MicroESM or High Performance ESM?

A paper by internationally renowned ESM scientist, Jon Roe, that answers the question:

Why would I acquire MicroESM when radar ESM equipment offerings from major manufacturers provide higher sensitivity detection against weak signals and more accurate direction of arrival measurement?

ESROE
Identifying the Spectrum

Contents

Abstract

Over the decades in which they have been a key capability for situational awareness and threat detection, improvement of Radar Electronic Surveillance Measures (ESM) systems has particularly focused on receiver sensitivity and directional discrimination:

- **Receiver sensitivity** to ensure that ESM retains its detection range advantage over radar (“detect the threat radar before I am detected”), even as opposition radars are able to reduce their power levels.
- **Directional discrimination** to get a more precise bearing to the target radar and to aid in distinguishing multiple radars on similar bearings.

From a detection perspective, this focus has been valuable. But from a vulnerability point-of-view, it has also been critical. This is because these high value and often heavy and power-consuming ESM systems have only been deployable on warships or high value aircraft, all of which need to be kept at acceptable range from any threat.

MicroESM, designed to be complementary to existing systems, brings very low size, weight and power (low SWAP) to ESM for the first time, enabling ESM to now be anywhere and even to be ‘disposable’. It does not even need an operator present and can be networked to provide a whole area ESM capability, whether along a coastline or across a battlefield.

This paper provides the context for deciding when MicroESM is the right solution, often as one element within an overall ESM capability.

High performance ESM deployable on warships

Low SWAP MicroESM deployable anywhere

The Key Question

Why would I acquire MicroESM when radar ESM equipment offerings from major manufacturers provide higher sensitivity detection against weak signals and more accurate direction of arrival measurement?

Person-portable MicroESM solution

Sensitivity Requirements

Usually measured on a logarithmic scale, sensitivity defines the weakest signal that the ESM can detect. MicroESM sensitivity is good at -55dBm for pulsed signals and enhanced for continuous wave (CW) signals (-70dBm). The logarithmic scale means that there is a very significant difference between these figures (CW detection gives more than five times greater range than for pulse detection).

A pulsed signal sensitivity of -55dBm was typical for major front line NATO radar ESM systems during the 1970's, 80's and 90's. Many front line systems in the rest of the world will still be operating with this level of sensitivity.

Most military search, targeting and tracking radars are still relatively high power signals. The Russian 30N6E (NATO Designation: FLAP LID) tracking radar that forms part of the S-300 air defence system is a good example. It has a peak transmit power of around 130kW and -55dBm sensitivity suggests that it should be detectable at over 200 km range. Search elements of the S-400 system are higher power again.

The primary reason for higher sensitivity is to detect Low Probability of Intercept (LPI) radars. These may have been designed to be difficult for ESM to detect but actually they have proliferated because the techniques to create a low power radar also result in low power consumption and compact design that lends itself to commercial navigation radars for small boats. These are often frequency modulated continuous wave radars (FMCW) but pulsed radars are now emerging with modulations that achieve the same effect.

These LPI radars can have a peak power of only a few watts, but at this power level the radar range will only be a few kilometres. LPI radars used by naval ships, such as the Kelvin Hughes SharpEye radar have a peak transmit power of around 200W.

This is significantly lower than traditional magnetron based navigation radars which would have a peak transmit power of around 5kW for small craft and much more for larger vessels. A sensitivity of -55dBm would still enable this type of low power radar to be detected at up to 12 km.

Higher sensitivity receivers will typically be offered as part of today's high performance systems. Indeed, -90dBm is certainly possible, but this level of sensitivity is not necessary to detect LPI radars at useful ranges, unless detection at 500km plus is required.

High Sensitivity Receiver Deployment Considerations

High sensitivity receivers bring their own deployment challenges. It will not make sense to make this kind of sensitivity available across the whole of the operating bandwidth of the ESM system as this will detect more signals than even an automatic system can cope with. Typically a 'side-arm' receiver will be deployed that requires specialist training to operate.

The greatest value of a high sensitivity receiver is to exploit the many 100's km of detection range suggested above from a stand-off platform, usually a surveillance aircraft.

The sensitivity of MicroESM is exceptional for the size of system, but does not go to the level of systems deployed on surveillance aircraft flying well back from the area to be monitored. Instead, however, its low SWAP means that it can be deployed well forward and on any number of stealthy unmanned air platforms at low cost and with the potential for high endurance, and, of course, with no crew risk. Being networked, it can also be deployed on low cost aircraft, vessels and vehicles to provide continuous monitoring across a wide area without any input from the crews of those platforms,
while simultaneously keeping them fully aware.

In summary, a high sensitivity capability, especially across a useful bandwidth, whilst very valuable in its own right, will present challenges in how to operate across all signal environments. It will also be expensive and, therefore, a scarce resource. MicroESM can be a highly complementary addition to the overall ESM mix, or meet use cases in terms of cost, location, endurance etc, which high sensitivity systems are not designed for.

MicroESM fitted to small boats for sea trials

Direction of Arrival Measurement Requirements

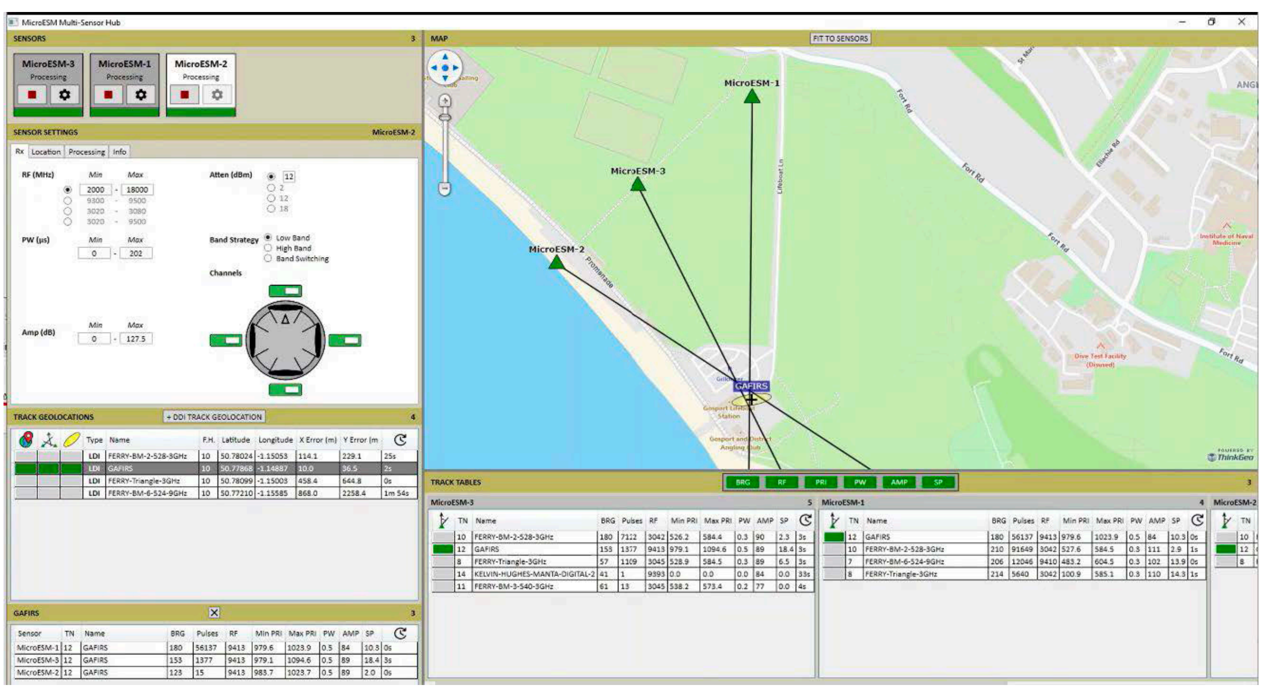
The other area where the MicroESM specification can, at first sight, seem behind the curve when compared to high performance systems is direction of arrival measurement accuracy, or bearing accuracy. State of the art is a few degrees or less measured as root mean square (rms). Across all bands MicroESM accuracy is 10° rms, although it is closer to 6° rms at 9GHz.

It is an error to assume that 10° rms means that signals that are less than 10 degrees apart cannot be separated and thus only one signal in such a sector can be reported. The MicroESM processing software is high performance and does not rely on bearing accuracy to separate signals. It can report 10’s to 100’s of signals within a 10 degree bearing sector.

Where manufacturers quote a few degrees of accuracy, this has been measured in an artificial environment in a test chamber and is not representative of the real world, which is much more complicated with reflections and so forth. Whereas MicroESM’s bearing measurement algorithms have been refined for the real world, and bearing measurement at the intercept level may be better than systems with a better specification figure.

One main advantage of MicroESM is that it’s small size and low cost means that it is easy to create a networked array of sensors to cover a particular region. It then becomes possible to combine radar intercepts to locate the radar signal. The location error can be of the order of 10’s of metres. For many use cases, this is a highly significant advance.

MicroESM multi-sensor GUI



Conclusion

When comparing solutions, it is easy to discount MicroESM as inferior to high performance ESMs, based on receiver sensitivity and directional discrimination, alone. But as is often the case when comparing traditional systems with 'next-gen' or disruptive technology, like for like comparisons can be arbitrary.

Which is why many buyers are now revisiting their situational awareness and threat detection requirements to determine the value of these specified ranges, to their real-world missions.

For what was once considered a "trade off" in terms of technical specification is increasingly proving to be a deployment advantage, as the benefits of low SWAP, fully autonomous, and resiliently networked MicroESM solutions prove their worth. In their own right, or as one element within an overall ESM capability.

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Jon Roe has established an international reputation in the field of Electronic Support Measures, having spent 25 years as a scientist at the UK's Defence Science & Technology Laboratory (Dstl) researching new techniques for the automatic processing of radar signals. He was also instrumental in defining the specification of all of the Royal Navy's ESM systems from the mid 1980's to the early 2000's.

Today, he is CEO and founder of ESROE, a company that harnesses his deep domain knowledge to lead significant breakthroughs in MicroESM, which is transforming access to and the use of ESM in the land, sea and air battle spaces, as well as in coastal maritime surveillance and other civilian applications.