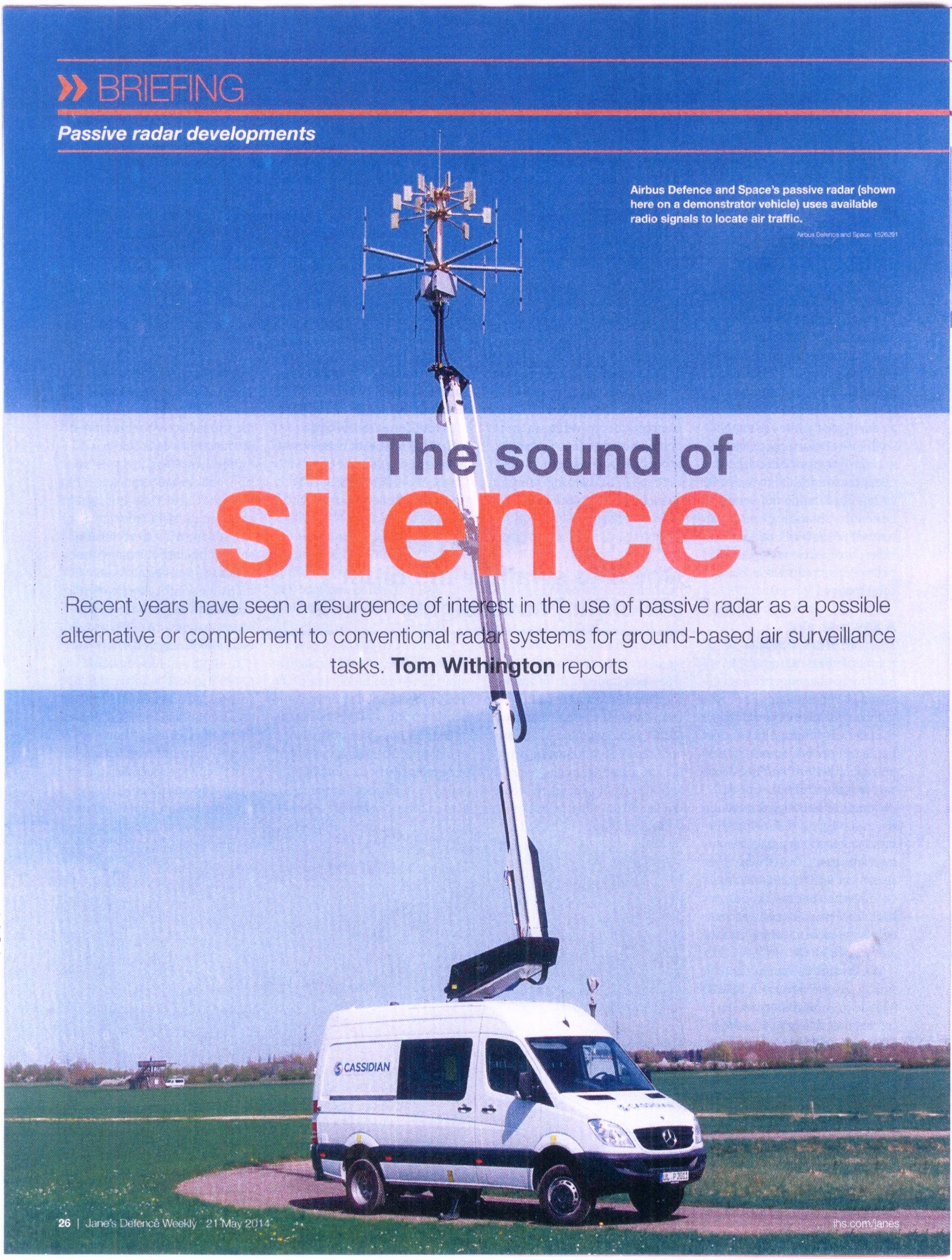


Airbus Defence and Space's passive radar (shown here on a demonstrator vehicle) uses available radio signals to locate air traffic.
Airbus Defence and Space: 1526291

The sound of silence

Recent years have seen a resurgence of interest in the use of passive radar as a possible alternative or complement to conventional radar systems for ground-based air surveillance tasks. **Tom Withington** reports

For more than 70 years, the sensor of choice for ground-based air surveillance has been radar. Radar detects airborne targets at ranges of hundreds of kilometres in all weathers during both day and night. Yet ground-based air surveillance radars have two major weaknesses: they can be disrupted, degraded, or destroyed by electronic countermeasures (ECMs) and anti-radar missiles (ARMs). This is because a radar's emission of radio frequency (RF) signals betrays its geographical location. Passive radar is, therefore, a potentially disruptive technology as it can provide aerial target detection without the emission of a radar signal, thus potentially enhancing its survivability.

Conventional radars emit either a pulse or continuous wave (CW) of electromagnetic energy at a specific frequency located in the radar section of the electromagnetic spectrum, typically between 1-40 Ghz. Regardless of the radar type (pulse or CW), the RF signal leaves the radar's antenna at the speed of light. The signal will collide with any object in its way as it travels through space, and is then reflected back towards the radar's antenna. The radar's signal processor then measures the time difference between the original RF transmission and the arrival of its reflection back to the antenna.

Radars also exploit a phenomenon known as the Doppler effect, which measures speed. As an RF signal is reflected from a moving target, its characteristics are changed by the motion of the object that it strikes. An audible analogy of this is the perception that the sound of an emergency vehicle siren appears to be higher in pitch as it approaches the listener than when it has driven past. For radar, the Doppler effect works in a similar fashion with the radar's signal processor measuring the frequency of the reflected RF signal compared with that of the transmitted signal to determine the so-called 'Doppler shift' (the frequency difference between the emitted and reflected RF signal). This allows the calculation of the object's speed.

The important discriminating factor with passive radar is that it does not generate its own RF signal, using instead electromagnetic energy already present in the atmosphere. Modern societies generate significant quantities of electromagnetic energy in the form of civilian FM radio broadcasting, cellphone communications, and television transmissions. Most of the passive radars surveyed here operate within the 30 MHz to 3 GHz portion of the RF spectrum, a range that includes the Digital Video Broadcasting-Terrestrial (DVB-T – including the 30-300 MHz and 300 MHz-3 GHz sub-bands), Frequency Modulated (FM) radio (88-108 MHz) Digital Audio Broadcasting (DAB – 174-240 MHz), and L-band (1-2 GHz) transmissions that are favoured by passive radar developers.

Passive radars monitor these sections of the spectrum detecting FM or DAB/DVB-T signal reflections from flying objects. Using either one or several receivers, a passive radar can monitor a defined section of airspace, or a 360-degree radius, to detect an airborne object by monitoring reflected RF signals.

Passive radar is not a new concept. The now-legendary experiment performed by Scottish physicist Sir Robert Watson-Watt in 1935 near the town of Daventry, in Northamptonshire, Central England, involving a Royal Air Force (RAF) Handley Page Heyford heavy bomber and the BBC short-wave (1.8-30 MHz) radio transmitter located near the town, proved its feasibility. The experiment used two receiving antennas, each positioned at a distance of 10 km from the BBC transmitter. Watson-Watt and his colleagues were able to detect the Heyford flying between the transmitter and the receivers by the disturbances that it caused to the radio waves produced by the transmitter. Crucially, it proved the ability of radar to detect aircraft and the experiment would become instrumental in the development of this technology by all of the major belligerents during the Second World War. Although conventional radar is used extensively for ground-based air surveillance, development of passive radar has not remained static and there is a resurgence of interest in its application for such tasks.

ERA

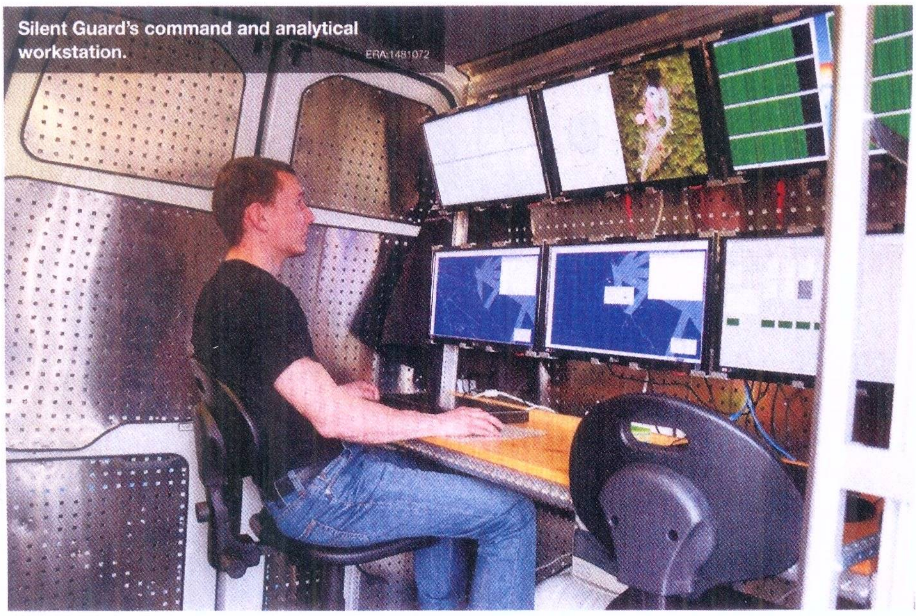
The Czech Republic is a centre of excellence regarding passive radar for ground-based air surveillance. ERA, based in Pardubice, east of Prague, has been involved in the development of passive radar since the 1960s.

In May 2013 the company launched its Silent Guard Passive Coherent Location (PCL) system. One month earlier, Silent Guard was deployed to support Czech armed forces manoeuvres in western Bohemia.

ERA is currently in the final stages of tests and operational evaluations of its Silent Guard passive radar demonstrator. A contract for a production version is under negotiation with the Czech armed forces, with entry into service expected in the coming year.

The Silent Guard passive radar is positioned on top of a mast that can be mounted on a vehicle. The radar itself uses a circular array antenna to detect reflections of FM radio transmissions from any direction. Silent Guard has a range of 150 km, sharing its output with other air defence assets such as command-and-control centres using the ASTERIX (All Purpose Structured Eurocontrol Surveillance Information Exchange) and NATO AWCIES

A close-up of the Silent Guard antenna array.



Silent Guard's command and analytical workstation.

(Air Command and Control System Wide Common Information Exchange Standards) communications protocols.

ERA will demonstrate the system to NATO during the 2014 iteration of Exercise 'Unified Vision': an exercise involving NATO forces that will test the possibilities of interoperability between coalition forces' information and intelligence systems.

Airbus Defence and Space

The pan-European Airbus Defence and Space (formerly Cassidian), a division of Airbus Group (formerly EADS), has also developed a demonstrator passive radar, a company spokesperson told *IHS Jane's*. The effort is largely company-funded, with some support from European armed forces.

The demonstrator has performed several field tests and development is ongoing, the spokesperson said, adding that the company is confident it can "reach full product status by 2017".

As yet no procurement contract has been signed and Airbus Defence and Space does not appear to have yet devised a product name for its offering. This is because the radar will not be a single product, per se, but will instead be developed into several products covering a wide range of applications.

In May 2014 the Civil Aviation Authority, the UK's specialist aviation regulator, granted the company a feasibility study to examine whether the technology could be used for better air traffic management.

According to the company, the radar uses for the first time FM radio transmissions and DAB and DVB-T signals combined in real time, which it claims provides a hitherto unprecedented performance. When receiving FM transmissions, the radar has a detection range of up to 200 km, while use of the DAB/DVT-B signals allows a detection range of 40 km for a small aircraft. The company's design also includes a mission planning tool, by which the optimum geographical location can be established for the positioning of the radar so that it can best exploit the VHF traffic in the atmosphere. The overall architecture employs an antenna that can be mounted on the top of a sports utility vehicle-sized platform, positioned at a height of up to 13 m on a mast.

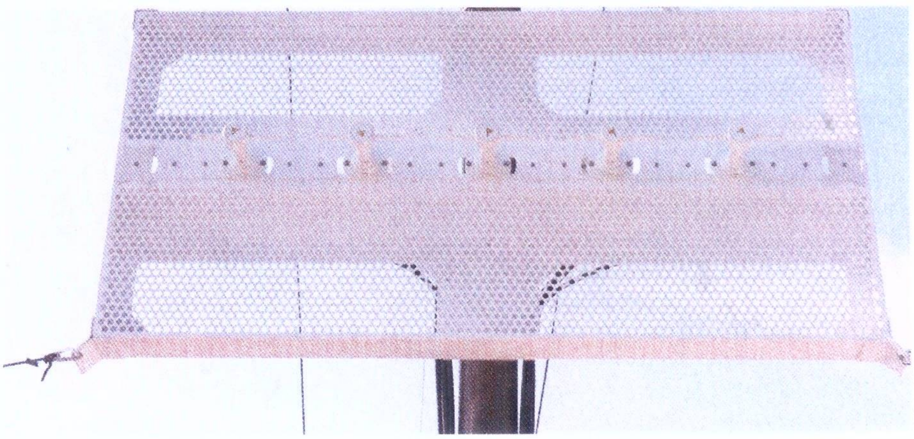
Airbus Defence and Space unveiled its passive radar in July 2012, revealing that it had supplied a demonstration system to the German Federal Office for Defence Technology and Procurement (BWB) and had also evaluated the air surveillance potential of the radar at Stuttgart Airport in southern Germany.

In development since 2006, the company initially experimented with a passive radar that could detect disturbances to FM radio signals. After further research, however, in 2011 it expanded the radar's detection range to include DAB and DVB-T signals. The radar can refresh its imagery every half a second and can perform the detection of flying objects up to an altitude of 40,000 ft. When detecting reflections from flying objects using FM transmissions, the radar provides a location accuracy of up to 1,650 ft, although this reduces to 33 ft when reflections from DAB and DVB-T signals are detected.

One of the applications mooted by Airbus Defence and Space for the radar is the provision of 'gap filler' coverage to facilitate air defence at high-profile events. During such occasions the radar could be deployed to provide local air surveillance where existing conventional radar coverage – either from the military or from local civilian air traffic management authorities – may not be present, or where environmental regulations may prohibit the electromagnetic pollution that can be caused by conventional radars.

Indra

Spain's Indra Sistemas is another European company closely involved with passive radar research and development via its Array Passive Inverse Synthetic Aperture Radar Adaptive Processing (APIS) programme. Indra's offering is remarkable in that it employs inverse synthetic aperture radar (ISAR) techniques that produce highly detailed


Thales has spent more than two decades developing passive radar technologies and techniques. It employed such technology to protect the 14th July 2010 Bastille Day celebrations in Paris. This picture shows one of its DVB-T passive radar antennas.

radar pictures of moving objects with sufficient clarity to perform target recognition using the radar picture. This allows the radar operator to distinguish between airliners, military aircraft, unmanned aerial vehicles, and missiles, thus greatly improving target discrimination. Indra's APIS passive radar detects disturbances to civilian terrestrial television signals to identify airborne targets. The company claims that the application of ISAR makes the APIS the world's first high-resolution passive radar.

Indra has now completed the development and demonstration of the functionalities of the radar through the sponsorship of the European Defence Agency (EDA), demonstrating these functionalities to the EDA in 2013. Although Indra led the APIS project, it also included contributions from Italy's National Inter-University Consortium for Telecommunications (CNIT), telecommunications and electronics specialists Vitrociset, Spain's University of Alcalá, the University of Cyprus, and the Hungarian Science Academy.

Selex

Italy's Selex ES is forging ahead with its AULOS passive radar, which utilises FM and DAB/DVB-T signals to track low-observable airborne targets and low-flying aircraft at ranges of several hundred kilometres. The company claims that AULOS's performance is sufficient to detect and track several targets with a low radar cross-section simultaneously and to determine their location and altitude.

Selex ES provides the AULOS in two configurations: AULOS-2D and AULOS-3D. Designed as a fixed system, the AULOS-2D (providing range and azimuth detection for airborne targets) uses FM signals, providing coverage of a 90° section of the sky, while the AULOS-3D can also provide estimates of target altitude. Selex ES exhibited the AULOS radar at the 2013 Paris Air Show and in June 2013 it was awarded the Oscar Masi prize by the Italian Industrial Research Association in recognition of the environmental benefits heralded by the AULOS design regarding its reduction of electromagnetic radiation.

Selex ES 1526285

Selex's AULOS passive radar is available in two versions: one that provides speed and range information, with the second providing altitude information for aerial targets. AULOS performs these functions through the detection of FM radio signals.

Thales

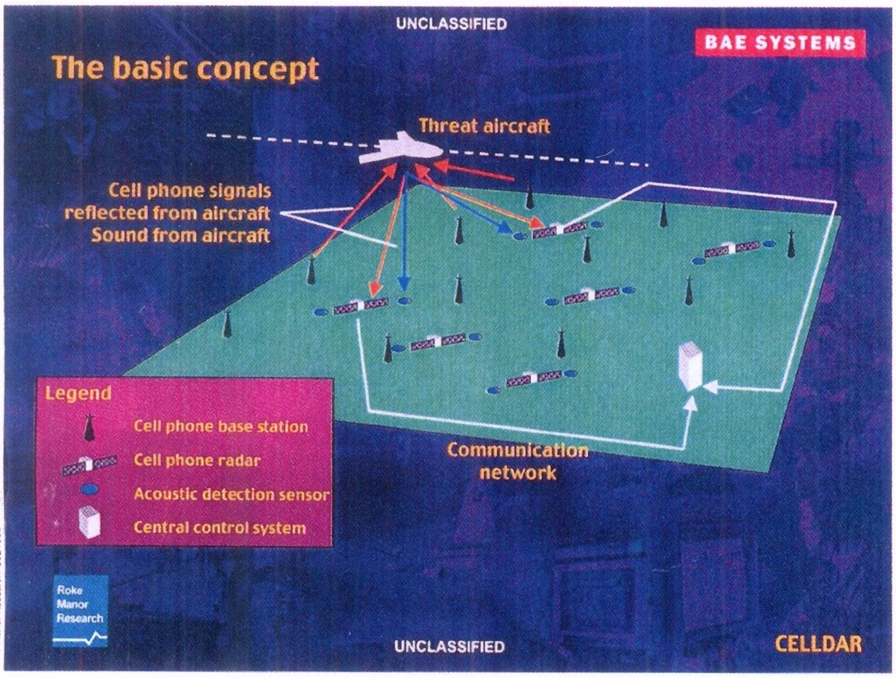
Thales of France has been working on passive radar for over 20 years, with much of this work focusing on the utilisation of FM signals for target detection. Luc Jolibois, the company's passive radar product manager, told *IHS Jane's* that Thales engineers also experimented with the use of DVB-T transmission during the mid-part of last decade, more recently combining FM and DVB-T transmissions to provide 3D information.

"Prototype systems developed by Thales have since performed up to 20 demonstrations of the country's passive radar technology at a range of different sites around the world," Jolibois said.

Thales' efforts have been funded by the company, France's Direction Générale de l'Armement (DGA) military procurement agency, and the European Union. Products developed by Thales in this domain to date include the Homeland Alerter 100 (HA 100), which in 2010 was used to provide air surveillance for the 14 July Bastille Day celebrations in Paris. The company says that production versions of the HA-100, utilising either FM or DVB-T or both these frequencies combined, will be available in the coming months.

Other players

Passive radar efforts in the United States include Lockheed Martin's Silent Sentry. This radar was unveiled in 1998 and has since then been cycled through a series of tests, during which its detection of fixed-



The Celldar basic concept functioning in a ground air-defence radar role.

wing combat aircraft and helicopters has been evaluated.

The Silent Sentry can be mounted at a fixed site or on a vehicle to allow rapid deployment and exploits reflections of FM radio transmissions to detect airborne targets. The company stresses that one of the key attractions of detecting reflections to FM radio transmissions, and VHF transmissions in general, is that such transmissions are not susceptible to degradation caused by weather that can affect some transmissions broadcast in other frequencies. Similarly, VHF transmissions can be detected with equal ease during the day and night.

Silent Sentry employs a minimum of three broadcast signal sources to determine a target's location. The passive radar has a detection range of around 220 km and can detect targets at either 60° or 360° azimuth, depending on antenna configuration, and provides up to 50° of elevation coverage. Silent Sentry updates its radar coverage every eight seconds and has sufficient processing power to track over 200 targets.

Meanwhile, in the United Kingdom BAE Systems teamed up with Roke Manor Research, based in southern England, to develop the Cellphone Radar (Celldar) system. Whereas several of the aforementioned passive radars utilise FM, DAB, and DVB-T transmissions, Celldar detects disturbances to civilian GSM digital cellphone communications networks that typically operate in frequencies between 380 MHz and 1.9 GHz across the UHF (300 MHz to 3 GHz) range. A prototype of Celldar was constructed in 1999, with BAE Systems reportedly joining the programme in 2002. However, since then there has been very little news regarding the programme's status or Celldar's specifications.

Passive radar development efforts have also moved forward in South Africa with the announcement in September 2013 that Peralax Electronics, together with defence electronics specialists CSIR and the University of Cape Town, have developed a prototype passive radar. Testing has involved the use of three receivers positioned in the Western Cape province of South Africa that demonstrated the radar's ability to detect airliners at a range of 150 km, according to a presentation made at the South African Aardvark Roost chapter of the Association of Old Crows electronic warfare organisation's 2013 Electronic Warfare conference, held in Pretoria.

Radar replacement?

Given the benefits of passive radar, particularly in terms of its lack of susceptibility to jamming and attack by anti-radiation missiles (ARM), could such technology replace conventional radars for the ground air surveillance role in the future?

Ondrej Chlost, commercial director of ERA, says that one application for the technology could include use in a so-called 'gap filler' role, ie providing coverage of airspace not falling under the purview of existing conventional radars. For example, a country may have several air surveillance radars positioned throughout its territory that may provide coverage of flat or gently undulating land but which may be obstructed by mountain ranges as RF transmissions cannot penetrate rock to survey the airspace in valleys. Here, passive radars could be deployed to valleys to monitor the airspace and thus prevent low-flying combat aircraft using them as a means of approaching a target below – or away from – the watch of conventional radar. Passive radars have the added attraction in this regard that, as they are not required to generate an RF signal, they are comparatively inexpensive to operate compared with conventional radars.

Likewise, Airbus Defence and Space believes the utility of passive radar lies in "enhancing air surveillance by filling radar gaps, for example in hilly terrain or close to inhabited areas where it might be crucial to avoid RF energy emissions to reduce electromagnetic pollution", adding that passive radar "could be a cost-efficient solution to protect critical infrastructure, military installations and large events". However, Thales told *IHS Jane's* that "passive radars will not replace conventional radars", while adding that "passive radar is perfectly suited to provide low- or very-low-altitude coverage at ranges of between 93-185 km".

One of the reasons why passive radar may not be able to replace conventional ground-based air surveillance radar in the short term could be because of target resolution. According to official literature released by the company, Airbus Defence and Space's passive radar has an error margin of 20 m when detecting small aircraft. Such resolution is fine for surveillance radars providing gap-filler coverage, but might not be suitable for providing the sharp resolution routinely generated by conventional radars used to provide fire control information for surface-to-air missiles.

Nevertheless, passive radar does hold promise as providing a low-cost yet reliable means to enhance existing ground-based air surveillance radar networks.

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