Soldier Power: A Growing Operational Concern

by MAJ Steven P. Meredith and MAJ David Bergmann

"In World War II, it took one to two gallons of fuel per day to sustain a Soldier on the battlefield. Today, it takes 20 plus gallons per Soldier, per day." —LTG Raymond V. Mason, deputy chief of staff, Army G-4 Logistics

"Every time we deliver fuel or batteries on the battlefield, we put Soldiers at risk." —Call to action, Sergeant Major of the Army Raymond Chandler, Army Chief of Staff GEN Raymond Odierno and Secretary of the Army John McHugh

With the proliferation of Soldier and squad-borne technologies, Soldier-power solutions are becoming a critical operational concern. Without access to adequate power, the Army's dismounted-unit capabilities rapidly become degraded on the battlefield. The Army prides itself on providing its Soldiers with the most technologically advanced equipment that overmatches potential enemies' systems and weapons. However, technological overmatch is unlikely if Soldiers are unable to power these systems.

This article explores some of the current and emerging power and battery limitations and potential developmental solutions.

Meeting a growing demand

It is one thing to create a battery that provides twice the amount of power within the same package, but when Soldiers already conduct battery swaps more than seven times over a 72-hour mission, this does not eliminate the need to carry spare batteries or recharge them. Also, with the given state of small, lightweight power-generation technologies, current batteries cannot be charged rapidly enough to fully self-sustain the unit.

In an effort to address potential energy shortages and logistical challenges, the Army is exploring a wide range of solutions to sustain the force through an operational-energy initiative. Operational-energy initiatives at the small-unit level are reducing the frequency of resupply (both aerial and ground), the number of batteries Soldiers must carry and how often Soldiers must replace their batteries. Initiatives are also providing solutions to better manage the power Soldiers do have.

The operational-energy initiative's goal is to improve combat effectiveness by becoming "net-zero," thereby saving Soldiers' lives and reducing Soldier load. Net-zero at the small-unit level is the ability for Soldiers to produce enough energy to power their own individual equipment, reducing the need for resupply related to power demand.

The Army continues to seek revolutionary solutions to generate power on-site, reduce system power demand and eliminate the need for spare batteries. Eventually, the Army will measure power-source life in terms of weeks and months, rather than hours and days.

The Maneuver Center of Excellence's vision is to provide every Soldier with the ability to wirelessly power every system within a one-meter radius of a centrally worn power source and create a power surplus at each echelon. The less power Soldiers use, the more power they preserve, and the more efficiently power is produced, the smaller the cumulative power demand is on the squad.

The same concept is true from squad to platoon, platoon to company, etc. In turn, the next higher echelon would require a lighter, more agile power-generation solution to support the power demand.

For example, to meet the power demand, a platoon could use a lightweight, compact 500-watt solar blanket, as opposed to a heavier 900-watt generator. Or, a squad could use a lightweight solid oxide fuel cell instead of a cumbersome solar blanket, which requires sunlight.

Regardless of the ultimate materiel solution, the objective is to increase the small-unit's ability to gain and maintain contact with the enemy by lightening Soldier load, increasing unit self-sustainability and self-sufficiency, and reduce frequency of mission interruptions due to resupply operations and battery swaps.

Today's challenge

Soldiers are unnecessarily placed in danger due to the frequency of exchanging batteries and exhaustion from carrying additional weight. Excessive loads, in both weight and bulk, negatively impact the mobility, lethality, survivability and combat effectiveness of Soldiers and small units. More physical energy is expended to perform each assigned task. The fatigue resulting from heavy loads decreases a Soldier's alertness and ability to move quickly, thereby making the Soldier and small unit more vulnerable. Reduced mobility requires small units to travel shorter durations and distances between routine resupply. Also, excessive loads may dictate which route a unit takes, potentially exposing them to threats.

The mass proliferation of Soldier-networked radios and advanced Soldier-borne sensors, optics and targeting devices requires a holistic approach to Soldier energy, with a focus on intelligent power management, low-power electronics and networked, smart battlefield-energy on-demand solutions. Included in this approach are both advanced energy sources and improvements in managing energy use and consumption by new Soldier-borne devices. This ensures dismounted small units and Soldiers will be better postured to conduct sustained combat operations in austere environments.

Current limitations

The dismounted infantryman or scout deployed in Afghanistan carries on average 9.7 pounds of batteries. Soldiers are unable to recharge these batteries when they are not in or near a vehicle, or have access to power from a combat outpost or forward operating base. This situation will become increasingly challenging as Soldiers are brought into the network.

Battery weight will likely increase to more than 14 pounds for a 72-hour mission if every Soldier is brought into the network. This weight increase will inevitably force small-unit leaders to make tough decisions to either leave equipment behind or further burden their Soldiers with more weight. As most of these systems have battery durations of eight hours or less, Soldiers will have to make about seven battery exchanges for each of their systems over the course of the mission. These battery exchanges could occur during decisive actions, not only reducing the effectiveness of that Soldier and the small unit, but also compromising mission accomplishment.

Potential solutions

The following are examples of the solutions the Army is researching and developing to help maintain enough operational energy at the small-unit level.

- **Integrated Soldier Power and Data**

System. Powering multiple Soldier-borne devices by a central conformal battery is one way the operational-energy community is trying to solve the energy limitations. The ISPDS will eliminate the need for spare batteries for each individual system. This central battery is flexible, lightweight and provides significant improvement in power duration.

The first generation of ISPDS and conformal batteries were evaluated at the Network-Integration Evaluation 13.1 with enormously positive results. During NIE 13.1, Soldiers were able to operate more than 24 hours without having to exchange a single radio or Nett Warrior end-user-device battery. This reduced the number of batteries the unit had to carry and increased its confidence that systems would have enough power when required.

Without the conformal battery and cables, the radio and EUD only lasted four to six hours. The short battery durations dictated many battery exchanges while engaged with the enemy. There were times when Soldiers had no power to operate their communication devices to coordinate for unit enablers (adjacent units, fire support, etc.).

- **Battery charging and power generation.** Although the conformal battery and power-distribution system showed significant promise for enhancing Soldier power, the Army recognizes this is not enough. This alone will not reduce energy demand required by dismounted Soldiers and units. To become net-zero, the conformal battery needs to be charged daily. Currently, this can only be done using a vehicle or while in a secure location like a FOB that has inherent generator support.

To help remedy this issue, the Army is working on a lightweight, man-portable battery charger that can charge many battery types simultaneously, including the conformal battery, using various power-generation inputs such as solar energy.

Another solution is providing a power-distribution and management device in conjunction with a solar blanket or folding solar panels that can recharge batteries or directly provide power to small electronic systems. This power-management device can scavenge power from almost any available energy source (alternating current, direct current, vehicle, solar, etc.) and convert it into useable power for Army communications and electronics devices. It can transfer power from batteries to other batteries and systems, allowing more flexibility for the unit. Recently, 1st Brigade Combat Team, 82nd Airborne Division, deployed to Afghanistan with this capability within the 3-73rd Cavalry Squadron.

Although the first-generation solar technology did not allow rapid battery charging, the power-management device did allow them to transfer power from partially depleted disposable batteries to rechargeable batteries and devices, thereby reducing wasted energy that would normally be lost when replacing a battery before being depleted of energy or thrown away. This device allowed a mortar position to operate continuously without battery resupply — an enormous benefit to the unit in that it could only receive aerial resupply.

The currently fielded state of solar technology provides a good backup at a secure location when fuel is unavailable or impractical, such as while a squad is occupying a combat outpost; however, current solar technology does not provide enough power to support the Soldier indefinitely at the tactical edge. Soldiers in Afghanistan and at the NIE have harnessed solar power and used this energy to power their personal devices. This level of confidence and trust in solar panels is witnessed at home station as well, demonstrated by large numbers of Soldiers who use solar panels to charge their personal devices while camping, hiking or at the beach.

Even with the current success of solar technologies, further development is required for lightweight, flexible solar technology to become a viable solution for the dismounted Soldier and offset the large quantities of batteries now required.

- **Kinetic energy.** As technology improves, kinetic energy could prove to be a viable option to further reduce the dependency on fuel and allowing more autonomy in small units. Harnessing kinetic energy generated from Soldier movement is another way to improve operational-energy efforts. This would provide energy to the conformal battery and other electronic devices. Possible locations for capturing this kinetic energy are the assault pack, rucksack or the Soldier's leg. Early prototypes of these technologies demonstrated potential; however, the energy produced did not merit the additional burden on the Soldier at this time.

Cultivating positive mindsets

Although this article has mainly focused on the materiel aspects of operational power, non-materiel solutions are just as important in addressing the power challenges of today and the future. Army culture and individual attitudes must change if the Army intends to overcome its operational-power challenge by reducing power demand and using power more efficiently. Finding non-materiel solutions to this operational concern can only be accomplished through educating our Soldiers and leaders, developing their confidence in newly established operational power practices and making these new practices routine and habitual.

Army leaders and Soldiers must be educated so they understand the positive and negative impacts of their actions from an operational power and energy perspective. To accomplish this, institutional courses from initial-entry-level training through senior-leader courses must include operational power and energy as it relates to their levels of responsibility and accountability. Education must include strategic, operational and tactical impacts, and it must include power and energy operating fundamentals, principals and best practices.

Operational power and energy impacts every principle of war, warfighting function, formation and form of maneuver across the operational environment. There is not a single aspect of the profession of arms untouched by operational power and energy. It is important; it is ubiquitous; and it can be the difference between winning and losing.

Education is the starting point for changing the current Army culture and attitudes, but it is not the endpoint.

The Army must make the paradigm shift toward operational power and energy an enduring consideration. This is not a fad, here today and gone tomorrow. To achieve permanence, the Army must prove that real progress in all indices of operational power and energy can be achieved by changing its institutional and individual behaviors. From these demonstrated and marked improvements in operational power and energy, individual confidence will take root and grow. Success will encourage expansion of operational power and energy best practices and further solidify the confidence Soldiers and leaders have for future improvements.

Finally, a culminating point is achieved when operational power and energy best practices and a net-zero state become the norm. This must be the enduring endstate of operational power and energy in the Army.

Way ahead

Power and energy represent a unique challenge to Soldiers, units and the Army at large. With the advent and proliferation of advanced technologies, the Army becomes more reliant on power to sustain operations.

Advancements must continue in rechargeable and non-rechargeable battery designs and chemistries. It is likely that electrochemical batteries, particularly rechargeable batteries, will remain the primary means for Soldier power and energy for decades to come. Battery modernization may be achieved through investment in science and technology such as advanced high-density battery improvements, nanotechnology applications to battery materials and design, lithium-based battery improvements and the capability for rapid recharging. Improved battery density will reduce battery size and weight, thereby improving operational effectiveness and unit self-sufficiency. There will be a continuing need to adapt advanced battery technologies for Soldiers through ergonomic design of conformal batteries.

Other focus areas include enhanced battery designs, intelligent power management, smart battlefield-energy on-demand apps, wireless energy sensing and wireless energy transfer, fuel cell use of JP-8, energy systems integrated with other systems (clothing and protection) and novel energy-harvesting sources.

The Army is also exploring the use of computing, networking and analysis tools to automate Soldier power-management and controls. For example, when a Soldier sits in a vehicle seat, the vehicle's intelligent power-management systems activate embedded seat sensors to analyze the Soldier's energy reserves. The sensors then activate the seat's embedded wireless charging pads and passively bring systems to a full state of charge.

To take advantage of this new paradigm, there must be novel approaches to Soldier-borne power and energy sources and a strategic imperative for energy demand-side management. There are opportunities to harvest Soldier-energy from many sources such as solid-state energy-conversion devices, microcombustors and physiological motion and reactions. These approaches will be essential to enable the Soldier systems of the future.

Wireless energy transfer will align with wireless information exchange. Opportunities exist to integrate power storage and harvesting into revolutionary concepts in Soldier protection and clothing systems, thereby easing Soldier power and energy supply demands and overall Soldier load.

For the near future, operational power and energy demands will continue to increase rather than decrease. Consequently, finding viable solutions are a driving force behind the growing Army support and activity in power-related research and development. As a result, advancement in Soldier power and energy solutions are an integral element of the Army's operational-energy requirements document and the soon-to-be-published Army Campaign Plan.

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Science & Technology and Research & Development Focus Areas

- Soldier-borne intelligent power management tools/devices
- Networked applications to enhance Soldier energy awareness and provide data-to-decision capability
- Energy demand efficiency considerations designed into new and future Soldier devices to extend the use of available energy
- Lightweight, compact highly efficient battery charging devices and advanced energy dense rechargeable batteries
- Improved battery energy density that is smaller, lighter, and conformal to the Soldier
- Wireless energy transfer and charging at very efficient levels and meaningful distances
- Intelligent energy interfaces that maintain/improve Soldier energy reserves across transitions
- Highly efficient compact power sources for Soldiers that may take advantage of solid state energy conversion, micro-combustors and micro power, and bio-energy harvesting

Acronym Quick-Scan

EUD — end-user device
FOB — forward operating base
ISPDS — Integrated Soldier Power and Data System
MCoE — Maneuver Center of Excellence
NIE — network-integration evaluation