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ARMY SCIENCE BOARD

AD HOC STUDY
FINAL REPORT

on

"TECHNOLOGY FOR THE FUTURE LAND WARRIOR"

October 1994

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CONFLICT OF INTEREST STATEMENT

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13. ABSTRACT (*Maximum 200 words*)

This report documents the results of a study to identify high payoff technologies applicable to the Land Warrior, to recommend programs to overcome technical and system barriers, and to recommend appropriate demonstration projects.

Near-term high payoff technologies identified include the squad radio, global positiong systems, a continous, positive pressure NBC mask blower, the AIM light, and a leg brace for parachutists called LEAP (Lower Extremity Assistance for Parachutist).

Longer term technology programs identified include location and target detection, combined arms integration, lighweight power, improved airdrop, NBC and individual equipment, and advanced medical/trauma care. A demonstration program is recommended for each of the longer term-programs as a means to evaluate trade-offs among various technical solution.

The report concludes that technology for the Land Warrior is available. Recently completed programs demonstrated that the use of technology for the soldier profoundly improves individual and squad capabilities. Careful planning and testing is needed to procure the right mix of equipment for an adequate number of soldiers to enhance capabilities at a reasonable cost.

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FINAL REPORT

ARMY SCIENCE BOARD AD HOC STUDY

TECHNOLOGY FOR THE FUTURE LAND WARRIOR

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EXECUTIVE SUMMARY

The Army Science Board (ASB) Ad Hoc Study on "Technology for the Future Land Warrior" had three purposes: first, to identify high-payoff technologies; second, to recommend programs to overcome technical and system barriers; and third, to recommend appropriate demonstration projects.

In the near-term, some technologies demonstrated by the Soldier Integrated Protective Ensemble (SIPE) Advanced Technology Demonstration (ATD) and Special Operation Forces (SOF) programs met criteria for high payoff; these include the squad radio, global positioning system, a continuous positive pressure nuclear, biological and chemical mask blower, AIM light, and Lower Extremity Assistance for Parachutist (LEAP). Further work was suggested on the thermal sight and aural enhancement.

Programs to overcome technical and system barriers include a review of the acquisition process to allow integrated fielding of basic systems; an emphasis on weight control as a key hurdle; and cost controls, which limit single unit costs to less than $10,000. Cost controls are intended to facilitate the fielding of equipment for an adequate number of soldiers.

To focus long-term technology management, six key areas were identified. Each of these areas could support a near-term demonstration project. Such a project could potentially be an ATD, but would most likely be a much smaller-level demonstration. The relative near-term importance is listed in the subsequent order of presentation.

The first area is location and target detection, including Identification Friend, Foe or Neutral (IFFN); it is a demonstration of a suite of electronic equipment with the focus on improved capabilities rather than expensive hardware. The second is a combined arms integration effort that would use the Training and Doctrine Command (TRADOC) Battle Laboratories to test which of the small unit capabilities will integrate and enhance total force capabilities. The third area is a comparative power demonstration that would prioritize near-term power sources and establish limits on equipment. The fourth is an improved airdrop demonstration that would integrate LEAP technology with novel parachute designs to provide safe high-speed, low-altitude airdrop. The fifth area is a demonstration of new nuclear, biological and chemical equipment and other clothing and individual equipment to determine whether the integrated versus add-on approach is optimal. The last demonstration is medical care, improved communications and trauma care.

Testing of the above demonstrations will require both simulation and field testing. Initial simulations should focus on the squad level. Virtual reality may not be the optimal simulation technology. Field testing should test different combat situations in urban, desert and forest terrains in all seasons to completely evaluate the strengths and limitations of novel equipment.

The long-term management of Land Warrior Technology (LWT) could be similarly organized into these focus areas with the goal of moving ideas into small-scale demonstrations. The panel found the 6.1 areas of work to be broad, with very few technologies not being explored. An example technology that is not being explored is the use of synthetic smell for land mine detection.

The panel found that SOF, although capable of developing useful technology, did not have a method for routing technologies back into the Concept Based Requirements System (CBRS) process. By incorporating SOF-developed materiel into demonstrations, and providing some seed money, integration would be obtained.

In conclusion, the panel found that technology for the Future Land Warrior is available—the future is here. The technologies demonstrated in recently completed programs will profoundly improve individual and squad capabilities. Careful planning and testing is needed to procure the right mix of equipment for an adequate number of soldiers to enhance capabilities at a reasonable cost. The panel believes this is not an impossible task, but will require a top-down management focus on results, not programs.

PROBLEM STATEMENT

The purpose of this study is threefold:

- Identify high-payoff technologies which enhance the capabilities and performance of land combatants;
- Recommend programs to overcome the technical and system barriers; and
- Recommend one or more demonstration programs to quantify enhanced capabilities and performance.

BACKGROUND

There is a universally recognized need in the science and technology communities for LWT to be upgraded. Operation Desert Storm demonstrated the effectiveness of superior technology in a range of combat platforms and scenarios.

This ASB Ad Hoc Study on "Technology for the Future Land Warrior" is the most recent in an ongoing set of evaluations performed by the ASB looking at the evolving programs within the Army for application of technology to the tasks of the dismounted combatant. Most notable of the studies which have preceded this report is the 1991 ASB Summer Study, "Soldier as a System," which looked at the newly forming initiatives in this area.

In the intervening years since that last ASB review, the program to provide new soldier capability has matured considerably. As well, the program has become an integral element of an overall future Army technology road map. Additionally, the Army soldier technology program has become an important piece of the overall Department of Defense Science and Technology Thrust initiatives.

A series of Army-led advanced technology investigations has illuminated additional technological opportunities ready for entry into a demonstration phase.

CURRENT STUDY OBJECTIVES AND CONCLUSIONS

Within the framework of its Terms of Reference (TOR), this Ad Hoc Study on "Technology for the Future Land Warrior" chooses to attempt to answer the questions, "Now that the Land Warrior Technology ball is rolling, what should we do with the momentum gained?" or more simply, "What should the Army do next?"

Probably the foremost of the conclusions reached by this ASB panel is that the acronym SIPE connotes an unfortunate, passively defensive vision of the objectives of the current Army Land Warrior Technology effort. Rather than SIPE, as it was named four years ago, being a program to produce a Soldier Integrated Protective Ensemble, it can now be more accurately described as a program to provide Soldier Integrated Performance Enhancement.

It is now time for the formalization of a change of emphasis which has been recognized within the community for some months. We suggest program recognition that the emphasis has indeed shifted from "protective" to "performance enhancement." We feel thereby that the contribution of technology to the Land Warrior can be greatly enhanced. As well, from the Army users' standpoint, new, predominantly offensive capabilities are perceived to be of far greater importance to the future Land Warrior than defensive capabilities.

The many detailed conclusions of this study are provided in substantial detail in the later sections of this report. A summary of the more top-level findings immediately follows.

TOP-LEVEL STUDY CONCLUSIONS

GENERAL FINDINGS:

1) Recent SIPE demonstrations offer convincing verification that new, important and affordable technology-derived techniques can provide cost effective improvements in Land Warrior capabilities. These are detailed in Issue #4.

2) These new Land Warrior capabilities will have a profound positive effect on the Army's ability to perform its most stressing future contingency missions (particularly the ability of small, light, early entry forces to sustain themselves against an aggressive, larger, armored force). The increased protection may also decrease casualties in all future missions.

3) There are three major barriers to implementation of LWT; one is administrative, the others are technical. The administrative barrier is the current acquisition system; the two key technical barriers are weight and cost.

4) Unlike larger platforms where a few "silver bullets" can be decisive, Land Warrior equipment must be delivered in quantity to soldiers in the field in order to be effective. Moreover, the effectiveness of LWT increases considerably after personnel are fully trained with these new capabilities.

5) Army planning is not adequately detailed for the evolution of LWT. Specific focus areas which set priorities are not defined.

6) Near-term fielding of new LWT is uncertain due to unclear descriptions of novel capabilities, which limit the ability of LWT to compete with other programs.

7) The Army does not have a top-down new product planning process typical of high technology U.S. commercial business. U.S. high technology firms go to extraordinary lengths to focus technology efforts into categories of potentially greatest improvement, to avoid substantial proliferation of options examined, and to solicit contributions from all affected organizational elements.

Members of this panel came to this review with extensive experience in the planning and execution of industrial research and development (R&D) programs, both military and commercial. The top-down R&D management process recommended has been crucial for high technology industry to remain competitive in its world of peers. We strongly feel that the process for formulation of successful military research programs must closely parallel those of their successful industrial counterparts.

In industry, the issues which define the flow from the research laboratory to the marketplace are inevitably defined by looking back down the technology process. This introspective look at technologies that should be emphasized must start with identified needs. The questions to be asked are:

A. What will the market buy?
B. What will it pay?
C. How much money is available for product introduction?
D. What and when must new supporting technologies be ready?
E. What are judged the most promising emerging technology options?
F. What scientific underpinning is necessary for success?

We found that many of the technology development elements necessary for successful production and fielding of LWT are included in the November 1992 Army Science and Technology Master Plan (ASTMP). Most notable of these elements are SIPE, The Enhanced Integrated Soldier System (TEISS) and Generation II Soldier ATD. However, with the absence of a firm commitment to produce stated technologies, and an estimation of funds available for production, prioritization of individual technologies within the current Land Warrior program is almost impossible. Without knowing the order of what is to be fielded, a responsive and efficient technology program is sheer guess work.

RECOMMENDATIONS:

Based on the above general conclusions, this ASB Study Panel recommends to the Army the following management strategies to use in its implementation of the LWT initiatives.

1) Immediate effort should be undertaken within the Army to quantify the comparative cost effectiveness of production and fielding of LWT compared to the utility derived from other non-Land Warrior production options.

2) A continuing funding wedge to support production must be budgeted.

3) The funding wedge should be based on procurement with the following approximate goals:

a.	Minimum fielding quantity/item	10,000
b.	Average build out period/item	5 years
c.	Average number of projects in pipeline at any time	5
d.	Average production cost/item	$10,000
e.	Total funding for new capability	$100 M/yr

4) The Army must formulate a prioritized list of appropriate production candidates based on programming for continuing production (along the lines of the outline above). Suggested technologies deemed appropriate for early production are included later in this report.

5) Based on the availability of Land Warrior items for production and funds available within the proposed budget wedge, a commitment to a schedule of new programs for future production must be obtained. Otherwise, funding will be used to procure initial equipment for all units rather than to continue procuring newly developed equipment.

6) Schedule a series of SIPE-like technology demonstrations to qualify candidate technologies.

7) Based on long-term user needs and the timing of future SIPE-like user/technology testing, focused advanced technology programs drawn from within the Army Land Warrior research and technology menu can be selected. While not all potential technologies need to be focused toward these testing gates and user preferences, the Army must ensure that the bulk of its technology exploration selections comes from this process.

8) The Army should adopt a top-down, industry analogous, new product planning process whose end product is definable. A definable product allows for meaningful prioritization, funding and sequencing of technology development efforts.

ISSUE #1:

THE WEIGHT BARRIERS

FINDINGS:

1) A key barrier in any Land Warrior program is weight.

Table 1 compares the Baseline and New tailored loads for the platoon leader. Even if the load is tailored to a typical combat situation in a temperate climate, the load is still substantial at 86.8 lbs. The tailored loads are more representative of the actual loads carried in the field and should be given additional emphasis by R&D for reduction in weight as well as bulk.

	Tailored Loads			
	Baseline		New	
	Lbs	%	Lbs	%
Clothing and Equipment	29.7	34.2	35.4	39.4
Weapons/Ammunition	23.1	26.6	23.1	25.7
Radio-Optics	14.0	16.1	12.6	14.0
Food/Water	12.8	14.7	10.8	12.0
Ballistic Protection	3.5	4.0	3.5	3.9
NBC Protection	3.7	4.3	4.5	5.0
	86.8	100.0	89.9	100.0

Table 1. Tailored Loads for Baseline and New Configurations

The tailored load still exceeds what an average soldier should optimally carry. Therefore, very little or no additional weight can be effectively added to the soldier's load.

Table 2 gives a breakdown of weight for the platoon leader's load (not tailored) in a temperate climate. From Table 2, less than 20% (22.2 lbs) of the platoon leader's load are consumable items such as ammunition, grenades, food and water. Therefore, major weight savings need to come from non-disposable equipment.

CLOTH/EQUIP	WT (lb)
Cap, Woodland	0.3
BD-Uniform	3.8
Underwear	0.2
Socks	0.8
Boots	4.1
Gloves	0.4
LBE w 1st Aid Kit	2.7
Face Paint Compact	0.2
Entrenching Tool	2.5
Matches/box	0.2
Watch, Wrist	0.3
Penlite	0.5
Jacket Gtx No Lin	2.4
(No Rainst-Poncho)	0.0
Ind Mult Shelter	5.3
Sleeping Bag	7.0
Pad, Sleeping	1.5
Backpack, Int Fram	8.0
Bag, Waterproof	0.8
Toilet Articles	1.5
Towel	0.4
Knife, Personal	0.4
Camo Net, Ind	0.3
(No Shelter Half)	0.0
Overshoes G. V.	3.2
Compass, Len	0.3
	47.1

FOOD/WATER	WT (lb)
Food Pack Asslt (4)	4.0*
Canteen/Water 1 QT (2)	6.7*
Water Tablets	0.1*
	10.8

BALLISTIC PROTECTION	
Helmet PASGT	3.5
Vest PASGT	8.5
Glasses, Ballistic	0.2
	12.2

NBC PROTECTION	
NBC Mask M40	3.8
Antidote Mark 1 (3)	0.5
Decon Kit M258	0.3
Detector Card M256 (2)	0.2
Chem Suite Lt Wt	4.2
CB Helmet Cover	0.1
CB Gloves (14mil)	0.3
Overshoes G.V. 2nd Pr	3.2
Chem Paper M8/M9	0.5
	13.1

WEAPONS/AMMO	WT (lb)
Rifle M16A2 W 3ORD	8.9
Ammo M16 3ORD (4)	4.4*
Bayonet M9 w/Scab	1.8
Cleaning Kit, Wpn	0.5
Grenade, Hand (2)	5.0
Gren, Mini Smk (2)	2.0*
Gren, Signal W.C.	0.5
	23.1

*Consumable Items

RADIO/OPTICS	WT (lb)
Binoculars Lt Wt	1.5
Sight, NVG PVS - & Mono	1.5
Radio 126 w/Battery	3.6
Tel TA-1	4.0
Battery, 68 BA1588 (3)	2.0
Signal Panel, VS-17	0.3
	12.9

PLATOON LEADER'S TOTAL	119.2

Table 2. Platoon Leader's Load, Temperate Climate

Since weight is a universal Land Warrior barrier, no technology can be allowed to proceed unless it meets some weight constraints. A rational weight criteria could be the requirement that any item in 6.2 must have a future potential to meet a fielded weight goal. An example of a slightly heavier item that should move to 6.3a is improved articulated body armor, which is more comfortable, provides better protection and has the potential for further weight savings. An example of a product that would likely never be fielded, except as a special equipment item, would be a mechanical or electronic device that adds 10-15 lbs without replacing any current equipment. Therefore, exit criteria from 6.3a should include weight.

Weight savings can be entered within subsystems or by total weight. For example, clothing items or microclimate cooling, if added, have to lead to a no-net increase in weight. A new weapon sight, if heavier, has to be compensated by a decrease in the weapon or ammunition weight. Improved electronics have to be net-weight neutral or replace items such as the DR-8 reel wire in the case of the rifleman. An important part of the weight problem is the tailoring of loads. Even if a no-net gain is achieved, the actual soldier load could increase because field commanders increase the equipment mix to take advantage of the enhanced performance. Likewise, tailoring may solve some weight problems, especially with special equipment that may only be needed in certain circumstances. The weight issue is fundamental and should be clearly laid out as a potential "show-stopper" in all 6.3a projects.

RECOMMENDATIONS:

1) Establish and design a no-net to 10% maximum gain in weight program; and

2) Prioritize programs based on weight criteria as much as enhanced performance criteria.

ISSUE #2:

COST OF FIELDING

FINDINGS:

1) Improved Land Warrior capability requires technology availability to most front line units (especially those in Force Package 1).

2) The large number of soldiers needing novel equipment directly leads to large acquisition and maintenance costs.

3) Rational planning requires a cap on per soldier or small unit costs, which can be predicted by funding limitations.

The panel recognizes that the fundamental goal of improving LWT will not be met if the technology is only provided to a limited number of soldiers. If the technology developed is so expensive that few or no soldiers benefit from it, the effort on 6.2 and 6.3a will be largely wasted.

Table 3 provides a range of costs for fielding new technologies (no economies of scale are assumed).

Cost/soldier	Number of soliders equipped, in thousands			
	5	10	50	100
$10,000	$50m	$100m	$500m	$1000m
$30,000	$150m	$300m	$1500m	$3000m
$100,000	$500m	$1000m	$5000m	$10,000m

Table 3. Millions of dollars required to upgrade LWT

Under the future projected force structure, there will be about 33,000 front line combat soldiers. Therefore, a $10,000 per soldier budget cost of $330 million (without maintenance) is required if fielded to all soldiers. However, a proportionally smaller funding wedge would suffice to equip Force Package 1 soldiers (approximately 5000). Clearly in the current cost reduction atmosphere, systems that are substantially more expensive will never be procured. Therefore, the work proposed later in this report needs to focus on affordable technology, not just the best.

Furthermore, $10,000 does not buy much in terms of equipment. The recently tested SIPE would have unit costs in excess of $10,000. In fact, if just the high-potential items were fielded, unit costs would likely exceed $10,000, easily cost $30,000 and would approach $100,000 if power and protection were included.

The 6.2 and 6.3a community needs to be informed about cost limitations, and focus on cost savings and potential manufacturing cost early in the acquisition cycle. All technologies elevated to demonstration status should have cost estimates as both entry and exit criteria.

The cost concern should lead to better planning and utilization rather than elimination of a technology. For instance, the value of the Global Positioning System (GPS) is unquestioned; however, its unit cost may prevent fielding to all soldiers. Tests should be conducted to determine the appropriate mix and match of equipment for maximum performance at minimum cost.

The fielding cost requires top-down judgement on two essential questions: 1) How many soldiers? and 2) How much per soldier? After these questions are answered, a funding wedge can be predicted, and hard decisions on what to transition can then be made.

RECOMMENDATIONS:

1) Decide how many soldiers will be outfitted and at what unit cost.

2) LWT program prosecutes only technologies that are within affordable bounds into demonstrations.

3) Immediately de-emphasize extremely expensive programs, such as those with unit costs greater than $10,000, in 6.2.

4) Establish a funding wedge for LWT upgrades.

ISSUE #3:

ACQUISITION PROCESS

FINDINGS:

1) Planning, development, type classification and acquisition processes for soldier-related equipment are fragmented and require prolonged periods of time to affect coordination by several organizations (i.e., Army Research, Development and Engineering Centers (ARDECS), Department of Defense (DoD), and Defense Logistics Agency (DLA)), who are players at different stages in the process.

2) Most items of soldier-related equipment are developed and procured individually and, therefore, move through the complex process separately.

3) The recent direction by the DoD to shift the preparation of the procurement technical data package and initial proof of its adequacy for manufacturing (production demonstration) to the DLA further complicates acquisition, because it transfers responsibility for complex items from Army materiel developers at an awkward point in the process.

4) There is currently no central plan which determines how much of what materiel would be needed to conduct operations in projected scenarios. As a result, there is difficulty matching materiel procured with the needs identified by the Commanders in Chief (CINCs), who have this responsibility for the Table of Organization and Equipment (TO&E) units for their theaters. Since Land Warrior force mix is likely to include Marine and SOF units, the procurement system must also be able to deal with their needs on common Clothing and Individual Equipment (CIE), especially in deployment situations such as Operation Desert Storm.

5) The DLA policy of stockage which utilizes "use rate" does not allow for realistic preparedness to meet a rapid deployment, especially when the number deployed is large (for example, Operation Desert Storm) and deployment needs to be completed in a short period of time.

6) The delays between the transfer of funds by the Army for procurement to DLA and the obligation of these funds to affect procurement of the items extend the process.

7) There is a hesitancy in DLA to replace an existing item already in stock with a new item which incorporates major new advances in technology.

8) The basic Army RDA/DLA acquisition process is so slow that it is unable to meet unexpected needs which require a rapid response. A separate system, outside the regular Army RDA system, had to be created to meet the CINC's requirements during Operations Desert Shield/Storm.

The system for acquiring integrated "Soldier System" equipment represents a serious challenge for the current acquisition system. This ASB Study Panel evaluated the current acquisition process as a basis for judging whether the current system would need revising to meet the challenges for the provision of an integrated, modular and incrementally improved soldier ensemble envisioned for the future.

The advent of the "Soldier System" brings with it a concept for equipping the soldier. The soldier's equipment ensemble will emphasize integration to assure fit and performance of all of the elements. The ability to change out components as technology matures will permit gradual advancement of the capability of the soldier. Modularity of the assembly will permit the commander to select different combinations of the ensemble that best meet the soldier's individual mission needs.

Army future force deployment may be one of rapid, massive deployment, as seen during the recent Desert Shield/Storm, or utilize small, highly mobile forces. The acquisition process for tomorrow's "Soldier System" equipment will require major streamlining and flexibility to be able to meet both the long-term planned acquisition of the changing ensemble and the ability to surge to meet contingency operations. Central planning at TRADOC for fielding "Soldier System" materiel appears mandatory.

RECOMMENDATIONS:

1) Institute central planning for "Soldier System" materiel.

2) Develop basic field packages, and buy and equip to functional levels rather than by individual item.

3) Realize, from the top-down, that the acquisition process is the key administrative barrier to "Soldier System" modernization.

ISSUE #4:

SIPE ATD/TEISS TECHNOLOGY ACHIEVEMENT

FINDINGS:

1) SIPE field testing has only recently been completed, and analysis is not yet available.

2) SIPE confirms need for "Soldier System" architecture.

3) Overwhelming advantage of Command, Control, Communication and Intelligence (C3I), as seen in large units, also works in small dismounted units.

4) Some technologies are ready for transfer to TEISS from both SIPE and SOF programs.

The field testing of the SIPE ATD was only recently completed. Analysis of the tests is not available; however, from discussions with both developers and testers, some preliminary observations can be made. The complexities of SIPE and the integration required reinforced the need for a system architecture. The overwhelming advantage of C3I, which is inherent in large units, was seen in a small dismounted unit. The soldiers participating in the tests became believers in the system; they expressed concern over the possibility of fighting an opposing SIPE-equipped unit in the future. Although some of the equipment was very "klugey," the capabilities which were demonstrated will dramatically change both tactics and doctrine.

A subtle paradigm shift occurred during both the development and testing of SIPE. Although the project was initially focused toward "integrated protective ensemble," the end result was only a small advance in passive protection, but a large increase in offensive and active defensive capability.

Technologies from SIPE that appear to be low risk include the squad radio, GPS with inertia augmentation, the Continuous Positive Airway Pressure (CPAP) blower for the Nuclear, Biological and Chemical (NBC) mask, the AIM light, and the protective vest. The squad radio and GPS with inertia augmentation improve C3I dramatically. Although all soldiers should be equipped with the radio, not all may need GPS for a squad to function well. The CPAP blower for the NBC mask drew rave reviews from the soldiers. Although the work of breathing 5 centimeters of water across the filter of the mask is hardly noticeable at rest, soldiers reported an extreme sense of dyspnea or breathlessness while exercising; the blower completely eliminated this problem. The utility of the AIM light, which is currently available, was reconfirmed. The protective vest was far more comfortable than the currently fielded model due to its articulating structure. The vest is one pound heavier than the currently fielded model and should be reduced in weight.

Two devices, the thermal sight and aural augmentation, were clearly proven in concept but are not ready for transition to TEISS. The thermal sight was well liked by the testing soldiers; however, they stated they had inadequate training time prior to the weapon accuracy tests and, therefore, the results may not reflect the sight's full capabilities. In addition, a practical fielded sight would require substantial weight reduction.

Enhanced aural augmentation proved to be an exciting development. The way in which it was tested was quite instructive regarding the interaction between tactics and doctrine. One squad of soldiers found that the noise of walking made the aural enhancement distracting at best; however, a squad conducting a raid was able to eavesdrop on the opposing forces' defensive plan with predictable results. An analogy is the use of binoculars, which are invaluable, but which are a great hinderance if used constantly. The Army does not have the intuitive knowledge nor the experience to maximize the potential of much of the novel technology being demonstrated in SIPE. Further work with a two-band aural augmentation may make the device useful in both of the above described scenarios.

An SOF program to develop and field increased lower extremity protection during airdrop is another technology that should be included in TEISS. Commercially available lower extremity passive exoskeletons have been shown to protect against ankle and knee injury. Injuries such as these were some of the most common in Operation Just Cause.

SIPE clearly had some equipment that did not work well. These included the helmet display, boots and gloves. All of these have potential and should be reworked into future demonstrations (see Issue #5).

An alternative or parallel approach to our recommendations would be to immediately equip a battalion-sized early deployment force with a first generation squad radio, AIM lights and GPS. This approach would provide early information on effectiveness and upgrade-capabilities in the very near-term.

RECOMMENDATIONS:

1) Transition to TEISS the following technologies:

   a) Squad radio;
   b) GPS with and without inertia augmentation;
   c) CPAP NBC mask blower;
   d) Protective vest;
   e) AIM light; and
   f) LEAP.

2) Do further 6.2 and 6.3a work on:
   a) Thermal sight; and
   b) Aural enhancement.

3) Write requirements with strict weight and performance criteria.

4) Rework the deficiencies on other items and incorporate them into future demonstrations (see Issue #5).

ISSUE #5:

FUTURE GOALS FOR LAND WARRIOR TECHNOLOGY

FINDINGS:

1) Current science and technology is not focused into distinct problems or interest areas.

2) There are multiple technologies which are not ready for TEISS, but could transition in a five-year time frame.

3) The panel identified six focused capability areas in which technologies may improve performance. These are:

   a) Location and target detection, including Identification Friend, Foe or Neutral (IFFN);
   b) Combined arms integration;
   c) Power;
   d) Improved airdrop;
   e) Personal biological, nuclear and environmental protection; and
   f) Medical care.

4) One demonstration cannot effectively integrate technologies over these six areas.

Some technologies, although very promising, are not ready for transition to TEISS. Technology groups were divided into potential improved capability areas for the future Land Warrior. These areas include location and target detection, combined arms integration, power, improved airdrop, protection, and medical care. Most, if not all, technologies fit into one or more of these areas. These functional subgroups may allow for more focused and manageable oversight.

Improved location and target detection includes all sights, GPS, IFFN, mine detection, C3I technologies and hardware such as helmet displays, soldier computers and thermal imaging. The panel believes some of this hardware is near-term; however, the focus should be on capability enhancement rather than hardware for its own sake. By focusing a demonstration on improved location and target detection, the result would be improved capabilities rather than functional hardware with ill-defined missions. Special efforts should be made in the areas of IFFN and personal mine detection.

The combined arms focus area would be a software rather than a hardware demonstration. The improved capabilities projected from the other areas would be tested in a

Battle Laboratory environment to determine how improved small unit capabilities would impact on force structure and whether these capabilities would be redundant in the force structure. This input would be valuable in choosing what additional technologies to transfer to TEISS upgrades.

Power is a key technical barrier. The current limits of power production need to be fully tested. This information is critical to the short- and long-term equipment choices that will be tested in demonstration programs and transitioned out. In the near-term, disposable batteries, rechargeable batteries with a squad size recharging unit and possibly internal combustion and Sterling cycle engines are available technologies. A focused demonstration that compares power output, weight, safety, duration, cost and environmental signals such as heat and noise will help in establishing limits for equipment in the future.

Personal protection includes ballistic, biological, chemical, nuclear and environmental protection. The SIPE effort in this area was one of both outstanding success (the vest) and mixed success (the boots and gloves). Clearly, protection technology is near-term, and another demonstration program should be undertaken.

Improved airdrop protection remains a pressing need. Multiple approaches are available, including next generation lower extremity braces (near-term), improved parachutes (near-term), and first generation contained pod protection (very long-term). A focused demonstration is needed to test and trade off the two former approaches. The focus should be on the compelling need for a safe system for high-speed, low-altitude mass airdrop capability such as was seen in Operation Just Cause. The incidence of ankle and knee injuries in Operation Just Cause was unacceptable. All of these approaches would integrate separate efforts.

The medical area holds promise for the future Land Warrior. Short-term capabilities include remote physiological monitoring and expert systems to assist in first aid. The former needs to be tested to see if the information can be effectively utilized.

The six science and technology focus areas outlined above should provide the basis for the next generation of demonstration programs. Focus areas of research will allow early prioritization within categories. Science and technology work may lead to clear, consensus solutions to some problems; however, two potential solutions could be pushed up to a demonstration to allow field testing to determine which, if either, is optimal. If the near-term equipment solves the problem, such as airdrop, an alternative focus area could be identified. The following paragraphs are included to focus long-term research (i.e., 6.1 and 6.2).

Location and target detection desired capabilities in the mid-term include target acquisition, sensors and IFFN. Technologies include electro-optics, micro sensors and micro-electronic communications. Hardware that may help meet needs includes the soldier computer, helmet electronic suites and weapon and helmet integration. In addition, science and technology efforts need to be integrated with the future combat rifle program. The SIPE single-band hearing augmentation was ineffective except in eavesdropping; a two-band directional system with a microprocessor may provide both direction and target acquisition. Olfactory sensors represent a key unfunded 6.1 area in location and target detection; no work appears to be ongoing in these sensors. Recent civilian work combining micro-electronics with bio-assays may lead to an "electronic hand-held dog," which could be useful in the detection of hidden munitions, including mines. A 6.1 investment in this area is warranted.

Combined arms integration mostly requires simulation technology. How improved small units function with new technologies and how technology affects force structure are questions crucial to the trade-off decisions required when technologies are being evaluated for transition. The Battle Laboratories may represent the best End Users of this technology.

Power will remain one of the key technical burdens with each new generation of LWT. The current batteries are approaching the energy density limit; the energy density is approaching that of high explosives. The alternative, a small internal combustion or Sterling cycle engine, suffers from the problems of weight, bulk, heat and noise that potentially limit capabilities. Some effort needs to be made in signature suppression to offset these limits. Fuel cells offer a great solution, but the challenges to produce a lightweight, safe fuel cell at reasonable cost make this technology long-term. Combined approaches need to be considered; for example, a rechargeable battery with a unit-sized recharger may offer a better near-term solution than reliance on primary batteries or an internal combustion engine alone. Unlike many of the other problems faced by Land Warriors, power is also a critical national need, in such diverse areas as electric cars to portable computers. The role of the National Laboratories in this area needs to be investigated, and Army Research Laboratory (ARL) programs should compliment rather than duplicate such efforts.

The technologies in personal protection should focus on further work in ballistic, chemical, nuclear and environmental protection. These technologies include low observables, lightweight materials, flash protection, improved fabrics, chemical/biological decontamination, air purification, microclimate cooling, and high strength polymers. It is believed that ballistic protection is a high-payoff area and that further weight reduction for a degree of protection is possible. Environmental protection includes the development of both passive and active cooling; passive cooling is a more likely candidate, however, due to power and weight requirements as well as the heat signal of active cooling. Trade-off decisions required in the science and technology base include the basic decisions on cost and weight as well as on architectural issues. Whether NBC protection should be integral to the basic uniform or a separate add-on has not been decided.

An area that also appears in need of focus is boots. Civilian technology on ergonomic boots is rapidly advancing, and work should proceed to evaluate their military potential as well as if some basic mine protection is possible. The science and technology developers should expect their products to be tested in all environments. The capabilities in improved airdrop include both individual equipment, such as external braces, and alternative approaches, such as pods or airbags. Supporting technologies include lightweight and high strength materials. Trade-off decisions need to be made by science and technology steering committees and Land Warrior managers on whether parallel or single approaches are needed. However, to invest all money in the current program that emphasizes novel parachutes when the SOF LEAP program demonstrated the value of alternative approaches does not appear optimal.

Improved medical care should be a priority. Long-term science and technology initiatives in combat casualty care that have been outlined by the Army Medical Research and Development Command, as well as further development of expert systems to provide first aid, need to be pursued. In addition, novel approaches to NBC prophylaxis need to be investigated. Recently, catalytic monoclonal antibodies that inactivate cocaine have been described. It may be possible to develop analogous antibodies for deactivation of nerve gas agents. Clearly some 6.1 effort in this area is warranted.

RECOMMENDATIONS:

1) Focus science and technology into six capability areas.

2) Prioritize funding based on these areas.

3) Fund six focus area demonstrations, one in each of the six areas noted above.

4) Plan to transition, as upgrades to TEISS in 4-5 years, only the top five or so items from these demonstrations.

ISSUE #6:

SPECIAL OPERATIONS FORCES CONTRIBUTION TO LAND WARRIOR TECHNOLOGY

FINDINGS:

1) SOF materiel developers with limited budgets have multiple pieces of hardware that could enhance the regular forces' capabilities.

2) SOF, by early development, tests equipment faster than the Army's ATD track.

3) No good pathway to incorporate SOF-developed equipment into regular forces is available.

This panel found that SOF initiatives had solved some problems that no Army program had directly addressed. The best example is LEAP, which adapted commercially available football knee braces to decrease knee injuries seen with low altitude insertion.

Furthermore, SOF field tests equipment and quickly determines if there are operational problems. However, SOF-developed equipment, having been developed outside the normal CBRS, is seldom if ever procured or fielded by regular Army units.

The panel believes a potential solution that both encourages SOF initiatives and ensures that SOF-developed equipment has a pathway back into the CBRS would be to enable the Land Warrior science and technology manager to match SOF initiatives in improving LWT with up to one-seventh of the next generation demonstration funds. Developed items would be first evaluated by SOF. If an item appears to offer potential for regular forces, it would be included in the next generation demonstration, and by that method re-enter the CBRS.

RECOMMENDATIONS:

1) Land Warrior science and technology manager should use one-seventh of the next ATD budget to match mutually agreeable SOF-funded programs.

2) Transition SOF-developed hardware into next generation ATDs as a pathway back into the CBRS.

ISSUE #7:

TESTING AND SIMULATION OF FUTURE LAND WARRIOR TECHNOLOGY

FINDINGS:

1) The field testing of SIPE was hindered by the lack of available squads to test equipment.

2) Field testing may give data that answer trade-off decisions between alternative technical, architectural and/or doctrinal approaches.

3) The 1991 ASB "Soldier as a System" Summer study recommended that simulation technology be developed at the individual soldier level.

4) Virtual reality is being used to emulate individual soldiers, but does not yet appear capable of simulating squad size activities.

The field testing of the SIPE ATD was limited. The testers, in some cases, did not have adequate time to familiarize themselves with the equipment prior to testing. An example is the indirect view rifle site. The testers did not determine the best technique for using the indirect viewing until after the rifle range accuracy test. Furthermore, the test was conducted in only one environment. Capabilities in urban, desert or arctic environments were not studied. A complaint was that soldier availability at Fort Benning, a training facility, was limited.

Field testing may allow testing of trade-off decisions that cannot be answered in the technology base. Examples of this include trade-offs between both individual power and water purification and squad level solutions such as rechargeable batteries or small water purification units.

Simulation technology does not yet appear to work at the squad level. The current efforts with virtual reality may allow individual soldier simulation, but do not mimic small unit interactions that are essential in evaluating potential improvements, especially in C3I. Simulation technologies other than virtual reality, e.g., Integrated Unit Simulation System (IUSS) and JANUS, may be more appropriate in evaluating squad level capability improvements.

RECOMMENDATIONS:

1) Have Forces Command (FORSCOM) allocate squads of soldiers that would be available for field testing.

2) Field test alternative solutions to unsolved architectural, technical and doctrinal problems.

3) Focus simulation efforts in the near-term on techniques that can mimic squad level activities rather than individual soldier performance.

4) Compare simulation efforts, both cost and results, to small squad field tests to validate any simulation.

5) Determine TRADOC and force structure implications of the capabilities provided by the Gen II Soldier ATD package of capabilities (see Issue #5).

APPENDIX A

TERMS OF REFERENCE

DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
WASHINGTON, DC 20310-0103

31 AUG 1992

Mr. James Jacobs
Chair, Army Science Board
Sandia National Laboratories
Organization 7800
Post Office Box 5800
Albuquerque, New Mexico 87185-5800

Dear Mr. Jacobs:

Request you initiate an Army Science Board (ASB) Ad Hoc study on "Technology for the Future Land Warrior." The Ad Hoc study should address the Terms of Reference (TOR) described below. The ASB members should consider the TOR as a guideline and may include in their discussions related issues or suggestions by the Sponsor. Modifications to the TOR must be coordinated with the ASB Office.

I. Background

The recently published ASB "Soldier as a System" Summer Study identified the Soldier Integrated Protective Ensemble (SIPE) Advanced Technology Demonstration (ATD) as a major stepping stone for Soldier System improvement. This ATD systemically evaluates new technology for enhancing the soldier's battlefield capabilities and performance.

Operation Desert Storm demonstrated the effectiveness of technology in a range of combat platforms and scenarios. The proposed Science and Technology Thrust #8, titled "Sharpening the Warrior's Edge", offers an opportunity, in addition to the SIPE ATD, to extend the use of high technology down to the individual combatant.

II. Terms of Reference

a. In light of the newly published Board on Army Science and Technology Strategic Technologies for the Army, Lessons Learned from Operation Desert Storm, and the proposed Science and Technology Thrust #8 titled "Sharpening the Warrior's Edge", reexamine the future soldier system emerging technologies identified by the ASB Summer Study on "Soldier as a System." Identify those high payoff technologies (both from the ASB Summer Study and others) which could be matured to a technology demonstration by FY96. Address only the technologies that apply to items that individual dismounted land combatants wear, carry or consume.

b. Determine the technical barriers that must be overcome to mature the technologies identified in paragraph II.a. Recommend investment strategies and technology base programs required to breach the technical barriers. Rank order the programs according to the capabilities and performance enhancements that the technology affords the individual combatant.

c. Recommend one or more demonstration programs, possibly as a follow-on to the SIPE ATD, to prove out the capability enhancements of the highest payoff technologies.

III. Study Support

I will sponsor this study. Mr. George T. Singley III, Deputy Assistant Secretary for Research and Technology, OASA(RDA), SARD-ZT, will be the Cognizant Deputy. The HQDA Staff Assistant will be Mr. Hugh Carr, SARD-TT, (703) 694-1447.

IV. Schedule

The panel should begin work immediately and conclude the effort no later than February 5, 1993. As a first step, the panel Chair should prepare a study plan and present it to the sponsor and to the ASB office.

V. Special Provisions

Your inquiry is not expected to go into any "particular matters" within the meaning of Section 208, Title 18, of the United States Code.

Sincerely,

Stephen K. Conver
Assistant Secretary of the Army
(Research, Development and Acquisition)

APPENDIX B

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PARTICIPANTS

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ON
"TECHNOLOGY FOR THE FUTURE LAND WARRIOR"

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COGNIZANT DEPUTY
Mr. George T. Singley III
Deputy Assistant Secretary for
Research and Technology

STAFF ASSISTANT
Mr. Hugh Carr
General Engineer
Belvoir RDE Center

APPENDIX C

MEETINGS

MEETINGS

1. 03-05 November 1992, Pentagon, Washington, DC

   Purpose: Receive technology briefings of interest to Land Warrior Technology

2. 10 December 1992, Pentagon, Washington, DC

   Purpose: Receive requirements briefings from potential users of Land Warrior Technology

3. 11 January 1993

   Purpose: Report writing

APPENDIX D

REFERENCES

REFERENCES

1. Army Science and Technology Master Plan, November 1992

2. Army Science Board Summer Study, Final Report on "Soldier as a System," 1991

3. Army Modernization Plan, 1993

APPENDIX E

GLOSSARY

GLOSSARY

ARDECS - Army Research, Development and Engineering Centers
ARL - Army Research Laboratory
ASB - Army Science Board
ASTMP - Army Science and Technology Master Plan
ATD - Advanced Technology Demonstration
C3I - Command, Control, Communication and Intelligence
CBRS - Concept Based Requirements System
CIE - Clothing and Individual Equipment
CINC - Commander in Chief
CPAP - Continuous Positive Airway Pressure
DLA - Defense Logistics Agency
DoD - Department of Defense
FORSCOM - Forces Command
GPS - Global Positioning System
IFFN - Identification Friend, Foe or Neutral
IUSS - Integrated Unit Simulation System
LEAP - Lower Extremity Augmentation for Parachutist
LWT - Land Warrior Technology
NBC - Nuclear, Biological and Chemical
R&D - Research and Development
RDA - Research, Development and Acquisition
SIPE - Soldier Integrated Protective Ensemble
SOF - Special Operation Forces
TEISS- The Enhanced Integrated Soldier System
TO&E - Table of Organization and Equipment
TOR - Terms of Reference
TRADOC - Training and Doctrine Command

APPENDIX F

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