

The cables and connectors industry is needing to innovate to ensure people, vehicles and buildings remain protected, while capability and weight requirements are met. **Beth Maundrill** examines how companies are responding.

Cables and connectors are integral components of any military vehicle subsystem, soldier modernisation kit or communication station, providing the means by which they receive power and data can be transferred. As a result, ensuring effective and efficient performance is imperative.

There are two main considerations that manufacturers of these items currently face: meeting SWaP requirements; and improving power and signal transfer capabilities.

Although soldiers' weapons and equipment have become lighter, they are now being burdened with heavier loads due to additional electronic equipment and its associated power supplies. This is also the case for vehicles, where greater capability is coming at the cost of increased platform weight and energy requirements.

Every respective system developer must look for weight savings, and the cable and connector industry is no exception. The challenge is to shave off as many grams as possible, while retaining the same functionality.

#### ■ RUGGED LOOKS

Future soldier programmes such as Australia's Land 125, Finland's Finnish Warrior, Italy's Soldato Futuro and the US DoD's Nett Warrior each have capabilities provided by multiple electronic devices. The connectors within the respective systems must be rugged enough to withstand the tough environmental challenges and be practical for the end user.

Mil-spec connectors must also be shock- and vibration-resistant and will be tested

against a rigorous set of performance standards, unlike commercial connectors where there is minimal guidance for performance testing.

Connectors comprise a mating pair, with a male and female element to them. The former is the movable plug element that goes into the latter, which can be a fixed receptacle or a jack/outlet piece. Contacts within the connector are the conductive elements, and are usually in the form of pins which transfer power and signals. The number and size of contacts can vary depending on the application and its power and signal requirements. The main housing of a connector is the shell, which is typically the ruggedised aspect.

Two of the most common MIL-DTL connector types are 38999 and 5015. The former comes in four series of miniature connectors and features quick disconnect coupling, operating temperatures between -65 and +200°C as well as environmental resistance to severe wind and moisture.

The type can be used in a variety of applications, including handheld devices, communications systems and manned and unmanned platforms. Although widely utilised, a number of developers are now working on smaller connectors for soldier-worn systems.

#### ■ IN AND OUT

Type 5015 connectors, meanwhile, can house different types of contact elements and are





ODU's easy-clean connector has a spring-loaded pin system that allows for a wipe-flat receptacle surface. (Photo: ODU)

#### ■ CABLE REDUCTION

For body-worn or handheld applications, the Swiss company produces the MiniMax series of connectors, which are also suitable for small unmanned vehicles.

Its 24-pin configuration has four power and 20 signal contacts, but it can also come in a 19-pin formation. Within the signal contacts, there is the option of two advanced contacts for USB power connections as well as three latching systems: push-pull, screw lock or quick-release. Each pin is joined to a wire – the more pins, the more data or power can pass through a single connector.

Replacing multiple cables with just one ultimately provides an increase in functionality for small devices.

'From a total cost of ownership, if you take

three cables and replace them with one, even if that one is a little more expensive, in the end cost-wise it is still better value,' Vanheertum stated.

Fischer is able to provide the MiniMax as a standalone connector or part of a complete pre-cable solution.

While the company does not manufacture cables itself, it does partner with such manufacturers and offers integration of their products. Fischer can carry out cable assembly even if there is need for an industry-standard or competitor connector at the other end of the cable.

Vanheertum added: 'Challenges on the practical side are faced when [the connectors] become so small the cable on the other end ➤

# mates

used in electronic, electrical power and control circuits. One of their main benefits is ease of engagement and disengagement – particularly useful for soldier-worn systems that need to be quickly unplugged to prevent snagging, for example.

With the increasing number and variety of soldier systems deployed around the world, the challenge facing the connectors industry is how best to adapt its technology for wearable systems that are powered in some way.

Manufacturers such as DRS, Harris and Thales must consider a multitude of factors when selecting connectors to use on their radios, including size and weight constraints and adhering to military standards. They also use

subcontractors – sometimes across multiple levels – to produce components for their solutions. As a result, connector developers might have to work with a number of companies simultaneously on one product.

Wim Vanheertum, product manager at Fischer Connectors, told *Digital Battlespace*: 'On the applications side, what we see is really linked to the technology evolution – everything is going much more digital. In the military, you find viewfinders on guns that are transmitting live videos to headquarters from the soldier in the battlefield.

'Portable computers, PDA, GPS, radios, all communications devices – all of that is combined into one or two devices and is on the soldier today. Soldiers are getting more digital.'



**Omnetics' USB 3.0 connector has been modified to provide twice the electromagnetic shielding for added hacker protection.** (Photo: Omnetics)



starts to become a limiting factor. To get all the high-speed data, you really need to have the right wire the other side.'

#### ■ HYBRID THEORY

Customers also want to combine power and signal transfer through one connector. Hybrid connectors provide a solution to this requirement as they contain power pins as well as signal pins.

Omnetics, for example, supplies a circular connector that contains large power supply pins alongside smaller digital signal pins. This means only one connector and one cable unit are required to deliver the same capability.

As connectors get smaller, the knock-on effect is that the production of the components gets more technical and requires more specialist equipment, machinery and trained staff to make them.

'The manufacturing processes are being challenged as the physical limitations of traditional methods are being overcome with higher levels of automation,' explained Peter Dent, managing director at Lemo, a designer and manufacturer of connectors. 'Designs are becoming more sophisticated and manufacturing processes more automated with each generation.'

Vanheertum also noted that the smaller connectors get, the more difficult it is to integrate them onto a circuit board. More skilled workers are required in the manufacturing process, which can drive up the cost of cable integration to the connectors.

Lemo's M-series includes a range of high-strength aluminium miniaturised connectors for man-portable and vehicle-mounted equipment, offering size and weight advantages over 38999-type connectors, according to the company.

However, Vanheertum does not believe that this is the right solution. He stated that aluminium, which is great for weight saving, does have drawbacks, such as being less resistant within marine environments.

Unlike Lemo's M-series, Fischer's MiniMax is made with nickel plating on brass, which according to Vanheertum is a more resistant metal. Brass is typically used as the standard material.

'When connectors get really small, the gain you get from changing the material becomes less important,' he said.

#### ■ CAREFUL CONSIDERATION

According to Bob Stanton, director of technology at Omnetics, connector development is made significantly more complex due to the high military standards for shock and vibration resistance, ruggedness and coupling.

The company produces both micro (Mil-DTL-83513) and nano (Mil-DTL-32139) interconnection systems for portable and ruggedised soldier-worn electronics.

Stanton said there is also a trend towards high-performance digital signal processing within a wide range of surveillance equipment, particularly with the addition of multiple camera angles and speeds of 60fps+.

This ultimately increases the amount of data that needs to be transferred though the connectors and cables at higher speeds.

Getting high-speed digital signal routing from A to B using ultra-miniature differential signal cable and micro connectors is essential in achieving the rapid changes in mission-sensitive equipment, according to Stanton.

Omnetics offers a high-speed signal protocol hook-up map, where it is possible to find how to get the greatest speed out of a cable and connector, even if they are just standard components. Stanton said that this means customers do not have to design a brand-new specialist connector for a job, as Omnetics is able to modify existing equipment.

The company is able to modify the hook-up of a ruggedised micro- or nano-connector to produce greater digital speeds without losing the shock and vibration resistance levels, and stated that militaries are currently asking for demonstrations of this type of capability.

Some of these features are being added to commercial cables by the company, such as USB 3.0, for which, following recent testing, it managed to double the shielding inside the cable. Omnetics is working on modifying further commercial products to a higher standard.

The company offers an electromagnetic-shielded USB 3.0 (5Gb/s) connector that includes a latch and waterproof seal. It also produces USB 2.0 connectors which run on most computers at about 480Mb/s – a speed rate many commercial customers are accustomed to.

'The government wants to be able to do what you and I do at home – it just wants to be able to do it better and faster,' said Stanton.

#### ■ OUT WITH THE OLD

However, Mark Owen, director of product management at TT Electronics' AB Connectors division, said that focusing on SWaP issues is outdated and is terminology from the last decade. He told *DB* that prioritising size and



**TT Electronics AB Connectors' new design concept mag-Net features on this BAE Systems Broadsword power system shown at DSEI. (Photo: TT Electronics)**

weight is a blinkered approach to connectors on soldier-borne equipment and can be wholly detrimental to soldier performance.

According to Owen, the main problem with traditional military circular connectors is that they do not satisfy human factors or the mobility needs of a soldier. He said that traditional connectors are designed for linking cables to boxes, and so to just adapt these existing blueprints for wearable systems can result in mobility compromises.

TT is currently working on a prototype design of a new flat and square connector called mag-Net, which has been developed with the BAE Systems Broadsword wearable soldier system in mind. The shape of the connector reduces the risk of snag hazards and the company has cooperated with the large defence prime as well as militaries to develop it.

Unlike circular barrel connectors, mag-Net is a robust, flush rectangular solution with a self-aligning, automatic magnetic latching system, enabling one-handed blind mating. Simple mating solutions are important for a soldier on the move who is likely to be wearing gloves and unable to easily visualise connector alignment.

The connectors are flush flat to minimise risks of abrasion damage and contain no moving parts to aid durability and reliability. The patent-pending concept was unveiled at DSEI in London in September and the company is set to officially launch the product in Q2 of 2016 following some modifications.

Designed to meet stringent military specifications such as MIL-STD-810 (environmental and mechanical performance) and MIL-STD-461 (EMC), the connectors are

mounted on textile materials and sewn into place.

This is relevant because BAE's Broadsword is aimed at reducing the burden on soldiers and changes how digital equipment is powered using smart fabrics. The central battery is flat and data and power are fed through the body armour, removing hazardous exposed cables.

With mobility such a key consideration, Owen noted that weight is only part of the equation – bulkiness and stiffness need to also be addressed.

TT produces small lightweight circular connectors for soldier-borne and man-portable applications. The MIL-PP, an ultra-lightweight push-pull connector, offers simple orientation alignment for the wearer and has a minimal electronic signature through its shell-to-shell continuity.

### **EASY CLEAN**

Elsewhere, ODU has developed the Easy-Clean connector solution for the European future soldier radio market. The connector uses a spring-loaded pin system that allows for an easy-wipe flat receptacle surface, helping remove mud, dust or moisture.

It also includes break-away functionality that allows quick disengagement of the connector – under a certain amount of force, the connector will detach without the need for the user to unscrew or unlatch it. It can endure up to 5,000 mating cycles and has a temperature range from -51 to +125°C.

Within the UK market, ODU supplies connectors to the MoD and around 150,000 mated pairs have been delivered.

Meanwhile, Lemo has developed a new corrosion-resistant material that connectors can be coated in to endure tough environments – a nickel fluorocarbon polymer the company calls NiCorAl. Corrosion can be a serious problem, especially in maritime environments, as anything exposed can get wet or be susceptible to salt spray.

To counter this, industry previously adopted the use of electroless nickel PTFE (EN-PTFE) or black zinc nickel (Zn-Ni) on plate connectors, although there are various



issues that come with the use of such materials.

'Both materials require a high plating thickness, which is undesirable and can lead to design issues,' explained Dent.

With Zn-Ni, there is a sacrificial nature to the plating that can result in excessive corrosion deposits, and ultimately operating issues such as threads jamming, he added.

'NiCorAl has been two years in the making and is REACH 2017-compliant,' Dent said. 'It has no detrimental effect on the locking system and we have tested the plating for 500 hours in a corrosive test chamber.'

Lemo's M-Series connectors have passed 500-hour salt spray tests with NiCorAl protection. The brass-bodied components have achieved over 1,000 hours.

#### ■ PREVENTATIVE MEASURES

With the increase in digitised equipment, manufacturers now need to also protect electronic equipment against hackers, jamming, detection and electromagnetic interference (EMI).

Such equipment can be damaged by the use of electromagnetic pulses (EMP) that travel along power lines and cables. Connectors and cables are a vulnerable point in a building or vehicle's security. In the former case, they often run from a non-secure outside zone into the facility.

Paul Currie, sales and marketing director at MPE, an EMP filter provider, told *DB* that cables often run through large filter systems installed in a building to prevent any damage from a pulse, which could be triggered by someone using a low-tech emitter such as a microwave connected to outside cables.

Meanwhile, ships can have EMP-protected safe rooms, although the electronic systems within those zones will still have cables running into them from outside. Land vehicles can have EMP protection fitted to their chassis, but even smaller filters are bulky and heavy.

One of the solutions that MPE has developed to protect high-power connectors is through integrating EMP filters into the shell housing. Previously, these two pieces of kit would be



**MPE has integrated EMP suppression into its connectors, removing the need for a separate filter assembly. (Photo: MPE)**

separate on military vehicles, taking up more space and adding weight.

Currie said that many companies do not include this high level of protection within their connectors, instead relying on external filters to be installed within the cable system. MPE has developed techniques that enable the capacitor to be wound into the back shell of a high-powered military connector. This can take the EMP and push it away from the electrical equipment into the chassis and down to the ground.

#### ■ THREAT RESPONSE

MPE is not the only company looking at such protection on its connectors due to the increase in the EMP threat.

'We are upgrading the EMI shielding of our connectors,' explained Omnetics' Stanton. 'The best way that is done is that you don't just put an overall metal shield around the connector, you also put in drain wires inside the cable that also couple any unwanted noise and drag it and drain it off.'

Omnetics is spending a significant amount of time looking into shield and drain combination cables, according to Stanton.

A metal shell provides sufficient protection by not allowing an alien signal to penetrate

that which is travelling through the connector or the cable. This is achieved by using a combination of outer jackets on the connector, and a braided shield plus a drain wire system on the cable.

Meanwhile, Lemo is also offering a new technology capability demonstrator that could provide the market with intelligent connectors. Programmable chips can be integrated to provide additional intelligence attributes, such as being able to give information on positive engagement confirmations, individual electronic coding and cycle counts to learn the remaining life of the connector. They can also provide information on counterfeit protection against non-standard, non-Lemo products.

While some of industry is looking at integrating protection measures and intelligence characteristics into their own connectors, the rest still relies on third parties to provide these additional capabilities.

Noting that Fischer Connectors has had some requests for this, Vanheertum said: 'We [would] then have our customer collaborate with other vendors that can build filters onto our connectors, because it is a very specific domain... We do have some requests for that, but it is still quite rare.' **DB**