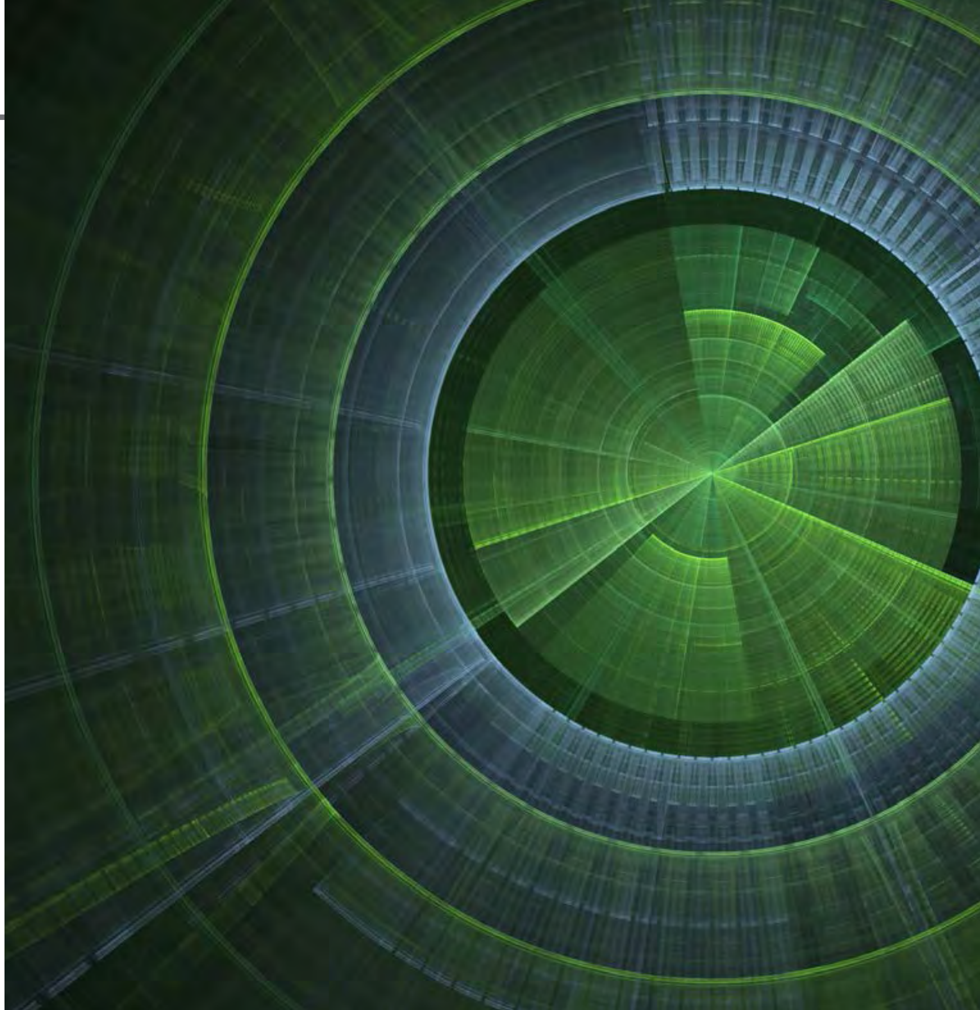


Countering "backdoor" threats with ADS-B and AIS-enhanced radar/video surveillance

By Andrew J. Haylett

Countering the growing "backdoor" threat posed by terrorists, smugglers, pirates, and political activists at military air and naval bases, airports, and ports requires sophisticated multisensor surveillance systems to ensure that incursions are rapidly detected and actioned. A hybrid approach that brings together conventional radar systems with high-resolution video imaging sensors, radar, and video trackers – incorporating Automatic Dependent Surveillance – Broadcast (ADS-B) and Automatic Identification System (AIS) transponder technology to filter out authorized targets – can deliver the high-accuracy threat detection needed even in adverse climatic conditions and poor visibility.

A typical secured site presents multiple challenges to the deployment of an effective surveillance and security system. The layout of the site may mean that certain locations are hidden from the view of a given sensor, resulting in a security vulnerability unless steps are taken to improve coverage. Differentiation between real threats and legitimate movements, both outside and within the site, is essential to avoid real incursions becoming "lost in the noise." Moreover, these threats may take multiple forms – unauthorized individuals/insurgents, vehicles or vessels, or airborne objects including small malicious drones may all represent real incursions; a surveillance system needs to provide early detection of all anticipated threat types.

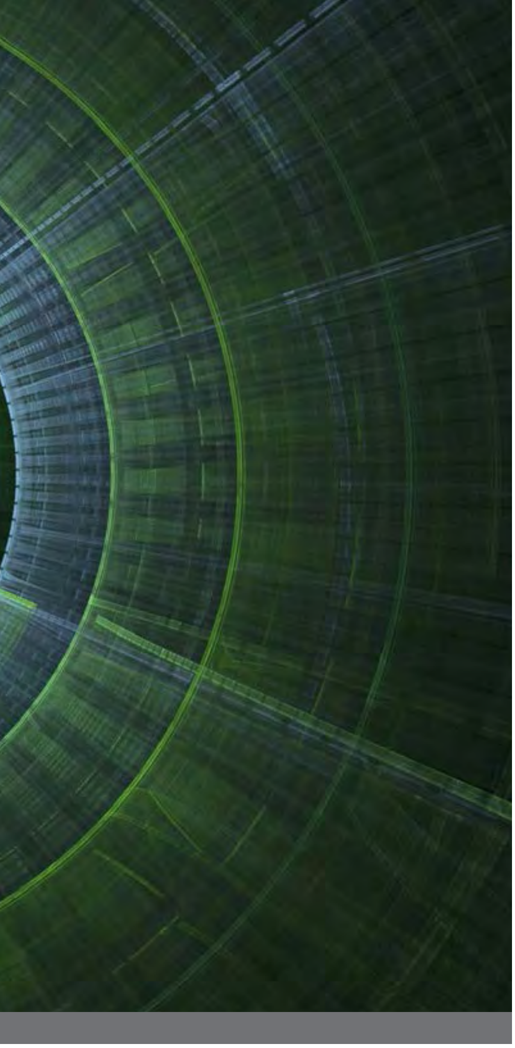
Multiple radar and video sensors

Primary radar has a long-established role in detecting objects at a distance, with moving target indication (MTI) further enhancing the radar's ability to differentiate targets from stationary objects and clutter. A typical radar can be configured to operate at longer range for early detection of distant objects or at shorter range, allowing more accurate determination of the object's characteristics such as size and shape.

Multiple radars can be combined to protect a given location, with the dual benefits of enhanced detection capability and a measure of redundancy. A process known as track fusion is able to combine reports from multiple radar trackers to form merged high-confidence tracks.

Cameras are the other essential component of a comprehensive surveillance system, providing high-definition video up to 1920 by 1080 resolution with optical zoom to 30 times or beyond. Such sensors are capable of identifying very small targets at a significant distance and providing a high level of detail, and their ability to identify object type and behavior is correspondingly enhanced.

"Daylight" camera sensors (those operating in the normal visible spectrum) are typically complemented by thermal sensors, whose ability to view the heat signature



of even very small objects such as individuals or an unmanned aerial vehicle (UAV) is an invaluable asset in surveillance solutions. Thermal sensors are not just useful at night; they also have a clear advantage over daylight sensors where visibility is limited for other reasons such as fog or smoke. Modern uncooled microbolometer-based thermal cameras offer a good compromise between performance and cost, and with higher resolution now widely available (typically 640 by 480 pixels), detection of individuals at a range of more than 2 km (approximately 1.24 miles) is possible.

Unlike a radar system, where the entire 360-degree field of view is typically scanned every second or two, cameras are normally aimed in a specific direction, with a field of view corresponding to the selected optical zoom. Any surveillance system needs to ensure that its cameras are pointed at the object of interest – the potential threat. Surveillance cameras can normally be steered using a PTZ (pan/tilt/zoom) interface implementing a standard protocol such as Pelco-D.

However, the challenge lies in automatically steering the camera towards the correct target, whether under operator guidance or in response to a newly detected threat. The radar system can detect the range of a target to within a few meters, and the target's bearing and approximate size can be determined with a resolution depending upon the radar's beam width, pulse repetition frequency (PRF), and rotation rate.

Armed with this information, the surveillance system can steer the camera towards a known target, using the target range for focusing, the target size for field of view/zoom, and the target bearing for steering, a process known as slew-to-cue.

Once the target is within the camera's field of view, advanced video-tracking algorithms can be used to lock the camera onto the selected target. Video tracking is significantly more accurate than radar tracking, due to the higher update rate (at least 30 frames per second) and superior resolution of the sensors. It involves frame-by-frame analysis of the target's presentation and velocity, together with a model of the camera's inertial properties when being steered, to predict and follow the target's movement and maintain it within the video frame. Figure 1 shows a typical system block diagram.

Filtering out ADS-B and AIS transponder data

The challenge of distinguishing real threats from legitimate movements remains. Two principal techniques can be employed: First, specific geographical areas within and outside the perimeter of the protected site can be defined, and radar-based tracking within those areas can be suppressed or enabled, enabling sensitive (alarm zone) or nonsensitive areas to be defined. Movement in nonsensitive areas can be ignored, while detection of new targets in alarm zones can initiate automatic slew-to-cue, video tracking, and operator alerts.

Secondly, the availability of secondary data from transponders fitted to many aircraft and marine vessels can be exploited to eliminate or identify nominally "friendly" targets identified by the radar system. Automatic Dependent Surveillance – Broadcast (ADS-B) transponders, which use GPS data to broadcast precise exact location and identity, are already fitted to many commercial aircraft.

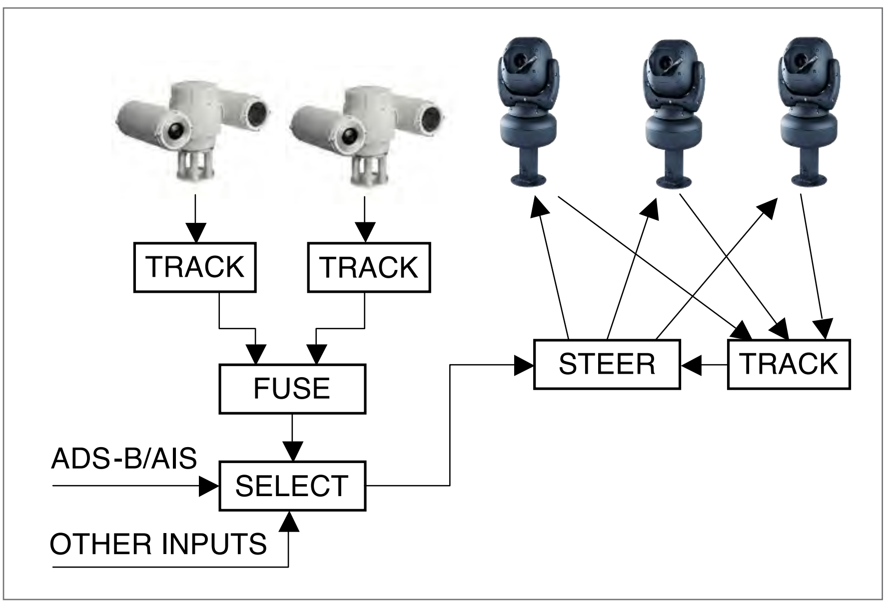


Figure 1 | A hybrid surveillance system uses radar together with video for high-accuracy threat detection.

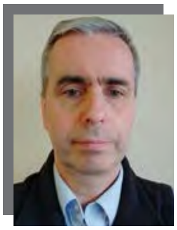
While primarily designed for air traffic control, increasing numbers of military aircraft will be ADS-B-capable in the future. Although such aircraft will normally permit the air crew to disable ADS-B transmission for security reasons, the presence of ADS-B can still be used to eliminate false positives when the surveillance system is equipped to receive ADS-B messages, since track reports can be correlated with ADS-B responses and "friendly" tracks eliminated. Ground vehicles may also be fitted with transponders, allowing effective reclassification of ground-based as well as airborne threats. The marine equivalent of ADS-B, Automatic Identification System (AIS), can be used when the protected site is, for example, a harbor or naval military base.

An example of a surveillance solution that integrates this multisensor data is Cambridge Pixel's VSD software application. Running on any embedded or industrial computing platform, VSD accepts primary video from one or more radar systems via an analog or network interface, initiating and maintaining tracks from these video streams and providing a fusion capability to link targets detected from multiple radars.

It also accepts camera video from multiple sensors, using conventional analog video or H.264-compressed video over a network, and steers the cameras towards targets reported by the fusion process. Support for AIS/ADS-B transponder input and user-defined alarm zones provides for automatic elimination and reporting of potential threats.

Map underlays with overlaid primary radar display and symbology present the operator with an overall view of camera and radar location and detected targets (Figure 2), with camera video displayed in separate full-size or picture-in-picture windows. The application can also be used to implement remote unmanned-surveillance installations, supporting full target reporting and camera control interfaces to manned headquarters over a wide area link (WAN) or uplink.

With ever-increasing security concerns notably from "backdoor" threats, air and naval bases and other military installations can benefit from hybrid multisensor systems that incorporate ADS-B and AIS transponder technology into the enhanced radar/video surveillance solution. With their ability to resolve small objects at significant distances, such surveillance systems offer repeatable, round-the-clock performance combined with ease of integration and a fully scalable architecture. **MES**



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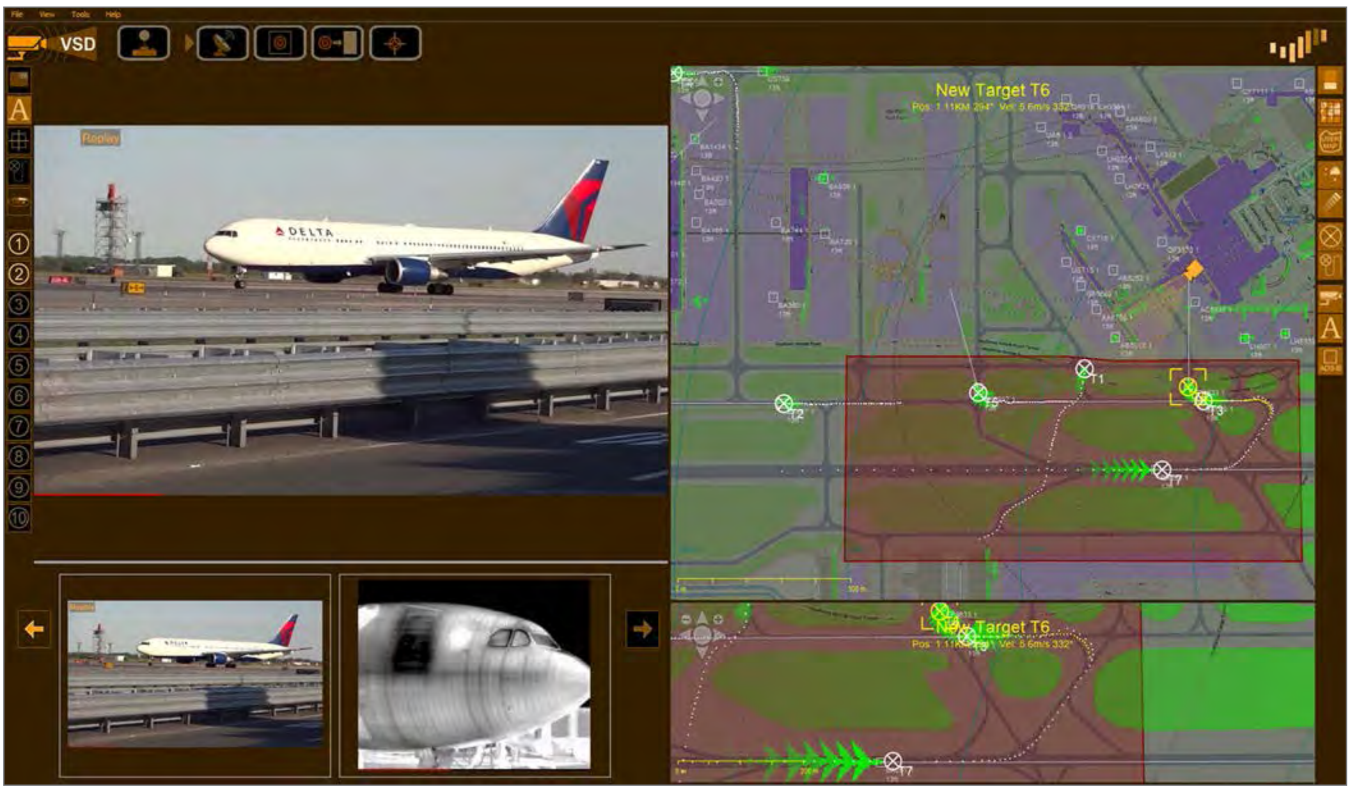

Figure 2 | The radar portion of the VSD display provides a geographic overview of the situation, showing all of the available radar videos, tracks, and secondary data, overlaid on a clear tiled map, while the camera video portion displays video from the currently selected camera, optionally with another camera video shown as picture-in-picture.