug and play" approach that will support the frequent updates anticipated to be available for the deployed COTS hardware and software.

It is important to note that the logistics system will connect to JMCIS, the Joint Maritime component of the Global Command and Control System (GCCS). GCCS establishes a common data distribution and processing standard for US forces worldwide to provide a full range of services from office support tools, to imagery evaluation, to Over the Horizon Targeting (OTH-T).

Delivery Systems



A significant element of the study was the examination of potential logistics delivery systems (to the warfighter). Quite a bit of emphasis was placed upon the role of unmanned systems, whether airborne, operating on the ground, or in the water. The delivery systems sub-panel explored a variety of prototype vehicles for differing support roles, and use of these prototypes as surrogates in AWEs. The purpose of the surrogates, as in the Hunter Warrior AWE, would be to explore and evaluate new operational concepts. The Panel believes an important product would be evaluation in an operational context and the derivation of potential operational requirements for such systems, whether manned or unmanned.

Three potential candidate systems for logistics support of SUOs in the near term (0-5 years) are depicted in this chart. They are:

- 1) **SARGE** - a prototype Tactical Unmanned Vehicle (TUV) is comprised of a remotely controlled multi-mission platform, operator control unit, transport HMMWV, mission planner, video, command and status data link, remote driving cameras, and reconnaissance, surveillance and target acquisition (RSTA) sensors. SARGE is a 4-wheel TUV, weighs 298 pounds and has a top speed of 30 mph. It has an endurance of 60 hours in "quiet mode," 6-to-8 hours in "surveillance mode" and a 50-mile refuel range. It is being used as a surrogate vehicle, in experiential use with Army troops, to develop the performance characteristics needed for a fieldable RSTA UGV. Capabilities of SARGE may be used directly to support preplacement by monitoring cache security; or indirectly, as an alternative surrogate to determine some of the important operational characteristics (such as speed,

terrain capability, navigation accuracy, control alternatives, and survivability) required for resupply UGV's.

- 2) **CL-227/CL-327** - a series of twin rotor Verticle Take-off and Landing (VTOL) UAV prototypes are being evaluated to meet future service requirements. The vehicle is peanut-shaped, 6 feet tall, 2.6 feet maximum diameter with rotor diameter of 13.2 feet and weighs 750 pounds. The CL-327 can carry a maximum payload of 235 pounds for three hours at a maximum altitude of 18,000 feet. The CL-327 vehicle is on flying status, having evolved from an earlier prototype (CL-227); and a follow-on prototype (CL-427) is believed to be in development. The CL-327 can fly from 0-to-85 knots and carry payloads of Electro-Optical/Infared (EO/IR) communications relays, active electronic warfare and Synthetic Aperture Radar (SAR) sensors.
- 3) **Hunter** - a rugged, modular designed operational UAV system is in use by the US Army. It is a twin engine, 1600 pound fixed wing UAV with a 275 pound payload capacity. The air vehicle is 23 feet long, has a wing span of 29 feet and fuel capacity for a 12-hour flight. It can fly to an altitude of 15,000 feet, with maximum payload, at cruise speeds of 60-to-80 knots, and maximum speed of 110 knots. It can be launched by Rocket Assisted Take-Off (RATO) or from a runway or carrier/LHA/LPD deck. Hunter's payloads include: FLIR, TV, laser designators, SARs, electronic warfare sensors, and airborne data relays. Hunter can carry launchable payloads from hard points on the wings, and could serve as a communications relay station.



Delivery Systems Technology/System Options

Manned

Skyhook (MH-53E/MH-46E/MV-22)
Tactical aircraft (AV-8B/F/A-18)

Unmanned

Guided Parafoil Air Delivery
Systems (GPADS)
Unmanned Air Vehicles (UAV)
Unmanned Surface Vehicles (USV)
Unmanned Ground Vehicles (UGV)
Recoverable Drones

"Out of the Box"

Recoverable Tomahawk
Electromagnetic Launch (EML)



Manned and unmanned systems were examined for application to logistics support for SUOs. Of those delivery systems depicted above, both the Skyhook and GPADS concepts were evaluated in the Hunter Warrior AWE.

Skyhook has near-term (0 to 5 year) potential. The Skyhook multi-hook helicopter cargo transport device is a system that allows for external delivery of cargo. It can handle up to three different drops in one sortie and reduce the number of resupply missions. The Skyhook uses three electronically controlled hooks and has a maximum payload of 27,000 pounds. Skyhook uses GPS to record the precise location where cargo is delivered. The Skyhook consistently and safely performed its mission with accuracy in the Marine AWE exercises. A current limitation of the system is that it is only compatible with the MH-46E.

While evaluated with -53E and -46E helicopters, application of the concept extends upon further examination to the MV-22 in the future. A particular problem with cable chaffing was observed with the MH-53 where the cable attaches to the underside of the aircraft. If not resolved in either alternative MH-53's or in future model modifications, near-term use may be restricted to the MH-46 series.

Another potential manned delivery system, in the mid-term (5-to-10 years), is use of external pods, perhaps with a low cost GPS/INS guidance package as in the Joint Direct Attack Munition tail kit, delivered in a quick response mode by a "fast-mover" such as the F/A-18C/D or AV-8B tactical aircraft.

Both the **F/A-18C/D** and **AV-8B** have the capability to carry and launch external pods, including those configured with GPS/INS as noted above, for up to 1600 pounds of logistics supplies (maximum) in the individual pods. The pods which weigh 98-to-130 pounds empty, are 130 inches long and 18.75 inches in diameter.

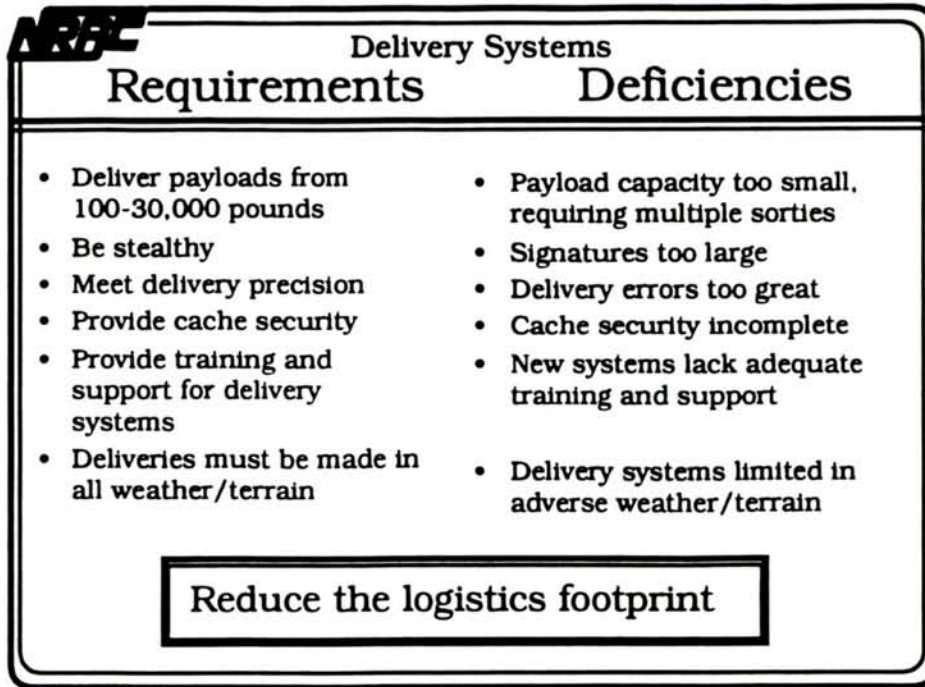
A near-term (0 to 5 years), unmanned example is the **GPADS** system. GPADS is an autonomously guided parafoil system currently capable of delivering a 750-to-1500 pound payload, with growth potential to 15 tons, from a maximum offset distance of 20 kilometers. GPADS is deployed from a variety of aerial platforms (helicopter and C-130). C-130 remains the primary delivery platform. The system deploys a parafoil, locks onto GPS satellites and steers to a programmed location. The system works reasonably well at delivering supplies within the accuracy required, but may be augmented by a locator beacon for more precise, safe delivery. A number of ancillary issues need to be resolved such as reduced payload signature, susceptibility to hostile fire, GPS jamming, and post-delivery cache protection.

A number of unmanned vehicles are candidates for both near and mid-term applications as discussed elsewhere in this section. Recoverable drones, such as the **BQM-74E**, may also have some potential, depending upon recovery environment and location of the SUO.

The **BQM-74E** is an operational aerial target system which could carry up to 80 pounds of external payload on two wing tip pods to 250 nautical miles at speeds of 220 to 400 knots. The air vehicle is 13 feet long, wing span of 5.8 feet, and weighs a maximum of 438 pounds. The **BQM-74E** is launched from a ship with Jet Assisted Take Off (JATO) bottles and recovered in the water. The recovery, decontamination, refurbishment, and retest of the vehicle can be accomplished within four hours.

By way of "out of the box," longer term thinking the Panel also conceived of a "recoverable Tomahawk" for precise delivery of smaller (ejected) payloads and the incorporation of Electromagnetic Launch Technology or an Electromagnetic large caliber gun for precision delivery of payloads at distances up to 300 km away.

An **Electromagnetic Launcher** is a device for accelerating objects, sometimes known as an electrical energy gun (EEG). The technology is impressive in its performance at moving projectiles at hypervelocities. Initial long-range planned applications may be Naval surface fire support, aircraft carrier catapult systems, and close-in weapons systems for defense against anti-ship missiles and theater ballistic missile defense. This technology should be tracked for potential use for accelerated long-range delivery of logistics supplies. This technology is immature today but could demonstrate potential over the next 10 years.



The requirements for logistics delivery systems for a USMC SUO operating in multiple terrains (urban, desert, jungle, and littoral) include the following:

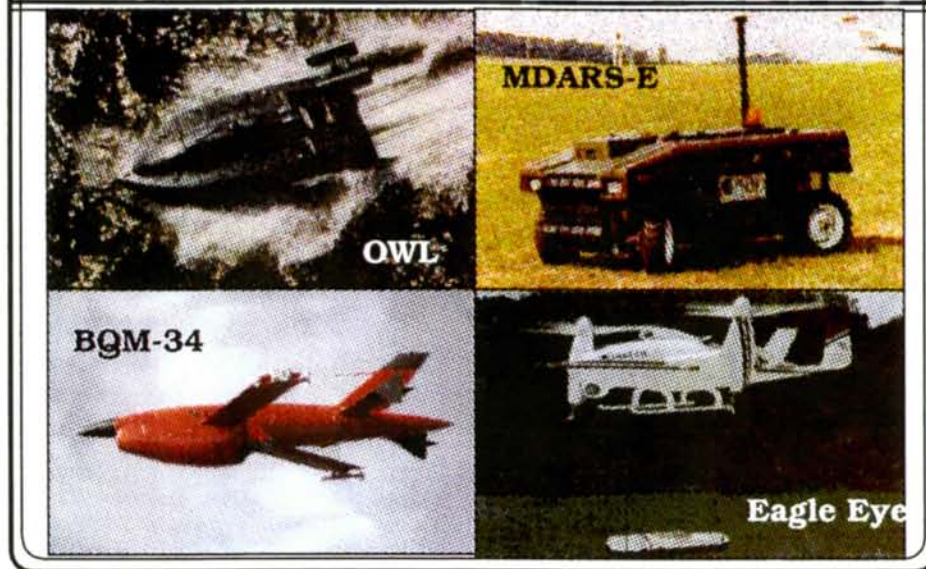
- 1) Payloads range from 100-to-30,000 pounds depending on the mission and length of mission.
- 2) The delivery must be clandestine for safety of the SUO.
- 3) The delivery must be within at least 100 meters of the specified drop location; in some cases 10 meters is preferred.
- 4) Cache must be protected from enemy tampering. Security systems must be capable of notifying SUOs of any potential tampering. It should contain a covert location beacon and users should be able to query the cache from a safe distance.
- 5) Training in use and support for delivery systems must be adequate for mission success.
- 6) Deliveries must be successful in all weather conditions.

Today's delivery systems, in general, do not meet all of the key requirements. Typically, payload capacities are too small, requiring multiple sorties. This is expensive and increases the vulnerability of the SUO and delivery system. Many of the current delivery systems are not stealthy. Signatures of the platforms themselves, or of the resupply kit (e.g. hanging under GPADS), are too large. Although accuracy of deliveries is improving, weather conditions and combat environment have a significant impact on precision and precision requirements.

Cache security is typically an issue because available MAGTF Sensors (which could be used to watch/monitor supplies) are typically committed for other priorities. Security solutions need to be integrated into the C² system.



Unmanned Delivery Systems



Additional unmanned delivery systems evaluated in the study, and depicted here, include the OWL USV, MDARS-E UGV, Eagle Eye VTOL UAV, and the BQM-34 target vehicle. For logistics support of SUOs, both the Owl and the Eagle-Eye are considered near term.

The **Owl** is an unmanned surface vehicle propelled by an internal combustion engine with a jet drive capable of speeds up to 35 knots and endurance of 8-to-24 hours. The Owl can be remotely operated from land, sea, or air. The straight RF signal range is 10 to several hundred miles, depending on antenna height and satellite link. The Owl's unique hull design delivers a high degree of stability and is capable of operating in shallow water. The internal payload capacity of the Owl is 450 pounds and it can tow an additional 200 pounds on a sled. Fuel capacity is 36 gallons. Vehicle sensors include sonar, laser scanner, underwater camera, night vision camera, thermal camera, and radar. This USV has the capability to carry logistics supplies to shore and a litter for extraction of a severely wounded Marine. The Owl is in operational use in Bahrain for port security.

Eagle Eye is a tilt-rotor VTOL UAV which was developed to meet specific needs of the services. It is currently flying and is one candidate for future VTOL UAV programs/applications. The air vehicle has a wingspan of 15.2 feet, length of 17.9 feet and rotor diameter of 9.5 feet. The vehicle can fly at cruise speeds of 0-to-200 knots. With a maximum payload of 600 pounds it has a three-hour endurance and can operate at altitudes up to 20,000 feet. The Payload options include: FLIR, TV, laser designators, electronic warfare sensors, airborne data relays, and capability to carry a litter for potential extraction of a severely wounded Marine.

BQM-34 (Firebee 1) is an operational aerial target which has carried up to 1000 pounds (500 pounds on each wing), at speeds up to 500 knots. The air vehicle is 22.9 feet long, has a wingspan of 12.9 feet and a launch weight of 2150 pounds. The Firebee 1 is JATO-launched and can be recovered via mid-air recovery (MARS), or in the water. This system offers a very quick response, heavy payload delivery of logistics supplies located several hundred miles from the launch ship.

Mobile Detection Assessment and Response System-Experimental (MDARS-E) is a robotic physical security system under development by the US Army. The system will consist of multiple interior and exterior mobile platforms controlled from a single control console. The patrol unit consists of a four-wheeled, all-terrain, hydrostatically driven platform designed to fit in a HMMWV, or a large, commercial pick-up truck. A turret containing the navigation, intrusion detection, and sensor modules mounts on the platform.

Navigation is accomplished using differential GPS, vehicle dead reckoning and commands to patrol a given path. The intrusion detection system consists of FLIR, narrow field of view radar and long-range passive infrared sensors. The sensors provide a 360-degree detection capability. MDARS-E also has a Tag/Lock Reading and Inventory control interface which provides users with an indication of intrusion or tampering with shelters or caches. The system operates autonomously in a semi-structured exterior environment (improved roads, defined fence lines, and standardized storage layout). The physical security tasks involve intruder detection, assessment, lock/barrier check and response to alarms. This vehicle has excellent potential for use in delivering logistics supplies and providing security to caches. This vehicle, or alternative design with autonomous control and specific attention given to logistics, or Medivac, payload integration could have excellent potential for use in SUO resupply/distribution. Some typical examples are: delivering supplies, cache resupply, providing security to caches, or for extraction of severely wounded Marines.

The technology developed with systems like SARGE and MDARS-E should be evaluated for its potential contributions to direct fire combatant roles; i.e. used as a surrogate in Urban Warrior to determine specific requirements, exploiting the technology for future applications.



Delivery Systems Observations

- Unmanned vehicles meet delivery system requirements and offer multiple applications
 - Logistics support
 - Surveillance and reconnaissance
 - Comm relay
 - Extraction of wounded Marines
- Environment dictates type of delivery platform
 - Urban/Jungle
 - VTOL; UGV
 - Desert/Open Terrain
 - Fixed Wing; Parafoils; UGV
 - River/Littoral
 - USVs
- Cache security issues can potentially be solved with covert location beacons and integration with command and control system
- Only Skyhook and GPADS have been demonstrated with measured success in Hunter Warrior demo

Naval Research Laboratory

Unmanned vehicles meet delivery system requirements and offer multiple applications. These applications include delivery system for logistics support, communications relays, surveillance and reconnaissance and extraction of wounded Marines. Depending on the particular SUO mission, dual or multiple use of the unmanned vehicles could provide an inexpensive solution to multiple mission requirements.

The environment for the SUO mission will dictate the type of delivery system required. Urban/Jungle terrain will require VTOL and/or UGV delivery systems. Desert and Open Terrain can demand fixed wing, parafoils or UGVs depending on terrain roughness. River/Littoral environments will require use of USVs or UUVs.

Cache security issues can be potentially solved by adding covert location beacons and integration with the command and control system.

In the recent Hunter Warrior Exercise, only Skyhook and GPADS have been demonstrated with measured success. Skyhook is limited today to the MH-46E platform. GPADS payload signature needs to be reduced for security and safety.

Training and support are key to success of the SUO mission. Skill cross-training is desirable and highly feasible to enhance the conduct of the SUO.

The acquisition cycle must continue to be streamlined. Use of surrogates in exercises like Hunter Warrior and Urban Warrior is key to concept evaluation and assessment for purposes of requirement generation. Joint use of service technology can accelerate solutions.

Summary

The following summary of delivery systems shows the technology options available Near Term (0-5 years), Mid Term (5-10 years), and Far Term (> 10 years).

	Options	Payloads (lb)	Accuracy (m)	Stealthy	Cache Security	Comments
Near Term (0 - 5 years)	SkyHook	9K, 18K, 27K	0 - 5	No	No	MH-46E Only
	GPADS	750 - 1500	100 - 200	Yes*	No	Payload Signature
	Hunter	~ 275	0 - 100	Yes	No	Pod w/Chute Needed
	EagleEye	~ 600	0 - 60	Yes*	No	
	CL-327	~ 230	0 - 60	Yes*	No	
	Owl	~ 650	5 - 100	Yes	No	200 lbs. in Tow
	SARGE	-	5 - 100	No	No	Remotely Operated
Mid Term (5 - 10 Years)	AV-8B and F/A-18	400 - 1600	100 - 200	Yes*	No	Pod w/Chute Needed
	BQM-74	~ 80	100 - 200	Yes*	No	Ship Launch/Recovery
	BQM-34	~ 1000	100 - 200	Yes*	No	Ship Launch/Recovery
	MDARS-E	400	5 - 100	Yes*	Yes	Cache Protection
Far Term (> 10 Years)	UGVs	50 - 1000	5 - 100	Yes	Yes	Semi-Autonomous
	EML	50 - 200	< 100	Yes	No	High "G" Launch

* Payload can be delivered at reduced signature.



Delivery Systems Recommendations

Near Term (0 - 5 years)

- **Use and train with unmanned systems to demonstrate logistic support capabilities in Urban and Capable Warrior AWEs**
- Determine cost and operational utility of adding low observable materials to the Guided Parafoil Air Delivery System
- Procure NDI tamper indication and covert location/detection systems for cache protection
- Determine the effect of using only the CH-46E for Skyhook

Mid Term (5 - 10 years)

- Explore Navy target drones (BQM -74/-34) and recoverable Tomahawk in an LOE or AWE for rapid precise resupply

Far Term (> 10 years)

- Track electromagnetic launch technology for resupply use

Unmanned systems offer significant potential to meet SUO logistic delivery requirements. The upcoming Urban and Capable Warrior Exercises provide excellent opportunities to demonstrate their applicability and evolve operational requirements. The Panel recommends that UAVs, UGVs and USVs should be borrowed or leased to support the upcoming exercises. Also, realistic training in an operational environment, with airspace management, is mandatory for success and safety.

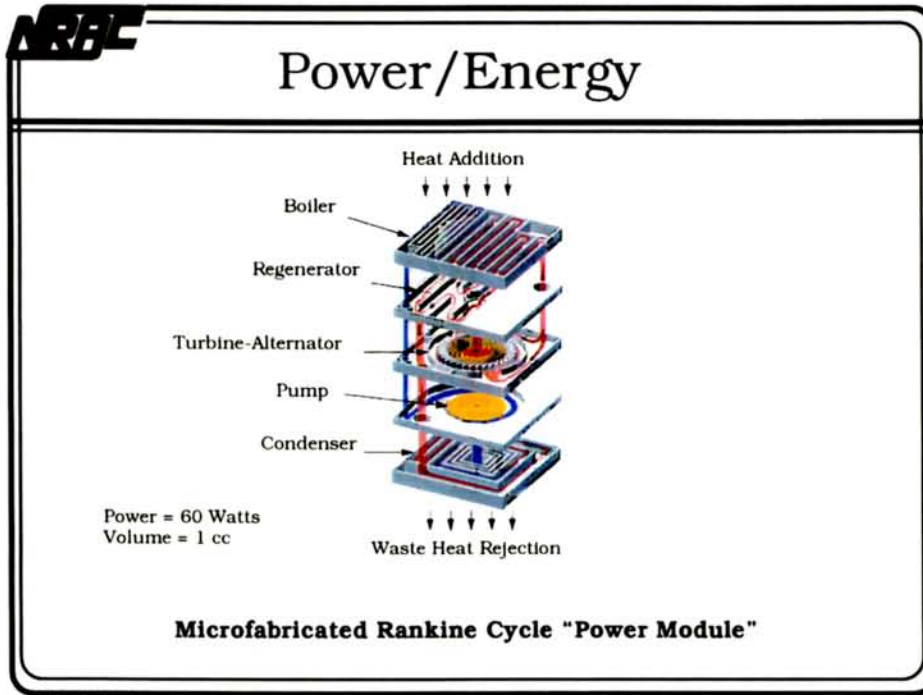
GPADS demonstrated reasonably accurate delivery of logistic supplies with good success in the Hunter Warrior Exercise. GPADS is in production for the US Army and can be easily procured. The only concerns with this delivery platform are the need to reduce the signature (RF/IR) of the payload and prevent GPS jamming as it glides to touchdown. The Marines should explore the US Army's National Research, Development and Engineering Center, (NRDEC) Laboratory at Natick, MA for use of stealth materials to decrease the detectability of the payload.

The AWE test directors should procure low cost, non-development item (NDI) tamper indication and covert location/detection systems which will permit detection and protection of delivered or pre-positioned caches.

While the Skyhook system offers the heaviest payload insertion capability, up to 27,000 pounds, it was shown in Hunter Warrior to only be usable from a MH-46E not a MH-53E, due to chaffing of the fuselage by the cables. The operational limitations of using only the 46E helo should be assessed.

The DON should explore the utility of using target drones like the BQM-34 and BQM-74, ship launched and water recovered, to provide a just-in-time fast resupply of customized payloads up to 1000 pounds. Likewise, a hard look at using a Tomahawk Land Attack Missile-Dispenser (TLAM-D) with recovery is warranted. These surrogates could be evaluated in Limited Objective Experiments (LOEs) prior to the Capable Warrior AWE to evaluate effectiveness and affordability.

In the future, there is potential to use electromagnetic launch technology which could, with reasonable acceleration levels, launch a payload of 50-to-200 pounds up to 100-to-200 miles from the ship.



Panel efforts for power and energy during the study became focused on man-portable systems, primarily for support of communications requirements for SUOs at the dismounted squad level.

General purpose power supply technology was found to be relatively mature, as were batteries. The Panel determined that there appears to be no near-term solution for man-portable fuel cells or relatively stealthy general purpose energy generation systems.

As a result, there was a concerted focus on energy conservation, particularly at the squad level.

One interesting long-term concept, depicted in this lead chart for the power/energy section, is a micro-machined Rankine Cycle generator, such as that developed at the Pennsylvania State University Applied Research Laboratory. This Rankine Cycle generator is capable of producing up to 60 watts of power in about one cubic centimeter volume.



Power/Energy Radios and Batteries

Requirement

- Energy efficient radios, power sources, and communications protocols are required to reduce the Marine's basic load

Deficiencies

- Existing radios (e.g. SINCGARS) and battery power supplies impose an unacceptable weight and resupply burden on SUOs
- Sub-optimum communications protocols waste energy

Mission effectiveness of SUOs is critically dependent on reliable communications links between widely dispersed units. This requirement places increasing demands for lightweight, energy efficient radios, high specific energy batteries or more efficient alternatives, and energy saving protocols. Today's operational radios (e.g., SINCGAR) and batteries (LiSO₂) impose an unacceptable weight and resupply burden on SUOs. Radios and a four-day supply of batteries can constitute as much as 20 percent of a small unit's backpack weight, comparable to the weight of the unit's ammunition. In addition to being a mature technology with limited growth potential, state-of-the-art LiSO₂ batteries are expensive and generate hazardous waste. Another current deficiency in small unit communications is the utilization of sub-optimum energy saving protocols which neither minimize transmission nor maintain user discipline.

These conditions are exacerbated by an increasing expansion of and reliance upon information and communications technology for command and control of both warfighting operations and logistics support.



Power/Energy Radios and Batteries

Technology Options

- Near Term
 - Energy efficient communications protocols and training
 - Battery: remaining life indicator; rechargeable option
- Mid Term
 - Low voltage, circuitry power management and signal processing architecture (30 x gains)
 - Evolutionary improvement in batteries (1.5 - 2.0 x gains)
- Far Term
 - Micro machined engine/generator (10 - 100 w/cm³)

A near-term technology opportunity to improve SUO communications is to deploy energy saving protocols and power management practices, emphasizing reduced transmissions and user training. The procedures can be designed for and validated in AWEs (e.g., Urban Warrior) and subsequently, as warranted, incorporated into training doctrine. More remedial technology options to improve SUOs include an accurate remaining battery life indicator for replacement management and a faster method for field recharging.

In the mid-term time frame (less than ten years) the most promising technologies for improved communication devices are low voltage electronics (microprocessor and support chip), power management controllers and advanced signal processing architectures. It is estimated that the collective benefits from these innovations can provide communication devices 30 times more efficient than today's COTS equipment. In other words, today's 12-hour duration battery would provide several weeks of power for these advanced devices. In contrast, it is projected that specific power density of advanced batteries will increase by less than a factor of two over the next decade.

A far-term, emerging technology which has the potential to revolutionize power sources in the 10-to-100 watt requirements regime is the micro-machined "power module." Here, engine and generator components are machined from silicon or silicon carbide utilizing micro fabrication techniques, such as IC photolithography or ion etching. A point design of a 60 watt, Rankine cycle power module (combustor, generator, turbo alternator, and condenser) occupies a one cubic centimeter volume. When coupled to a hydrocarbon fuel or chemical heat source, it is estimated that such a module can supply up to an

order of magnitude more energy than equivalent size advanced batteries.



Power/Energy Radios and Batteries

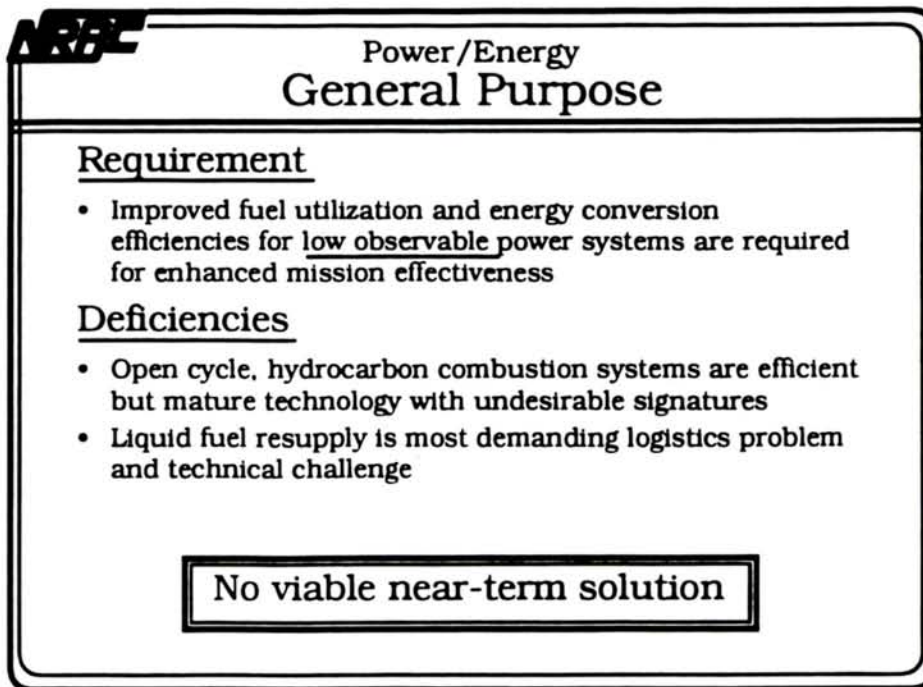
Recommendations

- **Benchmark communications volume and energy use**
- **Adapt COTS capabilities and protocols for energy management focus in future AWEs**

Immediate operational needs may be best served by discipline, training, and establishment of appropriate transmission protocols.

The Panel recommends that the upcoming AWEs, such as Urban Warrior, and intermediate training exercises be used as an opportunity to benchmark communications needs and operational practices.

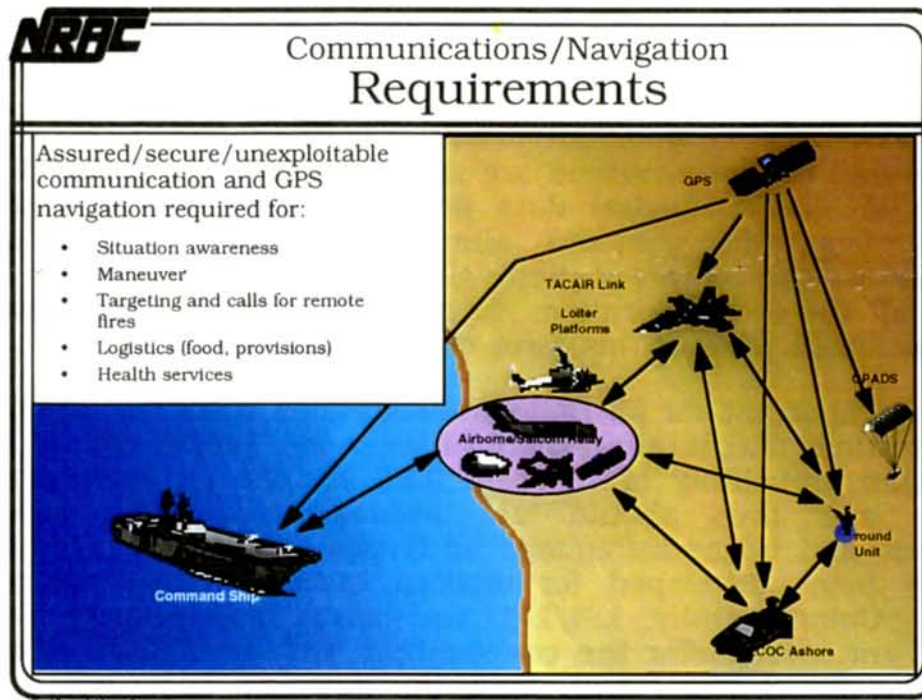
The recommended near-term follow-up is to adapt existing COTS capabilities for low energy signal processing and communications protocols which emphasize conservation of energy (transmissions) as a management focus in both upcoming AWEs and training syllabi.



SUOs of the sort considered by this study often will be dependent on stealth for security, and may not be able to rely on regular re-supply. Current primary power plants for vehicles or electric power generation are almost all Carnot cycle, limited heat engines, predominately diesels or gas turbines. Within the limits of currently available materials, these are products of mature technology. They also have undesirable heat and/or sonic signatures. Future improvements in either efficiency or signature levels appear to hinge upon developments in manufacturability of high temperature ceramic materials.

Liquid hydrocarbon (LHC) fuels combine high energy density and convenient characteristics for transportation, bulk storage, and on-vehicle storage and handling. Despite these attributes, they are dangerous to handle and military forces consume enormous quantities of them. This makes their resupply one of the most demanding logistics problem for a combat force. In World War II, 75 percent of the tonnage going into a combat zone was petroleum, oils and lubricants (POL). In Operation Desert Storm, during the 100-hour ground fight, the Allied Forces were consuming fuel at a rate of 26,000,000 gallons per day.

SUOs, as considered here, have the additional problem of working without a companion organically-deployed, readily accessible logistics support structure to keep them resupplied with fuel. Since, within the bounds of known physics, there are no better replacements for LHC fuels in prospect, the only certain way to minimize this part of the resupply problem is to improve power generation efficiency.



The central theme of establishing focused logistics for the warfighter places a high demand upon communications and navigation. It is at the heart of the ability to order, track and manage assets, then receive precision delivery.

This is a greatly expanding technology area in both the military and civilian worlds. However, rapid commercial technology development and exploitation have placed military demand, hence the DON as a consumer, in the position of needing to adapt COTS technology and equipment for warfighting leverage. It is, therefore, critical that aspects of military use are fully understood; to include not only opportunities for operational leverage, but, also, that potential operational weaknesses and vulnerabilities be resolved in a warfighting use environment.

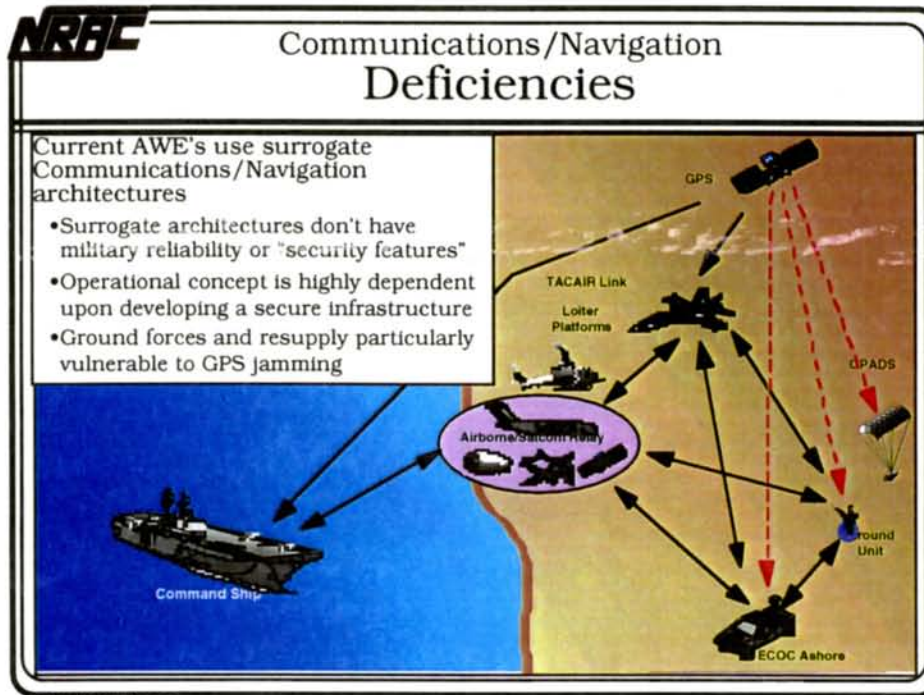
As envisioned today, successful SUOs depend to an extraordinary extent on assured, low-latency communications and GPS navigation. A squad-sized unit will be entirely dependent on sea-based firepower and logistics for the completion of its mission and its survival. A communications/navigation system for the 21st century Marine must also support sufficient bandwidth and be interoperable with legacy systems. The successful disruption or delay of either data/voice communications links or the L-band GPS navigation channel by enemy forces will severely diminish or nullify the effectiveness of such a unit.

Operational concepts being developed today envision the Marine unit knowing its location to within a few meters by way of the GPS; that location being used both for relative targeting and for logistics support. The unit's location and other ancillary information are routinely communicated to both an Experimental Combat Operations Center

(ECOC) for situation awareness and potential fire support and to a CSSE for logistics support.

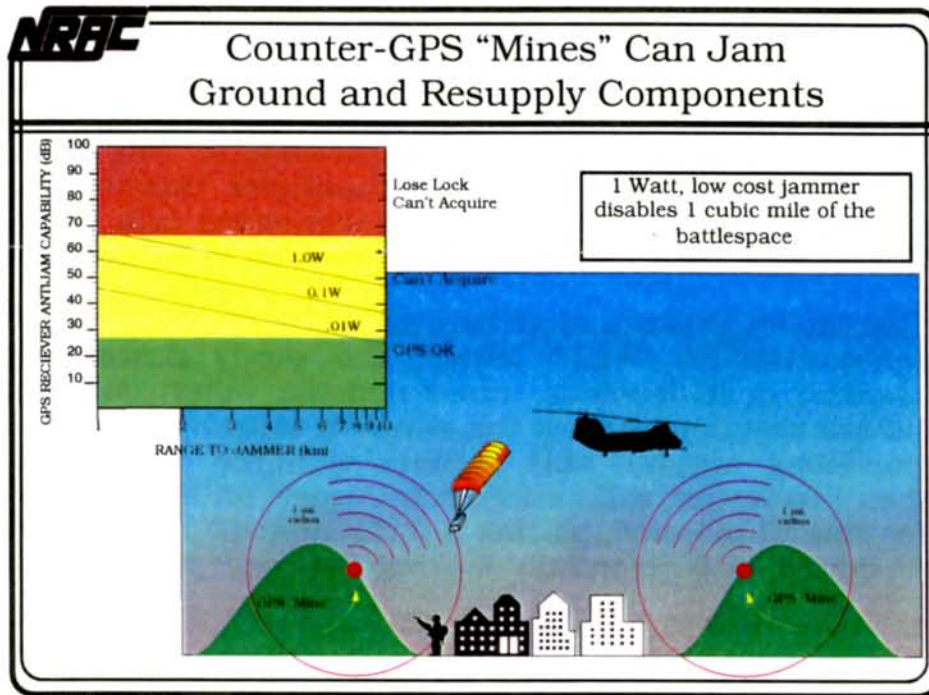
Assured communications are not the only requirement facing the dismounted Marine. Digital data and databases can be exploited or "spoofed" (e.g., the contents altered). Similarly, commercial GPS transmissions can be intercepted, altered and re-transmitted to modify or "pull off" the correct location. In general, properly encrypted, secure communications prevent this form of data exploitation.

It is important for all radio transmissions made by small units to be clandestine; that is, they should have a low probability of detection (LPD), a low probability of intercept (LPI), should not be subject to geo-location, and thus should use appropriate power management techniques and be as infrequent as is possible. Similar protocols are currently being developed for modern tactical fighter aircraft radar systems. Coincidentally, LPI/LPD and power management techniques, properly employed, offer the concomitant and synergistic advantage of minimizing the power drawn from the system's batteries, potentially lightening the Marine's load.



The Panel found that the current series of AWEs have, in some cases, been using "surrogate" communications and navigation equipment that would be subject to denial and various forms of exploitation during a crisis. Although the utility of encrypted communications is generally appreciated by the user community, the vulnerability of small units due to geo-location of their transmissions, and the vulnerability to denial and exploitation of even the more jam-resistant, military access, P(Y) Code GPS signals are far less widely appreciated.

In particular, the ground force and their airborne re-supply elements, may be the most vulnerable forces in the US inventory. Low power GPS jammers can be in close and prolonged proximity to slowly moving ground forces, while descending GPADS may run the whole gamut of threat geometries as they slowly descend from their release altitudes.



The graph contained in the above chart, which is derived from data provided by the Charles Stark Draper Laboratory, illustrates the susceptibility of unprotected military GPS receivers, such as the "Pluggers" to relatively low levels of broadband jamming. For instance, as little as a .01 watt jammer can prevent present day GPS receivers from acquiring the commercial (unclassified) C/A code, which even military (classified) GPS receivers use as a step in the eventual acquisition of the more precise and more jam-resistant P(Y) codes. Thus .01 watts of jamming power applied at a range of seven km can prevent a military GPS receiver from "locking on" to GPS if it has not already done so. Even if the military GPS receiver is "locked onto" the very low power (10^{-16} watts) signal, a one watt jammer as far away as 1-to-2 km can "break" that lock and render the system useless, since it will not be able to subsequently re-acquire the signal. Hence, a simple one-watt jammer can disable approximately one cubic mile of the battlespace.

This one watt jammer is very inexpensive to build (cheaper than the GPS unit it is jamming), and can probably be powered for several weeks on a single lead-acid car battery. These low cost jammers are similar to "mines" since they can be sown throughout the battlefield, and prevent electronic "access" by GPS-dependent entities. Furthermore, if the jammer is concealed in an operating vehicle, it can function for an indefinite period of time (since the battery is continually recharged by the ordinary use of the vehicle), operate at a significantly higher power, and yet would make detection, location and destruction of this mobile GPS-mine significantly more difficult.

Although ground forces are susceptible to this type of jamming, their airborne re-supply elements may be even more at risk. These susceptibilities are the focus of the recently formed Naval Warfare

(NAVWAR) ACTD and programs being lead by the US Air Force. A number of mitigating technologies have been proposed to counter this kind of a GPS minefield, including adaptive antennas, closely coupled inertial navigators, and advanced signal processors. The difficulty with the immediate introduction of these technologies into the field is that they are presently far too expensive to incorporate into every soldier's GPS unit, and even then may not fully protect all GPS applications.

In particular, it is not clear that even this combination of anti-jam (A/J) countermeasures would protect the slowly descending GPADS delivery system as it descends into a notional valley, surrounded by a number of low cost jammers. If the adaptive antenna and its associated signal processing are not able to neutralize the distributed jammer threat, then the system will be forced to "coast" on its integrated inertial system for several minutes, placing a fairly difficult requirement on this "low cost" device, and potentially making the concept unaffordable.



Communications/Navigation Recommendations

- **Train with denied and degraded Communications/Navigation**
- Develop SUO Command/Navigation metrics and requirements with Urban Warrior
- Develop consolidated expeditionary Communications and Navigation infrastructure
 - Ground Segment Light weight
 - Low cost
 - Clandestine
 - Low power
 - Airborne Communications/Navigation relay segment
 - Multiple nodes for robust uninterruptable service
 - Solve GPS vulnerability problem
 - Must be available to MEU commander or organically deployed from large deck (LHA, LPD)

To counter the apparent high cost of remediating the GPS-mine and other threats, high-powered GPS repeaters flying over the battlefield in loitering, airborne pseudo-satellites (pseudolite) have been proposed as an alternate A/J approach. This concept concentrates most of the recurring cost on the airborne segment, simplifying (and thus lowering the cost of) the more numerous ground units. In fact, some level of airborne communications assets is required to provide appropriate A/J nodes for the emerging littoral battlefield communications network already being explored by the ELB ACTD. Thus, it is reasonable to expect that a single system could be deployed to fulfill, simultaneously, both the littoral communications requirement, and the GPS survivability requirement.

The Panel was unable to obtain quantitative information regarding GPS availability, and communications volume or availability in the aftermath of the Hunter Warrior AWE. It is strongly suggested that future AWEs be carefully monitored to help develop the basic communications/navigation requirements that will be the basis for any future system acquisitions.

Finally, no matter what hardware capabilities are at hand, it is absolutely essential to train in a realistic communications/navigation threat environment. Unless truly "jam-proof" communications are slated to be deployed with all units (an expensive proposition), operational concepts for SUOs must take into account the potential degradation and eventual denial of both the communications and the GPS navigation channels. These SUOs must develop and train with contingency plans.

Consumables

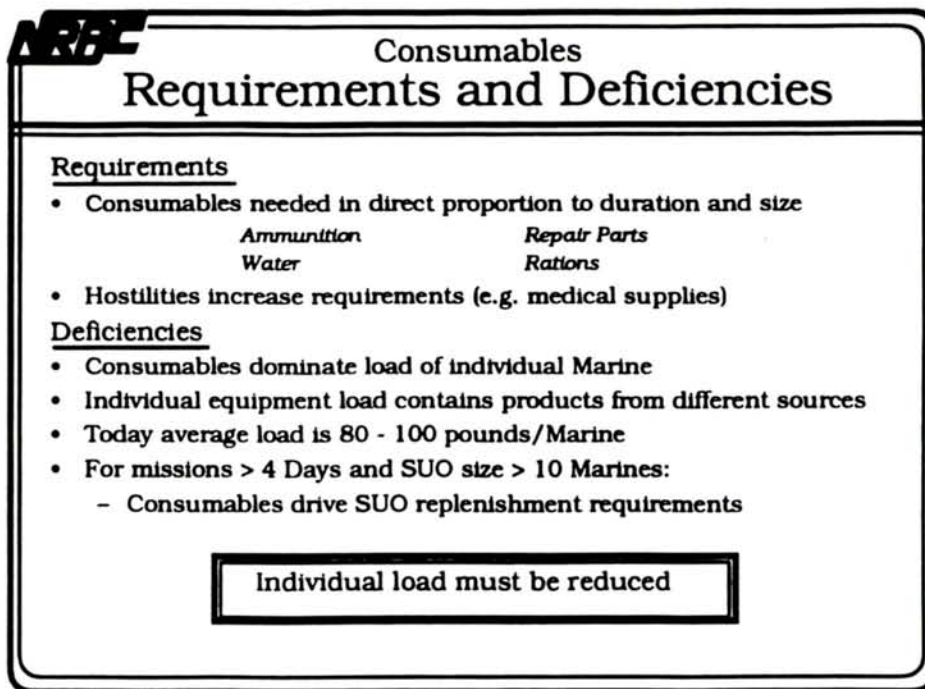


Panel Research Advisory Committee

This chart graphically illustrates what the Panel considered a central problem and focus area for SUOs. Small units are dependent upon the individual Marine, and the individual Marine is dependent upon the equipment he carries. The individual load, nearly all consumables, totals some 80-to-00 pounds per Marine.

As the Panel progressed through the study, it became apparent that a major recommendation would be to reduce the load of the individual Marine. This would create opportunities to customize the pack for specific operations; which could include additional rations, ammunition and/or water, or other special equipment.

A noteworthy recommendation is to manage the individual Marine and his equipment load as an integrated weapon system.



The Panel realized, following their deliberations, that not only was the individual pack large, but it has a propensity to grow even larger. There seems to be no central point which gathers the results of all studies which might affect "back pack" loading in order to keep the individual Marine's perspective in mind.

Ammunition, water, repair parts, and rations (and, in some cases, batteries) represent a large percentage of the load and require replenishment in almost direct proportion to the number of Marines in the SUO and the length of operation. In a hostile environment, the usage of ammunition and medical supplies will increase. Finally, the area of operation (e.g. desert, urban, forest) also impacts the logistics needs.

These consumables drive the "back pack" space and weight requirements, directly impacting the individual Marine. Individual research and development (R&D) efforts are not integrated for each area of consumables. Often, the reduction in one area, e.g. rations, leads to greater stockpiling of other "critical" items, like batteries. The result is the individual load remains unnecessarily high. This load must be reduced if SUOs are to be effective and mobile, and the stamina of the Marine is to be protected.

For longer missions and larger SUOs, consumables drive the need for replenishment from external sources.



Consumables Technology Options

Ammunition

- Two possibilities to improve ammunition weight and utility
 - Plastic-cased ammunition
 - Possible weight savings up to 50%; some cost savings
 - Frangible ammunition (tungsten/copper/nylon)
 - Used for training in military - full use in civilian world

Water Purification

- Army researching hand-held advanced polymer purifier
- USMC tested briefcase-sized purifier
- High power requirements

In the FY 1997 Appropriations Conference Report, Congress ordered the Army to study the feasibility of plastic-cased ammunition. That study concluded that plastic has the potential to be used in ammunition cartridge cases; this has not been demonstrated on a large scale. Hypothetically, weight savings of 30-to-50 percent are possible. Service life properties and performance under realistic operational conditions are unknown. The Army study did not recommend conducting further research into this, but the Panel believes there is too much potential not to continue to, at least, demonstrate the feasibility.

Frangible Ammunition (composed of tungsten and copper in a nylon polymer matrix) is proven, lead-free, conventional, small arms ammunition and can replace lead ball ammunition in firearms training. (It has been used at Quantico.) This ammunition is being used by an assortment of customers for diverse applications. The advantages are reduced fragmentation and elimination of lead contamination (particularly on firing ranges).

Water purification is vital for engagements longer than three or four days, but water represents a major weight and space requirement for each Marine. Power (energy) for any purifier is high. The Army After Next (AAN) study has proposed a hand-held polymer water purifier--with the possibility for a 30-day supply. The Marines have tested a briefcase-sized purifier, but the results to date have been erratic and inconclusive due to incomplete knowledge of the system (of Russian origin) being tested.



Consumables Technology Options

Repair parts

- Requirement: repair in place
- Fault prediction is possible
 - Condition-based prediction analysis
 - Built in programmable sensors (MEMs)
- Remote diagnostics utilize video transmission
 - Digitized manuals
 - Cross training


Rations

- Each Marine carries 2-3 days of MRE
- Army envisions (AAN Study)
 - Palatable energy tablets
 - Direct injection of nutrients

While it is desirable to never have an equipment failure, the requirement is to have the ability to repair in place. This can be facilitated with knowledge of any impending failure, having a plan to have replacement parts in place and the repair scheduled. Fault prediction, using condition-based prediction analysis, can be assisted by on-board prognostics and built-in programmable sensors (MEMs), sensitive to environmental conditions.

Tailored pre-packaged delivery packets can ensure necessary repairs are made rapidly. Remote diagnostics using video transmission to a remote site and digitized manuals with properly cross-trained Marines will enhance the necessary repair capability.

Rations are, of course, the most vital load. It can not be projected that the size and weight of MREs will decrease. However, the Army After Next studies envision a concept called "Tailored Nutrition," whereby the specified individual intake will be matched to the caloric, mental stress, sleep, and environmental conditions anticipated for individual operations. Their vision includes "palatable energy tablets" or, under certain conditions, direct injection of nutrients. In fact, the study even mentions "mental stimulants."

Consumables
Recommendations

General Recommendations
Greatest Return: Reduce the weight of load/Marine
Emphasize: Delivery, or pre-delivery of tailored support packages

Specific Recommendations

1. Participate with the Army to demonstrate the feasibility of plastic cased ammunition
(Do not allow the concept to wither and die)
2. Pursue the water purification methods using smaller equipment
3. Utilize and exercise condition-based maintenance concepts, the MEMs assisted diagnostic techniques and remote diagnostics utilizing video transmission
4. **Establish a focal point at the HQMC level for the oversight of the individual Marine and his load as an integrated weapon system**

The Panel was left with no doubt that the greatest return in the form of SUO mobility, efficiency, and covertness, as well as the individual Marine's stamina, will result from a reduced load weight for each Marine.

Although, not specifically discussed as a topic, the development of tailored support packages, to be pre-delivered or delivered on a timed schedule, is very important for the success of large SUOs ranging over the 100 mile, or so, field envisioned.

Specifically, despite some initial negative Army study findings, we feel the benefit from a plastic ammunition upgrade has the potential to be a major assist in SUOs. The study must not be allowed to die.

The mandatory and specific requirements for pure water make any improvements which result in smaller, mobile, effective purifiers extremely important.

Finally, the principles of condition-based maintenance utilizing specific procedures shown can make field repairs of equipment more practical and effective as well as economical.

Health Services



The Panel considered health services, as associated with SUOs, to fundamentally deal with two issues: expeditionary medicine and preventative medicine.

This section focuses on expeditionary medicine because of some unique issues associated with SUOs, such as trauma and casualty stabilization needs.

However, the Panel wishes to call attention to the importance of preventative care and medical readiness, including development of next generation chemoprophylactics, repellants, vaccines, and counter agents for C/B protection. Much important research is ongoing within the DOD and the DON. These efforts should be continued, with integration of results between the services, and incorporation of the results into the training syllabi and deployment preparations.

The above photo displays an evacuation. One determining issue for dealing with expeditionary medicine is whether "Medevac" is indeed an option. The Panel considered both cases.

Health Services Requirements

- Expeditionary medicine requires:
 - A trauma model which supports emerging operational concepts
 - Improved casualty stabilization and intervention
 - Improved medical readiness and prevention
- Requirements viewed two ways:
 - Immediate evacuation available
 - Not available



Panel Research Advisory Committee

The Panel related the medical requirements to the operational framework discussed in an earlier section of this report. With this in mind, three general requirements were noted. These requirements must be viewed in two scenarios. The first is when immediate evacuation is available, while the second is when it is not.

The requirements Include:

1. A revised current trauma model which supports expeditionary medicine.
2. Improved casualty stabilization and intervention (treatment) on the battlefield.
3. Improved medical readiness and prevention pre- and post-deployment.

ARCC	<div data-bbox="656 216 997 294" data-label="Section-Header"> <h2>Health Services Trauma Model</h2> </div>
<u>Deficiency</u>	<ul style="list-style-type: none"> - Current trauma model dependent on the civil EMS model
<u>Technology Options</u>	
	<ul style="list-style-type: none"> - Tactical Combat Casualty Care (TCCC) training for the first responder
	<ul style="list-style-type: none"> - Interactive computer-based training using medical simulation
<u>Recommendations</u>	
	<ul style="list-style-type: none"> - Rebaseline medical procedures to support emerging operational concepts
	<ul style="list-style-type: none"> - Develop a TCCC curriculum and syllabus now to incorporate: <ul style="list-style-type: none"> • Advances in medical simulation and interactive PC-based training • Emphasis on tactical thinking and key life saving skills
	<ul style="list-style-type: none"> - Continue commitments for: <ul style="list-style-type: none"> • Military specific R&D • Innovative skills training for expeditionary warfare

Within the operational framework where task organized small units are employed over an expanded battlefield, well inland and widely dispersed, the current medical model may require revision.

The current model appears heavily dependent on the civil EMS system built on first responder roles, transportation systems, and unlimited infrastructure. These will not be available to the small unit dispersed and hidden across the battlefield. While the civil EMS model is constructed around the "golden hour," unlimited physical resources, and priority going to the casualty, combat trauma are characterized by the need to prosecute the battle. On the expanded battlefield, combat trauma is resource constrained, dependent on the first responder, possibly communications limited, time-critical, and assessment and triage dependent. Evacuation from the battlefield will probably be delayed because of the clandestine requirements of the mission.

Medical requirements of small units in the urban environment may more closely resemble the civil EMS model; however, it appears that expeditionary medicine calls out for "rebaselining" the concepts of casualty care in order to avoid building medical care requirements and training that do not support emerging operational concepts.

Tactical Combat Casualty Care (TCCC) training for the first responder shows promise. Emphasizing tactical thinking and key life-saving skills, TCCC is currently being developed by the USMC Warfighting Laboratory.

Equally important, interactive training using medical simulation development promises to enhance both surgical and first responder

skills. The DON should align doctrine and training to better support the needs of expeditionary medicine.



Health Services Casualty Stabilization

Deficiencies:

- Methods to prevent early deaths
- Limited clinical competence in SUOs.

Technology Options:

- Near Term: - Advanced first aid skills for each SUO member
- Light weight hemorrhage control technologies, e.g., fibrin bandages, pro-coagulant foam, tourniquet
- Knowledge/use of methods to maintain airway e.g., relieve tension pneumo thorax
- Mid-term: - Physiological sensors plus MARC card
- Telemedicine, e.g., transmit visual, ultrasound & x-ray data
- Long-term: - Infectious disease specific sensors
- Generate water for injection to rehydrate blood product
- Explore methods to prolong life of casualty (suspended animation)
- Stealthy evacuation including life-sustaining transporter

Casualties include injuries and diseases. For many injuries, immediate resuscitation, stabilization and repair within 60-to-90 minutes are critical to recovery. An essential determinant for battlefield doctrine and training is the availability of helicopter (or other) evacuation. Without evacuation capability, each member of small units requires advanced first aid skills. He or she should be able to implement immediate hemorrhage control, particularly for extremity wounds. Available technologies include fibrin bandages and pro-coagulant foam. Combat team members should also be able to relieve tension pneumothorax (frequently a lethal complication of chest wounds). Mid-term future technology options should include a better tourniquet and the availability of sensors capable of transmitting physiological data (medical status sensor) which would be integrated with individual health data (MARC card). Long-term technology options might provide visual transmission of injury or disease status, including ultrasound and x-ray. In return, instructions for specific resuscitation procedures would be transmitted. Another option is the production of medically pure water for injection in the field. This would make available intravenous injection fluids or the rehydration of lyophilized oxygen-carrying blood products. Far future interventions might include technologies to induce a "suspended animation" which would lengthen the period of post-injury survival prior to definitive resuscitation, plus enhanced capabilities to exfiltrate casualties by ground or air (e.g. UGV, UAV).

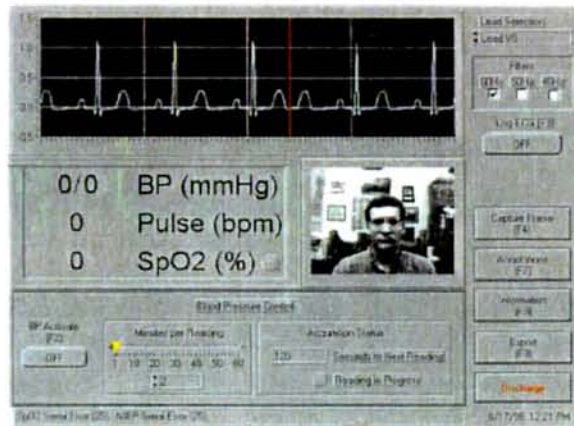
Currently available technologies do not permit remote diagnosis of the cause of infectious diseases, although mid- and long-term technology options will provide several types of disease agent identifying nanosensors. These, coupled with individual medical status sensors, will establish immediate, specific diagnosis of a wide range of infections

and other medical conditions in the field. These same sensors will be available to detect C/B agents.

Assuming that packaged food will be consumed during short duration deployments, water from local sources may be the only environmental health threat. Water may be contaminated with disease-producing agents or chemicals. A wide range of water purification technologies are presently available. However, large volumes of water may be required to support operations. In the mid to long term, nanosensor arrays should be capable of screening water sources indicating threat agents and suggesting the simple technologies that are needed to attain safety and purity.

Health Services Casualty Stabilization - Recommendations

- Emphasize advanced first aid training and supportive technologies
- Continue telemedicine and remote treatment protocols development
- Accelerate development of stealthy unmanned evacuation systems



Mobile Medical Monitor (M³) Display

Panel Research Advisory Committee

The Panel determined three straightforward recommendations for the issue of casualty stabilization:

1. Advanced first aid training and those technologies supportive of providing the "first responder" with the ability to stabilize the wounded should be emphasized.
2. Development of telemedicine and remote treatment protocols should be continued.
3. Development of stealthy, unmanned evacuation systems should be accelerated for SUOs.




Chemical/Biological Detection, Protection and Decontamination



National Research Advisory Committee

This particular picture provides a dramatic description of the problems surrounding decontamination, i.e. demands upon both people and water. The Panel found that the greatest leverage can be gained through emphases on both detection and a quest for a waterless (chemical based) decontamination system for the field. The Panel also agrees that improvements in protective gear are mandatory, particularly in weight, bulk (mobility), and comfort.

<div>  Chemical/Biological Detection, Protection and Decontamination </div>	
<u>Requirement</u>	<ul style="list-style-type: none"> - Improved C/B detection, protection and decontamination
<u>Deficiency</u>	<ul style="list-style-type: none"> - Need portable sensors for early detection - Chemical decontamination requires large quantities of water - Current generation of protective clothing inhibits effective operations
<u>Technology Options</u>	<ul style="list-style-type: none"> - Surface Acoustic Wave (SAW) chemical agent sensor development - Fluorescence and Fiber Optic Wave Guide (FOWG) technology for bacterial, viral, and toxin detection. Extension to UAVs may provide early detection and identification - Multiple-Input Sensing Technology (MIST) microsensors for real-time detection - Joint Services Lightweight Integrated Suit Technology System (JLIST)

A first generation of portable chemical and biological sensors is currently in the military supply system. A substantial investment, along with remarkable new technologies, will make it possible for small units or individual warfighters to sense low, sublethal concentrations of C/B agents. Sensitivity for some agents is at the parts per trillion level, although this is dependent upon high volume air sampling. When C/B weapons facilities are targeted, small units should include C/B specialists. C/B agent prophylactics and inactivating drugs are currently in the supply system, although they are bulky, and may require needle injection. A joint service program is developing new lightweight protective over- and undergarments. Currently available chemical detoxification requires large amounts of water. A new generation of universal C/B antidotes is needed, as are lightweight protective garments and a portable, waterless chemical decontamination process.

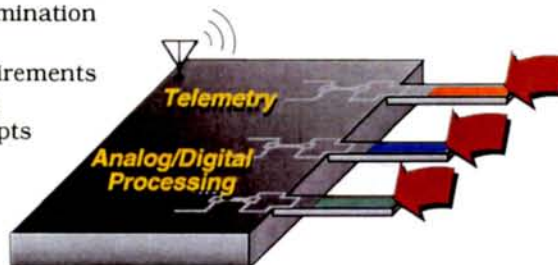


Chemical/Biological Detection, Protection and Decontamination

Recommendations

- Support SAW sensor, FOWG, nanosensor, and JLIST development
- Explore C/B antedotes
- Explore portable, waterless chemical decontamination process
- Ensure joint requirements support emerging operational concepts

• **Physical**
• **Chemical**
• **Biochemical**



Panel Research Advisory Committee

Perhaps the Panel's most important recommendation is for the DON to ensure that Joint Requirements be established in a framework to support and be aligned with emerging operational concepts, such as those typified by the SUO operational framework.

In addition, the Panel supports continued development of microelectronic technology applications to C/B detection, and continued development and fielding of the joint lightweight protective suit technology.

To cover those instances where exposure occurs, the Panel considered that the greatest leverage can be attained from: continued development and exploration of chemical and biological antidotes; and, exploration of portable, waterless decontamination processes.

Take Aways

- **Keep CSS-E going . . . grow into deployed logistics testbed**
- **It's not the batteries . . . fix the radios and communication protocols**
- **Need training and technology discipline across the board . . . tested in operational environments**
 - Disciplined communications/degraded environment
 - Wider use of surrogates
 - Integration of individual equipment load and the Marine as a weapon system

This study was unusually broad because of the number of logistics functions associated with maintaining operations and the resulting number of specific technology product areas which impact logistics and SUOs on a day-to-day basis. Therefore, the Panel chose to develop a set of three main issues and recommendations as "take-aways" for senior leadership which reflect a total of 29 detailed recommendations developed across the span of seven technology areas, described in those sections of the report and tied back to this chart.

The CSS-E experiment was a success and provides a low cost, low risk 80-90% solution to logistics information management. It should be grown into a deployed logistics testbed with the 15th MEU in 1998.

Batteries (and radios) heavily influence the load for the individual Marine and present a significant resupply problem. Unfortunately, battery technology is relatively mature, and significant gains in output power per unit size are not forecast. However, it is clear that today's commercial electronic technology applied and adapted to military radios and signal processing can provide a significant improvement in energy use, as can new communications protocols which focus on reduced transmissions, hence energy use.

It became clear to the Panel that training and technology discipline are needed across the board, including testing in operational environments. Elements include disciplined communications use in a degraded environment and wider use of surrogates to test operational concepts (e.g., unmanned ground or air vehicles) in order to define a proper set of operational requirements relevant to SUOs. In addition, we believe that the individual Marine and his equipment load should be treated as an integrated weapon system, with a focus on reducing the

load. Finally, technology is seductive. The Panel cautions that off-the-shelf technology, untried in a military environment, may be vulnerable to exploitation. The Panel believes this underscores the importance of the operational testing/requirements definition process. The Panel also believes that it is mandatory to leverage commercial technology while at the same time shortening the acquisition process.

Appendix A:**Acronyms List**

AAN	Army After Next
ACE	Air Combat Element
ACTD	Advanced Concept Technology Demonstration
A/J	Anti-Jam
ARG	Amphibious Ready Group
ARL	Applied Research Laboratory
ASD	Assistant Secretary of Defense
ASN(RD&A)	Assistant Secretary of the Navy (Research, Development & Acquisition)
ATLASS	Asset Tracking for Logistics and Supply System
AWE	Advanced Warfighting Experiment
BW	Biological Warfare
BWD	Biological Warfare Defense
C ²	Command and Control
C ⁴ I	Command, Control, Communications, Computers, and Intelligence
CINCPACFLT	Commander in Chief US Pacific Fleet
C/B	Chemical/Biological
CBW	Chemical/Biological Warfare
COMDAR	Common Data Repository
COTS	Commercial Off-The-Shelf
CSSE	Combat Service Support Element
CSS-E	Combat Service Support-Enterprise
CW	Chemical Warfare
DASN(C ⁴ I)	Deputy Assistant Secretary of the Navy (Command, Control, Communications, Computers and Intelligence)
DARPA	Defense Advanced Research Projects Agency
DOD	Department of Defense
DON	Department of the Navy
DOTES	Doctrine, Organization, Training, Equipment, and Support
DSO	Defense Sciences Office
ECOC	Experimental Combat Operations Center
EECS	Electrical Engineering and Computer Science
EEG	Electrical Energy Gun
ELB	Extended Littoral Battlefield/Battlespace
EML	Electromagnetic Launch
EMS	Emergency Medical Service
EO/IR	Electro-Optical/Infrared
FLIR	Forward Looking Infrared
FOWG	Fiber Optic Wave Guide
FSSG	Force Service Support Group
FY	Fiscal Year

GCCS	Global Command and Control System
GCE	Ground Combat Element
GOTS	Government Off-The-Shelf
GPADS	Guided Parafoil Air Delivery System
GPS	Global Positioning System
GPS/INS	Global Positioning System/Inertial Navigation System
HMMWV	High-Mobility Multi-purpose Wheeled Vehicle
HQMC	Headquarters, U. S. Marine Corps
I&L	Installations and Logistics
ITS	Individual Training Standards
JATO	Jet Assisted Take-Off
JLIST	Joint Services Lightweight Integrated Suit Technology System
JMCIS	Joint Maritime Command Information System
km	Kilometer
LAD	Logistics Anchor Desk
LHA	Landing Helicopter Assault Ship
LHC	Liquid Hydrocarbon
LOE	Limited Objective Experiment
LOGAIS	Logistics Automated Information System
LPD	Landing Platform Dock or Low Probability of Detection
LPH	Landing Platform Helicopter Assault Ship
LPI	Low Probability of Intercept
MARS	Mid-Air Recovery System
M ³	Mobile Medical Monitor
MAGTF	Marine Air-Ground Task Force
MARC	Multi-Technology Automated Reader Card
MARCORSYSCOM	Marine Corps Systems Command
MARFORPAC	Marine Forces Pacific
MDARS-E	Mobile Detection, Assessment Response System-Experimental
MEDEVAC	Medical Evacuation
MEMS	Micro-Electro-Mechanical Sensors
MERLIN	Medical Readiness Learning Interactive Triage Trainer
MEU	Marine Expeditionary Unit
MEU (SOC)	Marine Expeditionary Unit (Special Operations Capable)
MIST	Multiple-Input Sensing Technology
MOS	Military Occupational Specialty
MRE	Meal, Ready-to-Eat
MSS	MEU Service Support

MWSS	Marine Wing Support Squadron
MXU	Mobile X-Ray Unit
NAVWAR	Naval Warfare
NDI	Non-Development Item
NEO	Non-Combatant Evacuation Operations
NRAC	Naval Research Advisory Committee
NRaD	Naval Command, Control and Ocean Surveillance Center Research, Development, Test and Evaluation Division (Now: SPAWAR Systems Center, San Diego (SSC San Diego))
NRDEC	Natick Research, Development and Engineering Center
NRL	Naval Research Laboratory
ONR	Office of Naval Research
OPTEMPO	Operational Tempo
OUSD	Office of the Under Secretary of Defense
ORNL	Oak Ridge National Laboratory
OTH-T	Over The Horizon-Targeting
PM	Program Manager
POL	Petroleum, Oils, and Lubricants
RATO	Rocket Assisted Take-Off
R&D	Research and Development
RF	Radio Frequency
RPV	Remote Piloted Vehicle
RSTA	Reconnaissance, Surveillance, and Target Acquisition
RRTS	Rapid Request Tracking System
SATCOM	Satellite Communication
SAR	Synthetic Aperture Radar or Search and Rescue
SAW	Surface Acoustic Wave
SINCGARS	Single Channel Ground and Airborne Radio System
SPAWAR	Space and Naval Warfare Systems Command
SPMAGTF(x)	Special Purpose Marine Air-Ground Task Force (Experimental)
STOM	Ship to Objective Maneuver
SUO	Small Unit Operations
TACAIR	Tactical Air/Aircraft
TCCC	Tactical Combat Casualty Care
TCO	Tactical Combat Operations System
TLACS ³	Tactical Level Automated Combat Service Support System
TLAM-D	Tomahawk Land Attack Missile-Dispenser
TTO	Tactical Technology Office
TUV	Tactical Unmanned Vehicle

UAV	Unmanned Air Vehicle
UGV	Unmanned Ground Vehicle
USN	United States Navy
USMC	United States Marine Corps
USV	Unmanned Surface Vehicle
UUV	Unmanned Undersea Vehicle
VTOL	Vertical Take-Off and Landing

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