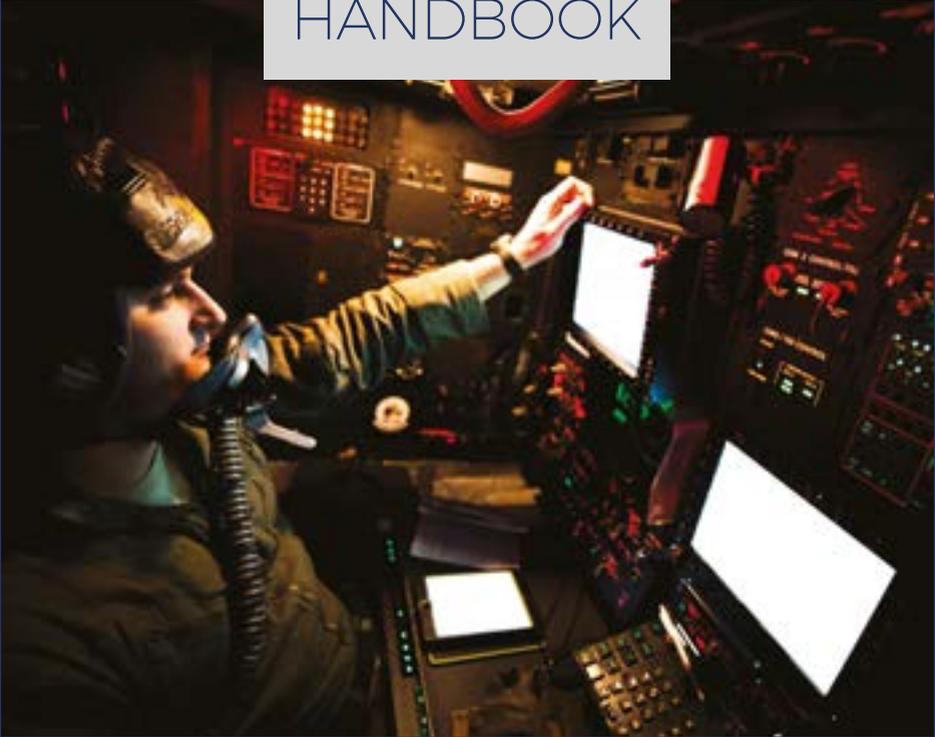


 SHEPHARD

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# ISSUE 2

## HANDBOOK



PUBLISHED MAY 2018

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THE CONCISE GLOBAL INDUSTRY GUIDE

# RADAR SYSTEMS

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**3 Introduction**

Editor Tony Skinner welcomes readers to Issue 2 of Shephard Media's *Radar Systems Handbook*.

**4 Airborne systems**

Selected radar systems in the following categories: airborne early warning and fire control; surveillance and maritime patrol; and weather. Listed alphabetically by company.

**28 Ground systems**

Radar systems in the following categories: battlefield and ground surveillance; land-based air defence; and weather. Listed alphabetically by company.

**54 Maritime systems**

Selected systems in the following categories: coastal surveillance; commercial; naval fire control; and naval surveillance. Listed alphabetically by company.

**72 Space-based systems**

A sampling of radar payloads used in satellite constellations for Earth observation, imaging and intelligence-gathering. Listed alphabetically by company.

**75 Guide to suppliers**

A worldwide listing of companies in the radar systems industry, listed by product type. Suppliers from p78 are listed by company and details include website, e-mail, telephone and fax.



**COVER:** A radar navigator watches monitors on a B-52 Stratofortress during a mission in support of bomber assurance and deterrence operations at RAF Fairford, England, in September 2017. (Photo: UK RAF)

**ABOVE:** A new weather radar under construction in Cayey, Puerto Rico, after the previous one was damaged by the strong winds brought by Hurricane Maria. (Photo: Federal Emergency Management Agency)

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## Radar Systems Handbook

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# Welcome

Welcome to the second edition of Shephard Media's *Radar Systems Handbook*, in which we aim to cover the plethora of radar systems across the maritime, land and air domains, including maritime patrol, fire control, search and detect, surveillance and other categories.

Since radar systems became an integral part of military operations more than 70 years ago, the capabilities they provide are only as beneficial as their ability to detect and track the latest generation of threats.

The recurring pattern of radar systems and CONOPS having to adapt in the face of changing and growing threats has been evident in recent months due to the number of upgrade programmes on the boil.

At the time of writing, the US Army was soon expected to release technical requirements for the replacement of its Patriot radar system. The Lower Tier Air and Missile Defense Sensor programme, currently in the concept definition phase (CDP), will replace the service's 1980s-era AN/MPQ-65 radar with a 360° sensor that will boost the performance of the PAC-3 Missile Segment Enhanced interceptor against threats in the lower-tier portion of the missile defence battlespace.

The programme received a significant funding boost in the DoD's FY2019 budget in February 2018. Lockheed Martin, Northrop Grumman, Raytheon and Technovative Applications are currently under contract for the CDP. The requirements for the next-generation radar are expected to be focused on providing defensive capabilities against emerging threats, such as slow and low flying aircraft, as well as for the system to be scalable and manoeuvrable.

The US Army is also pushing ahead with upgrades to its fielded AN/MPQ-64 Sentinel A3 radar systems as it looks to address similar growing threats on the battlefield, including from UAVs and cruise missiles. The upgraded radar, designated the Sentinel A4 and which has now progressed to its RfP phase, will also improve the service's ability to counter manned fixed- and rotary-wing targets, as well as offering capabilities against future rocket, artillery and mortar threats. Up to 200 legacy systems could be upgraded by the beginning of the 2030s.

By integrating new radar antenna technologies, the army intends to enhance the performance of the system by 75%, triple its search capabilities and double the radar's tracking accuracy. In response to the changing operating environment, the army requires the Sentinel A4 to be capable of performing in contested environments, where it could encounter electronic attacks, anti-radiation weapons and direction-finding sensors.

The service is also accelerating plans to integrate the Terminal High-Altitude Area Defense (THAAD) radar with the lower-tier Patriot system to better protect troops and assets from incoming missiles. US Army Defense Artillery School Commandant Brig Gen Randall McIntire said the plan is to feed information from the THAAD radar to the Patriot system through the Integrated Air and Missile Defense Battle Command System.

The *Radar Systems Handbook* continues to expand with each issue, reflecting the growth of the industry and the appreciation of such applications. Product entries in the handbook are free of charge, so if your company produces equipment that you believe should be included in the Shephard Plus online database and the next handbook, please contact us at [reference@shephardmedia.com](mailto:reference@shephardmedia.com)

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## EQUIPMENT

### AIRBORNE SYSTEMS

This section contains basic data on a selection of radar systems used in fixed-wing aircraft, helicopters and UAVs:

- airborne early warning (AEW) and fire control
- surveillance and maritime patrol
- weather

The equipment is listed alphabetically by manufacturer within the above subsections.

If you think your product should be listed, please contact the team at [reference@shephardmedia.com](mailto:reference@shephardmedia.com) to ensure it appears in the Shephard Plus online database ([shephardplus.com](http://shephardplus.com)) and is included in the next print edition.

**ABOVE:** A USCGC C-27J flies over San Francisco, California, during area familiarisation training in February 2018. The aircraft is outfitted with weather radar and communications equipment. (Photo: USCG)



## EQUIPMENT

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**ABOVE:** A USCGC C-27J flies over San Francisco, California, during area familiarisation training in February 2018. The aircraft is outfitted with weather radar and communications equipment. (Photo: USCG)

## AEW AND FIRE CONTROL

### AVIC – AVIATION INDUSTRY CORPORATION OF CHINA

#### Falcon S-7

The Falcon S-7 is an airborne FCR that equips the Chengdu F-7 multirole combat aircraft. The radar, which is produced by the Radar and Avionics Research Institute of China's AVIC is thought to be based on Leonardo's Grifo S-7. The Falcon S-7 is thought to be capable of detecting sea targets at a range of 150km and land targets at up to 250km. Air-to-air, the radar has a range of 80km for look-up engagements and 90km for look-down engagements. Applications: multi-functional airborne pulse-Doppler FCR Range: 150km for sea targets, 250km for land targets, 80km for look-up air-to-air engagements and 90km for look-down air-to-air engagements

### BIRD AEROSYSTEMS

#### SPREOS

Bird Aerosystems unveiled a new radar-based sensor/DIRCM system, the Self-Protection Radar Electro-Optic System (SPREOS), at Eurosatory 2016. The single-LRU system provides protection against IR missiles including those fired by MANPADS. It is intended for a range of airborne platforms, including helicopters and large transport aircraft. As soon as a warning is received from the onboard MWS, SPREOS pivots in the direction of the incoming threat and activates the dual-band radar function for confirmation and tracking, which are performed simultaneously on both frequencies. High-precision tracking is achieved using millimetric-wave frequencies. SPREOS then deploys the dual-band countermeasure laser, causing the missile to miss the aircraft. The system is a joint development with a large European company.

### IAI ELTA SYSTEMS

#### ELM-2032

The ELM-2032 is a multi-mode airborne FCR. Modular hardware design, software control and flexible avionic interfaces enable installation in F-16, F-5, Mirage, F-4, MiG-21 and other fighters and it can be customised. Air-to-air modes enable long-range target detection and tracking for weapon delivery or automatic target acquisition in close-combat engagements. Air-to-ground modes include high-resolution SAR mapping, target detection and tracking over real-beam mapping, DBS and SAR maps in addition to ranging. In maritime missions, the radar provides long-range target detection and tracking, target classification (rapid scan, ISAR). In addition to the aircraft mentioned above, the ELM-2032 also equips the Korea Aerospace Industries TA-50 lead-in jet trainer and FA-50 multirole combat aircraft. Applications: multi-mode Weight: 72-100kg Detection range: 144km Operating platforms: F-16, F-5, Mirage, F-4, MiG-21, TA-50, FA-50

#### ELM-2052

The ELM-2052 is an FCR designed for air-to-air superiority and strike missions, based on solid-state AESA technology, enabling the radar to achieve long detection ranges, mission reliability and multi-target tracking. The ELM-2052

provides simultaneous modes of operation air-to-air, air-to-ground, air-to-sea and weapon deployment. In air-to-air mode, the radar delivers long-range multi target detection and enables several simultaneous weapon deliveries in combat engagements. In air-to-ground missions, the radar provides high-resolution SAR mapping, surface moving target detection and tracking over SAR maps in addition to air-to-ground ranging. In air-to-sea missions the radar provides long-range target detection and tracking, including target classification capabilities (RS, ISAR). The ELM-2052 radar design reflects operational feedback received from Israeli Air Force fighter pilots. Applications: FCR for air superiority and strike missions

#### ELW-2090 AEW&C

The L-band ELW-2090 AEW&C radar has a synthetic aperture mode that allows it to detect moving ground targets, airborne threats and maritime targets. To date, the radar has been installed in a large mushroom-shaped radome on board an Ilyushin Il-76 transport. It performs 360° target detection, and has integral ESM, a self-protection system, an IFF interrogator and communications capability. The ELW-2090 is in service on board the six Beriev A-50EI Phalcon AEW aircraft operated by the Indian Air Force. Applications: multi-mode radar Frequency coverage: L-band Operating platforms: Il-76

### LEONARDO AIRBORNE & SPACE SYSTEMS

#### Captor-E

Captor-E is a multi-mode AESA pulse-Doppler radar upgrade to the Captor-M, designed for the Eurofighter Typhoon. Captor-E is being developed under a Eurofighter GmbH contract by the Euroradar consortium, of which Indra is a participant. Features of the radar include: increased air-to-air range, faster detection and tracking of targets, improved tracking performance and extended missile guidance and a wide field of regard re-positioner. Applications: multi-mode air/air and air/ground FCR

#### Grifo S

The Grifo S FCR is the most powerful version of the Grifo radar family, featuring a 560W air-cooled TWT-based transmitter with wideband frequency agility, a monopulse flat-plate slotted array antenna with guard channel fully processed and IFF dipoles, as well as a flight-proven suite of operative modes. Applications: X-band pulse-Doppler multi-mode radar Frequency: X-band Weight: <120kg

#### Grifo-346

The X-band Grifo-346 covers +/-60° in azimuth and elevation, and weighs under 1kg. It can track up to ten targets and display eight of these. The radar has air-to-air, air combat, air-to-surface and navigation modes. It reduces its probability of detection with low sidelobes, pulse compression, low peak power and both random and adaptive frequency jamming. From May 2014, it was being installed on board Brazilian Air Force Northrop Grumman F-5M/FM multirole combat aircraft as part of an upgrade package. More than 450 have been installed with 100,000 operational flight hours. Applications: X-band radar Frequency: 8.5-10.68GHz Weight: <100kg Operating platforms: F-5M/FM multirole combat aircraft



The Vixen 500E is an X-band, compact, lightweight, AESA radar for fighter and lead-in fighter trainer aircraft. (Photo: Leonardo)

### Raven ES-05

Raven ES-05 is an AESA radar under development by Leonardo. It has been designed to equip the Saab JAS-39C/D/E Gripen family of multirole combat aircraft. A production-standard Raven ES-05 has been installed on a Gripen demonstration aircraft. Few details have been released regarding the radar's performance characteristics, although it is thought to transmit in the X-band. According to Saab, the Raven ES-05 is the first production AESA in the world to be mounted on a rotating swashplate, improving the radar's FOV. Applications: AESA radar Frequency: X-band Weight: 215kg

### Vixen 500E

The Vixen 500E is an X-band, compact, lightweight, AESA radar for fighter and lead-in fighter trainer aircraft. It is currently fitted to US Customs and Border Protection's Citation II fleet. It has been designed to meet a full spectrum of FCR operational requirements – detecting, identifying, prioritising and engaging airborne or at-sea/on-ground targets while remaining resistant to countermeasures. Vixen 500E comprises three LRUs, easing installation and minimising system volume. Applications: X-band lightweight AESA radar Frequency: X-band Weight: 86kg

## LOCKHEED MARTIN

### AN/APG-67

The AN/APG-67 is a multi-mode radar providing situation awareness and fire control. Long-range detection and tracking allow manoeuvring to gain tactical advantage. Integrated and tested with BVR missiles (semi-active and data link). Lock-on and tracking are reliable during high-g manoeuvres. Coherent pulse-Doppler picks targets out of ground and sea clutter. Distraction due to false alarms is minimised. Fourth-generation design takes advantage of signal processing with a compact transmitter, processor and antenna using less than 0.05m<sup>3</sup>. Offers high-resolution SAR imaging, ECCM capabilities, monopulse tracking, guard channel with full two-channel processing, pulse compression, CFAR processing, ten-target TWS. Applications: multi-mode radar Frequency: 8-12GHz Range: 75km (fighter-sized target) Operating platforms: AT-63 Pampa, T-50 Golden Eagle, AIDC F-CK-1

### AN/APG-78 Longbow

The AN/APG-78 Longbow is a Ka-band, LPI FCR equipping the Boeing AH-64D Longbow Apache attack helicopter. It provides a claimed seven-fold improvement in survivability and four-fold improvement in lethality over the AH-64A, and automatically detects, prioritises and classifies highest priority targets. The radar reduces exposure (inside threat timelines) and is effective against ground and air targets. It has selectable automatic prioritisation and passively locates and attacks emitters (with RF interferometer). The system cues fire-and-forget AGM-114L Longbow Hellfire missiles and places effective fire on targets at a maximum range of 8km. Attack and no-fire zones are automatically displayed. In November 2014, Longbow International, the consortium of Lockheed Martin and Northrop Grumman, which manufactures the AN/APG-78, revealed that it would be adding a maritime surveillance mode to the radars equipping the US Army's new Boeing AH-64E Guardian fleet. The maritime surveillance mode is being developed as a hardware and software upgrade and will be installed on the Lot 6 production run for the AH-64E. These improvements will specifically equip the Radar Electronics Unit (REU), a component of the radar specific to the AH-64E that provides increased output power and processing improvements compared to the legacy AN/APG-78 radars equipping the legacy AH-64D. The REU also brings improvements in terms of weight and operating cost reductions. Testing of radar's maritime mode, which will allow the AH-64E to detect small targets in the littoral and open seas, is ongoing. The Lot-6 production run is expected to commence by 2020. All new AH-64Es will then receive the maritime mode enhancement to their AN/APG-78 radars, with similar enhancements being rolled out for aircraft already in service. The company states there have been ten export customers for the radar, including South Korea and Saudi Arabia. Applications: Ka-band LPI radar Frequency: Ka-band (33.4-36GHz) Range: 8km

### AN/APS-138

The AN/APS-138 can perform airborne and surface surveillance. The UHF radars use pulse compression to enhance resolution and to suppress clutter. With a range of 460+km, the AN/APS-138 is capable of detecting small targets, such as cruise missiles, at a range of 278km. The AN/APS-138 is used on board the seven Northrop Grumman E-2C Hawkeye aircraft operated by the Egyptian Air Force and some E-2Cs operated by the USN. Applications: multi-mode UHF AEW&C radar Frequency: UHF (420-450/890-942MHz) Range: 463km Operating platforms: E-2C Hawkeye (Egyptian Air Force – 7 aircraft; USN)

### AN/APS-139

The AN/APS-139 is an upgrade to the APS-138 radar on E-2C Hawkeye AEW&C aircraft, designed to improve performance against low-RCS targets. It was succeeded by the Lockheed Martin AN/APS-145. Frequency coverage: 0.3-1GHz

### AN/APY-9

The UHF AN/APY-9 radar has a range of circa 550km and equips the Northrop Grumman E-2D Advanced Hawkeye AEW&C aircraft operated by the USN. In 2010, Lockheed Martin received a low-rate initial production contract for AN/APY-9 radars for integration into the USN's E-2Ds. The AN/APY-9 features a solid-state transmitter with higher power than its AN/APS-145 predecessor for extended range, as well as digital receivers to increase

sensitivity. The AN/APY-9 can detect smaller targets, and more of them, at a greater range, particularly in coastal regions and over land compared to the AN/APS-145. Its electronically scanned array provides continuous 360° coverage. Lockheed Martin will produce AN/APY-9 radars to equip all 75 planned E-2D Advanced Hawkeye aircraft to be delivered to the USN. Applications: UHF-band hybrid mechanical/electronically scanned AEW&C radar Operating platforms: E-2D Advanced Hawkeye (USN) Frequency coverage: UHF (420-430/890-942MHz)

## MITSUBISHI ELECTRIC

### J/APG-1

Mitsubishi supplies the J/APG-1 FCR with phased-array antenna for the F-2 fighter, which was developed from the F-16. Multi-mode radar offers air-to-air, air-to-ground and anti-shipping modes. It supports targeting of weapons such as short-range and BVR AAMs, guns, ASMs and freefall bombs, for which it can perform continuously calculated impact point calculations. Aircraft are being upgraded to J/APG-2 standard to handle more capable missiles. Applications: phased-array multi-mode radar Operating platforms: F-2

## NORTHROP GRUMMAN

### AN/APG-66

The AN/APG-66 is a coherent pulse-Doppler FCR originally developed for the F-16, now adapted to platforms including Hawk 200, T-39N, Skyhawk, PBN Defender and aerostats. Compatible with radar-guided missiles including Sparrow, AMRAAM, MICA, Skyflash, Penguin plus IR-guided Sidewinder. Uses a mechanically scanned slotted flat-plate antenna. Applications: coherent pulse-Doppler radar Frequency: 6-10GHz Range: 148km Operating platforms: Hawk 200, T-39N, Skyhawk, F-16

### AN/APG-68

The AN/APG-68 is a multi-mode radar with a planar array antenna fitted to F-16 variants from Block 25 C/D on. Allows BVR engagements with AMRAAM missile. AN/APG-68(V)9 is the variant fitted to Block 50/52 aircraft. Air-to-air modes include TWS of up to ten targets, range-while-search, velocity search, rapid resolution, up-look search, situation awareness mode and an automatic acquisition air combat mode. Air-to-ground modes include real-beam mapping, DBS, freeze-frame, maritime search, GMTI and tracking, ranging and beacon homing. The (V)9 variant provides a 33% improvement in air-to-air detection range over earlier models and introduces SAR, which allows high-resolution ground mapping for 24-hour, all-weather precision strike capability. The combination of new technology with open-systems architecture also reduces total ownership cost of the radar. Applications: multi-mode radar Frequency: 8-12GHz Range: 296km (search) Operating platforms: F-16C/D

### AN/APG-76

The AN/APG-76 multi-mode radar system was developed as an upgrade for the Israeli F-4 Phantom 2000 programme. Features a mechanically scanned flat-plate antenna. Air-to-air modes include look-up/look-down, air combat and beacon modes. Air-to-ground modes include real-beam mapping, DBS, SAR/GMTI and

beacon tracking. Applications: multi-mode radar system Operating platforms: F-4 Phantom 2000

### AN/APG-77

LPI FCR for the F-22 Raptor. It is designed to significantly improve capability in air-to-air combat, allowing the pilot to track and shoot at multiple threats before the adversary's radar detects the aircraft. The antenna is an AESA with a separate transmitter and receiver for each of the radiating elements to provide the agility, RCS and bandwidth needed. Solid-state technology and elimination of mechanical moving parts aid reliability and field reparability. Speculation on range varies from 160km to 240km or even as far as 400km. Applications: multi-function LPI radar Operating platforms: F-22

### AN/APG-80

The AN/APG-80 is an agile beam radar with an AESA antenna designed to continuously search for and track multiple targets within the forward hemisphere of the aircraft. The radar was originally intended for use on the F-16/ F-16E/F Block 60 Desert Falcons. First orders of the radar were delivered by Northrop Grumman to Lockheed Martin for the F-16 Block 60 aircraft, which was developed and produced for the UAE. The AN/APG-80 shares basic technology with AN/APG-81 for F-35 JSF and AN/APG-77 for F-22 Raptor. Applications: agile beam radar with AESA antenna Operating platforms: F-16 Block 60

### AN/APG-81

The AN/APG-81 is an AESA multi-function radar for the F-35 JSF that incorporates the agile beam-steering capabilities developed for the F-22's APG-77. Its multi-mode capability supports air-to-air, air-to-surface and EW missions, the latter thanks to an RF subsystem integrated with the main radar array. It provides the pilot with precision all-weather targeting and air-to-ground automatic target cueing, says Northrop Grumman. Applications: AESA multi-function radar Detection range: 150km Operating platforms: F-35 Antenna size: 70cm

### AN/APG-83 SABR

The AN/APG-83 Scalable Agile Beam Radar (SABR) is being developed as an upgrade option for the F-16. It is designed to replace the existing AN/APG-66 and AN/APG-68 conventional radars used by legacy F-16s. The company is looking to offer the AN/APG-83 SABR design as part of a planned upgrade programme for around 350 USAF F-16A/B Block-40/42 and F-16C/D Block-50/52 MRCA. The AN/APG-83 descends from the AN/APG-80 AESA, which the company developed for the F-16C/D/E/F aircraft procured by the UAE Air Force. In January 2015, it was reported that Lockheed Martin had received a contract modification worth \$308.3 million from the USAF Life Cycle Management Center at Wright-Patterson AFB, Ohio, to install the AN/APG-83 SABR on board the F-16A/B Block 20s operated by the Republic of China Air Force. Installation of these radars is expected to be completed by 2021. A variant has been developed for the USAF B-1B bomber fleet. Applications: AESA radar Frequency: X-band (8.5-10.68GHz) Operating platforms: F-16A/B

### AN/APY-1/2

The S-band AN/APY-1 radar is installed in a large rotodome above the fuselage of the Boeing KE-3A/E-3A/B Sentry A/WACS aircraft in Saudi Arabian (KE-3A), NATO (E-3A) and the USAF (E-3B) service. The S-band AN/APY-2 radar equips

Boeing E-3C/D/F AWACS aircraft in French (E-3F), UK (E-3D) and USAF (E-3C) service. The AN/SPY-2 radar is also used on board the Boeing E-767 AWACS aircraft of the Japanese Air Self Defence Force. Both the AN/APY-1/2 radars have a 360° FOV, and a detection range of circa 400km and at 10-second intervals, a volume of airspace covering more than 500,000sq km around the AWACS. The radars can detect and track air and sea targets simultaneously and extract airborne targets from surface clutter. Azimuth scanning of the phased array is mechanical, but elevation scanning and beam-forming are electronic using phase-shifting elements. All AN/SPY-1/2 radars in service are being brought to an equivalent standard via the USAF/NATO Radar Sustainability Improvement Program (RSIP), which improves the radar's resistance to ECM. The RSIP also adds COTS computing elements to the radar's processing systems, changes the radar's software language and adds additional improvements to enhance processing. The last RSIP upgrade is being rolled out on board the Royal Saudi Air Force's five KE-3A aircraft. The AN/APY-1/2 radars are expected to remain in service with their operators until circa 2035. Applications: AWACS S-band (E-F band) surveillance radar Range: 400km Frequency coverage: S-band Operating platforms: E-3, E-767

## MESA

The L-band Multi-Role Electronically Scanned Array (MESA) radar is a phased-array radar fitted to Boeing 737-700 AEW&C aircraft. The radar's antenna is mounted longitudinally above the fuselage. It detects airborne and maritime targets simultaneously and electronically scans a 360° area in under ten seconds. The radar's IFF system is integrated with the overall MESA architecture and phased-array technology allows electronic beam-steering and multi-mode operation. Air-to-air targets can be detected by the MESA at a range of 600km, with maritime targets being detected at 370km. Up to 180 targets can be tracked by the radar while it manages up to 24 interceptions. Operating altitudes up to 40,000ft (versus typical 20,000 to 25,000ft altitudes of other AEW systems) provide a 20 to 50% range and line-of-sight advantage against low-flying missiles and aircraft in various terrains. MESA is operationally ready minutes after take-off, beginning at 5,000ft and with full power operation at 10,000ft. Orders for the 737-700/MESA combination have been forthcoming from Australia (six aircraft), the Republic of Korea (four) and Turkey (four). Future modifications are planned for the MESA radar which could include improving its resistance to clutter and ensuring Mode 5/Mode S military and civilian IFF/air traffic management transponder protocol compatibility. Applications: phased-array radar AEW&C Range: air-to-air targets 600km; maritime targets 370km Operating platforms: Boeing 737-700 (Royal Australian Air Force – 6 aircraft, Republic of Korean Air Force – 4, Turkish Air Force – 4) Frequency coverage: L-band

## NRIET

### KLJ-7A

KLJ-7A is an X-band AESA radar designed as a replacement for the KLJ-7 on the JF-17 Block I fighter aircraft and the KLJ-7V2 on the Block II variant. It may also be installed on the FC-31 fifth-generation stealth fighter. Modes for the radar include multi-object targeting and multi-target engagement, and track while scan; it can also carry out ground moving target identification. According to reports, the radar can track

15 targets simultaneously and engage four. The radar was unveiled in 2016 but its current status is unclear. Frequency: X-band Weight:  $\leq$ 120kg Range: 170km

## PHAZOTRON NIIR

### Komar

The Komar is a multi-role radar aimed at upgrades of older Russian and Chinese combat aircraft. Air-to-air modes include multiple target tracking, vertical manoeuvre, HUD and boresight. Air-to-ground modes include real-beam mapping, SAR and DBS. It can also designate targets for radar-guided ASMs and produce fire control solutions for guns and frefall bombs. Applications: multirole radar Frequency: 8-12GHz

### Kopyo

The Kopyo is a multi-mode coherent pulse-Doppler radar aimed at the MiG-21 upgrade market. Uses a slotted flat-plate antenna and DSP. Air-to-air modes include look-up/down, TWS (eight targets, engage two), vertical search, wide-angle search, HUD search and boresight. Air-to-ground modes include real beam mapping, DBS, SAR, zoom/freeze-frame, TWS (four targets), MTI and ranging. Applications: multi-mode coherent pulse-Doppler radar Frequency: 8-12GHz Operating platforms: MiG-21

### Kopyo 25

The Kopyo 25 is a podded version of Kopyo 21I designed for the Sukhoi Su-39 close support/strike aircraft. Provides the aircraft with a radar without major modifications to the airframe. Kopyo 25 may also be offered for Indian MiG-27L upgrades. Antenna is of the slotted, flat-plate type. Air-to-ground modes include ground mapping, SAR imaging, MTI and sea search. Air-to-air modes include TWS, range-while-search and single-target tracking. Air combat modes include HUD search, slewable search, boresight scan and vertical scan. Applications: podded multi-mode, steered array antenna radar Frequency: 8-12GHz Weight: 90kg Range: up to 57km Operating platforms: Su-39, Su-25 Antenna size: 50cm

### Moskit 23

The Moskit 23 is a multi-mode radar developed to replace Sapfir in MiG-23 aircraft. Offers air-to-air modes including: range-finding, search and track, TWS of eight targets and simultaneous engagement of two, close combat. Offers air-to-surface modes including: real-beam mapping, DBS, SAR, moving target detection on land and water. Compatible with R-27R(T), RVV-AE and R-73 AAMs (as well as R-23T and R-24T missiles), Kh-31A missile and KAB-500KR guided bombs, unguided rockets, guns and bombs. Applications: multi-mode radar Frequency: 8-12GHz Range: 90km (air target), 100km (ship) Operating platforms: MiG-23

### N019 Sapfir 29

The N019 Sapfir 29 is a pulse-Doppler FCR with look-down/shoot-down capability developed for the MiG-29. Dedicated to air-to-air combat, it has three PRF settings: high for closing targets, medium for retreating targets and interleaved high/medium for all-aspect detection. Multiple modes can be used together through TDM. Antenna is of the twist Cassegrain type. Applications: pulse-Doppler radar Frequency: 8-12GHz; wavelength  $\sim$ 3cm Range: 150km (max displayed), 70km if target is below 10,000ft Operating platforms: MiG-29

**RP-22 Sapfir 21**

The RP-22 Sapfir 21 is an upgraded Sapfir for late-1960s MiG-21 fighters. Frequency: 12.88-13.2GHz Range: 30km (16m<sup>2</sup> target) Operating platforms: MiG-21

**RP-25 Sapfir 25**

The RP-25 Sapfir 25 is a look-down/shoot-down radar for the MiG-25PD interceptor of late-1970s vintage, developed as a replacement for the RP-25 that was compromised by pilot Viktor Belenko's defection to Japan with his MiG-25. Range: 100km (16m<sup>2</sup> RCS target), 115km (bomber, look-up mode) Operating platforms: MiG-25PD

**RP-35**

The RP-35 is a multi-mode digital phased-array coherent radar with HOTAS operation. Reported air-to-air modes include range-while-search, velocity search, single-target tracking, TWS of 24 targets with engagement of four at once, raid assessment, vertical scanning, HUD search, wide-angle search, boresight mode and automatic terrain avoidance. Air-to-surface modes are ground mapping (including real beam), DBS, SAR, zoom/freeze-frame, GMTI, four-target TWS and ranging. Applications: multi-mode digital phased-array coherent radar Frequency: 8-12GHz Range: 140km (head-on), 65km (tail-on)

**Sokol**

The Sokol is a passive phased-array FCR and navigation radar with air-to-air and air-to-ground modes, initially associated with Sukhoi Su-27 variants. Air-to-air modes include wide-angle search, boresight search, HUD search and vertical scan. Air-to-surface modes include real beam mapping, DBS, zoom/freeze-frame, SAR, TWS (four

targets), ranging, GMTI. Applications: passive phased-array Frequency: 8-12GHz Range: 180km (head-on), 80km (tail-on) against a 3m<sup>2</sup> RCS target Operating platforms: Su-27

**Super Komar**

The Super Komar is an upgraded version of the Komar featuring DSP. Air-to-air modes include look-up/down, TWS, range-while-search, vertical manoeuvre and HUD search and boresight modes. Air-to-ground modes are as for Kopyo plus zoom/freeze-frame in mapping, TWS and MTI. Applications: multi-mode radar Frequency: 8-12GHz Range: 75km

**Super Kopyo**

The Super Kopyo is an upgraded Kopyo with longer detection ranges across all aspects, with lighter weight and faster processors. Applications: multi-mode radar Frequency: 8-12GHz (wavelength ~3cm)

**Super Kopyo PH**

The Super Kopyo PH is a lightweight version of the Super Kopyo with phased-array antenna. Air-to-air modes include look-up/down, range-while-search, single target tracking and air combat manoeuvring. Air-to-ground modes include real-beam mapping, DBS and SAR. Applications: phased-array antenna radar

**Zhuk Series**

Zhuk Zhuk-ME, Zhuk-MSE and Zhuk-MSFE constitute a family of radars with slotted flat-plate or phased-array antennas, offering multiple air-to-air and air-to-ground modes. Air-to-air modes include: target acquisition with



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speed/range measurement in free space and against ground or sea clutter; single/multiple target tracking with simultaneous engagement of several. Close manoeuvre combat modes include vertical scanning, HUD FOV scanning, wide FOV scanning, fixed-beam and turning beam; detection and engagement of hovering helicopters; recognition of target types and number (raid assessment); targeting, target illumination and radio (data link) guidance for RVV-AE, R-27R1/R1E missiles; targeting for R-73E, R-27T(TE), Kh-29T(TD) missiles. Air-to-surface modes include: real beam mapping, DBS, 'focused antenna' SAR, zoom and freeze-frame, multiple target tracking, maritime surveillance, MTI and tracking, slant range measurement, platform speed measurement, terrain following/avoidance, targeting for Kh-31A, Kh-29T(TD) missiles. Applications: multi-mode radar Range: 100km (head-on), 40km (tail-on)

## RAYTHEON

### AN/APG-63(V)1

The AN/APG-63(V)1 is a reliability/maintainability upgrade to the AN/APG-63 including new hardware with significant growth opportunities. As part of a radar retrofit programme for the USAF, the APG-63(V)1 is being produced to replace outmoded APG-63 radars installed in F-15C/Ds. Raytheon is supplying radar and spare systems, data requirements, programme management and test equipment to support this retrofit. Applications: multi-mode radar Frequency: 8-20GHz Operating platforms: F-15C/D

### AN/APG-63(V)2

The AN/APG-63(V)2 is a radar upgrade for USAF F-15C aircraft, adding an AESA, increasing pilot situation awareness as well as reliability and maintainability. Agile beam provides nearly instantaneous track updates throughout the FOV, enhanced multi-target tracking capability and elimination of the need for a hydraulic system. It can simultaneously guide multiple AIM-120 AMRAAM missiles to several targets widely spaced in azimuth, elevation or range. It retains controls and displays nearly identical to those of its predecessor, the AN/APG-63(V)1. Applications: radar upgrade to include AESA Frequency: 8-20GHz Operating platforms: F-15C

### AN/APG-63(V)3

The AN/APG-63(V)3 AESA radar is designed to provide adaptable technology and tactical flexibility as the newest member of Raytheon's F-15 radar family. It is designed to offer situation awareness, multirole capability, long-term support and future growth options. The APG-63(V)3 integrates the APG-63(V)3's AESA components with 'minimal' downtime. Applications: AESA radar Operating platforms: F-15, F-15SG, F-15K

### AN/APG-65

The AN/APG-65 is a multi-mode radar for air-to-air and air-to-surface missions, featuring programmable digital computers. For air-to-air operations, it offers 'clean scope', look-down/shoot-down capabilities, search, track and automatic acquisition modes such as high-PRF velocity search, high/medium-PRF range-while-search, single target track and a TWS mode that tracks ten targets simultaneously and displays eight. For air-to-surface operations, it provides DBS sector and patch mapping, medium-range SAR, real beam ground-mapping, fixed and moving ground target track, air-to-surface ranging, terrain avoidance, precision velocity update and a sea

surface search mode with clutter suppression. Fitted to F/A-18 Hornet, F-4 Phantom, AV-8B Harrier II Plus. Applications: multi-mode radar Frequency: 8-12GHz Operating platforms: F/A-18, F-4, AV-8B Harrier II Plus

### AN/APG-70

The AN/APG-70 is a multi-mode radar with air-to-air and air-to-surface capabilities. As an upgrade of the APG-63, the APG-70 was designed for greater reliability and easier maintenance. Gate array technology enables the APG-70 to incorporate modes not available in earlier radars, while providing enhanced operational capabilities in other modes. The APG-70 is employed on late-model F-15C/D/E aircraft and on the export F-15I and S. Applications: multi-mode radar Frequency: 8-20GHz Range: 185km Operating platforms: F-15C/D/E, F-15I and S

### AN/APG-73

The AN/APG-73 is a coherent, multi-mode, multi-waveform search-and-track sensor that uses programmable digital processors for air-to-air and air-to-surface missions. Its motion-sensing subsystem with reconnaissance software, a stretch waveform generator module and a test equipment instrumentation and reconnaissance module, enable the F/A-18 to make high-resolution radar ground maps comparable with those of the F-15E and the U-2 and perform precision strike missions using image correlation algorithms. It is an upgrade of the APG-65 that provides higher throughputs, greater memory capacity, improved reliability and easier maintenance. Reprogrammable, it responds to new threats and accommodates future modes and weapons through software rather than hardware changes. APG-73 is operational on board the USN F/A-18C/D/E/F, the USMC F/A-18A+/C/D and with the air forces of Australia, Canada, Finland, Malaysia and Switzerland. Applications: multi-mode, multi-waveform search-and-track sensor Frequency: 8-12GHz Operating platforms: F/A-18C/D/E/F, F/A-18A+/C/D

### AN/APG-79

The APG-79 is an agile beam radar with solid-state digital array that scans at nearly the speed of light, enabling detection and tracking of multiple air and ground threats simultaneously. The array is composed of numerous solid-state T/R modules to help almost remove mechanical breakdown. Other system components include a receiver/exciter, ruggedised COTS processor and power supplies. It offers increased range and resolution. A built-in resource manager lightens aircrew workload. Agile beam forming permits thousands of beam positions per second. Multiple radar modes include: real-beam mapping; SAR; air-to-air search; air-to-air track; passive; sea surface search; GMTI; near-simultaneous multi-target and multi-missile tracking; and interleaved radar modes, including air-to-air and air-to-ground. Supports independent dual-cockpit operation. Raytheon has delivered more than 125 APG-79 AESA radars to Boeing, with the navy programme of record totalling 437 systems ordered. In 2008, Raytheon delivered its first APG-79 for the EA-18 Growler aircraft and achieved its first operational AESA deployment on an F/A-18E/F Super Hornet Block II squadron. In September 2013, Raytheon was awarded a contract worth \$39 million to supply 15 AN/APG-79 radars for USN Boeing F/A-18E/Fs for delivery by 2015. In May 2013, a firm fixed-price delivery contract worth \$8.6 million was awarded to Raytheon by Naval Air Systems Command for the supply of three AN/APG-79 radars. The upgrade will allow some of the legacy

AN/APG-73 radars outfitting early F/A-18E/F airframes to be cascaded down to other USN and USMC Hornets which are still using the legacy AN/APG-65 system. Raytheon announced in mid-January 2015 that it had completed the first test flight of the AN/APG-79(V)X combat aircraft radar. The test flight was performed to validate the additional capabilities which this variant can offer to the F/A-18C/D. Improvements for the AN/APG-79(V)X include extended detection ranges, simultaneous air-to-air and air-to-ground operating modes and SAR imaging. Applications: agile beam radar Frequency: X-band (8.5-10.68GHz) Operating platforms: E/A-18, F/A-18E/F

### AN/APG-82(V)1

The APG-82(V)1 AESA radar is described as the latest radar advancement for the USAF F-15E fleet. It contributes to the platform's multirole mission capability. In addition to its extended range and improved multi-target track and precision engagement capabilities, the APG-82(V)1 is claimed to offer a more than 20-fold improvement in system reliability over the legacy F-15E APG-70 radar. Aircraft equipped with the APG-82(V)1 are claimed to be able to simultaneously detect, identify and track multiple air and surface targets at longer ranges. The longer stand-off range is said to facilitate persistent target observation and information-sharing for informed decision-making. Reports in early January 2015 stated that the Israeli Air Force (IAF) is expected to procure Raytheon's AN/APG-82(V)1 AESA as part of an effort to modernise the radars used by its Boeing F-15I multirole combat aircraft. This new radar will replace the existing AN/APG-70 radars currently used by these aircraft. It has not been revealed how many radars Israel will acquire from the US, or when deliveries of these radars could commence and conclude. However, open sources state that the IAF operates 25 F-15I aircraft, with it likely that at least 25 systems will be acquired – one for each aircraft – with the possibility of spares also being included. Applications: AESA radar Operating platforms: F-15I/E

### SAAB

#### Erieye

The S-band Erieye is a long-range AEW&C radar that detects and automatically tracks air and surface targets across a large area. The radar has an instrumented range of 400km. The Erieye is based on active phased-array pulse-Doppler technology and is designed to track small objects, such as cruise missiles and jet-skis, in heavy clutter/jamming conditions. The system can be installed on commercial and military aircraft, including regional jets or turboprop airliners. The full Erieye system includes: the radar with an integral IFF interrogator, ESM; communications and data links; a comprehensive C2 system; and a self-protection system. Key customers include Brazil, Greece, Mexico, Pakistan, Sweden, Thailand and the UAE. The UAE deal was announced in November 2015 and is believed to be based on a Global 6000 platform. It was part of a \$1.27 billion deal which included the upgrade of the country's existing Saab 340 platforms which carry the Erieye system. Applications: long-range phased-array pulse-Doppler radar for AEW&C Radar; 400km Frequency coverage: S-band Operating platforms: Embraer 145 (Brazil, Greece, Mexico), Saab 340 (Sweden, Thailand, UAE), Saab 2000 (Pakistan)

#### PS-05/A

Saab's PS-05/A is an X-band mechanically scanned pulse-Doppler radar used on the Gripen fighter aircraft.

It has undergone four iterations from the original variant which was based on the Blue Vixen and flew in the first of the aircraft. The PS-05/A Mk4 was unveiled in April 2015 and has a new hardware configuration and radar back-end, and full AMRAAM and Meteor integration. Hardware changes include a new RPU (radar processing unit) and ERU (exciter receiver unit). The radar features a new air-to-air mode that increases acquisition range. A fifth version of the radar is planned to be AESA. The PS-05/A Mk4 has an automated search mode and dedicated modes for long-range target acquisition and low probability of intercept. All search modes are designed to automatically detect and track targets and jammers. While detection distances remain secret the company states that there has been a 100% increase in air-to-air detection at low altitude and 40% at high altitude, with air-to-surface detection improved by >100%. Applications: air-to-air, air-to-ground, ECCM Frequency: X-band Power: 10kW nominal Weight: 150kg Operating platforms: Gripen

### THALES

#### Arabel

Arabel is a multi-function FCR capable of detecting, tracking and engaging multiple targets, including jet aircraft, cruise missiles and tactical ballistic missiles and can track 100 and engage ten simultaneously. It includes a data link to send target position updates to Aster 30 missiles until their own active radar seeker takes over. The phased-array antenna rotates at 60rpm, and the system performs electronic scanning with large deflection ( $\pm 45^\circ$  in elevation and bearing), narrow beam and a low sidelobe level. The transmitter is frequency-agile and varies pulse width. Receiver uses Doppler, pulse compression, monopulse tracking. It is in service on France's Charles de Gaulle aircraft carrier and the Royal Saudi Navy's Sawari 2 frigates. Applications: multi-function FCR Frequency: 8-10GHz (I/J-band) Power: 150W Range: 50km (missile, 0.5m<sup>2</sup> RCS), 100km (jet fighter)

#### Cyrano IV

The Cyrano IV is a family of multi-mode airborne radars fitted to Mirage F1 and Mirage 50 fighter aircraft. Offers air-to-air modes including search, automatic tracking, interception and fire control, dogfight and home-on-jam. Can also be used for terrain avoidance, ground mapping and air-to-surface ranging. Applications: family of multi-mode airborne radars Frequency: 8-20GHz Operating platforms: Mirage F1 and Mirage 50 fighter aircraft

#### RBE2

The AESA RBE2 is the first AESA radar produced in Europe for combat aircraft. The active phased array, which replaces the passive array in the RBE2 currently fitted to the Dassault Rafale F3/B/C/M combat aircraft. It offers a 50% range extension for compared to legacy combat aircraft radars, greater waveform agility for high-resolution synthetic aperture imagery in air-to-ground mode and better resistance to jamming. The French DGA awarded Thales a contract in October 2014 to continue research into enhancing the capabilities of the RBE-2 radar for future upgrades. The contract is four years in duration and will conclude in 2018. Much of the work will focus on extending the range of the radar and reducing its probability of interception. The contract covers advanced technology studies, which will then be industrialised

before entering production. The company has leveraged the radar in the development of the Searchmaster maritime surveillance radar which was unveiled in October 2014. Applications: AESA radar Frequency: X-band (8.5-10.68GHz) Detection range: 370km Operating platforms: Dassault Rafale F3B/C/M

## RC

The RC family comprises compact multi-mode radars of modular construction aimed at combat aircraft and advanced trainers, developed from the Mirage 2000-5's RDY radar. The mechanically scanned antenna is a slotted flat-plate type with four dipoles, serving the IFF interrogator and/or missile data link. Modes include automatic prioritisation, lock-on and engagement of multiple targets, look-down/shoot-down, look-up/shoot-up in air-to-air combat, ground mapping, DBS and ranging in air-to-ground work and TWS of two targets plus target calibration in maritime air-to-surface engagements. Applications: family of compact multi-mode radars Frequency: 8-12GHz Weight: <120kg

## REDI

The RDI is an optimised pulse-Doppler radar installed on Mirage 2000B and C models used in the air superiority role. The slotted, flat-plate antenna features integrated IFF capability. High PRF gives accurate target speed measurement. Air-to-air modes include all-altitude search, TWS and continuous tracking/missile guidance. Air-to-ground modes include mapping and ranging. Applications: optimised pulse-Doppler radar Frequency: 8-12GHz Operating platforms: Mirage 2000B/C

## RDM

The RDM (Radar Doppler Multifunction) is a multirole coherent Doppler radar developed for Mirage 2000B, C, D and E models. It has air-to-air capability, but air-to-surface functions are emphasised. Air-to-air modes include all-aspect, all-altitude search and interception. Air-to-surface modes are mapping, terrain avoidance and blind let-down, and maritime search and attack. Applications: multirole coherent Doppler radar Operating platforms: Mirage 2000B/C/DE

## RDY

The RDY multi-function radar equips the Mirage 2000-5 Mk 2, providing air-to-air, air-to-ground and air-to-sea capabilities and enabling simultaneous detection and tracking of multiple targets. In air-to-air mode, it can select several targets for MICA missiles equipped with active EM or passive IR seekers. In air-to-ground and air-to-sea modes, the radar generates information supplied to the system for firing conventional or guided weapons. The RDY equips all versions of the Mirage 2000-5 already delivered to French and other air forces. Applications: multi-function radar Frequency: 8-20GHz Weight: <120kg Operating platforms: Mirage 2000-5

## Searchwater 2000

The Searchwater 2000 is a heliborne AEW radar. It was selected for the upgrade of the UK RN's AEW Sea King fleet to Mk 7 standard. The system comprises a high-power pulse-Doppler radar integrated with Mk XII, ESM and an INS/GPS navigation. The system also includes an HMI specifically designed for AEW operations, using twin consoles for more effective operator interaction. Data communications between interceptor aircraft and

other C2 assets can be via a range of links such as JTIDS, Link 16, Link 11 and the future Link 22. The system is light enough to be installed in a range of fixed-wing aircraft or helicopters operating from shore or afloat. The Searchwater 2000AEW system provides long-range warning against high and low level attack, intercept direction of fighter aircraft using a high-resolution INS/GPS, an autonomous secure air defence C2 unit, a maritime surveillance system providing detection of very small, fleeting targets including periscopes, against high background clutter. It also provides an extension of surface-based systems to provide OTH targeting, search and rescue and coastal surveillance and special enforcement operations. The radar in the Searchwater 2000AEW system incorporates multi-bar scanning for multiple-level raid detection. Pulse-Doppler/pulse envelope interacting allows targets to be detected at maximum range and tracked through background clutter. Operator facilities provide for manual and automatic, multiple target tracking. Intercept information can be continuously relayed to the interceptor aircraft or surface-based assets via data link or voice. An improved version of Searchwater 2000 was selected in May 2015 for installation on RN Merlin HM2 helicopters under the Crowsnest programme to provide a replacement capability for the Sea King ASaC7 in 2018. The UK MoD in January 2017 announced that manufacturing of the Crowsnest system for its fleet of 30 Merlin Mk 2s would begin, following the award of a £269 million deal to prime contractor Lockheed Martin. Thales has been subcontracted to deliver the upgraded Searchwater radar and Cerberus mission system, while Lockheed Martin will integrate the Crowsnest onto the helicopters. Ten role fit kits will be produced as well as a full fleet modification. Applications: AEW

## V TIKHOMIROV NIIP

### Irbis-E

Irbis-E is an X-band multi-mode passive electronically scanned array radar system developed by Tikhomirov NIIP for the Sukhoi Su-35 fighter aircraft. It is based on the Bars system used on earlier Su-30 aircraft. The first flight of a prototype occurred in 2007 on a testbed Su-30MK2 aircraft. Sukhoi states the system is 'mounted on a two-step hydraulic drive unit (in azimuth and roll) [which] turns the antenna by mechanic means to 60° in azimuth and 120° in roll. The maximum deflection angle of the beam is 120°. Applications: air-to-air, air-to-surface Frequency: X-band Power: 5kW Detection range: 400km Antenna size: 90cm

### N001

The N001 is a mechanically scanned pulse-Doppler FCR associated with the Su-27, -30 and -33 fighters. Features single-target engagement capability. Applications: mechanically scanned pulse-Doppler radar Frequency: X-band Range: 100km (fighter aircraft), 140km (large aircraft) Operating platforms: Su-27/30/33 Antenna size: 1.07m

### N011

The N011 is an updated version of N001 for more advanced Su-27 family aircraft featuring both air-to-air and air-to-ground (terrain following/avoidance and mapping) modes and a slotted flat-plate antenna. Simultaneous tracking of 15 targets and engagement of

six are claimed. Applications: multi-mode X-band pulse-Doppler radar Range: 100km (head-on), 40km (tail-on) against 3m<sup>2</sup> RCS targets Operating platforms: Su-27

### N011M

The N011M is a multi-mode passive phased-array radar for advanced Sukhoi fighter variants, including Su-27M, Su-35, Su-30MKI. Air-to-air and air-to-surface modes are offered. Air-to-surface modes include terrain following, avoidance and mapping. Applications: multi-mode passive phased-array radar Frequency: 8-12GHz Range: 400km (AWACS-size target), 100km (head-on, 2m<sup>2</sup> target), 40km (tail-on 2m<sup>2</sup> target) Operating platforms: Su-27M, Su-35, Su-30MKI

### Osa

Osa is a lightweight, multi-mode phased-array radar, able to track and engage multiple targets simultaneously. Sources disagree on the numbers – some give it a 16-target TWS capability with simultaneous engagement of four, others say it can track eight targets and engage four, while yet others say it can detect eight targets, track four and engage two at the same time. Altitude coverage: 85km (head-on), 40km (tail-on) against 5m<sup>2</sup> RCS target. Applications: multi-mode phased-array radar Frequency: 8-12GHz Weight: 120kg

### SH121

The SH121 AESA airborne FCR is being designed for Russia's Sukhoi T-50 PAK-FA fifth-generation combat aircraft. The radar will be capable of simultaneous air and ground surveillance, multiple target engagement, possess target recognition and classification algorithms, and be able to perform communications and electronic attack functions. The X-band SH121 uses antennas located on the front and on the sides of the aircraft, together with L-band antennas located on the leading edge of the wings. Beyond the PAK-FA, this radar could be retrofitted onto legacy Russian Air Force Sukhoi Su-35UB/S jets. Applications: AESA radar Frequency: X-band (8.5-10.68GHz), L-band (2.3-2.5/2.7-3.7GHz)

### Zaslon

Reportedly the first phased-array radar to enter service on a fighter aircraft, Zaslon is the primary sensor of the MiG-31 interceptor. It is capable of detecting and tracking cruise missiles through ground clutter. Said to be able to track ten targets and engage four at the same time. Antenna is 1.1m in diameter and weighs 300kg of total 1,000kg weight. Altitude coverage down to 80ft. Applications: phased-array radar Frequency: 9-9.5GHz Weight: total 1,000kg Range: 300km against large airborne target (AWACS), 200km (bomber), 120km (fighter) Operating platforms: MiG-31 Antenna size: 1.1m

### Zaslon AM

Zaslon AM is a variant with upgraded data processing systems for all in-service MiG-31s. Applications: pulse-Doppler radar with passive electronically scanned array Frequency: 9-9.5GHz Operating platforms: MiG-31

### Zaslon M

Zaslon M is a further upgrade to the Zaslon series including the addition of a larger 1.4m-diameter phased-array antenna. Performance is reported to be 50-100 times better than the original, and it is reported to have



**The S-band Erieye is a long-range AEW&C radar that detects and automatically tracks air and surface targets across a large area. (Photo: Saab)**

hit a target 300km away with an R-37 missile. Tracks 24 targets at once, engages six. It also has an anti-tactical ballistic missile capability. Applications: Pulse-Doppler radar with passive electronically scanned array Frequency: 9-9.5GHz Range: 400km (20m<sup>2</sup> target) Operating platforms: MiG-31 BM Antenna size: 1.4m

## VEGA RADIO ENGINEERING CORPORATION

### E-801M

The X-band E-801 AEW&C radar equips the Kamov Ka-31 medium-lift utility helicopter. The radar can track up to 20 targets simultaneously and has a detection range of up to 150km for airborne targets, and up to 250km for large surface targets. Applications: AEW&C Range: 150km (airborne targets), up to 250km (large surface targets) Operating platforms: Ka-31 (Russian Navy 2 aircraft, Indian Navy 9 aircraft, 5 planned, PLAN 2 aircraft, 7 planned) Frequency coverage: X-band

### Shmel

The Shmel AEW&C radar is produced in four variants. The baseline version is an S-band system with up to 1MW of peak output power. The radar possesses frequency agility as an ECCM feature and can transmit low and high PRFs. The antenna has integrated IFF interrogator and data links. The radar performs mechanical azimuth scanning with electronic elevation scanning. Up to 60 targets can be tracked simultaneously, and the radar has a range of 150km. Shmel-2 is an enhancement of the baseline radar, with the addition of a digital computer and ability to track up to 150 targets simultaneously. It has a range of up to 230km for airborne targets and up to 400km for large surface targets. Shmel-2 equips the Russian Air Force's Beriev A-50M AWACS aircraft. Shmel-M was a modernised version of Shmel-2 with enhanced resistance to ECM. The design also increased the number of targets which it could track from 150 to 300. However, it is not thought that Shmel-M entered service. Shmel-2M is an export version of the Shmel-2 thought to incorporate several features developed for Shmel-M. This radar is believed to outfit the Beriev A-50E AWACS aircraft operated by the PLAAF in China. On 26 March 2014, the Russian Air Force received a third Beriev A-50U aircraft which has a Shmel-RM radar. This configuration

is thought to be an upgrade to Shmel-2, improving the ability to detect missiles and the radar's resistance to ECM. The Russian Air Force is thought to operate a total of 22 A-50M aircraft which are being upgraded to A-50U status with Shmel-RM. Applications: AEW&C Range: Shmel 150km; Shmel-2/2M 230km for airborne targets and up to 400km for large surface targets Power output: 1MW Operating platforms: Beriev A-50M (Russian Air Force 13 aircraft); Beriev A-50E (PLAAF 5 aircraft) Frequency coverage: S-band

## SURVEILLANCE AND MARITIME PATROL

### ARRAY SYSTEMS COMPUTING

#### SurSAR

The Surveillance SAR (SurSAR) system is a real-time, high-resolution, coherent X-band imaging radar for military and commercial applications. The SurSAR is derived from UPD-8/9 systems that were primarily used by USAF and USMC RF-4s. It combines a proven US military SAR with a COTS scalable generic processor that produces detailed images of stationary and moving targets at long ranges, recording them for in- or post-flight analysis. Its computer operates on the open-source Linux system. It offers touchscreen control of filters including special reduction, contrast enhancement etc, a moving map display with selectable resolutions, split-screen display modes with zoom, file-creation options and event markers, and playback for analysis of stored data. Applications: real-time, high-resolution, coherent X-band SAR imaging radar

#### TriSAR

The Tri-mode SAR (TriSAR) is a real-time, high-resolution SAR designed to meet land and maritime surveillance requirements. Configurations are available for fixed-wing aircraft, helicopters and UAVs. Its three imaging modes are strip map, ISAR and spotlight SAR. Missions include: maritime and harbour surveillance; ice surveillance; fisheries patrol; EEZ enforcement; border surveillance; search and rescue; environmental surveillance (such as oil slick detection); and battle damage assessment. Applications: real-time, high-resolution SAR Frequency coverage: 8-20GHz

### ASELSAN

#### Sarper

The Sarper SAR is capable of operation under all weather conditions. This enables radar imaging and moving target detection even in cloudy and rainy weather by day and night. Sarper supports strip map mode for wide-area imaging; spotlight mode for high-resolution imaging; GMTI mode; ISAR; sea search mode; and integration with manned and unmanned air vehicles. These features are tailored for the radar's use in reconnaissance and surveillance applications in the military field; and for post-disaster damage assessment and crisis management, city planning and mapping applications in the civilian field. The system provides high-resolution SAR images of the Earth's surface; onboard GMTI data and SAR image generation; and high-resolution image and GMTI mode on a wide area from a long

distance. Image data output is in STANAG 7023 format, while GMTI data output is in STANAG 4607 format. Applications: SAR Range: 40km Frequency coverage: X-band Operating altitude: up to 30,000ft

## GENERAL ATOMICS AERONAUTICAL SYSTEMS

### AN/APY-8 Lynx Block 20A

The Lynx Block 20A is a high-resolution wide-area surveillance Ku-band SAR/GMTI radar with intelligence analysis and targeting capabilities. It features multiple Synthetic Aperture Radar (SAR) image modes, fast scan Ground Moving Target Indicator, maritime and dismount capabilities that drive exploitation and tracking applications for demanding operations. Capabilities include dismount detection, change detection, precision targeting, near all-weather target classification and tracking. The radar is slated for multiple airframe configurations, including manned and unmanned fixed-wing systems and supports rotary-wing and airship use. Options: Claw payload sensor control and data exploitation software provides multi-sensor, multi-mode controls and databasing, along with advanced radar and optical sensor image exploitation processing. Power: 28V DC, <1,000W peak, 300W average Weight: 52kg Max range: SAR in clear weather in excess of 80km Maritime mode: up to 100km with a 270° field of regard Platforms: UAVs, airships GMTI mode range: up to 30km with a 270° radar field of regard

### AN/DPY-1 Lynx Block 30

The multi-mode AN/DPY-1 Lynx Block 30 is a reduced weight, power and volume variant of the AN/APY-8. It is a high-resolution, wide-area surveillance Ku-band SAR/GMTI radar with intelligence analysis and targeting capabilities. Lynx Block 30 has multiple SAR image modes, fast-scan GMTI and maritime capabilities that drive exploitation imaging and tracking applications for demanding operations, claims the company. Capabilities include change detection, precision targeting, near all-weather target classification and tracking. Lynx Block 30 has been ruggedised to meet demanding battlefield environments, with enhanced reliability and maintainability. It has been certified and approved for export. The radar is operational on multiple airframe configurations, including manned fixed-wing systems and supports rotary-wing and airship use. Options: Claw payload sensor control and data exploitation software provides multi-sensor, multi-mode controls and databasing, along with advanced radar and optical sensor image exploitation processing. Power: 28V DC, <1,000W peak, 300W average Weight: 37kg SAR range: >80km in clear weather Maritime mode: 100km with a 270° field of regard Platforms: Remotely Piloted Aircraft (RPA) GMTI mode range: 30km with a 270° radar field of regard

### Lynx

Lynx is a high-resolution SAR with GMTI, dismount MTI (DMTI) and maritime capability. Operating in the Ku-band, it produces 'photographic-quality' imagery with selectable resolution. A combat-proven system, it offers change detection capability, Synthetic aperture, spotlight and strip-map modes are available, along with arc scan and spot scan GMTI and DMTI. Designed for use on manned and unmanned systems, including

aerostats, it is approved by the US government for export to NATO and coalition forces. It offers synthetic aperture resolution of about 3m and range greater than 80km, with a GMTI range of 23km and DMTI range of 17km. The antenna measures 44.5x16.5cm, and the electronic module 51.4x29.6x26.7cm and the whole system weighs 37kg. The Block 20A version offers a range of up to 100km and weighs 52kg. The Block 30 offers the same performance as Block 20 in a smaller (37kg) package. It is offered with Claw payload control and data mining software. In 2014 it was tested aboard the Predator B/MQ-9 Reaper UAV surrogate (King Air 350 aircraft) during Exercise Spearhead II in Florida and is expected to be installed on Predators ordered by Spain in February 2016. It will also be on UAE and Italian Predator UAVs once those orders are finalised. Weight: 37kg, 52kg (Block 20A) Range: 80km (SAR), 23km (GMTI), 17km (DMTI) Antenna dimensions: 44.5x16.5cm SAR Resolution: 3m Frequency coverage: Ku-band Operating platforms: Predator B/MQ-9 Reaper UAV

### Predator B DDR

The Due Regard Radar (DRR) is an air-to-air radar being developed under company funding to meet the requirements envisioned to enable RPAs to fly in international airspace. The DRR consists of a two-panel AESA antenna and a radar electronics assembly (REA) that give the RPA pilot the ability to detect and track aircraft across the same FOV as a manned aircraft. AESA technology allows DRR to track multiple targets while simultaneously continuing to scan for new aircraft. Flight tests of a pre-production DRR are under way on both a manned aircraft and a Predator B RPA. DRR is a key component of GA-ASI's overall airborne detect and avoid (DAA) architecture for Predator B. The DAA system must detect and avoid cooperative (ie aircraft equipped with a transponder) and non-cooperative (ie aircraft not equipped with a transponder) aircraft. Detection and tracking of cooperative aircraft is performed by TCAS and ADS-B. By tracking non-cooperative aircraft, DRR enables a collision avoidance capability on board the RPA and allows the pilot to separate the aircraft from other air traffic in cooperation with ATC. GA-ASI is currently partnered with the FAA, NASA and several industry partners to mature a DAA capability on board NASA's Ikhana RPA. The FAA is developing a collision avoidance algorithm specifically for RPA, called ACAS XU, which uses the GA-ASI DRR to detect and track non-cooperative aircraft. Platforms: UAVs, airships

## HARRIS ELECTRONIC SYSTEMS

### Airborne CMMR

The Airborne Compact Multi Mode Radar (CMMR) is a small, lightweight, lower-price version of the mature X-band radar system originally designed by ELTA (EL/M-2022). Harris and ELTA have teamed up to manufacture and provide technical and logistics support in the USA. CMMR is primarily intended for operation on helicopters and UAVs. The CMMR's receiver processor is in use worldwide as a component on several airborne radar products. Applications include military operations: periscope detection, fleet protection; intelligence operations: coastal surveillance and intelligence-gathering; homeland defence: law enforcement, anti-drug smuggling, illegal immigration, pollution spills, shipping control, ice patrol. SAR. Modes: GMTI - detection

and display of moving targets on top of SAR image or on a geographical map; selective moving target indication - detection and display of moving targets on top of SAR image at sea; surface search - detects targets to 370km range in all sea states; spot SAR - high resolution imaging of a ground area of interest; strip SAR - produces a continuous image up to 65km wide; inverse SAR - used to identify and classify ships by creating an image, corrected for aspect; ground target track - accurate tracking of stationary and moving targets of interest; circular SAR - used to create an image of ships in calm waters; range signature - displays target outline features during normal search; air-to-air - detection and tracking of aircraft to 800kt; nav/weather - real-beam mapping and four-colour weather plus turbulence. Platforms: UAVs and helicopters

### Airborne MMR

The Airborne Multi Mode Radar (MMR) is a mature X-band radar system originally designed by ELTA (EL/M-2022). Harris and ELTA have teamed up to manufacture and provide technical and logistics support in the US. Over 100 radars are operational worldwide on over 15 aircraft types - fixed-wing, rotary-wing and unmanned - in over 15 countries. Modes: GMTI - detection and display of moving targets on top of SAR image or on a geographical map; selective moving target indication (SMTI) - detection and display of moving targets on top of SAR image at sea; surface search - detect targets to 370km ranges in all sea states; spot SAR - high resolution imaging of a ground area of interest; strip SAR - produces a continuous image up to 65km wide; inverse SAR - used to identify and classify ships by creating an image, corrected for aspect; ground target track - accurate tracking of stationary and moving targets of interest; circular SAR - used to create an image of ships in calm waters; range signature - displays target outline features during normal search; air-to-air - detection and track of aircraft to 890kt; nav/ weather - real beam mapping and four-colour weather plus turbulence. Platforms: UAVs

### AN/APY-11

The AN/APY-11 multi-mode radar performs 360° azimuth surface surveillance, classification and SAR imaging. The multi-mode radar automatically detects and tracks targets including signals from emergency beacons (SART). The radar also integrates with IFF transponders, ADS-B and AIS. It can provide cueing for EO and IR payloads. The system tracks up to 5,000 targets up to an instrumented range of 370km. A resolution of better than 1m, using inverse SAR, spot SAR and strip SAR modes, allows imagery of ships to be gathered for classification purposes, while the radar itself can cover a surface area of up to 685km<sup>2</sup>. Using the strip function, the radar can generate maps 55km in width. The AN/APY-11 offers near instantaneous mode change and automatically configures each selected mode for optimum performance. Air targets, including helicopters and aircraft moving at up to M=1.4, can be tracked using look-up or look-down surveillance mode, depending on the installation. In May 2013, Harris was awarded a \$6.5 million contract to integrate the AN/APY-11 with the Minotaur mission processor. The Minotaur system suite will equip Lockheed Martin HC-130J aircraft in USCG service. The radar is also installed on board P-3 Orion and Dornier 328 maritime patrol aircraft. The radar has been ordered for National Oceanic and Atmospheric Administration WP-3D Orion

aircraft with deliveries expected in 2017. Applications: SAR Range: 370km Operating platforms: HC-130J, P-3, Dornier 328 Azimuth: 360°

## IAI ELTA SYSTEMS

### ELI-3360 G5000 MPA

The ELI-3360 G5000 MPA is a long-range multirole MPA solution that is designed to provide a comprehensive multi-mission all-weather solution for EEZ and long-range maritime security, ASW, anti-surface warfare, environmental control and search and rescue, designed to fit the high-end class of business jets, such as the Bombardier Global 5000. The ELI-3360 G5000 MPA mission suite produces intelligence and situation awareness for maritime arena management, battle management and weapon fire control. The processed information is disseminated to onboard operators and C2 centres over network-centric data links. The ELI-3360 G5000 MPA provides capabilities to operate at altitudes of 42,000ft, climb performance, quick reaction time and deployment, endurance at ranges over 11,100km, and a mission cabin designed to be comfortable. The base version has a length of 29.5m, wing span of 28.7m, height of 7.7m, and wing area of 94.9m<sup>2</sup>. Applications: long-range multirole MPA Range: 9.630km

### ELM-2022A

The ELM-2022A is a maritime surveillance radar family which can be used for long-range surveillance and ASW, navigation and weather, maritime moving target indication, Doppler beam sharpening, SAR, ISAR and range profile classification and beacon interrogation. Specific tasks the radar system is design to perform include littoral warfare operations, maritime surveillance and patrols in EEZs, anti-drug enforcement operations, coast guard and fisheries patrol and location and SAR. Its modular hardware design, flexible avionics interfaces and antenna design enable installation in a variety of fixed- and rotary-wing aircraft. These include VANTs, helicopters, transport aircraft and business jets. The system features low false alarm rates, TWS of up to 100 targets, expand and freeze, sector/full scan, detection and track accuracies compatible with EO systems and ECCM with a low probability of intercept and low sidelobe levels. Its operational features include IFF interrogator compatibility, control interface to EO systems, integrated radar and optical sensor video display and different video interface standards. The ELM-2022A also has growth potential with spare memory space and computing power as well as different video interface standards. On 23 October 2017, it was announced that IAI had been contracted by Airbus Defence and Space to supply ELM-2022A radars to equip the 16 C-295 maritime surveillance aircraft being purchased from Airbus by the Canadian government for SAR operations. Weight: 100kg MIL Standards: MIL-STD-1553B, RS422 Azimuth: 360° Power consumption: 115V

### ELM-2022ES

The ELM-2022ES is airborne maritime surveillance radar produced by IAI. The radar is designed to accommodate fixed-wing MPAs, maritime support helicopters and UAVs. The radar performs mechanical horizontal scanning and electronic vertical scanning. It can generate both SAR and ISAR imagery. It also includes a GMTI. The ELM-2022ES's range is in the region of 370km. In addition to its SAR, ISAR and GMTI modes, the radar gathers navigation and

meteorological information and comes equipped with an integral AIS interrogator to determine civilian vessel identity, and also an IFF interrogator to determine the identity of military platforms. Applications: X-band multi-mode radar Weight: 120kg Range: 370km

### ELM-2022H

The ELM-2022H is the helicopter maritime patrol radar variant of the ELM-2022 family. Operating modes are: sea mode provides detection of small to large ships with automatic tracking of detected targets; classification mode performs range signature and inverse synthetic aperture imaging with automatic classification to class; imaging mode offers spot synthetic aperture imaging for littoral surveillance (performance dependent on platform velocity); air mode for detection and tracking of airborne targets; and navigation/weather mode allows beam mapping and generates four-colour weather avoidance display. Applications: maritime surveillance and EEZ patrol, maritime law enforcement and fishery patrol, search and rescue location and support, air-to-air surveillance, air-to-ground (SAR and GMTI) intelligence, ISR Weight: 85kg Power output: 3kW

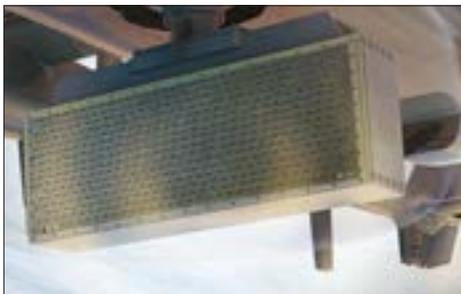
### ELM-2022ML

The ELM-2022ML is a lightweight X-band maritime airborne surveillance radar from the ELM-2022 family. The SAR has been designed to carry out missions by both day and night and in all weather conditions. According to the company, modular hardware, flexible interfaces and antenna design enable the ELM-2022ML radar, which consists of two LRUs, to be installed on a range of fixed- and rotary-wing, manned and unmanned aircraft, including small platforms for which the installation of the standard ELM-2022 system may not be possible. Operational missions include: maritime surveillance and EEZ patrol; coast guard drug enforcement and fishery patrol; air-to-air surveillance. Features include an Advanced Radar Operational System, automatic tracking of all targets, strip and spot SAR imaging and GMTI as support for ISR ground operations. Applications: maritime airborne surveillance radar Weight: 50kg Power consumption: 1KW Frequency coverage: X-band

### ELM-2022U

The ELM-2022 maritime patrol radar system consists of a UAV payload and a ground operator station that

**The ELM-2022ES is an airborne maritime surveillance radar that performs mechanical horizontal scanning and electronic vertical scanning. (Photo: IAI Elta Systems)**



controls the radar's operation and processes the data sent by the payload via the UAV's data link. The ELM-2022U is designed to provide a cost-effective force multiplier for: support of surface and littoral warfare; maritime surveillance and EEZ patrol; drug interdiction and prevention of illegal immigration and terrorist activities; coast guard and fisheries patrol; IMINT; and SAR location and support. The ELM-2022U supports automatic detection and tracking of maritime surface targets at all speeds and produces high-quality radar images. It operates as an all-weather, day and night sensor capable of penetrating clouds, rain, smoke, smog, fog and man-made camouflage. Weight: 75kg Platforms: UAVs

#### ELM-2054

ELM-2054 is a lightweight SAR/GMTI sensor for small tactical UAVs and similar applications, providing a solution for all-weather, air-to-surface ISTAR applications from manned or unmanned airborne platforms. The ELM-2054 can be configured for a range of platforms, from UAVs, ultra-light reconnaissance aircraft to tactical aerostats. Applications include surveillance, BDA and target acquisition, protection of borderlines and key facilities, anti-terror warfare, counter-narcotics and smuggling prevention and monitoring of disaster areas. Applications: lightweight SAR/GMTI sensor Weight: 10-15kg Range: 12km

#### ELM-2055 SAR/GMTI

The ELM-2055 provides all-weather, all-visibility, air-to-surface ISTAR for manned and unmanned airborne platforms. Together with the ELS-8994 GES, the ELM-2055 can be used for applications such as ISTAR, protection of borders and strategic assets, counter-terror/ smuggling/narcotics, cartography, forensic investigation and disaster relief operations. Features include real-time SAR imagery for wide-area surveillance and high-resolution SAR spot for stationary target classification; GMTI capabilities including persistent surveillance over large areas and detection and tracking of a range of target types; standoff ranges of up to 60km; facilitating covert operations. Power: 800W Weight: 50-58kg Platforms: tactical and MALE UAS, light reconnaissance aircraft and tethered aerostats

#### ELM-2060P

The ELM-2060P is a SAR/GMTI reconnaissance system for combat aircraft with three basic operating modes. Strip mode provides fast coverage of large areas at stand-off ranges plus overall assessment of a region with sufficient mapping detail for target detection; spot mode provides detailed examination of a designated area of interest with high resolution for target classification; and strip/GMTI mode allow moving targets to be highlighted on top of the strip SAR image. The ELM-2060P consists of a detachable pod containing a SAR with CTI indication, a data link and a ground exploitation station. Applications: SAR/GMTI reconnaissance system Weight: 590kg Range: >170km

#### ELM-2060T

The ELM-2060T is a SAR/GMTI reconnaissance system for transport aircraft offering strip, spot and strip/GMTI modes. Strip mode provides fast coverage of large areas at stand-off ranges and overall assessment of a region with sufficient mapping detail for target detection. Spot mode enables detailed examination of a designated area of interest with high resolution for target

classification. In strip/GMTI mode, moving targets are highlighted on top of the strip SAR image. An airborne exploitation station provides two or more onboard operator consoles. A ground exploitation station (in a fixed installation, transportable shelter or customised configuration) provides data processing and automatic and/or computer-aided tools for data exploitation and intelligence reporting. The system consists of an airborne radar sensor with an online signal processor, airborne exploitation station, a ground exploitation station and a bi-directional data link. Applications: SAR/GMTI reconnaissance system

#### ELW-2085 CAEW

The ELW-2085 is Elta's third-generation Conformal Airborne Early Warning and Control (CAEW) system. It is mounted on a modified Gulfstream G550 business jet. Elta's integrated sensor suite, with its communications system, supports missions such as long-range air surveillance, airborne C4I for air and naval operations, airborne C2 post, and net-centric warfare operations/communication node. The low-drag conformal installation on the G550 enables higher loitering altitudes for long-range detection of low-altitude targets. The CAEW integrates the data of the onboard sensors – radar, IFF, ESM/ELINT, communication support measures/COMINT and radar warning receiver – with the theatre situation picture via high-capacity multiple data links. The ELW-2085 has L-band and S-band antennas, with the former being fitted conformally to the sides of the aircraft's fuselage, and the smaller latter equipping the aircraft's nose and tail to provide 360° coverage. On 19 December 2016, it was announced that the first of two CAEW aircraft had been delivered to the Italian Air Force, with the second due to be delivered in 2017. Applications: CAEW system Operating platforms: G550 Frequency coverage: L-band, S-band

## LEONARDO AIRBORNE & SPACE SYSTEMS

### Gabbiano

The Gabbiano family is a range of X-band radars for surveillance over ground, along coasts and at sea, in all weather conditions. The radar supports a range of missions: homeland surveillance against drug trafficking, smuggling, illegal immigration and terrorism; EEZ protection; environmental surveillance (oil and hazardous material spills, wildlife protection); maritime patrol and search and rescue operations; combat search and rescue; support of covert operations by special forces (day, night and all-weather). The Gabbiano family's modularity and flexibility allow integration on UAVs, as well as fixed- and rotary-wing manned platforms. The two basic configurations (T20 and T200) are available with nose- or belly-mounted antennas, providing ±90° and 360° surveillance. Features: low weight, low power consumption; LPI capability; TWS >200 targets; ECCM capabilities (frequency agility, jammer avoidance etc); digital/programmable waveform generator; small blind zone; high-resolution modes (ISAR, spot SAR, strip SAR); maritime surveillance, up to 400km; SAR; MTI modes; weather detection and avoidance; beacon modes (SST-181X, DO-172, SART); standard and flexible interfaces. Leonardo states it completed flight trials of its Gabbiano T-20 radar on board its Falco UAV in Bulgaria. In February 2013, the company completed tests to evaluate the radar's strip and spot synthetic aperture performance.

TWS, plus its maritime surveillance and ground mapping capabilities. In June 2015 the company announced that T20 systems had been ordered for KC-390 transport aircraft for the Brazilian Air Force. In September 2014, the TS-80 Plus was introduced as the latest member of the Gabbiano product line. This radar can perform SAR and ISAR imaging. It has a range of 410km and is capable of detecting up to 200 targets simultaneously. The total weight for the TS-80 is 44kg. Applications: family of X-band radars for surveillance over land, sea and coasts in all weathers Weight: 28-62kg depending on system and antenna size Frequency coverage: X-band MTBF: 1,600h T20, 900h T200 Operating platforms: KC-390, Falco UAV

### Gabbiano TS Ultra-Light

The Gabbiano TS Ultra-Light (UL) is Leonardo's latest surveillance radar for unmanned aircraft. The multi-mode, multi-mission, mechanically scanning radar is Leonardo's lightest surveillance radar. Its compact size and reduced weight make it suitable for integration onto mini-class UAVs, such as the Hero, as well as small fixed- and rotary-winged aircraft. The new radar weighs less than 24kg whilst retaining the suite of Gabbiano family modes. Modes include optimised maritime patrol and SAR capabilities (small-target, high-sea-state detection and automatic, long-range non-cooperative sea target recognition) as well as high-resolution ground mapping with strip and spot SAR modes, GMTI, weather avoidance and air-to-air search and track capabilities. The Gabbiano TS UL can also work with an AIS and cue EO sensors. The radar system comprises just two units, a 30cm nose antenna and a separate receiver/transmitter processor. The Gabbiano family has been selected by 12 international customers and equips aircraft ranging from unmanned vehicles such as the Hermes 450, Hermes 900 and Falco EVO to helicopter including the AW139 and AW101 and fixed-wing vehicles such as the KC-390, King Air 350 and ATR42MP. Applications: surveillance Weight: 24kg Operating platforms: Hero unmanned rotorcraft, other small UAS Antenna dimensions: 30cm

### HEW-784/APS-748E

The X-band HEW-784/APS-748E is a pulse-Doppler surveillance radar designed for the AEW&C version of the Leonardo AW101 helicopter used by the Italian Navy. It can perform 360° surveillance and has an integral IFF interrogator. When operating in air-to-air mode, the radar can track around 128 targets, with up to 64 being tracked when the radar is performing surface surveillance. Applications: AEW&C Operating platforms: AW101 (Italian Navy) Frequency coverage: X-band

### MM/APS-784

The MM/APS-784 is a maritime search radar for the Italian Navy's AW101, originally designed and manufactured by Eliradar, a consortium set up by FIAR and Officine Galileo. It is designed to detect small objects such as submarine periscopes against heavy sea clutter, rain and ECM. Modes: ASuW and ASuW long-range (including missile launch assistance); ASW (periscope detection); weather avoidance; short-range detection and navigation. It features: pulse compression; pulse-to-pulse frequency agility; adaptive jammer avoidance; multiple-target TWS; and scan-to-scan integration. Antenna: parabolic with 360°, 2m radome. Transmitter: coherent TWT. Display: can feed digital MFDs. Two separate digital scan converters for video displays, different formats and orientations can

be presented on each, integrated IFF. Modules: fits into the aircraft as four separate LRUs. Interfaces: MIL-STD-1553B, multiple video outputs in MIL-STD-3350B format. Frequency coverage: X-band

### PicoSAR

The PicoSAR AESA radar provides an all-weather capability for UAVs, fixed-wing aircraft and helicopters. Installed on Camcopter S-100 rotary UAV and has been flown on ASS-355 Twin Squirrel helicopter. Using many low-power, solid-state T/R modules within its array, it is more reliable than conventional radar systems. The flexibility of AESA technology also allows the antenna to be resized to address specific platform constraints. Applications: AESA radar all-weather capability for UAVs, fixed-wing aircraft and helicopters Length: 9cm antenna, 13cm processor Width: 31cm antenna, 20cm processor Height: 22cm antenna, 20cm processor Weight: 10kg Range: 20km Resolution: spotlight mode images at a resolution of <1m at >10km Frequency coverage: X-band

### PicoSTAR

The PicoSTAR (Surveillance, Targeting And Reconnaissance) is designed to provide a compact, lightweight integrated AESA radar and EO capability for UAVs and other small fixed- or rotary-wing platforms. Twin AESA modules can be mounted up to 2m away from the central EO/processing unit to enable integration on different platform configurations. The EO subsystem uses a Swan II dual-mode imaging sensor together with a conventional zoom/e-zoom TV sensor.

### Seaspray 5000E

The Seaspray 5000E multi-mode surveillance radar is the lightest member of the Seaspray AESA radar family and employs the same common processor, coupled with a compact AESA antenna covering air-to-surface/air-to-air environments. Seaspray 5000E radars are installed in fixed- and rotary-wing platforms, for manned and unmanned operations, and are in operational service globally. The radar's technology minimises the impact of transmitter failure by removing the single point failure, the high-power, relatively low-MTBF LRU. This is replaced by many T/R modules with high MTBFs within the antenna array. At the centre of the radar design is the ability to tolerate individual item failure. Component failures within the array result in gradual performance degradation rather than complete system failure. In 2015, the company (then known as Selex) was awarded a contract from Cobham Aviation Services in Australia for the supply of its Seaspray 5000E radars. Cobham will use the radars to equip CL-604 Challenger aircraft for search and rescue operations with the Australian Maritime Safety Authority. Applications: surface surveillance, navigation, beacon detection and target imaging/classification Weight: 48kg Detection range: 370km Operating platforms: manned/unmanned aircraft MTBF: ~2,000h

### Seaspray 7000E

The Seaspray 7000E is an AESA radar for helicopters, fixed-wing aircraft and UAVs. It combines AESA with a COTS-based processor to deliver a range of surveillance capabilities covering air-to-surface, air-to-air and air-to-ground environments. The radar has ISAR, SAR, GMTI and other surveillance modes. Azimuth coverage uses a combination of electronic and mechanical scanning, while elevation scanning is all-electronic. The Seaspray

7000E features multiple low-power, solid-state T/R modules and the use of composite mechanical and electronic scanning enables performance in detecting small targets, such as fast inshore attack craft in high sea states. The UK RN was the launch customer, selecting the Seaspray 7000E for integration into the AW159. Applications: land, sea and air surveillance Scan rate: 360° Weight: 86kg Range: 370km (590km weather mode) Operating platforms: UK AW159 and other helicopters, fixed-wing aircraft and UAVs MTBF: 2,000h Frequency coverage: X-band

### Seaspray 7500E

The Seaspray 7500E multi-mode surveillance radar combines an AESA with a COTS processor, covering both air-to-surface and air-to-air environments and providing a 'leading edge' capability. Seaspray 7500E is an LPI radar with high gain and low sidelobes. It uses composite electronic and mechanical scanning to detect small targets such as fast inshore attack craft. Selected by customers in Ecuador, Italy, the UK and the US. Applications: multi-mode surveillance radar Height: 56cm Weight: 110kg Range: 592km MTBF: 2,000h

## LEONARDO DRS

### AN/APQ-170

The AN/APQ-170 is a multi-mode radar fitted to USAF MC-130H Combat Talon II special operations aircraft, used for terrain following/avoidance, weather mapping and avoidance, navigation and beacon interrogation. The radar allows aircraft to safely operate at altitudes as low as 250ft in adverse weather conditions. Applications: multi-mode radar Operating platforms: USAF MC-130H Combat Talon II Frequency coverage: I- and J-bands

### AN/APQ-175

The AN/APQ-175 is a dual-band radar at the heart of the Adverse Weather Aerial Delivery System fitted to USAF C-130 Hercules transports. As well as being able to image major terrain features and man-made structures, it is used for long-range and precision ground mapping, weather detection and beacon interrogation/reception. Applications: dual-band radar Operating platforms: C-130 Frequency coverage: I- and K-bands

## LOCKHEED MARTIN

### Advanced Imaging Radar System

The Advanced Imaging Radar System is a SAR developed from the ASARS-1 sensor used in the SR-71. Offers swath, fixed or moving target indication and navigation modes. Applications: radar offering swath, fixed or moving target indication and navigation modes Range: 185km

### AN/APS-145

The AN/APS-145 is a high-power UHF Doppler radar fitted to the Northrop Grumman E-2C Hawkeye-2000 AEW&C aircraft. Can be fitted to C-130 transport aircraft. The radar has a range of around 550km and can track 20,000 targets simultaneously. The AN/APS-145 uses a rotating antenna within a circular radome mounted atop the aircraft to detect and track multiple threats on the sea, in the air, over land and at the critical land-sea interface simultaneously. It maintains operation in high-clutter conditions when it automatically selects the clearest operating frequency.

A triple-PRF feature allows for continuous detection of all targets over the entire tactical area. Applications: UHF Doppler AEW&C radar Range: 500km Operating platforms: E-2C Hawkeye-2000 (French Navy - 3 aircraft; Japan Air Self Defence Force - 13 aircraft; Republic of China Air Force - 6 aircraft); E-2C Hawkeye 2000 (USN) Frequency coverage: UHF (420-430/890-942MHz)

### ASARS-3

Advanced Synthetic Aperture Radar System (ASARS-3) is a 75kg payload providing Ku-band SAR and GMTI capabilities for high-altitude and medium-range operations, used in conjunction with EO/IR full-motion video, target identification and tactical surveillance. An earlier version of the system is carried by U2 reconnaissance aircraft and this new version may be installed. Applications: airborne surveillance and maritime patrol Weight: 75kg Frequency coverage: Ku-band

### L-88(V)3

The L-88(V)3 is the latest variant of a family of radars developed for use in aerostats for coastal surveillance. Uses commercial technology to improve performance and reduce weight. The 8.8m radar antenna rotates within a fabric windscreen to provide 360° coverage. In 2002 the company was awarded a \$79 million contract to provide L-88(V)3 radar systems to the USAF Air Combat Command's Tethered Aerostat Radar System (TARS) along the southern border of the US and the system may also be in service with Pakistani forces. Applications: aerostat-borne coastal radar Range: 370km Frequency coverage: I-2GHz

### STacSAR

The Small Tactical Synthetic Aperture Radar (STacSAR) was developed for use on UAVs or small manned aircraft. Applications: light tactical radar for UAVs and small manned aircraft Range: 10km Frequency coverage: 17GHz

## NORTHROP GRUMMAN

### AN/APN-241

The AN/APN-241 is a high-resolution ground mapping radar developed for C-130 mission and operational requirements. It enables accurate low-level navigation and precision aerial drops, predictive windshear detection in all weather conditions, and situation awareness for all-weather formation flying. Fielded on C-130H, C-130J, C-27J and C295 transport aircraft. Applications: high-resolution ground mapping radar Frequency coverage: 8-10GHz

### AN/APQ-156

The AN/APQ-156 is a multi-function tactical radar fitted to USN and USMC EA-6B Prowler EW aircraft. Capable of search mapping, targeting, terrain following, terrain avoidance and beacon tracking. It is a member of the same family as the AN/APQ-148 and AN/APS-130. Applications: multi-function tactical radar Frequency coverage: 10-20GHz

### AN/APQ-164

The AN/APQ-164 phased-array multi-mode pulse-Doppler offensive radar system is integrated into USAF B-1B strategic bombers. Performs navigation, terrain following/avoidance and weapon delivery functions.

along with GMTI, beacon interrogation and air refuelling rendezvous. The USAF awarded Northrop Grumman a \$65 million Reliability and Maintainability Program (RMIP) base contract in September 2010 for 22 modification kits, along with test benches, spares, repairs, and technical data and services. Options worth an additional \$95 million have since been awarded for another 38 kits. The RMIP replaces two LRUs in the B-1's AN/APQ-164 radar to improve its reliability and maintainability. Applications: phased-array multi-mode pulse-Doppler offensive radar system Frequency coverage: 8-10GHz

### AN/APS-504(V)

The AN/APS-504(V) is a multi-mode maritime patrol radar with surface search, ASW, ground-stabilised search, weather and weather contour and beacon modes. TWT transmitter features frequency agility, two SAW-based pulse compression modes, three pulse modes. System offers selectable CFAR processing, pulse-to-pulse integration, selectable scan-to-scan integration and sector scanning plus multiple (20-target) TWS capability. The parabolic or high-performance flat plate antenna is stabilised on two axes. The radar is in service on CN235 MP Persuader MPAs operated by Irish, Spanish and Turkish forces. Applications: multi-mode maritime patrol radar with surface search, ASW, ground-stabilised search, weather and weather contour and beacon modes Range: 370km Frequency coverage: 8.9-9.4GHz (9.345GHz in weather mode, Tx 9.375GHz, Rx 9.310GHz in beacon mode) Pulse repetition frequency: 320-2.230pps depending on mode

### AN/APY-3

The AN/APY-3 is a large phased-array ground surveillance SLAR with SAR/MTI capability. It is the primary sensor of the USAF/US Army Joint Surveillance Target Attack Radar System in the E-8A, a converted Boeing 707. Frequency: 8-10GHz. Operating modes: MTI wide area surveillance, MTI sector search, SAR fixed target indication. The Radar Technology Insertion Program will add a more powerful radar, higher resolution and concurrent SAR and MTI modes. The system can detect ground targets at more than 250km and can cover 1,000,000km<sup>2</sup> in an eight-hour sortie. Applications: large phased-array ground surveillance SLAR with SAR/MTI capability Range: >250km Frequency coverage: 8-10GHz

### AN/ASQ-236

The AN/ASQ-236 SAR pod can be used to assist cartography, generate bomb damage assessments, and perform general day and night surveillance. The pod outfits the USAF's F-15E Strike Eagle combat aircraft. On 18 March 2013, Northrop Grumman was awarded a \$30 million contract to support the firm's AN/ASQ-236 radar pod. Several aspects of the system, including the number in the USAF inventory, remain classified. Moreover, the exact specifics of the work that Northrop Grumman will undertake on the pod have not been revealed, although this work was expected to be completed by March 2016. Applications: SAR pod Length: 3.3m Width: 0.5m Height: 0.5m Weight: 454kg Operating platforms: F-15E

### AN/ZPQ-1 TESAR

The AN/ZPQ-1 Tactical Endurance SAR (TESAR) lightweight SAR and associated ground station provides continuous imagery on board the Predator Tier II UAV. TESAR was first deployed in a peacekeeping mission in Bosnia in 1996 and was also used over Kosovo and other

locations. Applications: tactical lightweight SAR Weight: 75kg Frequency coverage: 10-20GHz

### AN/ZPY-1 STARLite

The AN/ZPY-1 Small Tactical Radar-Lightweight (STARLite) is a SAR/GMTI sensor for UAVs and manned platforms that support tactical operations. It is under contract to US Army Communications and Electronics Command for its MQ-1C Gray Eagle programme. Weighing 30kg, it offers strip and spot SAR modes as well as GMTI, with maritime MTI capability under development. It occupies 0.03m<sup>3</sup> of volume and draws less than 750W of power. In November 2012, it was reported that the AN/ZPY-1 would be integrated onto the Navmar Applied Sciences TigerShark UAV, which is used by the USN and US Special Operations Command. It has also been tested on MQ-8C Fire Scout rotary UAVs. Applications: light tactical radar for UAVs and small manned aircraft Weight: 30kg Power consumption: >750W

### AN/ZPY-5 VADER

The Vehicle and Dismounted Exploitation Radar (VADER) is being developed for use with the Sky Warrior UAV to enable accurate GMTI data and SAR imagery to be made available to ground commanders in real time. The antenna is designed to support multiple missions, including detection of dismounted personnel, and to facilitate exploitation of this data. In 2013, Northrop Grumman was awarded a sole-source contract operation of the VADER. The US Army's contract required the company to continue its support of two forward-deployed VADER systems in use in Afghanistan, and a single system operating in the US up until the end of the year. VADERS deployed to Afghanistan are flown on board conventional fixed-wing aircraft. Northrop Grumman won the contract to develop the VADER radar in 2006, completing flight tests in February 2010. Details regarding the performance of the VADER are scant. No information has been released regarding the system's range, resolution, wavelength or the inhabited platform that it equips. Applications: radar for tracking smaller ground targets such as vehicles and people

### OPTIMARE

#### Optimare SLAR

The Optimare Side-Looking Airborne Radar (SLAR), unveiled in June 2015, is used to detect oil spills from long ranges, find maritime targets, perform surveillance of fishing activities and detection and mapping of speedboat wakes. The lightweight wideband, cloud-penetrating radar can be used for detection and mapping of maritime areas. Available as a standalone system or as part of the Aerodata OctoPod, it has a swath width of 60-80km. Applications: lightweight airborne radar Length: 3.31m (antenna), 0.4m (transceiver) Width: 0.07m (antenna), 0.37m (transceiver) Height: 0.15m (antenna), 0.14m (transceiver) Weight: antenna 16kg, 2 required per system; transceiver 13kg Frequency coverage: 9.41 ±0.03GHz (X-band) Operating altitude: 1,000-6,000ft

### PHAZOTRON NIIR

#### Gukol 4

The Gukol 4 is a weather, navigation and terrain-avoidance radar for military transport aircraft. Applications:

weather, navigation and terrain-avoidance radar Range: 600km Frequency coverage: 8-10 or 20-40GHz

### Kopyo-211

The Kopyo-211 is a multi-mode radar fitted to Indian MiG-21Bis UPG strike fighters. Phazotron describes it as a fourth-plus generation radar that meets the requirements of the latest light multi-role combat aircraft. It is the first in a new modular family that includes the Kopyo-25, Kopyo-A and Kopyo-M. Applications: multi-mode radar Range: 200km for destroyers

### Kopyo-A

The Kopyo-A is a multipurpose 360° radar intended for helicopters and designed for coastal monitoring, search and detection of sea surface and ground targets, including small targets (boats, cutters, periscopes); search and detection of air targets; identification and tracking of up to ten targets; weather mapping and avoidance. Candidate for upgrade of Indian Navy Ka-28s and believed to be installed on Russian Navy's Ka-27 naval helicopters. Weight: >100kg Range: 250km

### Kopyo-M

The Kopyo-M is similar to Kopyo-211, but due to modifications including a new signal processor, its detection range against air targets is 25% greater, as it generates maps in SAR mode in half the time, says the company. Phazotron also claims greater reliability, lower weight and smaller size, and offers it for a further upgrade of the MiG-21Bis and similar aircraft. Believed to be installed on Yak-130 light attack aircraft. Applications: multi-mode, steered array antenna radar optimised for air-to-air Range: 80km for target Ssq m, 150km for destroyers

## RAYTHEON

### An Series

The AN Series of radars from Raytheon include Linear FM, fixed or agile ASW and ASuW radars derived from the AN/APS-137 which was installed on the P-3 aircraft. They are designed for the detection of periscopes exposed for under 5s. The modes for the series include: periscope and small target, surface surveillance, navigation and weather alert. The image antenna is stabilised, with 360° scan, six, 60 and 300rpm sector scans, 34.5dB gain transmitter. The systems' detection ranges include periscope in SS4 at 45km, large patrol boat in SS4 at 140km and a destroyer in SS5 at 315km. The capabilities of the AN Series include classification while scanning, coherent look-down air target detection and tracking, DBS, GMTI, image classification and control and display. Standard interfaces include: 1553, ARINC 407 synchro, RS-232, RS-343 and RS-170 video. Scan rate: 6, 60 and 300rpm Range: large patrol boat SS4 140km; destroyer SS5 315km Frequency coverage: 9.5-10GHz

### AN/APQ-180

Used on the AC-130U Spectre gunship operated by US special forces, the AN/APQ-180 is a modification of the APQ-70 and has fixed target track, GMTI and track, projectile impact point position, beacon track and weather modes. The APQ-70 antenna and analogue signal processors were modified and added to complete the APQ-180 system. Applications: fixed target track,

GMTI and track, projectile impact point position, beacon track and weather modes SAR

### AN/APQ-181

The AN/APQ-181 is an LPI radar fitted to USAF Northrop Grumman B-2 stealth bombers. During the B-2 Radar Modernization Program, completed in 2012, the B-2's legacy 2D scanned antenna and transmitter were replaced with an AESA antenna and the operating frequency was changed to avoid conflicts with other RF spectrum users. Frequency: 10-20GHz. Modes: Delivers capability in two separate radar mode sets. Mode Set 1 consists of conventional mission and weapons delivery capabilities. Mode Set 2 incorporates nuclear mission capabilities and enables the B-2 to conduct both nuclear and conventional missions in a GPS-degraded/denied environment. Each radar set consists of five LRUs: the AESA and its associated power supply, signal processor, data processor and receiver/exciter. It features full redundancy. Applications: LPI radar Frequency coverage: 10-20GHz

### AN/APS-124

The AN/APS-124 is a long-range maritime search and targeting radar originally developed for USN Sikorsky SH-60 Seahawk helicopters. It has a high mean output power, clutter rejection for detection of small targets in high sea states, a digital scan converter for scan-to-scan integration, a data link for communication and can operate in a ship-helicopter team for missile targeting and submarine hunting. Modes: long-range search (2µs pulse duration, PRF of 470Hz, 6rpm scan rate, 296km max display range); medium-range search (1µs pulse duration, 940Hz, 12rpm scan rate, 74km max display range), fast scan surveillance (0.5µs pulse duration, 1,880Hz, 120rpm). Antenna: stabilised linear array in belly radome, 360° scan capability Applications: long-range maritime search and targeting radar Operating platforms: USN SH-60B, Spanish Navy S-70B-1

### AN/APS-137B(V)5

The AN/APS-137B(V)5 is a maritime patrol radar fitted to USN P-3C Orion as part of the ASuW Improvement Program. It provides both multi-resolution SAR and ISAR, allowing performance over land, sea and in littoral regions. Current operational capabilities include long-range surface search/target tracking, periscope detection in high sea states, ship imaging and classification using ISAR, and SAR for overland surveillance, ground mapping and targeting. Related programmes and upgrades include a precision targeting capability at long stand-off ranges and a GMTI mode. Applications: maritime patrol radar Frequency coverage: 8-10GHz

### AN/APY-10

The AN/APY-10 airborne maritime surveillance radar equips the USN's Boeing P-8A Poseidon MPA. The radar is a direct descendant of Raytheon's AN/APS-149 Littoral Surveillance Radar which equips the Lockheed Martin P-3C Orion, which the P-8A is intended to replace. The AN/APY-10 uses an AESA antenna to gather SAR and ISAR imagery over land and water. It is thought to be an X-band system, based on its AN/APS-149 lineage. In October 2013, Raytheon received a \$48.8 million order to supply 13 radars, and one spare, to furnish the Lot 4 P-8A production run. These aircraft, and their accompanying radars, entered USN service by late 2016. In mid-2015, the company received a further order for 53 radars to

equip P-8As under a \$153 million contract. Applications: airborne maritime, littoral and overland surveillance radar Frequency coverage: X-band Operating platforms: Boeing P-8A Poseidon

### ASARS-2

The Advanced SAR System-2 (ASARS-2) equips the USAF U-2 high-altitude reconnaissance aircraft. Real-time, high-resolution reconnaissance system with all-weather, day/night, long-range mapping capabilities. Detects and locates fixed and moving ground targets. It gathers detailed information, formats the data and transmits high-resolution images. Raytheon is currently delivering upgrades under the ASARS Improvement Program. ASARS-2 is the foundation for current production and development radars such as HISAR, Global Hawk and the Airborne Reconnaissance Low-Multifunction/Crazy Hawk. Applications: high-resolution reconnaissance system with all-weather, day/night, long-range mapping capabilities

### ASTOR

The Airborne Stand-Off Radar (ASTOR) is a battlefield surveillance SAR/MTI system installed in UK RAF Raytheon Sentinel R1 aircraft, a version of the Bombardier Global Express business jet developed for the ASTOR programme by Raytheon. The radar is a variant of ASARS-2. The SAR provides high-resolution images for decision-makers and MTI monitors quantity, direction and speed of hostile forces. The UK MoD declared the Sentinel in service in November 2008. Since then, the system has deployed on two operational trials and has been deployed on an enduring basis. In mid-2015, ASTOR aircraft were deployed to Iraq to support operations against ISIS and aircraft may also be in service over Syria. Applications: battlefield surveillance SAR/MTI system Range: up to 300km

### HISAR

Hughes Integrated Surveillance and Reconnaissance (HISAR) is a border surveillance, remote sensing and maritime patrol radar with ground mapping, SAR and MTI capability. It has been installed on Global Hawk UAVs and RC-7 and Beech 200 King Air aircraft. It is related to radars used in the U-2 and B-2. Strip SAR mode offers 6m resolution, spot SAR offers 1.8m. Can detect oil spills. Applications: border surveillance, remote sensing and maritime patrol Range: 110km, 50km (oil spill) Frequency coverage: 8-12GHz

## RAYTHEON SPACE & AIRBORNE SYSTEMS

### AN/APQ-174/186 MMR

The AN/APQ-174/186 Multi-Mode Radar (MMR) family provides terrain following and terrain for a variety of military aircraft. The MMR allows safe flight down to a 100ft clearance at night, in adverse weather and in high-threat environments. It lowers the probability of detection by enemy forces and increases mission success through terrain masking and minimising time spent in threat range. The system also reduces risk to aircrew and the aircraft by balancing low-level terrain clearance altitude with flight safety considerations. MMR modes include: terrain following, low power and low velocity, terrain avoidance, ground mapping, air-to-ground ranging, weather detection, beacon interrogation and cross scan modes. The system's features include ECM resistance, semi-covert operation (power management),

low-reflectivity terrain performance and MIL-STD-1553 interface. The AN/APQ-174 is deployed on the US Army Special Operations Command MH-60K and MH-47E aircraft. The APQ-186 is currently being developed for the US Special Operations Command CV-22. Length: 109cm Width: 33cm Weight: 113kg Power consumption: 115V AC 400Hz 2,100VA, 28V DC 38W MIL Standards: MIL-STD-1553 MTBF: 144h specified Turn rate: use of terrain storage for pre-turn and turn-back status, 5.5°/s turn rate

### SeaVue

SeaVue is a family of maritime surveillance radars. The systems use colour or monochrome flat-panel displays, PPI and B-scan presentations, multiple high-resolution video formats, ISAR image, range profiling (A-scan) presentation in addition to ISAR images and SAR map. It also features full coherent operation for ISAR, SAR and moving target detection. The SeaVue has a range of modes including small target detection, surface surveillance, navigation and mapping, weather avoidance, ISAR with range profiling and SAR. It also uses a coherent, solid-state, grid modulator TWT transmitter and stabilised, parabolic or flat plate antenna. The system has sector and searchlight capability and integral IFF. Available enhancements include: moving target discriminator, ISAR classification aids, digital map coastline overlay, Doppler beam sharpening, coherent look-down air target detection and tracking. A contract was awarded in November 2015 by the US Army to Leidos to install a SeaVue radar onto a Bombardier DHC-8 aircraft for the Airborne Reconnaissance Low-Enhanced programme, worth \$662 million. Applications: family of maritime surveillance radars Scan rate: 6, 60 or 120rpm Weight: antenna 23kg, transmitter 30kg, RESP 37kg Range: typical detection ranges in SS3 - man in life raft 30nm, patrol boat 95nm, tanker 230nm Frequency coverage: 9.4-9.8GHz Power output: 8, 15 or 50kW peak Operating platforms: rotary- and fixed-wing aircraft, ship and land applications

## SANDIA NATIONAL LABORATORIES

### MiniSAR

The MiniSAR weighs 12kg and is made up of the antenna/gimbal assembly and the radar electronics assembly, measuring about 18cm on either side. The system's current mode is spot SAR, with plans to include strip map mode and a GMTI. Waveform synthesiser: 3U, cPCI, FPGA-based, quadrature outputs (1.2GHz clock, agile, programmable). Frequency: 16.8GHz frequency, extensible to X- and Ka-bands; antenna provides 3GHz frequency range in the Ku-band Length: 180mm Width: 180mm Weight: 12kg (antenna/gimbal assembly 8kg, radar electronics assembly 4kg) Platforms: UAVs Resolution: 4in resolution at 10km, 0.3m resolution at 15km, 1m resolution at 23km

## SRC

### FORESTER

The Foliage Penetrating (FOPEN) Reconnaissance, Surveillance, Tracking and Engagement Radar (FORESTER) is an airborne radar system that provides stand-off, persistent, wide-area surveillance for situation awareness of foliage covered areas. FORESTER provides real-time, all-weather, day-night target detection and tracking capability for actionable intelligence. The system



**SeaVue is a family of maritime surveillance radars with a range of modes and integral IFF. (Photo: Raytheon Space & Airborne Systems)**

was designed and developed by SRC under sponsorship from DARPA, the US Army and USSOCOM. It has been tested for use on manned or unmanned helicopters. FORESTER provides UHF GMTI/AMTI/SAR capabilities; real-time onboard processing; and 360° surveillance coverage with electronic beam steering to search a 90° sector. Applications: reconnaissance, surveillance, tracking and engagement Detection range: 15km Operating altitude: 5km Operating platforms: A160 Hummingbird UAS and Black Hawk helicopter

### RASAR

The Real-Time, Autonomous, Synthetic Aperture Radar (RASAR) is a self-contained, SWaP-compatible radar designed for installation under the wing of a UAS, including the Shadow 200, for counter-IED and foliage penetration missions. Additional applications of RASAR include: day-night all-weather imaging, wide-azimuth beam (WAB) capability and a direct, single-pass, thin target detection capability. The radar system is small, lightweight, and has a low power consumption to help minimise the impact on existing ISR payloads. RASAR weighs less than 12kg and requires less than 150 W of total power. Weight: 11.34kg Power output: 150W Operating platforms: UAS Frequency coverage: L-band Operating altitude: <8,000ft AGL

## SWISS AIR FORCE

### FLORAKO

The Swiss Air Force's FLORAKO (FLORIDA Radarersatz Radarluftlagesystem Kommunikationssystem or FLORES RALUS KOMSYS) air defence system comprises several subsystems, including Link 16 and radar systems to create a C2 system. FLORAKO is capable of correlating civilian and military data feeds in real time, enhancing the quality of the airspace picture and reducing decision-making times for operators. This air defence system has been fully operational since early 2004 and ThalesRaytheonSystems has been contracted to carry out ongoing maintenance and upgrades. On 18 January 2017, Thales announced that it was awarded a contract to upgrade the Swiss Air Force's Master radars. The contract is valued at €74 million. The radars are being modernised under the FLORAKO programme to extend their lifespan until 2030. Thales will work with subcontractor RUAG on the 60-month programme to develop a new radar signal and data processing and upgrade the antenna system. Manufacturers / contractors: Swiss Air Force

## TELEPHONICS

### AN/APS-128/128D

AN/APS-128 is a digital maritime surveillance radar fitted to a variety of fixed-wing aircraft using different radome and antenna shapes and sizes. Parabolic and flat plate antennas are in service. Range: 65km (fishing vessel), 111km (trawler), 185km (freighter), 222km (tanker)

### AN/APS-143C(V)3 OceanEye

The APS-143C(V)3 is a family of maritime surveillance, tracking and imaging radars. Features include: 46-frequency pulse-to-pulse agility; TWS of up to 200 targets; five-colour weather avoidance mode; sea MTI; integral IFF; built-in display/control generator; scan-to-scan integration; SART beacon detection. Antenna: stabilised, planar array; full 360°; 45-360° sector scan; searchlight; optional integral IFF interrogator antenna/RT/processor; optional integrated ESM antennas; polarisation V or H; azimuth accuracy 0.5°. Power: 8kW peak from helix TWT, no special cooling needed. PW: 0.1, 1.0, 23.4 or 40µs. Modules: antenna/pedestal; transceiver; signal processor. Interface: MIL-STD-1553B; optional RS-422. ARINC 429; interfaces for FLIR steering, ESM, data link, recording. Weight: typically 80kg with full capability set; display extra Options: integrated AIS receiver; moving map display; target data hand-off for Penguin missile; oil slick detection optimisation; iceberg detection/mapping optimisation. Part of the roll-on electronic Mission Systems Pallet (MSP) for the USCG's HC-144A Ocean Sentry MPA. Status: in production, more than 200 operational. Applications: ASuW, ASW, anti-mine warfare, combat search and rescue, long-range maritime surveillance and identification, fisheries protection, coastal and border surveillance, contraband control Scan rate: full 360° scan, stabilised with available integrated IFF dipoles Weight: 84.4kg Range: up to horizon at 28,000ft; detects 1m target at up to 45km in SS3; close-in range down to 90ft Power output: 115V, 400Hz, 3-phase, 1.8kVA and 28V, 12V DC Operating platforms: aerostats (anti-drug), C-26, Falcon 20, CN235/HC-144A, C-130, F27, C-212, Saab 340, Beech F90/100/200, DHC-8, P-3 Orion, S-70B/C, SH-2G, AS565 SAR Resolution: 1m Data interfaces: ARINC 429/571/575, IEEE-802 Ethernet, RS-232/422, serial I/O MTBF: 800h Frequency coverage: X-band, 460MHz MIL Standards: MIL-STD-1553

### AN/APS-147

The AN/APS-147 is a multi-mode maritime ISAR for the Sikorsky MH-60R. It provides target imaging, small target/periscope detection, long-range surveillance, weather avoidance, all-weather navigation, short-range SAR and target designation. The system uses a high-throughput signal and data processing and is capable of detecting small targets and displaying them in a high-resolution format. The radar combines low peak power waveform with frequency agility to detect medium to long-range targets with a reduced threat of ESM interception, and its modular design enables it to maintain upgrade flexibility. The USN will equip 350 MH-60R maritime strike helicopters with the system. Applications: target imaging, small target/periscope detection, long-range surveillance, weather avoidance, all-weather navigation, short-range SAR and target designation Production status: full-rate production and transitioning to the AN/APS-153(V)1 Operating platforms: Sikorsky MH-60R

**AN/APS-153(V)1**

The AN/APS-153(V) was designed by Telephonics to meet the requirements of the maritime military helicopter environment. It is rugged, lightweight, low-prime power, capable of small target detection, high resolution imaging and long-range surface search. The system provides the MH-60R and its host ship with littoral and maritime domain awareness. It supports a range of carrier and expeditionary strike group and USN missions, including: ASW, ASuW, C4SIR, surface surveillance, maritime interdiction, CSAR/SAR, MedEvac, logistical support, IFF, battle damage assessment and naval surface fire support. Radar operators are able to classify detected moving ship targets under night and restricted visibility, using the high-resolution ISAR mode. This mode allows the MH-60R to operate outside of visual and lethal range of a potential enemy and to identify detected targets when images are combined with other intelligence. The AN/APS-153(V) is fully integrated into the MH-60R Common Cockpit avionics suite by Lockheed Martin. It is controlled through the aircraft's mission computer with returns shown on 8x10 inch colour multi-function displays, providing the crew with independent views of radar data. The system's signal processing provides upgrade flexibility to enable future advancements. Applications: multi-mode radar Production status: full-rate production Operating platforms: MH-60R

**AN/APS-508**

The AN/APS-508, fielded under the Royal Canadian Air Force's CP-140 Aurora Incremental Modernization Project, integrates ASW/ASuW maritime patrol and overlaid air-to-ground SAR/GMTI functionality into a single radar. The sensor suite is designed for upgraded or new production platforms where the user must fly multiple missions with a single aircraft. APS-508 provides fine resolution and frequency agility. The three-channel receiver uses analogue and digital pulse compression, depending on mode. Operating platforms: CP-140 Aurora

**APS-143G/AN/APS-508**

Telephonics' APS-143G and AN/APS-508 multi-mission ISR radar systems combine maritime, littoral and land surveillance capabilities with an integrated IFF interrogator. This COTS-based radar is designed for medium to large fixed-wing aircraft on long-range surveillance missions over sea, land or air. Applications: multi-mission ISR radar Weight: 146kg

**RDR-1400C**

The RDR-1400C is Telephonics' search and rescue and weather-avoidance radar system. The radar's weather detection system has a 240nm maximum display range and for close-ups provides two modes, permitting selection of full-scale ranges of either one or 0.5nm, designed to enhance precision of movement. The weather alert feature flashes a warning whenever third-level (red) weather areas are detected, up to 25nm beyond the selected range. The airborne surveillance system has three specialised search modes. Search one incorporates special sea clutter rejection circuitry to help detect small boats or buoys down to a minimum range of almost 300m. Search two is designed for precision ground mapping, where high target resolution is important. Finally, search three includes normal ground mapping and can also be used to detect and track prominent land objects and coastlines. The RDR-1400C

provides features such as full-colour presentation of weather returns, auto pitch/roll correction, pilot-selectable antenna tilt and scan angle and BIT. The system is also capable of locating a 9m target in SS2 from up to 10nm away, while operating at a typical helicopter altitude of 500ft. Applications: weather, precision ground mapping (2 modes), navigation, beacon navigation and tracking/search, oil slick detection Scan rate: antenna - planar in 4 different sizes: sector scan 60° and 120°; scan rate 28°/s Weight: 15.4kg (RDR-1400C-106); 10.7kg (RDR-1400C-107) Detection range: 160nm max Frequency coverage: I-band Production status: in production Minimum detection range: 300 or 150m Power output: 10kW peak Operating platforms: Cougar, Super Puma, HH/MH-60, SH-3, Mi-8, H155, AB-212, AB-412, AW101, Bø 105, Oryx, S-61

**RDR-1500B/1700**

The RDR-1500B/1700 is an X-band land and sea surveillance radar, designed for medium to low altitudes. Modes include surface search, terrain mapping, and weather avoidance while the system features an LCD colour display, map overlay, FLIR steering and display. The RDR-1700 has a 20-target tracker and interfaces for glass cockpit integration. The RDR-1700 can be installed in helicopters or fixed-wing aircraft for support of search and rescue activities that require detection of small vessels. The system has an integral target tracking capability and 360° digital colour scanning. Antenna: 3 standard sizes, custom available; pedestal for 360/120° or 180° sector scan. Modules: RDR-1500B has antenna/pedestal, transceiver, processor, control unit, 6in cockpit display, 9in operator display; RDR-1700 has antenna/pedestal, transceiver, processor Weight: 34kg RDR-1500B; 22.5kg RDR-1700 Range: 295km max Operating platforms: HH-65, AW109, AW139, AB412, AS555N, An-32, AS355, Super Puma, Cougar, C-212, F.406, Do 228, P-166, Lynx 100, SH-3 Pulse repetition frequency: 200, 800 or 1.600Hz; PW: 0.1, 0.5 or 2.35µs

**RDR-1600**

The RDR-1600 is a SAR weather avoidance radar system selected for Danish EH101s. The system provides a full-colour presentation of weather returns, auto pitch/roll correction, pilot selectable antenna tilt and scan angle and built-in-test for a range of operational modes. These modes include weather detection and weather alert. SAR, surveillance, beacon detection and ground mapping. The RDR-1600 offers a 240nm display range and detailed close-ups at ranges of 1nm or 0.5nm, allowing for safety and precision of movement to plan weather avoidance manoeuvres. The weather alert feature provides operators with a warning whenever third-level (red) weather areas are detected up to 25nm beyond the selected range. The RDR-1600 also provides three specialised search modes: search one incorporates special sea clutter rejection circuitry to help detect small boats or buoys down to a minimum range of 130m. Search two is designed for precision ground mapping where high-target resolution is important and search three includes normal ground mapping used to detect prominent land objects or coastlines. The system enables land or sea approaches within a 60m ceiling and 1km visibility minimums. Its beacon modes allow detection of DO 172 two-pulse and six-pulse beacons and enables operators to easily change between modes. The RDR-1600 is available with

four different antenna sizes focused on the detection of small targets while operating at a typical helicopter altitude of 152m. Applications: SAR, weather avoidance Scan rate: 287/second Length: 35.6cm Width: 12.7cm Weight: up to 14kg for receiver/transmitter, antenna and drive, and control panel Minimum detection range: 450ft Frequency coverage: X-band Operating platforms: EH101, helicopters and fixed-wing aircraft Power output: 10kW Antenna dimensions: 25, 30, 45 or 30 x 45cm

### RDR-1700B

The RDR-1700B is an evolutionary development of the RDR-1500B and AN/APS-143 radars, with new capabilities from the RDR-1700 and AN/APS-143C(V3) systems. RDR-1700B is a 1kW X-band, airborne, coherent search radar providing manned or unmanned, fixed- or rotary-wing aircraft with the ability to search for, detect and track targets while performing over-water surveillance. It provides surface search, real-beam mapping, weather avoidance and SART beacon detection using techniques including digital waveform generation, digital pulse compression, frequency agility over the entire band, CFAR processing and scan-to-scan integration. The basic radar also includes inverse, strip and spot synthetic aperture plus an AIS overlay. Control of the RDR-1700B is via the self-contained Tactical Display Management System GUI. The RDR-1700B was designed using COTS CompactPCI-based, open architecture for flexibility in adapting to specific platforms and missions. In early 2013, the USN issued an urgent order to equip the Northrop Grumman MQ-8B Fire Scout rotary-wing UAV with the RDR-1700 (locally designated AN/ZPY-4(V)1). The contract is worth \$33.3 million. Applications: multi-channel, airborne, littoral and overland GMTI search and surveillance radar system Weight: 32-37kg (system-dependent) Operating platforms: MQ-8B Fire Scout

### RDR-1700B(V)1 and AN/ZPY-4(V)1

The RDR-1700B(V)1 and AN/ZPY-4(V)1 radar systems are designed for maritime surveillance, tracking and classifying targets of interest in a range of applications including naval aviation, maritime police, border patrol as well as environmental and fisheries protection. The systems are capable of tracking multiple targets and can be found on fixed- and rotary-wing aircraft as well as UAVs, enhancing situation awareness. Modes include ISAR, SAR, weather detection and avoidance as well as SART beacon detection. In January 2013 AN/ZPY-4(V)1 systems were selected to be installed on USN Fire Scout MQ-8B UAVs. Applications: multi-mode maritime surveillance radar Operating platforms: fixed- and rotary-wing UAVs, small manned surveillance aircraft Production status: in production

## THALES

### Agriion

Agriion is a surveillance and missile targeting pulse radar from the Iguane family. Missions include ASuW (search, surveillance, OTH targeting for friendly ship-launched missiles, automatic guidance for the helicopter's own missiles), search and rescue, environmental protection, navigation, weather avoidance. Features a paraboloid antenna with other types as options, pulse compression, frequency agility, ECM resistance. Frequency coverage: 8-20GHz

### Anemone

The Anemone is a multi-function radar developed as an upgrade for French Navy Super Étendard carrier-borne strike aircraft. Air-to-surface surveillance and targeting is its primary function, in which it feeds target data to the Exocet missile, but it also has air-to-air and ground mapping functions. It is a monopulse radar with a low-sidelobe slotted flat-plate antenna and TWS capability. Applications: Multi-function radar Frequency coverage: 8-20GHz Operating platforms: Super Étendard

### CATS

The Compact Airborne Threat Surveyor (CATS) is a modular and compact radar and surveillance system offering real-time threat detection and geo-location of radar emissions for UAVs, helicopters or transport aircraft. The CATS system provides real-time battlefield situation awareness, radar warning and immediate alert, for multiple simultaneous pulse, pulse-Doppler and CW emitters associated with air and surface threats; ESM functions with onboard data recording; EW core system management with multi-sensor data fusion and optimisation of countermeasures. Its modular architecture is intended to be configured for any type of UAV featuring low size and weight, minimal number of LRUs, interfaces with navigation equipment, compatible with off-board transmission and multi-platform cooperation. Processing unit: ARINC 600 (MCU) Applications: radar and surveillance Weight: 15kg Elevation: +/-45° Power consumption: 260W (28V DC) Frequency coverage: E-K-band (C-K optional) Azimuth: 360°

### ENR

The NH90 NFH is equipped with the European Navy Radar (ENR) developed by Thales in conjunction with Airbus and Leonardo. Derived from the Thales Ocean Master, the 360° surveillance radar is mounted under the nose of the aircraft and is used for the full range of maritime patrol missions, including ASuW, ASW, situation awareness (air/air, air/sea), maritime surveillance, border surveillance, search and rescue, vessel and submarine snorkel detection and tracking in rough seas, plus target classification. Applications: ASuW, ASW, situation awareness (air/air, air/sea), maritime surveillance radar Operating platforms: NH90

### Horizon

Horizon is an I-band long-range ground surveillance radar. The primary sensor is mounted on the AS532 UL Cougar and feeds information to a ground station in a 5t truck via a data link. The frequency coverage of the Horizon system is 8-12GHz (I/G-band) with operating modes including high-resolution ground mapping, MTI, fixed echo indication and ELINT. The system's resolution is 40m in range, 2m/s in velocity. Its scanning capabilities include combined mechanical and electronic, sector width of up to 360° at any sector axis and with a rate of 2, 4 or 8°/s. Horizon also features panoramic surveillance of 20,000km<sup>2</sup> in ten seconds and is able to perform target location, classification and speed measurement tasks while scanning. Horizon is compatible with helicopters, wheeled and tracked vehicles and others. Applications: long-range ground surveillance Scan rate: combined mechanical and electronic, sector width up to 360°, any sector axis, rate 2, 4 or 8°/s Detection range: 200km (clear weather), 150km (rain and clouds) Operating platforms: AS532 UL Cougar Frequency coverage: I-band Data link range: 100-150km

**I-Master**

The I-Master is a lightweight SAR/GMTI for tactical UAVs and small fixed/rotary-wing platforms. I-Master is capable of wide-area, all-weather surveillance, detection, classification and location of fleeting and time-sensitive targets. The radar system has been installed on Royal Jordanian Air Force AC-235 gunships and British Army Watchkeeper UAVs. Width: 370mm Height: 470mm Power: 500W SAR Weight: 30kg Range: >27km (35km resolution-dependant) Elevation: +10/-55° SAR Resolution: 3m-<30cm GMTI mode range: 20km (vehicle and infantry movements)

**Iguane**

The Iguane is a frequency-agile, pulse compression maritime surveillance radar with search and rescue capability. Missions include ASW, ASuW, search and rescue, environmental monitoring and weather avoidance. Installed on ATL3 Atlantique MPAs of the French Navy. Applications: frequency-agile, pulse compression maritime surveillance radar Frequency coverage: 8-20GHz

**Ocean Master**

The Ocean Master is a sea surveillance and patrol radar for detection of all types and sizes of targets in all sea states. It has been sold to the French Navy and export customers. The wideband frequency agility of the Ocean Master makes it resistant to countermeasures and improves detection performance in sea clutter, it is claimed. The three-LRU system comprises one exciter receiver processor, one transmitter (TX) and one antenna unit. The system is capable of installation on rotary- and fixed-wing aircraft. Ocean Master missions include long-range detection of up to 370km for blue/brown water surveillance. It is also capable of surveillance missions in high-traffic density areas and EEZs. Other tasks include illegal immigration control, fisheries protection, anti-smuggling, trafficking control, counter-piracy, prevention of asymmetric threats and search and rescue. The radar's main features include air target detection mode, navigation and weather avoidance modes, dynamic range profile, multi-target TWS of up to 200 tracks, MTI and oil spill detection. The Ocean Master was installed as part of a joint Thales-PAL Aerospace upgrade of two UAE Air Force Q300 MPAs. The radar was installed along with a mission system based on Thales' AMASCOS. Applications: sea surveillance, target detection Weight: <85kg including HMI Range: 445km Production status: in production Target tracking: TWS - 200 targets Power consumption: 2.1kW

**ORB 32 Series**

ORB 32 is a modular family of maritime surveillance and FCRs intended for EEZ protection, ASW, ASuW and SAR missions. Modes: search, missile fire control, navigation and weather avoidance. Paraboloid antenna is stabilised in pitch and roll and to true motion or azimuth. Scan modes include 360° at 80rpm or selectable sector scans. ORB 3203 and 3214 versions are optimised for ASW. ORB 3202 and 3212 for reconnaissance and target designation. ORB 3201 and 3211 are smaller, less complex versions optimised for search and rescue. EEZ protection and surface search. Frequency coverage: 8-10GHz

**Searchmaster**

The Searchmaster is an airborne multirole surveillance radar that employs an AESA antenna, and is derived

from qualified technologies developed for the RBE2 radar of the Dassault Rafale combat aircraft. It offers threat detection over land or sea and in all weather conditions. Its compact, lightweight design allows the system to be integrated on a range of platforms. It can be deployed on medium-altitude long-endurance (MALE) UAVs, helicopters for medium to heavy missions and turboprop-powered special mission aircraft. Searchmaster has a range of 200nm (air to sea). It can detect small stationary and moving maritime targets, including in high sea states. It also provides very high-resolution radar imagery. On 4 February 2017, Thales announced that the Searchmaster radar completed its first flight, marking the start of a six-month test campaign. At DIMDEX 2016, the Qatar Armed Forces announced an MoU for the selection of the Searchmaster radar. It will equip its Optionally Piloted Vehicles - Aircraft and respond to land and naval surveillance requirements. On 5 April 2017, Thales announced that the Searchmaster radar has been declared ready for delivery to its first export customer. In June, Thales announced it will integrate its Searchmaster 400 radar on a Bombardier Q300 turboprop as part of a cooperation agreement with Canadian company PAL Aerospace. The two companies are aiming to have the aircraft complete for demonstrations by year-end, with Thales officials explaining that integration work had already begun in Canada. Applications: multirole radar Scan rate: 360° Weight: 75kg Range: 370km Operating platforms: Atlantique-2 Frequency coverage: X-band MTBF: > 2,000h

**Super Searcher**

Super Searcher is a maritime surveillance radar. Modes: surveillance, weather, ground mapping. Antenna: planar and paraboloid reflector types are available. Can be selected to fit existing radomes. 360° operation with operator-selectable sector scanning and blanking. Transmitter: 4 PRFs, 3 pulse widths, frequency-agile. X-band transponder optional, combined T/R Displays: 625/525-line standard raster scan Display scales: 4, 8, 16, 32, 64, 128 and 256mm Monitors: 14, 12, 10 or 8in colour, or 10 or 7in monochrome Flat-panel 16-20in option Power: 1.4kVA typical Cooling: ambient air via integral fans BIT: comprehensive Missile compatibility: fire-and-forget missiles, eg Exocet, Sea Eagle, Penguin Applications: maritime surveillance Weight: >85kg typical Operating platforms: Sea King helicopters Frequency coverage: X-band

**WEATHER****HONEYWELL AEROSPACE****IntuVue RDR-4000**

The IntuVue weather radar uses 3D volumetric scanning and pulse compression technologies to provide a view of the weather from 0 to 60,000ft across a 590km detection range. IntuVue weather analysis tools are designed to help pilots better understand weather hazards and calculate the best strategic and tactical responses. Pilots can select individual slices of the airspace, including specific range, azimuth or altitude displays, to make more informed routing and manoeuvring decisions. According to the company,

these features have demonstrated a 26% improvement in weather hazard detection over conventional radar systems. The system uses three MCUs, and provides up to a 30% weight reduction, allowing enough space for dual system installation in less space than a current A708 standard system. This weight and space reduction can provide as much as \$10,000 per year per aircraft fuel savings and allows for the additional avionics space to be allocated for other equipment needs, it is claimed. Applications: weather radar Coverage: 590km

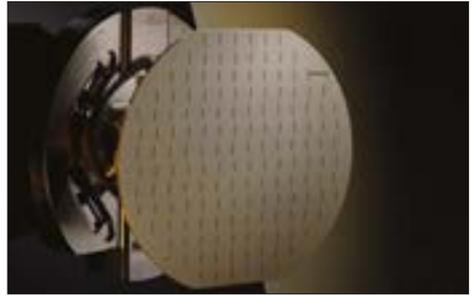
### Primus 440, 660 and 880

The Primus 440, 660 and 880 weather radars are lightweight, high-sensitivity, narrow pulse width systems. The radars include the Rain Echo Attenuation Compensation Technique (REACT) safety feature which alerts pilots to areas where storms may be hidden behind other storms. REACT performs three distinct functions. First, it maintains target calibration by compensating for attenuation caused by intervening rainfall. Secondly, it advises pilots of areas where target calibration cannot be maintained by changing the screen background to blue, warning that attenuation may be hiding areas of severe weather. Thirdly, any target displayed in the blue field will appear in magenta to alert the pilot to its probable severity. Primus 660 and 880 include Target Alert (TGT) which notifies the pilot of potentially hazardous targets directly in front of the aircraft that are not yet within the selected range. When 'T' is displayed in green, TGT is armed. When the yellow 'TGT' is displayed, the pilot is warned of a red level target directly in front of the aircraft (within  $\pm 7.5^\circ$  of the aircraft's nose). The two systems scan once every four seconds in normal mode but in sector scan mode, the rate increases to two seconds when faster updates are needed due to storm activity directly ahead at short range. The Primus 880 also includes ground mapping, turbulence detection and altitude compensated tilt (ACT) which allows easier detection of weather that may affect the aircraft in an en-route condition and reduces the amount of tilt management required by the pilot. When ACT is selected, the Primus 880 reads the altitude and selected range, then points the antenna at the ground just inside the selected range. ACT automatically adjusts the tilt with any change in altitude. It also changes the tilt control from the normal  $\pm 15^\circ$  to  $\pm 2^\circ$  for finer control. Applications: weather radar Coverage: Primus 880/660 590km, Primus 440 440km

## NORTHROP GRUMMAN SPERRY MARINE

### AN/APN-242

The AN/APN-242 is a colour weather and navigation radar marketed as a form, fit and function replacement for the AN/APN-59. Detects weather with full-colour, black and white or green displays of storms. Terrain mapping and navigation in high-resolution ground mapping mode with latitude/longitude-stabilised electronic cursor to provide range and azimuth information to waypoint. Detects fighter aircraft at extended ranges through intervening rain showers concurrent with other operating modes. Detects airborne and ground beacons and optionally interrogates IFF-equipped aircraft. The company was contracted to replace aging AN/APN-59 systems originally installed on the RC-135 fleet with AN/APN-242 radars. It can also be installed on C-130 and C-135 aircraft. Applications:



TWR-850/WXR-840/WXR-80 weather radar systems use Doppler-based turbulence and weather detection. (Photo: Rockwell Collins)

colour weather and navigation radar Range: 445km  
Frequency coverage: 8-10GHz

## ROCKWELL COLLINS

### TWR-850/WXR-840/WXR-80

The TWR-850/WXR-840/WXR-80 weather radar systems use Doppler-based turbulence and weather detection for faster analysis and a solid-state transmitter for optimum pulse width for different ranges and modes. The systems are supported by sensitive coherent receiver architecture with bandwidth optimised for each transmitter pulse width and ground clutter suppression mode reduces ground returns using Doppler processing. Auto tilt reduces pilot workload by automatically readjusting the antenna tilt after a range or altitude change and automatic picture rotation is capable, during aircraft turns, of keeping a clear weather picture at all times meaning no waiting for a scan update. A typical system consists of receiver/transmitter/antenna and turbulence weather radar, such as RTA-854 or RTA-844, and panel/weather radar, such as WXP-850A or WXP-840A. Applications: airborne weather navigation Frequency: X-band Coverage: 630-780km



## EQUIPMENT

### GROUND SYSTEMS

This section contains data on a selection of radar systems in the following categories:

- battlefield and ground surveillance
- land-based air defence
- weather

The equipment is listed alphabetically by manufacturer within the above subsections.

If you think your product should be listed, please contact the team at [reference@shephardmedia.com](mailto:reference@shephardmedia.com) to ensure it appears in the Shephard Plus online database ([shephardplus.com](http://shephardplus.com)) and is included in the next print edition.

**ABOVE: A BMEWS installation at RAF Fylingdales, England. The radar is capable of detecting ballistic missile attacks and conducting general space surveillance and satellite tracking. (Photo: UK RAF)**

## BATTLEFIELD AND GROUND SURVEILLANCE

### ASELSAN

#### ACAR

The ACAR ground surveillance and artillery fire adjustment radar is a land-based system for detecting, classifying and tracking targets moving on or close to the ground or sea, mainly for security applications. The system can also be used for artillery fire adjustment purposes. ACAR is a man-portable, all-weather, day-and-night operable system. It is a Ku-band, pulse-Doppler radar, employing pulse compression and DSP techniques. It also has low peak output power, leading to LPI characteristics. ACAR has 40km instrumented range and can detect and track a pedestrian at a range of up to 12km. According to operational needs, ACAR can be used on tripod for standalone applications or it can be mounted on a vehicle, tower or mast. The system also offers interfaces for integration with a C2 centre, allowing for remote operation. TWS, automatic and multi-target tracking, automatic target classification, digital map overlay, alarm/friendly zone selection and sector blanking are some of the features of the ACAR. Applications: ground surveillance and artillery fire adjustment radar Frequency: Ku-band Detection range: 40km, pedestrian 12km

#### Serhat

Aselsan's Serhat counter-mortar radar has been designed for the purpose of detecting and tracking mortar shells to determine the point of origin and the point of impact. The radar covers 360° in azimuth. The counter-mortar radar has a modular design, so that it can be used on a tripod, placed on a building or on a vehicle with an extendable mast. The radar system, which uses an active array antenna structure with electronic scanning, can detect more than one simultaneous fire. Applications: counter-mortar radar Frequency: L-band Power: 24V DC Detection range: >10km

### BATS BELGIAN ADVANCED TECHNOLOGY SYSTEMS

#### GR05

The GR05 tactical ground surveillance radar family provides 360° coverage using a single rotating antenna. These radars can either be used remotely or networked into a larger group to provide coverage over a wider area. They can track up to 200 targets and be used for a number of applications, including coastal and border protection and port and harbour security. All radars in the GR05 series use pulse-Doppler architecture and transmit across the X-band, generating up to 10W of peak power, while a LAN provides external communications. The GR05 family consists of three systems: the GR05, GR05ER and GR05LR, all with varying detection ranges. These stretch from: 5km for a pedestrian and 8km when detecting a vehicle (GR05); 10km for a pedestrian and 20km for a vehicle (GR05ER); and 15km for a pedestrian and 25km for a vehicle (GR05LR). All have a minimum detection range of 50m and a 1m range accuracy. The GR05 and

GR05ER has an azimuth accuracy of 0.5°, while this reduces to 0.3° for the GR05LR. Similarly, the GR05 has 10° of altitude coverage, with the GR05ER providing 8° of accuracy coverage and GR05LR 5°. Applications: battlefield/ground surveillance Frequency: X-band Power: 10W peak

#### GR12

The GR12 is a family of radars using FM CW architecture. 360° azimuth coverage is provided by four antennas, each of which provides 90° azimuth coverage. The GR12 family includes the GR12/1, GR12/2.5, GR12/5, GR12/10 and GR12/15. The GR12/1 is a C-band radar that has a detection range of 1km for a pedestrian and up to 2km for a vehicle. The radar has a range accuracy of under 10m and 2° of azimuth accuracy. Up to 200 targets can be tracked simultaneously using the GR12/1. The GR12/2.5 is an X-band radar which has a detection range of up to 2.5km for a pedestrian and up to 5km for a moving vehicle. Range and azimuth accuracy are similar to the GR12/1, as is track performance. The X-band GR12/5 offers detection ranges of 5km for a pedestrian, 10km for a vehicle and up to 32km for a medium-sized ship. The radar has an azimuth accuracy of 0.5° and a range accuracy of below 10m. It can also track up to 200 targets. The GR12/10 is also an X-band radar like the GR12/5. It has a range of 10km for a pedestrian and up to 20km for a vehicle. It has a range accuracy of under 10m and an azimuth accuracy of 0.25°. It is able to simultaneously track up to 500 targets. Another of the X-band radars in the GR12 series is the GR12/15, which has a 15km range for a pedestrian-sized target, 30km for a vehicle and up to 96km for a medium-sized ship. It has a range accuracy under 10m, an azimuth accuracy of 0.25° and can track up to 500 targets. Applications: ground and coastal radars using FM/CW architecture Frequency: X-band, C-band Detection range: 2.5-96km, depending on radar model

#### GR14

The persistent perimeter detection radar GR14 is a high-resolution system. It provides surveillance and instantaneous target detection and tracking within a radius in 90° increments: pedestrians at 500m and vehicles at 1,000m. The GR14 is intended as an affordable 24/7 solution with high MTBF. Intrusions are marked on a GIS display. It is designed to be portable with 5x13x17cm dimensions, 1.2kg weight and 15W power. Applications: battlefield/ground surveillance Frequency: K-band Power: 15W

#### GR20

The GR20 X-band radar can detect flying objects such as helicopters and ground targets (eg pedestrians and vehicles). In addition, it can be used for artillery fire control. Customers also have the option of increasing the radar's detection range by adding a power amplifier and an enlarged antenna. A rain detection algorithm programmed into the radar's software enables its use in inclement weather and it can present imagery in 2D or 3D representations as desired by the operator. The radar transmits at either 5W or 25W output. This alters the detection ranges for the radar's targets. For example, when transmitting at 5W, a pedestrian can be detected at 8km, a helicopter at 15km, a light vehicle at the same range, with a heavy vehicle being detected at 24km and an artillery shell at 10km. When transmitting at 25W, the radar can detect a pedestrian



The COBRA is a large, long-range radar mounted on a four-axle, off-road-capable truck. (Photo: Hensoldt)

at 10km, a helicopter at 16km, a light vehicle at 17km, a heavy vehicle at 30km and an artillery shell at 12km. When transmitting at both 5W and 25W, the radar has a range accuracy of 25m and 0.5° azimuth accuracy, with the ability to track circa 100 targets. Applications: pulse compression ground-based radar for ground and aerial targets and artillery fire control Frequency: X-band Power: 5W, 25W Detection range: at 5W pedestrian can be detected at 8km, helicopter 15km, light vehicle 15km, heavy vehicle 24km

### GR40

The GR40 can be used for artillery fire control along with the detection of ground targets, such as pedestrians and vehicles, and airborne targets such as helicopters and low-flying aircraft. This X-band radar provides 25W of peak transmitting power. In terms of range, the GR40 can detect a pedestrian at 15km, a helicopter at 25km and a heavy vehicle at 60km when operating in surveillance mode. For artillery fire detection, the radar can predict shell impact at circa 15km. It can scan across 360° offering a 50m range accuracy in surveillance mode. When operating in artillery fire detection mode, the radar has a range accuracy of 25m and can scan a sector of between 2 and 6°. Applications: artillery fire control and detection of ground targets Frequency: X-band Weight: 65kg Detection range: pedestrian at 15km, helicopter 25km, heavy vehicle at 60km in surveillance mode; artillery fire detection, can predict shell impact at circa 15km Coverage: 360°; 2-6° in artillery mode

### GR80

The GR80 is a fifth-generation family of movement-detection tactical ground surveillance radars. The GR80 has a high update rate and the radar enables high probability of target detection and tracking to support complex missions. The GR80 is a solid-state, active electronically scanning phased array multi-beam radar family operating under all weather conditions and providing accurate detection data, either locally or to remote C2 systems. There are four configurations, which are: 90° fixed, 180° fixed, 360° fixed, 360° rotating. It has three types of antenna: 5° long-range application, 10° hard terrain, 30° land and aerial applications.

Applications: battlefield/ground surveillance Frequency: X-band Power: 90W peak Detection range: pedestrians (RCS=0.5m<sup>2</sup>): 8km, vehicles (RCS=5m<sup>2</sup>): 15km, mini-drone (RCS=0.01 m<sup>2</sup>): 2.5km, low-flying airborne targets, maritime targets

## BHARAT ELECTRONICS

### BFSR-MR

The BattleField Surveillance Radar – Medium Range (BFSR-MR) is a ground-based surveillance and acquisition radar capable of detecting and displaying moving targets, including people, vehicles, tanks and low-flying helicopters. It supports artillery units by providing location of shell bursts and fire-correction data. Pulse-Doppler radar with parabolic reflector, pulse compression, superhet receiver. Can track up to 60 targets. Applications: ground and air surveillance and acquisition radar Frequency: 8-12GHz

### BFSR-SR

The BattleField Surveillance Radar – Short Range (BFSR-SR) is a man-portable, battery-powered surveillance and acquisition radar, capable of detecting and displaying a variety of moving targets, such as pedestrians, vehicles, tanks etc. The radar can be carried in three manpacks. Range: crawling man with 0.05m<sup>2</sup> RCS 0.5km; moving man with 0.2m<sup>2</sup> RCS 2km; moving personnel with 4m<sup>2</sup> RCS 5km; moving soft-skin vehicle with 4m<sup>2</sup> RCS 8km; moving armoured vehicle with 20m<sup>2</sup> RCS 10km; low-flying helicopter with 2m<sup>2</sup> RCS 7km. Can track 50 targets simultaneously. In service with Indian, Indonesian and Sudanese forces. Applications: man-portable, battery-powered surveillance and acquisition radar Weight: 30kg Detection range: 18km, pedestrian 2km, heavy vehicle 10km

## BLIGHTER SURVEILLANCE SYSTEMS

### Blighter Explorer Nexus

On 16 February 2017, Blighter Surveillance Systems announced the development of the Blighter Explorer Nexus. This is an integrated, battery-operated, man-portable radar/camera surveillance system designed for rapid deployment. The system can be transported in backpacks or vehicles for use in remote border surveillance, temporary camp protection, forward reconnaissance and other covert operations. The Blighter Explorer Nexus is compact, lightweight and low power, capable of operating in all weather conditions. It comprises the Blighter B202 Mk2 e-scan micro-Doppler ground surveillance radar, an integrated visible and IR thermal imaging camera system, a Windows HMI, covert eyepieces and optional rugged laptop. The radar automatically cues a long-range camera to enable the operator to identify any target. Detection range: 1.5km (crawler); 8km (moving vehicle)

### Blighter Radars

Blighter B400 series radars are long-range movement-detection sensors for fixed and mobile surveillance applications. Modular construction provides azimuth e-scan angles from 90° for a single unit up to a full 360° e-scan for four units. They can detect human intruders at ranges in excess of 10km and vehicles in excess of 20km. Blighter Surveillance Systems also produces the Blighter Revolution 360 – a lightweight mobile radar

system for deployment on vehicle or trailer masts. It introduces a maintenance-free, cable-drive azimuth positioning unit to provide 360° of coverage from a single, lightweight unit. The radar supports continuous 'scan and pan' - performing a 90° e-scan, followed by a 90° mechanical pan - and 'stare' surveillance modes. The Blighter B303 is a medium-range movement-detection sensor for vehicle/mobile and fixed-installation applications and the Blighter B202 Mk 2 is for portable and mobile surveillance applications. These integrated radar units provide azimuth e-scan angles of 180° and 90° respectively and can detect a human intruder out to 3.3km and vehicles to 8km. The Blighter B303 is lightweight and compact, allowing it to be deployed on a vehicle mast and the Blighter B202 Mk 2 can be backpacked and carried by one man. Both can be operated for extended periods from compact batteries or solar power. Key features of these radars include: high reliability, 'zero-maintenance' operation, operation over complex terrain including hills, ability to detect crawlers, low false-alarm rates, low power consumption and low data communications bandwidth.

## ECRIE - EAST CHINA RESEARCH INSTITUTE OF ELECTRONIC ENGINEERING

### JY-17

The JY-17 is a man-portable battlefield radar developed for detection, location and recognition of targets moving on the ground. This solid-state, tripod-mounted system can be operated remotely and has automation and signal processing techniques. Antenna is of the flat-plate type. Applications: man-portable surface radar Frequency: 10-20GHz

### JY-17A

The JY-17A radar is designed for detection, location and identification of moving targets on the ground or water surface and of aircraft at low altitude. It is a solid-state, coherent pulse-Doppler system that uses pulse compression and both linear and circular polarisation. Can be mounted on vehicles or sited independently. Applications: portable surface radar Frequency: 8-10GHz Detection range: 30km (ship), 25km (large armoured vehicle), 20km (helicopter), 15km (small vehicle), 10km (personnel)

## ELBIT SYSTEMS EW & SIGINT - ELISRA

### Foxtrack

Foxtrack is a man-portable, lightweight and compact ground surveillance radar system that can be carried by two operators. It functions in a tripod-mounted configuration or installed on board a vehicle or on a tower. Foxtrack is designed to provide surveillance at medium to long ranges (6km for pedestrians and 15km for small cars). Intended to identify both people and vehicles, the system differentiates individuals and/or vehicles from their surroundings, while identifying vehicle types by their characteristics (tanks, trucks, small vehicles etc). Capable of operating independently, in two/three-system clusters, or as a comprehensive system of interconnected, interoperable, multi-sensor units, the Foxtrack operates in concert with a variety of intelligence and C2 systems. Applications: man-portable, lightweight and compact ground surveillance

radar Weight: 30kg Detection range: pedestrians 6km, large vehicles 24km

### VWS Radar

The Vehicle Warning Systems (VWS) includes VWS 1, part of an APS for hard-kill applications, destroying the threat; and VWS 2, part of an APS for soft-kill applications, diverting the missile. The VWS is a CW radar, designed for APS installed on board light and heavy armoured vehicles, and stationary applications. With a high probability of detection and low false alarm rate, the radar detects, classifies and automatically tracks antitank rockets and guided missiles. Providing 360° long-range, real-time coverage, the system enables continuous search for potential threats and, upon detection of a flying object, calculates threat parameters and triggers the response by the APS. Applications: vehicle warning system Weight: 30kg Detection range: V1 up to 0.6km, V2 up to 2km

## ELETTRONICA

### MUROS Family

The MUROS family of systems is grouped into surveillance, communication and mission control (MC) systems. MUROS surveillance systems are multi-sensor, based on radar, EO, IR and passive coherent location systems and provide persistent ground surveillance and real-time situational awareness. It detects, identifies, classifies and responds to missions along borders or improves safety and security of public and industrial infrastructure. The MUROS communication family is designed to break into the communication networks to provide information superiority. MUROS communication detects all signals in range. Decrypting algorithms are able to follow a conversation and reveal communication networks. MUROS MC coordinates the operation of vehicles.

## EYELYNX

### EPR-100

EPR-100 is a radar which autonomously monitors, detects and alerts users of objects in protected regions. Used around perimeters, EPR-100 can detect objects over 360°, up to 250m away (across flat terrain, no obstructions). The EPR-100, which is suitable for all-weather operations, can be used for applications including: military bases, industrial sites and public utilities. Type: high-resolution digital beam forming radar Height: 250mm Power: 9-15V DC power supply, 2W at 12V DC power consumption Weight: 5.1kg Detection range: 0-250m Temperature range: -20/+70°C Output: contact relay Interface: RS-422, contact relay

## HENSOLDT SENSORS

### COBRA

The Counter Battery Radar (COBRA) is a large, long-range radar mounted on a four-axle, off-road-capable truck developed for the armies of France, Germany and the UK. It employs a fully active, microwave phased-array antenna. Search and track beams are automatically scheduled and multiple projectiles - hostile as well as friendly counterfire - are simultaneously detected, verified, classified and tracked. In 2004, the Euro-Art consortium of Thales, EADS (now Hensoldt) and Lockheed Martin delivered

the first COBRA production system for the French armed forces. In August 2007, Euro-Art announced the roll-out of the last of 29 COBRAs that was delivered to the German government. France had received ten systems, Germany 12 and the UK seven. The €500 million contract included logistics and services. COBRA is a high-mobility weapon-location radar which meets NATO requirements, and is currently being manufactured by the Euro-Art consortium. In February 2009, the UAE became the first export customer after ordering three systems under a \$243 million contract. The order followed desert trials in the UAE in 2005. Applications: large long-range radar Detection range: 40km

### SPEXER 10

The SPEXER 10 radar was designed for the surveillance of small perimeters and infrastructures (eg industrial plants, prison facilities, airports and seaports) and can be used outdoors and indoors. It detects and tracks small and slow-moving targets such as pedestrians at up to 100m. SPEXER 10 is small and lightweight and supports multi-radar operation, also in combination with cameras (in a network). Applications: small infrastructure and perimeter radar

### SPEXER 500

The SPEXER 500 radar was designed for camp, perimeter, infrastructure and border surveillance against asymmetric threats – including the surveillance of sensitive and protected areas (oilfields, power plants, airports). It automatically detects, classifies and tracks ground targets and low-flying air targets (even small and slow-moving ones) at up to 9km. SPEXER 500 allows the surveillance of large areas and medium distances. Its update rate facilitates early warning, as well as situational awareness. The portable, lightweight and small-sized radar provides flexible surveillance and can be integrated into a C2 system. In addition, it is ready for multi-radar operation and in combination with cameras (in a network). Applications: camp, perimeter, infrastructure and border surveillance radar Detection range: 9km, pedestrian 5km, truck and low-level helicopter 9km

### SPEXER 1000

The SPEXER 1000 radar was designed for camp, perimeter, infrastructure and border surveillance with asymmetric threats – including the surveillance of sensitive and protected areas (eg oilfields, power plants and airports). It automatically detects, classifies and tracks ground targets, low-flying air targets and coastal sea targets (even very small and slow-moving ones) at up to 18km. SPEXER 1000 ensures the surveillance of large areas and long distances. Its update rate facilitates early warning, as well as situational awareness. The portable, lightweight and low-size provides flexible surveillance and can be integrated into a C2 system. In addition, it supports multi-radar operation and can be used in combination with cameras (in a network). Applications: camp, perimeter, infrastructure and border surveillance radar Frequency: X-band Detection range: 18km, 8km pedestrian, 17km truck

### SPEXER 1500

The SPEXER 1500 radar was designed for large-perimeter surveillance, border surveillance and security applications with asymmetric threats. It automatically detects, classifies and tracks ground targets, coastal

sea targets and low-flying air targets (even small and slow-moving ones) at up to 40km. SPEXER 1500 allows the surveillance of large areas and long distances and facilitates an early warning, as well as situational awareness. Due to its multi-tasking and dual-beam capability, one SPEXER 1500 can replace several conventional radars, it is claimed. The portable, lightweight and low-size radar can be integrated into a C2 system. In addition, it is ready for multi-radar operation and in combination with cameras (in a network). Applications: large-perimeter surveillance, border surveillance radar Frequency: X-band Detection range: 40km, pedestrian 15km, large vehicle 30km

### SPEXER 2000

The SPEXER 2000 radar was designed for border surveillance and security applications against asymmetric threats. It automatically detects, classifies and tracks ground targets, coastal sea targets and low-flying air targets (even small and slow-moving ones) at up to 40km. SPEXER 2000 allows the surveillance of large areas and long distances and facilitates early warning, as well as situational awareness. Due to its multi-tasking and dual-beam capability, one SPEXER 2000 can replace several conventional radars, it is claimed. It can be integrated into a C2 system and is ready for multi-radar operation and in combination with cameras (in a network). Five systems were ordered by Malaysia in December 2015 for coastal surveillance and deliveries were expected to be completed in 2016. Hensoldt has received orders worth around \$43 million for the SPEXER 2000 from unnamed customers in the Middle East and North Africa region since the beginning of 2017, the company announced on 4 May. Applications: border surveillance radar

### TRML-3D/32

The TRML-3D is a short/medium-range surveillance and target acquisition radar system housed in a six-axle cross-country vehicle. Self-contained and mobile, it includes an integrated secondary radar system and operator workstations in one vehicle for rapid deployment. Fully coherent multi-mode phased-array surveillance and target acquisition radar system for detecting/tracking small, fast and low-flying aircraft, missiles and hovering helicopters. It can be deployed as a standalone radar or integrated into air defence networks in coordination with other radars and C2 systems. Set-up/tear-down takes two people ten minutes. Is capable of tracking >400 targets. Applications: short/medium-range surveillance and target acquisition radar Frequency: 4-6GHz, C-band Detection range: 200km

## IAI ELTA SYSTEMS

### ELM-2105 Family

The ELM-2105 is a range of tactical ground surveillance radars forming an extension of the ELM-2127 family, designed to provide 360° coverage with a single rotating antenna. With a high update rate of targets, the ELM-2105 delivers a high probability of target interception and supports the missions of military forces and paramilitary law enforcement units. The ELM-2105 lightweight, all-weather, movement-detection radar is designed to detect, alert and monitor intruders' movements in protected and selected zones of interest. This solid-state, continuously rotating LPI dual-beam radar is

rapidly deployed and has low power consumption. The ELM-2105 can be locally or remotely controlled, either as a standalone unit or integrated into a larger ground surveillance network. Applications: tactical ground surveillance radars Weight: 25-35kg Detection range: ELM-2105 5km pedestrian, 10km vehicle; ELM-2015ER 8km pedestrian, 15km vehicle; ELM-2015LR 15km pedestrian, 25km vehicle

### ELM-2112 Family

The ELM-2112 is a family of high-resolution radars with simultaneous multi-beam technology. The radar provides detection surveillance and target detection and tracking over a wide area. The radars are designed for dual use – ground and sea-surface surveillance, even in adverse weather conditions. In operational use by military, paramilitary and security agencies, the radars detect, monitor and track moving targets in the region of interest, such as walking persons and moving vehicles and various vessels at sea. These radars have up to four stationary (non-rotating) planar antennas, each covering a sector of 90°. The radars cover detection ranges from 300-22,000m for a moving person or a rubber boat and ranges of up to 44km for a moving vehicle and a sailing boat, depending on the version. Can track up to 500 targets simultaneously. Applications: family of high-resolution target detecting surface radars Detection range: boat: 44km for V15 version and 2km for V1 version

### UHF Radar Family

At the Paris Air Show in June 2015, IAI unveiled a UHF AESA radar. The ULTRA-C1 (single-cluster configuration) is a lightweight mobile system designed to provide an autonomous search and detection capability up to 500km for a typical fighter aircraft. Another variant is the ULTRA-C6 (six-cluster configuration), which is designed for early warning of ballistic missiles and airborne targets at long ranges. The ULTRA C-22 (22-cluster configuration) is a strategic system designed for ballistic missiles and space object detection and tracking at very long ranges. The new radar, which has already become operational with an unspecified customer, can be used as an autonomous search radar. Applications: air defence surveillance for medium-range, early warning system for long ranges and strategic system for very long ranges Detection range: 500km

## KELVIN HUGHES

### SharpEye SxV

Kelvin Hughes' SharpEye SxV is an X-band lightweight ground-surveillance radar. SharpEye SxV is described as a low-power and environmentally sealed X-band surveillance and tracking system that provides capability in cluttered environments, day or night and in all weather conditions. The radar employs the same pulse compression, Doppler processing and solid-state electronics technology that characterises all SharpEye products. The radar is designed to detect targets with small RCS, which can include dismounted troops, across a coverage area of 360°. It has resistance to jamming and includes an integrated GPS. Concurrent long- and short-range detection is achievable with the radar and its data can be shared with other users via an Ethernet output, which can carry several gigabits of data. In addition to surface targets, the radar can detect

air targets. The radar offers up to 80W of peak power and has an instrumented range of 44km. It produces a beam width of 4° in azimuth and 25° in elevation. It can detect a pedestrian at a 5km range and a vehicle at 15km. In October 2014, the company announced that it had commenced deliveries of the SharpEye SxV to an undisclosed UK military customer and that it is in service on the Kenyan border. Applications: lightweight ground surveillance radar Frequency: X-band Detection range: 15km for vehicle Coverage: 360° in azimuth Setup/takedown times: 25 seconds

## KINTEX

### NR-100

The NR-100 is a man-portable pulse-Doppler radar designed to detect and track moving people and vehicles, providing targeting information for infantry weapons. Applications: man-portable pulse-Doppler tracking radar Detection range: 1.5-1.8km (standing soldier); 3.5-4km (vehicle)

## LEONARDO DRS

### AN/PPS-5C MSTAR V4

The lightweight AN/PPS-5C man-portable Surveillance and Target Acquisition Radar (MSTAR) has wide-area surveillance, acquisition and audio mode (for target classification) to 42km range. Clutter map overlay on detection is available as an aid to set up and determine areas of visibility. Also provides fall-of-shot mode for adjustment of friendly artillery and mortar fire. Available with ruggedised PC-based HMI. System is IP-addressable for use in an integrated sensor suite. The MSTAR is transportable by two people and can be put into action in less than five minutes. It can also be integrated into larger security systems and used as the anchor for other surveillance sensors. The MSTAR locates moving targets and classifies them as personnel, tracked vehicles or wheeled vehicles. The HMI allows for rapid self-location and surveillance area set-up, and also provides for various interface support features. Applications: man-portable battlefield surveillance and targeting radar Frequency: J-band Weight: 39kg Detection range: 42km, pedestrian 11km, large vehicle 36km

### AN/PPS-5C MSTAR V6

The AN/PPS-5C man-portable Surveillance and Target Acquisition Radar (MSTAR) V6 is a ground-surveillance radar that is the latest addition to the MSTAR series. It has wide-area surveillance and audio mode (for target classification) over a continuous 27km range. The V6 is designed for emerging applications and as a drop-in replacement for existing MSTAR integrations. Used as the wide-area, long-range sensor, the MSTAR V6 can be integrated into security systems, providing detection of moving targets. Once a target is detected, position information is provided to cue optical sensors to assess the target. The MSTAR V6 classifies target reports as personnel, tracked or wheeled vehicles, rotary-wing, or unknown. System is IP-addressable for ease of use in an integrated sensor suite as the anchor for other surveillance sensors. Applications: man-portable battlefield surveillance and targeting radar Frequency: J-band Weight: 39kg Detection range: pedestrian 11km, heavy vehicle 36km, artillery rounds 15km

## LOCKHEED MARTIN

### AN/TPQ-53

The AN/TPQ-53 counterfire target acquisition radar can track incoming rounds at a range of 60km when using its 90° search mode, or at 20km range when performing a 360° search. In May 2013, Lockheed Martin won a \$12 million contract for the repair and support of 32 of the company's AN/TPQ-53 Quick Reaction Capability Radars used for counter-battery work. The AN/TPQ-53 has been procured to replace the legacy Raytheon AN/TPQ-36 and AN/TPQ-37 fixed and mobile Firefinder radars. On 30 April 2012, Lockheed Martin was awarded a production order worth \$391 million, encompassing two contracts for the delivery of up to 33 radars by the end of 2014. Options exist for the US Army to order an additional 38 systems, which could take the total value of orders to over \$800 million and in October 2015, the company was awarded an \$85m contract to supply seven Q-53 systems. The company announced in April 2017 that 95 systems, of 100 ordered in 2007, had been delivered to the US Army and that a further contract had been placed which would take the total number of systems to 170. In November 2016, Lockheed Martin was awarded a \$28 million contract for 'quick reaction capability to add counter-unmanned aerial system to the AN/TPQ-53 radar system' simultaneous with its core counter-fire mission. In August 2017, it was announced that Singapore had finalised the acquisition of six Lockheed Martin AN/TPQ-53 counter-fire target acquisition radars after a deal was signed in April under the FMS programme. Applications: counter-fire target acquisition radar Detection range: 60km

### DART

DART (Digital Array Row Transceiver) is a radar technology that will improve the performance of existing Lockheed Martin radar technology products. DART, which was introduced in November 2015, combines row transmitter and row receiver into a single LRU, reduces array power consumption and can help extend a radar's useful life. The new technology is available in the recently launched TPS-77 Multi Role Radar system and is compatible with legacy products (TPS-77, TPS-59, FPS-117). Applications: radar technology

## POLY TECHNOLOGIES

### Ground Artillery Location Type 904

The 904 artillery-locating radar is designed to provide rapid and accurate location of various hostile artillery and rocket launcher positions simultaneously. It has a multi-target capability of up to eight. It is also able to calculate the co-ordinates of friendly impact points for fire correction. The deployment time for the 904 is less than ten minutes and it has a reaction time of less than five minutes. It comes with both a GPS and north-seeking system. Applications: artillery locating radar Detection range: 82mm mortar ≥15km; 122mm howitzer/rocket ≥6km; 155mm howitzer ≥18km

## RADA ELECTRONIC INDUSTRIES

### Compact Hemispheric Radar (CHR)

RADA's Compact Hemispheric Radar (CHR) is one of a family of radars used in hostile fire location (RPS-15),

all threat air surveillance (RPS-12), active protection (RPS-10) and 3D perimeter surveillance (RHS-14) systems, as well as other systems. The radar can operate in track-while-search, target-revisit and single-target-tracking modes. The RPS-10 can detect relevant threats that may be fired at combat vehicles - including RPGs, ATGMs, and projectiles - and provide 360° hemispheric coverage. The system provides threat data to enable neutralisation of threats. The RPS-15 detects tracks, classifies and locates direct and elevated threats fired at combat vehicles. It was announced in early 2017 that CHR will be part of the IMI Systems' Iron Fist Active Protection System (APS) being installed on the Dutch army's CV90 infantry fighting vehicles for testing and verification. In mid-2016, it was announced the RPS-10 system will be provided to Artis for integration and testing with the Iron Curtain close-in APS. It was announced in December 2017 that the Colombian Army's Pegaso 4x4 armoured vehicle's new Myolnir T30 unmanned turret will be fitted with CHR. Type: hemispheric radar Applications: target and fire tracking Frequency: S-Band Length: 16.5cm Width: 47.5cm Height: 27cm Power: 110W Weight: 18kg (with armoured antenna) Detection range: RPG 250m, direct attack rocket/missile 2km, pedestrians 4km, light transport aircraft 6km, vehicles and medium-sized vessels 8km, large vessels 15km Azimuth coverage: 120° Elevation: 90° MTBF/MTBCF: 25,000h

### eMHR

RADA's Enhanced Multi-mission Hemispheric Radar (eMHR) forms the basis of hostile fire locating (RPS-70/71), perimeter surveillance (RPS-72) and all-threat air surveillance (RPS-74) systems. It can be installed on vehicles or vessels and at fixed bases. The system can operate in search-while-tracking, target-revisit and single-target-tracking modes. Applications: hostile fire detection and target detection and tracking Frequency: S-Band Width: 67cm Height: 16.5cm Power: 590W Weight: 40kg Detection range: light/medium mortar and short-range rocket 8.5km; heavy mortar 10km; direct attack rocket/missile 10.5km; pedestrian 16km; vehicles and small vessels 32km; light tactical aircraft 38km; large vessels 60km; RPG max firing range MTBF/MTBCF: 11,500h

### Hostile Fire Location Radar Systems

RADA's Hostile Fire Location radar systems detect, track, classify and locate all types of direct and indirect fire, including rockets, artillery, mortars (RAM), ATGMs, RPGs and small arms. The system classifies threats, calculates the point of origin and point of impact, displays tracking and provides an audible and visual warning/alert, as well as data over Ethernet to external C4I systems for alerting the threatened forces. The radar systems can be based on any member of RADA's Multi-mission Hemispheric Radar (MHR) family of tactical platforms and also the Compact Hemispheric Radar. These radar platforms differ primarily in antenna sizes, resulting in maximal detection ranges: 5-10km for light/medium mortar and short-range rockets, up to 12km for heavy mortars and 2-12km for ATGMs. RADA's radar platform attributes: S-band, 90° azimuth coverage using MHR and 120° using CHR; hemispheric coverage (360°) is achieved when three/four identical and interchangeable radars are employed as a system. AESA antenna: solid-state, digital (software-defined), no moving parts and mobile for tactical applications. The radar systems can be integrated

with a protection system and other radars/sensors. They can be installed on fighting vehicles for deployable, on-the-move force protection or at fixed bases. Frequency: S-band Detection range: 5-10 km for light/medium mortar and short-range rockets, up to 12km for heavy mortars and 2-12km for ATGMs

#### ieMHR

RADA's ieMHR (Improved and Enhanced Multi-mission Hemispheric Radar) is the largest in a family of MHRs manufactured by the company to provide hostile fire location (RPS80/81), 3D perimeter surveillance (RHS-84) and all-threat air surveillance (RPS-82). It is an S-Band radar which provides detection for pedestrians to a range of 20km and large transport aircraft to 100km. Applications: hostile fire detection and target detection and tracking Width: 79cm Height: 17cm Power: 760W Weight: 58kg Detection range: pedestrian 20km, light/medium mortar and short-range rocket 10km, vehicles and medium-sized vessels 40km, medium UAV 30km, fighter aircraft 50km, large vessels 80km, heavy transport aircraft 100km MTBF/MTBCF: 8.500h

#### Multi-Mission Hemispheric Radar (MHR)

RADA's Multi-Mission Hemispheric Radars (MHR) are S-band, software-defined, pulse-Doppler, active electronically scanned array (AESA) radars. The radars have beam forming capabilities and advanced signal

processing, which can provide for various missions on each radar platform. The radars are compact and mobile, enabling multiple missions on each radar, and work while on the move. In August 2017, the company announced it had received a first order for dozens of MHR from the US military. Totalling over \$8 million, this order will be delivered during 2017. The radars will be used by a key US military force, providing it with air surveillance with an emphasis on counter-UAS with advanced on-the-move capabilities. The radars are expected to be fielded for operational use soon after delivery. Applications: active protection, hostile fire detection, counter-UAS, all-threat air surveillance and 3D perimeter security surveillance

#### pMHR

The pMHR (Portable Multi-Mission Hemispheric Radar) is the smallest in the family of MHRs manufactured by Israeli company RADA and provides hostile fire location as part of the RPS-40/41 system, all-threat air surveillance (RPS-42), and 3D perimeter surveillance (RHS-44). It can detect all types of aerial vehicles (including UAVs of all groups), missiles, rockets and mortars. The radar can operate as fixed or deployable/manoeuvrable on tactical land vehicles, littoral or shipborne (combat and patrol ships). Type: hemispheric radar Applications: fire location and target detection and tracking Frequency: S-Band Width: 50.4cm Height: 16.5cm Power: 350W

**The Credo-M1 system operates in all weather conditions, including zero visibility such as in fog, snow, rain, smoke and dust. (Photo: Rosoboronexport)**



Weight: 20kg Detection range: light/medium mortar and short-range rocket 5km, heavy mortar 6km, direct attack rocket/missile 6.5km, RPG max firing range, pedestrian 10km, light transport aircraft 25km, vehicles and medium-sized vessels 20km, large vessels 40km MTBF/MTBCF: 15.500h

### Three-Dimensional Perimeter Surveillance Radars

RADA's Three-Dimensional (3D) Perimeter Surveillance Radars provide border and perimeter surveillance through detection, classification and tracking of surface and aerial intruders, such as pedestrians, vehicles, slow and small aircraft, vessels and more. These radar systems can be based on any member of RADA's Multi-Mission Hemispheric Radar (MHR) family of tactical radar platforms or Compact Hemispherical Radar. The radar platforms differ primarily in antenna sizes, resulting in maximal detection ranges: 4-20km for pedestrians, 6-50km for light transport aircraft and 8-40km for vehicles/medium-size vessels. MHR radar platform specifications: S-band, 90° cone coverage from antenna axis for single radar (up to 360°), AESA antenna: solid-state, digital (software-defined), no moving parts and mobile for tactical applications. RADA's 3D Perimeter Surveillance Radars can be integrated with a C4I system and other radars/sensors/EO using standard Ethernet interfaces and can operate standalone or as part of a large-scale surveillance system, vehicle-mounted or static. Frequency: S-band Detection range: 4-20 km for pedestrians, 6-50 km for light transport aircraft and 8-40 km for vehicles/medium-size vessels

## ROCKWELL COLLINS

### PSR-500 Perimeter Surveillance Radar System

The PSR-500 is a high-resolution compact radar system designed for perimeter surveillance. PSR-500 radars are designed to detect mobile targets in all weather conditions, including rain and fog, 24h a day. The radars are adapted to the surveillance needs of many types of sites because of their range and target behaviour analysis algorithms. Each PSR-500 can be coupled to a camera that is controlled by radar detections, allowing multi-target, accurate video visualisation and recording in real time. The PSR-500 is suitable for locations such as airports, industrial and military sites, hydroelectric dams, nuclear power plants, railway stations and public or private urban sites. Features of the PSR-500 include IP radar connectivity, LPI because of FM CW technology, accuracy for range, speed and azimuth, extended detection range up to 500m for human detection, multi-target capability, multi-radar on-site radio compatibility and connection to video management/recording system. The radar also has a compact design with low SWaP-C and a low radiated power, which poses no health risks. Frequency: C-band Length: 37cm Width: 15cm Height: 5cm Weight: 1.5kg Detection range: 500m (person), 900m (vehicle) Coverage: up to 90° azimuth, 35° elevation

## ROSOBORONEXPORT

### Credo-M1

The Credo-M1 is a portable battlefield surveillance radar designed to detect ground and above-water moving targets. It is also capable of controlling artillery fire. The

system operates in all weather conditions, including zero visibility such as fog, snow, rain, smoke and dust. Credo-M1 is able to track up to ten operator-selected targets as well as determine their co-ordinates, motion direction and speed. Radar data is displayed on the control console and overlaid onto a digital map. Target data transmission is achieved via RS-232 interface to operators. The system includes a transceiver with antenna and rotating device, data processor, control and view console, carrying case, optical sight, compass, accumulator batteries and a cable set. Applications: surveillance Frequency: J-band Power: 2x battery Weight: 51 kg Detection range: 32km max Coverage: 32km, 540° and +/-18° elevation

## SAAB

### ARTHUR

The Artillery Hunting Radar (Arthur) was designed to be the weapon-locating element within a counter-battery system at brigade or division level. Arthur is capable of detecting, tracking and determining the point of origin and impact of artillery shells, mortar projectiles and rockets. The system can also be used to register and correct outgoing fire. It is also used for force protection to warn of incoming fire. The phased-array antenna and operator shelter can be mounted on a 4x4 truck or tracked armoured vehicle. Its range is 30km (guns) to 60km (rockets, mortars), while functioning modes include weapon location/fire control/sense and warn. Some 800 Arthur units have been sold and their capability is proven from thousands of hours of operation, states the company. Customers include the Czech Republic, Denmark, Greece, Italy, Norway, Spain, Sweden, South Korea, Thailand and the UK. In April 2015, Norway signed a contact with Saab worth about \$13 million for a mid-life upgrade of that country's existing Arthur systems. Delivery was expected in 2017. Applications: weapon-locating element within a counter-battery system Scan rate: >100 targets/min Frequency: C (G/H)-band Power: internal Detection range: 60km Coverage: track interval 8.5°, 120° search sector, 360° mechanical Operating platforms: HMMWV, medium to large truck Setup/takedown times: 2min deployment Pulse repetition frequency: passive phased array - azimuth and elevation electrically scanned

## SRC

### LCMR Counterfire Radars

The Lightweight Counter-Mortar Radar (LCMR) family of systems provides continuous 3D 360° surveillance and 3D rocket, artillery and mortar location using a non-rotating, electronically steered antenna. The radars perform with a TWS capability, allowing simultaneous detection and tracking of multiple threats fired from separate locations. Once a RAM threat is detected, the radar sends an early warning message indicating that a round is incoming. After sufficient data is collected to enable an accurate point of origin, the weapon's location is reported back for a counterfire response from any integrated system. The LCMR family of radars have the following characteristics: low life-cycle cost; unattended remote operation; transportable with rapid emplacement in challenging locations; ruggedised with no moving parts for maintenance; rooftop, tower, tripod or vehicle mountable; network-ready for

integration with FAAD; capable of fulfilling multiple missions simultaneously. The LCMR radar family includes: the AN/TPQ-49 counterfire Radar designed for use by expeditionary forces, which can be assembled or disassembled by two soldiers in 20 minutes; and the AN/TPQ-50 Counterfire Radar, which builds upon the AN/TPQ-49, is adapted to fulfil multiple missions and offers detection of incoming RAM from low-quadrant elevations and a more accurate POI calculation from greater distances. Applications: continuous 3D, 360° surveillance and 3D rocket, artillery and mortar location radar Weight: AN/TPQ-49 68kg, AN/TPQ-50 <227kg Range: AN/TPQ-49 >10km, AN/TPQ-50 >50km

### Omni-Directional Weapon Locating Radar

The Omni-Directional Weapon Locating Radar (OWL) is a target-acquisition radar being developed for the US Army by SRC. The radar is able to run multiple missions at the same time (including hemispherical sense-and-warn, counter-fire target acquisition, air surveillance and counter-UAS). The OWL is able to provide surveillance over a hemispherical coverage volume (-20° to 90° elevation, 360° azimuth), which the company says is a feature that is not available with current radars. The OWL has an enhanced Doppler processing capability and non-rotating antenna, which enables it to detect and track small, low, slow moving air targets while also meeting counter-fire mission requirements. Frequency: S-Band Length: 6ft Width: 6ft Height: 13ft Power: <40 kW Weight: 2.631kg

### O-PEN Wall Penetration Radar

SRC's O-PEN sense-through-the-wall radar system, previously known as SOMISR II, was developed to address urban warfare requirements under a US Army Technology Objective programme. The radar system can detect and locate people behind concrete walls, doors and other barriers from a significant standoff range. It also generates an image of the building that maps the walls of the building, for a clear tactical picture of the operation. This vehicle-mounted radar can operate in either stationary or moving mode, making it flexible to meet the complexity of the urban terrain being explored. It provides soldiers with situational awareness before breaching a building or while policing an area and can be applied to other missions including ground surveillance and foliage penetration. Applications: sense-through-the-wall radar system

### SR Hawk Ground Surveillance Radar

The SR Hawk surveillance radar provides continuous 360° surveillance of the ground, ports and harbours and airspace. It performs these tasks in a single system. It detects personnel, land vehicles, marine vessels, avian targets and low-flying aircraft such as UAS. These capabilities make it suitable for applications such as ground surveillance, air surveillance, border and perimeter surveillance, counter-UAS mission support, port and harbour surveillance, wind farm bird strike avoidance, avian surveillance and artillery spotting. It supports image cueing, classification and identification of targets. Automated EO/IR camera cueing, audible alerts, multi-target tracking and anti-clutter techniques allow the operator to focus on the threat. According to SRC, the SR Hawk radar offers: a rapid update rate, with continuous 360° coverage or definable sector scanning; low false alarm rate; automated sensitivity settings for weather

and clutter management; simultaneous short- and long-range coverage; automated priority target track mode; and tower, vehicle mount and tripod configurations. Applications: surveillance radar Weight: 21kg

### STRELA

#### ARK-1M

The ARK-1M is a mortar, artillery and rocket-locating and FCR. Frequency: 6GHz Wavelength: 5cm Applications: mortar, artillery and rocket-locating and FCR Frequency: 6GHz Detection range: up to 9km (artillery location); up to 13km (mortar location); up to 15km (artillery fire control); up to 17km (mortar fire control); up to 30km (rocket location and fire control); 30km (TBM location); 40km (TBM fire control)

#### Monitor

Monitor is a man-portable, tripod-mounted ground surveillance radar designed to detect moving targets. Control and display via PC. Applications: man-portable, tripod-mounted ground surveillance radar Frequency: 5-8GHz Detection range: 5km (person); 8km (vehicle); 12km (helicopter); 20km (ship)

#### P-200 Credo-1

The P-200 Credo-1 is a tripod-mounted, pulse-Doppler ground/coastal surveillance radar capable of detecting and tracking a variety of targets including people, vehicles, ships and helicopters, as well as providing fire control data for artillery. Applications: tripod-mounted, pulse-Doppler ground/coastal surveillance radar Frequency: 10-20GHz Detection range: 15km (people); 20km (small vehicle); 25km (MBT); 30km (ship)

#### RP-100 Fara-1

The RP-100 Fara-1 is a tripod-mounted, pulse-Doppler ground/coastal surveillance radar capable of detecting and tracking a variety of moving targets and cueing infantry weapons. Can be operated remotely and transmit warnings over radio link. Applications: tripod-mounted, pulse-Doppler ground/coastal surveillance radar Frequency: 10-20GHz Detection range: 2km (person); 4km (small vehicle, helicopter, ship)

#### Zoopark-1

Zoopark-1 is a counter-battery and ATC radar system mounted on a tracked MT-LB armoured vehicle. Tracks incoming artillery, mortars, rockets and missiles. Applications: vehicle-mounted counter-battery and ATC radar system Frequency: 6-8GHz Detection range: 8km (105mm shell); 10km (155/203mm shell); 12km (81mm mortar/122mm rocket); 15km (120mm mortar); 20km (220mm rocket); 35km (TBM)

### TELEPHONICS

#### ARSS

Relied upon by US as well as international paramilitary and government agencies, Telephonics' Advanced Radar Surveillance System (ARSS) uses pulse-Doppler technology, providing wide-area ground surveillance for border security and perimeter protection applications. Applications: pulse-Doppler ground radar Frequency: X-band Detection range: from person at 8km to large vehicle at 30km; hovering helicopter at 15km



The Ground Fire Radar system can be mobile on any type of surface and is transportable by air. (Photo: Thales)

### FoPEN

The FoPEN is a wideband, pulse-Doppler and ground-surveillance radar which operates in the UHF band, minimising foliage attenuation. The system has TWS and pulse compression technology, providing wide-area surveillance capability to search, detect, acquire and track targets through mixed foliage. The FoPEN employs an array of pulse widths for continuous coverage at short ranges while maintaining detection at longer ranges. The system can detect large vehicles at a range of 2.1 km and a crawling person at 1.2 km in a clear environment. Applications: wideband, pulse-Doppler and ground-surveillance radar Weight: 17kg

### RaVEN-M

The Radar and Video Enforcement Network-Mobile (RaVEN-M) offers an integrated deployable mobile ground surveillance system capable of operating as a standalone or networked system, creating a 'virtual fence'. RaVEN-M offers a flexibility, enabling effective border surveillance in all terrains and environments. Large vehicles can be detected up to a range of 30 km and single people up to 12 km. Applications: integrated deployable mobile ground surveillance system Weight: 1,700 kg

### RaVEN-P

Addressing the needs of military and border security agencies, Telephonics' Radar and Video Enforcement Network-Portable (RaVEN-P) system is designed for the surveillance of borders, ports and harbours as well as security for bases and critical infrastructure. When paired with ARSS, the RaVEN-P is capable of locating moving personnel, day or night, at ranges of 5,000 m and vehicles at ranges of 8,000 m. Applications: radar for surveillance of borders, ports and harbours as well as security for bases and critical infrastructure

## THALES

### AMSTAR

The Australian Man-portable Surveillance and Target Acquisition Radar (AMSTAR) is designed to meet peacetime and battlefield surveillance requirements of observer and reconnaissance elements of infantry, armour and artillery forces. Radar performance is optimised for operation against targets including personnel, vehicles, inshore vessels and low-flying helicopters. A version of the MSTAR system which is

known as the AN/PPS-5C, is in service with the US Army. Applications: all-weather ground, sea and air surveillance radar Detection range: (single scan at 9°/s) pedestrian 11 km; vehicle 22 km; tank 26 km; helicopter 21 km; boat 13 km; vessel 42 km

### AN/TPQ-37(V)9 RMI

The Reliability Maintainability Improvement (RMI) upgrade to the AN/TPQ-37 is aimed at improving reliability and maintainability. Long-range weapon-locating radar that automatically locates simultaneous fire from up to ten different enemy mortars, artillery and rocket launchers, reporting their positions on the first round in seconds. It can be positioned and ready for operation in 30 min. Adjusts friendly fire. The upgrade is intended to improve availability by 90%, a significant reduction in life-cycle cost and extension of its useful life beyond 2018, while maintaining performance capabilities. It also adds computer-based training and electronic technical manuals. The new radar processor combines VME-64x architecture and high/low-temperature performance with proven AN/TPQ-37 operational and maintenance software. Applications: long-range weapon locating radar Detection range: (max) 50 km; (effective) mortars 20 km, artillery 30 km, rockets 40 km

### BOR-A 550

The BOR-A 550 is a ground, coastal and low-level air surveillance radar that detects, locates, automatically classifies and tracks moving targets. It has performance at long ranges against small and slow targets such as people and rubber boats. The mechanically scanned parabolic reflector and receiver/processor are tripod-mounted and linked by cable to a laptop-style control and display unit. Applications: ground, coastal and low-level air surveillance radar Frequency: 9.5 GHz Detection range: pedestrian 16 km (19 km option); vehicle 33 km (39 km); tank 42 km (50 km); helicopter 31 km (36 km); boat 19 km (22 km); large vessel 60 km (80 km)

### Cymbeline

The Cymbeline is a phased-array, mortar-locating radar that detects the flight path of a mortar bomb at two points in its trajectory, as it passes through the radar beam, allowing the point of origin to be identified and engaged. Cymbeline has been delivered in vehicle-mounted and towed configurations. In British Army service from 1975 until 2003. Other users include Denmark, Egypt, Finland, Iraq, Kuwait, Malawi, New Zealand, Nigeria, Norway, Oman, Saudi Arabia, Singapore, South Africa and Switzerland. Applications: phased-array, mortar-locating radar Frequency: 8-12 GHz Detection range: 10 km (81 mm mortar bomb)

### GA10

Ground Alerter 10 (GA10) is an anti-mortar force protection solution that performs early detection of an incoming mortar shell or rocket and warns persons located in the threatened sector, prior to threat impact. GA10 provides the estimated location of the mortar shell or rocket launch point, enabling any appropriate counter-operation. It is a deployable RAM alerter system, which contributes to the protection of deployed forces located in bases or compounds as well as important civilian installations. The system comprises: a radar which provides 360° surveillance up to 10 km; an alerter

subsystem, with up to three wired alerter devices and three wireless alerter devices (each consists of a siren and a flashing light), to cover the protected area; and a ruggedised laptop for system monitoring and control. GA10 is field-proven by the French Army. Applications: anti-mortar radar

### GO12

Ground Observer 12 (GO12) is a lightweight ground surveillance radar. Ku-band, pulse-Doppler. GO12 is suitable for applications including battlefield, border, coast and site surveillance by military/paramilitary forces or civilian users. It can be operated standalone on a tripod or integrated with masts/vehicles. The manpack configuration with tripod and laptop MMI can be set up in  $\leq 2$ min and operated by one individual. It allows surface and low-altitude air surveillance up to 27km. Applications: lightweight ground surveillance radar Weight: 30kg Detection range: 17km for large vehicle, 8km for person (with extended range option) Setup/takedown times:  $\leq 2$ min

### GO80

The Ground Observer 80 (GO80) is a ground-surveillance radar for use by armies, navies, border and coast guards and other security forces. A lightweight system, it is able to detect humans at up to 24km and larger targets at up to 80km. High resolution is provided by a large antenna and 2,000 range gates down to 10m width. The GO80 can be flexibly configured with 40W or 80W transmitters, 0.8m or 1.6m antennas. It can be mounted on masts on vehicles, on fixed towers or operated standalone on a tripod up to 200m away from the operator console. Moreover, due to its standard Ethernet/Asterix interface, the GO80 sensor can be integrated into larger systems and operated by the client-server principle via any IP network. Applications: ground surveillance radar Weight: 34kg Detection range: humans at up to 24km and larger targets at up to 80km

### Ground Fire Radar

Thales unveiled its Ground Fire Radar family, a range of multifunction ground radars, on 19 June 2017 at the Paris Air Show. Using AESA technology, the radar system, which is fully digital, has been designed to carry out air defence and surveillance missions and is able to simultaneously detect and track targets such as ballistic missiles from the Aster family in hostile environments such as clutter, rain and jamming. The Ground Fire family is compact and deployable in under 15 minutes. The system can be mobile on any type of ground surface and is transportable by air. The Ground Fire range system includes a mobile, truck-mounted antenna and is designed to operate on any type of ground surface. According to Thales, this radar system is identical to its naval Sea Fire radar family, which is set to equip the future intermediate-size frigates of the French Navy. Detection range: 400km Coverage:  $360^\circ$  Setup/takedown times: 15min

### MSTAR

The man-portable Surveillance and Target Acquisition Radar (MSTAR) is designed to detect ground-based and low-flying moving targets such as aircraft, vehicles and infantry. Powered by a standard army field battery, it provides a day/night wide-area surveillance capability. Colour map-based display shows dead ground, relief and

target track history. Support for vector, raster and DTED maps including a variety of datum and grid standards. Direct read-out of target position in any supported grid/datum format including military grid. The 37.5kg radar can be carried in a vehicle (for example, the British Army's Warrior Observation Post Vehicle) or broken down into three man-packed loads. Has seen service in the Middle East, Balkans and Afghanistan and is in service with Australian, Canadian, Polish, UK and US forces. More than 800 systems have been fielded. Applications: man-portable radar for detecting ground-based and low-flying targets Frequency: 17GHz Weight: 37.5kg Detection range:  $>40$ km

### RASIT

The Radar d'Acquisition et de Surveillance Terrestre (RASIT) is a ground surveillance pulse-Doppler radar designed to detect and classify moving targets on the ground or at very low altitude. Can be mounted on light utility trucks, armoured vehicles, shelters or a tripod. More than 700 units have been sold to customers in at least 32 countries including Australia, Estonia, France and Germany. Applications: ground surveillance pulse-Doppler radar for ground and low-altitude air targets Frequency: 8-10GHz Detection range: 40km (aircraft, vehicle), 20-30km (helicopter), 20km (soldier)

### RATAC-S

The Radar d'Aide au Tir d'Artillerie de Campagne (RATAC-S) is a multipurpose radar designed to detect, locate and classify ground targets or low-flying aircraft at medium to long ranges. It can also be used for artillery fire control and probably as a counter-battery radar. More than 300 units have been sold to the armed forces of France, Germany, Morocco, the UAE and others. Applications: multipurpose ground-air radar for medium and long range Frequency: 9.5GHz Detection range: light vehicle 24km, helicopter 28km, MBT 30km, vehicle convoy 38km, 105mm shell 8km, 155mm shell 15km, soldiers 18km

### RB-12

The RB-12 is a short-range, portable surveillance radar. Detects, automatically locates and recognises pedestrians, vehicles, light aircraft, helicopters, microlights and UAVs. The RB-12 fulfils multiple tactical surveillance missions such as battlefield intelligence, infantry reconnaissance, artillery, border or sensitive site surveillance. Applications: short-range, portable ground-air surveillance radar Frequency: 12-18GHz Detection range: 3km (lone person), 21km (light vehicle), 28km (heavy vehicle/tank)

### RB-12B

The RB-12B is a short-range ground surveillance radar optimised for detection, classification and tracking of moving targets on the ground from individuals to armoured vehicles. Has a tripod-mounted flat-plate antenna and receiver/processor, and separate laptop-style control and display unit linked by a 25m cable. In service with the French Air Force. Applications: short-range ground-surveillance radar Frequency: 10-20GHz Detection range: 6.4km (vehicle), 3km (person)

### RD-170BT

The RD-170BT is a man-portable surveillance radar deployed ashore to protect moored patrol boats of the Royal Norwegian Navy. Applications: ground-based man-

portable surveillance radar for littoral zones Frequency: 9.38-9.44GHz Detection range: 89km, 0.47, 1.39 and 2.8km range scales Pulse repetition frequency: 1.500pps

## THALES NETHERLANDS

### Squire

The Squire radar has a range of up to 48km and can detect targets moving at a minimum speed of 0.5m/s. A tank-sized target can be viewed by the radar at 24km, a helicopter at 15km and a pedestrian at 10km. The radar uses a Windows XP operating system and can employ wireless connectivity. In terms of operating modes, the radar scans up to 270° in azimuth, and has a scan speed of between 7° and 14°/s. The horizontal beamwidth transmitted by Squire is 2.8° with the vertical beamwidth 7.5°. The radar can transmit between 1W and 10mW of output power. The total system weight is 16kg, and the radar can be transported and operated by a single soldier. In March 2013, it was reported that the Norwegian Army will receive 44 Squire radars which are being produced in partnership with Vinghog Optronics of Norway. Ten systems were delivered in 2013, with deliveries concluding in 2017. Applications: man-portable, battlefield surveillance system Frequency: (single scan at 7°/s) pedestrian 10km, vehicle 21km, tank 28km, helicopter 21km, boat 12km, vessel 48km Weight: 18kg radar, 4kg operator unit Detection range: 8-12GHz, I/J-band

## WEIBEL SCIENTIFIC

### Integrated 3D RMS

The Radar Multi-Sensor (RMS) is the newest member of the Weibel family. It combines a phased array 3D surveillance radar with an optional independently controlled EO pan and tilt head for a wide range of day and night camera solutions in one very compact system. With a Weibel RMS, it is possible to detect, track, and identify even very small intruders such as human beings, small vehicles and micro drones. The RMS provides early warning detection capability, with a very high update rate, using variable rotation speeds up to 60rpm. The RMS transmits in X-band, using FMCW or CW waveforms as well as clutter mapping, which provides superior 3D detection and tracking of targets on the ground and in the air. The RMS is applicable for critical infrastructure protection, wide-area surveillance, border protection, camp perimeter protection, homeland security, intrusion detection and identification, and situational awareness.

### MFSR Air Surveillance and Tracking Radars

Weibel's MFSR surveillance radars combine an advanced phased array 3D surveillance radar with a highly accurate tracking radar in one radar, providing full dome coverage. For detected targets, the radar can be switched from surveillance to tracking mode (stop and stare), either for fire direction of a weapons system or for intelligence collection of suspicious flight behaviour. The radar provides early warning detection based on pre-programmed rules that allow the radar to switch automatically to verification mode for all fast targets. This enables provision of early warning track output for use in C2/display systems. For the mobile solution variant of the MFSR, set-up time takes less than one hour with a two-person crew. The systems are applicable for airspace surveillance, detection of asymmetric threats, monitoring

of UAV/drones, ground-based air defence, fire direction, and military ATC.

### MVRS

Weibel's Muzzle Velocity Radar System (MVRS) was introduced in 1992 and has since then seen service in more than 25 countries and on more than 4,000 howitzers and other weapons systems. The MVRS-700 series radars are small, ruggedised radars meant to be installed on the actual weapon. The system is developed to measure velocities from 30 to 3,000m/s and is designed to be mounted on tanks, howitzers, mortars and naval gun systems, interfacing directly to the fire control system (FCS). Many parameters, such as temperature, humidity and barrel conditions, influence a round's muzzle velocity. It is pivotal to compensate for these parameters in order to improve accuracy and reduce dispersion by adjusting individual gun settings according to precisely measured muzzle velocity. The radar system consists of an antenna with an integrated processor and an optional display unit placed near the gunner or battery coordinator. The antenna unit contains all necessary electronics and an acoustic trigger. Its trigger and Doppler signals are digitised by the processor unit and stored for digital analysis immediately after recording. The result is visible on the display unit less than two seconds after fire and the result can be submitted simultaneously to an FCS in order to adjust fire. The MVRS-700 series comes with a number of optional features for enhanced performance, eg self-calibration, which eliminates the need for calibration throughout the entire system life cycle, motion compensation for precision in velocity measurement and variable frequency to avoid interference from other guns. The MVRS-700 series is qualified to NATO STANAG 4114, MIL-STD-810, MIL-STD-461 and MIL-STD-1275E. The radar series measures with an accuracy better than  $\pm 0.05\%$  and has a precision better than  $\pm 0.1\%$ .

### SL Velocity Radar

Weibel's SL velocity radars are fixed-headed Doppler radar systems, first introduced in 1983. Each radar is a one-man-portable system, which connects directly to the TCP/IP network and can be accessed and controlled from any standard PC on the network running the WinDopp software. With the SL radar, it is possible to measure the full velocity development over the time of flight, projectile spin, micro-movements, sudden velocity changes and indicate yaw or tumbling throughout the trajectory. The systems are designed to measure velocity from 10 to 10,000m/s with an accuracy of  $\pm 0.05\%$ . The system can measure all types of ammunition and calibres, eg projectiles, artillery, mortars and tracers, with a typical range reach from 250-4,000m.

## LAND-BASED AIR DEFENCE

### ALMAZ-ANTEY

#### 1L121-E

The vehicle-mounted 1L121-E radar system operates in the UHF segment of the spectrum and is thought to have a range of circa 90km when operating with 60° elevation. When the radar's FOV is increased to 90°

elevation, it is able to track up to 64 targets, although this brings a range decrease to around 20km. The accuracy of the 1L121-E is in the region of 1° in elevation and azimuth, while it is capable of performing electronic target classification. In particular, the radar is optimised for the detection of small battlefield targets such as UAVs and precision-guided munitions. The baseline 1L121 radar is not a new system, having debuted in 2011. It is not clear how the 1L121-E variant differs from the original baseline radar. In terms of vehicles, the 1L121 has been seen on a number of different chassis in the past, including a MT-LB tracked vehicle and a GAZ-3937 four-wheel drive truck, although the version showcased at the 2013 Aero India event was displayed mounted on a BTR-80 eight-wheel drive APC. Applications: mobile 3D radar Frequency: UHF Range: 90km Number of targets tracked simultaneously: 64

### 55Zh6UE NEBO-UE

The Almaz-Antey 55Zh6UE NEBO-UE is a VHF mobile, long-range, 3D digital phased array air-surveillance radar designed to detect medium targets and large targets such as ballistic missiles. It has been in service since 2008 and deployed alongside S-400 systems. It can detect a fighter aircraft up to a range of 700km and a hypersonic cruise missile up to 300km. Applications: long-range air defence Range: 400km MTBF/MTBCF: 250h Number of tracks handled: 100

### 9S19M2

The Almaz-Antey 9S19M2 Imbir (NATO: High Screen B) long-range phased-array air defence radar is a mobile sector scanning system designed for the rapid acquisition and initial tracking of shorter range ballistic missiles, cruise missiles and aircraft. It operates in the I/J Band. Applications: sector scanning air defence Frequency: I/J-Band Range: 185km Number of targets tracked simultaneously: 16 Antenna dimensions: 4mx6m

### Kasta-2E

The Kasta-2E2 (39N6E) is a low-altitude three-dimensional circular scan radar system. Operating in stand-by mode, it is designed to monitor air space and determine the range, azimuth, flight level and route parameters of airborne objects, such as aircraft, helicopters, remotely piloted aerial vehicles and cruise missiles. The radar system is used in air defence, coastal defence, and border control systems and air traffic control and air space control systems at airfields. The Kasta-2E1 system uses two antennas and two vehicles, while the Kasta-2E2 uses three vehicles and a single antenna. Applications: low altitude air defence Range: 5-150km Altitude coverage: 6km Deployment/setup time: 20min Number of targets tracked simultaneously: 50

## ASELSAN

### FCR

Fire Control Radar (FCR) is a mobile Ku-band short-range 3D track radar for point air defence of critical assets. FCR offers an instrumented range of 30km and can track air targets, adding classification information to target track. FCR is a monopulse track radar with a cassegrain antenna. The system employs electronic protection measures and uses digital pulse compression for high-range resolution, low transmission power and pulse

coding. FCR can detect separate targets and can send target and jammer reports to a vehicle C2 system and can receive commands back. FCR is currently the main radar of the Turkish Armed Forces' mobile air defence gun systems. Applications: mobile air defence weapon system Frequency: Ku-band Range: >30km Coverage azimuth: 360°

### MSR

Mobile Search Radar (MSR) is a mobile X-band short-range 3D search and track radar for point air defence of critical assets. MSR offers an instrumented range of 70km and can track multiple targets accurately, adding classification and identification information to each track. MSR is an active phased-array radar with digital beam-forming architecture. The system employs electronic protection measures and uses digital pulse compression for high-range resolution, low transmission power and pulse coding. It is designed to be integrated on military vehicles with search-on-move capability. The system includes a built-in IFF interface and IFF antenna. MSR can send target and jammer reports to a vehicle C2 system and can receive commands back. MSR is currently the main radar of the Turkish Armed Forces' mobile air defence gun systems and low-altitude air defence missile system. Elevation positioning: -5/+70° Azimuth coverage: 360° Applications: mobile 3D search and track radar Frequency: X-band Range: >70km

## AVIBRAS INDÚSTRIA AEROESPACIAL

### EDT-FILA

Trailer-mounted FCR system designed for use with 35-40mm anti-aircraft guns. Has one 8-20GHz and one 20-40GHz radar, laser rangefinder, IFF, TV camera. Applications: trailer-mounted FCR system Frequency: 8-40GHz

## BAE SYSTEMS

### Celldar

BAE Systems and Roke have developed the Celldar passive radar which detects disturbances to civilian Global System for Mobile Communications digital mobile phone networks operating in the UHF range. A prototype was constructed in 1999, with BAE Systems joining the programme in 2002. Applications: air traffic monitoring using passive GSM emissions Frequency: UHF

### iMOTR

The Innovative Multiple-Object Tracking Radar (iMOTR) system has been designed to provide military test ranges with more accurate time, space and position information for several in-flight objects. iMOTR has a C-band or X-band active electronically scanned array antenna and enhanced clutter suppression for improved accuracy. The radar system is mounted on a commercial trailer optimised for enhanced mobility. It is ruggedised and weather-proof to resist shock, dust, sand, humidity and rain to improve performance and sustainability. iMOTR has a tracking range of over 100km and can track over 20 targets in real time. BAE Systems introduced the iMOTR on 8 August 2017 at the annual Space and Missile Defense Symposium in Huntsville, Alabama. Range: >100km Frequency coverage: C-band or X-band

**LAADS**

The Low Altitude Aircraft Detection System is a truck/helicopter/C-130-transportable low-altitude air defence radar. C2 and FCS for short-range anti-aircraft systems such as MANPADS and guns. Stowable, parabolic reflector antenna is supported by an extendable mast on a standard S-280 shelter. Applications: transportable low-altitude air defence radar, C2 and FCS Frequency: 1-2GHz Range: 60km (30km for hovering helicopter) Pulse repetition frequency: 4,160-4,840pps

**BATS BELGIAN ADVANCED TECHNOLOGY SYSTEMS****AD06**

The AD06 is a fourth-generation, 3D tactical air defence radar. It can also be used in the gap-filler role and provide local ground-based air defence coverage for MANPADS. The L-band radar is portable, weighing less than 100kg. It produces 400W of peak transmit power and is compatible with NATO's Modes 1, 2, 3/A and C IFF protocols, with the option available for Mode 4 compatibility. The AD06 has an instrumented range of 60km. It can detect a fighter aircraft-sized target at these ranges and a helicopter at 25km. The AD06 offers 2° of elevation accuracy and 0.5° of azimuth accuracy, and can detect targets travelling at over 16kt. Applications: 3D tactical air defence radar Frequency: L-band Range: 60km (fighter-sized); 25km (helicopter) Coverage elevation: 2° (elevation accuracy)

**AD06 ATAR**

The AD06 Advanced Tactical Acquisition Radar (ATAR) is a 3D solid-state L-band medium-range tactical air defence radar which uses an AESA to provide elevation coverage. The radar detects a variety of low-RCS targets such as low-velocity ultralights and UAVs. The radar provides accurate target measurements of range, azimuth and elevation angles, differentiating between aircraft and helicopters and classifying the helicopter type according to echoes from the aircraft's rotor blades. The AD06 ATAR can be deployed to enhance a local air defence system, providing warning and target designation to surface-to-air weapon systems including MANPADS. The radar can also be deployed as gap fillers to support C2 centres and can be used for ATC. The AD06 ATAR has been field-proven and can operate in dense electromagnetic environments. The radar has an instrumented range of 180km. It can detect a combat aircraft-sized target at up to 110km, a hovering helicopter at 40km and a UAV-sized target at up to 60km. The radar provides 1° and 0.5° of elevation and azimuth accuracy respectively, offering up to 60° of elevation coverage. In terms of output language, the radar can share its data with other users via the ASTERIX (All Purpose Structured Eurocontrol Surveillance Information Exchange) protocol. It is also compatible with NATO Modes 1, 2, 3/A and C IFF interrogator/transponder protocols with an option for Mode 4 compatibility. Frequency: L-band Coverage elevation: 60°

**AD26**

The AD26 Very Short Range Air Defence (VSHORAD) radar is a fifth-generation 3D tactical air defence system. The AD26 is a lightweight, transportable

X-band solid-state electronically scanned, pulse-Doppler radar. It delivers early warning and target data for supporting SAM weapon systems. The radar employs multi-beam elevation coverage by applying digital beam-forming and 360° azimuth coverage by antenna rotation. The radar detects a wide variety of low-RCS targets such as low-flying fighter aircraft, low-velocity ultralights and UAVs. The radar provides accurate target measurements of velocity, range, azimuth and elevation angles. The AD26 VSHORAD can be deployed to supplement a local air defence system, providing early warning and target tracks to surface-to-air weapon systems. The radar has a range of 25km, with the detection of a combat aircraft possible at 15km. It has an azimuth and elevation accuracy of 0.3° and 0.5° respectively, and can track up to 100 targets simultaneously. Applications: tactical 3D air defence radar Frequency: X-band Weight: 75kg Range: 25km; 15km for detection of combat aircraft Data renewal time: 2s at 30rpm; 4s at 15rpm Number of targets tracked simultaneously: 100

**AD26D**

The BATS AD26D is a key component of the Drone Guard counter-UAV system and is designed specifically for detecting UAVs but also detects low RCS and ground targets. Key applications for the lightweight system is the protection of airports or high value sites and border monitoring as well as a gap filler for larger radar systems. Applications: counter-UAV Power: 150W Weight: 30kg Range: 6km for ultralight aircraft, 3km for small quadcopters Coverage elevation: 20° surveillance mode, 60° in high priority target mode Number of targets tracked simultaneously: 100+

**AD88**

The AD88 is a 3D S-band pulse-Doppler, ground-based air surveillance radar family that uses digital beam-forming for elevation and is capable of automatic target tracking. The AD88 product range includes two radars; the AD88 Medium Range (MR) and AD88 Extended Range (ER). The former is housed in a single shipping container and has an antenna with 32 row elements. It is designed for rapid deployment. The AD88ER's antenna has 60-row elements and is designed to be deployed at fixed-site locations. Both have an instrumented range of 480km, 360° azimuth coverage, 30° elevation coverage and can detect targets at up to 100,000ft. Applications: 3D ground-based air surveillance radar Range: 480km instrumented, AD88-MR 300km for fighter aircraft, AD88-ER 430km for fighter aircraft Coverage elevation: 30°

**MR84**

The MR84 is an S-band 3D air-surveillance radar which can also be used for artillery fire control. Employing an AESA antenna the MR84 can scan a 120° sector when being used for weapons location and a 360° sector for air surveillance. When operating in an air surveillance mode, the radar has a detection range of up to 474km. It can cover altitudes of up to 100,000ft and can track up to 1,200 targets. When performing weapons location, the radar has a range of up to 100km and offers up to 50° elevation coverage. The MR84 can track up to 200 targets when operating in weapon location mode. Applications: 3D air-surveillance radar Frequency: S-band Range: air surveillance mode - 474km; weapons location - 100km

Altitude coverage: 100,000ft Number of tracks handled: up to 1,200 in air-surveillance mode; 200 in weapons-location mode

## BHARAT ELECTRONICS

### 3D Tactical Control Radar

Bharat's 3D Tactical Control Radar is a mobile, air-transportable, short-range warning, alerting and cueing radar system with weapon control and other C2 functions. It is designed to minimise mutual interference between air defenders and friendly airspace users. Features multiple target handling and engagement capability. It makes local threat evaluation and engagement calculations to assist the commander's decision-making process and gives local fire distribution. Facility for automatic transmission of data to target receiver (co-located with weapon system) up to 20km from radar using fibre and secure VHF radio set. Mounted in a single vehicle, it takes two people 10min to set up. Applications: mobile, air-transportable, short-range warning, alerting and cueing radar system Frequency: 8.2-12.4GHz Range: 40km (against 4m<sup>2</sup> target), TWS of airborne targets up to 90km Altitude coverage: 9,800ft

### Indra II

The Indra II is a low-altitude radar designed for the gap-filling role in an air defence network. It is a transportable, self-contained system with mobility and deployment features. Capable of handling 200 tracks, it is a coherent system, uses frequency agility, pulse compression and signal-processing techniques such as MTI and CFAR. TWS operates in 2D mode. Offers full tracking capabilities against manoeuvring targets. Has integral IFF and can associate with primary targets. Probability of detection is 90% with a single scan. Deployment time is about 60min. The system consists of an antenna, transmitter cabin and display cabin mounted on three separate vehicles. Applications: low-altitude gap-filling radar Frequency: 1-2GHz Range: 90km (for fighter aircraft) Altitude coverage: 115-9,800ft Number of targets tracked simultaneously: 200

## CEIEC - CHINA NATIONAL ELECTRONICS IMPORT & EXPORT

### H-200

CEIEC's H-200 is the basis of the KS-1 air defence missile which is believed to developed from reverse engineering a Patriot air defence system. It is believed to operate in the G-band and can be set up in ≤30 minutes. It is reported to be able to track targets at a speed up to M=2.18. Applications: air defence Frequency: G-band Range: ≥120km at 8km altitude; ≥50km at 0.1km Number of targets tracked simultaneously: 3

### JL3D-90A

The CEIEC JL3D-90A is a fully coherent, 3D radar with a low side-lobe, planar, phased array antenna. It is believed that the system uses an agile radio frequency transmitter with a klystron amplifier chain and a low-noise linear receiver using digital pulse compression techniques to achieve long-range detection. Adaptive digital signal processing is employed with comprehensive BITE. Power: 700kW Range: 300km Altitude coverage: 20km Antenna dimensions: 5.2m×5.4m Coverage elevation: 0.5°-20°



The EDT-FILA is a trailer-mounted FCR system designed for use with 35-40mm anti-aircraft guns. (Photo: Avibras Indústria Aeroespacial)

## CHINA AEROSPACE SCIENCE AND INDUSTRY CORPORATION (CASIC)

### HK-JM2

The HK-JM2 is a long-range 2D surveillance radar for detecting various air-breathing targets. It can be used for early warning in national air defence as well as providing target designation for weapon systems. Features include: all-solid-state, coherent pulse compression; stealth target detection capability; anti-jamming capability. Applications: long-range 2D surveillance radar

### Phased-Array Precision Tracking and Measurement Radar

CASIC's Phased-Array Precision Tracking and Measurement Radar can perform real-time flight trajectory measurement of multiple air targets. It can be used for tracking and measuring missiles, launch vehicles, conventional weapons and other air targets on the test range and also for the acquisition, tracking and trajectory measurement of space targets. Features include: quick search, acquisition and tracking of multiple targets; wideband imaging; capable of measuring a target's RCS. Applications: phased-array precision tracking and measurement radar

### SJ-231

The CASIC SJ-231 air defence passive phased array radar is based on the HT-233 PESA antenna and cabin design. It operates in the C-band. It serves as the C2 centre of the KS-1A weapon system and is capable of guiding between four and eight missiles to intercept four targets at the same time. It can detect targets to an altitude of 27km over a range of 120km, with a minimum detection range of 3km. Applications: air defence Range: 120km Altitude coverage: 27km Wavelength: C-band Coverage elevation: -1°-+70°

## CHINA ELECTRONICS TECHNOLOGY GROUP CORPORATION (CETC)

### JY-29

The CETC JY-29 (LSS-1) is a mobile 2D low-altitude tactical radar which is designed to act as a gap filler. It is believed to operate in the L-band and can track up to 72 targets. It was reported in 2013, that the system or

a variant of it had been deployed at four sites by Syrian armed forces. Applications: air defence Frequency: L-band Range: 250km Altitude coverage: 12km Number of tracks handled: ≥72 Coverage elevation: 0°-30° Deployment/setup time: 5min MTBF/MTBCF: ≥800h

## CPMIEC

### HT-233

The CPMIEC HT-233 fire control radar is designed to detect and track flying targets and is associated with HQ-9 and HQ-10 surface-to-air missile batteries. Sources indicate it is believed to operate in the G-band, possibly between 5.2GHz and 5.9GHz. It is believed to be passive phased array and can track up to 50 targets simultaneously. It can be mounted on range of vehicles and has been noted on 10x10 Taian TAS-5380 platforms. It is believed to have a detection range of 120km and tracking range of 90km. Applications: air defence Frequency: G-band Range: 120km Number of targets tracked simultaneously: 50

## ECRIE - EAST CHINA RESEARCH INSTITUTE OF ELECTRONIC ENGINEERING

### JY-9

The JY-9 is an air defence surveillance radar designed to detect targets at low altitudes, in clutter and ECM. Antenna, ops shelter and power cart are air-transportable. Set-up time 90min by eight personnel. Applications: low-altitude surveillance radar Frequency: S-band Range: 150km Coverage elevation: 0-40° Number of targets tracked simultaneously: 72

### JY-9F

The JY-9F is a multipurpose, low-altitude air defence, fire control and ATC radar mounted in two truck/trailer pairs. Applications: multipurpose, low-altitude air defence, fire control and ATC radar Frequency: 2-4GHz (E/F-band) Range: >150km

### JY-10F

The JY-10F family of cabinet-mounted data processing systems is capable of handling inputs from up to six radars, performing A/D conversion and generating an air picture. Applications: family of cabinet-mounted data processing systems

### JY-11

The JY-11 is a fixed-site or mobile solid-state low-altitude surveillance radar for integrated or standalone applications. Features include a dual-frequency antenna and solid-state transmitter. Uses pulse compression and CFAR processing techniques. Applications: fixed-site or mobile solid-state low-altitude surveillance radar Range: 180km

### JY-14

The JY-14 is a large, long-range 3D air-surveillance and GCI radar with frequency agility/diversity and low sidelobe antenna. 1mW transmission power and low-power decoy mode. Covers 20° in elevation. Applications: large, long-range 3D air-surveillance Frequency: 2-4GHz (E/F-band) Range: 450km Altitude coverage: 98,400ft Coverage elevation: 20° Number of targets tracked simultaneously: 100

### JY-27

The JY-27 is a long-range surveillance radar with airborne MTI and CFAR processing capabilities. Solid-state transmitter offers frequency agility, pulse compression, spectrum filtering. Can be operated unattended. Applications: long-range surveillance radar Frequency: 0.2-0.3GHz (A/B-band) Range: >330km

## ERA

### Silent Guard

ERA's Silent Guard is a passive radar which detects airborne objects by detecting the reflection of FM radio signals from flying objects. The radar is housed on top of a mast which can be mounted on a vehicle and uses a circular array antenna to detect disturbances to FM radio transmissions. Silent Guard does not emit, but instead detects disturbances to civilian broadcasting FM radio signals (typically within the VHF frequency range in the atmosphere). Silent Guard can detect airborne targets across a 360° radius at ranges of up to 150km. The radar can share its information with third-party air defence systems using the Eurocontrol ASTERIX and NATO AWCIES protocols. Applications: passive radar Frequency: VHF Range: 150km

## HARRIS ELECTRONIC SYSTEMS

### AN/SPS-48C(V)1

The AN/SPS-48C(V)1 is a 3D, long-range air surveillance radar used for detection and tracking of aircraft and missiles. The radar is available in fixed-site, transportable or shipboard configurations to support customer needs on land or at sea. The multi-pencil beam architecture provides jamming immunity, low false alarm rates and the ability to detect and track small targets, as well as weather detection and display capabilities. The AN/SPS-48C(V)1 is built with an open architecture for growth, a solid-state transmitter and an integrated built-in test system with remote support capability. Applications: transportable 3D air defence surveillance radar Frequency: 2.9-3.1GHz Range: 463km Altitude coverage: 100,000ft

### Series 320

The Series 320 is a family of E/F-band air defence radars with large planar phased-array antennas, electronically scanned in elevation and mechanically in azimuth. Available in two versions with either 6.4x5.18 or 3.65x9.75m trailer-mounted antennas. They use a high degree of automation. MTI helps penetrate ground clutter. Applications: family of E/F-band air defence radars Frequency: 2.9-3.1GHz Range: 370 or 556km depending on transmitter power

### SkySense-2020 Radar

Harris has created the Skysense-2020 family of sense and avoid 3D radars leveraging its Airborne Sense and Avoid (ABSAA) radar for the USN's Triton UAS. The Skysense-2020H is based on the Triton design and readily available for high-altitude UAVs. The Skysense-2020M is a smaller, modular version of the 2020H, suitable for medium-altitude and VTOL UAVs. The Skysense-2020G is a mobile, ground-based sense-and-avoid system for safely navigating and detecting low-flying UAVs, claims the company. Platforms: UAVs

## HENSOLDT SENSORS

### ASR-NG Deployable

On 5 March 2018, Hensoldt launched a new air traffic control (ATC) radar called the ASR-NG Deployable. The rapidly deployable ATC radar complies with all International Civil Aviation Organization, Eurocontrol and safety standards for civil and military ATC. The ASR radar family consists of integrated primary and secondary radar systems. The primary radar is based on a semiconductor transmitter and helps to detect non-cooperative objects such as small aircraft that do not have transponders, or hostile aircraft. The secondary radar, MSSR 2000 I, ensures the automatic identification of cooperative aircraft. It meets the new Mode S/Mode 5 ATC standard, which improves aircraft identification queries and is currently being introduced by all NATO and allied forces. Applications: civil and military Scan rate: 12rpm/15rpm Range: 222.24km Frequency coverage: 2.7 – 2.9 GHz (PSR); 1030 MHz & 1090 MHz (SSR)

### MSSR-2000-I

In terms of performance, the MSSR-2000-I family (Monopulse Secondary Surveillance Radar 2000-I) has an instrumented range of up to 613km and can detect up to 1,500 targets across a 360° radius, 400 targets across a 45° segment of the sky and 110 targets in a 3.5° segment. Six radars comprise the MSSR-2000-I family including the MSSR-2000-I Mode 5/S 500W and MSSR-2000-I Mode 5/S 1,500W single chain systems, the MSSR-2000-I Mode 5/S 2,000W variant and the MSSR-2000-I Mode 5/S 500W dual-redundant radar. This latter product includes two of the single chain 500W interrogators, as does the MSSR-2000-I Mode 5/S 1,500W dual-redundant radar along with the MSSR-2000-I Mode 5/S 2,000W dual redundant system which has two 2,000W single-chain interrogators. Circa 350 MSSR 2000-I systems have been sold to 26 nations worldwide, including Australia, Finland, France, Germany, Norway, the UK and the US. In August 2014, the company announced it was supplying two systems to the Indonesian Air Force. The radar's architecture, all of which is enclosed in a single box, can connect to any 8m antenna and can export its information using the ASTERIX radar data format. In December 2014, the German MoD awarded a contract to Airbus Defence and Space for the upgrade of the MSSR-2000-I radars used by its armed forces to ensure that they have Mode 5 compatibility. On 18 October 2017, Hensoldt announced that the MSSR-2000-I radar systems had received certification from the AIMS Program Office of the US DoD. The certification confirms that the MSSR 2000 I is reliable and interoperable for delivering Identification Friend or Foe in accordance with the future NATO standard Mode 5 and all earlier modes (1, 2, 3/A, C, 4, S). All NATO identification systems are set to convert to the Mode 5 standard by 2020. Applications: monopulse secondary surveillance radar Range: 613km Number of targets tracked simultaneously: 1,500 targets across a 360° radius

### Passive Radar

The Passive Radar detects airborne and sea targets by detecting disturbances to civilian FM radio, DAB and DVB-T transmissions in the VHF range. When receiving FM transmissions, the radar has a detection range of up to 200km, while the use of the DAB/DVB-T signals

allow a detection range of 40km for a small aircraft. The Passive Radar employs a mast-mounted antenna on the top of a van at a height of up to 13m. The radar refreshes its imagery every half a second, providing detection of flying objects up to an altitude of 40,000ft. When detecting reflections from flying objects using FM transmissions, the radar provides a location accuracy of up to 1,650ft, although this reduces to 33ft when disturbances to DAB and DVB-T signals are detected. To date, several field tests of the technology demonstrator have been performed. Production is expected to commence in 2017, although as of February 2014, no procurement contract had been signed. Applications: passive radar Frequency: VHF Range: 200km Altitude coverage: 40,000ft

## IAI ELTA SYSTEMS

### ELM-2026B VSHORAD

The ELM-2026B Very Short Range Air Defence Radar (VSHORAD) is designed for detection and tracking of airborne targets, including a variety of low-RCS and low-flying targets such as fighter aircraft, ultralights and UAVs. It is IAI Elta's fifth generation of 3D tactical air defence radars, with a lightweight transportable, X-band, pulse-Doppler solid-state electronically scanned array. The radar employs multi-beam elevation coverage through digital beam-forming and 360° azimuth coverage by antenna rotation, providing accurate target measurements of velocity, range, azimuth and elevation angles, target detection and tracking and support of SAM weapon systems. Applications include local air defence, gap filler for complementing main air defence radar systems, border airspace protection and critical infrastructure airspace protection. The radar can be either fixed on the ground or a tower, mounted on a pedestal or transported on a vehicle. Applications: very-short-range air defence Frequency: X-band Weight: 75kg Range: instrumented range 25km, fighter aircraft 15km

### ELM-2080 Green Pine

The ELM-2080 is transportable ground-based, multi-mode solid-state phased-array radar designed to autonomously detect and simultaneously track multiple tactical ballistic missiles from long ranges, under all weather and ECM conditions. Modular active array technology includes multiple advanced T/R modules, provides high redundancy, graceful degradation, high reliability and high availability, says the company. The radar is part of the Arrow anti-ballistic missile system. In service with Israeli and Indian forces. Applications: transportable ground-based, multi-mode phased-array long-range anti-ballistic-missile radar Frequency: L-band Range: >500km

### ELM-2084 MMR Iron Dome Radar

The ELM-2084 radar is an S-band system optimised to detect incoming rocket and artillery rounds in environments with significant ground clutter and electromagnetic noise. It forms an integral part of the Israeli Iron Dome SAM system. The radar has a detection range of up to 474km and can detect weapon launching points at a 100km range. When the antenna is fixed, the ELM-2084 provides up to 120° of azimuth search, although this increases to 360° when the antenna is rotating. Meanwhile, up to 100,000ft of elevation coverage is provided. When performing

air surveillance, the ELM-2084 can track up to 1,200 targets, with up to 200 targets per minute being detected when the radar operates in a weapons-location mode. In July 2015, it was announced that Canadian Department of National Defense had ordered systems to be produced in Canada in cooperation with Rheinmetall Canada. Applications: S-band artillery and rocket tracking system Frequency: S-band Range: 474km, weapons launching points 100km Altitude coverage: 100,000ft Number of targets tracked simultaneously: 1,200

#### ELM-2106 ATAR

The ELM-2106NG tactical 3D air mobile truck-mounted defence radar can detect a variety of airborne platforms, including low-altitude high-speed fighter aircraft, hovering helicopters, UAVs and low-speed ultralights. The radar provides accurate range, azimuth and elevation angle measurements for each target, differentiating between fixed-wing aircraft and helicopters and classifying helicopters by rotor rotation rate. The radar can be used as a local air defence system, a gap-filler radar complementing a main air defence system or as a search radar in support of anti-aircraft weapon systems. The ELM-2106NG is currently in operation in numerous countries around the world. Applications: vehicle-mounted defence radar Weight: 320kg including carriage boxes Range: 110km, 40-60km fighter aircraft, 25km hovering helicopter, 20km UAV

#### ELM-2106NG

The ELM-2106NG tactical 3D air defence radar can detect a variety of airborne platforms, including low-altitude high-speed fighter aircraft, hovering helicopters, UAVs and low-speed ultralights. It can be used as a tripod- or vehicle-mounted system. The radar provides accurate range, azimuth and elevation angle measurements for each target, differentiating between fixed-wing aircraft and helicopters and classifying helicopters by rotor rotation rate. The radar can be used as a local air defence system, a gap-filler radar complementing a main air defence system, or as a search radar in support of anti-aircraft weapon systems. The ELM-2106NG is currently in operation in numerous

**Kelvin Hughes' SMS-D is designed for detection and real-time tracking of small aerial targets using an integrated, medium-range, radar-based surveillance system. (Photo: Kelvin Hughes)**



countries around the world. Applications: tactical 3D air defence radar Range: 100km instrumented, 40-60km fighter aircraft, 25km hovering helicopters, 20km UAV

#### ELM-2138T Green Rock

The Green Rock is a mobile autonomous tactical C-RAM radar system. It is designed to support a variety of ground force protection missions, including fire source location, friendly forces warning, friendly fire correction and low-RCS and slow-flying airborne target (such as UAVs, gliders and hovering platforms) detection. The system provides a low/high trajectory target, real-time intelligence and rapid response for tactical forces. It can locate fire squad positions, distribute selective warning alarms and enable a fire response. The Green Rock system can be installed on mobile or stationary platforms such as APCs, HMMWVs, ATVs etc. It includes a phased-array pulse-Doppler radar which acquires and tracks trajectories of ballistic munitions, such as rockets, artillery and mortars, calculates the launching point and predicts the impact location. This information is reported, via a communication system, to friendly forces to indicate and provide warning for relevant threats. Threat data can be also sent to precision weapon systems for response to the threat source. Applications: mobile autonomous tactical C-RAM radar system Frequency: X-band Range: 10km for low-RCS targets

#### ELM-2288 AD-STAR

The ELM-2288 Advanced Air Defense, Surveillance, Threat Alert and Air Traffic Control Radar (AD-STAR) is a 3D solid-state long-range S-band family of transportable radars designed to support air defence, early warning and ATC activities. Featuring digital beam-forming in elevation (receiving and transmitting) the AD-STAR provides 3D data on detected targets, initiating automatic target tracking based on pre-programmed parameters. Including multiple transmitters and digital receivers, the AD-STAR supports high redundancy, graceful degradation, reliability and availability. The radar system can integrate a compatible IFF (SSR) antenna mounted on the primary antenna. The SSR performs synchronised detection, interrogation, decoding and tracking. The AD-STAR antenna can be folded on its container roof to enable transportation on standard roads, under standard bridges and inside C-130 aircraft. It can operate as a standalone radar or as part of a larger air defence system. The company announced in May 2012 that it had received a \$33 million contract from a foreign customer for AD-STAR systems. Applications: 3D solid-state long-range S-band family of transportable radars Range: 480km, ELM-2288 MR >300km fighter aircraft, ELM-2288 ER 430km fighter aircraft Coverage elevation: 30°

#### INDRA SISTEMAS

##### APIS

Indra successfully led the Array Passive ISAR Adaptive Processing (APIS) programme sponsored by the European Defense Agency. At the core of the initiative is the employment of Inverse SAR imagery techniques. These have sufficient detail to perform target recognition via the radar picture, rather than the target being represented as a 'blip' on the radar operator's screen. This allows the radar operator to distinguish between airliners,

military aircraft, UAVs and missiles, greatly improving target discrimination. Indra's APIS passive radar detects disturbances to civilian terrestrial television signals to identify airborne targets. The APIS project also included contributions from Italy's National Inter-University Consortium for Telecommunications, Vitrociset, Spain's University of Alcalá, the University of Cyprus and the Hungarian Science Academy. Applications: passive high-resolution primary radar system Frequency: VHF

### Civil PSR 3D

The Civil Primary Surveillance Radar (PSR) 3D is part of the Lanza family of 3D radar systems. The Civil PSR 3D has been designed especially for airport and air route surveillance. It operates in an L-band frequency and is ICAO compatible. In addition to aircraft detection and tracking, the radar has a weather processor that provides the controller with the required weather information for safe air traffic control management Applications: air surveillance and weather analysis Frequency: L-band Range: 330km instrumented range

### Lanza LRR

The Lanza Long Range Radar (LRR) is a long-range tactical fixed radar, part of the Lanza family of 3D radar systems. The Lanza LRR operates in an L-band frequency and at a range of up to 470km. The radar has a NATO FADR (Class I) compliance in both fixed-site and transportable installations, and with the extended long-range possibility (XLR) for very-low-RCS targets or TBMs. Applications: long-range air target detection Frequency: L-band Coverage: 360° Range: 470km

### Lanza LTR-20

The Lanza Long Range Tactical system-20 (LTR-20) is a deployable radar and part of the Lanza family of 3D radar systems. Missions that the radar has been designed to carry out include air defence and air policing (illegal traffic interception). The LTR-20 operates in an L-band frequency and with a range of up to 470km. The radar is NATO-compatible and can be deployed in under two hours. Applications: air defence, air policing (illegal traffic interception) Frequency: L-band Range: 470km Deployment/setup time: <2h

### Lanza LTR-25

The Lanza Long Range Tactical system-25 (LTR-25) is a long-range tactical deployable radar, part of the Lanza family of 3D radar systems. The LTR-25 operates in the L-band frequency and with a range up to 470km. The radar has NATO FADR (Class I) compliance and can be deployed in under two hours. On 10 July 2015, Indra announced that the NATO Communications and Information Agency had ordered two Lanza LTR-25 3D systems. The contract was valued at around \$24.52 million and ran for approximately 38 months. It includes an option for a third radar and other equipment. The Lanza LTR-25 comprises a primary radar integrated with a secondary radar, a power generator, and an operation shelter. It can be transported in two trucks or a C-130 type aircraft and deployed at non-prepared sites. Frequency: L-band Range: 463km Deployment/setup time: <2h Operating platforms: C-130

### Primary Surveillance 2D S-Band Radar

Indra's Primary Surveillance 2D S-Band Radar is an airfield surveillance radar with dual channel configuration.

Weather conditions detected by the radar are measured in six levels of intensity conforming to ICAO and US Weather Bureau standards and are processed using a weather channel in parallel with the target channel. Frequency: S-band Power: 22kW Coverage: 15rpm with a 1m<sup>2</sup> target Range: >110km or >150km (detection range), 230m (short pulse), 170m (long pulse)

### SkyFender ADR

SkyFender Air Defence Radar (ADR) is a pulse-Doppler radar, operating in the X-band, that performs signal processing in time and spectral domains to provide target detection and tracking capabilities. It uses Indra's X-band radar technology from air defence fire control and surveillance radar systems. The SkyFender ADR is able to detect and track aircraft flying at low and very-low altitudes in strong clutter/ECM environments providing early warning to air defence C2 or fire direction centres and aiming effectors (launchers or guns) in short-range and very short-range air defence applications. The radar is interoperable with a secondary surveillance radar, providing identification of detected targets and Indra's INT-50 IFF system is suitable for this objective. SkyFender ADR radar (and associated IFF, if required) are installed in a high mobility shelter (vehicle-mounted or towed), allowing tactical usage. Its mechanical design is intended to provide a fast deployment/recovery time combined with easy access to all radar elements. Frequency: X-band

### KB RADAR

#### Rosa

A low-altitude target detection radar system, Rosa is designed for automatic detection and tracking of low-altitude aerial platforms and output of track information to an automated control system. The radar system is composed of one to five autonomous low-altitude target detection radar sets. The sets are fully automatic (operator-free) with the capability of functional checks. The radar sets are controlled from the remote-control system. The system provides for detection of small-RCS aerial platforms flying at up to 250ft altitude within 0-360° azimuth, 0.3-50 km range and ≤30° elevation coverage. The radar sets use digital synthesis of the probing signal and digital processing of the received signal. The radar has high levels of concealment and jamming immunity. The system has been designed to use a ring-shaped solid-state phased array. Fast activation time (less than 5min including functional check) and continuous operation time for a minimum of a month with no need for deactivation, make Rosa radars a solution for monitoring low-altitude environments along national borders. Applications: stationary radar Frequency: X-band Coverage: 360°

#### Vostok-E

The Vostok radar family is designed for detection of aerial platforms, measurement of their range, azimuth and range rate, automatic target tracking and classification, and transmission of radar information into an integrated control system. Vostok is a new fully Belarusian development capable of replacing the P-18 radar, Oborona and similar systems. The radar has a detection range of up to 360km, accurate co-ordinate measurement with RMSE per scan being 25m in range and 50 angular minutes in azimuth, high mobility (setup/breakdown

time is maximum 6min by a three-man crew), automatic functional check of all radar components and effective detection of small-sized and stealthy targets. The Vostok-E radar encompasses digital signal-shaping and processing and uses modern algorithms. The radar possesses jamming immunity, protection against precision weapons and an automatic operation mode including detection and tracking of airborne platforms. Applications: tracked vehicle: VHF band

## KELVIN HUGHES

### SMS-D

Kelvin Hughes has developed the Single Mast Solution-D (SMS-D) for UAS detection. It is designed for detection and real-time tracking of small aerial targets using an integrated, medium-range, radar-based surveillance system. The SMS-D is based on the company's SharpEye X-band transceiver technology and is able to detect targets up to 1.5km away. It provides updated bearing, distance, altitude and velocity data. The SMS-D identifies targets automatically through its video tracing system. The system is designed to accommodate a combination of radar, optical and TI devices in order to provide 360° surveillance of a site perimeter or border and provides early detection of aerial targets. It can be fixed to a permanent structure or mounted on a vehicle to extend the envelope of detection. Range: 1.5km

## LEMZ

### 1L117M Mobile 3D Radar

The 1L117M is designed to detect, identify and measure three co-ordinates (azimuth, slant range and altitude) of air targets and provide the data to external users. The EN version has a power amplifier enhancing the stability of emitted signals, increasing passive noise suppression characteristics and improving ability to detect low-flying targets. Frequency agility improves the radar's jamming resistance. The system is mounted on a transmitter vehicle, a vehicle housing data link equipment and operator workstations, a vehicle with two diesel generators and two more to carry antenna systems and other equipment. The centimetric radar has a range of 350km and is designed to detect a 1m<sup>2</sup> RCS target in a jamming-free environment at 70km at a target altitude of 1,600ft, at 140km/9,800ft and 180km/16,400-49,200ft. Equivalent ranges for a 10m<sup>2</sup> target are 70, 160, 280 and 320km. The radar can track 200 targets simultaneously and offers an MTBF of not less than 350h. It is reported that the system is in service in Myanmar. Applications: early warning radar Range: 350km MTBF/MTBCF: 350h Number of targets tracked simultaneously: 200

### 96L6E

The 96L6E is a 3D target acquisition radar with an AESA antenna. The radar can be acquired in either a mobile configuration (96L6E), or as a tower-mounted system (966A14). The radar itself is a C-band system which can cover ranges of between 5 and 300km. It provides 360° azimuth scanning and angles of elevation between 0° and +20°. In addition, the radar can be used in a sector-scan configuration watching a 120° area with 0-60° elevation coverage. The radar also has a low-altitude detection mode. The 96L6E can track up to 100 targets with between three and five false target indications

during every 30min of operation. The radar's architecture uses frequency-hopping transmission to provide ECCM protection. The 96L6E is used as the target acquisition radar for the S-400 Triumf (NATO reporting name SA-21 'Growler') medium-to-high altitude SAM system and can provide target information to S-300 family medium-altitude SAM batteries. The 96L6E was developed as a replacement for the legacy 96D6 (NATO reporting name 'Tin Shield') and 76N6 (NATO reporting name 'Clam Shell') target acquisition radars. As of August 2013, Russian press reports stated that four 96L6E radars have been pressed into service to enhance the defence of Moscow. There is no word on when these new radars may formally enter service. Applications: 3D target acquisition radar Coverage: 360° Range: 5-300km detection range Number of targets tracked simultaneously: <100

## LEONARDO LAND & NAVAL DEFENCE ELECTRONICS

### AULOS

The AULOS passive radar utilises civilian FM, DAB and DVB-T signals in the VHF range to track low-observable airborne targets and low-flying aircraft. The company has not publicly revealed the range of the AULOS, although it is thought that detection can be performed out to several hundred kilometres. AULOS can detect and track several targets with a low RCS simultaneously and determine the location and altitude of these targets. Leonardo provides the AULOS in two distinct configurations: AULOS 2D and AULOS 3D. Designed as a fixed system, AULOS 2D (providing range and azimuth detection for airborne targets) uses FM signals, giving coverage of a 90° section of the sky, while the AULOS 3D can provide estimates of target altitude. Applications: low-altitude VHF signal passive radar Frequency: VHF

### RAT 31DL

The RAT 31DL is a high-performance, transportable L-band (NATO D-band) land-based phased-array 3D long-range radar, with solid-state antenna. It has multiple independent simultaneous narrow pencil beam-scanning architecture, with monopulse technique for height measurement. Classified as a NATO Class 1 radar, RAT 31DL incorporates 'advanced technical capabilities' for ECCM. Designed to operate in a modern, complex environment, RAT 31DL is able to adapt to a broad spectrum of changing scenarios where jammers co-exist with heavy clutter. The RAT 31DL also has anti-tactical ballistic missile capabilities. Applications: transportable phased-array 3D long-range radar Frequency: 2-4GHz Range: >500km

### RAT 31DL/M

The RAT 31DL/M is a tactical long-range radar operating in the L-band, designed to support NATO troops on peacekeeping missions. It can be deployed in the battlefield as a front-line system to protect and survey territories and assets against air threats. To perform these tasks in a worldwide tactical environment, RAT 31DL/M is mobile and does not require any special loading/unloading equipment. The system is housed in two 20ft ISO containers, mounted on two commercial cross-country trucks for land mobility. This radar is designed for rapid deployment to provide a corps with the capability to move quickly for regrouping.

It is equipped with its own electrical power source and is self-sufficient for extended periods. The radar architecture is takes the form of multiple simultaneous pencil beams. The beams are electronically and independently steered in elevation, both in transmission and reception. This technology allows solutions against threat sources such as theatre ballistic missiles, ECM and mass raids. The system 'exceeds NATO requirements' for deployable air defence radar. The system can be set up in 2h by five people. Transportable by CH-47 helicopter, C-130 transport aircraft or 10t truck. Applications: tactical long-range radar Frequency: L-band Weight: 30,000kg Range: 400km

### RAT 31SL

The RAT 31SL is a 3D S-band radar system designed to operate within both military air defence and ATC networks. It can adapt to changing operational scenarios where jammers co-exist with heavy clutter. The RAT 31SL 3D early warning radar uses multiple simultaneous independently phase-controlled pencil beams. This technology provides flexibility in scanning and a high data rate, effective for clutter processing. Reduced peak power provides resistance against anti-radiation missiles and ECM. ECCM are provided by very low sidelobe antenna, reduced peak power, frequency agility, jam strobe reporting and a separate receiver for ECM monitoring. In October 2013, it was reported that Spain had completed its replacement of its legacy General Electric AN/FPS-113 and AN/FPS-90 systems with RAT-31SL/T radars to perform the air surveillance mission. Applications: 3D early warning radar Frequency: S-band

### LIG NEX1

#### Counter-Artillery Detection Radar-II

South Korea's Defense Acquisition Program Administration (DAPA) announced on 24 April that it had concluded development and successful testing of the Counter-Artillery Detection Radar-II mobile system. The radar will be mounted on a Doosan DST 8x8 truck chassis with armoured cab and will be deployed close to the DMZ to counter North Korean artillery, mortar or rocket fire. The system has a detection range of more than 60km and can operate continuously for eight hours. It was developed by the government's defence development agency and LIG Nex1 and is expected to be deployed next year. It will replace the Arthur-K radar system which had a range about 20km less than the new system and was manufactured under licence by LIG Nex1. Detection range: 60km

### LRADSR

The LRADSR is an L-band system which has a range of circa 370km and a ceiling of 100,000ft. This 3D radar uses an AESA antenna. The LRADSR is being procured to eventually replace the Lockheed Martin AN/FPS-117 L-band air surveillance radars which the Republic of Korea Air Force currently uses. In terms of performance, the LRADSR has similar capabilities to the AN/FPS-117. Applications: air surveillance radar Frequency: L-band Range: 370km Altitude coverage: 100,000ft

### MRADSR

The Medium Range Air Defence Surveillance Radar (MRADSR) has a range of around 140km and a 40,000ft

ceiling. It is an S-band radar which is expected to soon enter service with the Republic of Korea Air Force. There is no word on when this radar may enter service nor on how many of the MRADSR the air force may procure. Applications: medium-range air defence surveillance radar Frequency: S-band Range: 140km

### Weapon Locating Radar

LIG Nex1 exhibited two new vehicle-mounted radar system prototypes – the Weapon Locating Radar and the Short-Range Air Defence Radar, at Seoul ADEX 2017. According to its designer, the self-contained Weapon Locating Radar is capable of weapon location and identification by detecting, tracking and calculating the ballistic trajectory of field guns and rockets. The Weapon Locating Radar weighs 8,866kg and requires two crewmen to operate the system – a driver and radar operator. The system uses a C-band frequency, can begin operations within ten minutes of arriving at a location and can be mounted on a Hanwha (formerly Doosan DST) 8x8 truck chassis. The Defense Acquisition Program Administration announced in April 2017 that the Weapon Locating Radar had passed all tests. From 2018 it will be deployed close to the DMZ ready to respond to any North Korean mortar, artillery or rocket fire. Frequency: C-band Weight: 8,866kg Operating platforms: 8x8 truck chassis Deployment/setup time: 10min

### LOCKHEED MARTIN

#### AN/FPS-117

The AN/FPS-117 is a medium- to long-range air defence, ATC and GCI radar with MTI and Doppler processing to assist in clutter rejection and integrated IFF capability. Large, square (7.32m sides) phased-array antenna produces multiple short- and long-range pencil beams. Antenna is scanned electronically in elevation, mechanically in azimuth. Offered in both fixed-site and mobile variants. As of May 2014, the Indonesian Air Force was taking delivery of AN/FPS-117 radars as part of an overarching effort to improve the air defence of the country. These are produced locally under licence from Lockheed Martin and are being introduced into service also alongside AN/TPS-77 air surveillance radars. The upgrade of US fixed-site systems was announced as completed in October 2015. Applications: medium- to long-range air defence Frequency: 1.215-1.4GHz Range: 5.8-330km Altitude coverage: 30.5km MTBF/MTBCF: >2,000h

#### AN/FPS-124(V)

The AN/FPS-124(V) is a 2D medium-range surveillance radar designed for unattended operation in fixed sites, tower-mounted and protected from weather by a dome. Applications: medium-range surveillance radar Frequency: 1-2GHz Range: 130km Altitude coverage: 4.5km

#### AN/TPS-59

The AN/TPS-59 is a long-range tactical surveillance radar with capability against tactical ballistic missiles. Solid-state transmitter elements feed a large rectangular (9.1x4.9m) planar array that generates pencil beams scanned mechanically in azimuth. Antenna is truck- or trailer-mounted with processing electronics and operator console in a separate shelter. TPS-59M variant has smaller antenna for easier mobility. In August 2017, Lockheed Martin was awarded a \$25.2 million

contract to perform a refurbishment of a USMC AN/TPS-59A(V)3 ground-based air surveillance radar. This will replace the radar's processor, operator consoles and re-integrate the software. Although the 'vanilla' AN/TPS-59 entered service in 1985, the (V)3 upgrade performed in 1998 enables the radar to detect and track TBM targets, alongside conventional air-breathing threats. Applications: long-range tactical surveillance radar Frequency: L-band Weight: 20,000kg Range: 740km instrumented, 350km for ABT Altitude coverage: 30.5km Coverage elevation: 0-60° MTBF/MTBCF: >2000h

### AN/TPS-77

The AN/TPS-77 is an L-band medium-range ground-based air surveillance radar. The AN/TPS-77 uses an AESA and shares many characteristics and specifications with the company's AN/FPS-117, with the exception that the AN/TPS-77 is transportable, as opposed to the AN/FPS-117 which is designed as a fixed-site radar. The AN/TPS-77 has a range of 470km and a ceiling of 100,000ft. In November 2012, Thailand became the 34th customer for the AN/TPS-77 and in May 2015 a system was declared operational in Latvia as part of the NATO network. The radar and system is capable of being transported in a C-130 aircraft or large helicopter, truck or train. Applications: medium-range ground-based air surveillance radar Frequency: L-band Range: 470km Altitude coverage: 100,000ft

### AN/TPS-77 MRR

The AN/TPS-77 MRR is a multirole radar (MRR), designed for low power consumption and is the most transportable version of the TPS-77 product line. This radar can be truck mounted or transported via C-130, truck, rail or helicopter and is the newest member of Lockheed Martin's ground-based surveillance radar family. It is believed to be the first US radar system, utilising Gallium Nitride (GaN) technology, to be fielded for tactical ground-based air surveillance missions. The TPS-77 MRR's multi-role single scan technology allows operators to select specific roles for the radar such as long-range or medium-range low-level flight surveillance in specific sectors. As the radar rotates through each 360° scan, the system automatically adjusts to the operator selected mission. Changes can be easily made and once the radar is set no further operator inputs are required. The GaN technology enables the radar's high-power amplifiers to consume much less power, lowering life-cycle costs and extending the useful life of the radar. Latvia, will receive three newly-manufactured TPS-77 multi-role radars (MRR) ordered from Lockheed Martin in November 2015. In March 2018, it was announced that Latvia will finalise the delivery of the first TPS-77 MRR by testing its air surveillance capabilities, which is said to boost the Latvian army. Applications: transportable multirole radar Range: 10-463km (surveillance), 2-185km (terminal control), can detect fighter aircraft at 260km Altitude coverage: 0-30.5km Antenna rotation - scanning rate: 10rpm Number of targets tracked simultaneously: 1,500

### Silent Sentry

The Silent Sentry passive radar was unveiled in 1998. It can be mounted at a fixed site or on a vehicle. The radar exploits disturbances to FM radio transmissions in the VHF range to detect airborne targets. Silent Sentry employs a

minimum of three broadcast signal sources to determine a target's location. It has a detection range of 220km, detects targets at 60° or 360° azimuth and provides up to 50° of elevation coverage. Silent Sentry updates its radar coverage every eight seconds and can track over 200 targets. Applications: passive radar Frequency: VHF Range: 220km Number of tracks handled: >200 Coverage elevation: 50°

### THAAD Radar

Theater High Altitude Air Defense (THAAD) radar is a long-range surveillance and FCR system for detection, tracking and engagement of TBMs as part of the US Army's THAAD system. Uses a trailer-mounted phased-array antenna with an area of 9.2m<sup>2</sup>. Applications: long-range surveillance and FCR system Frequency: 8-20GHz Range: 1,000km

## MITSUBISHI ELECTRIC

### J/FPS-5

The J/FPS-5 is a long-range 3D phased-array air defence radar. Applications: long-range 3D phased-array air defence radar

## NANJING RESEARCH INSTITUTE OF ELECTRONICS TECHNOLOGY (NRIET)

### YLC-2

The NRIET YLC-2 is a three-dimensional L-band long-range air surveillance radar and is believed to be an active phased array system. There is little in the way of confirmed details for the system, but it is believed to have a range of 330km and is reported to have a height accuracy of 400m at 200km and 750m at 300km. Frequency: L-band Width: 9m (radar) Height: 7m (radar)

### YLC-4

YLC-4 is a P-Band UHF solid-state, fully coherent 2D long-range surveillance radar. It is able to synthesise data from up to four other radars. When equipped with height-finding radar, it can perform the function of guidance and providing target data for an air traffic control system. With long-range detection, high reliability and easy maintenance, YLC-4 radar is a main radar in the air defence network. Range: 410km Altitude coverage: 0°-360° Coverage elevation: 0°-25° MTBF/MTBCF: 500h

### YLC-6

NRIET's YLC-6 is a demountable medium-range two-dimensional radar with a range of up to 150km to an altitude of 10km. It is believed to be deployed on the south-east coast of China to detect aircraft operating out of Taiwan and it is also thought to be in service with Pakistani forces. A static version of the system has been developed for use with air traffic control. Applications: air defence Frequency: E/F-band Power: 180kW Altitude coverage: 10km Deployment/setup time: 8min Coverage elevation: 0°-40°

### ADAR-1 Chang Bei

The ADAR-1 Chang Bei is a truck-mounted multi-function phased-array search, target tracking and FCR associated with Taiwan's Tien Kung SAM system. It cues

a CW illuminator for missile guidance, enabling multiple target engagements. Applications: truck-mounted multi-function phased-array search, target tracking and FCR Range: 500km

## NATIONAL CHUNG-SHAN INSTITUTE OF SCIENCE AND TECHNOLOGY

### MPG-25

The MPG-25 is a CW target-illumination radar cued by ADAR-1. Uses centre-fed dish antenna to illuminate targets for Tien Kung SAMs. Applications: CW target illumination radar Frequency: X-band Range: 200km

## NORTHROP GRUMMAN

### AN/TPS-43

The AN/TPS-43 is a mobile tactical 3D surveillance, GCI and FCR system. Digital coherent MTI, pulse-to-pulse frequency agility, jamming analysis and transmission selection, coded pulses and sidelobe blanking provide performance in the face of clutter and countermeasures. Fits into two M35 trucks or one C-130 aircraft. Has a flat-plate antenna. Applications: mobile tactical 3D surveillance, GCI and FCR system Frequency: 2.9-3.1GHz Weight: <3,400kg (including shelter) Range: 450km (fighter-sized target)

### AN/TPS-70

The AN/TPS-70 is a long-range tactical radar capable of detecting and tracking tactical ballistic missiles and aircraft simultaneously. A flat-plate antenna generates multiple beams to scan all ranges and elevations at same time. Azimuth scanning is mechanical. System consists of antenna and separate electronics and operator shelter. The system had been in service with Colombia since 1990 but these have been replaced by the more advanced AN/TPS-74. Applications: long-range tactical radar Frequency: 2.9-3.1GHz Range: 450km Altitude coverage: 30.3km Number of targets tracked simultaneously: 500 Pulse repetition frequency: 250-275pps

### AN/TPS-75

The AN/TPS-75 is a deployable, long-range, tactical 3D radar system used as an integral sensor in the US Ground Theater Air Control System. Transportable by truck, helicopter or C-130, its main components are the shelter and the large flat-plate ultra-low sidelobe antenna. IFF is integrated. As of mid-2015 a contract to replace the system had been delayed by court appeals against an award to Raytheon for its 3DELRR. Applications: deployable, long-range, tactical 3D radar system Frequency: 2.9-3.1GHz Range: 445km Altitude coverage: 95,500ft Deployment/setup time: takes 9 people 2.5h Pulse repetition frequency: 235, 250, 275pps

### AN/TPS-78

The AN/TPS-78 tactical mobile radar system is the next generation of the AN/TPS-70. It has the capabilities of its predecessor, but is a completely air-cooled solid-state radar with the additional capabilities of MTI processing and increased tactical mobility using a redesigned mobile pallet. Can be configured for aircraft or missile detection. In addition to the antenna, all electronics, including the transmitter, are packaged in a 4.3m ISO

shelter that can be transported in a single C-130 aircraft or large helicopter and be deployed by a team of four in less than 30min. In September 2013, the Colombian Air Force selected the AN/TPS-78 to fulfil part of the country's requirement for a National Air Defence System and all four units ordered were delivered in October 2015. In April 2012, the Peruvian Air Force ordered two of AN/TPS-78s as part of a wider initiative to upgrade the country's air defences. Applications: tactical mobile radar Frequency: 2.8-3.1GHz Range: 450km Altitude coverage: 99,400ft

### AN/TPS-80 G/ATOR

AN/TPS-80 Ground/Air Task Oriented Radar (G/ATOR) is a multi-mission system designed to support worldwide expeditionary requirements. It provides detection and tracking capabilities, and offers traffic-control capabilities. The multi-network capability enables compatibility with additional US DoD C2 systems. The AN/TPS-80 uses an AESA and can perform a range of tasks, from air surveillance to ATC. The radar can be mounted on a trailer or on the back of an HMMWV and will be progressively upgraded through four incremental improvements once it enters service. These improvements will add functionality such as the ability to perform short-range air defence and baseline IFF functions (Increment 1); counter-battery and artillery location (Increment 2); Mode 5/Mode S IFF enhancements, improved countermeasures resistance, and health and usage monitoring (Increment 3); and ATC functions (Increment 4). The USMC is expected to receive 17 Increment 1 AN/TPS-80s, 38 Increment 2/3 systems, and 14 Increment IV radars. In October 2014, Northrop Grumman was awarded a low-rate initial production contract worth \$207.7 million for the delivery of four radars, with the marine corps officially taking delivery of the first factory-built G/ATOR in early 2017. In October 2015, the company was awarded a \$58 million contract from the USMC to develop and test a Ground Weapon Locating Radar mode for the AN/TPS-80. Applications: multi-mission radar system

### ARSR-4 (AN/FPS-130)

ARSR-4 is an unmanned, long-range, 3D air surveillance radar capable of civil ATC and military air defence roles in

**The multi-network capability of the AN/TPS-80 G/ATOR enables compatibility with additional US DoD C2 systems. (Photo Northrop Grumman)**



fixed installations. Includes full SSR/IFF capability. An array of feed horns generates two stacks of elevation beams from the single antenna. Circular polarisation improves detection performance in bad weather. The 44-radar system is used for commercial ATC by the FAA and the USAF for peacetime air sovereignty and drug interdiction purposes. The system also entered service with the Royal Thai Air Force in 1999. Applications: unmanned, long-range, 3D air surveillance radar Frequency: 1-2GHz Range: >400km

### Tactical Ballistic Missile Detection Radar

Tactical Ballistic Missile Detection Radar is a variant of the AN/TPS-70 designed to detect and track tactical ballistic missiles or switch back to air defence mode. Twin, angled phased-array antennas mounted on the back of a truck. Applications: detect and track tactical ballistic missiles and air defence

## OKB TSP

### RLS-50

OKB TSP gave its first public display of the RLS-50 3D air surveillance mobile radar at ADEX 2016, at Baku, in September 2016. Its beam has a width of 32° of elevation, which can be reduced to 6° for a longer-range detection. With a wider setting, the maximum detection range is 50m against a target with 1m<sup>2</sup> RCS, although a narrow beam width setting provides an increase in the detection range of up to 100km. The S-band pulse-Doppler radar, which has three scanning speeds, also has automatic detection and jamming-resistance features. It can be integrated into air defence systems containing early warning radars, command posts and surface-to-air systems. Applications: 3D air surveillance mobile radar Frequency: S-band Range: 100km Coverage elevation: 360°

## PIT-RADWAR

### N-22

The N-22 is a family of medium-range 3D surveillance radars for tactical use, mounted on a four-axle truck chassis. Reflector antenna elevated on twin arms, deployment time three minutes. The family includes two mobile radars: lightweight (N-22B) and armoured (N-22C). Applications: mobile medium-range tactical 3D surveillance radar Frequency: S-band Range: 100km Altitude coverage: 7km Number of targets tracked simultaneously: 100

## WEATHER

## ELDES

### WR-10X

The Eldes WR-10X weather radar is designed as a small lightweight transportable system which is designed for easy deployment or part of a mobile or fixed system. It can be used in both urban and regional areas or as a gap filler in an existing network. A mobile version can be deployed in cases where meteorological alerts occur in areas with significant hydrological risks, acting as an important tool for civil protection emergencies.

The radar can be installed alone or in a cluster and this allows the system coverage to be extended practically without limit. The resulting image products are mosaics integrating the data collected by all the sensors composing the network. Once a scanning schedule has been programmed, the system will begin acquiring data and generating images of the weather events detected, with colour levels proportional to weather intensity, superimposed on a local map, with adjustable distance and time scales. Applications: mobile and fixed weather radar Peak power: 10Kw (magnetron) Frequency: 9.410MHz, ±30MHz

### WR-25XP

The WR-25XP radar is able to operate in simultaneous dual-polarisation and Doppler modes. The system is able to partially compensate the path attenuation that typically penalises X-band radars and whose effect can be further mitigated by the use of a network of interconnected mini-radars with partially overlapped coverage sectors. Doppler processing is designed to allow filtering of clutter and the instantaneous estimation of velocity vectors and of the turbulence of the rainfield, in this way classifying its level of danger. The WR-25XP can be installed on a light trailer for quick relocation to areas sensitive to hydro-geological risk or to areas with a high concentration of people for civil protection needs. The reflectometric coverage of the sensor is 120km of radius on medium-high intensity phenomena, while weak perturbations (ie light rain) are visible up to around 40-50km. The WR-25XP can be installed in unattended stations as it can be remotely controlled and transmit pre-processed data even on low-speed transmission channels. Applications: mobile and static weather radar Frequency: 9.410MHz ±30MHz

## ENTERPRISE ELECTRONICS CORPORATION

### Defender C-band Series

EEC's Defender C-band series of radars consist of two 250kW variants, C250 and CK250; the C350 350kW version; the C500 500kW version; and the C1000 1000kW version. Systems are available in magnetron and klystron transmitter configurations. The company offers bespoke options for the systems including single or dual-polarity transmitters and a variety of control and display systems. The systems use polarimetric rainfall estimation and attenuation correction techniques and a super-high resolution IQ2 16-bit digital signal processor and can be set with 500 configurable diagnostic points, which can be monitored in real time. Applications: fixed C-band weather radar Scan rate: 10rpm Frequency: C250/ C350 5.200-5.700MHz; C500 5.400-5.900MHz Coverage: 600km/min

### Defender S-band Series

Magnetron- and Klystron-powered Defender S-band series weather radars are designed and engineered with an output of 850kW to 1,000kW, which the company claims is the most powerful in commercial radars of this type. The radar is coupled with an IQ2 digital receiver and signal processor for data processing and the company offers turnkey design, manufacturing, and installation processes to configure the radars to meet customer specifications. Options include single or dual polarity transmitters and a variety of control and display systems as well as the type of installation and radome

to meet environmental needs. Applications: S-band weather radar Radome diameter: 8.5m Peak power: 850-1,000kW Scan rate: up to 10rpm Frequency: Defender S850/S1000 2.700-3,000MHz; Defender SK850/SK1000 2.700-3,000MHz/3,500-3,600MHz Coverage: 600km (min)

### Defender X200

EEC's shorter wavelength X-band weather radar is designed to be able to detect smaller particles such as high-altitude water droplets or light snow. The size of the system makes it suitable for portable applications and 'filling in' geographical areas that S-band and C-band skip over. Dual-polarity capabilities are standard. Algorithms have been developed and tuned for performance at X-band frequencies and the system is designed for fixed-site and transportable configurations. Applications: weather radar Scan rate: up to 10rpm Frequency: 8,500-9,600MHz Coverage: 600km

### Ranger X-band Series

EEC's Ranger X-band radars are sold in two variants, the X1 (100W) and X5 (500W). The Ranger series is designed as a light mobile system which can in-fill and serve for military manoeuvres or at small airports and installations. The company worked with the University of Oklahoma's Atmospheric Radar Research Center to develop algorithms and end-to-end dual-polarisation measurements. This is designed to provide more accurate estimates of rainfall, but also provides better discrimination between different types of precipitation and non-meteorological signals, such as birds, insects, dust storms or even the debris field of an approaching tornado. Applications: X-band weather radar Scan rate: 0-8rpm Frequency: 9,200-9,700MHz

### FURUNO

#### WR-2100

The WR-2100 dual-polarimetric/Doppler weather radar has a high-definition spatio-temporal resolution capability, to calculate omni-directional precipitation intensity in a 50m mesh at six-second intervals. By conducting high spatio-temporal resolution monitoring of the development process three-dimensional structure

as well as movement of a cumulonimbus, which causes precipitation, the development of short localised rainstorms can be predicted. The system is designed to be transportable at 68kg and can be carried in a standard elevator for rooftop installation or in a regular civilian people carrier. Applications: weather and rain prediction Radome diameter: 1.08m Scan rate: 16rpm Frequency: 9.4GHz Coverage: 50km

### VAISALA

#### WRM100

WRM100 is a single polarisation Doppler weather radar which can be upgraded to dual polarisation. The modular system consists of an antenna/pedestal and a cabinet that contains the transmitter, receiver, power supplies, dehydrator and processor. The various components have been engineered and tested for harsh environments. The WRM100 is built around Sigmet's family of signal and data processing products. Sigmet processors are used in radar networks such as the US NEXRAD, Environment Canada, Spanish INM and at various international airports for TDWR windshear detection applications. An interface into Sigmet's IRIS product line provides radar product generation, display and forecasting features. Integration into other Vaisala systems such as lightning detection networks, rain gauges, Low Level Windshear Alert System and surface weather is also available. Peak power: 250kW Scan rate: 40°/s (min)

#### WRM200

The WRM200 is a dual polarisation Doppler weather radar which uses the real time operational hydro-meteorological classification software applications HydroClass. The software is described by the company as 'the first COTS product that uses real-time polarisation measurement for classifying targets into categories such as hail, snow pellets, snow or rain'. Applications include weather surveillance, severe weather monitoring, hydro-meteorological tasks such as flood forecasting, airport windshear detection, and hurricane/typhoon/cyclone tracking. The antenna has a diameter of 4.5m. Peak power: 250kW Elevation range: -2/+108° Scan rate: 40°/s (min) Frequency: 5.5-5.7GHz

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## EQUIPMENT

# MARITIME SYSTEMS

This section contains basic data on a selection of radar systems used in surface vessels, submarines and coastal installations:

- coastal surveillance
- commercial
- naval fire control
- naval surveillance

The equipment is listed alphabetically by manufacturer within the above subsections.

If you think your product should be listed, please contact the team at [reference@shephardmedia.com](mailto:reference@shephardmedia.com) to ensure it appears in the Shephard Plus online database ([shephardplus.com](http://shephardplus.com)) and is included in the next print edition.

**ABOVE:** An electronics technician performs a monthly maintenance check on an SPN-43 air traffic control radar on the aft mast aboard the USS *Iwo Jima* on 16 February 2018. (Photo: USN)

## COASTAL SURVEILLANCE

### ASELSAN

#### Serdar

The Serdar coastal surveillance radar is a fully solid-state, X-band, FMCW system designed and developed for automatic detection and tracking of above-water naval and low-flying airborne targets. The radar can be installed on a stationary ground platform and controlled by a remote C2 centre. Due to low output power and the waveforms used, it is able to detect without being detected (LPI), claims the company. Close-range performance or high target resolution can be obtained through antenna configuration according to user requirements. Both configurations are compatible with IALA Recommendation V-128 on Operational and Technical Performance of VTS Systems. The system uses solid-state amplifier technology and a modular design approach to contribute to a long useful and short maintenance periods. This radar family can be integrated with C2 systems and used for coastal surveillance, vessel traffic and harbour control applications. Applications: coastal surveillance. Frequency: X-band. Range: 65/90km instrumented range. Antenna rotation rate: 6/12/18rpm

### BLIGHTER SURVEILLANCE SYSTEMS

#### Blighter C400

Blighter C400 series radars are based on the company's B400 ground surveillance range. The C400 series has a modular, non-rotating solid-state design and are fitted with an electronic scanning system. The radars are designed for coastal surveillance missions and Doppler signal processing to examine the motion of waterborne objects. This also allows the radar to separate targets of interest from background clutter so that it can detect small targets in busy environments. There is also a sea clutter filter to reduce the false alarm rate. Applications include the protection of seaports and land-based coastal assets such as oil and gas installations. They can also be used for river and estuary monitoring in situations where larger coastal surveillance radars are unsuitable. The C400 series has an operating temperature of -32 to +60°C and a modular scan of 90, 180 or 360°. Frequency: Ku-band. Width: 666mm. Height: 503mm. Weight: wide-band: 21kg, narrow-band: 24kg. Range: 11km. Minimum range: <10m. MIL Standards: MIL-STD-810F

### DIGINEXT

#### Stradivarius

Stradivarius is a high-frequency surface wave radar (HFSWR), able to provide permanent surveillance in the EEZ as well as detect small vessels out to 200nm from the coastline. Stradivarius is currently deployed on the French Mediterranean Sea and under RANGER (RADars for loNG distance maritime surveillance and search and rescue operations), the European project for the long-range surveillance of maritime borders. The programme was announced in May 2016. The HFSWR can be used as a standalone system or integrated in an

existing maritime surveillance solution, able to optimise the usage of legacy assets (such as UAVs, AIS, satellites, OPVs or surveillance aircraft). In addition, Stradivarius combines various characteristics, designed to help optimise the capabilities and the cost of maritime domain awareness including: low electromagnetic wave emission and power consumption through a patented design of HF antenna array; and low operating and maintenance costs as one operator can remotely control and operate the radar through the GUI of the command centre.

### EASAT RADAR SYSTEMS

#### EA3462

The EA3462 X-band shaped reflector radar antenna is designed for coastal surveillance and VTS applications. The inverse elevation beam shape is designed for detection of small and large targets at short and long range when operating from towers, buildings or hills. The antenna incorporates remotely controlled polarisation switching, while variants can be supplied for C- or dual-band operation. The unit is designed to survive winds of up to 130kt and operate in winds of up to 100kt. Applications: coastal surveillance. Frequency: X-band. Width: 5.5m. Height: 1.9m. Weight: 1,350kg. Antenna rotation rate: 22rpm

### FURUNO

#### TZ Coastal Monitoring

A coastal surveillance solution that incorporates Furuno radar with TimeZero TZ Coastal Monitoring software and systems. It is designed for the monitoring of oil rigs, sea farms, ports, waterside facilities and protected areas. TZ Coastal Monitoring packages are designed to provide the functions of a standard system that covers most business requirements at a lower cost as a custom-made option. Applications: coastal and site surveillance

### GEM ELETTRONICA

#### SeaFalcon

The SeaFalcon coastal surveillance and VTM frequency-diversity radar is available in 25 and 50kW versions. The unit is designed for high azimuth and range discrimination and can be remotely operated via a LAN interface operating on a Windows-based package. It is believed production has ceased. Applications: coastal surveillance. VTM Length: 0.3m. Width: 0.55m (25kW); 0.94m (50kW). Height: 0.67m (25kW); 0.84m (50kW). Power: 115/220V AC. Weight: 44kg (25kW); 65kg (50kW). Antenna rotation rate: 6-60rpm (25kW); 12-20rpm (50kW)

#### Sentinel

Sentinel is a family of X-band solid-state coastal and maritime surveillance radars. There are four standards of peak transmitter power, two sizes of antenna in each standard and two types of antenna polarisation in each group, resulting in 16 different types of system. Transmitter peak power standards are 50, 100, 200 and 400kW, with antenna sizes of 5.8 and 6.4m with horizontal or circular polarisation. Applications: coastal surveillance. Frequency: 9,300-9,500MHz. Selectable Width: 5.8 or 6.4m. Weight: 317kg (5.8m antenna); 520kg (6.4m antenna). Antenna rotation rate: 16-22rpm (5.8m); 11-22rpm (6.4m)



The LCR-2020 is based on COTS open-architecture processor and receiver hardware. (Photo: Harris Electronic Systems)

## HARRIS ELECTRONIC SYSTEMS

### LCR-2020

The LCR-2020 is a dual-beam surveillance radar designed to detect and track low-flying air and sea surface targets. It can be operated remotely and configured as a mobile system. It features a dual-feed, reflector-type, low sidelobe antenna. Based on COTS open-architecture processor and receiver hardware. Additional features include ECCM capabilities, weather processing and display. The LCR-2020 can be integrated with existing C2 centres or as a part of a turnkey coastal surveillance offering. Applications: dual-beam low-altitude and sea surveillance radar Frequency: 5.4-5.9GHz, C-band (NATO G) Range: 100-185km

## HENSOLDT SENSORS

### Spexer 2000 Coastal

The Spexer 2000 Coastal radar was designed for surveillance and security applications against asymmetric threats. It automatically detects, classifies and tracks sea targets (eg swimmers, rubber dinghies) ground targets and low-flying air targets at up to 40km. The system allows surveillance of sea and ground sectors with a single radar, as well as the surveillance of large areas at long distance. It can be used for early warning as well as situation awareness and may be integrated into a C2 system. The system supports multi-radar operation and use in combination with cameras in a network. Applications: coastal surveillance against asymmetric threats Frequency: X-band Range: 80km instrumented; 18km pedestrian; 20km small boat, RIB; 36km truck, low-level helicopter

## IAI ELTA SYSTEMS

### ELM-2270

The ELM-2270 OTH radar is a long-range, high-frequency-band coastal surveillance radar. The system uses radars that monitor activity within the nation's EEZ by employing HF surface wave propagation to detect sea surface targets and low-flying aircraft beyond the local horizon. Employing phased-array technology and

interference cancellation techniques the radar is capable of providing persistent coverage of the broad maritime area at all times, regardless of atmospheric conditions or sea state, claims the company. The system's other features include noise cancellation, pulse-Doppler large integration time and flexible receiving antenna array size. The system is capable of detecting a 1,500t ship at a range of 370km and low-flying aircraft at a range of 130km. It was promoted at IMDEX Asia in 2017. Range: 370km (ship); 130km (low-flying aircraft) Coverage azimuth: 120°

### IUHDSS

The Integrated Underwater Harbour Defence and Surveillance System (IUHDSS) comprises surveillance, observation, surface, and underwater sensing arrays that can detect, locate and track various threats including small boats and submersibles, swimmer delivery vehicles, swimmers or divers. Features of the system include a C2 suite, coastal surveillance radars, diver-detecting sonars, EO sensors and automatic threat identification systems. IUHDSS was delivered to the Indian Navy on 13 February 2017, to provide security and protection for the Port of Mumbai.

## INDRA SISTEMAS

### Aries CS

Aries CS is a coastal surveillance radar and part of a family that includes submarine and precision approach variants. It is shore-based and capable of detecting small targets at short and long ranges in rough seas and severe weather conditions. It can be employed as a VTM system. Applications: coastal surveillance. VTM Frequency: X-band Range: 463km

### iCSR-20

The iCSR-20 is a low-power solid-state radar available in both X-band and S-band for medium/long-range coast surveillance VTS applications. It is able to operate in severe weather conditions and has been developed specifically to meet the recommendations of the International Association of Lighthouse Authorities (IALA) Advanced (V-128) for radar sensors for VTS. iCSR-20 is a configurable system, which can work with frequency diversity techniques. The radar has a solid-state power amplifier output exceeding 200W in order to obtain longer life. This technology allows a low degradation rate capability in the output power. It has a flexible design, high resolution in range, high probability of detection of small targets in the presence of high sea clutter returns, pulse compression and maintainability. Frequency: X-band and S-band

## KELVIN HUGHES

### SBS-800

The Shore Based Sensor (SBS) 800 family is designed to provide coastal surveillance and meet operational requirements of port, harbour and river traffic operators as well as government agencies responsible for protection of coastal and littoral zones. SBS-800 family radar installations are configured to provide an upmast system without the need for dual redundancy of the radar itself. They include the company's SharpEye transceiver and sensor. There are four

types of SBS-800 (-1, -2, -3, and -51) systems and all are configured as a single upmast transceiver with the SharpEye integrated with the antenna turning unit, reducing downmast housing requirements. Chevron, which operates oil and gas export facilities on Barrow Island in Western Australia, has received the SharpEye SBS-800 series radar. The system was supplied under a contract won by AMS Group to upgrade the VTS system for Chevron's production activities. On 7 July 2017, Kelvin Hughes announced that two ports in Indonesia had selected variants of the SBS-800 to assist the safe entry, exit, management and monitoring of vessels. The second largest port in Indonesia, Surabaya, opted for the SBS-800-2 model. On 3 October 2017, Kelvin Hughes announced it had supplied coastal surveillance and radar sensors and VTS to a number of Australian ports to improve security and control of shipping. Applications: coastal surveillance Frequency: X-band (800-1/2/3); S-band (800-51) Height: 3.7m (800-1); 5.5m (800-2/3); 3.9m (800-51) Weight: 135kg (800-1); 145kg (800-2/3); 185kg (800-51) Turn rate: 10-20rpm

### SBS-900

The SBS-900 family of coastal surveillance systems are improved versions of the SBS-800 and provide dual redundancy for the transceiver. They are configured for a mast-mounted, sealed enclosure and designed to provide a complete sensor package. The SBS-900-1 system is X-band with a mast-mounted SharpEye transceiver, the SBS-900-2 provides similar capability with frequency diversity, the SBS-900-3 is similar to the 900-2 with dual redundancy and the SBS-900-4 has both S- and X-band SharpEye transceivers. Applications: coastal surveillance Frequency: X-band, S-band Weight: 110kg (SBS-900-1/2); 130kg (SBS-900-3/4) Range: <89km Antenna rotation rate: 10-20rpm

## LEONARDO UK

### Argos 30VS

Argos-30VS is a coherent X-band primary radar for combined surface and air surveillance of sensitive coastal zones and EEZ protection. It can be integrated to create a surveillance network (point-to-point serial link, Ethernet standard data LAN) and perform up to three operational roles: long-range surveillance of small air/surface targets; medium-range surveillance, using a high rotation speed; and OTH with a low rotation speed. The reflector antenna generates two different beams (in linear and circular polarisation), used for different types of application. Argos 30VS is remote-controlled so the radar site is normally unmanned. The radar can be sheltered (ISO standard container) for truck transport. Applications: combined surface and air surveillance

## LOCKHEED MARTIN

### JORN

The Jindalee Operational Radar Network (JORN) is a three-radar system designed to detect aircraft and ships, including small passenger planes, fighter jets and boats, off the northwest coast of Australia to a range beyond 3,000km. It uses 2km-long HF transmitters located at Longreach in Queensland and Laverton in Western Australia, sites more than 2,000km apart. There is a third radar in Alice Springs which was used

for development and testing of the system in the 1970s. Signals are reflected off the ionosphere and the signal return is processed through software to detect targets within clutter. There are 11 receiver stations in Western Australia and Queensland and one test and evaluation unit in South Australia. Each receiver consists of two 3.4km-long ranges and there are 980 individual antennas. The operator of the system, the RAAF, has stated that it operates beyond its unclassified range of 3,000km, but it is unclear if the radar can reach the distances some have claimed such as China, Russia and Singapore. JORN is believed to have strong capabilities against stealth aircraft because it uses HF radio signals rather than the microwaves of conventional radar and detects aircraft from above. While the system has been refined to be able to detect Cessna-size passenger aircraft at a range of 2,700km, its capability against wooden and smaller boats is more limited. The apparent current success of the system is in stark contrast to its laboured birth, where the programme had to be rescued from its original contractors by RLM Systems, a JV of Lockheed Martin and Tenix Defence, which was eventually taken over by Lockheed Martin. Applications: OTH radar network Length: 2x 3.4km ranges at each of the 11 receiver stations Range: >3,000km

## MDA - MACDONALD,

### DETTWILER AND ASSOCIATES

#### MDA BlueHawk

MDA developed BlueHawk, a multi-sensor, unclassified maritime domain awareness solution that provides navies, coast guards, environmental and regulatory agencies with near real-time access to broad-area maritime surveillance across EEZs and global areas of interest. Fusing SAR and optical satellite imagery, AIS data, vessel registries and other maritime information, MDA BlueHawk provides critical information and tools to detect, track, and respond to security and environmental threats. It detects non-reporting 'dark' vessels in various weather and lighting conditions, including observed vessel size and heading information. It provides coverage of open ocean and coastal environments to automatically generate alerts of suspicious vessel behaviour, delivers vessel registry data and displays historical and predicted vessel tracks. MDA BlueHawk can ingest unclassified data and fuse it into meaningful information, reducing costs and enabling inter-agency sharing, it is claimed. It is available as an online web-based service, a full system implementation, or as a direct data feed into existing customer systems. Applications: fused multi-sensor system Coverage: 250,000km<sup>2</sup>

## NORINCO

### 905A Coast Defence Radar

The 905A Coast Defence Radar is a mobile 1D phased-array system used for panoramic monitoring of the coastline, low-altitude target detection and tracking and fire correction. It can be used as an anti-terrorism and anti-smuggling system, for search and rescue missions and marine resource protection. Multi-target performance: 200 batches for target searching and processing, 20 batches for target tracking Resolution range: 15m Resolution angle: 9mil Applications:

coastal surveillance Range: 1-140km Coverage azimuth: 360°

### CY-1011

The CY-1011 is a fixed long- and medium-range 2D coastal surveillance radar. It can perform routine surveillance on passing vessels, track vessel targets of interest in specific areas, examine suspicious surface targets and alert higher-level command in real time if necessary. It can be used as a coastal defence system against amphibious assaults and asymmetric threats, as well as for anti-piracy, anti-smuggling, port security, vessel traffic control, marine infrastructure protection and search and rescue. Multiple target capability: search 500 batches; track and record 200 batches Applications: coastal surveillance Frequency: X-band Range: 140km (1,000t vessel); 100km (1,000t vessel) Minimum range: 800m Coverage azimuth: 360° Turn rate: 10-15rpm

### PLATH

#### MACOS

MACOS is designed as an entry-level solution including a passive radar and a communication signal DF sensor. The combined passive antenna solution makes it unnecessary to deal with different suppliers for different sensors. The combined antenna weighs less than 55kg and incorporates elements for communication frequency ranges from 20 to 3,000MHz and a compact passive radar detection system, covering the 2 to 18GHz range. The system can be controlled by a single operator. Detected radar and communication emitters are fused on a layer basis on a map and reporting application. This allows the operator to align different emitter types to one result and to obtain a situational picture.

## RADA ELECTRONIC INDUSTRIES

### Three-Dimensional Perimeter Surveillance Radars

RADA's Three-Dimensional (3D) Perimeter Surveillance Radars provide border and perimeter surveillance through detection, classification, and tracking of surface and aerial intruders such as pedestrians, vehicles, slow and small aircraft, vessels and more. These radar systems can be based on any member of RADA's Multi-Mission Hemispheric Radar (MHR) family of tactical platforms or Compact Hemispherical Radar (CHR). The radar platforms differ primarily in antenna sizes, resulting in maximal detection ranges. MHR radar platform specifications: S-band, 90° cone coverage from antenna axis for single radar (up to 360°), AESA antenna: solid-state, digital (software-defined), no moving parts and mobile for tactical applications. RADA's 3D Perimeter Surveillance Radars can be integrated with a C4I system and other radars/sensors/EO using standard Ethernet interfaces and can operate standalone or as part of a large-scale surveillance system, vehicle-mounted or static. Frequency: S-band Detection range: 4-20 km for pedestrians, 6-50 km for light transport aircraft and 8-40 km for vehicles/medium-size vessels

## ROSOBORONEXPORT

### MR-10M1E

The MR-10M1E is a coastal radar designed to detect, track, locate and identify surface ships and small, high-

speed targets in the open sea and littoral areas. The radar determines target co-ordinates and motion parameters in the relative and geographic co-ordinate system. The system transfers the data to automated gathering and processing systems. The MR-10M1E is a stationary radar which can also be used for ship piloting in narrow straits. The system is capable of automatic detection and tracking in two areas of responsibility as defined by the operator. It is also able to track up to 89 targets at ranges of 51 km and perform semi-automatic tracking of up to ten targets. Applications: coastal surveillance and tracking Power: 50Hz, 380 or 220V Range: 200km Antenna rotation rate: 6rpm Coverage azimuth: 360°

## SRC

### SR Hawk Ground Surveillance Radar

The SR Hawk surveillance radar provides continuous 360° surveillance of the ground, ports and harbours and airspace. It performs these tasks in a single system. It detects personnel, land vehicles, marine vessels, avian targets and low-flying aircraft such as UAS. These capabilities make it suitable for applications such as ground surveillance, air surveillance, border and perimeter surveillance, counter-UAS mission support, port and harbour surveillance, wind farm bird strike avoidance, avian surveillance and artillery spotting. It supports image cueing, classification and identification of targets. Automated EO/IR camera cueing, audible alerts, multi-target tracking and anti-clutter techniques allow the operator to focus on the threat. According to SRC, the SR Hawk radar offers a rapid update rate with continuous 360° coverage or definable sector scanning; low false alarm rate; automated sensitivity settings for weather and clutter management; simultaneous short- and long-range coverage; automated priority target track mode; and tower, vehicle mount and tripod configurations. Applications: surveillance radar Weight: 21kg

## TERMA

### Scanter 5000 Series

The Scanter 5202/5102 coastal surveillance radar and VTS is designed for management and detection of ships and boats as well as low-level air surveillance. A Scanter 5102 system was evaluated by the Port of London and radars of the series are in service in several major international ports. The Scanter 5000 series was launched to the market in 2011 and more than 200 units are operational for coastal surveillance, vessel traffic services and surface movement radar (Scanter 5502/5602). The system comprises coherent, frequency- and time-diverse solid-state radars with software-defined functionality, and is based on the ship-based Scanter 6000. Applications: coastal surveillance, VTM Frequency: 9.0-9.5GHz programmable Power: 50W equivalent pulse power, programmable up to 75kW (Scanter 5102); 200W equivalent pulse power, programmable up to 300kW (Scanter 5202)

## THALES

### CW100

The Coast Watcher (CW) 100 long-range surface and low-altitude surveillance radar is designed to provide medium-range detection of small threats and longer-range detection of larger targets. Small aircraft can be

detected up to a range of 65km at an altitude of 500ft. small boats at a range of more than 30km and medium boats at more than 35km. The kinematic scan-to-scan signal processing technology of the algorithm is designed to provide filtering of all environmental clutter (including poor weather conditions), allowing small target detection, discrimination and a low false-alarm rate. The company states that it allows small target detection in an environment such as rain in SS5. Applications: long-range surface and low-altitude surveillance. Frequency: HF. Power: 1,000W peak. Range: 185km. Altitude coverage: up to 3,500ft. Antenna rotation rate: 6-10rpm

## WESTMINSTER INTERNATIONAL

### WG Ground & Marine

The WG Ground & Marine radar can detect small and slow-moving targets on land and over water, allowing it to operate in littoral or coastal regions. It can also detect fast-moving boats and large ships. The radar uses high-resolution Doppler processing technology to enable it to discriminate movement and reject radar reflections from static objects, allowing it to detect small boats moving alongside moored ships, jetties and other structures. Applications: ground and marine surveillance. Length: 12cm. Width: 67cm. Height: 50cm. Weight: 25kg wideband, 27kg narrow band for main radar unit. Range: 15.5km walking person, 19km moving RIB, 28km large moving vehicle, 32km large moving vessel

## COMMERCIAL

## FURUNO

### FAR-21x7

FAR-21x7 is a series of S-band and X-band radars with a 19in LCD display unit. The family consists of FAR-2117 and FAR-2127 X-band radars and FAR-2137S S-band radar with a power of 12, 25 and 30kW respectively. It is suitable for ships up to 10,000t and can track up to 100 targets. Up to 200 waypoints and 30 routes can be stored and each route can contain up to 30 waypoints. The map data can be stored and recalled for repeated use in a routine navigation area. Width: 38cm. Height: 30cm. Range: 230km

### FAR-28x7

The FAR-28x7 series consists of the FAR-2817/2827/2827W X-band radars and the FAR-2837W/2837S/2837SW S-band TR-up and down radars. Target detection is enhanced by signal processing techniques featuring short-range detection. AIS information can be incorporated when a transponder/receiver is interfaced. The display unit is a 23.1in LCD with an effective picture diameter larger than 34cm. The X-band systems can be fitted with a 4, 6.5 or 8ft antenna with rotation speeds of 24rpm. S-band radars use a 12ft antenna at 42rpm. Width: 47cm. Height: 35cm. Minimum range: 22m

## KELVIN HUGHES

### X-band Navigation Radar

At the SMM trade fair in September 2016 in Hamburg, Kelvin Hughes launched its navigation radar transceiver.

The commercial marine 12kW X-band series upmast magnetron radar has 'improved' target resolution and beam sharpening and has been designed to meet IMO requirements (with IEC 62388, MSC192/79 type approval.) The radars have an 'increased' gain and a narrow antenna beam width which offers a greater range and bearing resolution for performance and target separation. Its compact lightweight design can be installed with a single waterproof connector and includes an integral health monitor. Additional features of the antenna include blanking sectors and a low-noise-level transceiver. Frequency: X-band, 9.4GHz. Length: 1.9m. Power: 12kW. Weight: 29kg. Minimum range: <40m

## NAVICO

### Simrad R3016 12U/6X

The Simrad R3016 12U/6X is a radar system rated as Category 3 SOLAS and targeted at tugs, coastal fishing vessels and workboats. Its 12kW X-band transceiver and 6ft open array scanner are designed to provide performance, reliability and low maintenance in commercial applications. The Simrad R3016 radar control unit is an all-in-one system which incorporates the display, controls and processor in a single console. The system does not require an additional PC processor and reduces the need for cabling between components, which is useful for smaller vessels with less space. The system uses Ethernet cabling and a bulkhead-mounted power supply unit. Power: display: 20W; antenna: 360W. Range: 133km. Antenna rotation rate: ≥20 or ≥36rpm nominal

## NORTHROP GRUMMAN SPERRY MARINE

### VMFT

VisionMaster FT (VMFT) radar is designed to provide ship owners and operators with the ability to automatically acquire and track targets at relative speeds as well as provide support for safe navigation and collision avoidance under all maritime conditions. The VMFT is part of Northrop Grumman Sperry Marine's Automatic Radar Plotting Aid, and can acquire and track targets moving at up to 150kt, using either two annular acquisition zones or two operator-configured polygon zones. The radar can display AIS reports and supports the processing and display of SAR craft, AIS SARTS, AIS base stations, safety messaging and AIS MKD. The VMFT 340 control station contains a 57.15cm screen including the Conning Information Display and radar in high resolution, a processor and interfaces, a compact console, and an antenna unit (S- or X-band). The station is available in deck standing, kit, desktop and integrated formats. The smaller VMFT 240 is available in deck stand and kit. The radar is configurable to meet the ship owner's requirements/vessel types and has a built-in upgrade path. Length: X-band 1.2m, 1.8m or 2.4m; S-band 3.6m. Power: transceiver: X-band 10kW or 25kW; S-band 30kW

## RAYTHEON ANSCHÜTZ

### NautoScan NX

NautoScan NX network radar transceivers distribute radar raw video via Ethernet to an 'unlimited' number of workstations on the bridge (depending on network

setup). According to the company, one of the major benefits of digital raw data distribution is to provide flexibility for system design, interswitching and functional upgrades. In this networking environment a transceiver can be controlled from any workstation, while maintaining operational integrity with a master/slave concept. All transceivers integrate a continuous performance monitoring function. This automatically measures transceiver performance and provides early maintenance warnings. Built-in tests, fault indicators and a removable tray for the electronics help speed up service and exchanging of parts. It is claimed. Length: X-band 6ft, 8ft; S-band 12ft Weight: X-band 75kg, 78kg; S-band 148kg Antenna rotation rate: X-band 24/48rpm; S-band 24rpm

### Synapsis Workstation

Synapsis Workstations are available as a multifunctional console with access to all nautical applications or as a standalone system for a single application only. Applications include radar, Electronic Chart Display and Information System (ECDIS) and conning. According to the company, the base for Synapsis ECDIS 'is a clear presentation of voyage-related information, the vessel's position relative to shore and structures, traffic separation zones, restricted areas, or other ships'. Synapsis NSX radars include functions which contribute to target presentation, the situational picture and decision-making with regard to collision avoidance and navigation.

## NAVAL FIRE CONTROL

### CEA TECHNOLOGIES

#### CEAMount

CEA is providing the CEAMount active phased-array illuminator for the anti-ship missile defence upgrade to the Royal Australian Navy's ANZAC-class frigates. It performs target illumination and missile uplink for multiple simultaneous semi-active homing missiles. The CEAMount can be configured as a mechanically trained face or a fixed multi-face solution. Applications: active phased-array illuminator

#### SSCWI

The Solid State Continuous Wave Illuminator (SSCWI) is a high-powered solid-state transmitter providing semi-active missile air target illumination for ship self-defence. The SSCWI uses broadband solid-state power amplifiers and features a sophisticated control and monitoring system, including remote maintenance and access options. Installed on UAE *Baynunah*-class corvettes and Royal Australian Navy ANZAC-class frigates. Applications: semi-active missile air target illumination

### CHINA ELECTRONICS TECHNOLOGY GROUP CORPORATION (CETC)

#### LR66

The China Electronics Technology Group Corporation (CETC) LR66 FCR is a component of ship-defence close-in weapon systems including the Type 730. The major role of the radar is to search, capture and automatically track cruise or low-RCS missiles and provide control for anti-missile gun systems. The system can be either X-band

or J-band with a range up to 18km. Applications: anti-missile radar Frequency: X- or J-band Range: 18km

### LEONARDO LAND & NAVAL DEFENCE ELECTRONICS

#### NA30S

The NA30S is a modular weapon control system designed to control SAMs and guns (up to three gun outputs) in a sophisticated threat environment and in coordinated fire reaction mode. It is based on the Orion RTN-30X tracking naval radar and I-band fully coherent equipment, which is characterised by anti-nodding, ECCM and anti-clutter features together with tracking accuracy. A set of two EO sensors (TV/IR camera) can be mounted on the radar director to enable firing assessment and provide an alternative LOS on the same target. A third sensor (LRF) can be mounted to provide a complete EO tracker. NA30S can be equipped with a dedicated twin-monitor multi-functional console or controlled by a combat management system console. Through an additional internal function, the NA30S can be integrated inside an artillery system (including at least two FCS) in order to optimise the use of onboard guns against multiple concurrent targets (missiles, air and surface). The system is installed on the *Abu Dhabi*-class ASW ships of the UAE Navy. Applications: FCS Height: 1.5m antenna Weight: 700kg antenna

### LOCKHEED MARTIN

#### AN/SPY-1

Aegis is an integrated missile guidance system used on USN and allied ships to perform anti-air and ballistic missile defence missions. The S-band phased-array AN/SPY-1D(V) radar acquires and tracks multiple targets, handing off to the missile control station via the MK99 FCS. The SPY-1D(V) is a transmitter that supports search, track and missile guidance functions, illuminating targets to be destroyed as commanded by the FCS. The initial design work on the Aegis system began in the 1960s and the first SPY-1 transmitter was delivered in 1981. Since then, the technology has been continually enhanced. Aegis SPY-1 transmitters and MK99 FCS are on all USN *Ticonderoga*-class cruisers and *Arleigh Burke*-class destroyers, along with Japanese *Kongo*-class destroyers, Spanish *F100*-class frigates, Korean *King Sejong the Great*-class destroyers and Australian *Hobart*-class destroyers. Some 110 ships have been fitted with the system. Applications: integrated missile guidance system

### RADA ELECTRONIC INDUSTRIES

#### All-Threats Tactical Air Surveillance

RADA's All-Threats Tactical Air Surveillance radar systems detect all types of aerial vehicles (including UAVs of all groups), missiles, rockets, and mortars. It classifies threats, provides and displays tracking and warning/alerts, and provides data to external C4I and air defence systems over Ethernet. These tactical radar systems can also function as gap-fillers, complementing medium and long-range air surveillance systems. The air surveillance radar systems can be based on any member of RADA's Multi-mission Hemispheric Radar (MHR) family and Compact Hemispheric Radar which differ primarily in antenna sizes, resulting in maximal detection ranges: 3.5-7km for DJI's Phantom quadcopter drone, 15-30km

for medium-size UAVs, 25-50km for a fighter jet, 5-10km for light/medium mortar and short-range rockets, up to 12km for heavy mortars. RADA's MHR attributes: S-band, 90° on azimuth and elevation coverage, hemispheric coverage (360°) is achieved when four identical and interchangeable radars are employed as a system. AESA antenna: solid-state, digital (software-defined), no moving parts and mobile for tactical applications. The radars can work with various installation methods: fixed, deployable/manoeuvrable, operate on-the-move on-board tactical land vehicles, littoral or shipborne (combat and patrol ships). Frequency: S-band Weight: 20kg (pMHR platform), 35kg (eMHR platform), 45kg (ieMHR platform)

## SAAB

### Ceros 200

The Ceros 200 is a radar and optronic tracking system designed for use on naval vessels. When interfaced with modern missile or gun systems, it provides defence against threats including sea-skimming missiles and asymmetric surface combatants in littoral environments. Ceros 200 combines acquisition speed, tracking precision and the ability to track targets in any weather, says the company. Ceros 200 numbers over 200 installations worldwide, including Royal Swedish Navy *Visby*-class corvettes, Royal New Zealand Navy and Royal Australian Navy ANZAC-class frigates, Royal Thai Navy *Naresuan*-class frigates and Royal Canadian Navy *Halifax*-class frigates. Applications: radar and optronic tracking system Frequency: Ku-band Length: 1.82m Width: 1.63m Height: 1.96m above deck Power: 230V, 3 phases Weight: 625-750kg depending on variant Range: >100km Minimum range: 300m Altitude coverage: -25/+85° Antenna rotation rate: >2 rad/s Coverage azimuth: unlimited

## THALES

### Castor 2B

The Castor 2B is a monopulse MTI I/J-band radar featuring with integral EO sensor used for weapon control, including gunfire splash-spotting. It is designed to operate against low-altitude targets and in the presence of jamming and in severe weather conditions. Key features of the system include automatic target acquisition for quick reaction times: passive tracking of a jammer; and autonomous surveillance, continuous and by sector, with absolute elevation. The radar provides a display of splashes in the case of anti-surface vessel firing.. Applications: FCR Frequency: 8-20GHz Range: 0.5-27km

### Castor 2C

The Castor 2C is an I/J-band target-tracking radar for gunfire control against air, surface and shore targets. It uses Doppler filtering techniques to track targets in heavy clutter and ECM. Integrated with EO sensors. In service on Taiwan's *Kang Ding*-class frigates. It is able to acquire targets and track them in conditions of heavy clutter, chaff and active jamming. According to the company it uses frequency agility, analysis of jamming signals and fully coherent transmissions to create a clear picture. The use of automatic detection and tracking provides rapid information to operators and tracking can also be focused on sectors. Applications: target tracking Frequency: 8-20GHz Range: 0.5-27km



The Ceros 200 is a radar and optronic tracking system designed for use on naval vessels. (Photo: Saab)

## Castor Family

The Castor radar family includes several products. This X-band radar is designed to perform fire control. It has a beamwidth of 2° and a peak power of 200kW. The Castor-1 (also known as the TRS-3200) has a range of around 30km, transmitting up to 8,000pps from its magnetron transmitter. The Castor-2/TRS-3201 can transmit up to 7,200pps using a 30kW coherent TWT transmitter. The Castor-2C/TRS-3204 (known in French Navy service as the DRBC-33A) has a computer-controlled TWT and has frequency agility across up to 700MHz, with the ability to acquire a fighter-sized target at 25km and an anti-ship missile at 30km. This radar has slightly improved sea clutter rejection than the Castor-2/TRS-3201 (35dB versus 30dB for the latter). Meanwhile, the Castor-IJ (also known as the CTM) uses a Ku-band radar combined with an IR camera. Applications: surveillance and fire control Frequency: X-band Range: 30km

## DRBC 32

The X-band DRBC-32 radar family includes the DRBC-32B, 32C, 32D and 32E. Designed to provide fire control for naval guns, the radar has a range of circa 15km and a 1.5° beamwidth. With a peak power of 80kW, the radar uses monopulse compression. Applications: FCR Frequency: X-band Range: 15km

## Herakles

Thales' Herakles radar provides 3D imagery for surveillance and fire control. The S-band radar has an integrated Mode-5/Mode-S compatible IFF interrogator. When performing air surveillance, it has a range of 250km and a range of 80km when performing surface surveillance. In terms of azimuth and elevation, the radar covers 360° and 70° respectively. The antenna revolves at 60rpm and the radar can track >400 targets. Applications: 3D surveillance and fire control radar Frequency: S-band Range: 250km air surveillance, 80km surface surveillance Altitude coverage: 70° in elevation Coverage azimuth: 360°

## SF 500

The SF500 is a multifunction radar providing simultaneous long-range air and surface surveillance, target acquisition and tracking and fire control (ASTER missiles and guns) against any type of targets in harsh

environment. These targets may be conventional, asymmetric or ballistic. SF500 has a compact AESA, digital array and instantaneous bandwidth associated with a large number of multibeam clusters and adaptive radar resources management. It is claimed to be the first fully digitalised naval radar. The system can be integrated aboard ships from 4,000-7,000t.

### Variant

Variant is a 2D C/X-band naval surveillance and fire control radar. Providing a horizontal beamwidth of 1.8° and a vertical beamwidth of 14° it has a detection range of 30km in the C-band and 28km in the X-band. The use of two frequency ranges is intended to make the radar less susceptible to ECM. The radar has a selectable pulse width of 4.5, 12.8 or 16µs and a PRF of between 3 and 9KHz. Variant runs at between 14 and 28rpm and has a peak output power of 200W. Applications: 2D naval surveillance and FCR Frequency: C and X-band Range: 120km air targets, 70km surface targets Antenna rotation rate: 14 and 28rpm

## THALES NETHERLANDS

### APAR

APAR is operational on the four *De Zeven Provinciën*-class vessels of the Royal Netherlands Navy, the three *Sachsen*-class ships of the German Navy and the three *Iver Huitfeldt* ships of the Danish Navy. The Active Phased Array Multifunction (APAR) radar is an X-band naval surveillance and FCS. The radar provides 360° azimuth scanning and a range of circa 150km, with an 8.5° angle of elevation coverage. In order to achieve 360° azimuth scanning, four antennas are installed on a vessel, each of which provides 90° of coverage. Resolution Doppler processing aids coverage in high clutter conditions. When performing fire control, the radar can handle simultaneous firings of different SAMs. Applications: surveillance and FCR Frequency: X-band Weight: 10,000kg Range: 150km active tracking

### Flycatcher Mk 2

The Flycatcher Mk 2 is an FCS for short-range air defence guns and missiles. Features 3D radar and IR/TV sensor with laser rangefinder. It is an older system but production was restarted in September 2015 on the back of an order from Germany believed to be worth €17 million (\$19 million). Applications: FCS for short-range air defence guns and missiles Frequency: 8-12GHz Range: 25km

### STIR 1.2 EO Mk 2

STIR 1.2 EO Mk 2 is a tracking radar for gun and missile fire control. Its claimed reliability and stealth target detection capabilities support long missions. The STIR 1.2 is the first track radar with a full set of solid-state transmitters, it is also claimed. It has been designed for stealth target detection in littoral and ECM environments. An EO suite complements the dual-band radar. In 2013, Thales announced the signing of a contract with Damen Schelde Naval Shipbuilding for the delivery and installation of a full mission systems suite (including STIR 1.2 EO Mk 2) for the two PKR-class vessels under construction for the Indonesian Navy. Applications: tracking FCR Height: 2.3m Weight: 850kg above deck, 510kg below deck Range: 120km I-band, 36km K-band

## WEIBEL SCIENTIFIC

### RR-2100/33 Fire Control Radar

Weibel's RR-2100/33 is an all-weather FCR capable of providing guidance to ground or naval weapons systems. The system provides detection, acquisition, and tracking of air and surface targets. The Doppler radar is based on technology that combines continuous wave with multi-frequency CW (MF-CW) and frequency-modulated CW (FM-CW), allowing the radar to always use two waveforms, switching between MF-CW and FM-CW according to the tactical situation.

## NAVAL SURVEILLANCE

## ASELSAN

### ALPER

ALPER (Aselsan Low Power ECCM Radar), being an X-band radar with high range resolution, has no blind range. Its performance is achieved by use of a dual-slotted antenna with low sidelobe levels, digital FM CW waveform, and a digital receiver with DSP architecture. Low and adjustable output power makes the radar virtually undetectable by enemy ESM, it is claimed, while providing the user the advantage of detecting before being detected. The radome is tailored to decrease RCS. Managed and controlled from commercial navigation radar consoles on board, saving valuable space on the bridge/CIC. Applications: LPI radar. High range resolution Range: 65km Frequency coverage: X-band

### ANX3100 Naval 3D Air & Surface Surveillance Radar

ANX3100 Naval 3D Air & Surface Surveillance Radar is a lightweight, multi-beam, solid-state active phased array radar system operating in the X-band. ANX3100 is designed to provide medium-range air and surface surveillance and target designation. It is suitable for installation on OPVs, corvettes and fast attack boats due to its lightweight antenna and below-deck compactness. The system has a slotted waveguide antenna with low antenna sidelobes; graceful degradation with solid-state T/R modules; LPI mode; electronic beam stabilisation and signal processing architecture. In addition it employs Doppler processing and interference suppression; an integrated IFF antenna; radar-IFF track correlation, provision of surface video for surveillance and gunfire support; ECM features; multiple beams in elevation through digital beam-forming; sidelobe blanking; BIT and monitoring capabilities; jammer detection and tracking; high-velocity target warning; broadband frequency operation and frequency agility; MIL-STD compliant. Target Tracking: 200 track capacity, automatic target classification. Elevation coverage -5/+70° Power: consumption <6kW Weight: mast-top <300kg Range: 100km

### SMART-S Mk 2

SMART-S Mk 2 is a naval air and surface surveillance radar that applies a multi-beam concept. Its reliability and stealth target detection, including in clutter, support long missions and operation in littoral environments. The SMART-S Mk2 is designed to be easy

to operate, using two automatic operational modes, as well as easy to install, integrate and maintain. The SMART-S Mk 2 is able to automatically detect and track air and surface targets. Applications: multi-beam naval search radar Range: 250km Elevation: -5/+70° Operating platforms: MILGEM corvettes Frequency coverage: S-band Target tracking: 500 track capacity, automatic target classification

## BAE SYSTEMS

### Artisan 3D Radar

The Advanced Radar Target Indication Situational Awareness and Navigation (Artisan) is a medium range 3D radar series. Designed for the UK RN's Type 23 frigates, Artisan will be replacing the Type 996 surveillance and target indication radar and has already been fitted on 11 frigates to date. Artisan is able to track more than 900 targets at any one time, can monitor more than 800 objects simultaneously from 200 to 200,000m away and can cut through radio interference, equal to 10,000 mobile phone signals. Artisan 3D is already deployed with on HMS *Iron Duke* and fitted on HMS *Ocean*. It will also be fitted from build to the *Queen Elizabeth*-class aircraft carriers and retrofitted to all amphibious assault ships and helicopter carriers. The company announced in January 2017 that the 19th radar has now successfully completed factory acceptance testing and all radars would be delivered to the UK MoD by mid-2017. Weight: <700kg Range: 200m-200km

### Sampson

Sampson is the multi-function 3D radar selected for UK RN Type 45 anti-air warfare destroyers, following development from the Multifunction Electronically Scanned Adaptive Radar programme. Sampson is a software-controlled radar that provides search and precision tracking of multiple targets, along with weapons control, offering the option of automatic operation. It is designed for point and area defence against current and future air threats, including stealthy ones, in an environment of heavy jamming, land and sea clutter. Its S-band frequency enables high search rates in clutter. It can provide target illumination for semi-active homing missiles, and target cueing and mid-course updates via integral data link for active radar-homing weapons. Sampson uses variable data rates for threat tracking, the higher rates being used for precise guidance and manoeuvre detection. Its modular design enables it to be tailored to individual applications, and signal, plot and track processing are programmable. The antenna consists of two arrays with over 2,000 radiating elements each, the whole assembly rotating at 30rpm. Anti-jamming features include adaptive nulling, very low antenna sidelobes, monopulse accuracy, very high bandwidth, frequency agility, pulse compression, automatic waveform selection, sideload banking, jammer strobe extracting and tracking and jammer burnthrough. Applications: multi-function Range: 400km

## BEL-THALES SYSTEMS

### Pharos

Pharos is a multi-target tracking radar designed for gun and very short-range air defence missile control, developed as a joint venture between Thales and Bharat

Electronics Ltd. It will be used to control medium-calibre guns ranging from 30 to 76mm for ground-based and naval applications. With guided ammunition the radar will be able to provide anti-ship missile capability. Features include target engagement on any 2D or 3D designation, radar surveillance capability for improved situation awareness and early threat detection and simultaneous control of conventional and guided ammunition. It is capable of simultaneously tracking up to three targets. Applications: gun and missile control Frequency: Ka-band Width: 1400mm Height: 1.850mm Weight: 950kg (above deck) Coverage azimuth: 360°

## CEA TECHNOLOGIES

### CEAFar

CEA is providing the CEAFar active phased-array radar for the anti-ship missile defence upgrade to the Royal Australian Navy's ANZAC-class frigates. The CEAFar provides digital beam-forming radar capability able to perform 3D volume search, surface search, fire-control support or target classification in demanding, cluttered and jamming environments. Five ANZAC ships have been fitted with CEAFar as of September 2015, when work was completed on HMAS *Ballarat*. Work on the remaining three ships will be completed in 2017. Applications: missile defence

## HARRIS ELECTRONIC SYSTEMS

### AN/SPS-48(V)1

The AN/SPS-48(V)1 is a 3D long-range air surveillance radar used for detection and tracking of aircraft and missiles. The radar is available in fixed-site, transportable or shipboard configurations to support customer needs on land or at sea. The multi-pencil beam architecture provides jamming immunity, low false-alarm rates and the ability to detect and track small targets in hostile sea and land clutter environments as well as weather detection and display capabilities, it is claimed. The AN/SPS-48(V)1 is built with an open architecture for growth, a solid state transmitter, integrated BIT system with remote support capability, and the technical integrated digital environment enables logistics and low-cost life-cycle support, it is also claimed.

### ES-3601

The ES-3601 is a tactical radar ESM and surveillance system designed for submarines, surface ships and land-based applications. It provides situational awareness, self-protection and surveillance in a small footprint, operated via a dedicated operator console or from the multi-function console (MFC) of the combat management system. The ES-2601 covers the 2-18GHz band, with a 100% POI and 360° instant DF. It measures all received radars simultaneously and provides long-range detection, DF and tracking. The system works in all polarisations, including RHCP and LHCP. Sapience signal processing has pulse-type grouping in both RF and PRI and allows the merging of emitters into one report without a library. The ES-3601 performs multi-path and reflection processing and can handle 1,000,000pps signal environments. The threat library has a capacity of more than 20,000 emitter modes, and the system can track 500 signals simultaneously.

Submarine antenna units are available either for the ESM mast, optronics mast or both. The system can be offered with a parallel narrowband digital receiver for detection and identification of FMCW radars. The ES-3601 includes multi-layer protection against interfering signals. Applications: tactical radar ESM and surveillance system Frequency coverage: 2-18GHz, extensions of 1-2 and 18-40GHz offered

### ES-3701

The ES-3701 is a radar surveillance and precision monopulse DF system intended for submarines, surface ships and land-based applications. It provides situational awareness, targeting, self-protection and surveillance, operated via a dedicated console or from the multi-function console of the combat management system. The ES-3701 offers a 100% POI and provides instantaneous frequency coverage over the 2-18GHz band. Sapience signal processing has pulse-type grouping in both RF and PRI and allows the merging of emitters into one report without a library. The ES-3701 is capable of multi-path and reflection processing. The signal processor system can handle 1,000,000pps environments, and draws on a 20,000-emitter mode threat library capacity. It has multi-layer protection against interfering signals within the omni and DF channels. Fielded options include frequency extensions of 0.5-2 and 18-40GHz, a digital receiver-based parallel subsystem for higher sensitivity, increased ELINT functionality; and handling of FMCW radars. Applications: radar surveillance and precision monopulse DF system Frequency coverage: 2-18GHz; option of 0.5-2GHz and 18-40GHz extensions

## HENSOLDT SENSORS

### TRS-3D (AN/SPS-75)

The TRS-3D/AN/SPS-75 radar is a modular, countermeasure-resistant, medium-range air and surface surveillance system designed for the automatic detection, track initiation and tracking of all types of air and sea targets. With the latest signal processing technologies, it is suited for the detection of low-altitude and fast-moving objects and asymmetric threats under severe environmental conditions. More than 50 TRS-3D

The TRS-4D can be operated as a conventional rotating radar, and in addition the operator can exploit AESA-based capabilities such as cued track and search. (Image: Hensoldt)



radars have been sold to Denmark, Finland, Germany, Malaysia, Norway, Spain and the US. In November 2014, the TRS-3D radar was integrated on board the USS *Milwaukee Freedom*-class Littoral Combat Ship (LCS). By early 2015, eight TRS-3D radars had passed the USN's equipment acceptance tests for installation on board the *Freedom* class. The USS *Milwaukee* represents the third *Freedom*-class vessel to receive the TRS-3D integration following the USS *Freedom* and the USS *Fort Worth*. In USN service, the TRS-3D is designated as the AN/SPS-75. The first eight ships of the class will have the TRS-3D installed, while the remaining four ships of the class, from the USS *Indianapolis* onwards, will receive the TRS-4D. Applications: medium-range air and surface surveillance system Frequency: S-band

### TRS-4D

The TRS-4D C-band AESA multi-function air/surface radar is designed for dangerous, target-dense, blue waters and littoral environments. The TRS-4D is based on GaN AESA technology along with multiple simultaneous beams. It can be operated as a conventional rotating radar, and in addition the operator can exploit AESA-based capabilities such as cued track and search. The number of conventional modes is limited to two, surveillance and self-defence. Three power transmission levels are available: full power 360° (default); reduced power in several user-definable sectors; and several user-definable silence sectors. To concurrently exploit anti-air and its ASuW and asymmetric capabilities, TRS-4D processes several channels in parallel: a high-resolution sea surface channel down to a minimum range of <100m, and an air channel for the detection and tracking of fast air targets, at up to 250km in range and 70° in elevation. TRS-4D has been sold in a non-rotating, four-antenna array version to the German Navy for the future frigate F125. The TRS-4D radar will also be installed on board the USN *Freedom*-class Littoral Combat Ship. The first eight ships in the 12-strong class are equipped with Hensoldt's TRS-3D radar, although installation of the TRS-4D will commence from the ninth ship in the class, the USS *Indianapolis*. It will then be installed on the remained three vessels. Applications: multifunction air/surface Frequency: C-band Antenna rotation rate: 15rpm, 30rpm

## IAI ELTA SYSTEMS

### ELM-2248 MF-STAR

The ELM-2248 Multifunction Surveillance Track and Guidance Radar (MF-STAR) is a solid-state active phased-array radar system. The radar system delivers a situation picture and weapons support under severe target/environmental conditions in the naval arena. The MF-STAR employs multi-beam and pulse-Doppler techniques, as well as robust ECCM to extract low-RCS targets from complex clutter and jamming environments. The MF-STAR antenna uses four active S-band arrays. The hardware architecture and technology enable system availability, low maintenance and low life-cycle cost, it is claimed. The MF-STAR incorporates a lightweight antenna that can be tailored to fit even relatively small ship sizes (corvette and above). The Israeli Navy's Sa'ar 5 corvettes are being fitted with the system. Applications: solid-state active phased-array radar Weight: 1,500kg per face, 900kg

below deck Range: 125km for high-altitude fighter aircraft, >25km for low-altitude missile

### ELM-2258 ALPHA

The ELM-2258 Advanced Lightweight Phased Array (ALPHA) naval radar is a multi-function solid-state active phased-array system for modern medium-sized combat ships. The ALPHA radar antenna consists of a lightweight, rotating/scanning, 3D active S-band array that is suited for installation on board ship classes such as corvettes, frigates and larger vessels. The system delivers a maritime theatre situation awareness picture and supports the ship's weapon systems under tough target/environmental conditions. The ELM-2258 ALPHA employs multi-beam and pulse-Doppler techniques, as well as ECCM to extract fast, low-RCS targets in clutter and jamming environments. The hardware architecture and technologies enable system availability and low life-cycle cost, it is claimed. On 15 May 2017, IAI announced that the ELM-2258 radar had been installed on the Israeli Navy's Saar 4.5 missile ship and has proceeded to operational sea trials. Applications: multi-function solid-state active phased-array system Weight: 700kg on mast, 500kg below deck Range: >120km high-altitude fighter aircraft, >25km low-altitude missile

### INDRA SISTEMAS

#### Aries-S

The Aries-S submarine radar is part of Indra's Aries family of radars, providing a surveillance and navigation solution for submarines. According to Indra, its low transmission power makes it 'virtually undetectable' by tactical ESM systems. Features include LPI, designed to operate as a 'silent' radar, a solid-state transmitter, target tracking and trajectory estimations and a high-resolution solution. The radar also uses a compact antenna with low RCS and is easy to install. Aries-S operates in X-band, with frequency hopping. Operational modes of the system include: surface surveillance, air surveillance and air moving target indicator. Frequency: X-band

#### Lanza-N

The Lanza-N is a long range naval radar, part of the Lanza Family of 3D radar systems. The Lanza-N operates in an L-band frequency and has a range of under 334km. The radar is IFF/SIF integrated and also uses soft fail technology and solid-state transmitters. The system is fitted to the Spanish Navy's *Juan Carlos I* amphibious assault ship. Frequency: L-band Range: 334km Coverage azimuth: 360°

#### Skyfender AMSR

The SkyFender AMSR is an all-weather pulse-Doppler radar that operates in the X-band. It is able to provide air and maritime target detection and tracking capabilities allowing for situation awareness and a timely response to air and seaborne threats in naval shipborne scenarios during all weather, night and day conditions. SkyFender AMSR provides air and sea operational capabilities for a range of applications including surface surveillance, air surveillance, helicopter control and navigation support. Applications: surface surveillance, air surveillance, helicopter control, navigation support Frequency: X-band

### KELVIN HUGHES

#### SharpEye

The SharpEye radar is available in S-band and X-band configurations. In the former, the radar has a peak output power of 200W, and an average output power of 20W. According to Kelvin Hughes, SharpEye has a solid-state design, is reliable and has a low-noise design. Its pulse sequence and compression techniques allow radar targets/contacts out at sea to be detected and tracked typically earlier and at longer ranges than comparable systems, it is claimed. Up to 32 filters provide clutter discrimination, and the radar has frequency diversity. The X-band version has similar performance characteristics, although its average RF power is 39W. On 1 February 2016, Kelvin Hughes announced that SharpEye was successfully installed on four Damen Stan Patrol 5009 vessels commissioned by the Trinidad and Tobago Defence Force. The radar was selected due to its target detection capability, especially in poor weather conditions such as heavy rain and high sea states. In that same month, Lockheed Martin was awarded a £44 million contract to install SharpEye systems onto 60 UK RN ships. On 14 February 2017, Kelvin Hughes was contracted by Boustead Naval Shipyard (via its in-country representative D'Aquarian Services) to supply a pair of type-approved, upmast I-band (X-band) and E/F-band (S-band) SharpEye Doppler radars for each new ship in the Royal Malaysian Navy's Second Generation Patrol Vessel programme. On 21 February 2017, Kelvin Hughes announced that it has been contracted to supply the I-band SharpEye submarine radar system as part of a mid-life upgrade program for the Pakistan Navy's Agosta 90B-class submarines (also known as the *Khalid* class). The company will be working with Turkish company STM, the main contractor for the refurbishment programme, and is expected to supply the SharpEye system to the first submarine in 2018. On 4 April 2017, Kelvin Hughes announced that its SharpEye downmast submarine navigation radar will be used in support of the Royal Canadian Navy's sustainment programme. Two of the navy's *Victoria*-class long-range patrol submarines, currently equipped with Kelvin Hughes 1007 radar, are to be upgraded with SharpEye. On 23 October 2017, Kelvin Hughes announced that it will supply Hyundai Heavy Industries (HHI) with two SharpEye navigation radars and multifunction bridge radar displays for the Philippine Navy's Frigate Acquisition Project. The following month the company received an order to supply the SharpEye radar system for the second submarine in the Pakistan Navy's Agosta 90B class mid-life upgrade programme. Working with Turkish defence contractor STM, the main contractor for the refurbishment programme, Kelvin Hughes will supply the SharpEye system in 2019. Applications: naval surveillance, coastal surveillance Frequency: S-band, X-band Range: 89km

### LEONARDO LAND & NAVAL DEFENCE ELECTRONICS

#### EMPAR

The European Multifunction Phased Array Radar (EMPAR) operates in the C-band, performing concurrently 3D detection, multiple target tracking and missile guidance. Fitted on board medium and large vessels, playing the role of main ship sensor, it can be integrated within

combat and missile systems, supporting self-defence, local area defence, medium-range defence, long-range defence and detecting high-diving and sea-skimming missiles, aircraft and helicopters, large vessels and fast patrol boats. EMPAR is a rotating phased-array antenna radar that uses a single pencil beam in transmission and multiple beams in reception. Each beam can be steered within a wide angular sector along any bearing and elevation direction with respect to the antenna broadside, resulting in whole-hemisphere coverage. It adapts its operation mode, selecting transmitted frequency waveforms, signal and data processing in real time. Its multi-function capabilities are: full volumetric search coverage; low-altitude and surface search; and multiple target tracking uplink transmission for missile guidance. In service with the Algerian, French and Italian navies. Applications: multi-function radar Frequency: C-band Range: 480km

### Kronos Naval

Kronos Naval is a multi-functional radar family based on AESA technology. Kronos can simultaneously perform a range of functions, including air and surface surveillance, threat evaluation and tracking, missile guidance, ECM and firing. The Kronos family is designed to provide maximum operational flexibility due to an enhanced modular architecture. In order to fit a wide range of requirements, Kronos can be realised in different configurations by changing the radar size and the number of radiating elements. The Kronos radar is available in both naval and land versions. Applications: multi-functional AESA radar family Frequency: C-Band Range: 250km instrumented range, 140km large aircraft, 80km fighter aircraft, 40km helicopter Antenna rotation rate: 60rpm

### NA25X

The NA25X is a radar/EO FCS capable of controlling medium-calibre guns in the anti-aircraft and anti-surface roles, as well as small-calibre guns in the close-in weapon system role. Up to three guns of different calibres can be controlled at the same time. It features a tracking radar and J-band fully coherent equipment, which is characterised by anti-nodding, ECCM and anti-clutter features together with high tracking accuracy. A set of two EO sensors (TV/IR camera) can be fitted on the radar director to enable firing assessment and to provide an alternative LOS to the same target. A third sensor (LRF) can be added to provide a complete EO tracker. NA25X can be equipped with a dedicated twin-monitor multi-functional console or controlled by a combat management system console. Through an additional internal function, the NA25X can be integrated inside an artillery system (including at least two FCS) in order to optimise the use of all onboard guns against multiple concurrent targets (missiles, air and surface). Applications: radar/EO FCS Frequency: X-band Height: 1.4m antenna Weight: 490kg antenna

### RAN-30X/I

The RAN-30X/I is a 2D air/surface surveillance radar in the X-band. RAN-30X/I plays four different roles: air/surface surveillance; navigation support and helicopter control; OTH detection; and anti-sea-skimming missile detection. Each mode has been designed with a set of transmitting waveforms. The antenna is mechanically stabilised in roll and pitch. The reflector

antenna has two different beams and polarisation methods (linear and circular) used to cope with the different applications. Fixed and adaptive MTI filters allow updating of clutter maps and optimising of performance in poor environmental conditions. In service on Italy's Commandante-class patrol ships and Italian and French *Horizon*-class frigates. Applications: 2D air/surface surveillance radar Frequency: X-band Height: 2.3m antenna and platform Weight: 600kg antenna and platform

### RAN-40L

Leonardo's RAN-40L (also known as the SPS-798) is a 3D L-band naval surveillance radar. Capable of detecting aircraft at a range of 400km, it can use both short- and long-range waveforms, the former of which can be used for clutter suppression from natural phenomena, and the latter allows the radar to perform in conditions of intensive ECM jamming. Rotating at between 6 and 12rpm, the radar also has frequency agility and sidelobe blanking to enhance its resistance to jamming. The system has been installed on the Indian Navy's *Vikrant* aircraft carrier. Applications: 3D surveillance radar Frequency: L-band Range: 400km, 1,000km Antenna rotation rate: 6rpm, 12rpm Coverage azimuth: 360°

## LOCKHEED MARTIN

### Aegis Weapon System

Aegis is an integrated missile guidance system used on USN and allied ships to perform anti-air and ballistic missile defence missions. The S-band phased-array SPY-1 D(V) radar acquires and tracks multiple targets, handing off to the missile control station via the MK99 FCS. The SPY-1 D(V) is a transmitter that supports search, track and missile guidance functions, illuminating targets to be destroyed as commanded by the FCS. The initial design work on the Aegis system began in the 1960s and the first SPY-1 transmitter was delivered in 1981. Since then, the technology has been continually enhanced. Aegis SPY-1 transmitters and MK99 FCS are on all USN *Ticonderoga*-class cruisers and *Arleigh Burke*-class destroyers, along with Japanese *Kongo*-class destroyers, Spanish F100-class frigates, Korean *King Sejong the Great*-class destroyers and Australian *Hobart*-class destroyers. Some 110 ships have been fitted with the system. Aegis is the primary naval weapon system for Japan's four *Kong*-class destroyers and the two newer *Atago*-class, and for two European frigate programmes - the Spanish Navy's F-100 *Álvaro de Bazán* class and the Norwegian Navy's *Fridtjof Nansen* class. South Korea is building Aegis variants of its KDX destroyers. The system is capable of countering threats to a naval battle group as well as striking inland targets. Aegis Weapon System capabilities are on more than 65 USN cruisers and destroyers. Plans are under way to install the system on an additional 22 USN destroyers. Australia is acquiring three Aegis-equipped *Hobart*-class air warfare destroyers based on the *Álvaro de Bazán* and it was announced in March 2016 that evaluation of the system on the first of class has begun. It was announced in November 2016 that the company had been awarded a \$77 million modification to a previously awarded contract to exercise options for Aegis Combat System engineering agent efforts with work expected to be completed before the end of

2017. Between 24 September and 17 October 2017, the Aegis Combat System successfully completed a series of air and missile defence tests during the *Formidable Shield* NATO exercise.

## MDA – MACDONALD, DETTWILER AND ASSOCIATES

### MDA BlueHawk

MDA developed BlueHawk, a multi-sensor, unclassified maritime domain awareness solution that provides navies, coast guards, environmental and regulatory agencies with near real-time access to broad-area maritime surveillance across EEZs and global areas of interest. Fusing SAR and optical satellite imagery, AIS data, vessel registries and other maritime information, MDA BlueHawk provides critical information and tools to detect, track, and respond to security and environmental threats. It detects non-reporting 'dark' vessels in various weather and lighting conditions, including observed vessel size and heading information. It provides coverage of open ocean and coastal environments to automatically generate alerts of suspicious vessel behaviour, delivers vessel registry data and displays historical and predicted vessel tracks. MDA BlueHawk can ingest unclassified data and fuse it into meaningful information, reducing costs and enabling inter-agency sharing, it is claimed. It is available as an online web-based service, a full system implementation, or as a direct data feed into existing customer systems. Applications: fused multi-sensor system Coverage: 250,000km<sup>2</sup>

## NORTHROP GRUMMAN

### AN/SPQ-9B

The AN/SPQ-9B TWS radar is used with the MK86 and MK160 gunfire control systems. It detects sea-skimming missiles on the horizon, including in heavy clutter, and simultaneously detects and tracks surface and air targets. Also interfaces with the SPY-1 radar. Equipped ships include US *Ticonderoga*-class cruisers, LHD-1 amphibious ships, LPD-17 *San Antonio*-class amphibious ships, *California*-class cruisers, *Virginia*-class cruisers, and USCG National Security Cutters. It is planned for installation on DDG-51 destroyers. In 2013, Northrop Grumman was contracted to install the AN/SPQ-9B system onto *Ticonderoga*-class cruisers. The company has installed, or been contracted to install, more than 53 systems. Applications: multi-purpose surface search and fire control Frequency: 8-12GHz

## RADA ELECTRONIC INDUSTRIES

### pMHR

The pMHR (Portable Multi-Mission Hemispheric Radar) is the smallest in the family of MHR's manufactured by Israeli company RADA and provides hostile fire location as part of the RPS-40/41 system, all-threat air surveillance (RPS-42), and 3D perimeter surveillance (RHS-44). It can detect all types of aerial vehicles (including UAVs of all groups), missiles, rockets and mortars. The radar can operate as fixed or deployable/manoeuvrable on tactical land vehicles, littoral or shipborne (combat and patrol ships). Applications: fire location and target detection and tracking Frequency:

S-band Width: 50.4cm Height: 16.5cm Power: 350W Weight: 20kg Detection range: light/medium mortar and short-range rocket 5km, heavy mortar 6km, direct attack rocket/missile 6.5km, RPG max firing range, pedestrian 10km, light transport aircraft 25km, vehicles and medium-sized vessels 20km, large vessels 40km MTBF: 15,500h

## RAYTHEON

### AN/SPY-6 AMDR

Raytheon's Air and Missile Defence Radar (AMDR), now officially designated as AN/SPY-6, is being purchased by the USN to equip the three new Arleigh Burke-class destroyers that the service is procuring under its Flight III initiative. Testing is being performed at the USN's Pacific Missile Range Facility in Kauai, Hawaii. The company expects to complete testing by the middle of 2017. Raytheon is due to commence low-rate initial production with installation on the first Flight III ship occurring in 2019, with deliveries then following at a rate of two per year for the duration of the AMDR programme, with IOC in 2023. Designed as a scalable radar to equip a range of vessel sizes from corvettes up to frigates and cruisers, the AMDR's architecture uses gallium nitride T/R modules equipping its AESA arrays. The AMDR is an S-band (2.3-2.5/2.7-3.7GHz) radar which is intended to supersede the existing Lockheed Martin AN/SPY-1D naval surveillance radars, which are deployed on board existing *Arleigh Burke*-class vessels. Applications: 3D AESA air and missile defence radar Frequency: S-band

### DBR

The Dual Band Radar (DBR) phased-array system works in both X- and S-bands simultaneously, coordinated by a resource manager. The system performs multiple functions automatically and simultaneously, detecting and tracking high- and low-altitude anti-ship cruise missiles. It combines the functionality of the X-band AN/SPY-3 multi-function radar and the S-band Volume Search Radar (VSR). The X-band system generates narrow beams and wide frequency bandwidth, providing coverage and discrimination of low-altitude targets, along with illumination and uplink/downlink capabilities for SM-2 and Evolved Sea Sparrow missiles. The S-band VSR is designed for all-weather search capabilities with a high-powered aperture and narrow beam width that enables it to resolve and track targets. The X-band SPY-3 array is 272x208x64cm, weighing 2,500kg. The S-band VSR array is 406x132x76cm, weighing 10,200kg. It is being installed on the first of class *Gerald R Ford* aircraft carriers but is not expected to be used for the rest of the class. Applications: phased-array X/S-band system Weight: 10,200kg S-band VSR array, 2,500kg X-band SPY-3 array

## RHEINMETALL

### TMX/EO

Three-axis tracking module equipped with X-band radar and TV camera, IR camera and LRF, for precision measurement of aerial, naval and land-based targets for guns and missiles in the Seaguard family of ship defence systems. CW signal-in-beam injection for target illumination is optional. The system has been ordered for Malaysia's Second Generation Patrol Vessel Littoral

Combat Ships (SGPV LCS). Applications: 3-axis tracking module equipped with X-band radar and TV camera. IR camera and LRF Frequency: 8.6-9.5GHz Range: 0.3-80km

## RHEINMETALL AIR DEFENCE

### Oerlikon Seaguard Biax

The Oerlikon Seaguard Biax is a naval tracking system. Derived from the three-axis Oerlikon Seaguard Triax, it is a two-axis multi-purpose tracker suitable for all-weather use. Both use radar to counter above-water symmetric and asymmetric threats including anti-ship missiles. The Biax is fitted with a naval TV camera and can integrate additional EO sensors such as an IR camera. A video tracking module is also included. It is able to carry out an active search function as a complement or substitute for search radar. The function offers 360° search or sector scan with selectable rates and boundaries in azimuth and elevation. This provides redundancy for smaller ships or vessels operating as escort for battle groups. Applications: naval tracking system, X- or Ku-band (NATO I/J) Weight: 750kg (2-axis tracker mount) Range: 45km (autonomous search)

## RRS - REUTECH RADAR SYSTEMS

### RSR 210N

The RSR 210N is a lightweight X-band 2D naval air/sea surveillance radar designed for application on smaller naval and coastguard vessels. This radar, which provides coverage to beyond 100km, may be supplied with a dedicated console or interfaced to a combat management system. While it is suited to helicopter support operations aboard ship, it can also be used for general surveillance and in a gunfire support role. In 2010, it was announced that the system had been installed on Royal Norwegian Navy frigate KNM *Otto Sverdrup* and it is in service on South African Navy vessels. Applications: lightweight 2D naval air/sea surveillance radar Frequency: X-band Range: 100km

### RTS 3200 FORT

FORT (FMCW Optronics Radar Tracker) is a lightweight optronics radar tracker. It operates in X-band, is instrumented to 40km and provides the operator with an all-weather target engagement capability. The product is designed for application aboard smaller naval vessels which would normally only employ EO trackers. Applications: X-band lightweight optronics radar tracker Range: 40km

## SAAB

### Sea Giraffe 4A

Sea Giraffe 4A is a medium/long-range AESA surveillance radar, combining designs from the (Sea) Giraffe AMB and Arthur product families with a new radar sensor. It was unveiled in January 2016. It can scan a search volume of up to 70° at 60rpm and provides a 3D target update rate, along with high-altitude coverage and monopulse accuracy. The radar simultaneously detects small fast-moving targets at all altitudes and in clutter. Features: integrated logistics support; target indication to weapon systems for anti-air and anti-surface engagements; 360° mortar/rocket alert and weapon location; target designation for long-range SAMs Frequency: S-band (E/F) Range: 280km Altitude

coverage: >70° (elevation coverage) Antenna rotation rate: 30 or 60rpm

### Sea Giraffe AMB

Sea Giraffe AMB is a 3D multipurpose medium-range surveillance radar with the ability to simultaneously track air and surface targets, with an optional mortar and rocket detection (C-RAM) capability. Sea Giraffe AMB has the designation AN/SPS-77V(1) for installation on the USN's Littoral Combat Ship (LCS-2/4) and AN/SPS-77V(2) for LCS-6 and higher. It permits instantaneous and simultaneous 0-70° coverage on all antenna revolutions and has a DDS interface for CMS integration. Its functions include: air surveillance and tracking, including tracking-on-jam; surface surveillance and tracking; 360° mortar/rocket alert and weapon location; target classification of moving and hovering helicopters; navigation/close combat capabilities; and target indication to weapon systems for anti-air and anti-surface engagement gunfire support, including high-resolution splash spotting. On 3 October 2017, it was announced that Saab will supply Sea Giraffe to the USCG under a contract with the USN. The contract is worth \$16.8 million, covering the procurement of two systems with options for additional radars. The radar will be installed on the coast guard's new Offshore Patrol Cutters. On 23 November 2017, Saab announced that the company had received an additional order from General Dynamics for delivery of its Sea Giraffe AMB for the *Independence*-class LCS-28 and LCS-30. Applications: medium-range surveillance Range: 180km Turn rate: 60rpm

## SOLUSI247

### Indera MX-3AH

The Indera MX-3AH is an X-band naval radar system featuring solid-state FMCW technology with low transmit power, frequency agility and LPI. Its hardware and signal processing techniques lead to greater capability in detection of surface targets, it is claimed. Indera MX-3AH is equipped with Maritime Tracking Aid software enabling it to function as an onboard navigation system on its own. Applications: naval radar system Frequency: X-band Length: 1.7m Width: 0.6m Height: 1m Weight: 160kg Antenna rotation rate: 20rpm

## TERMA

### Scanter 6000

The Scanter 6000 is designed to detect surface and aerial threats and particularly track small targets at close ranges. It can also monitor low-level airspace around a vessel. For SAR operations, it has the capability to detect small surface targets in combination with helicopter control. Operable in all weather conditions, the system uses low-voltage solid-state power amplifier technology. Programmable frequencies within 9.0-9.5GHz. Terma will supply Scanter 6000 radars to the Indonesian Coast Guard under an order announced in October 2016. On 24 October 2017, Terma announced that the Scanter 6002 radar system had been selected for the Royal Canadian Navy's (RCN) Arctic and Offshore Patrol Ships (AOPS) programme. Terma will provide the radar system to Lockheed Martin Canada, which was selected by Irving Shipbuilding to provide its combat management system, CMS 330, for the RCN's new fleet of AOPS currently under construction at the Halifax

Shipyard. Applications: surface and aerial target radar  
Frequency: 9.0-9.5GHz

## THALES

### Arabel

Arabel is a multi-function FCR capable of detecting, tracking and engaging multiple targets, including jet aircraft, cruise missiles and tactical ballistic missiles and can track 100 and engage ten simultaneously. It includes a data link to send target position updates to Aster 30 missiles until their own active radar seeker takes over. The phased-array antenna rotates at 60rpm, and the system performs electronic scanning with large deflection (+/-45° in elevation and bearing), narrow beam and a low sidelobe level. The transmitter is frequency-agile and varies pulse width. Receiver uses Doppler, pulse compression, monopulse tracking. It is in service on France's *Charles de Gaulle* aircraft carrier and the Royal Saudi Navy's *Sawari 2* frigates. Applications: multi-function FCR Frequency: 8-10GHz (I/J-band) Power: 150W Range: 50km (missile, 0.5m<sup>2</sup> RCS), 100km (jet fighter)

### Castor family

The Castor radar family includes several products. This X-band radar is designed to perform fire control. It has a beamwidth of 2° and a peak power of 200kW. The Castor-1 (also known as the TRS-3200) has a range of around 30km, transmitting up to 8,000pps from its magnetron transmitter. The Castor-2/TRS-3201 can transmit up to 7,200pps using a 30kW coherent TWT transmitter. The Castor-2C/TRS-3204 (known in French Navy service as the DRBC-33A) has a computer-controlled TWT and has frequency agility across up to 700MHz, with the ability to acquire a fighter-sized target at 25km and an anti-ship missile at 30km. This radar has slightly improved sea clutter rejection than the Castor-2/TRS-3201 (35dB versus 30dB for the latter). Meanwhile, the Castor-III (also known as the CTM) uses a Ku-band radar combined with an IR camera. Applications: surveillance and fire control Frequency: X-band Range: 30km

### Herakles

Thales' Herakles radar provides 3D imagery for surveillance and fire control. The S-band radar has an integrated Mode-5/Mode-S compatible IFF interrogator. When performing air surveillance, it has a range of 250km and a range of 80km when performing surface surveillance. In terms of azimuth and elevation, the radar covers 360° and 70° respectively. The antenna revolves at 60rpm and the radar can track >400 targets. Applications: 3D surveillance and fire control radar Frequency: S-band Range: 250km air surveillance, 80km surface surveillance Altitude coverage: 70° in elevation Coverage azimuth: 360°

### IM400

The Integrated Mast 400 (IM400) is an integrated naval sensor and communications suite packed into a mast structure. By resolving the electromagnetic conflicts and LoS obstructions inherent in traditional topside arrangements, it provides advantages in terms of operational performance and shipbuilding risk. Being built and tested in parallel with the construction of the ship, the IM400 solution will reduce risk and time for the entire programme. IM400 includes Sea Watcher 100 surface surveillance radar, Sea Master 400 air surveillance



The Scanter 6000 is designed to detect surface and aerial threats, and particularly track small targets at close ranges. (Photo: Terma)

radar, a Gatekeeper optronic surface surveillance system, ICAS integrated communications antenna system, and a non-rotating IFF system. IM400 is in operation with the Dutch Navy. Applications: integrated naval sensor and communications suite Frequency: 0.5-18GHz Weight: 52,000kg Range: 250km

### LIROD Mk 2

The LIROD Mk 2 is a K-band naval FCR. Using a travelling wave tube architecture, the radar is equipped with a TV camera for visual target identification. Offering a detection range of up to 36km, the LIROD Mk 2 has a beamwidth of 0.55° and 1.5°. The use of the K-band frequency provides higher levels of accuracy and the ability to discriminate small targets in conditions of high clutter, says the company. Applications: FCR Frequency: K-band Range: 36km

### MRR-3D

The MRR-3D radar family includes the MRR-3D and the MRR-3DNG. The C-band architecture of the MRR-3D family can perform 2D and 3D surveillance. Although the antenna rotates, it uses an AESA configuration which provides up to 70° of elevation coverage. Along with providing general surveillance, the radar can perform fire control and air traffic management tasks. MRR-3D radars have a surveillance range in the region of 180km. Applications: 3D surveillance and fire control Frequency: C-band Range: 180km, 125km fighter aircraft, 40km small target Antenna rotation rate: 10rpm, 30rpm

### Pollux

The X-Band Pollux FCR family includes the THD-1280 and TRS-3220 systems. The radar has a peak output power of 200kW and a beamwidth of 2°. With a pulse width of 0.3µs, the radar has a PRF of 1,500pps. The radar has an instrumented range of 9km for a small aircraft. Applications: FCR Frequency: X-band Power: 200kW Range: 9km for a small aircraft

### Sea Fire 500

The Sea Fire is a naval surveillance radar developed by Thales unveiled in 2014. This S-band radar is designed to outfit vessels displacing between 3,500 and 7,000t. To this end, it can be scaled up or down according to the vessel size, with the only element of the radar which

needs to be changed being the antenna. The radar's back end remains the same regardless of vessel size. Equipped with an AESA antenna, the radar uses gallium arsenide T/R modules. It provides 360° azimuth coverage using four flat AESA panels and has an instrumented range of 400km. Thales expects production of the radar to commence in 2019, with deliveries following in 2020. The company adds that it expects the radar to be upgraded in the future using a software-only approach. Applications: multi-function fixed radar Frequency: S-band Range: 400km Coverage azimuth: 360°

### Sea Master 400

The Sea Master-400 (also known as SMILE) is an E/F-band naval surveillance radar which uses much of the architecture from Thales' APAR and SMART-L/S families. The radar can perform air and surface surveillance, fire control and air traffic management. Using fixed as opposed to rotating antennas, the radar can cover between 0 and 70° of elevation using stacked beams on each antenna, and also cover up to 120° in azimuth with three antennas, providing 360° of azimuth coverage. The radar has a range in the region of 250km. Applications: surveillance and fire control Frequency: E/F-band Range: 250km instrumented, 70km for surface targets

### Sea Watcher 100

The Sea Watcher 100 (also known as the Sea Star) is an X-band radar which uses fixed-panel antennas. Offering a range of up to 40km, this 2D radar uses active phased-array architecture and can update every two seconds for short- and medium-range surveillance, and every five second for longer-range target detection. The radar alters its waveforms accordingly regarding whether it is performing short-, medium- or long-range surveillance, although all three modes are displayed to the operator simultaneously. The Sea Watcher 100 is offered as an integral part of Thales' I-Mast integrated mast product. Applications: 2D surveillance and fire control Frequency: X-band Range: 40km

### Sting EO Mk 2

Sting EO Mk 2 is a short-medium-range, lightweight dual-band (I and K) weapon control system, primarily for gun control. It combines a 1.2m radar director with TV, IR and laser sensors, allowing optronic tracking and an automatic 'best sensor' selection process. The three data sources provide redundancy, performance and ECCM resistance, says the company. A shell-measuring feature is incorporated to support facilities such as pre-action calibration and miss distance indication. Applications: short-medium-range, lightweight dual-band weapon control system Range: 120km I-band, 36km K-band

### Variant

Variant is a 2D C/X-band naval surveillance and fire control radar. Providing a horizontal beamwidth of 1.8° and a vertical beamwidth of 14° it has a detection range of 30km in the C-band and 28km in the X-band. The use of two frequency ranges is intended to make the radar less susceptible to ECM. The radar has a selectable pulse width of 4.5, 12.8 or 16µs and a PRF of between 3 and 9KHz. Variant runs at between 14 and 28rpm and has a peak output power of 200W. Applications: 2D naval surveillance and FCR Frequency: C and X-band Range: 120km air targets, 70km surface targets Antenna rotation rate: 14 and 28rpm

### WM20 Series

The WM20 is a family of gun and missile radars which includes the WM20, WM22, WM25, WM27, WM28 and the Mk92. The system can be used as a multi-channel FCR to accompany a ship's gun, missile or torpedo systems. All of the WM20-series radars can provide air and surface search, navigation and fire control, however, the WM24 has an additional anti-surface role, while the WM26 is designed for surface target engagement. Applications: family of gun and missile radars Frequency: X-band

## THALES NETHERLANDS

### APAR

APAR is operational on the four *De Zeven Provinciën*-class vessels of the Royal Netherlands Navy, the three Sachsen-class ships of the German Navy and the three *Iver Huitfeldt* ships of the Danish Navy. The Active Phased Array Multifunction (APAR) radar is an X-band naval surveillance and FCS. The radar provides 360° azimuth scanning and a range of circa 150km, with an 8.5° angle of elevation coverage. In order to achieve 360° azimuth scanning, four antennas are installed on a vessel, each of which provides 90° of coverage. Resolution Doppler processing aids coverage in high clutter conditions. When performing fire control, the radar can handle simultaneous firings of different SAMs. Applications: surveillance and FCR Frequency: X-band Weight: 10,000kg Range: 150km active tracking

### NS100

The NS100 is a 3D E/F-band naval surveillance radar. It uses an AESA antenna and has an instrumented range of circa 200km, with up to 70° elevation. It has an integral IFF interrogator compatible with Mode-5/S NATO and ICAO protocols. It was announced in August 2015 that factory acceptance tests had been completed for installation on the Republic of Singapore Navy's first-of-class LMV RSS *Independence* and sea trials began in late 2015. All seven ships in the class will be fitted with NS100. The NS100 is to equip the Royal Netherlands Navy's HNLMS *Rotterdam* amphibious support ship with installation being completed by 2017. It will replace the Thales DA08 radar currently used on board this vessel. Applications: 3D naval surveillance radar Frequency: E/F-band Width: 3m Height: 3m Range: 200km

### SMART-L

The SMART-L naval surveillance radar is a 3D system transmitting in the D-band. Capable of detecting targets at a range of up to 400km, the radar also offers up to 70° of elevation. Variants of the SMART-L include the SMART-L EWC, which is a specific modification for the *De Zeven Provinciën*-class frigates of the Royal Netherlands Navy to provide them with a ballistic missile detection capability. This increases the radar's range to 1,000km. In British, French and Italian service, the SMART-L is designated S1850M. Applications: 3D surveillance and fire control Frequency: D-band Weight: 7,200kg Range: 60km surface targets, 400km air targets, 2,000km ballistic missile defence

### SMART-S Mk 2

The SMART-S Mk 2 S-band 3D air and surface search radar has a maximum instrumented range of 250km.

with the ability to detect missiles at 50km and large aircraft at 200km. Up to 500 air and surface targets can be tracked simultaneously, and the radar has an integral IFF system. Each beam is 2° in width, with the radar capable of detecting targets at 0-70° of elevation. When performing general surveillance, the radar rotates at 13.5rpm, increasing to 27rpm when it is defending the ship against incoming threats. The system is installed on Canadian Halifax-class frigates and New Zealand ANZAC-class frigates as well as Algerian C28A-class corvettes.

### STIR Family

The STIR family of tracking and illumination radars includes the STIR 2.4, STIR 1.8, STIR 1.8HP, STIR 1.2, SPG-501 and SPG-503 systems. These radars were designed to detect anti-ship missiles and the principle discriminating factors between each member of the STIR family is the radar's dish size and transmission power. Transmitting in the X- and K-bands, such

high frequency ranges are suitable for the detection of small targets. When transmitting, the STIR family provides continuous wave illumination. More than 150 units are in service in 11 navies and six of these are NATO countries. Applications: family of tracking and illumination radars Frequency: X- and K-bands Height: STIR 1.2 2.3m Weight: STIR 1.2 850kg above deck, 510kg below deck Range: STIR 1.2 120km I-band, 36km K-band: STIR 2.4 512km

### Surface Scout

Surface Scout is an X-band medium-range surveillance radar with a range of up to 44km. It covers 20° of elevation and has a beamwidth of below 1.2°. It can automatically detect and track up to 500 targets. Surface Scout uses frequency modulated continuous wave architecture which reduces its output power. Applications: medium-range surveillance radar Frequency: X-Band Range: 44km Minimum range: 15km

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## EQUIPMENT

### SPACE-BASED SYSTEMS

This section contains basic data on a selection of radar payloads used in satellite constellations for Earth observation, imaging and intelligence-gathering.

The equipment is listed alphabetically by manufacturer.

If you think your product should be listed, please contact the team at [reference@shephardmedia.com](mailto:reference@shephardmedia.com) to ensure it appears in the Shephard Plus online database ([shephardplus.com](http://shephardplus.com)) and is included in the next print edition.

ABOVE: A Geostationary Operational Environmental Satellite image of Hurricanes Jose in the Atlantic Ocean and Maria in the Caribbean Sea from 18 September 2017. (Image: USN)

## AIRBUS DEFENSE & SPACE

### TerraSAR-X/TanDEM-X

TerraSAR-X and the more advanced TanDEM-X (TerraSAR-X add-on for Digital Elevation Measurement) are designed to operate closely together to generate an accurate 3D image of Earth that is homogeneous in quality and accurate. TerraSAR-X began operating in 2007 and TanDEM-X in 2010. The mission will survey all 150 million square kilometres of Earth's land surface several times. Apart from its measuring-point density (a 12m grid) and vertical accuracy (better than 2m), the elevation model generated will be homogeneous and serve as a basis for maps that are globally consistent. It was announced in October 2016 that a 3D map of the world had been completed. Applications: 3D mapping Weight: 1,330kg Orbit altitude: 514km Orbit inclination: 97.4° Nominal mission life: 5.5 years

## IAI MBT DIVISION

### TecSAR

TecSAR (Synthetic Aperture Radar Technology Demonstrator) is designed for LEO IMINT and carries an X-band radar payload with multi-beam electronic steering. It is also designated ELM-2070 and can operate in a range of modes including spot, scan, strip, mosaic, and multi-look, with an option for multi-polarisation. The ground-image exploitation segment has a number of automatic modes including target, cluster and change detection. Applications: LEO IMINT Weight: 300kg plus 100kg payload

## INDIAN SPACE RESEARCH ORGANISATION

### NISAR

The NASA-ISRO Synthetic Aperture Radar (NISAR) is a joint programme between NASA and the Indian Space Research Organisation (ISRO) to build and launch an observation satellite fitted with both L-band and S-band polarimetric SAR payloads. It is designed to observe and take measurements of Earth activity including ecosystem disturbances, ice-sheet collapse and natural disasters such as earthquakes, tsunamis, volcanoes and landslides. Data collected from NISAR will reveal information about the evolution and state of Earth's crust, help scientists better understand the planet's processes and changing climate and aid future resource and hazard management. Mission concept review was passed in October 2013 and launch is expected in 2020/21. Applications: geological observation Orbit altitude: 747km Orbit inclination: 98° Nominal mission life: 3 years Sensors: L-band and S-band polarimetric SAR

### RISAT-1

Radar Satellite-1 (RISAT-1) is a microwave remote sensing satellite carrying a SAR payload operating in C-band (5.35GHz), which enables imaging of surface features during both day and night under all weather conditions. These characteristics of C-band SAR enable applications in agriculture, particularly paddy monitoring in monsoon season, and management of natural disasters like floods and cyclones. The satellite was launched in April 2017 on a PSLV-C19 rocket and has a

nominal life of five years. Weight: 1,858kg Orbit altitude: 536km Orbit inclination: 97.552° Orbit period: 95.49min Number of orbits per day: 14 days Repetitivity: 25 days Satellite type: circular polar sun synchronous Attitude and orbit control: 3-axis body stabilised using reaction wheels, magnetic torquers and hydrazine thrusters

## LOCKHEED MARTIN

### Lacrosse

The Lacrosse constellation consisted of five satellites, the first launched in 1998 and the last in 2005. The two earlier satellites are believed to be no longer in operation. The system is operated by the US National Reconnaissance Office. It is unclear if additional satellites have been launched to support the ageing constellation, but it is due to be replaced by the Future Imaging Architecture. The remaining satellites operate at altitudes between 670km and 710km. Applications: observation satellite Sensors: SAR Constellation used: Lacrosse

## MDA – MACDONALD, DETTWILER AND ASSOCIATES

### Radarsat-2

Owned and operated by MDA, Radarsat-2 was launched in late 2007 as a follow-on radar satellite to Canada's Radarsat-1. The satellite's resolution ranges from a wide-beam swath width of 500km, with resolution of 100m to 1m resolution in spotlight mode. The satellite operates at an altitude of 800km with more than 14 orbits per day. It is planned to operate with the Radarsat Constellation Mission, an evolution of the Radarsat programme, comprised of three satellites expected to launch in 2018. Radarsat-2 weighs about 2,200kg and has solar panels measuring 3.73x1.8m each. Applications: maritime and land surveillance, ice monitoring, disaster management, environmental monitoring, resource management Coverage: single Radarsat-2 satellite Satellite type: worldwide Sun-synchronous orbit Sensors: radar imaging Constellation used: SAR

## OHB SYSTEM

### SARah

SARah is the planned follow-on system for the SAR-Lupe radar satellite constellation operated by the German armed forces. In 2013, it was announced that OHB System had signed a contract for the development and integration of the SARah satellite-based radar reconnaissance system. The contract was valued at €816 million. OHB System developed and built Germany's SAR-Lupe system which comprised five satellites and a ground station. The system was delivered in 2008 and the contract expired in November 2017. To maintain Germany's reconnaissance capabilities in the future, planning for the SARah follow-up system is underway. SARah will have a different architecture to SAR-Lupe. It will have three satellites in the space segment and two ground stations. Two of the three satellites will be based on the reflector technology. It will be supplemented by a third satellite, which is a further development of the phased-array technology developed by Astrium. SARah is expected to be delivered and enter into full operation at the end of 2019. Applications: reconnaissance Power: solar cells Weight: 1,800kg

**SAR-Lupe**

Germany's Strategic Reconnaissance Command SAR-Lupe constellation consists of five orbiting satellites, with the first launched in December 2006 and the last in July 2008. The 770kg satellites operate from an altitude of 500km about 60° apart and use SAR to provide 24h capability in all weather conditions. Satellites can provide resolution of about 50cm in spotlight mode or 1m in strip-map mode. OHB signed a \$1 billion contract with Germany's BWB defence procurement agency in 2013 for development of the SAR satellite-based radar reconnaissance system, which will be the follow-on system and is scheduled to be operative in 2019. Applications: observation Connectivity: S-band Coverage: worldwide Sensors: SAR Constellation used: SAR-Lupe

**THALES ALENIA SPACE ITALIA****ESA Sentinel-1**

Sentinel-1 is a planned constellation of four satellites, with two already in orbit and two on order. They carry a payload of a C-band SAR and commissioned from Thales Alenia Space Italy by the European Space Agency. The first satellite, Sentinel-1A, was launched in April 2014 and Sentinel-1B in April 2016. The development contract for the second pair was signed in December 2015. Primary roles include monitoring land surface motion risks, monitoring sea ice zones and the Arctic environment, surveillance of marine environment,

mapping of land surfaces: forest, water and soil, and mapping in support of humanitarian aid in crisis situations. Four nominal operational modes designed for interoperability with other systems: strip map mode with 80km swath and 5x5m (range x azimuth) spatial resolution; interferometric wide-swath mode with 250km swath, 5x20m (range x azimuth) spatial resolution and burst synchronisation for interferometry; extra-wide-swath mode with 400km swath and 20x40m (range x azimuth) spatial resolution; and wave mode with 5x5m (range x azimuth) spatial resolution leapfrog sampled images of 20x20km at 100km along the orbit, with alternating 23° and 36.5° incidence angles. Weight: 2,300kg launch mass with 130kg of fuel Orbit altitude: 693km Orbit inclination: 98.18° Nominal mission life: 7 years

**COSMO-SkyMed**

COSMO-SkyMed (Constellation of small Satellites for the Mediterranean basin Observation) is a system of four medium-sized satellites fitted with SAR owned and operated by Italy's MoD and Ministry of Research. The satellites operate at an altitude of 620km and orbit the earth every 98 minutes. They can operate in strip-map, spotlight and scan synthetic aperture modes, with two specific sub-modes within each of these. The Italian government approved funding for two next-generation COSMO-SkyMED satellites in late 2014. Applications: observation Coverage: worldwide Satellite type: sun-synchronous Sensors: SAR Constellation used: COSMO-SkyMed

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## PRODUCTS

# GUIDE TO SUPPLIERS

This section lists key companies supplying goods, services and equipment to the military unmanned systems industry worldwide.

The section is separated into two listings, by product then by supplier.

Products are listed alphabetically with suppliers and their location under each.

Supplier listings from p78 are shown alphabetically and include:

- Company address
- Email and website addresses
- Telephone and fax numbers
- Contact names

Highlighted listings also include the company's logo and a summary of activity.

To update a listing or submit new information, email the team at [reference@shephardmedia.com](mailto:reference@shephardmedia.com).

**ABOVE:** Army personnel align a radar system while establishing a tactical operations center during *Saber Junction 17* at the Hohenfels Training Area, Germany, on 4 May 2017. (Photo: US Army)

PRODUCTS

**Airborne – AEW and fire control**

AVIC – Aviation Industry Corporation of China (CHINA)  
 BIRD Aerosystems (ISRAEL)  
 CEIEC – China National Electronics Import & Export (CHINA)  
 Cobham Advanced Electronic Solutions (USA)  
 IAI ELTA Systems (ISRAEL)  
 Leonardo Airborne & Space Systems (ITALY)  
 Lockheed Martin (USA)  
 MBDA (FRANCE)  
 Mitsubishi Electric (JAPAN)  
 Nanjing Research Institute of Electronics Technology (NRIET) (CHINA)  
 Northrop Grumman (USA)  
 Phazotron NIIR (RUSSIA)  
 Raytheon (USA)  
 Saab (SWEDEN)  
 TATA Advanced Systems (INDIA)  
 Thales (FRANCE)  
 TMD Technologies (UK)  
 V Tikhomirov NIIP (RUSSIA)  
 Vega Radio Engineering Corporation (RUSSIA)

**Airborne – surveillance and maritime patrol**

Aerodata (GERMANY)  
 Array Systems Computing (CANADA)  
 Aselsan (TURKEY)  
 Boeing Defense, Space & Security (USA)  
 Cobham Advanced Electronic Solutions (USA)  
 Communications & Power Industries (CPI) (USA)  
 Elta North America (USA)  
 General Atomics Aeronautical Systems (USA)  
 Harris Communication Systems (USA)  
 IACIT (BRAZIL)  
 IAI ELTA Systems (ISRAEL)  
 Leonardo (ITALY)  
 Leonardo Airborne & Space Systems (ITALY)  
 Leonardo DRS (USA)  
 Lockheed Martin (USA)  
 Northrop Grumman (USA)  
 Northrop Grumman Sperry Marine (USA)  
 Optimare (GERMANY)  
 Phazotron NIIR (RUSSIA)  
 PJSC Kiev Radar Plant (UKRAINE)

QinetiQ (UK)  
 RADA Electronic Industries (ISRAEL)  
 Raytheon (USA)  
 Raytheon Space & Airborne Systems (USA)  
 Saab (SWEDEN)  
 SRC (USA)  
 Telephonics (USA)  
 Thales (FRANCE)  
 Vega Radio Engineering Corporation (RUSSIA)

**Ground – battlefield and ground surveillance**

Advanced Defense Systems, Inc (ADS) (USA)  
 Aselsan (TURKEY)  
 BATS Belgian Advanced Technology Systems (BELGIUM)  
 Bharat Electronics (INDIA)  
 Blighter Surveillance Systems (UK)  
 Cobham Advanced Electronic Solutions (USA)  
 ECRIEE – East China Research Institute of Electronic Engineering (CHINA)  
 Elbit Systems (ISRAEL)  
 Elbit Systems EW & SIGINT – Elisra (ISRAEL)  
 Elettronica (ITALY)  
 Elta North America (USA)  
 Hensoldt Optronics GmbH (GERMANY)  
 Hensoldt Sensors (GERMANY)  
 IACIT (BRAZIL)  
 IAI ELTA Systems (ISRAEL)  
 Indra Sistemas (SPAIN)  
 Kelvin Hughes (UK)  
 Kintex (BULGARIA)  
 Leonardo DRS (USA)  
 LIG Nex1 (SOUTH KOREA)  
 Liteye Systems (USA)  
 Lockheed Martin (USA)  
 Poly Technologies (CHINA)  
 RADA Electronic Industries (ISRAEL)  
 Rockwell Collins (USA)  
 Rosoboronexport (RUSSIA)  
 Saab (SWEDEN)  
 SCRIEEE – Southwest China Research Institute of Electronic Equipment (CHINA)  
 SRC (USA)  
 Strela (RUSSIA)  
 TATA Advanced Systems (INDIA)  
 Telephonics (USA)  
 Terma (DENMARK)  
 Thales (FRANCE)  
 Thales Netherlands (NETHERLANDS)

**Ground – land-based air defence**

Almaz-Antey (RUSSIA)  
 Aselsan (TURKEY)  
 Avibras Indústria Aeroespacial (BRAZIL)  
 BAE Systems (UK)  
 BATS Belgian Advanced Technology Systems (BELGIUM)  
 Bharat Electronics (INDIA)  
 Cobham Advanced Electronic Solutions (USA)  
 CEIEC – China National Electronics Import & Export (CHINA)  
 China Aerospace Science and Industry Corporation (CASIC) (CHINA)  
 ECRIEE – East China Research Institute of Electronic Engineering (CHINA)  
 ERA (CZECH REPUBLIC)  
 FLIR Systems (USA)  
 Harris Electronic Systems (USA)  
 Hensoldt Sensors (GERMANY)  
 IAI ELTA Systems (ISRAEL)  
 Indra Sistemas (SPAIN)  
 KB Radar (BELARUS)  
 Kelvin Hughes (UK)  
 LEMZ (RUSSIA)  
 Leonardo Land & Naval Defence Electronics (ITALY)  
 LIG Nex1 (SOUTH KOREA)  
 Lockheed Martin (USA)  
 Mitsubishi Electric (JAPAN)  
 National Chung-Shan Institute of Science and Technology (TAIWAN)  
 Northrop Grumman (USA)  
 OKB TSP (BELARUS)  
 PIT-Radwar S.A (POLAND)  
 Poly Technologies (CHINA)  
 QinetiQ (UK)  
 QinetiQ North America (USA)  
 Rafael Advanced Defense Systems (ISRAEL)  
 Raytheon (USA)  
 RETIA (CZECH REPUBLIC)  
 Rheinmetall Air Defence (SWITZERLAND)  
 RRS – Reutech Radar Systems (SOUTH AFRICA)  
 RTI Systems (RUSSIA)  
 Saab (SWEDEN)  
 Siemens (USA)  
 SRC (USA)  
 Thales (FRANCE)  
 Thales Air Operations (FRANCE)  
 V Tikhomirov NIIP (RUSSIA)

**Maritime – coastal surveillance systems**

Advanced Defense Systems, Inc (ADS) (USA)

Aselsan (TURKEY)  
 BATS Belgian Advanced Technology Systems (BELGIUM)  
 Blighter Surveillance Systems (UK)  
 Cobham Advanced Electronic Solutions (USA)  
 CEIEC – China National Electronics Import & Export (CHINA)  
 Controp Precision Technologies (ISRAEL)  
 Diginext (FRANCE)  
 Easat Radar Systems (UK)  
 Elta North America (USA)  
 Furuno (JAPAN)  
 Gem Elettronica (ITALY)  
 Harris Communication Systems (USA)  
 Hensoldt Optronics GmbH (GERMANY)  
 Hensoldt Sensors (GERMANY)  
 IAI ELTA Systems (ISRAEL)  
 Indra Sistemas (SPAIN)  
 Kelvin Hughes (UK)  
 Leonardo UK (UK)  
 Lockheed Martin (USA)  
 Marlan Maritime Technologies (UK)  
 Norinco (CHINA)  
 Plath GmbH (GERMANY)  
 Saab (SWEDEN)  
 SCRIEEE – Southwest China Research Institute of Electronic Equipment (CHINA)  
 Synetics (UK)  
 TATA Advanced Systems (INDIA)  
 Terma (DENMARK)  
 Thales (FRANCE)  
 Westminster International (UK)

**Maritime – commercial shipping radar**

Cobham Advanced Electronic Solutions (USA)  
 Furuno (JAPAN)  
 Kelvin Hughes (UK)  
 Navico (NORWAY)  
 Northrop Grumman Sperry Marine (USA)  
 Raytheon Anschütz (GERMANY)

**Maritime – naval fire control**

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 Cobham Advanced Electronic Solutions (USA)  
 Leonardo Land & Naval Defence Electronics (ITALY)  
 Saab (SWEDEN)

SCRIEE – Southwest China  
Research Institute of  
Electronic Equipment  
(CHINA)  
Thales (FRANCE)  
Thales Netherlands  
(NETHERLANDS)

### Maritime – naval surveillance systems

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BAE Systems (UK)  
BEL-Thales Systems (INDIA)  
CEA Technologies  
(AUSTRALIA)  
Cobham Advanced  
Electronic Solutions (USA)  
Communications & Power  
Industries (CPI) (USA)

Harris Electronic Systems  
(USA)  
Hensoldt Sensors  
(GERMANY)  
IAI ELTA Systems (ISRAEL)  
Leonardo Land & Naval  
Defence Electronics  
(ITALY)  
Northrop Grumman (USA)  
Raytheon (USA)  
Rheinmetall (GERMANY)  
Rosoboronexport (RUSSIA)  
RRS – Reutech Radar  
Systems (SOUTH AFRICA)  
Solusi247 (INDONESIA)  
TenCate Advanced Armor  
(USA)  
Terma (DENMARK)  
Thales (FRANCE)

Thales Netherlands  
(NETHERLANDS)

### Navigation radar

Transas Marine UK Ltd (UK)

### Space-based radar

IAI MBT Division (ISRAEL)  
Indian Space Research  
Organisation (INDIA)  
MDA – MacDonald,  
Dettwiler and Associates  
(CANADA)  
NASA Jet Propulsion  
Laboratory (JPL) (USA)  
Thales Alenia Space France  
(FRANCE)  
Thales Alenia Space Italia  
(ITALY)

### Weather radar

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(USA)  
Cobham Advanced  
Electronic Solutions  
(USA)  
Communications &  
Power Industries (CPI)  
(USA)  
Eldes (ITALY)  
Enterprise Electronics  
Corporation (USA)  
Furuno (JAPAN)  
Honeywell International  
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The guided-missile cruiser USS *Mobile Bay* (CG 53) sails past Port Hueneme, California, testing the updated AEGIS Baseline 9 weapons system. (Photo: USN)

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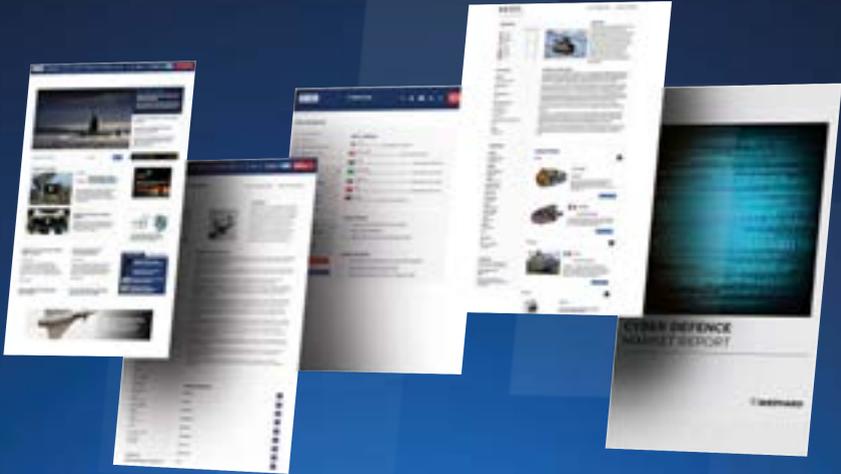
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