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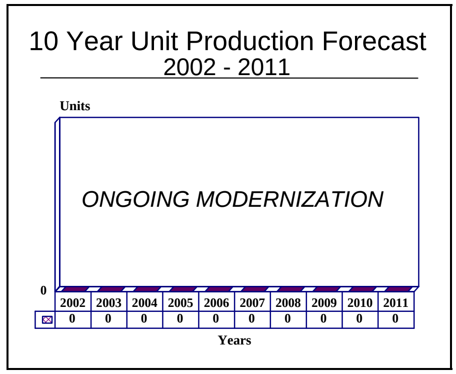
AYR-1(V) (AWACS ESM) - Archived 03/2003

Outlook

- Installed in all USAF and NATO E-3s
- France acquired four systems for its AWACS fleet
- Spare parts, maintenance and upgrades continue
- Fleet maintenance a priority



Orientation

Description. Airborne passive electronic support measures (ESM) system.

Sponsor

US Air Force
Electronic Systems Center
Hanscom AFB, Massachusetts (MA) 01731-5000
USA
Tel: +1 617 377 5191
Web site: http://www.hanscom.af.mil
(Block 30/35 Upgrade Program sponsor, ESM Cooperative Development Program joint sponsor)

NATO Airborne Early Warning & Control (AEW&C)
Program Management Agency (NAPMA)
Brunssum, the Netherlands
(ESM Cooperative Development Program joint sponsor)

Contractors

Boeing Defense and Space Group
Information & Electronic Systems Division
PO Box 3999
Seattle, Washington (WA) 98124-2499
USA
Tel: +1 206 655 1212
Fax: +1 206 544 4971
Web site: http://boeing.com
(AYR-1 prime, Block 30/35 integrator)

Condor Systems
430 N Mary Avenue
PO Box 3452
Sunnyvale, California (CA) 94088
USA
Tel: +1 408 524 1771
Fax: +1 408 737 9236
Web site: http://www.condorsys.com
(AYR-1 ESM)

Status. In production, logistics support beginning.

Total Produced. An estimated 59 units have been produced.

Application. ESM capability for the USAF, NATO and French AWACS fleet.

Price Range. The current unit cost is estimated to be US$3.6 million per aircraft. Group A kits and other installation/support have been contracted at US$2.5 million.

Price is estimated based on an analysis of contracting data and other available cost information, and a comparison with equivalent items. It represents the best-guess price of a typical system. Individual acquisitions may vary, depending on program factors.

Technical Data

	Metric	US
Dimensions		
Antenna		
Fore/aft	59 x 37 cm	23.3 x 14.6 in
Cheek	52 m x 84 cm	13 ft x 33 in
Rise above skin	46 cm	18 in
Receiver processor	57 x 80 x 56 cm	22.5 x 31.5 x 22 in
Workstation	22 x 48 x 51 cm	8.6 x 19 x 20 in
Weight		
Antenna	28 kg	61.7 lb
Receiver/processor	32 kg	70.6 lb
Workstation	23 kg	50.7 lb
Characteristics		
Frequency	2 to 6 GHz 6 to 18 GHz	
Range		300 nm
Probability of intercept	100%	
Coverage	360º	
Frequency measurement		
Displayed resolution	1 MHz	
Accuracy, rms	3 MHz (2 to 6 MHz) 6 MHz (6 to 19 GHz)	
DF measurement accuracy	3.5º (2-6 GHz) 2º (6- 18 GHz)	
System sensitivity	-65 dBm	
Dynamic range	> 70 dB	
Pulse width measurement		
Range	0.1 to 99.9 msec	
Resolution	0.1 msec	
Amplitude measurement		
Range	>60 dB	
Resolution	0.5 dB	
PRI measurement		
Range	2 to 10,000 msec	
Resolution	0.1 msec	
System reaction time	1 sec maximum	
Number of signals tracked	500	
Pulse density capacity	1,000,000	
Threat library capacity		
Emitter modes	5,000	
Radars/platforms	500	
Threat alarms	Threat Steady illumination CW	
Signal types detected	Conventional pulse trains Frequency agile FM on pulse Jittered PRI Staggered PRI	

Characteristics

Scan types	Circular Conical Bi-directional Unidirectional
Polarizations	Horizontal Vertical Slant linear Circular

Design Features. The AYR-1(V) electronic support measures (ESM) system is a passive sensor designed to detect and acquire radio frequency emissions from threat radars and identify the type of emitter from which the signal came. It is based on the ARGOSystems AR-900. The antennas are carried in canoe-shaped additions on either side of the E-3's forward fuselage. The AYR-1(V) uses four antennas to provide 360º coverage: two cheek antennas on the left and right fuselage forward of the wing, one on the nose, and one on the tail.

Each antenna is coupled to a superheterodyne receiver where the signal is digitized and sent via a MIL-STD-1553 databus to the ESM suite, where it is analyzed and identified. The system breaks the RF signal into its basic parameters. In order to identify a received RF signal, the AYR-1(V) generates data on frequency, pulse width and pulse repetition interval. These parameters are compared to the system's data libraries and the identification solution forwarded to the AWACS' modified IBM CC-2E central mission computer so that it can be presented on the console operator's displays.

The ESM system correlates the received signals to type of platform and identifies the emitter by type (acquisition radar, TACAN, or Doppler system). In the case of an acquisition radar, the AYR-1(V) determines if it is operating in the search or track mode.

The operator workstation consists of a keyboard with integrated trackball; a high-resolution, flat panel, color display; a floppy disk drive; a printer; and an embedded computer. User-friendly pull-down menus aid operator efficiency and training. The Activity, Tactical Graphics and Tactical Summary options give the operator threat warning information. The Frequency x Azimuth, Frequency x PRI and Frequency x Amplitude display pages are provided for analysis. An Intercept Report Generator prepares intelligence reports.

The AYR-1(V) augments the AWACS APY-1/2(V) surveillance radar in identifying threat aircraft to a range of 350 nautical miles. The system was designed to identify over 100 non-cooperative targets in 10 seconds and can scan across its entire frequency band in two seconds.

The AYR-1(V) ESM suite is made up of 23 Line Replaceable Units, and the operational computer program uses 67,000 lines of code in Assembly and C language. The heart of the system is the receiver/processor unit composed of two Digital Instantaneous Frequency (DIF) receivers, a Monopulse Bearing Receiver and an Electronic Signal Processor (ESP). The antenna assembly uses a wide-open-amplitude monopulse direction finding (DF) system that provides better than 3º rms bearing accuracy.

The processor analyzes the measurements for each received radio-frequency pulse and the continuous wave signals from the DIF receivers, while the monopulse bearing processor provides the direction of arrival and amplitude of each pulse. The ESP processes this information in parallel and compares the pattern with a signal library to identify the emitter and its platform. It alerts the operator to a high-threat signal within one second of acquisition.

Operational Characteristics. AWACS ESM allow crews to cross-correlate target location and provide more information about detected targets. It helps AWACS become a more all-purpose command and control as well as intelligence platform.

For a given mission, ESM system support personnel select and load a database with the radio frequency and platform parameters the AWACS is likely to encounter. This includes airborne, maritime and ground emitters such as surface-to-air missile acquisition radars. The emitter libraries can be programmed with up to 5,000 emitter modes and reference as many as 500 radar names and associated platforms.

The information from the AYR-1(V) can be used to determine the movement and location of hostile forces, making engagement of these forces more effective and efficient and reducing potential fratricide. Signals make it possible to detect surface-to-air missile/gun sites and advise friendly forces accordingly. Improvements to the AWACS datalinks make it possible to share information received and analyzed with other forces on the battlefield. As AWACS gets more involved in littoral operations, this ability to perform SIGINT along the shoreline could significantly enhance a naval force's situational awareness.

Variants/Upgrades

The USAF continues to expand and update the AYR-1's threat library, displays and processors. Interoperability of the various users' systems is a major consideration in modifications for both the sensor and its ancillary processing and datalink systems.

Program Review

Background. The AYR-1(V) was derived from the Advanced Quicklook system for the US Army's Improved Guardrail V, now known as the GUARDRAIL/Common Sensor, on the RC-12K aircraft. Although UTL developed Advanced Quicklook, (then) ESCO Electronics Corp (formerly Emerson Electric Co) was awarded the initial production contract. In 1990, Boeing selected a highly modified variant of Advanced Quicklook, now designated AYR-1(V), as the electronic support measures (ESM) system for the Air Force AWACS upgrade.

A US$290.8 million contract for the NATO ESM retrofit upgrade and NATO Modification Block 1 was awarded in January 1993. The effort included retrofit and acceptance testing of the AWACS ESM system for NATO mission simulator #2 at Geilenkirchen AFB, Germany, and associated production of the NATO modification, including color displays, HAVE QUICK radios, Link 16 JTIDS for 18 NATO aircraft, and two simulators. The effort was completed in December 1995.

In September 1994, the first NATO E-3 arrived at the Boeing plant in Seattle from the NATO Main Operating Base in Geilenkirchen for the initial installation of new mission equipment. This effort was conducted under a 1993 Boeing contract from the NATO Airborne Early Warning & Control Program Management Organization (NAPMO) to design, integrate and oversee the production of three new mission system enhancements. The Mod Block 1 contracts were valued at about US$330 million and were planned to run through 1997.

Under Mod Block 1, the NATO AWACS fleet was equipped with new color displays to improve the form and usability of incoming situational information, as well as HAVE QUICK radios to enhance UHF communications by adding security and anti-jamming features. A version of the US Air Force's Joint Tactical Information Distribution System (JTIDS), Link 16, was added to increase the amount of information collected and distributed among other AWACS planes, allied aircraft and ground stations.

The four phases to the Mod Block 1 installation included trial installation, test, "kit-proofing," and fleet-wide retrofit. During the trial installation phase, Boeing outfitted the first aircraft, designated N-1, with the upgrades to verify that the hardware and software engineering had been done correctly and that installation instructions were accurate. The company completed this phase in late 1994.

In mid-1995, the company then oversaw the installation of the new equipment on a second AWACS aircraft at Deutsche Aerospace AG (DASA) facilities in Manching, Germany. This kit-proofing phase ensured that the modification kit equipment and instructions were complete, and that DASA employees understood the installation instructions well enough to retrofit production-quality hardware into the remaining 16 NATO AWACS aircraft. The fleet-wide retrofit program was planned to begin in 1996.

In July 1996, France announced that it planned to acquire AWACS ESM for its fleet of four E-3Fs. The official notice of a planned procurement was sent to Congress in May 1997. A contract for the installations was awarded in March 1998, and the first system was delivered in July 1999.

A series of integrated upgrades and enhancements is being programmed and implemented for the E-3. All parts of AWACS are intimately intertwined; these are discussed in more detail in the Forecast International "APY-1/2(V) (AWACS)" report, which can be found in the *AN Equipment* and *Rada*r Forecasts.

NATO Sends AWACS to Relieve US E-3s. In October 2001, NATO sent five AWACS aircraft from Germany to Oklahoma to free US AWACS radar aircraft for operations against terrorism elsewhere. This is the first time in NATO history that the alliance's assets are being used to help protect the United States. The NATO AWACS planes, plus a support aircraft, are assisting the US with stepped-up continental defense operations in the wake of the September 11, 2001, terrorist attacks in New York City and Washington. A

Boeing 707 transported detachment personnel and their equipment.

The NATO aircraft began deploying October 9 from Geilenkirchen, Germany, and the last of the five were scheduled be in place at Tinker Air Force Base, Oklahoma, by October 11. The aircraft are under NORAD command and flown by multinational crews from 12 NATO nations. The NATO AWACS provides radar coverage and surveillance operations for NORAD combat air patrols. After the terrorist attacks on America, NATO invoked Article 5 of its charter, which states that a foreign attack on one member is considered an attack on the other members.

Below are the number of military personnel, by nationality, deployed from the NATO E-3A component to Tinker Air Force Base, Oklahoma.

Belgium	11
Canada	22
Denmark	1
Germany	55
Greece	1
Italy	11
Netherlands	7
Norway	5
Portugal	2
Spain	2
Turkey	5
US	74

A total of 31 NATO civilian employees were also deployed.

Funding

US FUNDING

	FY00		FY01		FY02(Req)		FY03(Req)	
	QTY	AMT	QTY	AMT	QTY	AMT	QTY	AMT
RDT&E (USAF)								
PE#0207417F								
AWACS	-	43.4	-	35.3	-	39.8	-	104.4
Procurement (USAF)								
Mod Kits	-	114.5	-	87.9	-	92.7	-	29.9

All US$ are in millions.

Note: This funding covers a variety of AWACS upgrades and enhancements. The percentage allocated for ESM improvements is not known and varies from year to year, and is relatively small compared to that allocated for radar upgrades.

Recent Contracts

(Contracts over US$5 million.)

Contractor	Award ($ millions)	Date/Description
Boeing	26.6	Mar 1998 – FVI to FFP to provide for installation and check-out of the ESM system in four E-3F AWACS aircraft; FMS for France. Completed December 2000. (F19628-97/C-0005)
Boeing	5.1	Aug 1999 – Mod to an FPI contract to provide for EMD, multi-sensor integration, ESM, and platform-specific improvements and administrative refinement of baseline specifications to support AWACS aircraft. Supports FMS to NATO. Completed July 2001. (F19628-97-C-0012-P00015)

Timetable

Month	Year	Major Development
	1977	AWACS first fielded
	1982	NATO AWACS deliveries begin
Mar	1987	FSD contract for ESM upgrades
Sep	1990	ESM DT&E/IOT&E initiated
Mar	1992	ESM DT&E/IOT&E completed
Mid	1992	Block 30/35 approved for production
Late	1992	Block 30/35 production award
Jan	1991	NATO ESM and Mod Block 1 award
FY	93-97	Block 30/35 kit production
2Q	FY95	ESM full-rate award, PCA
FY	95-99	Block 30/35 installations
Oct	1996	Emitter ESM Library update complete
Jan	1997	France decides to acquire ESM system
Jan	1998	ESM installation and testing of ESM complete
Mar	1998	France contracts for ESM
Jan	1999	French installations begin
Jul	1999	First French ESM installation complete
Dec	2000	French installations complete
3Q	FY01	Last Block 30/35 Mod
1Q	FY02	Block 30/35 FOC

Worldwide Distribution

France. France acquired ESM for its four AWACS aircraft.
Japan. Japan is procuring four E-767 AWACS and has expressed interest in ESM.
NATO. NATO flies 18 AWACS aircraft.
Saudi Arabia. Saudi Arabia operates five AWACS and has discussed a requirement for four more. It is interested in a possible procurement of ESM upgrades.
United Kingdom. Britain has a fleet of seven AWACS aircraft that carry the Loral 1017 ESM suite.
United States. The US Air Force has a fleet of 33 AWACS aircraft and is upgrading them with ESM suites as aircraft cycle through depot maintenance.

Forecast Rationale

AWACS is probably the most low-density, high-demand asset in the inventory. Whenever a contingency operation evolves, AWACS is one of the first assets requested. The Persian Gulf War, operations in the Balkans, Kosovo, and Afghanistan, and enforcement of the Iraqi no-fly zone have proved that AWACS can do the job for which it was designed. It is capable of expanded operations, such as anti-drug operations in the Gulf of Mexico and Caribbean, and since September 11 patrolling over key US cities. The powerful multimode radar, advanced processor, and extensive communications and ESM capabilities of the aircraft, combined with operational flexibility and rapid deployability, make AWACS the premier command and control system.

Future upgrades will further increase the capabilities of and uses for AWACS, with better standardization improving the interoperability of the various national fleets. The Radar System Improvement Program is adding the latest technology and takes advantage of commercial off-the-shelf (COTS) developments. The massive improvement in processing power will generate significant operational capability improvements.

The AYR-1(V) ESM system extends the AWACS' capability to detect and identify RF emissions and non-cooperative targets at beyond visual range. It supplements IFF capabilities with the ability to detect signals emitted by both hostile and friendly targets, and gives fighter pilots an edge by informing them of the type of aircraft they will be encountering before they get close enough for a visual identification. It thereby can prevent friendly-fire accidents.

As the US and NATO operational philosophy adopts the concept of data fusion from multiple sources and multiple services, systems like AWACS become increasingly important. The ability to combine high-quality AWACS data with ESM details improves the performance of ground commanders who formerly had to rely on sometimes less-than-effective ground sensors. The correlation of radar, IFF, and ESM data makes it possible to merge track information, improving position and heading data and track continuity, and reducing operator workload. In the future, Joint Composite Tracking will provide near real-time data sharing and composite tracking data fusion to improve situational awareness and fire control significantly. Multiple AWACS aircraft, operating as a coordinated team, have proven effective. JSTARS planners are not going to install new ESM equipment on those aircraft, preferring instead to interlink with AWACS and Rivet Joint.

There are no plans to replace the E-3 until the follow-on Multi-Mission Surveillance Platform (MMSP) program begins. MMSP could combine AWACS, JSTARS and ABCCC (airborne battlefield command and control center) functions in a single platform, but the cost of development and procurement can be expected to impact the start and scope of such a program. The newly developed Multirole Electronically Scanned Array (MESA) aircraft being developed for the Australian Wedgetail and selected by Turkey is a less costly, new-technology sensor that will be an attractive option to the E-3/E-767.

The AYR-1(V) is installed on all USAF E-3s and NATO E-3s as part of the E-3 Block 30/35 upgrade program. France is installing ESM systems in its E-3Fs and Saudi Arabia wants to add ESM to its KE-3 fleet. Whether or not the AYR-1(V) will be installed on Japan's new AWACS remains unclear. The RAF AWACS are fitted with a Loral 1017 ESM system and are not expected to receive the AYR-1(V); the Loral systems are undergoing upgrades to improve their performance and reduce their weight. Planners are concerned about the interoperability of AWACS users around the world and would like to see all users carrying the same basic sensor configurations.

Spare parts, maintenance and upgrades will create a steady, active market as long as the AWACS fleet is operational.

Impact of the War on Terrorism. When terrorists attacked the nation on September 11, the idea that America was completely protected by oceans was shattered, the feeling that we knew what threats the nation faced evaporated, and the thought that there was time to prepare went out the window. The murderous attacks on the World Trade Center in New York City and the Pentagon in Washington sent shock waves across the nation and planners into overdrive.

First came rescue and recovery, then retaliation, protection of the homeland, and eliminating (to the extent possible) terrorism around the globe. This was followed by planning for the longer term effort of providing a homeland defense, while at the same time making sure the US military was ready to defend against the conventional threats and support the missions it faced around the world. Budget restraints were lifted, and Congress appropriated US$40 billion in emergency funds, twice what the President requested. Planners began to evaluate how to best spend the defense money.

It was not possible to make many changes in the FY02 budget, so changes would be more prominent in future cycles, beginning in FY03. The attacks revealed a need for prioritizing that could end up with some efforts being found less important and not as time-critical as once thought. Weaknesses in intelligence and homeland protection could result in significant amounts of money being diverted from DoD accounts to the budgets of agencies like the NSA, CIA, and FBI, or to meet the protection needs of local governments. Instability and uncertainty may characterize defense spending over the next few years.

In the longer term, program uncertainty is greater. Besides the possibility of programs being found irrelevant, ill-timed, or unnecessary, a budgetary ripple effect could result in the delay or even demise of some programs. The early emphasis on intelligence, homeland defense, and Special Operations equipment may result in some more strategic or conventional combat weapons programs being revised. Major weapons programs, naval systems, and some heavy ground weapons are vulnerable. Light, mobile systems are favored, boding well for the Army's transformation, and some "black" budget items for intelligence and counter-terrorism will surface.

The *Quadrennial Defense Review 2001* was delivered to Capitol Hill on September 30, 2001. Unlike previous reviews, this *QDR* made no specific recommendations on force size or procurement numbers for any particular weapons system. These recommendations would be generated by ongoing reviews and studies aimed at providing strategic guidance for the future.

These studies will have a direct impact on individual programs and projects over the next decade and beyond, but will not have much influence until the FY03 and FY04 budgets. FY02 was in the final stages on Capitol

Hill and guidance for FY03 had already gone to the Services. This could be adjusted, but the most impact on budget planning will be felt in FY04 and beyond. Besides dealing with ongoing plans, these budgets will contain adjustments needed to get programs hit by emergency cuts and delays back on track.

Projecting exact changes in development, production, etc., is difficult at this early stage. There are too many unknowns and uncontrollable variables to make firm plans. At this stage, understanding the various influences and possibilities is more important than trying to predict what will happen. This makes it possible to better understand the implications of the rapidly changing operational situation for specific programs.

The intensity and duration of the anti-terrorism conflict will determine how much defense money will have to be diverted to meet operational needs and for how long. Some programs will need to be enlarged and expanded and some deferred or ended. Moreover, upgrade programs will be initiated and new developments started. Anti-terrorism operations and an emphasis on homeland defense (such as Combat Air Patrols over selected US cities) will increase spare and repair parts requirements. This will in turn increase the percentage of defense funding for Operations & Maintenance.

By the end of 2001, the bipartisan spirit on Capitol Hill was beginning to crumble as lawmakers began looking to the 2002 elections. Partisanship became a part of the debate, with political posturing becoming more significant, even though there was a fine line to be walked between criticism which could hinder the war and scoring political points against the opposition.

The Senate went so far as to invoke a seldom-used parliamentary maneuver to block legislative moves by the House during the House/Senate conference on the FY2002 defense appropriations bill. Without Senate Rule 28 being enforced, House Members and party leaders could have inserted forgotten legislation and earmarked hometown projects into the bill without having to go through a House Floor vote. This tactic saved what can sometimes be a time-consuming part of the appropriations process that could have made it impossible to send the two-month-late bill to the White House for signature.

It also helped short-stop items that could have pushed the bill over the top-line limit that the President said would cause him to veto the bill. As a result, the FY2002 Defense Appropriations bill cleared Congress just days before Capitol Hill recessed and left town for Christmas.

A major wild card is the economy. There were conflicting indications as to whether the fiscal health of the nation would improve or not. More than anything else, this would be the biggest determiner of how much support Congress could give to the Department of Defense and support of Homeland Defense over the next few years.

The economy will also be the main source of congressional squabbling, with defense budget requests getting caught between the partisan bickering and posturing for the mid-term elections (with a major push to ensure control of the House and Senate consuming both parties) and a lack of funding. The Congressional Budget Office is saying that the Bush tax cuts enacted in 2001 did not help the economy as promised, Capitol Hill did not pass an economic stimulus bill before the end of the first session of the 107th Congress, and the surpluses left by the last administration are gone.

This came as the war in Afghanistan appeared to be winding down and calls for funding of the war against terrorism less vocal, releasing the pressure to control partisan urges. Republicans are digging in on tax cut issues, while Democrats are trying to make political hay with calls for increases in funding for domestic programs, homeland defense, and health care. The Pentagon made plans to ask for a US$20 billion-plus increase in FY03.

It does not take a rocket scientist to figure out that something is going to come up short, and defense issues are at risk. Under the best of circumstances, defense requirements will have to compete with funding for civil agencies and airport security, an intelligence overhaul (some experts say a re-do may not be needed and would be very costly, and that capitalizing on many current programs would be better). A new type of congressional earmark (pork) is likely to emerge – funds for district-specific security projects. All if this will impact the defense top line for years to come.

There is little/no chance that the situation will prompt new production of AWACS. The time it would take for new aircraft to be fielded and the cost of procuring additional AWACS conspire against such a move by the Pentagon or allies. In addition, there are other options developing, including the MESA aircraft that feature newer technology and lower cost. There will be increased pressure to speed upgrades, with an emphasis on interoperability. The NATO aircraft patrolling the United States frees US crews for East Asia duty, improving platform-to-platform consistency in the combat arena and making a more manageable OPTEMPO/PERSTEMPO for US assets possible.

Ten-Year Outlook

No further production expected, but upgrades will continue.

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