Revision's NervCentr SharePack provides 14.6V of power.
(Photo: Revision Military)

THE LI-ION'S SHARE

The adoption of lithium-ion batteries, among other technologies, has helped boost the power capabilities of militaries, but the logistical trail of a soldier's devices remains an issue. **Anthony Hall** looks at how this is being addressed.

Electric power has become the great operational enabler, but the management and storage of the energy it provides are areas that were not seen as mission-critical until the beginning of this decade.

Increasing demands for power through the growth of C4ISR and its networks have reached a point where dependence on a secure energy supply is now a challenge to the resilience of future operations – and a possible brake on future capabilities.

This was one of the main the conclusions drawn by the US Army in its Power and Energy Strategy white paper published in 2010. Management and control of energy was declared to be one of the 'grand challenges' to be met by 2030.

CLOSER TO BALANCE

Batteries are playing an increasing role in bringing the supply and demand for power closer to balance. As the most commonly utilised type of energy storage, they are the perfect components by which to leverage innovation in power use, monitoring and management.

The commercial need to enhance the performance of electric vehicles is creating an R&D boom in producing lighter and more powerful batteries with greater capacity. These efficiencies are being achieved through improvements in battery chemistries – that combination of metals and electrolytes that produce the electrochemical charge.

One of the most important has been the use of lithium – in both its metal form in non-rechargeable primary batteries, and as a non-metallic compound in secondary rechargeable types, known as Lithium-ion (Li-ion).

The latter has the benefit of being one of the lightest metals, as well has having a high electrochemical potential. This combination creates batteries with some of the highest energy density for weight currently available.

Lithium batteries were introduced commercially in the early 1990s, and within ten years procurement agencies were investing heavily in the technology. Quick off the mark was the UK MoD. In 2002, it awarded AEA Technology a £45 million ($69.1 million) ➔

The Conformal Wearable Battery, which is shown being placed into a tactical vest, is flexible and wraps around the body. *(Photo: RDECOM)*

contract for Li-ion batteries for its Bowman communications and data system. Now known as Denchi Power the company still provides Bowman's Li-ion batteries and vehicle-based chargers.

US ADOPTION

The US was slower in adopting lithium technologies. It was in 2008 that the Defense Logistics Agency awarded Saft a $64 million contract to supply each military service with such batteries for what it referred to as 'portable military applications', including radios and surveillance equipment. Once adopted, the technology does win strong advocates, and in 2012 Saft's contract was renewed for five years at a cost of $98 million.

Light, efficient and long-lasting though they are, the uptake of Li-ion batteries has been slow because of the expense. The metal is not a common element to source and despite the widespread use of such technologies in communications electronics, until this decade global production volumes of the batteries remained too low to reduce prices significantly.

The situation has changed with the growth in the electric vehicle market, led by manufacturers such as Tesla Motors. In October 2013, the OEM announced that it had reached agreement with Panasonic to supply two billion vehicle-grade Li-ion battery cells by 2017. With quantities like that, unit prices will fall – market analysis published in March 2015 registered a 14% reduction since 2007, and predicted a 9% reduction in price every time production volumes double.

As unit prices have dropped so battery manufacturers, including Saft, Denchi Power, Navitas Systems and A123 Systems, have seen possibilities for Li-ion batteries in the defence market, and are now in competition to provide alternatives to the NATO standard 6T lead-acid vehicle battery.

MAKING ASSESSMENTS

Interest from customers has been encouraging. In 2014, the US Army's Tank Automotive Research, Development and Engineering Center (TARDEC) assessed Li-ion batteries from Saft, Navitas and EaglePicher Technologies.

Saft's Li-ion batteries have played a key role in tactical vehicle development programmes. Alex Bynum, sales director for the company's Space and Defense division, told *Land Warfare International* that its new Xcelion 6T Li-ion battery was selected by Lockheed Martin for use in its bid for 2015's multi-billion dollar Joint Light Tactical Vehicle contract, while Thales also selected the Xcelion 6T for use in its Hawkei vehicle, part of Australia's light tactical vehicle replacement programme.

Bynum explained that the benefits of Li-ion technology are not just in improved weight-to-power ratios, but enabling vehicles to become more operationally effective, especially as an enabler of silent watch – the ability of a vehicle to use sensors and communications suites on full power without the need for a running engine, which uses up liquid fuel and leaves both noise and heat signatures.

'One 24V Xcelion 6T battery replaces two 12V lead-acid 6T batteries for starting and silent watch,' he told *Military Logistics International*. 'The emphasis on silent watch and the demands for more energy to support this activity, not to mention the increased amount and sophistication of the technology installed on military vehicles, means there is a greater demand on the battery. [This] has created opportunities for Li-ion technology, which has significantly longer life, is half the volume and a quarter of the weight.'

SILENT SUPPLY

Delivering silent watch has been a major selling point for Li-ion vehicle batteries, including Navitas Systems' Ultanum 6T and Revision Military's NervCentr SWatPack scalable battery system. Better known for its protective headgear and eyewear, the latter company has recently entered the power management and storage market with success. In June, it was awarded a $20 million contract to retrofit Canada's Reconnaissance Light Armoured Vehicles with SWatPack specifically to enhance silent watch.

Revision makes the claim that a single SWatPack can provide eight hours of silent watch time at the same power level as 30 6T lead acid batteries – numbers that are putting pressure on the manufacturers of lead-acid types.

Not least of these is EnerSys. The company dominates the military vehicle battery market in the US and as of 2015 had sold the DoD two million lead-acid 6Ts. EnerSys has made technical improvements to its products to hold market share. While it cannot compete with Li-ion types in terms of energy density, it has introduced the Armasafe Plus 6TAGM to improve the transportability and safety of the battery.

The danger of sulphuric acid spills is always present in lead-acid 6Ts when handled in rough conditions and EnerSys has sought to mitigate this in the Armasafe. By using absorbent glass matting (AGM) wrapped in a tight cylinder it contains the acid and makes the battery structurally more robust. ➔

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NAVITAS SYSTEMS

Saft Li-ion batteries were used during testing of Lockheed Martin's contender for the US JLTV programme.
(Photo: Lockheed Martin)

However, safety is also a problem with the use of lithium technologies. The element is not stable chemically, and battery fires have been common. It is a serious issue for the further development of the technology, as Deanna Tyler, system engineering lead for tactical power generation in the US Army's Communications-Electronics Research, Development and Engineering Center's Power & Integration Directorate explained.

'Safety of our soldiers as it relates to rechargeable lithium batteries is of critical importance to the army,' she stated.

For this reason, she said new technologies are investigated 'that specifically focus on mitigating dangers associated with items such as overcharging, short circuits, bullet penetration, extreme temperature operation and various other operational conditions'.

SECOND GENERATION

This area of battery research is also being pursued by the UK's Defence Science & Technology Laboratory. In 2013, it awarded a contract to Lincad and Oxis Energy to develop a second-generation rechargeable lithium battery to replace lithium-ion, based on new lithium sulphur technologies.

Mark Crittenden, head of business development at Oxis Energy, explained: 'There are several advantages, with the key ones generally considered to be lightness and safety.'

As regards reduction of the weight burden on soldiers, he told *MLI*: '[It] continues to be a priority for the armed forces. Secondly, it is also extremely important that the batteries remain safe during abuse – we have shown that lithium sulphur can survive a barrage of electrical and physical abuse, include being punctured, without any adverse reaction.'

The need to reduce the burden on the dismounted soldier has spurred further technological advances. As the soldier has become a platform for sensors and networked communications, so the power burden of his or her equipment has increased – as has the logistic trail providing all the batteries to keep everything from binoculars, GPS and weapons sights to shot detection systems and radios all working.

According to NATO, dismounted soldiers now have to use and carry at least seven different batteries, often of different types. The need to replace them regularly is accentuated by the fact that in some NATO forces, notably the US Army, the use of rechargeable lithium batteries in man-carried equipment is only permitted while training or on garrison duty – never on combat operations.

UNIFIED APPROACH

Faced with the need to provide a supply solution for constant spares, and the environmental impact of leaving used batteries across areas of operation, a solution is being found to provide the soldier with a single portable battery that powers all his equipment.

Introduced in the 2010s, conformal, or wearable, batteries using Li-ion technology can allow solutions to be made that are thin and light enough to sit in pouches on a soldier's load-carrying system, such the US MOLLE or the new British VIRTUS. Denchi Power's conformal battery, for example, weighs under 900g and is 197mm(w)x233mm(l)x32mm(h), while having a nominal voltage of 14.4V and nominal capacity of 9.3Ah.

The next developmental step has been to integrate the battery, equipment and load carriage together with cables and connectors to create a single system. This is the thinking behind the US Army's Soldier Worn Integrated Power Equipment System (SWIPES).

Produced by Arotech and introduced in 2011, the system has seen great success and now been upgraded to the SWIPES II PD. The solution uses a conformal battery made by Palladium Energy weighing just 2lb and providing continual power for up to 36 hours.

Using a single battery to run different items of equipment at the same time and at varying power levels requires a distribution and power management system creating what is now known as a smart battery. Integrated circuits measure and provide data on the health of the battery such as its state of charge and inner temperature – an important safety feature in lithium batteries given their tendency to overheat.

POWER SITUATION AWARENESS

The development of the smart battery now means power levels on the individual soldier can be accurately measured and communicated. It can also be network-enabled and combined with energy data from across a unit up the chain of command, where all the energy use can be managed in real time. At its most basic, any piece of equipment can be turned off when it is not mission-critical.

The concept is known as 'power situational awareness' and is now being developed by the US Army, with the aim of ensuring that soldiers in future will not have to second-guess when the power will run out.

It acknowledges that energy is a finite resource, but that its operational effectiveness can be maintained if it is managed intelligently. As Tyler puts it: 'The sharing of power usage data across a squad operating in a remote area with limited energy resources enables the unit to intelligently maximise energy usage in order to sustain critical missions.'

The control standards and energy situational awareness tools being developed within the army 'are focused on enhancing decision-making operations of the soldier and small unit by alerting the user only when action is required', she explained.

'[These tools] enable soldiers and small units to be proactive and ensure energy resources are available, even before they are required.' **MLI**