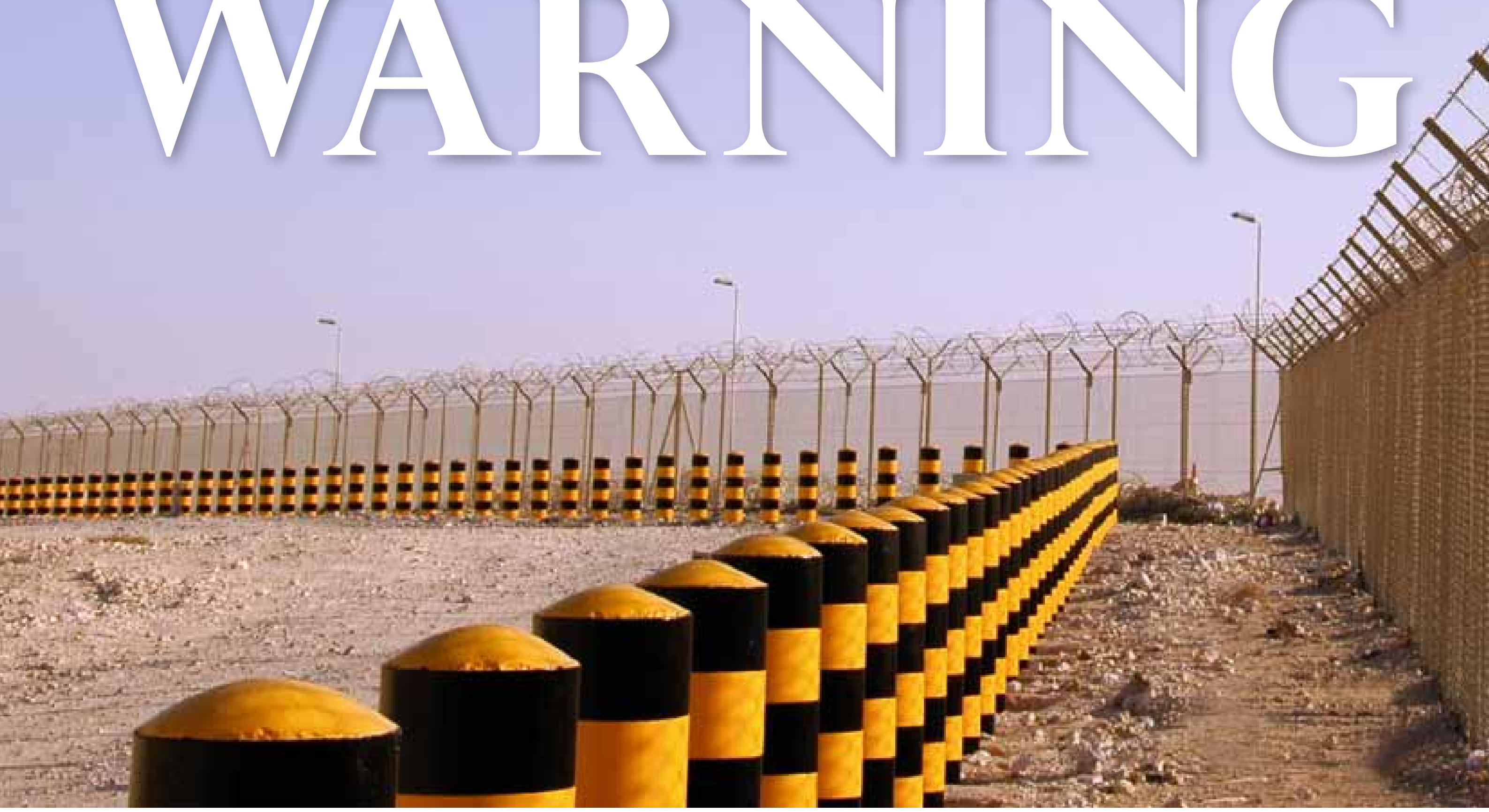
Rupert Swinhoe-Standen considers the use of 360-degree pulse radar in advanced surveillance, security and detection systems for border security and critical infrastructure protection

BORDER WARNING



Area or line surveillance has typically been achieved using a range of techniques and sensors which may promise a great deal but which all have limitations in one way or another. For example, solid barriers and wire fences can provide a strong physical barrier. When lined with passive sensors, both beneath the ground and along the fence line, and linked to microwave intrusion detection systems backed up with CCTV, they can also provide an excellent alert and alarm capability. But what they do not provide is early warning. There is no development of a situational awareness picture. The threat is already on your doorstep by the time the system alarms. Moreover, where the requirement is for surveillance of a large area, or where the terrain inhibits the construction of perimeter fencing, or where earlier warning that humans are operating near a restricted area, then an alternative approach is clearly needed.

Situational awareness is now a core requirement for security operations, and those charged with border and perimeter protection and control are increasingly turning to radar (an acronym for RAdio Detection And Ranging). Using the lower end of the microwave area of the electro-magnetic spectrum, rather than the higher frequencies, much longer detection ranges are possible as well as the penetration of cluttered environments such as sand storms, heavy rain, snow and fog.

There are now various radar manufacturers worldwide offering radar sensor devices as well as, in some cases, the software required for the application of border and perimeter security, surveillance, force protection and intruder detection. But not all radar devices are the same. For maritime purposes, low-cost systems have typically been used which operate with magnetron devices for navigation, safety at sea, vessel traffic management and coastal surveillance. At the other end of the scale are multi-million dollar military grade systems providing long-range surface search and air surveillance. But several years ago, solid-state radar was introduced to the commercial marine market, removing the need for a magnetron. With the development of an X-Band variant, the naval market was later able to benefit from the technology in terms of highly capable situational awareness and navigation radar.

While the introduction of solid-state, low-power yet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highly capable coherent pulse radar has revolutionised the maritime radar domain, it could be argued that solid-state technology has been around for much longer in the form of land-based applications such as flat panel array radars or dishes. However, most flat panel and dish type radars are designed for short range detection and they "look" in one direction only with a limited field of view depending on the resolution being set by the operator.

Flat panel systems are able to "steer" the transmission of high frequency energy beams and "stare" in a given direction from the face of the antenna and, by focusing the energy in a concentrated area, thereby delivering potentially more mean energy on target. These systems often offer higher angular accuracy and resolution, but the discrimination between two targets is often similar to X-band pulse radar.

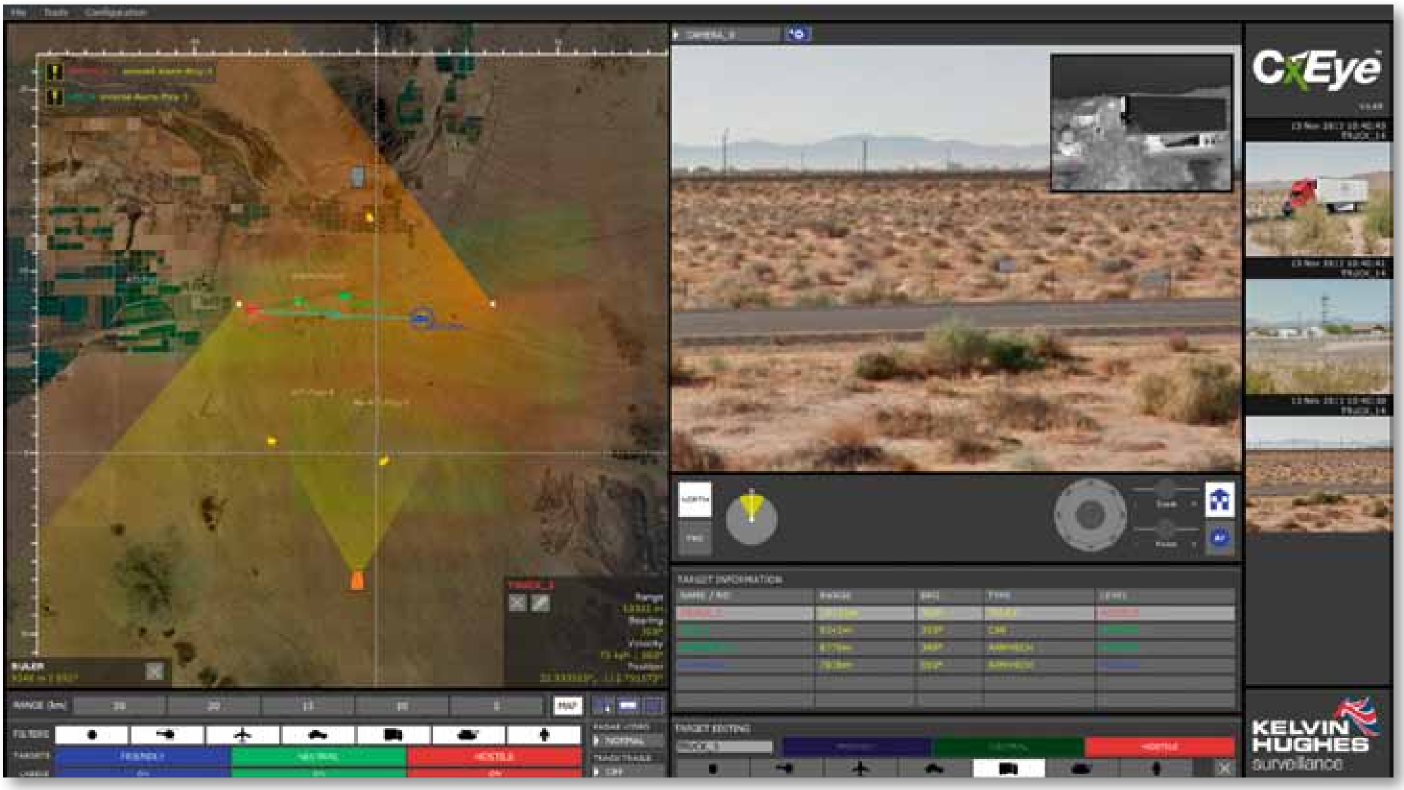
When used for border and perimeter security applications, most flat panel and dish-type radars operate in the Ku, K or Ka-band. But these are potentially limited in range and highly susceptible to inclement weather such as heavy rain or sand storms. In addition, these systems normally operate on a continuous wave (known as FMCW or Frequency Modulated Continuous Wave) as opposed to "pulse radar". In general, X- band radars will outperform Ku, K or Ka-band radars in an identical environment. This technology has recently been harnessed to produce lightweight mobile radar systems such as Kelvin Hughes' SharpEye SxV, which is designed to overcome some of the problems referred to above in relation to border and perimeter surveillance applications.

There are a number of important differences between this technology and traditional approaches. First, pulse radar (as opposed to FMCW models) gives simultaneous short, medium and long-range transmission and detection. Second, the provision of a rotating antenna provides 360-degree radar coverage. To achieve the same with a flat panel phased array system, for example, you would have to add more radars at the appropriate angles to get the area coverage. The single sensor required for a 360-degree radar cuts down considerably on cost, infrastructure and complexity.

Thirdly, the system operates in operator selectable frequencies within the X-Band, a frequency lower than the Ku, K and Ka bands typically used, thus considerably improving its ability to penetrate and work in bad weather. With its Doppler processing of the received pulse return, the receive module of the radar is able to process out (or filter) clutter without radar picture degradation, through the application of complex algorithms. ("Clutter" is a term used to describe unwanted returns such as rain, snow, sand and moving grass or, in a maritime environment, sea waves that may be hiding a target).

X-band pulse radar outperforms FMCW radars in a number of other areas too. Importantly, it is less susceptible to interoperability issues or jamming than FMCW, due to its broad transmission frequency. Another key disadvantage of FMCW is platform integration. FMCW is susceptible to nearby signal reflectors such as metal structures. These could be from the structure of the radar and camera mount, the protected fence line or buildings. Solid state pulse radar overcomes this because it is not continuously transmitting and receiving. To deal with transmitting and receiving in unwanted areas, a technique known as "sector blanking" is used. This is where the radar controls when it is transmitting and receiving within its 360-degree cycle. The use of solid-state electronics also means that peak power can be significantly reduced which, together with the pulsed waveform, makes it much less likely that anyone observing the frequency spectrum with detection devices will be able to detect the radar.

A distinct advantage of the new solid-state technology is its size and portability. It is now possible to produce and deploy a radar system small and light enough for multiple field-based scenarios. A critical infrastructure location surrounded by a fence line or a wall can be protected with 360-degree radar coverage either from a central mast or at optimum positions on the perimeter. The elevated radar provides early warning of planned



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intrusion as well as the apparent point of breach. Should a response unit not be able to prevent an incursion, the radar will still track and follow intruders inside the compound, providing key information on the intruders' intended destination.

For border patrolling, radars can be mounted on a retractable mast fitted to a vehicle. Surveillance can then be conducted over a very wide area, with the surveillance patrol able to move its position based on intelligence, covering known incursion points and areas frequently targeted by intruders. Patrols can operate from fresh locations to confuse intruders with a random patrol pattern.

Of course, in order to determine a response to a potential threat detected by the radar, the precise nature of the target must be classified properly. Simple CCTV or powerful electro-optical cameras can be combined with the radar on the same mast, providing an integrated solution. Control and integration software is then used to take the radar video (pre-processed with the clutter removed) and provide targets on a screen overlaid with a geo-referenced map. Day and night cameras can be directed onto targets and areas of interest. Imagery from the cameras is sent to the command centre or control room. Stills and video can be captured for use in immediate response decision making, for future reference and sent to other mobile devices.

The latest software innovations are also required to integrate situational awareness radar with state-of-the-art camera technologies and other sensors. Such software can provide a means of command and control, and can be networked through multiple iterations of the software into a much larger real time C4I.

A system running on software such as Kelvin Hughes' CxEye system can display radar video on a main screen area under laid with geo-referenced maps. Integrated into the software is aerial imagery, and it accepts open source maps and raster maps with fully customised local information. In the top right corner is a real-time video display showing the feed from one of a number of selectable electro-optical cameras with a picture-in-picture feed from a second camera.

The premise of such software should be to assist the operator in evaluating and co-ordinating a response through a "detect, recognise, identify and then classify" methodology. Each track can then be categorised on screen with clear symbols and "tote" table information. This table should prioritise threats depending on range direction, speed and its area. The classifications of the target tracks should include hostile, neutral, or friendly, then sub-categorised as a walking person, car, truck, armoured vehicle or aerial target (helicopter or plane).

The software should provide clear and unambiguous situational awareness, offering early warning from the radar, detailed picture evidence from the camera and the continuous tracking ability of the radar. Swift and simple classification of all tracks should establish what is happening, where and who is doing it. A clear "situational picture" will facilitate a controlled response.

In summary, there are significant security advantages to the use of modern pulse radar systems for land-based surveillance. Much improved situational awareness, early warning (as opposed to simply intruder alert), operational flexibility and adaptability, as well as reduced risk of detection by ESM equipment, are all key benefits. There can be significant cost benefits too. Only one 360-degree radar is required to achieve full coverage of a protected area as opposed to multiple sensors and, because of the high reliability of today's solid-state electronics, maintenance costs are significantly lower than those associated with traditional radar devices.

On overwatch: pulse radar offers enhanced situational awareness for border security and critical infrastructure protection

Rupert Swinhoe-Standen is Regional Sales Manager for Kelvin Hughes Security Systems. Following 17 years British Army, Rupert has garnered a wealth of commercial defence industry experience over 12 years operating both in the UK and overseas. He has recently joined Kelvin Hughes' Surveillance business, focusing on surveillance and security solutions.