Electronic Warfare
Visualising the spectrum
Introduction

Visualising the spectrum

We are on the cusp of a revolution in the way that the electromagnetic spectrum (EMS) is visualised.

Investment in the four pillars of digital transformation, big data, artificial intelligence (AI), connectivity and cyber security, will transform how we can “see” which systems and devices are accessing the spectrum. This will enable richer levels of data to be generated than ever before, turned into valuable insight and presented in easy to understand, accessible formats.

From detection, to identification and the processing of data, digitalising Radar Electronic Support Measures (RESM) will enable operators to make decisions faster, with greater accuracy and clarity, leading to a step-change in the operational approach to sensing, identifying and mastering Electronic Warfare (EW).

The need for change

The EMS has become increasingly crowded and complex as a result of the number of signal generating sources that are accessing the spectrum, such as ships, aeroplanes, complex emitters, communications and mobile phone networks.

With modern EW systems required to analyse up to five million pulses per second, you can begin to gain an understanding of the density of the signal environment and the amount of processing power that is required.

Today it is estimated that there are over 2 billion 3/4G phone subscribers worldwide, which is up from only 297 million subscribers in 2007. The impending arrival of 5G is only going to intensify the number of electronic signals that are generated as mobile communications expand further across the EMS.

Furthermore, since 2003 all marine vessels of over 300gt but less than 50000gt have needed to be fitted with dual-band radar for safety and insurance purposes. As a result there has been a 50% increase of merchant ship radar transmissions worldwide in 15 years.

The airline industry has also reported a 7% year on year increase in the number of civil flights since the early 2000s, which has resulted in a 30% increase in civil air radar transmissions.

At the same time, the quest for greater intelligence, surveillance and reconnaissance has resulted in an increasing number of complex, high duty cycle military emitters, accessing the EMS.

Detection needs to become more sophisticated, we need to sample the environment in a different way and we must become faster and more automated.

As a result of the ever-increasing volume, velocity and variety of signals, traditional analogue systems are now suffering from saturation. This means the production of relevant and timely intelligence for decision-makers is becoming more challenging than ever.

To protect against the complex and diverse threats that exploit the EMS, detection needs to become more sophisticated, we need to sample the environment in a different way and we must become faster and more automated, allowing the commander to move further up the kill-chain.

This will require the uptake of digital visualisation tools that can assist with the smooth organisation of data and decision aids that will help to speed up operational responses.

A quest for clarity

Field trials undertaken with the armed forces have demonstrated that due to the congested electromagnetic environment, there is a 30% – 40% loss in signal detection when using traditional analogue RESM systems to determine which emitters and systems are harnessing the EMS.

This means that critical threats are not being detected, undermining an operator’s decision-making ability and leaving units extremely vulnerable to attack.

As the depth, breadth and volume of data increases, this can also bring its own problems. Studies have shown that EW operators struggle to cope with an overload of mainly unstable tracks visible on their screen. Yet analogue systems often have over 250 tracks showing at any one time, which creates a highly stressful combative environment. Units become thwarted, unable to “see” and protect themselves against incoming threats as it becomes impossible to “separate the wheat from the chaff”.

Simplifying the operational picture

The utilisation of digital receivers is the only way forward to improve threat identification and will provide forces with 100% probability of intercept, even in the most congested electromagnetic environments.

The technology is the equivalent of being able to tune into any DAB radio station in your car from the click of a button. Instead of having to remember numbers, frequencies and parametrics, operators can be automatically provided with the identity of systems that are accessing the spectrum, just like a digital radio can automatically tell you it is “Radio 5 Live” when you select your chosen radio channel.

Rather than sorting through lengthy tabular listings of parametric data, operators are provided with the name of the platform that the signal originates from, lifting EW from the parametric domain to platform level. This helps to prevent operator overload and decision paralysis in the quest to identify a threat, speeding up operational responses.

The simplification of EW systems at an operational level, also reduces the reliance on specialist EW operator skills and enables decision-makers to focus on their mission, instead of trying to optimise the equipment.

A question of confidence

The utilisation of full spectrum digital wideband receiver technology is also helping to improve identification, by providing forces with emitter information reports that deliver 10 times more fidelity than previous analogue systems.

Currently, there is a huge gap in the richness of data available in the master library databases that are used to provide threat identification. Reports suggest that only 10% of data that is produced from analysis of the EMS is currently stored and used to update library databases.

Digital processing will enable us to automatically record the vast quantities of information (up to 25GB of I&Q data per hour) that is captured from across the spectrum and cross-reference the data against a central repository of signals. This will help to improve library performance and provide enhanced confidence in the identification of threats.

AI and advanced data sciences will also enable much more digital data to be utilised in the construction of libraries so that operators have access to the most relevant and accurate data available. This shift in data analysis is key to future EW operations.

As advances in processing power and big data improves, the information can also be fused with other available sources of data, which will help to build the intelligence picture.

However, supporting frontline commanders requires more than the production and storage of data. It requires figuring out which data is worth sending in the first place. AI and deep learning techniques can take on much of this data crunching.

Turning insight into intelligence

Machine learning algorithms can analyse large volumes of information with lightning speed and accuracy, “learning” how to identify and categorise information, without the need for human intervention. Signals can be automatically cross referenced against a central catalogue of data, homing in on whether the emitter is from a “red” enemy source or “blue” friendly force and presenting the information at a platform level.

As the quantity and quality of data that AI can draw upon develops over time, this process will become increasingly accurate and automated so that normal patterns of behaviour and anomalies become easier to identify and distinguish.

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<th>The utilisation of digital receivers is the only way forward to improve threat identification</th>
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Loss in signal detection

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Probability of intercept
Building the intelligence picture

Once data has been mined, the information can be used to form easy to understand, visual displays that enable operators to swiftly interpret the electronic intelligence at a glance through user-friendly interfaces.

This will make it easier to visualise the physical effects of EW and removes the tedious, time-consuming and highly stressful tasks that operators currently undertake as they attempt to sift through the data. Instead, operators will be able to draw intelligence from comprehensive, platform level, visual displays, so that they can quickly assess the developing tactical picture and informed decisions can be made as threats develop.

The visualisation of data using AI techniques will also help measurement and classification, so that platforms can be quickly ranked in order of priority.

Operators will be able to easily filter the level of data they require, choosing to display the whole spectrum, or solely focusing on objects that have been alerted as suspicions by the machine. This provides operators with a clear picture of the most up to date, significant information, so that they can concentrate on the signals that are exceptions and unknowns, rather than trying to manage the entire spectrum.

Furthermore, while operators concentrate on the tracks that are most significant, the technology can continue to monitor tracks across the entire spectrum in the background. This facilitates continuous analysis of the EMS, whilst reducing the cognitive burden on operators.

Operators will be able to draw intelligence from comprehensive, platform level, visual displays, so that they can quickly assess the developing tactical picture and informed decisions can be made as threats develop.

Automated decision-making support

From the detection of hostile emitters, to homing in on the geolocation of threats, AI can also support decision making by providing the commander with a list of options or courses of action to protect against threats once they have been identified. For example, the release of countermeasures.

This demonstrates how visualisation tools will help to speed up the observe, orient, decide, act (OODA) loop, enabling real-time-critical intelligence to be gathered so identification can be achieved.

The command chain can be informed of threats faster, with greater accuracy and efficiency so that early warning, force dispatch, decision and orders to destroy a target can be carried out in a matter of milliseconds.

This is essential to protect against threats like missiles, where operators need to make momentous decisions at rapid speeds.

As a result, improved visualisation of the EMS activity, utilising AI techniques will allow command teams to move up the kill-chain, so that the earliest possible decisions can be made to counter threats to an individual unit and/or task force.

However, while AI can be used to aid human decision making, people must always remain the central decision-maker, with AI machines only ever there to ‘advise’ the operator for both moral and practical reasons.

Unlocking smarter working practices

Digital processing capabilities also enable us to swiftly share the information between multiple assets, with AI acting as the central “brain” that filters information to where it is required within the system. This automated process improves efficiency by reducing error-prone processes and enables the command to benefit from a global representation of the operational picture.

As a result mission-critical decisions can be made faster, using extensive real-time intelligence, which increases operational effectiveness.
Conclusion
Seeing the bigger picture

Digitalisation is set to transform EW operations, through the provision of visualisation tools that will give operators and commanders a much better understanding of the dense and complex electromagnetic battlespace.

This will help to reduce the cognitive burden on operators and enable decisions to be made better, faster and with greater accuracy.

Digital systems and sensors can filter data much more quickly than the human brain, enabling focus to be placed on management of the exceptions and unknowns, with data being swiftly transmitted through secure data storage and transmission networks to where it is needed most in the system.

This will support operators to find the “needle in the haystack” efficiently and quickly. A micro second could be the difference in surviving, or not.

EW is a multifaceted, intricate discipline which has become hugely complex due to the content and nature of the modern EMS environment. Therefore, we need to change our whole approach to how we detect, analyse and visualise the resulting output, or we run the risk of losing the ‘true’ value of EW.