With military requirements for data connectivity at an all-time high, OEMs are striving to offer cost-effective, innovative SATCOM solutions that can operate in both on-the-move and static positions. By Tim Fish

Increased space-based satellite capabilities and burgeoning private and military constellations with higher data rates mean attention is now firmly fixed on portable satellite terminals. A stationary ground terminal in a facility with a large antenna is a fixed point and is able to gain the power and support services it needs to operate. It can, therefore, send and receive large amounts of information. But this is not the case for the portable terminal. SATCOM equipment fitted to a vehicle or manpacked will have SWaP constraints that will limit the amount of data that can be transferred. Additionally, if it is being moved around, there has to be a way of maintaining connectivity across different types of terrain and environmental conditions.

Technological developments are being driven by reduced budgets and the need for lower costs. This runs alongside standardisation of equipment, allied with international collaboration in procurement and most military services requesting cheaper commercial satellite solutions.

On spec
Kenneth Arndt, senior manager for product line management and lead for dismounted and embedded product offerings at Harris, told DB that militaries are looking for more SATCOM availability, greater throughput and more connectivity between forces as well as...
a smaller SWaP package for the terminals to reduce power consumption and heat generation. He said SATCOM-on-the-move (SOTM) capabilities at tactical level – that have reachback into HQ and command elements – are helping provide more connections on the battlefield.

SOTM can take the form of both manpack and vehicle mounted terminals. Norsat International, a SATCOM services provider, told DB that in project RfPs, the main functional/specification requirements from its defence customers for manpack terminals are: lightweight, portable terminals with small SWaP; single carry-on cases for ground air transmit/receive; wideband global SATCOM (WGS) certification; and Ka-band and X-band systems that are easy to use and have UPS battery back up. For vehicle mounted systems, there is the additional requirement to be low profile – a maximum of 20cm, with the vibration and shock resistance required to meet environmental qualifications (eg MIL-STD-810) and the ability to operate in temperatures of up to 70°C.

A Norsat spokesperson added that in recent years there have been a larger percentage of RfPs requiring WGS certification so that end users can use ‘free-bandwidth’, typically provided by government-owned satellites and therefore reducing end user budgets.

Patrick Heuline, product line manager for network infrastructure systems activities at Thales, said that in the manpack segment the trend is towards Ka band, although some products are multi-band (K, Ka, Ku, etc) capable.

Ka band has a higher throughput compared to other frequencies, so this supports the need for more data, especially video, but the problem with Ka band is that it is much harder for moving terminals to pick up. It is therefore usually used for static terminals. However, with more commercial satellite service providers now offering Ka- and X-band services, it makes sense for SOTM manpack terminals to have this capability too, with improved antennas that can point to the satellites.

Military need

Heuline also identified hardware issues for manpack terminals: ‘The main challenges are optimisation, simplification and shorter set-up/tear-down times. This has led Thales to optimise the design, integration and SWaP of its terminals, for example with the Thales Ka-band manpack solution selected for various programmes.’

He added: ‘The latest developments include lightweight materials like carbon fibre, higher-performance SSPAs with 4 Watts RF, more efficient batteries and the use of GPS for antenna pointing.’

Martin Lobiondo, waveform offering strategist and Mobile User Objective System (MUOS) lead at Harris, told DB the coverage and capacity provided does not always match what militaries need in terms of availability and data throughput, and that even when more is provided, it is instantly eaten up.

Arndt stated that there is a need to increase connectivity without increasing SWaP. On larger vehicles, militaries use a wideband SOTM solution that ‘consumes a fairly large portion of vehicle space and a fairly large portion of power on the vehicle to the point where you have dedicated power sources and air conditioning and cooling units… What forces need is to get away from that kind of requirement with smaller SWaP’.

One way to take a bite out of that is through the MUOS. Although it cannot provide all the capability of the wideband Ka-band solution, it can offer enough to allow situation awareness.

Lobiondo said: ‘MUOS operates in a different frequency band and there are efficiencies to that. It is not all hardware issues; it is related to the waveform. But there are advances in integrated circuitry that are helping us shrink the overall package sizes of the equipment, and that continues to evolve.’

He added: ‘In the case of the Ka-band transceiver, there is a fairly dedicated solution set within the radio architecture – losses that you don’t get between the power amplified and the antenna that don’t happen at lower frequencies like LHF, for example.’

In a Ka band SATCOM solution, the power amplifier is as close as possible to the antenna. This stops RF energy migrating to cables and losing power, which can happen when the cabling becomes a filter. The physics of the waveform mean systems are susceptible to this loss.
Mobile tactical terminals use UHF up to the satellite and the satellite uses Ka band to the stationary ground terminals. The Ka band is an aggregated type of solution and can carry more data, but it is not as wide a spectrum so whilst it is suitable for a fixed ground station it is less so for a moving terminal.

Lobiondo said another issue is satellite availability. SATCOM terminals are software-defined radios that can use different waveforms. The waveforms that go from dedicated channels to IP-based technology allow users to share the channel more effectively than in situations where the pipe is dedicated.

New medium earth orbit and low earth orbit (LEO) satellite networks and constellations represent a new opportunity for militaries, particularly in personal mobile communications.

These satellites are much smaller in size and weight than traditional satellites and are often referred to as mini-satellites (in the region of 300kg) or micro (up to 50kg), nano (less than 10kg) and even pico-satellites (up to 5kg).

Norsat said that effective, fast and low-cost micro-satellites can be used for both civil and military missions for specialised communications, earth observation, small-scale space science, technology demonstration/verification, education and training.

**Band innovation**

In the meantime, military customers are looking for commercial solutions to minimise costs as well as more WGS-certified terminals, especially in Canada. Norsat said that more of its customers are using WGS satellites instead of commercial bandwidth due to constrained operational budgets.

There is continued demand for Ka band and X band, with Ka-band products coming up in the OTM market. Although Ku band is still the tried and tested band for troop morale and welfare, according to Norsat, customers are looking for emerging Ku bands like Appendix 30A (12.75-13.25GHz) and Appendix 30B (14.5-14.8GHz) as well as multi-band ability to allow for flexibility as their network changes.

Another option for future military SATCOM systems is AEHF (advanced extremely-high frequency), where the principal uplink band is 43.5-45.5GHz and downlinks are 20.3-21.2GHz. The AEHF package comprises an earth cover, a theatre spot, a steerable spot and an agile beam overlay, with full interconnectivity between them.

However, Norsat said that there are disadvantages of AEHF: heavy attenuation during rainy season constituting ‘a real problem’, (although it) can to some extent be overcome by including large link margins; narrow beam widths achievable at 44GHz demanding more accurate pointing mechanisms for the terminal; and high initial stage component and system costs.

The company added: ‘Due to reduced dimensions and power consumption, the different transceiver and transmitter versions are suitable for pico-satellites as well as nano-satellites. The radio devices operate on S band (frequencies of 2.0-2.3GHz) and allow payload data rates of up to 20Mbps depending on the configuration in the downlink.’

Heuline explained that UHF OTM solutions present interesting advantages ‘in the fact that the tracking need is very light’, however he added that ‘the throughput is very limited, which allows essentially...’
voice and messaging services when more and more higher throughput are required for OTM command activity.’

He added: ‘Ka band allows much higher gain antennas for almost equivalent antenna sizes compared to X band, for example (UHF antennas are smaller with very limited directivity). This increased gain translates into a better link budget and finally to higher datarates for the end user.

‘It is that smaller aperture that makes it more challenging in tracking the OTM product. This is where a good design can help in particular in the mechanical, electronic antenna (with beam deviation) and tracking algorithms domains.”

Clinching connectivity
Meanwhile, Harris has stated it will continue to add to its Falcon III family. Arndt said that the PRC-117G supports different waveforms as well as MUOS. Looking ahead, he stated that the STC two-channel handheld product the company is developing for the USSOCOM community will eventually be able to host the MUOS waveform. He clarified that while the capability will not be available on launch, it will come later. Its AN/PRC-115 Manpack radio also has MUOS potential.

‘There is also the future option for mission modules for the handheld radios that will migrate to the manpack. They will allow hardware upgrades without the need to come back to Harris facilities for an upgrade. This capability will be added, like other waveforms, like Iridium, which is an LEO satellite capability that provides voice and IP capability down to the ground. It has different coverage – such as polar orbits – and... we are looking to augment our product line offerings for that capability going forward.’

However, Arndt explained that for connectivity to be maintained there is more to consider than merely having a satellite in view: ‘You need an availability to communicate on that channel. Just because there is [a satellite] in view, you still need authorisation and a slot to communicate with. Maintaining connectivity with that satellite is with a tracking antenna that is complex and has some mechanical wizardry to keep the antenna pointed – which is a drawback of the Ka solution.’

He added: ‘But most of the OTM solutions in the UHF range have an omni-directional antenna that does not require any mechanical pointing; the antenna is designed to keep connectivity. There are environmental challenges like bridges and you have the calculate that.’

Omnidirectional antennas have gain that is upwards, a radiation pattern that is verticalised instead or horizontal, like a cone pattern, with the opening upwards.

With something like Iridium, a satellite is potentially going overhead every eight minutes, so an operator is able to maintain connectivity. However, others are geo-synchronous in stationary orbit with a direct line to the earth, so if an operator goes behind a mountain, the connection will be disrupted and the operator has to move back out again to reconnect.

Packing light
Norsat’s 0.9m Journey Manpack is designed to be a portable, lightweight system in a single backpack that can provide HD video and IP transmission and over four hours of continuous runtime with a battery pack.

The company spokesperson said that the Journey Manpack is a ‘highly integrated complete solution including a compact, segmented antenna system, BUC, LNB, optional modem, comprehensive alignment tools, and a single backpack. The spokesperson added that it weighs less than 18kg, is MIL-STD-810G-compliant for tough environments and is “optionally equipped with Norsat’s Satellite Acquisition Assistant [SAA], which provides everything necessary to easily point, peak, and acquire a satellite.’

Tools included in the SAA package include: a spectrum analyser, GPS, inclinometer, compass, narrow band power meter, DVB/S2 receiver and LinkControl software.

Thales’ Heuline said the market for SATCOM systems for vehicles is increasing. ‘Demand for this type of SATCOM terminal is now expanding fast, after a relatively slow build-up since 2006. The growth is driven by positive feedback from operational units as well as falling prices’.

He added: ‘The United States, Canada, countries in the Middle East, Israel and France all have these solutions, most
SATCOM TERMINALS

of which were developed for command vehicles.

However, there is also a trend towards miniaturisation (smaller footprint) to make these terminals available to more users for lower-bandwidth services such as voice, messaging and BFT – services traditionally provided by V/UHF radio over limited range. In other words, we believe that both types of solution will co-exist in the future.

He expects SATM systems will be part of most of the major European military SATCOM programmes (Skynet 6, Syracuse 4, SATCOMBw3, MoFalko, etc).

‘In terms of technical challenges, the most critical aspects of SATCOM terminal performance – and the key differentiators in the marketplace – are discretion, resilience (ie the ability to provide uninterrupted service even in the event of an RF failure), off-road tracking capability, “keyhole” management (capability to stay locked on to the satellite when it is directly overhead or close to the horizon), and advanced skew angle management for significant satellite bandwidth savings.’

But he believes that the smaller systems on the market will not offer all of these functions and features because of the cost of providing this type of terminal in large numbers. He said Thales has developed ‘commander’-type solutions in X band that have high levels of availability using active electronically scanned array technology, and the development of a Ka-band solution based on the same principles is “nearing completion”.

He added: ‘A number of different solutions are available on the market, most of them based on passive reflector or printed antennas. They are not technically capable of meeting all the performance criteria described above for ‘commander’ application.’

Thales also offers military products based on Modern 21, which has variants for both manpack and vehicle OTM systems. This includes protection from jamming and spoofing to guarantee data integrity as well as OTM functions such as resistance to fleeting terrain effects and the ability to recover communications if the signal is lost for longer periods. ‘These highly robust waveforms support secure transmissions at low and high data rates in FDMA and TDMA as well as DAMA modes,’ Heuline said.

PHASED APPROACH

Eyal Ben David, marketing consultant at IAI Elta, told DöB that the company has a solution that uses phased-array radar technology and implements this in communications. He said that mechanical communications antenna is the ‘last generation’ and that the new generation will be directed electronically. This means that, whilst on the move, there can be direct uninterrupted communication with the satellite and this will mean more data.

IAI has developed the ELK-1895 lightweight manpack SATCOM terminal. It weighs just 5.5kg and takes only minutes to set up. It works in Ku band and can access any commercial geostationary Ku-band satellites. It has a tripod-mounted 3D rotating head and is operated by a laptop computer or the soldier’s digital assistant and is an all-in-one unit that has a transceiver, antenna, power amplifier, GPS and user interface.

‘For the armed forces, like special forces or a unit that is far away and needs to communicate, we have this device for the soldier or vehicle. You put it on the three legs, connect it and with some adjustment (almost automatically as it will tell you where to point the antenna) in a few minutes you have full communication,’ Ben David said.

He explained: ‘You cannot use [the device] while walking, but it is quick and you are not on the move all the time. [When stationary] then you can connect. Then you... communicate, download data, move again; it is nothing, like two minutes.’

Ben David added: ‘Military requirements are to be connected at all times if needed. If a mission is out of normal line of sight communication, then you cannot communicate; you must use SATCOM. But to use military standard communication that is encrypted, and wideband because you want to download video, data, information, not just talk, also uses a lot of data. There are still mechanical systems, but [the] next generation will be multibeam, smaller devices and more on the move.’

Changing times

The SATCOM terminals market is changing largely as a result of the expanding network of satellites of different types and the need to cut costs by securing more commercial-based services, although some countries – like Canada – are opting for joining military constellations.

The move towards Ka band offers the opportunity for more data for front line units but there still remain significant SWaP challenges for the terminals. Other hurdles include providing consistent service in remote areas and maintaining antenna connectivity when units are on the move.

It could be the case that motorised and infantry units are unable to stop and conduct SATCOM work so the ability to retain SATCOM links whilst on the move will be the next big step. For vehicles, there is a need to reduce weight and power requirements so that equipment takes up less space.

There are interesting times ahead for the SATCOM community, both for the most modern militaries, which have an insatiable thirst for more data, and for the less modern militaries that simply want to expand their existing capabilities.