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Report to the Chairman, Subcommittee on Defense, Committee on Appropriations, House of Representatives

December 1999

BATTLEFIELD AUTOMATION

Army's Restructured Land Warrior Program Needs More Oversight

GAO

Accountability * Integrity * Reliability

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DOD Department of Defense

United States General Accounting Office
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National Security and
International Affairs Division

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The Honorable Jerry Lewis
Chairman, Subcommittee on Defense
Committee on Appropriations
House of Representatives

Dear Mr. Chairman:

According to the President's fiscal year 2000 budget request, the Army plans to invest $20.8 billion in digitization over the next 6 fiscal years. Digitization involves the application of information technologies that enable battlefield systems to acquire, exchange, and employ timely information throughout the battlespace. This report responds to the Subcommittee's request that we evaluate the Army's efforts to develop and acquire command and control systems to digitize the battlefield. Specifically, this report addresses the Land Warrior system.

Land Warrior, with an expected cost of $2.1 billion, is the Army's key command and control system for infantry soldiers on the digitized battlefield. It is intended to enable the soldier to know where both friendly and enemy soldiers are located and to facilitate communication between the soldier and higher command levels. The system is comprised mainly of a computer/radio, weapon, and helmet-mounted display eyepiece that are linked together for transmission of messages (voice and data) and imagery between soldiers and other battlefield systems. It also includes protective clothing, body armor, and a carrying harness to support the weight of the equipment.

The Army set a goal of fielding Land Warrior by September 2000. As requested, we assessed the Army's progress in implementing this system. Specifically, we

- identified the status of the system;
- evaluated whether the current level of monitoring and oversight is sufficient based on projected Land Warrior development costs;
- determined how the Army is ensuring that Land Warrior will be able to operate with other digitized battlefield systems; and
- assessed whether technical and human factor problems still need resolution.

We previously reported on this program in September 1996.[1] At that time, we were concerned about the high risk of the acquisition strategy in view of significant technical and human factor problems.

Results in Brief

The Land Warrior system, which has been in development since January 1996, will not be fielded by September 2000 because Land Warrior technologies could not be developed in time. The estimated cost of acquiring 34,000 units, including research, development, test, evaluation, and procurement, has increased from $1.4 billion to $2.1 billion. Although originally planning to use only mature technologies to permit expeditious fielding, the Army's design incorporated technologies that had to be developed specifically for Land Warrior, the effect of which has been to extend development and delay fielding until fiscal year 2004.

Oversight of the Land Warrior program is not sufficient based on its projected development costs. Department of Defense Regulation 5000.2R provides the general criteria for managing the acquisition process for systems such as Land Warrior and requires program managers to structure their program to reduce risk, ensure affordability, and provide information for decision-making. In general, Department of Defense programs that are costly, complex, and risky receive greater oversight and program officials must provide more information for decision-making. Also, programs with estimated research, development, test, and evaluation costs over $355 million are to receive departmental oversight. Land Warrior's estimate of $588.8 million meets these criteria. Despite its claim that Land Warrior is urgently needed, the Army grouped Land Warrior with less complex and less costly acquisitions, resulting in the program receiving routine Army attention. Oversight responsibility remained unchanged despite development problems that threatened to lengthen the acquisition schedule and the inability of system prototypes to pass certification tests.

At present, Land Warrior will not operate with a key digitized battlefield system—Force XXI Battle Command Brigade and Below—the Army's principal digital command and control system at and below brigade level. Further, when this capability will be incorporated into the Land Warrior system has not been determined. In March 1999, Army officials obtained a

[1] *Army Land Warrior Program Acquisition Strategy May Be Too Ambitious* (GAO/NSIAD-96-190, Sept.11, 1996).

waiver, which allowed them to defer developing the necessary software to make Land Warrior able to interoperate (communicate) with Battle Command Brigade and Below until well after Land Warrior equipment is fielded. To be effective, Land Warrior must be able to transmit data to and receive data from higher command levels, thereby providing the soldier with a relevant common picture of the battlefield and ensuring an integrated communications link from soldier to higher command. This link has not been established. According to program officials, the waiver was needed because the Land Warrior computer architecture was not compatible with the Battle Command Brigade and Below system software. Although the waiver is in effect, the Land Warrior program manager contends that the most recent program revision will achieve the desired operability without the need for a waiver. However, he concedes that considerable hardware and software development will be needed before this can be assured.

The Land Warrior Program has not resolved technical and human factor problems that may render the system ineffective. For example, problems include overweight equipment, inadequate battery power, uncertain battery logistics, inadequate load-carrying design and comfort, and electromagnetic interference. Typical of the problems encountered in field tests were those associated with the load-carrying harness. During tests, soldiers had problems raising their heads to fire their weapons from the prone position because the pack attached to the harness would ride up and press against the back of their helmets. Army officials believe that the load-carrying system contemplated in the most recent program revision should solve this problem. However, the current Land Warrior system design has not been sufficiently field tested to ensure that old problems have been resolved and new ones have been avoided.

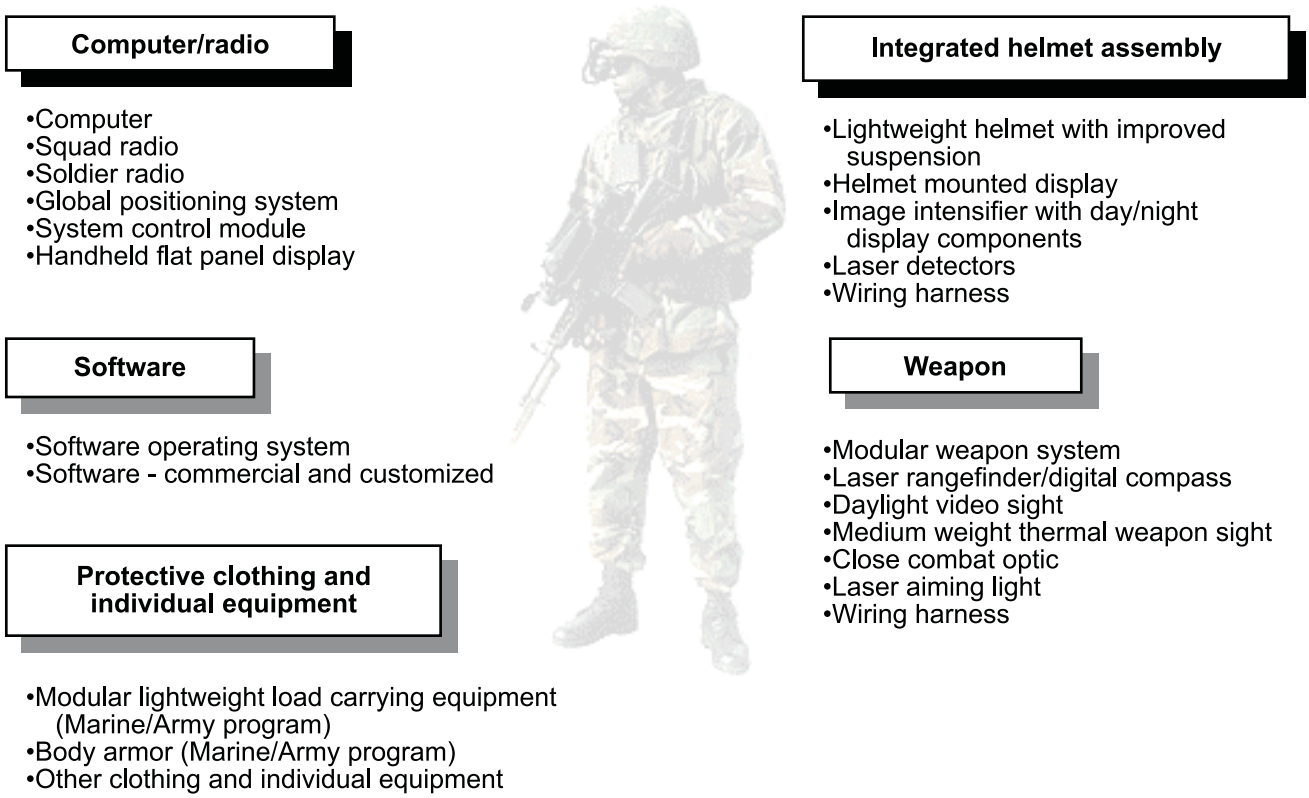
This report contains recommendations directed at improving program monitoring, oversight, testing, and operability with other key Army digitized battlefield systems.

Background

The Land Warrior system is intended to significantly improve the lethality, mobility, survivability, command and control, and sustainability of infantry soldiers by integrating a variety of components and technologies. Land Warrior includes a computer/radio, software, integrated headgear, including an imaging display, weapon subsystem, and protective clothing and equipment to be integrated on the individual soldier (see fig.1). When fielded, Land Warrior is expected to operate with digitized battlefield

systems, such as Force XXI Battle Command Brigade and Below.[2] Furthermore, the Army plans to introduce additional technologies later on to enhance the soldier's battlefield performance.

Figure 1: The Land Warrior System



Source: PM Soldier, Fort Belvoir, Virginia.

In September 1996, we reported that (1) the Land Warrior program was based on a high risk and costly acquisition strategy, (2) Land Warrior's ability to function with other components of the digital battlefield had not been demonstrated, and (3) technology and human factor problems needed

[2] *Acquisition Issues Facing the Army Battle Command, Brigade and Below Program* (GAO/NSIAD- 98-140, June 30, 1998).

to be resolved. For example, the computer/radio battery provided less than 2 of an expected 12 hours of continuous operation and the equipment weighed so much that soldier movement was impeded and comfort compromised. At that time, we recommended that the Secretary of the Army defer or restrict the purchase of Land Warrior systems until the Army

- determined the Army Acquisition Objective—that is, the total number of units to be acquired;
- resolved critical technical and human factor problems;
- demonstrated successful digital battlefield integration; and
- ensured through testing that Land Warrior-equipped soldiers would outperform standard-equipped soldiers.

The Army has established its acquisition objective of 34,000 systems, but has not implemented our other recommendations.

There have been two major revisions to the Land Warrior program, which originally called for fielding the system in fiscal year 2000. The effect of both the interim revision in August 1998 and the current plan, developed in February 1999, has been to delay fielding. Land Warrior officials have not submitted the current plan for Army Acquisition Review Council approval. This senior-level review authority provides guidance and recommends program revisions to the Army Acquisition Executive and Army Vice Chief of Staff for referral to the Defense Acquisition Board.

Program Has Not Progressed as Planned

The Land Warrior program has not progressed as planned. The program's research, development, test, evaluation and procurement cost estimate has increased from $1.4 billion to $2.1 billion. Fielding has been delayed from fiscal year 2000 to fiscal year 2004. Development has been ongoing since January 1996 and has not yet yielded workable prototypes. The Army initially intended to use mature technologies to ensure that it could field Land Warrior expeditiously, but it has increasingly relied on technologies that had to be developed specifically for Land Warrior. Problems in completing these Land Warrior-unique developments prevented the Army from meeting its acquisition schedule and successfully developing working prototypes.

Testing Problems With Prototypes Led to Major Program Revisions

In April 1998, contractor-delivered Land Warrior prototypes failed several basic certification tests that would have permitted the system to proceed with development testing. Failed tests included an airborne certification test, an electromagnetic interference test, and a water immersion test. Consequently, the Army rejected the prototypes and began restructuring the program. For example,

- The airborne certification test was to assure that soldiers could parachute with Land Warrior equipment. With the load-carrying design then being used, the containerized computer/radio could not be worn under the parachute. This necessitated placing the system in a bag tethered to the soldier and dropping it just prior to the jump. However, the equipment required too much space on the aircraft and was too rigid and heavy to maneuver comfortably. In addition, the prototypes experienced hardware failures from the stress induced by landing shock. Moreover, the Army became concerned about soldier safety when several soldiers became tangled in the gear when getting ready to jump.
- Electromagnetic interference occurs when various pieces or types of electrical equipment are operated in close proximity to one another. Land Warrior electronic emissions exceeded the military standard for such emissions, raising the likelihood of electromagnetic interference with other electrical devices. Program officials contend that electromagnetic interference problems are common in the development phase.
- On April 30, 1998, the contractor conducted a water immersion test, one of the requirements of the Land Warrior system. The purpose of the test was to ensure that the system could be operated after exposure to the immersion environment typically encountered in the field. The system failed the test. Substantial water leakage was observed in the interiors of many system components, including the squad radio, soldier radio, computer, and Integrated Helmet Assembly Subsystem display components.

Program Revision Is Not Complete

As of September 1999, the Land Warrior Program has been in the Engineering and Manufacturing Development[3] phase for 45 months. In January 1996, when Land Warrior entered Engineering and Manufacturing Development; the Army planned to use mature technologies—technologies requiring minimal development—to meet an urgent need to field equipment by September 2000. However, as development proceeded, the Army moved away from this strategy. It began pursuing technologies requiring considerable development. Ultimately, the Land Warrior program became more technologically challenging than the Army projected.

In April 1998, when prototypes failed their basic certification tests, the Land Warrior system included (1) laser range finder/digital compass, (2) wiring harness, (3) video sight, (4) helmet and helmet-mounted computer display, (5) modular body armor, (6) load-carrying equipment, (7) computer (hardware and software), and (8) radio (leader and soldier). All major Land Warrior subsystems featured some Land Warrior-unique components (see app. II).

In August 1998, the Army proposed an interim strategy based on the original design. The interim strategy would have extended development and delayed fielding by about 15 months. However, the interim strategy was never implemented and in January and February of 1999, the Army began examining a new open system design strategy—one that relied more on equipment that was either commercially available or already in military use. Accordingly, the Army began seeking alternative approaches, with the goal of avoiding proprietary solutions to Land Warrior development problems.

Although not yet formally approved, the Army is proceeding with its current revision of Land Warrior, which emphasizes commercially available technology, such as Windows-based operating system software. The plan's

[3]Department of Defense Regulation 5000.2R describes the four major acquisition phases. The second—Program Definition and Risk Reduction—precedes Engineering and Manufacturing Development. During this phase, the program becomes defined as one or more concepts, design approaches, and /or parallel technologies are considered. This phase includes assessments of advantages and disadvantages of alternative concepts, and includes prototyping, demonstrations, and early operational assessments as necessary so that technology, manufacturing, and support risks are well in hand before the next decision point. The third—Engineering and Manufacturing Development—translates the most promising design approach into a stable, interoperable, producible, supportable, and cost-effective design and demonstrates system capabilities through testing and prototyping.

features include a new load carrying harness and computer/radio subsystem (see app. II). Land Warrior will now incorporate the same load-carrying system being adopted by the rest of the Army, known as Modular Lightweight Load-Carrying Equipment. This load carrying equipment is still being tested, but it is already considered "jump-qualified," according to Army officials. However, the new load carrying equipment configuration will require redesign of the computer housing and various cable connectors to the carrying frame. It also will mean that soldiers must evaluate the form, fit, and function as they did with the previous load-carrying design.

The Army believes that the current revised plan, which resulted from the process of evaluating alternative designs, requires fewer Land Warrior-unique developments. Program officials believe they will be better able to decide on necessary interfaces and technical additions. The Army plans to assume the role of systems engineer and integrator, a role that had been initially performed by the Raytheon Corporation. Raytheon will retain responsibility for developing the Integrated Helmet Assembly System, laser range finder, and daylight video sight.

Program Cost Has Increased and Fielding Has Been Delayed

In November 1998, Land Warrior's estimated cost for research, development, test, evaluation and procurement increased from $1.4 billion to $2.1 billion for 34,000 systems. In August 1999, the Army reduced Land Warrior procurement funding by about $340 million because of competing priorities and Land Warrior's development problems. At the time of our review, the Army could not provide a reliable total program cost estimate for the current revised program because the design is still evolving and funding issues are not resolved. The November 1998 cost estimate for research, development, test, evaluation, and procurement was $2.1 billion, and total program cost was $3.5 billion. The $1.4 billion difference represented estimated operations and maintenance cost, much of which is for battery supplies and resupply, storage, and disposal.

A Land Warrior Program official told us that procurement funding was to have begun in fiscal year 2000, when the original program called for Land Warrior fielding. However, procurement funding has been eliminated until fiscal year 2004. Congress has already reduced Land Warrior fiscal year 2000 research, development, test, and evaluation funding by $50 million. The official said that the Army, sensitive to congressional concerns, wants time to allow program officials to explore new technical approaches. According to Army officials, Land Warrior will not be fielded

until fiscal year 2004, at the earliest, which is a 4-year delay from the original milestone.

Land Warrior Oversight Is Not Sufficient Based on Projected Costs and Complexity

Land Warrior has not received the management monitoring and oversight needed based on its projected development cost, complexity, and urgency of need. Department of Defense (DOD) Regulation 5000.2R provides general criteria for managing the acquisition process for programs such as Land Warrior. The regulation requires program managers to structure their program to reduce risk, ensure affordability, and provide adequate information for decision-making. Program acquisitions are classified as Categories I, II, or III, depending on cost and complexity. Generally, Category I programs are major systems that receive more scrutiny in terms of increased oversight and monitoring, as well as requiring milestone decisions at the DOD level.[4] Category II programs are also considered major acquisitions, but milestone decision authority is at the service level. Acquisition Category III programs are not considered major systems and milestone decisions are made within the service at the lowest appropriate level.

In general, DOD programs that are costly, complex, and risky receive greater oversight and program officials must provide more information for decision-making. For example, for an acquisition Category I program, the program manager must regularly report key cost, schedule, and performance milestones. If certain parameters are breached, the DOD acquisition executive conducts a program review at the Vice Chairman of the Joint Chiefs of Staff level. This review determines whether there is a continuing need for programs that are behind schedule, over budget, or not in compliance with performance or capability requirements. The review results in a recommendation to the Under Secretary of Defense for Acquisition and Technology regarding suitable action to be taken.

The Army classified the Land Warrior Program as an acquisition Category III from the beginning of Engineering and Manufacturing Development in January 1996 until January 1997. In our September 1996 report, we recommended that the program be upgraded to acquisition Category II status because the projected cost of the program met the basic Category II requirement at that time. The Army implemented our

[4]The Secretary of Defense also has the authority to delegate this oversight.

recommendation in January 1997 and Land Warrior has remained in Category II to the present.

Land Warrior's Category II classification was not changed when development problems threatened the acquisition schedule during the remainder of calendar year 1997. Further, the classification was not changed after the prototypes failed certification testing in April 1998. The most recent research, development, test, and evaluation cost estimate of $588.8 million now exceeds the basic $355 million requirement for an acquisition Category I. While another program classification cannot by itself resolve technical issues or ensure better management, a Category I designation would ensure that development problems are surfaced to higher levels of the department. Army officials told us in November 1998 that the Army was in the process of reclassifying Land Warrior as an acquistion Category I. However, as of November 30, 1999, this had not been accomplished.

Land Warrior Lacks the Ability to Communicate With a Key Battlefield Component System

Land Warrior has not demonstrated the ability to communicate with the Army's digitization linchpin—Battle Command Brigade and Below—and it is uncertain when this will be accomplished.[5] Similarly, Land Warrior has not demonstrated that it can communicate with other digitized battlefield systems, a capability needed to ensure optimum situational awareness. For example, Land Warrior must communicate with artillery systems to provide or receive mapping data on both enemy and friendly positions.

Communication Ability With Battle Command Brigade and Below Has to Be Established

In December 1996, the Army required that Land Warrior and other digitized infantry platforms operate with Battle Command Brigade and Below and its Embedded Battle Command software. Battle Command Brigade and Below is the principal digital command and control system for the Army at brigade level and below. Battlefield data flows between Battle Command Brigade

[5]In September 1996, we reported that Land Warrior had not demonstrated its ability to function with other components of the digitized battlefield, including Force XXI Battle Command Brigade and Below.

and Below and Land Warrior through the Tactical Internet.[6] This provides the Army with a common picture of the battlefield. Without this capability, Land Warrior-equipped soldiers cannot receive messages from higher commands and will not be able to transmit critical information, such as the sighting of an enemy tank column, to higher command. However, Land Warrior and Battle Command Brigade and Below cannot communicate with each other primarily because Land Warrior's computer/radio subsystem cannot accommodate Battle Command Brigade and Below software without added memory and associated cooling capacity. The added memory and cooling capacity would have significantly increased weight.

Land Warrior is a soldier-worn, battery-powered infantry-fighting system for which weight and power are critical design parameters. In contrast, Battle Command Brigade and Below development has largely focused on mechanized platforms (trucks, tanks, Bradley Fighting Vehicles, etc.) on which the Applique computer, Single Channel Ground and Airborne Radio System, and Internet Network Controller hardware are mounted and where weight and power issues are not as challenging. According to a Land Warrior official, the vehicle-mounted equipment would be prohibitively heavy to carry. Soldiers must carry their own batteries and are unable to draw operating power from vehicle generators.

In March 1999, the Land Warrior Program obtained a waiver from the Army Digitization Office that would postpone the need to address operability requirements. Battle Command Brigade and Below includes Embedded Battle Command software. Program managers of other Army systems are expected to modify this software to interface with their systems. The waiver request cited inconsistencies with Battle Command Brigade and Below, which included: (1) Embedded Battle Command software did not accommodate real time management of the system;[7] (2) the demand for computing resources required to meet Embedded Battle Command software implementation exceeded available system resources and translates to increased power consumption, weight, and cost; and

[6]The Tactical Internet is a radio network comprising the Enhanced Position Location Reporting System and the Single Channel Ground and Airborne Radio System. When platforms are connected through the Tactical Internet, commanders at all levels of the Army's Battle Command System receive data needed for battlefield situational awareness and command and control decisions.

[7]This refers to the ability to preempt and prioritize processes so critical messages have system priority over noncritical messages.

(3) implementation of Embedded Battle Command software functionality did not match Land Warrior requirements.[8]

The Army Digitization Office granted the waiver subject to the approval of a plan to integrate the system into the digitized battlefield. The plan must address (1) Land Warrior requirements for operating with the Tactical Internet and Battle Command Brigade and Below, (2) a technical implementation approach for meeting the requirements (to include critical milestones), and (3) a test strategy to demonstrate that technical requirements are accurately implemented. As of November 30, 1999, Land Warrior had not responded to the conditions.

Land Warrior and Battle Command Brigade and Below use different computer operating systems, which further complicates operability. Both programs plan to eventually use the Windows operating system, but Battle Command Brigade and Below will not be able to use the Windows operating system software until fiscal year 2002, at the earliest. According to Land Warrior program officials, they have discussed the possibility of Land Warrior funding Battle Command Brigade and Below to begin earlier movement to Windows-based software. According to a Battle Command Brigade and Below official, the program has not initiated an assessment of the magnitude of this effort.

In our opinion, ensuring that Land Warrior will operate successfully with Battle Command Brigade and Below will be challenging. Considering that Land Warrior funding for Battle Command Brigade and Below operability will not be available until fiscal year 2002, it is likely that such a demonstration is several years away. Although the program has been granted the operability waiver, the Land Warrior program manager told us that he wants to redesign the computer/radio subsystem and make better use of commercially available computer technology. He believes that using commercial software and hardware will eliminate the original need for the waiver and reduce the cost of developing, maintaining, and upgrading the subsystem to commercial standards. However, he concedes that

[8]For example, the Embedded Battle Command Communications Manager module works with a vehicle-mounted Single Channel Ground and Airborne Radio System—System Improvement Program or Enhanced Position Location Radio System. It does not provide the necessary interface or control to soldier-worn Land Warrior Single Channel Ground and Airborne Radio System—System Improvement Program compatible radio or the Land Warrior squad radio. The Command and Control message parser module does not address all the message requirements of the Land Warrior system.

considerable hardware and software development will be needed before this can be assured.

Demonstration of Operability With Other Digitized Systems Is Several Years Away

Land Warrior's ability to function with other digitized systems was to have been demonstrated in previously conducted Advanced Warfighting Experiments, such as the Task Force XXI experiment in March 1997 and the Division experiment in November 1997. However, Land Warrior prototypes were not ready at the time and did not participate. Because of budgeting problems, program officials were not certain about the extent to which Land Warrior will participate in the Joint Contingency Force Advanced Warfighting Experiment[9] scheduled to begin in September 2000.

Technology and Human Factor Problems Remain

Certain technology and human factor problems have not been resolved. In December 1996, the Army completed an Early Operational Experiment that showed that power, equipment weight, and human factor issues still needed to be addressed. Until April 1998, when the Land Warrior prototypes failed their tests, the Army had been conducting risk reduction exercises to resolve the problems. Although the Army has not met its equipment weight and battery power requirements, it has made progress. Soldiers experienced weight shifting and other comfort problems during and after an Early Operational Experiment that were so troublesome that the Army decided to change its load-carrying equipment configuration. Electromagnetic interference problems happened because the original design's cable connectors and cable shields did not prevent unacceptably high emissions.

Equipment Weight Requirement Is Being Redefined

Program officials told us that the Land Warrior Operational Requirements Document is being revised and will not specify a numeric weight requirement. Land Warrior will replace equipment items and enhance equipment capabilities without increasing the weight of a typical soldier's combat load, which has been redefined as 91 pounds. The current Land Warrior weight is about 90.5 pounds. Land Warrior officials said that the difference from the previous requirement of 80 pounds comes as a result of

[9]The purpose of the Joint Contingency Force Advanced Warfighting Experiment is to improve the warfighting capability for light contingency forces by determining which new systems or linkages improve battlefield communication and increase the lethality and survivability of the forces.

reassessing the equipment to be carried and actually weighing instead of estimating the equipment normally carried on an extended patrol. The new requirement will also permit the Army to accept greater weight if it results in sufficiently improved functionality.

Land Warrior Will Use New Load-Carrying System

The initial Land Warrior load-carrying design consisted of an over-the-shoulder and around-the-waist harness, plus accompanying backpack. Weight distribution was centered near the middle of the back, which worked in some situations, but not in others. For example, in Early Operational Experiment field tests held from October through December 1996, soldiers experienced problems lifting their heads to fire from the prone position because the backpack would ride up and press against the rear of the helmet. In addition, when soldiers rolled onto their backs to execute ground maneuvers, the system's bulk held them too far from the ground, resulting in temporary helplessness—the so-called "turtle-on-its-shell effect."

The Army recently decided to move to a load-carrying system called the Modular Lightweight Load Carrying Equipment system, which shifts the weight load to achieve more soldier comfort. According to Land Warrior officials, initial testing has been promising. If the Modular Lightweight Load-Carrying Equipment system becomes the load-carrying system for the current Land Warrior revision, the waist belt will have to be redesigned to accommodate a new computer and battery pack.

Battery Power and Logistics Remain Problematic

The final power source has not yet been determined for Land Warrior and program officials are still exploring alternatives. Land Warrior is required to sustain continuous operations for 12 hours using battery power. Batteries tested to date have produced about 4 or 5 hours of continuous operations. The Army has made technological advances using lithium-manganese batteries that, in controlled testing, have achieved the required continuous operating times at various temperature extremes. However, the batteries have yet to be field tested in Land Warrior or in any totally integrated systems environment.

Other battery issues relate to usage and replacement. Specifically, the problems of how the Army will get the needed quantities of replacement batteries to the field, store them until needed, and dispose of the spent batteries have not been solved. Batteries will have to be dispensed on the battlefield in the same manner as ammunition and food and disposed of as

hazardous material. Whatever the solution, battery logistics will be very expensive. The Army estimates that over half the $1.4 billion of estimated operations and maintenance costs are related to Land Warrior battery resupply, storage, and disposal. Although the Army is considering using rechargeable batteries for training purposes, it plans to field disposable batteries.

Electromagnetic Emission Problems Persist

According to program officials, the electromagnetic emission problems are the result of the Land Warrior's cable connector and cable shield design, which leak too much electricity. The program manager believes that the risk of not meeting the standard has been reduced as a result of recent improvements to the cable connectors and cable shielding.

Conclusions

Land Warrior is no closer to fielding today than it was when development began in January 1996. The program has been in the Engineering and Manufacturing Development phase for 45 months and program officials are still evaluating alternative designs and attempting to resolve technical problems. The Army has not demonstrated that it can deliver workable Land Warrior prototypes that meet test requirements with the requisite safety and comfort to the soldier. We believe that the Program Definition and Risk Reduction phase more accurately reflects Land Warrior's status than does the Engineering and Manufacturing Development phase.

The Land Warrior program has been solely overseen by the Army even though projected research, development, test, and evaluation costs justified DOD oversight. We believe that Land Warrior would benefit from the higher level departmental oversight accorded acquisition Category I systems. If more management attention is not focused on Land Warrior, the Army may face the same problems in fiscal year 2004 when fielding is now scheduled.

If Land Warrior/Battle Command Brigade and Below operability is not assured before fielding, the full value of Land Warrior cannot be realized. Land Warrior-equipped soldiers run the risk of not having the required battlefield situational awareness and not being fully integrated with higher command levels as currently required. Further, if Land Warrior does not meaningfully participate in the Army's Advanced Warfighting Experiments, the Army cannot test the system's ability to operate with other components of the digitized battlefield.

Land Warrior continues to be challenged by technical and human factor issues. Although progress has been made, we believe that high priority should be given to building fully functional prototypes that meet all basic requirements and should include thorough field testing. Otherwise, the Army runs the risk of costly changes after committing to production.

Recommendations

In order to ensure that Land Warrior development is completed before systems are fielded, we recommend that the Secretary of Defense direct the Secretary of the Army to return the Land Warrior program to the Program Definition and Risk Reduction phase until workable prototypes are produced. Further, we recommend that Land Warrior be

1. reclassified as an acquisition Category I system to ensure appropriate program monitoring and oversight;

2. required to demonstrate operability with Force XXI Battle Command Brigade and Below before any systems are fielded to minimize the risk of Land Warrior-equipped soldiers not having adequate battlefield situational awareness; and

3. required to thoroughly field test prototypes and ensure that they pass water immersion, electromagnetic interference, and airborne certification tests before any systems are fielded.

Matter for Congressional Consideration

In view of the significant changes and revised design to the Land Warrior system, Congress may wish to consider withholding further funding until the Army determines what it plans to develop and provides a detailed approach, including revised cost, schedule, and performance estimates, to acquire and field the system.

Agency Comments and Our Evaluation

In commenting on a draft of this report, DOD concurred with two of our four recommendations. The Department's comments are included as appendix I.

DOD did not agree with our recommendation to return Land Warrior to the Program Definition and Risk Reduction acquisition phase, stating that doing so would set the program back 1 to 2 years and result in increased costs due to the delay. DOD also stated that Land Warrior has been

demonstrated successfully by field soldiers, that it is continuing its drive to integrate off-the-shelf products, and that the program conducted competitive prototype demonstrations of a fully integrated computer/radio subsystem at the end of October 1999 to further improve the system—reducing weight and costs.

We continue to believe that Land Warrior should return to the Program Definition and Risk Reduction acquisition phase until workable prototypes are produced. Land Warrior development and testing results to date are characteristic of activities in the Program Definition and Risk Reduction acquisition phase rather than the Engineering and Manufacturing Development phase. As defined in DOD Regulation 5000.2R, the Program Definition and Risk Reduction acquisition phase includes prototyping, demonstrations, and early operational assessments so that technology, manufacturing, and support risks are well in hand before the next decision point—Engineering and Manufacturing Development. For Land Warrior to be legitimately in the Engineering and Manufacturing Development phase, application of the same DOD regulation would require the Army to be able to translate the most promising design approach into a stable, interoperable, producible, supportable, and cost-effective design and to demonstrate system capabilities through testing and prototyping. The Army is not in such a position. Stability, interoperability, and supportability are yet to be achieved. The Army has not produced and demonstrated any complete and workable prototypes that meet test requirements with the requisite safety and comfort to the soldier. However, the issue is larger than one of categorization. Since the Army is currently exploring new technical approaches, returning Land Warrior to the Program Definition and Risk Reduction phase would reduce the risk of prematurely committing to an unproven or unsupportable design.

Further, regarding DOD's point on delay and costs caused by return to the Program Definition and Risk Reduction phase, we note that the Land Warrior program has already experienced substantial cost growth and a 4-year delay from the original estimated fielding date. In addition, the Army will need to conduct additional testing prior to production regardless of acquisition phase. Doing so during the Program Definition and Risk Reduction phase would provide the Army with greater flexibility if designs need to be changed. We believe that investing in additional development will provide greater assurance that fielded Land Warrior systems will be cost-effective. While it is encouraging that the Army recently found demonstrations of off-the-shelf Land Warrior components to be successful,

we believe that the unavailability of a complete Land Warrior prototype for testing purposes supports the need for our recommendation.

DOD concurred with our recommendation that Land Warrior be reclassified as an acquisition Category I system, stating that the Army has reached a similar conclusion and is currently staffing a recommendation to do so.

DOD did not agree with our recommendation to require that Land Warrior demonstrate operability (interoperability) with Force XXI Battle Command Brigade and Below before any systems are fielded. DOD stated that the draft report we provided for comment assumes that the Land Warrior system must run the Force XXI Battle Command Brigade and Below application. The Department's response stated that some Force XXI Battle Command Brigade and Below functions are of value to the Land Warrior systems, as this would maximize government-off-the-shelf reuse. However, it stated that the Land Warrior system is a weapons systems first, while Force XXI Battle Command Brigade and Below is a command and control software application.

We believe that DOD's response indicates misunderstanding of our recommendation. Our central issue in this recommendation focuses on operability (interoperability), not commonality. As stated in our draft report, if Land Warrior and Force XXI Battle Command Brigade and Below interoperability is not assured before fielding, the full value of the Land Warrior system cannot be realized. Land Warrior-equipped soldiers run the risk of not having the required battlefield situational awareness and not being fully integrated with higher command levels as is currently required. While maximizing government-off-the-shelf reuse is a worthy goal if practical, our concern is that operability of Land Warrior with Force XXI Battle Command Brigade and Below may not be assured before fielding. In December 1996, the Army required that Land Warrior operate with Force XXI Battle Command Brigade and Below, and its Embedded Battle Command software. In March 1999, the Land Warrior Program obtained a conditional waiver from this requirement, citing fundamental incompatibilities. The waiver was granted subject to the approval of a plan to integrate the system into the digitized battlefield. The plan was to address (1) Land Warrior requirements for operating with the Tactical Internet and Battle Command Brigade and Below, (2) a technical implementation approach for meeting the requirements (to include critical milestones), and (3) a test strategy to demonstrate that technical requirements are accurately implemented. As of November 30, 1999, the

plan had not been submitted for approval. Operability with Force XXI Battle Command Brigade and Below can be achieved either by using Embedded Battle Command software or by designing a Land Warrior-unique software application interface. If Embedded Battle Command software is not used, the Land Warrior–unique application must result in software that allows the systems to work together. We have clarified our recommendation to make clear that we are concerned about the lack of interoperability between Land Warrior and Force XXI Battle Command Brigade and Below and that we continue to feel that this interoperability needs to be demonstrated before any systems are fielded.

DOD agreed with our recommendation that Land Warrior prototypes must be fully tested with soldiers in field environments and that it must successfully undergo water immersion, electromagnetic interference, and airborne certification tests. DOD further stated that other stringent tests by components and of the fully Land Warfare integrated system must and will be conducted. We note that the Department's response does not state when such testing will be completed. Our recommendation specifies that field tests should be accomplished before any systems are fielded.

Based on the Army's negative response regarding our recommendations concerning the proper acquisition phase for this program and the need for interoperability with Force XXI Battle Command Brigade and Below, we have added a matter for congressional consideration. We ask Congress to consider withholding further funding until the Army determines what it plans to develop and provides a detailed approach, including revised cost, schedule, and performance estimates, to acquire and field the system.

Scope and Methodology

To identify the status of the Land Warrior program, we interviewed responsible officials, collected pertinent documentation, and analyzed plans from both DOD and the Army. In the course of our work, we also visited the Program Manager-Soldier and Program Manager-Land Warrior at Fort Belvoir, Virginia; and the U.S. Army Soldier Biological and Chemical Command, Natick, Massachusetts. With Army officials, including those from the Training and Doctrine Command System Manager for Land Warrior and the Combat Development Division, U.S. Infantry School, Fort Benning, Georgia, we discussed the status of the Army's revised Land Warrior acquisition strategy, including the program events that necessitated the restructuring, alternative developments, and design strategies. We also reviewed plans for low-rate initial production, and revised fielding

schedules. Additionally, we analyzed changes to the cost, schedule, and performance milestones.

To evaluate whether the current level of program monitoring and oversight is appropriate, we interviewed responsible officials in DOD and the Army and reviewed Land Warrior program documentation, including program cost estimates and DOD and Army acquisition regulations. In the course of this work, we also visited the Program Manager-Soldier and Program Manager-Land Warrior at Fort Belvoir, Virginia. We also discussed related matters with officials from the DOD Office of the Director, Test Systems Engineering and Evaluation, and Office of the Director, Operational Test and Evaluation.

To determine how the Army is ensuring that Land Warrior will operate with other command and control systems, particularly Battle Command Brigade and Below, we reviewed Land Warrior program interoperability requirements with Army officials, the Land Warrior prime contractor—Raytheon Corporation in El Segundo, California, and subcontractor officials. We reviewed the Army's plan for obtaining a waiver from using the Battle Command Brigade and Below Embedded Battle Command software and assessed its impact on interoperability. We visited the above facilities and also witnessed a Land Warrior/ Battle Command Brigade and Below interoperability demonstration at the Land Warrior contractor software test facility, Fullerton, California.

To assess the technical and human factor problems requiring resolution before the Army makes a production decision, we discussed related technical issues with Army program officials. We also discussed test and evaluation issues with DOD officials from the Director of Operation, Test, and Evaluation and Director Test Systems Engineering and Evaluation, and the Army's Operational Test and Evaluation Command and Test and Experimentation Command, as well as contractor personnel. We reviewed the results of the Early Operational Experiment conducted from October to December 1996 and the ensuing risk-reduction exercises. We also reviewed the Army's plans for addressing outstanding technical and human factor problems prior to entering production.

We performed our review from November 1998 through November 1999 in accordance with generally accepted government auditing standards.

We are sending copies of this report to Representative John Murtha, Ranking Minority Member, Subcommittee on Defense, House Committee on Appropriations; C.W. Bill Young, Chairman, and Representative David Obey, Ranking Minority Member, House Committee on Appropriations; Senator Ted Stevens, Chairman, and Senator Robert C. Byrd, Ranking Minority Member, Senate Committee on Appropriations; and other interested congressional committees. We are also sending copies to the Honorable William Cohen, Secretary of Defense; the Honorable Louis Caldera, Secretary of the Army; General James L. Jones, Commandant of the Marine Corps; and the Honorable Jacob Lew, Director, Office of Management and Budget. Copies will also be made available to others upon request.

If you have any questions regarding this report, please contact CharlesF. Rey at (202) 512-4174 or Arthur S. Fine at (617) 565-7571. A key contributor to this report was Joseph Rizzo, Jr.

Sincerely yours,

Allen Li
Associate Director
Defense Acquisitions Issues

Comments From the Department of Defense

Note: GAO comments supplementing those in the report text appear at the end of this appendix.

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ACQUISITION AND TECHNOLOGY

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This is the Department of Defense (DoD) response to the GAO draft report, "BATTLEFIELD AUTOMATION: Army's Restructured Land Warrior Program Needs More Oversight," dated October 25, 1999 (GAO Code 707393/OSD Case 1913). The DoD concurs with recommendations 2(1) and 2(3). The DoD nonconcurs with GAO recommendation 1 and recommendation 2(2). Our specific responses to the GAO's recommendations are attached.

The DoD appreciates the opportunity to comment on the draft report.

for George R. Schneiter
Director
Strategic and Tactical Systems

Attach
a/s

GAO DRAFT REPORT DATED OCTOBER 25, 1999
(GAO CODE 707393) OSD CASE 1913

"BATTLEFIELD AUTOMATION: ARMY'S RESTRUCTURED LAND WARRIOR PROGRAM NEEDS MORE OVERSIGHT"

DEPARTMENT OF DEFENSE COMMENTS ON
THE GAO RECOMMENDATIONS

See p. 18.

RECOMMENDATION 1: In order to ensure that Land Warrior is completed before systems are fielded, the GAO recommended that the Secretary of Defense direct the Army to return the Land Warrior Program to the Program Definition/Risk Reduction phase until workable prototypes are produced. (p. 19/GAO Draft Report)

See comment 1.

DOD RESPONSE: The Department of Defense nonconcurs with the recommendation to return Land Warrior to Program Definition/Risk Reduction. In November 1998, the Land Warrior Program Manager put into practice the tenents of DoD-directed acquisition reform guidelines, and, in turn, made a major shift in both direction and approach to leverage the commercial sector in developing the Land Warrior system. This strategy is now paying off. Land Warrior has been demonstrated successfully by field soldiers. Continuing its drive to integrate off-the-shelf products, the program conducted competitive prototype demonstrations of a fully integrated computer/radio subsystem at the end of October 1999 to further improve the system--reducing weight and costs. Similar "shoot-offs" were conducted to "down-select" commercial software vendors, cabling, and image-enhancing (night vision) systems. The outcome of this strategy is to do precisely what acquisition reform had in mind--integrating commercial practices and products, expediting development, and reducing both development and acquisition costs of military systems. To return the program to the Program Definition/Risk Reduction phase would set the program back by one to two years--not to mention the increased costs associated with such delays.

RECOMMENDATION 2: The GAO further recommended that Land Warrior:

1) be reclassified as an Acquisition Category I system to ensure appropriate program monitoring and oversight;

2) be required to demonstrate operability with Force XXI Battle Command Brigade and Below before any systems are fielded; and

See p. 18.

3) be required to thoroughly field test prototypes and ensure that they pass water immersion, electromagnetic interference, and airborne certification tests before any systems are fielded. (p. 19/GAO Draft Report)

DoD Response to GAO Recommendation 2(1).

See p. 20.

See comment 2.

The Department of Defense concurs with the recommendation to designate the Army's Land Warrior Program as a Category I system. The Army had reached a similar conclusion and is currently staffing a recommendation to do so. The Land Warrior Program has received increasing oversight since April 1998 with frequent reports and reviews by the Army's Assistant Secretary for Acquisition, Logistics, and Technology, Army Acquisition Executive, Deputy Chief of Staff for Operations and Plans, and Vice Chief of Staff.

DoD Response to GAO Recommendation 2(2).

See p. 20.

See comment 3.

The Department of Defense does not agree with the recommendation to require demonstration of operability with Force XXI Battle Command Brigade and Below (FBCB2) before any systems are fielded. The Key Performance Parameter requirement in the August 3, 1999, Operational Requirements Document is that the Land Warrior system will integrate and manage system functions and implement core Joint Variable Message Formats in compliance with the Joint Technical Architecture-Army.

The draft report assumes that the Land Warrior system must run the FBCB2 application. Recalling Land Warrior is a weapons system first, situational awareness needs to be best structured for the environment in which the systems are being used. FBCB2 is a command and control software application. Some functions are of value to the Land Warrior systems, particularly the leader version, and to maximizing Government-Off-The-Shelf re-use. Program Manager Soldier is working with Program Manager FBCB2 to transition code for Land Warrior use. The FBCB2 is a likely candidate if converted for Land Warrior use.

DoD Response to GAO Recommendation 2(3).

See p. 21.

The Department of Defense agrees that Land Warrior prototypes must be fully tested with soldiers in field environments and that it must successfully undergo water immersion, electromagnetic interference, and airborne certification tests. Other stringent tests by components and of the fully Land Warfare integrated system must and will be conducted.

The following are GAO's comments on the Department of Defense's letter dated November 30, 1999.

GAO Comments

1. Our report recognizes that the Army has begun examining a new open system design strategy—one that relies more on equipment that was either commercially available or already in military use. However, we also indicate that, at the time of our review, such a strategy was not yet formally approved. While we are encouraged that the Army recently found demonstrations of off-the-shelf Land Warrior components to be successful, we note that the unavailability of a complete prototype for testing purposes reinforces our position regarding returning Land Warrior to the Program/Risk Reduction acquisition phase.

2. Although DOD concurred with our recommendation that Land Warrior be designated an acquisition Category I system, we remain concerned that this has yet to be accomplished. When we began our work in December 1998, we were told that the Land Warrior program was in the process of being designated a Category I system.

3. We are concerned that operability of Land Warrior with Force XXI Battle Command Brigade and Below be assured before fielding. The waiver granted to the Army postponed the need to address operability requirements. The waiver was granted subject to the approval of a plan to integrate the system into the digitized battlefield. Such a plan would include Land Warrior requirements for operating with Tactical Internet and Force XXI Battle Command Brigade and Below. As of November 30, 1999, the waiver conditions had not been met.

Comparison of Land Warrior Unique Developments Original Design and Revised Design

System/component	Original design	Revised design
Software		
Program language	**Land Warrior unique**	**Land Warrior unique but minimized with emphasis on commercial and customized software**
Software operating system		
Weapon Subsystem		
Weapon		
Laser rangefinder and digital compass	**Land Warrior unique**	**Land Warrior unique**
Wiring harness	**Land Warrior unique**	**Land Warrior unique**
Video sight	**Land Warrior unique**	**Land Warrior unique**
Thermal Weapon Sight		
Close Combat Optic		
Laser Aiming Light		
Integrated Helmet Assembly Subystem		
Helmet	**Land Warrior unique**	**Considering Standard Army helmet or variant**
Helmet display		
Day/night sensor w/ display		
Personal Clothing and Individual Equipment		
Modular body armor	**Land Warrior unique**	**Adopting Marine/Army Program body armor**
Load carrying equipment	**Land Warrior unique**	**Adopting Marine/Army load carrying equipment and adapting for Land Warrior**
Nuclear, Biological, Chemical Suit		
Ballistic Laser Eye Protection		
Computer Radio Subsystem		
Computer	**Land Warrior unique**	**Commercial item**
Soldier radio	**Land Warrior unique**	**Commercial Wireless Network Card Radio**
Leader radio	**Land Warrior unique**	**Repackaged Army radio or commercial radio**
Global Positioning System		
System Control Module	**Land Warrior unique**	**Land Warrior unique**
Hand held display	**Land Warrior unique**	**Commercial touchscreen**

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