Blighter® Surveillance Systems

Airport Security White Paper

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Introduction

With the continued targeting of aviation by terrorist groups worldwide, attention is turning from the strict levels of security employed for passenger screening to targeting 'backdoor' threats arising from relatively low levels of perimeter security at many of the world's tier one and tier two airports. Other threats include intrusion by political activists or intruders intent on criminal activity, sabotage or attempting to stow away on aircraft.

Hitherto, airports have employed large numbers of CCTV cameras and security personnel to monitor for perimeter intrusions. However, the flat, open nature of airports allows perimeter surveillance radars (PSRs) to be installed as the primary sensor for the detection of breaches of the airport perimeter.

But not all radar technologies are equal in meeting the specific circumstances and needs of airport operators. This white paper discusses and compares low cost mechanically scanned ground surveillance radars with sophisticated solid state electronic scanning radar systems.

It briefly assesses active electronically scanned array (AESA) radar technology with the newer passive electronically scanned array (PESA) approach in the context of airport installation and use. And, there is a discussion about the increasing trend towards integrated radar/ camera surveillance solutions as are now in operation at major airports such as London Heathrow.

Finally, the characteristics of an idealised system are listed and a brief summary of how Blighter products meet these goals is presented.

Figure 1 - Aerial view of a typical large tier one airport

Benefits of Long-range Electronic Scanning Doppler Radars

Recent developments in electronic-scanning (e-scan) radars have seen a move away from the expensive and power-hungry AESA (active electronically scanned array) military approach to the newer and much lower-cost PESA (passive electronically scanned array) radar technology. The lower entry point allows PESA security radars to be employed for both their traditional military force protection roles and for some more cost-sensitive applications in the homeland security market, such as securing critical infrastructure like airports and seaports.

Using PESA technology, man detection ranges of up to 3, 5 or 7.5 miles (5, 8 or 12 km) and ultra-wide elevation beams (up to 20 degrees) can be achieved. This allows the radars to stand off from the area to be monitored, mounted on top of existing airport buildings, for example, giving a clear line-of-sight to the airport perimeter, while still maintaining the full integrity of the radar coverage zone. Being able to mount the sensors on the existing airport buildings makes for ease of connection to readily available sources of power and network connectivity.

Fully e-scan radars are entirely solid-state with no moving parts and hence have no requirement for any routine maintenance. Such radars are said to be ‘zero maintenance’ with much lower associated through-life costs and a long in-service life of 10 years or more.

PESA radars usually include a fully integrated Doppler processing engine, unlike their counterparts, which often require external radar processing servers or PCs that have to be hosted in a remote server room at the airport. Doppler processing is essential for the cluttered airport environment. As colour is to CCTV images, Doppler is to radar detection. Doppler adds a third dimension to target detection, so not only are targets identified in Azimuth and Range, but they are also discriminated by Doppler velocity – the relative speed of each object. This allows valid targets to be discriminated and separated from the surrounding airport clutter.

Another benefit of e-scanning radars is that during the scanning process, the radar’s microwave beam is entirely stationary, allowing such systems to detect very small and slow-moving targets in extremely cluttered environments.

This improves their detection capabilities and reduces the false alarm rate. It also means that e-scan radars are able to detect wild animals within the airport perimeter, including coyotes, deer and wild dogs. This offers airport operators an unexpected benefit when installing such systems. Contrast this with mechanically rotating radars, where the reflected signals received by the radar are always blurred by the continuous rotational movement of the antenna.

In summary, the benefits of PESA e-scan radars are clear: 24/7 persistent surveillance capability in all-weathers with lower installation costs, lower through-life costs and lower false-alarm rates.

Figure 2 - Typical installation of 180 degree e-scan Doppler radar at a large international airport in South America

Shortcomings of Low-cost Short-range Radars for Aviation Security

Over the last five to ten years, many tier one airports have experimented with the installation of relatively low-cost short-range PSRs, usually as part of an integrated perimeter intrusion detection system. Such radars typically offer maximum man-detection ranges of between 400 m and 1.6 km. The relatively low capital outlay associated with these small, mechanically-scanned radars is initially very attractive to the airport operators.

However, the short detection ranges offered by these radars means that they must be located close to the perimeters and/or boundaries being monitored; this also means that they must be installed close to the airport's operational taxiways and runways. Short-range radars tend to use very high frequencies and have an inherently narrow elevation beamwidth. The combination of short range and narrow beamwidth makes it necessary to site the radars close to the ground in order to avoid a shadow area below the radar and close to the area to be monitored.

This can lead to a number of shortcomings:

- The view of the radar may be obstructed by the shape of the ground, buildings and other infrastructure, aircraft and vehicles, and leads to increased multipath effects;
- Proximity to the fence raises installation costs, often necessitating groundwork to provide networking and power cables for the multiple short-range radar units needed to cover the areas and distances involved. This work is generally disruptive to normal airport operations and often has to be carried out overnight;
- The detection capability of radars of this type is significantly reduced in rain and they tend to not to have rain filters either, further reducing their usability in poor conditions. Short-range radars are also often positioned at the limit of their range, leaving no room for less-than-perfect weather conditions and the possibility of gaps in coverage that are not apparent to either installer or operator.
- Low cost radars also tend to rely on plot extraction taking place on a server rather than within the radar. This requires high bandwidth communication from the radar to the server and a server capable of processing data from multiple radars before information can be presented to the operator. Low-cost radars very often have a basic, unintuitive user interface which provides poor rendering of information relating to targets to the operator and few controls.

False alarms

Short-range perimeter surveillance radars also suffer from high false alarm rates. It can be very difficult for these mechanically-scanned sensors to distinguish genuine targets of interest from the large clutter returns caused by radar reflections from terminal buildings, hangars, fences and other airport structures or objects. The airport apron will also have a large quantity of legitimate moving traffic of all shapes and sizes, from A380 aircraft to small ground support vehicles. The relatively crude filtering techniques used in non-Doppler radars have difficulty supressing clutter and an inherent inability to distinguish unique targets.

Airport operators have also experienced problems with high false alarm rates during periods of inclement weather (high winds, rain, hail, snow, etc.). Without Doppler processing, short-range radars will have real difficulty in detecting small targets in the presence of larger targets at the same range. Non-Doppler radar technology is inherently troublesome in all but the simplest environments and airport operators have reported unacceptably high false alarm rates with these radars, to the extent that it has been anecdotally stated that “poorly performing mechanically scanning radars are getting all radars a bad name in airport security”.

Poor reliability

Because of their mechanical operation, rotating radars offer poor reliability compared to solid-state technology. In a desktop PC, for example, it is the rotating hard disks and power supply cooling fans that are most likely to fail. The same is true of rotating radars. Regular routine maintenance of the drive belts and motors of the antenna turning gear is needed to avoid breakdowns. Because of the location of the radars, this maintenance has to be carried-out when the runways and taxiways are not in use. The overall inherent unreliability of mechanical systems leads to much higher through-life costs and longer periods of potential downtime for the security system.

Ideal Radar Characteristics for Surveillance at Airports

An efficient and effective radar-based surveillance solution specifically for use at airports would have a number of attributes:

Configurability

As no two airports are the same, a radar system should be configurable in azimuth, elevation beamwidth, range and scan time to suit the particular topography, building and runway layout, traffic and infrastructure arrangements of each in order to optimise performance and efficiency.

Overloading operators with irrelevant information reduces their ability to detect intruders quickly and reliably, so it is highly desirable that there should be a facility to define zones of interest to maximise the possibility of detection of genuine targets and minimise disruption by unwanted information and false alarms. Zone controls may range from supressing simple arc, rectangular or polygonal areas altogether or filtering results from these areas according to target size or velocity, to more sophisticated techniques in which different parameters are assigned to different areas based on likely activity and potential level of threat.

Flexible Installation and Integration

Radar designs with wide elevation beamwidth can be located high on existing terminal buildings to avoid blocking by objects at short range; the elevated position also allows the radar to 'see' over obstacles including aircraft and vehicles. These locations are more likely to be able to make use of existing power and network infrastructure, simplifying installation and radars with onboard signal processing electronics reduce both the network bandwidth required for communication with and the processing burden on the host control station, reducing ancillary computer hardware costs.

Integration with camera and other security systems allows audible alarms to be triggered and cameras to be directed automatically towards the target for visual inspection. Alarm trigger conditions might be based on a range of target attributes such as location, size, velocity or track. Many operators also find it useful to be able to see the raw plot in order to more accurately interpret alarm conditions.

Detail and Distance Performance

In the cluttered airport environment, it's important to be able to discern smaller, slow-moving targets such as intruders on foot from larger and faster objects such as taxiing aircraft or support vehicles. This requires Doppler processing capability. Adequate range is also essential and ideally this will exceed the designated surveillance area by a comfortable margin in order to allow for degradation of capability in inclement weather.

Figure 3 - 90 degree e-scan radar with co-mounted thermal camera system

Blighter PESA E-scan Radars and Sensor Systems

The Blighter system already forms part of the perimeter security solution at major international airports in the UK, Europe, United States, South America and Africa. A typical Blighter airport configuration consists of the Blighter B400 Series PESA radar, BlighterTrack software, and slew-to-cue PTZ (pan, tilt, zoom) thermal imaging surveillance systems. The BlighterView HMI 2 control system displays and records all the elements including additional sensors such as a perimeter intruder detection system (PIDS).

Blighter perimeter surveillance radars meet the unique requirements of airports. They are highly configurable radars that support azimuth from 90° to 360°, elevation beamwidth up to 20°, ranges from 2 to 16 km and four scan rates. Because of their compact size and wide elevation beamwidth they can be mounted high on buildings or other existing infrastructure, gaining an unobstructed view and simplifying power and network access. Because they are solid-state designs they are highly reliable and require near-zero maintenance, giving a low total cost of ownership.

Blighter's PESA e-scan modules use a unique waveguide structure to achieve the azimuth beam steering which requires just one efficient transmitter and one receiver unit per radar unit. This compact and simple architecture gives Blighter radars exceptionally low side lobe levels, which allows them to operate in complex and cluttered environments without detecting phantom targets from objects outside of the radar beam.

Blighter's combination of technologies including PESA e-scan and Doppler, which are all controlled through sophisticated Digital Signal Processing (DSP) and Waveform Generation (WG) units, allows a wide diversity of radar waveforms and azimuth scan speeds. The Blighter radar allows both fast scanning simultaneous with Doppler velocity filtering using its 'Coactive Doppler fast-scan' capability. Traditional non-Doppler radars can scan fast, whereas traditional Doppler radars rotate slowly. Blighter achieves the best of both capabilities.

Blighter's advanced frequency modulated continuous wave (FMCW) transmission technology is an alternative to the traditional Magnetron pulse transmitters or solid-state pulse-compression transmitters used by older radars. Key attributes of FMCW include an enormous instantaneous dynamic range in the receiver channel, allowing small targets to still be detectable alongside large targets or clutter. FMCW is also very efficient allowing considerably less transmitter power to be required.

The FMCW transmission is like a whisper compared to the 'shout' from traditional rotating radar's high power pulsed transmitters. Blighter's low power FMCW transmission therefore cannot be detected on conventional 'radar speed trap warning detectors' meaning that intruders are not aware that they are being monitored. Also, given that the transmitter power for a standard power (SP) Blighter radar is just 1 Watt, the safe working distance (SWD) from the front the antenna is typically only 3 meters. From behind, the radar unit is actually touch-safe, making it non-hazardous.

The Blighter radar unit contains an integrated Digital Signal Processing (DSP) unit that provides all the functions performed by a stand-alone radar processing unit in traditional systems. The integrated DSP provides the FMCW, Doppler, Thresholding, CFAR, Plot Extraction and target filtering functions. The output from the Blighter radar is a low bandwidth digital data stream over a 10/100BASE-T/TX Ethernet interface.

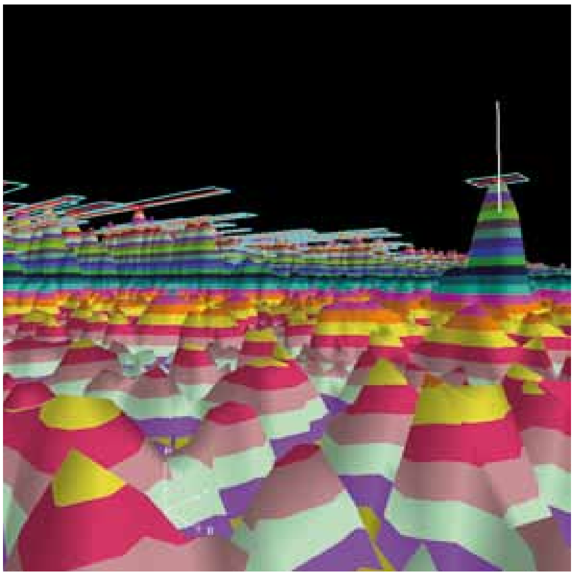

Figure 4 - 3D Doppler view of detected target

Radar and Electro-optic Sensors

Almost every security radar system requires the interaction of a camera system in order to observe the object initially detected by the radar. Blighter is no exception, it provides early warning of intruders over long ranges and potentially thousands of square kilometres. Additionally it attempts to classify the target by assessing its key radar characteristics - the radar cross sectional area and Doppler velocity.

BlighterView HMI 2 is PC-based control software that allows control of multiple radars and cameras with automatic slew-to-cue of cameras to target, and sophisticated control over alert and exclusion zones. Operators have a simple but highly configurable display that enables them to make decisions rapidly based on different representations of incoming data.

BlighterView HMI 2 includes an extensive long-range camera control panel with lots of functionality to provide automatic, semi-automatic and manually initiated cueing of the camera system to observe the target or targets of interest.

Typical 'cameras' include multi-sensor electro-optic camera systems including daylight colour, night time thermal imager, often a wide field-of-view 'context' camera and sometimes a Laser Range Finder (LRF), though this is less necessary with the radar already providing accurate range measurement. Each alert zone can be configured to cue a selected camera either to a fixed point in the zone, the target position in that zone, or to initiate auto-tracking. Some camera systems include a video tracking capability, which BlighterView HMI 2 supports.

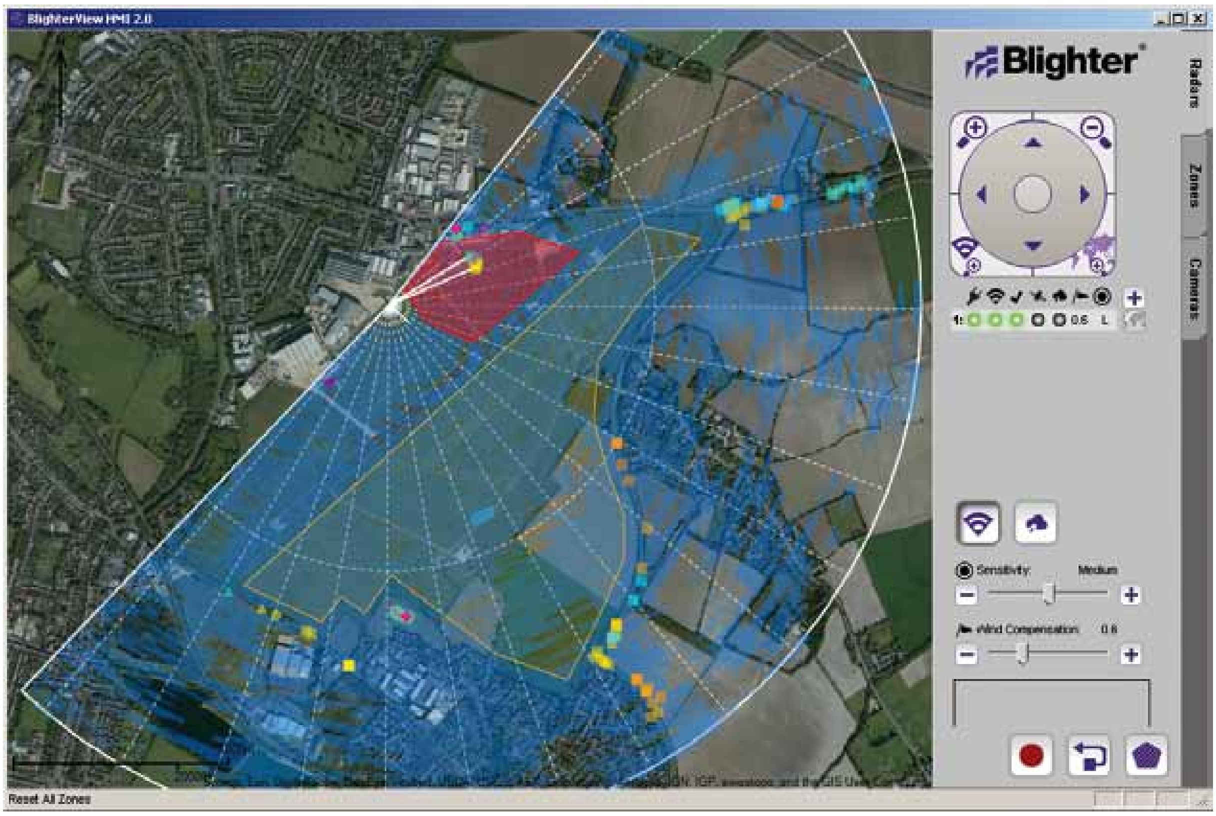

**Figure 5 - BlighterView HMI 2
(Cambridge International Airport, UK)**

Blighter in Use at London Heathrow Airport

Heathrow Airport is the world's busiest international airport. Over 72 million passengers travelled through Heathrow in 2013, travelling to more than 85 countries. The Blighter B400 series e-scan PESA radars are part of an integrated perimeter security system, supplied to airport operator BAA Ltd (now Heathrow Airport Holdings Ltd).

BAA needed a highly reliable, maintenance-free system that could provide intensive 24-hour surveillance of the airport in all weather and light conditions. The airport perimeter surveillance solution includes long-range day and night cameras and a network of high definition cameras, capable of identifying and tracking intruders detected by the radar. The Blighter system is technically superior to previous systems and met BAA's requirements in full. Since deployment in 2012 it has led to considerable operational savings, reduced security staff costs and a marked improvement in detection.

Figure 6 - Heathrow airport control tower

Conclusion

Sophisticated electronic scanning PSRs are proving increasingly popular with international airports, as they provide highly reliable maintenance-free surveillance of airport perimeters and key airport zones in all weather and light conditions, as well as delivering improved intruder detection performance and considerable operational cost savings.

Integrated with cameras, the PSR platform combines the strengths of radar – wide area continuous surveillance for detection and location – with the strengths of cameras (recognition and identification of targets). These technologies also complement each other in other more subtle ways and the platform capability is generally greater than the sum of its component parts.

Summary

Blighter-based perimeter security radar systems deliver a 24/7 persistent surveillance capability in all-weather with lower installation costs, lower through life costs and lower false alarm rates. Here is a list of the key benefits:

- Low cost of ownership due to ultra-high reliability and zero routine maintenance for 5 years thanks to Blighter's solid-state, PESA e-scan technology
- Reduces false alarm rates due to Blighter's Doppler signal processing unit which uniquely filters out clutter returns in both velocity and amplitude
- Blighter's wide elevation beamwidth, compact size and low power consumption allows easy installation on to existing terminal building infrastructure, which helps to gain an unobstructed view of the airport runways and perimeter
- Long range detection from 2-16 km exceeds airport requirement but allows room for degradation in poor weather – rain, fog or snow
- Easy to use/simple user interface (BlighterView HMI 2) allows control of multiple radars and cameras with automatic slew-to-cue of cameras to target, and sophisticated control over alert and exclusion zones.

About the Author

Mark Radford is the Co-Founder & CTO of Blighter Surveillance Systems. He has been working in the radar industry since 1985, initially as a designer of high performance signal processing solutions for naval radar systems and later as a system designer and development manager.

Since joining in 2000, Mark has been involved in various radar development projects including the specification, design and development of the Blighter radar, a unique electronic-scanning FMCW Doppler surveillance radar.

Mark's experience in the radar industry allows him to provide customers with advice on the use and specification of radars for ground and water based intruder surveillance systems.

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