ROGUE TRANSMISSIONS

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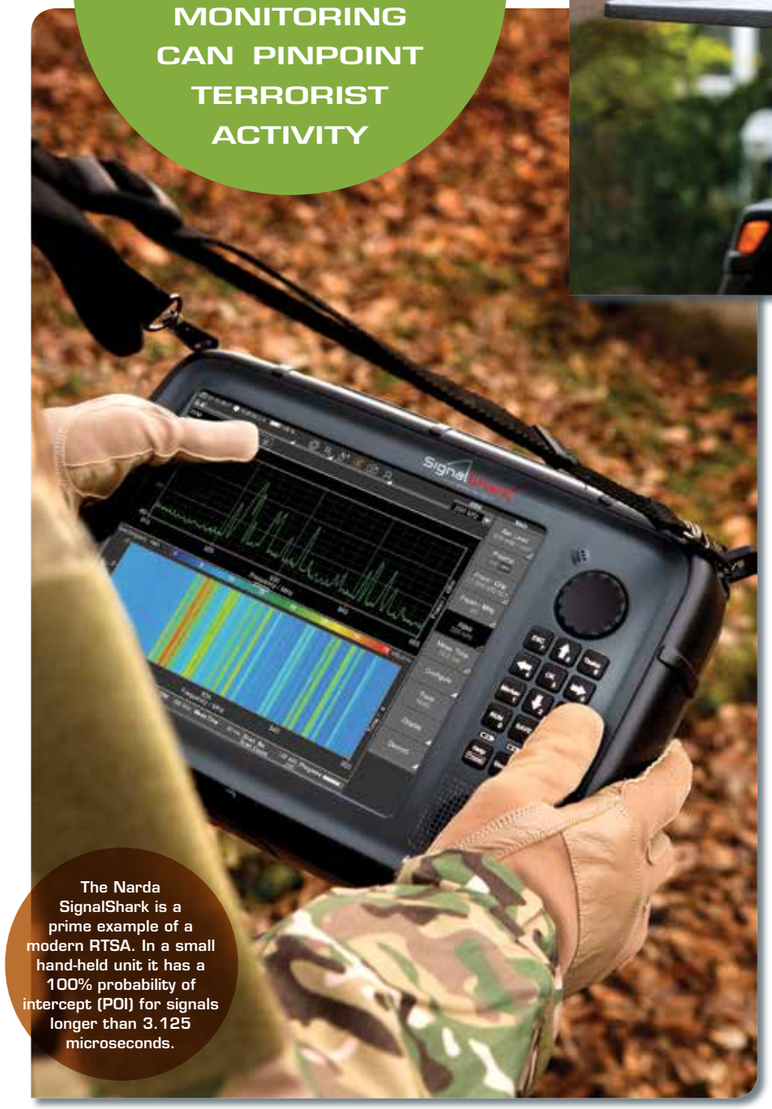
HUGO BIBBY DESCRIBES HOW REAL-TIME RADIO-SPECTRUM MONITORING CAN PINPOINT TERRORIST ACTIVITY

Manual DF antennas should include sensors to measure elevation and polarisation.



The Narda SignalShark is a prime example of a modern RTSA. In a small hand-held unit it has a 100% probability of intercept (POI) for signals longer than 3.125 microseconds.

Whenever a radio or telephone signal is transmitted it is possible to detect it using spectrum monitoring equipment. Add direction finding (DF) capability and the source of any suspicious signals can be located for appropriate action to be taken

The range of electronic devices that could be put to nefarious use in the hands of terrorists is diverse: mobile phones, remote-control systems, satellite phones, two-way radios and jamming systems are just a few examples.

However, anyone operating these devices opens themselves up to the possibility of being tracked down, as they all emit radio-frequency (RF) signals that can be detected, and in most cases identified, using radio-spectrum monitoring equipment. Even the receiver of a remote-detonation IED can produce some telltale RF emissions.

Traditionally, the equipment needed to monitor such transmissions would have been bulky and expensive and, if mobility was required, probably a vehicle-mounted system. However, the pace of change in this area of technology has been such that today military forces and surveillance technical teams have access to powerful hand-held instruments designed for spectrum monitoring.

Various spectrum analysers and radio receivers are available – and now there is a new addition to the hand-held armoury: the real-time spectrum analyser (RTSA).

Real-time spectrum analyser

So, what is the difference between an RTSA and a conventional swept-tuned spectrum analyser? As the name suggests, a swept-tuned analyser sweeps across a frequency band from left to right, displaying measurement results sequentially, that is, not in real time.

By comparison, within a given frequency span, an RTSA displays the energy across all frequency components simultaneously.

By using a fast Fourier transform (FFT) process and overlaying multiple FFTs in a staggered way rather than sequentially, the RTSA provides a gapless view so the user does not miss any transient signals. Modern hand-held instruments such as the Narda SignalShark have a 100% probability of intercept (POI), even for signals with a duration of just a few microseconds.

The processing power required for the FFT process also makes it possible to obtain magnitude and phase information from the input signal as opposed to just amplitude with a traditional spectrum analyser.

Phase is important

Phase is particularly important for DF systems based on the Doppler effect: when an antenna is turned in a circle, it changes the distance to the transmitter and thus the phase of the received signal. The direction producing maximum negative phase shift is therefore the angle of arrival.

Since the FFT process takes information from the time domain and converts it to the frequency domain, it is straightforward to switch between frequency and time domains and look at changes in frequency over time. This is extremely useful whenever signals are frequency modulated or when the rogue transmissions use frequency-hopping techniques.

All of this means the RTSA is ideal for evaluating communication signals and monitoring the radio spectrum.

Key specifications

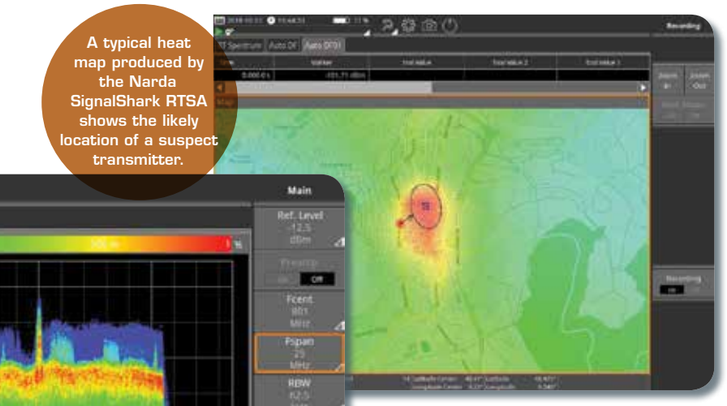
It is worth noting that not all hand-held instruments are equal. Manufacturers are adept at emphasising the good points and burying equally important details deep in the specification.

For radio monitoring and direction finding, a good range is obviously desirable – users want to see signals as far away as possible – and to achieve this, a device with good sensitivity is required. This means that the intrinsic noise or displayed average noise level (DANL) of an instrument needs to be as low as possible.

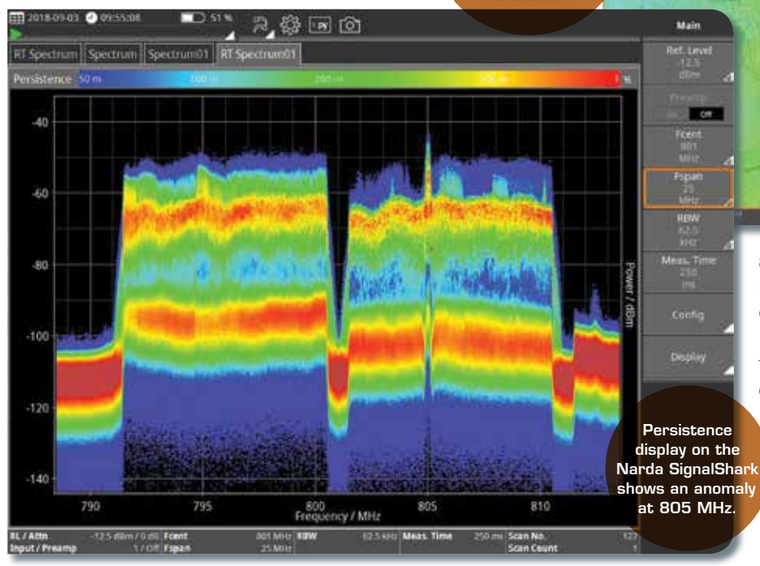
Signal-to-noise ratio

A rule of thumb is that a 6 dB difference in signal-to-noise ratio (S/N) equates to double the distance or four times the area covered. A recent comparative test revealed that there was a 10-12 dB difference in S/N between the best and worst performing hand-held instruments. This means that devices like the Narda SignalShark could detect signals at four times the distance (or 16 times the area) that some others were able to manage.

A high dynamic range is also vitally important as it enables the detection of weak signals in the presence of strong transmitters, a very common operational occurrence.



A typical heat map produced by the Narda SignalShark RTSA shows the likely location of a suspect transmitter.



Persistence display on the Narda SignalShark shows an anomaly at 805 MHz.

Harmonics

Consideration should also be given

Automatic DF antennas like the Narda ADFA can be attached to the roof of any normal vehicle using a strong magnetic mount.

to the level of internal 'artefacts' or harmonics generated by the equipment itself. If a measurement device displays a strong signal, the harmonics generated by that may mask the signal being hunted. This also applies to intermodulation products, which can occur if a measurement device sees two or more strong signals; the user can end up hunting the intermodulation rather than true signals.

Comparing specifications carefully will help users to select an instrument that is capable of identifying low-level signals when stronger signals are present.

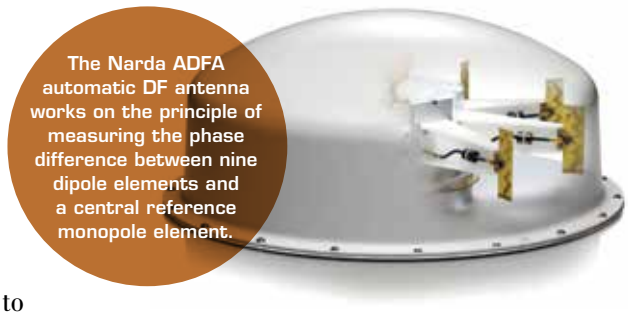
Graphical displays

Assuming that an instrument with appropriate RF performance has been chosen, it is then very important to make sure measurements can be viewed so that suspect signals stand out from the crowd.

A spectrogram or waterfall display gives a good representation of spectrum versus time, but a persistence view (displaying spectrum as level versus frequency) means that sporadic signals can be detected easily, even if they are 'hidden' by another signal.

Direction-finding antennas

All hand-held devices for spectrum monitoring need an antenna. Assuming direction finding is required, it is best to choose antennas optimised for frequency range, sensitivity and directivity in order to achieve good bearing accuracy. As well as a choice of hand-held manual DF antennas, there are automatic DF antennas designed for either vehicle-based or static monitoring.



The Narda ADFA automatic DF antenna works on the principle of measuring the phase difference between nine dipole elements and a central reference monopole element.

Manual DF antennas are particularly suitable for use in buildings or terrain where the larger automatic DF antennas would be impractical. A manual DF antenna should include a built-in electronic compass plus sensors to measure elevation and polarisation (roll) angles of the antenna as these are important factors in determining the direction of a signal source.

The elevation aspect is obviously critical in identifying the height of a signal source, for example, the right floor in a block of flats. Frequency range is another major consideration but the right antenna – such as with a range 400 MHz to 8 GHz – will be able to cover all common mobile-communication frequencies.

Automatic DF antennas

Automatic DF antennas are more complicated as a number of elements need to be used to provide the necessary DF accuracy. The Narda Automatic Direction Finding Antenna (ADFA) uses a central monopole as a reference element for DF and as an omnidirectional monitoring antenna.

Nine dipole elements situated around the central monopole provide the DF aspect. The control software is fast, allowing the ADFA to take a bearing in 1.2 ms, so short-duration push-to-talk (PTT) or pulsed signals can be located.

During this short bearing cycle, channel power and spectrum are measured, enabling the user to monitor changes in the signal level or spectrum concurrently with bearing information. Thus it is possible to optimise bearing settings to the signal of interest and monitor adjacent channels.

Just like the manual antenna, the bearing results from the ADFA also contain elevation information as well as azimuth.

Software is important in displaying the DF information to the operator, and the heat map algorithm running on the Narda SignalShark analyser will provide the right location even in dense urban areas with a lot of RF reflections. The heat map is a colour-coded overlay of the area of interest, ranging from red indicating a very likely location to blue for very unlikely. An ellipse with a 95% probability of transmitter location will be displayed with the estimated transmitter position at its centre.

Hand-held easily portable RTSAs are now becoming so powerful that they have capabilities which previously would only have been associated with large benchtop or vehicle-mounted devices. Coupled with a suitable DF antenna, the RTSA is a powerful tool for monitoring terrorists' RF activity and locating the source of the transmissions. ✺

Hugo Bibby is Technical Director of Link Microtek Ltd, the UK representative for Narda Safety Test Solutions. A chartered member of the Society for Radiological Protection, he has been working with Narda's measurement and monitoring equipment for 25 years.