UPPING THE GAME

More automation is needed within EW systems for faster responses and to make it easier for personnel to manage operations. (Photo: US DoD)

In modern warfare, the electromagnetic spectrum has always had its place in defence and attack capabilities, but never has this invisible battlespace been considered to hold such importance as it does today.

By Heidi Vella

Recent clashes between suspected Russian forces and coalition troops near Syria have served to demonstrate the genuine threat of the electromagnetic spectrum (EMS), so much so that in October 2018 the USN announced for the first time that it is now recognising EMS as a warfighting domain on par with sea, land, air, space and cyber.

Months before, at the US Geospatial Intelligence Foundation's 2018 GEOINT (geospatial intelligence) Symposium, Gen Raymond Thomas, commander of US Special Operations Command, discussed EW air attacks near Syria. He said that enemy forces were 'testing us every day, knocking our communications down, disabling our AC-130s'.

According to reports, officers who experienced the jamming first-hand claimed it is, in terms of danger, on par with conventional kinetic attacks.

For naval crews in particular, the EMS is crucial to their operations – it allows them to navigate, communicate, detect and defend against the enemy. If these systems are disabled, officers can become little more than sitting ducks, unable to locate or defend against oncoming enemy attacks, or else repeated EM interference can create a confused picture of unfolding events that increases the risk of attack by adversaries.

Uphill race

The ongoing, advanced attacks near Syria have served as a test and challenge to the US. However, it is clear that the country, alongside its allies, is keen to get ahead in the EW capabilities race.

The SECNAV [The Secretary of the Navy] Instruction released in October that upgrades the status of EMS to a new fighting domain works to instruct navy policy to take an enterprise approach to all activities necessary for EMS operations, including assigning roles and responsibilities for developing, implementing, managing and evaluating the electromagnetic battlespace programmes, policies, procedures and controls for US naval superiority.

Kevin Hays, director of navy surface information warfare, navigation and maritime systems division at Northrop Grumman, described the announcement as a 'tremendous, pivotal turning point for the navy and the nation in general'. He added: 'Future conflicts will be fought and won in this new realm, in both cyberspace and the electromagnetic spectrum.'

According to Hays, it is 'very significant' because it is 'a message to the rest of the world and its allies that it is going to dominate this battlespace, and it will ultimately enhance present and future EM technologies'.

But why now? EW is not a new threat. To this, Hays responded: 'Good question – I think ultimately it shows [the US] recognises it is important to fully integrate these capabilities and be fully operable, connected and coordinated to fully dominate the environment.'

Upgrading capabilities

At its core, EW is about controlling the electromagnetic spectrum to attack enemies, control the domain, degrade their networks to deny them an advantage and/or to defend and halt their assaults, and – in extreme scenarios – stop their missiles and other weapons.

The last century saw the rise of electronics in the battlespace, but it is in the last several decades that technology has come on in leaps and bounds to encompass endless data, AI and increased automation. Keeping up with advances in EW has become a key priority, albeit a challenging one. The Pentagon previously described its strategy to ensure continued US superiority across the electromagnetic spectrum as 'agile, adaptive and integrated electronic warfare'.

For its part, the USN's Surface Electronic Warfare Improvement program (SEWIP), an evolutionary development block upgrade programme for the AN/SLQ-32(V) EW system – the primary one in use on USN ships since the 1980s – is offering incremental enhancements in capability under three ongoing established block upgrades, with a fourth planned.

Block 1 will provide enhanced EW capabilities to existing and new ship combat systems to improve anti-ship missile defence, counter-targeting and counter-surveillance capabilities. Block 2 is for enhanced electronic support (ES) capability by means of an upgraded ES antenna, ES receiver and an open combat system interface for the AN/SLQ-32. Block 3 is for electronic attack (EA) capability improvements required for the AN/SLQ-32(V) system to keep pace with the threat. Block 4 is a future planned upgrade that will provide advanced EO and IR capabilities to the AN/SLQ-32(V) system.

The new upgraded solution is said to represent a quantum leap in the early detection, signal analysis, threat warning and protection from anti-ship missiles, enabling ships to counter threats non-kinetically. It will be installed on as many as 50 ships.

The US military is aware of how crucial the EW domain is, and is investing heavily into naval programmes. (Photo: US DoD)

Similarly, the UK RN is in the midst of its own Maritime Electronic Warfare Programme (MEWP), for which it has teamed with BAE Systems, CGI and Thales to upgrade critical components of electronic surveillance sensors, EW C2 and EW operational support.

Going digital

Both SEWIP and MEWP target several key capabilities modern navies are in a hurry to incorporate into their current EW arsenal. These include more intuitive systems, more automation, full spectrum capability and digitisation.

EW has been using equipment that is predominately based on analogue radio frequency (RF) equipment. However, as the analogue-to-digital converters become more capable, there is an opportunity to directly digitise more of the spectrum. This is a key priority for OEMs.

'I would characterise it by saying [that] as the threat environment becomes more complex, operators are over-tasked with dealing with electronic threats, no matter what the spectrum is,' said Mark Bruington, a former commanding officer and currently VP of strategic development at Mercury Systems.

The company manufactures secure and safety-critical processing subsystem solutions and supplies high-speed and sensor parts for the EW market, working both in the analogue and the digital domain, with everything from acoustics or low frequency to EO/IR.

Bruington said that Mercury Systems is focusing part of its R&D efforts into directly digitising more of the RF spectrum to have less classical RF in its subsystem solutions and to get 'digital data faster and closer to the antenna'. He explained: 'That allows us to do more data processing, so we can apply adaptive or cognitive techniques to all of the electronic domain data and ascertain key aspects of threat signals that may have not been seen before. This allows us to take a broad view of the problem space and apply our research and development resources in a very directed way to help our customers and, ultimately, the naval fighters.'

The digitisation trend is driven by commercial advances and technology, he added, noting that the RF spectrum is not necessarily disappearing, but that it is ▶

becoming clouded with more threats. 'Now, it is possible to apply artificial intelligence and cognitive and adaptive techniques in the digital domain and do more sophisticated processing than previously – that's where the technology is headed in five, ten years,' Bruington continued.

In June 2018, the company won a $20.5 million order to provide the USN with 36 additional Digital Radio Frequency Memory-based airborne radar-spoofing systems that can confuse enemy devices by projecting several different false images. It is also a partner for the SEWIP Block 2 programme, providing ultra-fast RF tuners and digital receivers, as well as technology for the full signal-processing subsystem design.

Similarly, Northrop Grumman has been focused on developing what it calls a 'full mission picture'. Brandon White, director of navy surface EW, navigation and maritime systems division at the company, said: 'We are investing in things like Active Aces – active electronically scanned array antennas that are very high performance and can be used in this environment – as well as digital receivers and digital exciters, so fully digitising those systems to integrate them with the latest signal processing and processing capabilities.'

He added: 'That is really where the focus is, in taking… legacy and analogue solutions and providing a very state-of-the-art digital capability that is flexible and can be altered very quickly and efficiently.'

The company is also a partner in the SEWIP programme in Block 3, with a $91.7 million contract to bring the EA component of the navy surface warfare programme and integrate it with all of the prior blocks to provide what it calls a 'revolutionary capability to the surface warfare environment'. It also conducted a critical design review for the SEWIP Block 3 AN/SLQ-32(V)7 EW system.

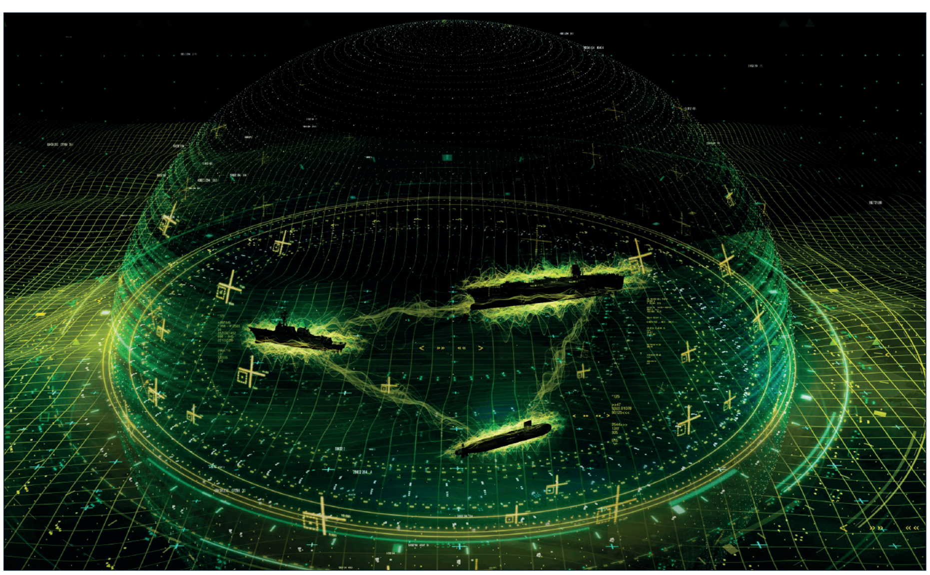
Growing sophistication

As these systems become more complex and advanced, and technology development happens faster, there is a growing need for them to be more interoperable and more easily updated, as well as smaller and modular in formation to accommodate limited space on vessels.

An ongoing USN programme called Integrated Topside recognises and is looking into, among other things, reducing the number of topside apertures present on navy ships through the use of integrated, multi-function, multi-beam arrays.

It notes that in the past, the topside design approach was based on developing separate systems and associated antennas for each individual RF function, which led to a significant increase in apertures. This created problems with electromagnetic interference, radar cross-section and the overall performance of critical ship EW-sensing and communication functions.

Northrop Grumman is a partner for the SEWIP programme in Block 3. (Image: Northrop Grumman)



Therefore, to meet this need, OEMs are now focusing on designing scalable and modular open systems that mitigate the need for re-engineering every time an update is required, according to Charlie Hudnall, chief technology officer at the advanced microelectronics solutions group at Mercury Systems. 'With the complexity of the threat environment comes the need to process more intense signal processing, and we are dedicating more field-programmable gate arrays or computer power to address the more complex threats moving forward, while trying to keep the systems the same size,' Hudnall explained.

'It's important to not only scale-up but to have processing capability that can be updated any time by changing the software when needed,' he added. This means flexibility in the hardware is paramount so it does not need to be changed each time an update is needed. 'We can work with our customers and make changes within a few months versus a few years, whereas in the past it might have required an entirely new subsystem design,' Hudnall said.

In this regard, the company is focusing on spectral density, which enables a large amount of data from the RF spectrum to be ingested and processed. This is an important element because the number of simultaneous threats happening at any given time increases exponentially over time.

Lockheed Martin is also investing heavily in developing smaller systems. However, this presents a significant challenge, one of physics principles, according to Joe Ottaviano, director at Lockheed Martin EW systems. 'You want to provide as much capability as possible in a very small form, say a coffee can, but you also need to find a way to extract the tremendous heat such a system will generate so it can operate effectively,' he said.

This can make technology design choices paramount; the solution needs to be adaptable. Lockheed's Advanced Off-board Electronic Warfare (AOEW) programme is an example, Ottaviano noted, of an extremely capable system in a constrained form factor. 'Technology is changing so rapidly, and we're having to find new and unique ways to bring updates into our systems,' he said. 'If you architect the system right at the start, it can be easy, but if you do it wrong, it can be difficult. But it's important to move

The USN is looking to dominate the future battlespace through EW capabilities. (Photo: US DoD)

with speed, which is not typically how systems are delivered, right? So that to me is one of the biggest challenges.'

According to the company, AOEW will deliver persistent electronic surveillance and attack capability against naval threats like anti-ship missiles via a self-contained EW pod hosted by an MH-60R or MH-60S Seahawk helicopter, which will provide the navy with advanced ASM detection and response capabilities. It can work independently or with the ship's onboard electronic surveillance sensor, SEWIP Block 2, to detect an incoming missile and then evaluate where it is going.

Under SEWIP, the company is also developing SEWIP Lite or AN/SLQ-32C(V)6, an EW surface system capable of both littoral and open-ocean electronic surveillance. It will be installed on fast frigates and USCG offshore patrol cutters.

Increased automation

Hand-in-hand with ever more complex and advanced operations is the need to increase automation within the systems themselves to make it easier for personnel to manage and operate all the equipment, as well as the information collected.

In particular, according to Petter Larsson, media relations manager at Saab, reaction times are becoming very short, so it is no longer always possible to rely on man-in-the-loop systems. Instead, AI and cognitive- based EW systems are needed for faster reaction times when managing information overload.

'Traditionally, these systems have been very rule-based, which means they have been programmed to cater for different types of scenario, but now the environment is so complex we cannot allow rule-based systems any more,' said Larsson. 'At Saab we try to use AI algorithms to predict what is going to happen in the next few seconds, minutes and hours. It's like one of those chess computers – they try to predict one of several future outcomes and make the best choice based on its simulations,' he added.

Saab offers compact surface tactical ESM and ELINT systems for enhanced situational awareness. The SME uses library files to classify and identify intercepted signals and ELINT analysis functions for intelligence gathering and post-mission analysis of raw and event recordings.

Ottaviano also noted that because threats are evolving at such a pace, 'the old ways of doing electronic warfare do not work anymore'.

'Cognitive and deep learning are key to making systems user-friendly because otherwise you overload the operator with too much data coming from the spectrum and then the system becomes unusable,' he said. 'We have reached the point, in my opinion and the opinion of many others, where a single operator or multiple operators can't handle all the data that's flying in the RF spectrum right now, so they need automated, cognitive, deep-learning capabilities to address that problem,' he added.

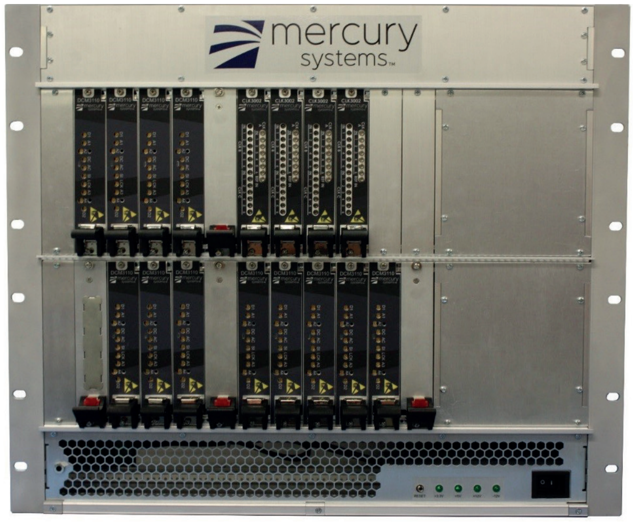
The role of technology is to whittle down the data to a set of information that can be used by the operator to make decisions when they're in the heat of the fight.

Ottaviano added that there has been discussion about doing AI and deep learning at the chip level. 'But this is challenging, as chips take 18 months to spin and you just can't respond quickly enough versus something that runs on the GPGPU – those are at the core of your deep learning, and they're very open. They're quick to upgrade, and they can keep you ahead of the threat,' he said.

Lockheed also builds in a large amount of cyber capability to its technology architecture that is automated and protects from attacks at the system level.

Ottaviano believes that eventually the EMS, EW systems and cyber needs and capabilities will all be merged. 'Sensing ▶

and then reacting and protecting – now it includes cyber. If you have a good EW system, it can become a cyber system as well. There are many synergies across that,' he said. 'We're seeing things that used to be segmented in both the RF and the EO/IR and visual spectrum that are now becoming merged and so we're having to deliver systems that have all those capabilities and in a way that they can be upgraded very quickly.'



Mercury Systems provides processing subsystem solutions, such as this coherent multi-channel direct conversion receiver system. (Photo: Mercury Systems)

Trending now

Raytheon's Next Generation Jammer (NGJ) is a good example of modern EW technology encompassing all the above trends. The USN made a significant investment in the NGJ in 2013 to replace the legacy ALQ-99 system, which is still rooted in analogue technology. It is used on the EA-18G airborne EA aircraft, the Growler.

Built with a combination of high-powered, agile beam-jamming techniques and cutting-edge, solid-state electronics in a cost-effective open architecture, according to Raytheon, the NGJ will integrate the most advanced EA technology into the EA-18G.

'The NGJ can perform missions at greater standoff ranges; a single NGJ-equipped aircraft can do what took multiple aircraft with legacy systems, and with greater effectiveness,' said Dan Kilfoyle, senior fellow and technical director at Raytheon Electronic Warfare Systems. 'It will handle more threats from a single aircraft and cover a wider frequency spectrum without making hardware changes.'

Kilfoyle added that Raytheon has also focused on making its solutions for dense and near-peer EMS environments modular, scalable and interoperable to quickly manage resources and optimise for the threats, while ensuring its other systems sharing the spectrum are not affected. 'Let me give you one example. Modern and future radar threats are becoming more adaptable and agile. If you try and jam them one way, they change their operating patterns to avoid being jammed,' he explained. 'That's why we incorporate expandable open-systems architecture to allow for seamless upgrades.'

In 2016, the USN awarded Raytheon a further $1 billion NGJ engineering and manufacturing development contract. According to the company, it is making strategic investments in its NGL Electronic Warfare Planning and Management Tool and radar warning receiver ALR-69A(V).

Future technologies

As already noted, the ability and speed at which technology can process information in this environment is key to gaining an advantage over the enemy. However, although systems are getting quicker, they are still limited. 'As you digitise more spectrum and you ingest more of this huge amount of RF data, that creates a big data problem,' said Hudnall. 'And just as you have big data in the commercial world, this creates huge amounts of information that needs processing, so compute cycles are very precious. The more of them you can get in a fixed amount of time, the better.'

Therefore, with the development of quantum computers and quantum processing becoming a reality – IBM has built one of the first working processors – OEMs are considering how it could be used in future EW technology.

While Hudnall said that for now, quantum processing in EW is 'not a today technology', it would help increase the processing capabilities on the back end.

Bruington, meanwhile, noted that quantum has key capabilities in cryptography. 'Quantum will probably start to show up in the areas of assured communications [and] assured computing, whereby with the quantum effects, you can put in something that will assure your communications are truly uninterrupted,' he added.

Furthermore, detection of quantum radar could be key in the future. This is something Ottaviano said Lockheed Martin is taking very seriously, investing money into 'looking into it'.

'I think there's ways to go to get that out of the lab. I've seen lots of articles on how quantum radar is going to defeat everything in the world,' he said. 'I think we're quite a way away from that, but it's not something that can be ignored and it does have applications, and – right now – unlimited capability, so the systems we're putting out there have to have the ability to detect them.' He added that 'certainly in our lifetime' something will come to fruition.

However, although quantum processing has 'potential' in the present, the future is rooted firmly in machine learning, cognitive EW and AI, according to Kilfoyle. 'Our adversaries are investing heavily in advanced capabilities that are generating new threats. Their systems are getting smarter. They're attempting to find ways around our own. Consequently, our systems must learn new behaviours on the fly and respond in real-time or near-real time,' he explained. 'Machine learning, cognitive electronic warfare and AI are all essential to combating these advanced threats.'

Kilfoyle said that Raytheon is working on several classified R&D programmes supporting RF sensing and machine learning, efforts they are complementing with internal investment.

Battle in the EMS is nothing new, but it has certainly entered a new, advanced phase of adoption and leverage, posing its biggest threat yet. Technology manufacturers are responding accordingly. Therefore, it seems in today's rapidly advancing technological world, the race for EW superiority is just getting started. ■