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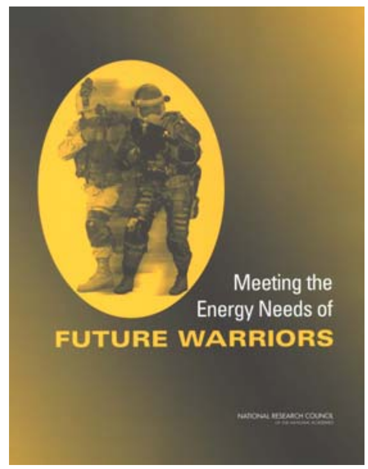
Meeting the Energy Needs of Future Warriors—*Summary*

BOARD ON ARMY SCIENCE AND TECHNOLOGY

Introduction



The central characteristic of the evolution of the combat soldier in recent years is an increasingly sophisticated array of sensing, communications, and related electronics for use in battlefield situations. The most critical factor for maintaining this evolution will be the development of power supply systems capable of operating those electronics effectively for missions up to 72 hours long. To address the challenge presented by fielding a myriad of separate communications and electronics components, the Army recognized in the early 1980s that it must approach equipping soldiers with a single integrated system, the Land Warrior (LW) system. At its current stage of development, the LW ensemble of electronics and batteries would add more than 30 pounds to a soldier's load, which would severely limit effectiveness. Given this prospect, it is important that new approaches be sought on how to integrate and power these electronics. To assist in addressing this problem, the Army requested the National Research Council to review the state of the art and to recommend technologies that will support the rapid development of effective power systems for the future warrior.

Technical Findings and Recommendations

For the purposes of the study, three power regimes had been identified by the Army that would cover the spectrum of requirements for current and future electronic devices: 20 watts, 100 watts, and one to five kilowatts. The committee compared possible energy-source alternatives using energy per unit mass as the primary factor. Battery, fueled, and hybrid systems with the highest levels of technology readiness were considered.

Technologies for Target Power Regimes. While many commercial energy sources exist, they are not developed in sizes that match the broad spectrum of Army needs. **For the 20 watt regime, the Army should support development of 300 watt-hour/kilogram batteries and smart hybrid systems capable of supplying 50 watt peak loads. In the 100 watt regime, the Army should develop smart hybrid systems that can also provide all energy requirements. For the one to five kilowatt regime, the Army should continue to develop lightweight engines with high specific power.**

Battery and Fuel-Cell Developments. Batteries will be a principal power source—both alone and as part of hybrid systems—for the foreseeable future. The challenge is to make them smaller, lighter, cheaper, and more reliable. **The Army should focus on developing batteries with specific energy of 300 watt-hour/kilogram and higher. It should consider tradeoffs between lifetime, specific power, safety, and cost when evaluating technology alternatives.**

Logistics and Operational Considerations. Fueled hybrid systems offer promise for weight reduction on long missions but complicate logistics. **The Army should evaluate the applicability of small-scale, portable fuel processors.** The Army must also determine the logistics feasibility—ideally including field testing—of alternative fuel sources such as methanol or hydrogen. **It should immediately conduct a full analysis of the implications of fielding non-battery power sources including modeling them in simulations of battlefield operations.**

Small Engines. Several types of internal and external combustion engines show potential for military applications, although they currently all have distinctive heat and noise signatures that would limit their utility. **The Army should focus internal combustion engine development on achieving capabilities appropriate to specific Army applications with reduced heat and noise signatures.**

Hybrid Power Systems. For longer mission times, hybrid systems could be very advantageous. They can be optimized for both high energy and high power demands. The development of models to simulate patterns of electronic equipment usage by LW systems is critical for the design of acceptable hybrid systems.

Land Warrior System Findings and Recommendations

An important consideration for energy efficiency is matching power source technology with particular electronic applications. In designing LW electronics, the Army has focused on improved combat effectiveness rather than power. An earlier NRC study determined that a LW system requiring only 2 watts of average power should be possible using commercial design approaches. Since that study in1997, the energy efficiency of commercial circuits has improved by at least a factor of five, but the Army has not availed itself of those gains. While the Army's near term objective is to provide a rational budget for power usage, the longer-term development horizon needed to address power issues appears to be lacking. Dramatic gains in energy density are unlikely, so the Army needs to put more R&D emphasis on reducing power demand if current soldier agility is to be maintained as new and improved electronics applications are developed.

None of the programs developing new electronics for the LW program have adequate incentives to use commercially proven techniques to reduce energy use. In considering the cost of new equipment, the Army acquisition system does not adequately account for logistics costs in providing power to soldiers on the battlefield. **The Army should make realistic estimates of the life-cycle cost, including the logistics costs of supplying**

power on the battlefield. More funding is needed to enable the Army to include low-power designs and power management in electronics development programs.

Power for Soldier Communications. Wireless communications offers the best opportunity for reducing energy requirement for future combat soldiers. Currently, however, taking such steps is not a high priority for communications-electronics development. For example, the Joint Tactical Radio System (JTRS) program, which is responsible for developing radios for both mounted and dismounted applications, does not appear to be focusing sufficiently on improving power performance in the soldier portable radio. **The Army should make energy efficiency a primary design parameter when specifying system performance parameters in contracts.**

Overarching Recommendations

The focus of the Objective Force Warrior-Advanced Technology Demonstration (OFW-ATD) program appears to be on increasing combat effectiveness for the future Land Warrior without regard for the key role that energy efficiency must play. To provide power for soldiers on future battlefields, this focus will have to shift toward actively reducing power demand by soldier electronics.

Future Warrior Goal. Soldier electronics requiring no more than two watts average, five watts peak, is attainable for the far term if the recommendations of this study are applied. By adopting state-of-the-art commercial design practices and incorporating energy-efficient technologies, peak power demand can be reduced and combat effectiveness increased. **The Army should aim for a future soldier system requiring no more than two watts average and five watts peak power demand.**

Determining Energy Needs. Precise determination of an optimum type, quantity, and distribution of power sources for a given mission is needed to determine the directions that energy-efficiency developments must take to have the greatest effect. **The Army should develop a modeling capability for soldier equipment that includes power sources and enables detailed simulation, verification, and analysis of power requirements.**

Ensuring adequate power requires consideration and management of both energy sinks and sources. Solutions do exist to satisfy known power requirement, and major technological breakthroughs are not needed. The Army must move power to the forefront of considerations, however, if the power needs of future warriors are to be met.

For further information

Copies of the complete report, *Meeting the Energy Needs of Future Warriors,* can be obtained on the National Academy Press Web site <http://books.nap.edu/catalog/11065.html >**.**

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