

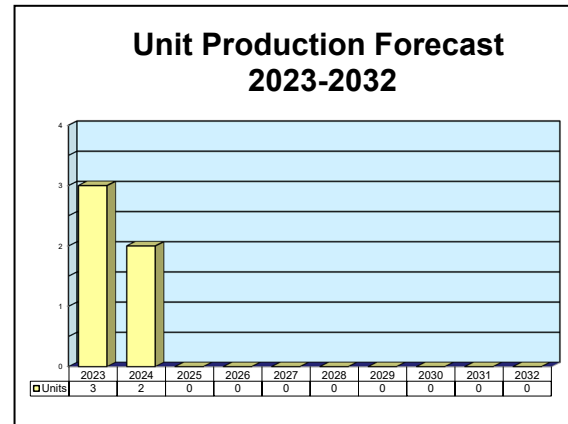
# ARCHIVED REPORT

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## Searchwater

### Outlook

- First three Searchwater-equipped Crowsnest Merlins were deployed in a baseline configuration in March 2021
- IOC for Searchwater-equipped Crowsnest Merlins was achieved in summer 2023
- Production will end with delivery of the 10th and final radar for the Crowsnest package in 2024



### Orientation

**Description.** I-band, high-powered, pulse-Doppler radar for maritime patrol and airborne early warning (AEW) aircraft.

**Sponsor**

U.K. Ministry of Defence (MoD)  
 Procurement Executive  
 Main Bldg, Whitehall  
 London SW1A 2HB  
 United Kingdom  
 Tel: + 44 171 218 90 00

**Status.** In production and service.

**Total Produced.** Thales produced approximately 100 radar systems (including historical production) through

January 2012. The Crowsnest program would add another 10 units by program's end.

**Application.** The radar is specifically designed for AEW&C applications over land and sea.

**Price Range.** Based on the contract for 21 Searchwater 2000MRs as part of the U.K.'s Replacement Maritime Patrol Aircraft (RMPA) program, the price of Searchwater is estimated at \$4.6 million (1996 U.S. dollars), including installation.

The price of a Searchwater ASaC in support of the U.K. Navy's Merlin-based Crowsnest package is estimated to be \$5.0 million.

### Contractors

**Prime**

Thales UK, HQ	<a href="http://www.thalesgroup.com">http://www.thalesgroup.com</a> , 350 Longwater Ave, Green Park, Reading, United Kingdom, Tel: + 44 118 943 4500, Prime
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Contractors are invited to submit updated information to Editor, International Contractors, Forecast International, 75 Glen Road, Suite 302, Sandy Hook, CT 06482, USA; [rich.pettibone@forecast1.com](mailto:rich.pettibone@forecast1.com)

## Searchwater

# Technical Data

### Specifications

#### Searchwater 2000MR

Type	TWT
Frequency	I-band (selectable)
Elevation coverage	Single sweep
Polarization	Vertical and horizontal
Target tracking	≤100
Power consumption	<4 kVA, 115 V, 3-phase
Cooling	Air
Interfaces	MIL-STD-1153B (control/data) Two RGB video outputs

#### Searchwater 2000MS

Frequency	I-band
Peak transmitter power	8 kW (typical)
Pulse widths	Multiple
PRF	Multiple
Antenna type	Planar or reflector
Polarization	Vertical or horizontal
Track while scan	≤100 tracks
Power consumption	2.5 kVA (typical)
Cooling	Air
Interfaces (user-defined)	MIL-STD-1553 RS422, ARINC 429

**Design Features.** The Searchwater system consists of a high-power pulse-Doppler radar integrated with Mk XII identification friend or foe (IFF) electronic support measures (ESM) and an INS/GPS navigation system. The radar has long-range, air-to-air, look-up / look-down capability, and incorporates multibar scanning for multiple-level detection. An advanced Human Computer Interface, specifically designed for airborne surveillance and control (ASaC) operations with twin operating consoles, ensures efficient, effective operator interaction.

A signal processor enhances surface target detection (including submarine periscopes) in high seas, and a digital scan converter permits classification of target and transponder returns. The system features bright, flicker-free television-type PPI and A- and B-scope displays in a variety of interactive operating modes. Weather radar and navigation facilities are provided within the system. A real-time dedicated digital computer continuously and automatically tracks, stores, and analyzes target data.

Searchwater reduces the vulnerability of maritime patrol aircraft (MPA) by permitting them to operate effectively in an entirely standoff mode, and by relieving them of the need to overfly the target to confirm its type. The system is modular, with the interfaces and mechanical construction designed for easy fault location and replacement. Major units are designed to be functionally self-contained, with a minimum of interconnections to

other parts of the system. Hybrid and integrated circuit techniques are extensively used.

The transmitter uses solid-state frequency generators and mixers, followed by two cascaded traveling wave tubes. A fluorocarbon liquid cooling system is employed for both transmission and reception. The scanner, which transmits and receives radar and IFF information, uses a lightweight-construction resin-bonded carbon-fiber reflector.

Searchwater also includes over-the-horizon targeting facilities, allowing operation with anti-surface weapons systems such as the Harpoon anti-ship missile and the Stingray homing torpedo. The pitch, roll, and azimuth axes are controlled by the hydraulic servomechanism. Surface acoustic wave technology is employed in the pulse-compression system.

In 1985, Thorn-EMI was awarded a contract to develop a new color display for the Nimrod MR2 aircraft. This display enables processed radar data to be overlaid onto raw radar data, thus improving target detection and enhancing cloud and anti-collision performance. A three-color format is utilized for radar data, auxiliary displays, markers, and alphanumerics. The display occupies the same volume as previous versions and retains the TV raster-type format.

**Operational Characteristics.** In the helicopter AEW version, Searchwater Mk I ARI 5980/3 is pallet-mounted between the cabin doors. The Kevlar

## Searchwater

drum radome containing the antenna assembly is fixed to the pallet on a swiveling sponson on the exterior of the central fuselage. The radome is inflated during operation and folded aft during takeoff and landing. In flight, the radome swivels 90 degrees downward, placing the radar's antenna beneath the helicopter for complete 360-degree coverage. The Searchwater-equipped Sea King is designed to fly at an altitude of

approximately 9,700 feet and a range of 190 miles. At this height and distance, the helicopter can provide the fleet with a 20- to 25-minute warning of fast attacking aircraft. A Cossor IFF interrogator antenna is integrated as part of the Searchwater aerial radar, rotating as part of the main array. The radar is nose mounted on fixed-wing aircraft.

For additional information, see **Variants/Upgrades**.



U.K. Royal Navy Sea King AEW Helicopter, Featuring the Telltale Searchwater Radome in a Retracted Position Aft of the Cabin Door

Source: U.K. Royal Navy, SAC Oldfield

## Variants/Upgrades

**Searchwater AEW.** This version features the single operator console of the Searchwater system, augmented by a second tactical console.

**Skymaster.** Skymaster is an AEW-optimized variant that retains the transmitter and receiver from the previous design but incorporates a new display. The Skymaster, which also employs a Doppler mode for look-down detection of ground targets, uses a lighter antenna, and can gather over-the-horizon targeting

information and relay it via datalink to ground control stations or to ships offshore. Thorn-EMI (now Thales) marketed the Skymaster on board a Pilatus Britten-Norman Islander as its entry in the U.K. Airborne Stand-Off Radar (ASTOR) program. Thorn-EMI was awarded a development contract in 1983. After many delays, the decision was made to adopt a different approach to the ASTOR requirement. The aircraft, with its new AEW suite, was renamed the Defender AEW.

## Searchwater

Skymaster also operates in I-band and employs a traveling wave tube (TWT) transmitter – capable of either pulse-Doppler mode operation to discern airborne targets in a look-down attitude, or conventional pulse transmission for detection of surface vessels (look-down) or airborne targets (look-up). The radar offers four modes of detection: look-up, look-down, maritime surveillance, and adverse-weather warning. A fully stabilized antenna array provides a 360-degree, narrow-beam search function with automatic sector scan.

Skymaster has improved signal processing and simultaneous target tracking of 32 surface and 100 airborne targets. The original manufacturing team reported a time on station of five hours with standard equipment. The calculated maximum detection range is 125 nautical miles for bomber aircraft and 100 miles for fighters in look-up mode. The maritime surveillance mode range is 130 nautical miles for larger vessels and 125 nautical miles for fast-moving attack craft.

**Searchwater Mk II.** In 1987, Thorn-EMI completed its Searchwater upgrades for the Royal Air Force (RAF) Nimrod MR2 aircraft and subsequently developed an improved radar version. The Mk II radar is a multimode system incorporating the Skymaster reconfigurable processor for target classification, Fast Fourier Transformation (FFT) pulse-Doppler processing for AEW, and clutter suppression to enhance surveillance capabilities. Thorn-EMI claimed that Searchwater Mk II offered performance similar to that of the original version at about half the weight.

**Searchwater 2000.** This is a further development of the Searchwater Mk II that incorporates advanced signal processing to improve detection, as well as tracking and target classification at extended ranges. It is about 40 percent lighter than its predecessors and is designed for full compatibility with advanced electronic warfare equipment. When linked to high-resolution color displays and GPS navigation systems, the system can contribute to a fully integrated avionics suite. There are several Searchwater 2000 subvariants, as follows:

**Searchwater 2000MR (Maritime Reconnaissance).** The RAF selected this model for the Replacement Maritime Patrol Aircraft, a highly modified and upgraded Nimrod MR2 that is also called Nimrod 2000. The new radars will replace the old Searchwaters in service aboard Nimrod MR2 aircraft for two decades, in order to provide the refurbished aircraft with look-up/look-down detection and multitrack capability (up to 100 targets).

Searchwater 2000MR is a TWT radar designed for all-weather anti-submarine and anti-surface warfare (ASW

and ASuW) operations, as well as for air-to-air detection in pulse-Doppler mode, search-and-rescue operations, and weather avoidance. The radar is fully integrated with an IFF interrogator, optimized for detecting submarine masts, and can be readily adapted to sea and atmospheric conditions using its Detection Range Display feature.

Raytheon furnishes various subcomponents and the antenna array for the Searchwater 2000MR. Array Systems Computing of Toronto supplies TriSAR imaging software for the Nimrod RMPA program.

### **Searchwater 2000AEW (Airborne Early Warning).**

This version provides a long-range AEW capability as part of the U.K. Royal Navy's Sea King AEW radar upgrade. Consisting of a radar and operator facilities, the system features a high-power pulse-Doppler radar integrated with Mk XII IFF, a GPS/INS, twin operating consoles with an advanced man-machine interface, and data communications via Link 16.

Searchwater 2000AEW is designed to function over land and sea, with air-to-air (look-up/look-down), multiple target interception (MTI), ASW, and ASuW maritime surveillance capability (including searches for small targets, such as periscopes) in all sea states. This version incorporates navigation and ground mapping, target classification, and weather and beacon modes. The system discriminates between high-velocity airborne targets and lower-velocity land and sea targets.

Under a 1997 contract, Radamec Defence Systems supplied stabilized platforms and servo-control electronics for the system.

### **Searchwater 2000MS (Maritime Surveillance).**

This model is derived from the Searchwater 2000MR and 2000AEW systems but, at less than 100 kilograms (220 lb), is designed for smaller platforms. The system offers 360-degree operation for look-up/look-down searches, as well as navigation and ground mapping, target classification, and weather and beacon modes. It features fully coherent pulse-compression and pulse-Doppler techniques combined with advanced digital signal processing for high-resolution synthetic aperture radar (SAR) and inverse synthetic aperture radar (ISAR) capabilities. To meet specific integration requirements, Searchwater 2000MS also incorporates a flexible hardware and software architecture.

**Searchwater 2000 ASaC (Airborne Surveillance and Control).** The Searchwater 2000 ASaC is the most current variant. It provides organic fleet protection (Sea Shield) and power projection (Sea Strike).



Searchwater Platform: U.K. Royal Air Force Nimrod Reconnaissance Aircraft

Source: Wikimedia, Tim Felce

## Program Review

**Background.** Searchwater resulted from work performed by Thorn-EMI (now Thales) in close collaboration with the Royal Signals and Radar Establishment (RSRE) in the early 1970s. The objective was to establish the viability of a number of technological options open to any new ASuW radar program. The first upgraded Searchwater-equipped Nimrod aircraft was delivered to the RAF and became operational in 1979. Nimrod MR2 deliveries concluded in 1985.

### *Sales: One Confirmed, One Rumored*

In 1984, the Spanish Navy purchased Searchwater radars for its Sea King SH-3D/AEW helicopters. In 1996, there were press reports of an alleged sale of Searchwater radars to China. However, Thales states that Searchwater radars have never been sold to China.

### *IPS Adds New Capabilities*

Thales was awarded a contract to replace the existing Searchwater I radar with the Searchwater 2000MR version as part of the RAF's Nimrod MRA4 upgrade program. In June 2001, Array Systems Computing released its image processing software (IPS) for incorporation into the Searchwater 2000MR. The IPS provides stripmap and spotlight SAR modes, as well as an ISAR function. Three aircraft were completed before the RAF's Nimrod MRA4 upgrade program was restructured and work halted in 2003.

The RAF ordered 12 2000MR radar-equipped Nimrod MRA4 aircraft in 2006, and ordered nine additional 2000MR radars as spares. Thales has delivered all 21 radars. The first production Nimrod MRA4 made its maiden flight in September 2009.

### *'TOSSing' Searchwater on the Osprey*

*Flight International* reported in June 2007 that the U.S. Navy was seeking support for a demonstration of the Thales Cerberus maritime-surveillance mission system, which includes Searchwater, on the Bell/Boeing V-22 Osprey. The Totally Organic Sensor System (TOSS) project would demonstrate the capability of the Thales Sea King Mk 7 ASaC Cerberus system to be modularized and installed on a wide range of U.S. Navy and Marine Corps aircraft, starting with the V-22. The Navy is interested in Cerberus-equipped V-22s for the expeditionary strike group mission. At this time, Cerberus is not a part of the Osprey's upgrade roadmap.

In a report on the FlightGlobal website (July 2008), the USMC deputy commandant for aviation was quoted as saying that the Marine Corps remains "very interested" in potentially integrating a so-called TOSS with the MV-22. The move would provide situational awareness for mission commanders via the use of a Thales-developed ground moving target indication (GMTI) sensor.

### *Nimrods Become Scrap*

In March 2010, six months after the first flight of the first production MRA4, the second production MRA4 made its first flight. The U.K. MoD then formally accepted the Nimrod MRA4 and declared the type "ready to train." BAE Systems stated at the time that the remaining seven production aircraft were in the build cycle.

Shortly thereafter, the Nimrod program (and by extension the Searchwater) took a negative turn when, in October 2010, the U.K. Ministry of Defence decided

## Searchwater

to cancel the remaining aircraft. The existing Nimrod fleet was to be scrapped to save money, marking the end of the radar's service on the aircraft.

### *Crowsnest – Decisions Delayed*

The U.K. MoD will be replacing its Searchwater-equipped Sea King helicopters under the Crowsnest program (formerly known as the Maritime Airborne Surveillance and Control, or MASC, program). When the program was known as MASC, contenders included an AgustaWestland AW101 Merlin, a Bell/Boeing V-22 Osprey derivative, and the Northrop Grumman E-2C/E-2D Hawkeye. However, Parliament reports dating to September 2012 suggested that the new platform would almost certainly be the Merlin helicopter.

Boding well for the future of Searchwater, the proposed Thales UK-AgustaWestland Merlin solution would be equipped with the ASaC Cerberus mission system and a Searchwater 2000 radar. In this instance, the palletized Searchwater 2000 radar would be deployed through the rear ramp aperture. The radar housing fits inside the helicopter when in operation and stows in the cabin when not in use, enabling rapid transit between tasking. In this configuration, two mission crew stations are located at the forward end of the cabin, and the mission package and two operator consoles can be removed.

Competition arose for the final Crowsnest award as Lockheed Martin pitched its Vigilance product. Vigilance was originally based on the F-35's Northrop Grumman radar, but is now thought to utilize an Elta-built EL/M-2052 variant.

In the past, it was believed that the Sea Kings would be retired in 2016, but it later appeared that a replacement would not be available until sometime between 2018 and 2022. In the interim, the U.K. Royal Navy will upgrade the Sea Kings to keep them flying. The MoD has not announced a procurement quantity for Crowsnest, but sources estimate a range of six to 12 aircraft. Forecast International believes the smaller buy is more probable.

### *U.S. Osprey – Searchwater Platform?*

In the past, Boeing has pushed to install the TOSS on the V-22. TOSS, including the Searchwater, would

provide the Osprey with AEW, GMTI, and sea surface surveillance capabilities. A Boeing official stated that TOSS "actually represents two-thirds of the capability of a combined JSTARS, AWACS, and E-2 all in one platform." Boeing added that the company would like to install TOSS on a number of different medium transport assets, from fixed-wing aircraft to helicopters and tiltrotors.

At this time, however, there is no government sponsor to fund the Boeing proposal, and the situation is further complicated by the fact that installing TOSS would require changes to the V-22. Boeing would have to install specialized electrical connections as well as an intercom system so that the two TOSS operators could communicate with the cockpit.

### *U.K. – Looking Out for Crowsnest*

With the cancellation of the U.K.'s Nimrod MRA4 procurement, the Sea King helicopter became the country's lone platform carrying the Searchwater. As the Sea King was scheduled to be withdrawn from service in the 2017 to 2018 timeframe, the U.K. would be left with a significant AEW capability gap, and replacement of the helicopters would be necessary.

The U.K.'s Sea King replacement program is known as Crowsnest, and the Merlin was chosen as the replacement aircraft. The Searchwater-equipped Cerberus from Thales and Lockheed Martin's Vigilance, based on the F-35's radar, were the primary contenders to serve as the Merlin's electronics suite.

In October 2013, the U.K. Defence Ministry said that it would use GBP1.8 billion (\$2.46 billion) to accelerate development of the Crowsnest helicopter-borne radar system. The surplus money, a result of underspending, would be used to bring Crowsnest into service two years earlier than originally planned.

In May 2015, Thales announced that the Searchwater/Cerberus system had won the Crowsnest competition, thus ensuring the Searchwater's future. Deliveries under the program were to begin in 2018, but the first unit did not fly until March 2019. Initial Operational Capability (IOC) was expected in 2020, but this was later postponed to 2022 and was ultimately not achieved until Summer 2023.

## Contracts/Orders & Options

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<u>Contractor</u>	<u>Award (\$ millions)</u>	<u>Date/Description</u>
Thales	56.0	May 2005 – Contract from the U.K. Ministry of Defence to convert two U.K. Royal Navy Sea King HAS Mk 6 helicopters to the Sea King Mk 7 ASaC configuration. This conversion would include installation of the Searchwater 2000AEW pulse-Doppler radar. Work was to be completed in 2007.
Lockheed Martin UK, AgustaWestland, Thales UK	6.3	Jun 2006 – A 15-month contract to study the potential of using Merlin helicopters as platforms for both maritime AEW and command and control. The overall study includes two other contracts that will cover other airframes and mission system options. The Thales UK-led team was studying potential enhancements to the Sea King Mk 7 ASaC mission system.

## Timetable

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<u>Year</u>	<u>Major Development</u>
1972	Trials underway in association with RSRE
1976	Trials carried out on board Nimrod MR1
1978	Searchwater evaluated by U.K. Royal Air Force
1979	First Nimrod MR2 becomes operational
1982	U.K. Royal Navy orders Sea King AEW with Searchwater
1983	U.S. acquires Searchwater system for evaluation
1984	Spanish Navy purchases Searchwater AEW radar
1985	Contract for development of color display
1995	Racal acquires Thorn-EMI Sensors unit
1997	Searchwater 2000MR selected for U.K. Nimrod MR2 remanufacture program
1997	Searchwater 2000AEW selected for U.K. Sea King upgrade program
2002	Delivery of two U.K. Royal Navy Sea King AEW.7 helicopters upgraded with the Searchwater 2000AEW
2005	Thales awarded a contract to convert two U.K. Royal Navy Sea King HAS Mk 6 helicopters to the Sea King Mk 7 ASaC configuration carrying the Searchwater 2000AEW radar
2006	U.K. RAF orders 12 Nimrod MRA4 aircraft fitted with Searchwater 2000MR and nine radars as spares
2007	Thales completes installation of Searchwater 2000AEW on two U.K. Royal Navy Sea Kings
2010	Delivery of first Nimrod MRA4 aircraft
2014	Proof of concept flight tests with a side-mounted Searchwater on board a Merlin HM2 as part of Crowsnest
2017	Crowsnest test and evaluation period begins
2018	Scheduled first delivery for U.K. Crowsnest program; deadline missed
2019	First U.K. Crowsnest package flies
2021	First Crowsnest helicopter enters service
2023	Crowsnest IOC achieved
2024	Searchwater deliveries expected to end

## Searchwater



Merlin Mk2 ASaC Crowsnest Helicopters with Searchwater Radar

Source: U.K. Ministry of Defence, Jay Allen

## Worldwide Distribution/Inventories

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Searchwater radars have been delivered to **Spain** (Sea King SH-3D/AEW) and the **United Kingdom** (Merlin AW101, Nimrod MR2, Nimrod MRA4, and Sea King AEW.2).

## Forecast Rationale

Searchwater is a high-powered pulse-Doppler radar for airborne surveillance and control that is installed on aircraft as part of an airborne early warning mission system.

Searchwater is an older system, having first entered trials in the 1970s. Even though it has been updated significantly through the years, the radar has almost reached the end of its production life. With few market opportunities remaining, the only Searchwater production forecast is related to the U.K.'s Crowsnest program.

In 2015, the U.K. MoD confirmed Searchwater as the Crowsnest contest winner. Initial Operational Capability was scheduled for 2020, with an overall run of 10 units expected. However, the first Crowsnest platform fell

behind schedule. It first took to the air in March 2019, the first radar-powered flight was in February 2020, and operational training with the first unit did not begin until 2021. With software issues and other problems continuing to hamper the program's progress, the U.K. MoD did not declare IOC until summer 2023.

By the end of program procurement, 30 Merlin helicopters in the U.K.'s fleet will be modified to be Crowsnest-capable, but only 10 quick-change Crowsnest package installations will be provided. Consequently, only 10 full Searchwater radar upgrade packages are being produced in support of the program.

Beyond the Crowsnest program, it is difficult to foresee any further Searchwater procurements. Opportunities like Brazil's S-2 Tracker modernization presented

**Searchwater**

possibilities that never materialized. More recently, Qatar said that it might equip its Q01 optionally piloted, medium-altitude, long-endurance (MALE) surveillance aircraft with the radar. However, by 2018, news had emerged that Qatar had instead opted for the Searchmaster.

At this time, Forecast International does not foresee any further Searchwater opportunities evolving into actual sales.

**Ten-Year Outlook**

<b>ESTIMATED CALENDAR YEAR UNIT PRODUCTION</b>												
Designation or Program	High Confidence					Good Confidence			Speculative			Total
	Thru 2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	
<b>Thales UK</b>												
<b>Searchwater ASaC &lt;&gt; United Kingdom &lt;&gt; Navy &lt;&gt; AW101 &lt;&gt; Crowsnest Program</b>												
<small>Note: Maritime Surveillance and Control (MASC) program; Part of the Cerberus system</small>												
	5	3	2	0	0	0	0	0	0	0	0	5
<b>Total</b>	5	3	2	0	0	0	0	0	0	0	0	5