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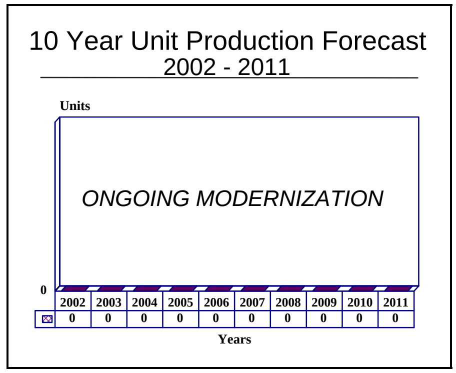
AWACS – Archive 01/2003

Outlook

- In service, with ongoing logistics support and maintenance
- Radar System Improvement Program under way
- NATO Mod Block 1 upgrades complete
- Upgrades for France and Saudi Arabia



Orientation

Description. Airborne early-warning surveillance and control radar (AWACS).

Sponsor

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(Color Monitors)

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(Data displays, in cooperation with Hazeltine)

Status. In service, ongoing logistics support.

Total Produced. A total of 73 systems have been produced.

Application. Long-range aircraft surveillance, aircraft and weapons control operations, command and control relay, and ESM operations.

Price Range. US$111.9 million per aircraft (US$, FY83) APY-2 retrofit, US$17 million; RSIP upgrade, US$24 million per aircraft. The September 1997 Selected Acquisition Report noted that the RSIP program cost was US$181.6 million (FY97 base), a decrease of US$6.4 million, reflecting a decrease of one unit.

Technical Data

	Metric	**US**
Dimensions		
Weight		
Radar:	3,632 kg	8,000 lb
Processor:	829 kg	1,826 lb
Dimensions (antenna):	7.3 x 1.5 m	24 x 5 ft
Dimensions (radome):	9.1 x 1.8 m	30 x 6 ft
Height above fuselage:	3.4 m	11 ft

	Metric	**US**
Characteristics		
Aircraft		
Boeing 707-320B		

	Metric	US
Characteristics		
Endurance:	11.5 hr	
Max range:	6,496 nm	
Ceiling:	39,000 ft	
Crew		
E-3A/D/F:	17 (4 flight crew, 13 AWACS specialists)	
E-3B:	21 (4 flight crew, 17 AWACS specialists)	
Boeing 767-200ER		
Endurance:	7 hr @ 1,000 nm radius	
	10 hr @ 300 nm radius	
	22 hr (with in-flight refueling)	
Max range:	5,000 nm (unrefueled)	
Maximum take-off weight:	385,000 lb	
Crew:	20 (2 flight crew, 18 AWACS specialists)	
Radar		
Frequency:	2 to 4 GHz (10 cm)	
Downlook range to horizon		
E-3 at 30,000 ft:	400 km	245 mi
Antenna		
Slotted planar		
array:	30 slotted waveguide sticks	
Antenna rotation rate		
Operational:	6.0 rpm	
Non-operational:	0.25 rpm	
Radome weight:	13,000 lb (including struts)	
Processor		
Performance:	2.7+ Mips	
	2.0+ Mflops	
Main memory storage:	2.5 M words	
Bulk memory:	4 M words	
Growth potential		
Main:	22 M words	
Bulk:	16 M words	
MTBF:	4,300 hr	
MTTR:	36 min	
Useful life:	15 years	

Design Features. The E-3 AWACS aircraft is a modified Boeing 707-320B airframe with a dorsal radome that houses the rotating surveillance radar system antenna. The antenna is mounted back-to-back with a complementary IFF/secondary surveillance radar antenna. The fuselage houses the radar transmitters, computers, displays, and associated communications and electronics equipment.

The radome antenna has a normal rotation rate of 6 rpm. A non-operational rate of 0.25 rpm prevents rotodome bearings from freezing up during flight. The radar operates in the 10 cm frequency band, and has seven operating modes. On any azimuth scan, the surveillance volume can be divided into 32 subsectors, each with its own operating modes and conditions. These modes can be accommodated on subsequent scans, or rearranged to vary the types of coverage in any particular area of interest to accommodate changes in operating conditions.

The first 24 of the 34 USAF AWACS aircraft were equipped with the APY-1(V) radar and the remaining 10 were delivered equipped with the APY-2(V). The newer radar has an enhanced maritime surveillance mode which enables the E-3 to detect large and small surface ships, either moving or stationary. The "lookdown" AWACS radar performs satisfactorily in all kinds of weather and above all types of terrain.

The radar's reliability and ease of maintenance is the result of several initiatives. These include the use of the following: high-reliability components throughout the system, digital technology, proven integrated circuits and functional groupings of circuits, redundancy of critical circuitry with automatic switchover, and built-in test with fault isolation to an individual circuit board. Also included is in-flight maintenance capability. Radar operation is constantly monitored by software-controlled, built-in test equipment.

Fault detection tests provide an approximate 98.5 percent probability of detecting on-line faults. Redundant circuitry automatically reconfigures the system in case of malfunction. Replacement of many non-redundant units can be accomplished while airborne.

Operational Characteristics. The modes of operation are:

PULSE DOPPLER NON-ELEVATION SCAN (PDNES). This mode provides aircraft surveillance down to the surface using pulse Doppler, with narrow Doppler filters and a sharp beam to eliminate ground clutter. Target elevation is not measured in this mode.

PULSE DOPPLER ELEVATION SCAN (PDES). This mode is similar to PDNES, but target elevation is derived from electronically scanning the beam in the vertical plane.

BEYOND-THE-HORIZON (BTH). This mode uses a radar pulse without Doppler for extended-range surveillance where ground clutter is in the horizon shadow.

INTERLEAVED. PDES and BTH can be used simultaneously with either portion active or passive. PDNES can be used simultaneously with the maritime mode.

MARITIME. The radar was modified to provide a maritime surveillance capability. This involves the use of a very short pulse widths to decrease sea clutter, enhancing the detection of moving or stationary ships.

PASSIVE. In this mode, the radar transmitter is shut down in selected subsectors, while the receivers continue to process electronic countermeasures (ECM) data. A single strobe line passing through each jamming source's position is generated on the display console.

TEST/MAINTENANCE. Control is delegated to the radar technician for maintenance purposes.

STANDBY. In this mode the radar is kept in an operational condition, ready for immediate use.

Blanking commands in BTH and pulse Doppler modes can be used in each of the subsectors, enabling system resources to be concentrated in those subsectors of greatest interest.

The radar pulse was reshaped to prevent interference with certain ground radars in the Western European theater. A program called Salty Net enabled AWACS to operate with the 412L, NADGE and other systems. The NATO AWACS was designed to interface with the 407L Tactical Air Control System.

AWACS has become a major asset in peacekeeping, peacemaking, and resolving regional conflicts. The radar surveillance capability is now just one mission typical of the Sentry. Improved electronic support measures (ESM) equipment is making it a valuable electronic surveillance asset, in spite of the existence of dedicated ESM aircraft. Command and control, as well as positive control of fighter forces, have been added to the surveillance role of AWACS.

During operations in the Middle East and Balkans, AWACS became a focal point for communications between ground commanders and their air forces and maritime assets.

AWACS has been used in all major conflicts since it was first fielded, including the Persian Gulf War and Bosnia. E-3s still monitor the skies over Iraq and Bosnia, and are often deployed on drug interdiction missions off the south and southeast coasts of the United States.

AWACS

Source: DoD DOTE

Variants/Upgrades

E-3A. NATO and Saudi Arabian standard. NATO is upgrading its fleet with the Radar Technology Insertion Program. Saudi Arabia is beginning a program to upgrade its mission computers and software to increase ease of use and operator efficiency. RSAF modifications begun in March 1999 were to be completed by November. Two ground support systems were to be modified in 1998 and 1999.

E-3B. Upgraded US aircraft. In addition to an ongoing series of radar and datalink upgrades, the USAF added a Boeing phased array communications antenna to support the Air Force Expeditionary Experiment (EFX '98) to enhance the command and control capabilities. The new antenna could receive large amounts of information quickly, allowing operators to make decisions and direct actions with the most current information available. The antenna consists of 1,500 elements in a 2 foot x 3 foot, 1-inch thick surface mount. The phased array aperture directs two independent beams electronically. This permits instantaneous connections between satellites and mobile platforms. The antenna system has a demonstrated ability to automatically acquire and track broadcast satellites and display television onboard the aircraft. The antenna will be evaluated on C-135 and KC-135 aircraft as well.

The US Fleet is also receiving seven Electronic Control Signal Programmer (ECSP) kits and seven A3 circuit boards as the first step in providing a more modern computing architecture for AWACS operators. This will allow the use of a Windows-like environment, better maps, additional colors and symbols, and an improved airborne tracker. Production of the kits is expected to be competed by July 2000.

E-3D. United Kingdom version, Sentry AEW.1. The RAF intends to upgrade all seven aircraft to 14 mission consoles (from the current nine). This will create a common configuration with US E-3Bs. A time schedule is pending.

E-3F. French version. The French Air Force is installing a US$16.5 million set of ESM upgrades on its four aircraft. The first modification began in early 1999; the fourth installation is scheduled to be completed in December 2000.

E-767. The Japanese version. Four have been acquired. Two were delivered in mid-1998 and the second pair a year later. This is considered the future standard AWACS platform.

Since initial fielding, the US E-3 AWACS has undergone nearly continuous modification. Early modification included adding a maritime ship radar detection capability, integrating first generation Class I Joint Tactical Information Distribution System (JTIDS) datalink terminals, and increasing operator displays from nine to 14 to support considerably broadened mission tasks and workloads. A significant number of modifications have updated mission systems, subsystems, flight controls and navigation software, and replaced selective hardware components with more reliable parts.

Block 30/35. This upgrade adds a 360° passive Electronic Support Measures (ESM) system (AYR-1(V)) to support detection and identification; adds a Global Positioning System navigation capability; replaces the Class I JTIDS terminal with a Class 2H (High-Power Amplifier (modified)) terminal; and adds memory capacity to the central mission computer to support ESM and JTIDS.

Radar System Improvement Program (RSIP). This upgrade improves the overall performance of the APY-1/2(V) radar against small airborne targets, improves electronic counter-countermeasures (ECCM) capability, and increases reliability and maintainability. The upgraded system will detect and identify non-cooperative targets out to 300 nautical miles. The modification replaces the aging AWACS radar subsystem computer, the Airborne Radar Technician workstation, other selected radar system hardware, and radar subsystem software, to improve pulse-Doppler radar sensitivity and resistance to electronic countermeasures, as well as increase reliability and maintainability of the modified components. It increases the E-3's radar sensitivity, including the development of new waveform and processing algorithms. Improved E-3 reliability and availability are increasingly important as theater commanders continue to rely heavily on the E-3's surveillance and control capabilities to provide the information superiority required to control the battlespace.

New radar algorithms and other software serve to upgrade system performance, as does a new general-purpose computer that replaces the existing Radar Data Correlators. The new processing computers are based on commercial off-the-shelf (COTS) hardware. The Digital Doppler Processor is replaced by a new Signal Processor. A pulse-compressed radar waveform will improve the sensitivity of AWACS to low-radar-cross-section targets. Re-written software will be easier to maintain and upgrade.

On October 23, 1997, Boeing delivered the first radar system improvement kit to DaimlerChrysler Aerospace (then Daimler-Benz) in Manching, Germany. This was the latest step in the multinational AWACS RSIP effort.

Boeing and its subcontractors, Northrop Grumman, OGMA of Portugal, and ATA of Greece, are on contract to build 18 kits for NATO, four for the USAF and eight for the United Kingdom. DASA began installing the kits on NATO aircraft in mid-November 1999.

Air Force personnel at Tinker Air Force Base, Oklahoma, are charged with installing the RSIP kits for the US fleet. A 1996 contract procured 13 kits for US AWACS. USAF plans were to award a follow-on contract for 18 kits to complete the buy in FY00, with the contract extending through FY05. The planned delivery schedule calls for delivery of three kits in FY02 and five kits each year from FY03 to FY05. The contract will require continued contractor support for software maintenance and may also require the contractor to redesign hardware and software as a result of Diminishing Manufacturing Sources, without degrading system performance.

British Aerospace, which will retrofit the United Kingdom fleet, began receiving kits in June 1998. By the end of 1999, 11 of 17 NATO aircraft had been retrofitted by DaimlerChrysler Aerospace with the RSIP kit. The remaining would be completed by early 2000.

<u>Common Large Area Display Set Program (CLADS)</u>. In September 1999, the Raytheon Marine Company Digital Display Group was awarded a firm-fixed-price contract, with options, to replace the CRT-based crew station monitors with variations of the Raytheon 21" Digital Ruggedized (21 DRD). This was part of the USAF Common Large Area Display Set Program begun in 1995 to address the reduction in manufacturing sources for the large display systems used aboard AWACS, JSTARS, and ABCCC aircraft.

It moves away from cathode ray tube technology toward digital display systems which will have greater reliability and image clarity. AWACS, JSTARS, and ABCCC are the initial aircraft to be retrofitted under the CLADS program. A US$29 million contract calls for up to 1071 displays; initial deliveries began in the fourth quarter of FY99.

The CLADS program defined requirements for a common display that could be used on multiple platforms. Testing took place from 1996 to 1998.

<u>Wide-Band Klystron</u>. The APY-1/2 klystron power amplifier has a low mean-time-between-failure and is costly to repair. The Air Force announced an FY2001 Foreign Comparative test Program (FCTP) which will evaluate a wide-band klystron power amplifier manufactured by Thorn TMD of the United Kingdom to determine if it can achieve greater reliability and lower operating and maintenance costs. If successful, procurement of the new tubes could follow.

Program Review

Background. Boeing received the prime contract for AWACS in July 1970. Two prototype aircraft were derived from the commercial 707-320B and used as test platforms for two competitive radar designs developed by (then) Westinghouse and (then) Hughes. The Westinghouse design was selected in 1972.

Full-scale development began in January 1973. Four FSD aircraft were then produced for mission avionics and airworthiness testing that was completed at the end of 1976. The first production E-3A delivery to the Air Force took place in March 1977; the last delivered in June 1984.

In FY84, six E-3As were delivered to NATO. Research and development continued on communications equipment, ECM and ECCM, but not the radar. USAF E-3As, Nos. 25-34, carried new communications equipment and featured the APY-2(V) sensor with a maritime surveillance capability, bringing them to the standard NATO AWACS aircraft configuration.

In FY85, the last three E-3As were delivered to NATO, and retrofit of the standard NATO AWACS systems to USAF E-3As Nos. 1-24 was begun. These aircraft were redesigned E-3Bs. Delivery of the radars for five Saudi Arabian AWACS aircraft began.

The USAF canceled plans to procure any aircraft beyond the planned 34. The funds appropriated for these aircraft were diverted to the development of new wide-area sensors, such as the over-the-horizon radar.

In April 1985, the Air Force solicited Boeing and (then) Westinghouse for full-scale development of the radar upgrades. Within one month, the Air Force ran into cost and technical risk problems. The program was delayed pending resolution of several cost and engineering questions.

By mid-year, Boeing had developed software tools which would improve the productivity and efficiency of the AWACS development phase. The Air Force cut back some of the radar requirements as a cost and risk reduction strategy.

The British decided to order six AWACS aircraft in December 1986, and the French placed an order for three aircraft in March 1987. The British and the French orders each contained an option for another two aircraft. Combined, the British and French orders were worth US$1.8 billion; the two countries were able to achieve economy of scale advantages in unit pricing.

During FY88, engineers studied radar system and software improvement options for the E-3A to improve performance against low radar cross-section targets. In October 1988, the US Air Force announced that it would reissue its solicitation for the radar system improvements. The Improved Radar Group B Class V modifications would replace the Radar Data Correlator & Digital Doppler Processor with a Surveillance Radar Computer (SRC), replace the Radar Control & Maintenance Panel with a Surveillance Radar Control & Maintenance Console, modify the receiver, and replace the Surveillance Radar Computer Program with new software.

The acquisition would be scheduled so that the installation would provide maximum concurrence with the Integration Contract Block 30/35 retrofit, which had been scheduled to begin in FY92.

On September 25, 1989, the USAF Electronic Systems Division awarded the Group A (airframe) and Group B (radar) modification, full-scale development contracts to Boeing and Westinghouse. Boeing's contract was valued at US$65,262,580, and Westinghouse's award was for US$223,594,800. Both efforts were completed in September 1994. Modification costs were set at approximately US$20 million per aircraft (in then-year dollars) with the costs shared by the various user nations. One estimate had the US footing approximately 40 percent of the cost of the NATO upgrades.

Westinghouse was contracted to replace the Digital Doppler Processor with a new Adaptable Signal Processor and provide a new General Purpose Processor to replace the Radar Data Processor. The enhanced processing capabilities would improve the radar's ability to track smaller radar-cross-section targets. Contract requirements called for a ten-fold increase in system reliability, with processor enhancements improving onboard maintenance capabilities.

The Air Force planned to conduct 90 DT&E flight tests of RSIP, as well as perform reliability verification testing, a maintainability demonstration, and software qualification. Boeing was contracted to accomplish structural upgrades to accommodate weight increases, manage equipment integration, accomplish cooling/wiring modifications, and conduct flight tests. The RSIP FSD program included fabrication of the first five modification kits, and concluded after the flight tests were completed in the 1994/1995 time frame.

An Addendum Multilateral MOU (MMOU) for NATO AWACS Modernization was signed by all 12 NATO nations on December 7, 1990. This MMOU included NATO participation in the RSIP program and other US

E-3 improvements (CC-2E Memory Upgrade, Color Consoles, HAVE QUICK Communications, JTIDS TADIL-J COMSEC, Self Protection, & Mobility Support Equipment).

The US and NATO would cooperatively develop the E-3 RSIP, according to a cooperative agreement signed on May 7, 1992. The UK and France indicated a desire to participate in the RSIP program, and other US E-3 improvements. A NATO CC-2E Memory Upgrade production contract was awarded in June 1991.

Production of the radar for the last 707-based AWACS ended in February 1991. Boeing shut down its 707 line in the middle of that year when orders were insufficient to keep the facility open. Boeing then selected the 767-200ER airframe with GE CF6-80C2 engines to carry the radar. The new aircraft would have a 10 to 20 percent range advantage over the 707-based AWACS.

Aside from structural upgrades, modifications include increased electrical power to support the electronics equipment carried by the airborne early warning (AEW) aircraft. This was accomplished by installing two 150 kVA generators per engine. With this capability, a 767 AWACS can operate on station with one engine out. The new aircraft also has an in-flight refueling capability. The radar configuration does not change, but the aircraft has been configured to carry improved communications and JTIDS terminals.

Japan once expressed interest in procuring up to 14 AWACS aircraft during the 1990s, but decided to procure four during its 1991 to 1995 five-year defense spending plan. In late 1991, budget problems and price increases caused Japan to drop the AWACS request from its FY92 plans. Also, reports indicated that the cost of the aircraft had nearly doubled. Air Force sources said that the original price was based on a requirement for 14 E-3s. Dropping procurement to four, together with the production-line shutdown, increased costs significantly. The US government continued to promote a Japanese purchase of AWACS.

By late 1992, after reconsidering its position and prompted by a price reduction of up to 30 percent, Japan announced that it would include two 767-based AWACS radars (E-767) in its FY93 budget. This was done even though the US$840 million order caused other aviation programs to be deferred. Japan placed the order in November 1993. The aircraft would have 14 mission consoles, a crew of 20, and flight duration of 12 hours. Patrols will be conducted off the central and western coasts. The APY-2(V) radar would include the Maritime Surveillance Mode.

Budget constraints and a new Japanese government elected in 1993 delayed formalizing the purchase of the second pair of aircraft. In October 1994, Boeing received the order for a second pair of 767 AWACS, a US$773 million order that comprised a Foreign Military Sale of the AWACS mission equipment, and a commercial sale of two Model 767-200 aircraft modified to carry the mission electronics and related equipment.

Modifications included strengthening the aircraft structure to carry the large rotodome on top of the aircraft, and installation of a larger electrical-power generation and distribution system. Following modification, the aircraft was flown to Seattle, Washington, for installation and testing of the rotodome and mission system.

After production of the first 767 AWACS platform was completed on October 3, 1994, the aircraft was flown to Wichita, Kansas, in late November 1994. The first two AWACS aircraft were to be delivered to Japan in 1998, the third and fourth aircraft in 1999.

In October 1993, the Pentagon announced a series of pilot programs for changed acquisition policy and procedures. One was the <u>Commercial Derivative Aircraft (CDA)</u>, whereby the military would purchase commercial aircraft built on the same production line as commercial airframes using commercial practices, and then add mission-specific equipment and modifications. The purpose was for companies to produce aircraft with little change from the existing production line, resulting in significant cost reductions. The Japanese AWACS aircraft fell into the Phase 1 category of this program. The Boeing 767s were built on the basic 767 line, flown to St. Louis, Missouri, and outfitted for AWACS.

The Air Force announced that it would solicit a proposal and issue a sole-source contract to Westinghouse to serve as the prime contractor and chief evaluator of an AWACS Radar Assessment Project. The purpose of the project would be to assess the radar performance of each operational E-3 AWACS aircraft in the US fleet. The plan included a pre-assessment operational check-flight, in which current radar performance would be established; and a ground assessment, in which the radar subsystems/assemblies located in the rotodome, cabin, and lower lobe would be inspected in detail. Anomalies would be troubleshot, and assemblies/components repaired and/or replaced as required.

A post-assessment operational check-flight would establish the improved radar performance baseline. Each aircraft would be monitored for 12 months. The effort would also include a radar configuration audit.

The acquisition phase of the RSIP program began in earnest in FY96. A cooperative agreement struck in mid-1995 would upgrade the 18 NATO aircraft and provide for two US LRIP upgrade kits, with options for 11 additional US kits. The US planned a follow-on RSIP contract in the year 2000, and would carry roughly 65 percent of the estimated US$487.9 million upgrade cost. Congress and NATO have both been favorably disposed toward AWACS and continued funding of the upgrades.

In January 1997, the first E-767 completed a six-month flight test and received FAA certification. The first flight was made in August 1996, and the testing included 130 flights and over 360 flight hours.

On September 3, 1997, the Pentagon formally notified Congress that the government of Korea had requested the purchase of four E-767 AWACS. In November 1998, Korea revealed that the AWACS program was among the US$18.5 billion in defense programs which would be delayed or canceled as a result of the nation's fiscal woes. Lack of funds and governmental priorities caused the changes in the nation's budget.

The United Kingdom received the first of eight RSIP kits (seven aircraft, one support) in December 1999. The RAF is also upgrading its AEW.1 ARI.1842 *Yellow Gate* ESM systems and installing radios and airborne command-element capabilities in three aircraft.

The first four E-767 AWACS entered operational service with the Japan Self-Defense Force in May 2000.

<u>NATO Upgrades</u>. The NATO Airborne Early Warning and Control Program Management Agency (NAPMA) has been engaged in or considering a variety of AWACS upgrades.

Near-term enhancements include:

- ESM system installation
- Radar upgrades (RSIP)
- Jam-resistant HAVE QUICK II radios
- Color displays to replace nine black-and-white screens on each aircraft
- JTIDS and Link 16 enhancements

These enhancements make the NATO aircraft interoperable with US, British, and French AWACS. The US$1.2 billion program was planned to end in 1998. These mid-life upgrades were being considered for implementation after 1997. A replacement platform for AWACS is not going to be considered until after 2020.

In early 1993, Boeing received a contract for the NATO Mod Block 1 contract from the NATO AWACS Program Management Organization. The contract would involve production and installation of color displays to improve the form and usability of incoming situational information; of HAVE QUICK radios to enhance UHF communications by adding security and anti-jamming features, and of a version of JTIDS called Link 16, which would increase the amount of information that could be collected and distributed among other AWACS airplanes, allied aircraft, and ground stations. This contract was amended in 1994 to include ESM upgrades. This would be jointly funded by NATO and the US Air Force.

The first NATO aircraft to receive the Mod Block 1 upgrades arrived at Boeing's Seattle facility in late 1994. Boeing crews outfitted the first aircraft, N-1, with the upgrades to verify the hardware and software engineering as well as the installation instructions. A short flight-test phase ran through early 1995. Boeing was then committed to oversee installation of the upgrades into a second aircraft at Deutsche Aerospace AG (DASA) in Germany.

In November 1995, the United Kingdom requested manufacture and integration of the USAF/NATO RSIP into its E-3D AWACS aircraft. The estimated cost of the proposed sale was put at US$182 million.

The NATO Mod Block 1 contract was completed in December 1997.

A second upgrade being considered would include:

- Replacing the Omega/VLF navigation system with GPS
- Improving the man-machine interface with a mouse-operated, Windows-based computer technology at crew workstations, along with automatic radio tuning and switching
- Improving satellite communications
- Mode-S IFF
- A rapid data fusion capability
- The IRST TMD upgrade
- Radar improvements to include low-flying, slow targets, as well as improved non-cooperative target identification

In November, 2000, Boeing and a team of companies completed the first hardware upgrade as part of the NATO Mid-Term Airborne Warning and Control System (AWACS) Modernization program. The enhancements installed included state-of-the-art flat panel displays with graphic user interfaces; multi-sensor integration to improve the tracking and target identification reliability and accuracy; the new mission computing system with an open-system architecture to allow for cost-effective future upgrades; digital communications systems with automatic record and replay and satellite communications capability; broad-spectrum very-high frequency radios for greater interoperability with Eastern European air forces; improved transponders for greater compatibility with international air traffic control systems; and an upgraded aircraft navigation system using GPS.

Boeing started work on the first aircraft in December and is awaiting a follow-on contract for upgrades to the remaining 17 NATO aircraft. With the completion of the hardware upgrade, Boeing will now install the mission computer software and conduct an engineering, test and evaluation phase that will lead to flight testing in January 2001. The work was originally expected to be completed by the spring of 2000.

The Pentagon has also been considering a contract to maintain interoperability and commonality among US, British, and French AWACS aircraft. The NATO effort could run through 2004.

In May 2001, the Defense Security Cooperation Agency notified Congress of a request from France for the manufacture integration of RSIP modification kits for their E-3Fs. The requirement was for four kits, installation, system integration and ground/flight testing, software development and installation, a ground-based RSIP kit, spare/repair parts, and support. The value was put at US$190 million.

In August 2001, Boeing began installing new mission computers and other hardware/software upgrades designed to bring the five Saudi AWACS to the same level as US AWACS. The effort would include operator training and was valued at US$60 million. The first two aircraft would be retrofitted in 2001 and the remaining three in 2002.

In August 2001, Raytheon and Boeing completed a demonstration of CEC-AWACS interoperability. The same CEC USG-3(V) suite as is carried by the E-2C *Hawkeye* was installed. This will be the same as what will be installed in the AWACS Fleet, should that program be approved. AWACS is also considered an important part of future Joint Composite Tracking Network (JCTN) plans.

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 was 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, would assist US with stepped-up continental defense operations in the wake of the September 11th terror attacks in New York City and Washington. A Boeing 707 transported detachment personnel and their equipment.

The NATO aircraft began deploying October 9th from Geilenkirchen, Germany, with the last of the five planned to be in place at Tinker Air Force Base, Oklahoma, by October 11th. The aircraft would be under NORAD command and flown by multinational crews from twelve NATO nations. The NATO AWACS would provide radar coverage and surveillance operations for NORAD combat air patrols. After the terror 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.

Military personnel, by nationality from the NATO E-3A Component, deployed 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.

AWACS Upgrades (PE#0207417F). This DoD budget program element develops and integrates system improvements which will enable the E-3 AWACS to remain an effective, survivable airborne surveillance system for command and control of tactical forces, and for strategic defense of the United States. This program is considered Operational Systems Development within the RDT&E category established by the DoD.

The Block 30/35 upgrade included Electronic Support Measures, Central Computer Memory Upgrade, Joint Tactical Information Distribution System (JTIDS) Class 2H/TADIL J and NAVSTAR GPS integrated navigation (GINS). The Block 30/35 upgrade is a production program.

The Radar System Improvement Program (RSIP) increases radar reliability and maintainability, improves E-3 surveillance capability against evolving threats posed by low radar-cross-section fighters and cruise missiles, improves ECCM, and enhance man-machine interfaces for the Airborne Radar Technicians (RSIP is a production program).

Block 40/45 Risk Reduction performs research and analysis of selected high-risk areas to the next major AWACS Mission System Computers and Displays upgrade. This essential modernization will improve the sensor-to-shooter capability, improve Combat ID, and open the existing architecture to enable cheaper and faster upgrades. To ensure the warfighter requirements are met, these risk reduction studies include concept exploration to obtain Track Quality 7, modeling/simulation of the Block 40/45 architecture, designing a COTS technology insertion process, and reducing the total ownership cost. Other research efforts focus on design alternatives for data fusion with Multi-Source Integration and Data Link Infrastructure timing constraints.

The <u>Command & Control, Intelligence, Surveillance, and Reconnaissance (C2ISR) System Architecture Improvements</u> (formerly Offensive Counter Air Upgrades/ Systems Architecture Improvements) are concept exploration and program definition/risk reduction efforts that implement a spiral development process allowing continuous improvements and implementation of the C^2ISR road map for the Airborne Early Warning & Control mission area. These efforts include AWACS augmentation with UAV surveillance sensors, AWACS weapon system integration with Integrated Command and Control System, development of and migration to Real-Time Defense Information Infrastructure Common Operating Environment, development and execution of Joint Expeditionary Force Experiment (JEFX) initiatives to be demonstrated on AWACS during JEFX live-fly experiments, rapid prototyping of "plug and play" applications that provide significant situational awareness improvements to the Air Battle Manager in Offensive and Defensive Counter Air missions.

<u>Periodic Depot Maintenance/Airframe (PDMA)</u> are modifications to the E-3 mission equipment and aircraft systems designed to keep the aircraft operational.

The <u>E-2/E-3 Commonality</u> effort focused primarily on advanced receiver and processing technologies. This effort provides a forum to review all activities in the E-2 and E-3 AWACS programs and identify additional opportunities for technology and development exploitation.

<u>Test System 3 (TS-3)/AWACS Development and Production Test (ADAPT)</u> support included maintenance and operations of the government-owned/contractor-operated test aircraft and associated laboratory facilities located at Boeing in Seattle, Washington.

<u>Cooperative Engagement Capability (CEC)</u> funding in FY00 provided the initial design to integrate the Navy-developed CEC hardware with the AWACS mission system to support a Single Integrated Air Picture (SIAP) flight demonstration. This activity reduces the risk of a full development program to integrate and demonstrate the AWACS contribution to a tactical sensor network with CEC on AWACS.

The 2001 Program Element Descriptor update was as follows:

The funding set forth in this document investigates, develops, and integrates system improvements to enable the E-3 AWACS to remain an effective Battle Management airborne surveillance system for command and control of combat forces and for strategic defense of the US This PE funds the following efforts:

<u>Modernization Programs (3600)</u>. The Satellite Communication (SATCOM) Demand Assigned Multiple Access (DAMA) compliance was mandated by the Joint Chiefs of Staff to expand Ultra High Frequency (UHF) SATCOM access and improve UHF SATCOM system interoperability. The AWACS DAMA SATCOM program will replace two non-DAMA UHF SATCOM terminals on each aircraft with two new DAMA compliant terminals. RDT&E funding covers AWACS aircraft integration risk reduction/Engineering Manufacturing Development (EMD) beginning in FY02.

The Block 40/45 risk reduction program drives down risk of utilizing new technology to meet the AWACS Block 40/45 Operational Requirements Document (ORD) ensuring the Block 40/45 program will meet war fighting requirements. Some of the techniques that will be utilized are modeling and simulation, requirement analysis, and designing a commercial off-the-Shelf (COTS) insertion process. Block 40/45 expects to deliver sensor fusion capability in support of the Single Integrated Air Picture (SIAP) via Multi-Sensor Integration (MSI), improve AWACS' contribution to Time Critical Targeting (TCT) via Data Link Infrastructure (DLI), and replace a 70's-vintage mission computer and display system to improve quality and timeliness of sensor data to the shooter, improve Combat Identification (CID), and enable cheaper, faster upgrades via open systems architecture.

Communication projects such as HF Email, provide the AWACS system with an effective method for electronically receiving critical mission information such as the Air Tasking Order. The program will focus on engineering and retrofitting the current fleet.

Air Traffic Control (ATC) Compliance, the first spiral of the Global Air Traffic Management (GATM) program seeks to make communications and navigation improvements required to meet current mandated Air Traffic Control requirements through EMD and production.

Command & Control, Intelligence, Surveillance and Reconnaissance (C2ISR): C2ISR System Architecture Improvements provide timely enhancements to improve critical areas of the AWACS mission system, particularly in three areas:

1) Worldwide deployment and airspace access: Increasingly restrictive International Civil Aviation

Organization (ICAO) and FAA standards require the AWACS to achieve navigational and communications enhancements in order to retain its worldwide deployment commitment. Programs will focus on risk reduction, EMD, and fielding.

2) Mission Capable (MC) rate improvement: Reliability, Maintainability, & Availability (RM&A) analysis and development projects provide system improvements that boost the below-standard MC rate of this critical C2 platform and increase airframe longevity in order to support its flight commitment to end of operational life.

Such efforts focus on increasing reliability of the air vehicle, command, control and computer, and sensor systems and infrastructure improvements as well as providing solutions to diminishing manufacturing sources. Efforts will also focus on reduction of maintenance man-hours along with periodic depot maintenance improvements to increase aircraft availability. Programs will focus on risk reduction, development, and fielding.

3) C2ISR enhancement and integration: AWACS seeks to fulfill the requirements of Joint Vision 2010/2020, Real Time Defense Information Infrastructure Common Operating Environment, and the Expeditionary Air Force Concept of Operations, as well as supporting the needs of the warfighter (as outlined in Kosovo Lessons Learned and other sources). AWACS seeks to achieve horizontal integration through Network Centric Collaborative Targeting (NCCT).

Sensor and communications improvements, such as the ability to send and receive the air and ground picture via data link to fighter aircraft and record mission data for timely and accurate debriefings, will be developed through rapid prototyping, modeling, and simulation, participation in joint live and simulated exercises (e.g., Joint Distributed Engineering Plant (JDEP)), and collaboration with other sensor platforms through tools such as NCCT. Certain near-term efforts, required by the warfighter to improve the timelines and accuracy of information passed between fighter aircraft in the engagement zone and to provide consistent and replayable mission data once the mission is complete, are quick-reaction programs that can be developed and fielded to support the next air war.

The program includes concept exploration and technology development as well as system development and demonstration efforts. These efforts support continuous improvements and implementation of C2ISR capabilities to enable a joint global strike task force.

This effort includes, but is not limited to, manned and unmanned platforms, space, data links and advanced Battle Management Command, Control and Communications (BMC3) concepts. Fielding strategies will provide for immediate field retrofit when able, otherwise occur in current or future modernization programs. All programs are designed to integrate with and transition into the next C2ISR platform.

<u>Test System 3 (TS-3) and lab support</u> includes maintenance and operations of the Government owned/contractor-operated test aircraft and associated laboratory facilities located at Boeing in Seattle, Washington. These facilities support AWACS modernization and support programs. They also provide the infrastructure for AWACS to participate in live fly and ground-based simulation exercises such as JDEP, Virtual Warfighter Center (VWC), SIAP, and Cooperative Engagement Capability (CEC) studies.

<u>Acquisition Strategy</u>. Most major programs (SATCOM DAMA, Block 40/45, TS-3 and lab support) will be sole-source to Boeing aircraft in Seattle, Washington.

Through FY99, the Air Force spent US$476.803 million on a variety of efforts, particularly bringing the Block 30/35 effort through EMD and into full-rate production. RSIP was shepherded through EMD and OT&E; ESM development was included.

The first Radar System Improvement modification kit was planned for installation on the first AWACS aircraft in mid-1998. RSIP mods for all 17 NATO AWACS aircraft were completed by February 2000. The 32 US Air Force AWACS RSIP modifications are in progress and are slated for completion in mid-decade.

Under subcontract to Boeing, BAE Systems installed seven AWACS RSIP and navigation kits for the UK RAF at the Royal Air Force Base in England.

In FY00, US$7.653 million was budgeted for the C^2ISR effort, US$7.003 million for Test System-3/ADAPT support and program-sustaining efforts, and US$11.981 million for Cooperative Engagement Capability on TS-3. US$16.745 million was budgeted for Block 40/45 Risk Reduction, as a result of congressional transfers from AWACS procurement lines.

The FY01 plan earmarks US$12.112 million for C^2ISR, US$13.775 million for Test System-3/ADAPT support and program-sustaining efforts, and US$8.831 million for Block 40/45 Risk Reduction. US$1.007 million was budgeted for "other" efforts.

The FY02 program budgeted US$5.884 million for C2ISR, US$14.750 for Test System 3/AITS, and US$7.444 for Block 40/45. US$1.029 million was allocated for the ATC compliance development, with US$8.869 million budgeted for Comm projects. SATCOM/DAMA was budgeted at US$8.869.

DOT&E FY2000 Annual Report.

SYSTEM DESCRIPTION & CONTRIBUTION TO JOINT VISION 2020. The E-3 Airborne Warning and Control System (AWACS) provides battle commanders with the ability to observe, assess, and control the entire air battlespace, enabling precision engagement through information superiority to the dominant maneuver force as they engage the enemy. AWACS has been employed in support of joint and multinational operations around the world.

E-3 AWACS is a commercial Boeing 707-320C airframe, modified with an APY-1(V) or APY-2(V) radar. It is equipped with general and specialized mission computers, multi-purpose displays, and clear and secure multiple-voice and data link communications. The United States has a total of 33 E-3s, assigned to Pacific Air Forces and Air Combat Command. NATO, Great Britain, France, and Saudi Arabia also operate variants of the E-3.

The Radar System Improvement Program (RSIP) is a joint U.S., U.K., and NATO radar hardware and software upgrade for the E-3 Sentry AWACS. RSIP is designed to improve the E-3 radar detection capabilities in both benign and jamming environments, as well as enhance radar system reliability.

The Air Force is currently studying which upgrades to include in the next major AWACS modification, Block 40/45. This upgrade will center on replacing the current mission computer and the operators terminals with a COTS computer and a network of operator workstations. It will also enable the Air Force to incorporate several necessary improvements to AWACS functionality, including: (1) multi-source integration; (2) increased Electronic Support Measures system memory; and (3) integration of the Intelligence Broadcast System. These improvements will also be supported by new tracking algorithms, software control of the communications sub-system, human-machine interfaces, and improved data link latency. This upgrade supports continued improvements to E-3 detection and information correlation functions, which extend AWACS capabilities through the 2025-2035 timeframe.

BACKGROUND INFORMATION. Since initial fielding, the U.S. E-3 AWACS has undergone nearly continuous modification. Early modifications included adding a maritime ship radar detection capability, integrating first generation Class 1 Joint Tactical Information Distribution System data link terminals, and increasing operator displays from 9 to 14 to support considerably broadened mission tasks and workloads. A significant number of modifications update mission systems, sub-systems, flight controls, and navigation software, and replace selective hardware components with more reliable parts. The most recent modification, prior to RSIP, was the Block 30/35 upgrade, which included significant improvements in navigation, communication, central mission computer, and electronic countermeasures capabilities.

RSIP replaced the aging AWACS radar sub-system computer, the Airborne Radar Technician workstation, other selected radar system hardware, and radar sub-system software, to improve pulse-Doppler radar sensitivity and resistance to electronic countermeasures. RSIP also increased reliability and maintainability of the modified components. RSIP modification to increase the E-3's radar sensitivity is also planned.

Block 40/45 will replace the aging AWACS computer system, the CC-2E, which is based on an IBM 360 mainframe and the operator's terminals with a network of UNIX-based COTS workstations for the operators linked to several UNIX-based COTS computers, which will perform functions currently resident in the CC-2E, including controlling sensors and processing sensor data and sending/receiving data to data link terminals. The foundation for the Block 40/45 upgrade will be the NATO Mid-Term Upgrade. Block 40/45 should improve the reliability and availability of the E-3, since it will replace obsolete computer hardware for which spare parts are in limited supply. Improved E-3 reliability and availability are increasingly important as theater commanders continue to rely heavily on the E-3's surveillance and control capabilities to provide the information superiority required to control the battlespace.

The Block 40/45 development and test will employ the spiral approach with a number of OT oversight and dedicated OT events to evaluate maturity and reduce risk for IOT&E.

TEST & EVALUATION ACTIVITY. The U.S. RSIP IOT&E started with its first sortie on August 3, 1995. The scheduled six-sortie IOT&E was suspended twice and completed in October 1996. RSIP met operational performance requirements at that time; however, suitability issues remained. Data from U.S. IOT&E were augmented by system performance data gathered during NATO and U.K. tests/exercises, as well as a series of combined developmental/operational test flights.

After the conclusion of IOT&E, the Air Force developed a post-IOT&E action plan to correct the suitability deficiencies highlighted by IOT&E. The plan primarily consisted of software improvements, but also included some hardware improvements. DOT&E monitored the testing of those improvements and analyzed the data. Post-IOT&E results verified significant improvements in RSIP suitability.

The first FOT&E sortie took place on April 8, 1998, using a pre-RSIP APY-1(V) equipped E-3. This provided a performance baseline of the pre-RSIP APY-1(V) radar. The RSIP upgrade was installed on that same E-3 in summer 1998, the first operational USAF E-3 to be RSIP-equipped. The first acceptance flight occurred in October 1998. The second FOT&E sortie was conducted on April 16, 1999, as part of the Green Flag 99-3 exercise. The third and final dedicated sortie, the counterpart to the pre-RSIP first sortie, was flown on May 20, 1999. FOT&E collected 500.2 hours of suitability data from the 552nd Air Control Wing's normal use of the aircraft. FOT&E data collection was completed April 14, 2000.

The USAF is currently scoping the Block 40/45 development effort, including starting to prepare a TEMP. During RSIP, combining developmental and operational tests, as well as gathering test data from NATO and U.K. tests/exercises, significantly reduced test costs and duration. Future testing of Block 40/45 will use this same approach, leveraging existing activities wherever practical. Additionally, modeling and simulation will be employed to evaluate maturity and maximum capacity of some of the Block 40/45 components.

TEST & EVALUATION ASSESSMENT. DOT&E analyzed data from both U.S. and NATO IOT&Es and from combined DT/OT, including post-IOT&E testing. DOT&E determined that RSIP is capable of tracking smaller radar cross-section targets at longer ranges than the predecessor AWACS radar. RSIP is also far more effective when operating against electronic countermeasures. Additionally, we found that the RSIP-modified radar provided significant improvements in several areas of suitability. In-flight repair time, diagnostic effectiveness, fault detection, fault isolation, and built-in-test "cannot duplicate" rates were all system successes and there have been no critical failures of RSIP hardware. However, the issue of software maturity plagued RSIP throughout testing prior to Milestone III. DOT&E found the RSIP-modified E-3 to be operationally effective and suitable, with some limitations. The only negative impact to current system capabilities was to the Beyond-the-Horizon (BTH) radar mode. U.S. crews indicated that they experienced degraded ability to use the BTH mode effectively, although NATO crews reported that they actually preferred the change to how the BTH mode worked.

The initial FOT&E sortie flown in April 1998 provided baseline target detection and radar performance data for the APY-1(V) equipped E-3. This aircraft was subsequently modified with the RSIP upgrade, and the May 20, 1999 dedicated RSIP FOT&E flight collected data to compare against the baseline data. Observations of the second dedicated FOT&E flight, conducted at Green Flag, showed that the aircraft was able to perform its mission as effectively as a pre-RSIP aircraft. No crew or computer workload issues were apparent during this sortie. RSIP hardware and software reliability improved during FOT&E, although software immaturity still has a very high failure rate. Overall, the RSIP radar's reliability is significantly better than that of the pre-RSIP radar. A software change corrected the problem with the BTH mode, providing the same performance as BTH did before the RSIP modification. However, the Air Force has yet to decide whether to implement the change or provide the operator with the option of switching between pre- and post-RSIP settings for BTH.

CONCLUSIONS. In the 1997 B-LRIP, the RSIP-modified E-3 was found to be operationally effective and operationally suitable overall, with some limitations. FOT&E re-examined those areas and found that the Air Force had made significant improvements to the system's hardware and software reliability. The only remaining operational suitability limitation is software maturity. The system's software has continued to mature, significantly reducing the rate of critical software failures. Overall, the RSIP-modified E-3 provides significant suitability improvements to the current system.

LESSONS LEARNED. Re-hosted radar software led to several problems during the RSIP program, in particular, resulting in inadequate protection of aircraft radar hardware under certain operating conditions and degrading the long-range detection and tracking performance of the BTH radar. Both of these issues have been corrected, and steps have been taken in the ground and air test procedures to prevent recurrences of these problems. However, software maturity remains a concern for RSIP. The Block 40/45 program will require re-hosting significantly more software. The 40/45 program should learn from the RSIP program to prevent a repeat of the problems seen in RSIP. DOT&E will ensure coordination occurs between the E-3 AWACS and E-2C Hawkeye program experts to leverage lessons learned and highlight potential pitfalls during multiple simultaneous upgrades.

Funding

US FUNDING

	FY00 QTY	FY00 AMT	FY01 QTY	FY01 AMT	FY02 QTY	FY02 AMT	FY03 QTY	FY03 AMT
RDT&E (USAF)								
PE#0207417F								
AWACS	-	43.4	-	35.3	-	39.8*	-	104.6
Procurement (USAF)								
Mod Kits	-	114.5	-	87.9	-	92.7	-	29.9
Spares	-	40.5	-	18.2	-	28.3	-	16.1

	FY04(Req) QTY	FY04(Req) AMT	FY05(Req) QTY	FY05(Req) AMT	FY06(Req) QTY	FY06(Req) AMT	FY07(Req) QTY	FY07(Req) AMT
RDT&E (USAF estimate)								
AWACS	-	159.8	-	214.2	-	191.6	-	98.4
Procurement (USAF)								
Mod Kits	-	28.7	-	13.1	-	49.9	-	150.2
Spares	-	17.9	-	17.2	-	0.0	-	0.0

*NOTE: The House and Senate Armed Services Committees made no changes in the funding request for FY2002.

All US$ are in millions.

Recent Contracts

(Contracts over $5 million.)

Contractor	Award ($ millions)	Date/Description
Boeing	452.5	Nov 1997 – FPIC contract to provide EMD of functional improvements to the AWACS aircraft. These improvements will include expanding the performance and flexibility of the aircraft and involve radar, communications, avionics, computer, and navigation systems. To be completed July 2001. Supports FMS to NATO. (F19628-97/C-0112)
Boeing	6.0	Aug 2000 – Mod to FFP contract to provide for Phase Two of the Aero Simulation Data Gathering Flight in support of the AWACS Level D Flight Simulator. This will involve test flight of a modified Boeing 707 airframe AWACS, specially modified to record flight performance data. It will subsequently be used to program Level D Flight Simulators. Complete April 2001. (F19628-00-C-0004-P00011)
PLEXYS Interface	12.6	Sep 2000 – Mod to an FFP, ID contract to provide for the upgrade of the AWACS Mission Training Center program to allow it to support top-secret missions; included development of mission simulations and necessary hardware/software support. Complete January 2001. (F33657-98-0021-P00005).
Northrop Grumman	5.8	Sep 2000 – FFP contact for sixteen Trigger Pulse Amplifier (Driver) units for the APY-1/2. Completed September 2000. (F09603-98-G-0017-0013)

Contractor	Award ($ millions)	Date/Description
Boeing	62.4	Nov 2000 – FFP contract to provide for the following on support of the Radar System Improvement Program (RSIP) for USAF AWACS aircraft: five Group A and B radar kits, ten Group A and six Group B in-flight maintenance spares, 19 High Voltage Auxiliary spares kits, special test equipment for the Avionics Integration Support Facility, one log commodity spares, one lot production spares, and engineering support through November 2001. In addition, six spare Transmit Angle controls and 15 spare Thermal Assemblies will be modified to the RSIP configuration. Complete December 2004. (F19628-99-C-0042-PZ0001)
Boeing	25.5	Feb 2001 – FFP contract to provide for procurement, certification, and installation of Global Positioning System Integrated and reduced Vertical Separation Minimum system hardware and software in support of four E-3F. Complete December 2000. (F19628-00/C-0009)
Boeing	7,000.0	May 2001 – Indefinite delivery/indefinite quantity contract for AWACS modernization and sustainment support efforts and effectiveness. the. The purpose of this contract was to lengthen the service life of the AWACS system and sustain and improve operational capabilities. The Air Force can award delivery orders totaling up to the maximum above, though actual requirements may necessitate less than that amount. Period concludes September 2007. (F19628-01-D-0016)
Boeing	27.7	Oct 2001 – Option to provide support for AWACS RSIP program: four Group A and B radar kits and four Group A and B in-flight maintenance spares. Complete December 2005. (F19628-99-C-0042, P00008)
Boeing	70.1	Nov 2001 – FFP contract mod to provide for FY02 AWACS RSIP follow-on production. Under this program, the Air Force will procure nine Group A and Group B radar kits, in-flight maintenance kits, one commodity spares lot, and engineering support. In addition, six spare transmit angle controls and 15 spare thermal assemblies will be modified to the RSIP configuration. Complete December 2005. (F19628-99-C-0042, P00010)
Boeing	7.7	Nov 2001 – FFP contract mod to continue post-production delivery support by adding Phase III. Post-delivery support is Boeing on-site technical assistance in support of the Japanese Air Self Defense Force 767 AWACS. Complete September 2002. (F19628-94-C-0004, P00103)

Timetable

Month	Year	Major Development
	1962	Program initiated
Jul	1970	Prime contract award
Dec	1974	Production decision
Sep	1976	NATO decision
Mar	1977	First production E-3A delivered
	1982	NATO deliveries begin
Jun	1984	Last USAF AWACS delivered
Apr	1985	Last NATO AWACS delivered
Jun	1986	First Saudi Arabian AWACS delivered
Mar	1987	FSD contract for ESM upgrade
Sep	1989	RSIP FSD contract award
Feb	1991	Last new-production radar completed

Month	Year	Major Development
	FY92	Block 30/35 EMD complete
May	1992	RSIP made joint US/NATO program
Jun	1992	RSIP Milestone IIIA decision (LRIP)
Aug	1992	RAF AWACS squadron declared NATO-operational
Mid	1992	Block 30/35 approved for production
Late	1992	Block 30/35 production award scheduled
FY	93-97	Block 30/35 kit production
Nov	1994	Block 30/35 Milestone IIIB full-rate production
Oct	1994	Contract for AWACS integration into two Boeing 767 for Japan Self-Defense Force, announcement of contract for second two E-767 AWACS for Japan
1Q	FY95	Block 30/35 full-rate production decision
Jan	FY95	Begin RSIP DT&E
2Q	FY95	RSIP DT&E flight test completed, ESM full-rate contract awarded, ESM PCA
3Q	FY95	RSIP IOT&E start
4Q	FY95	ESM PCA
Aug	1995	EAGLE sole-source development contract awarded
1Q	FY96	RSIP LRIP decision
2Q	FY96	RSIP PCA
3Q	FY96	RSIP IOT&E completed, RSIP PCA, LRIP decision, Block 30/35 trial installation completed
4Q	FY96	Block 30/35 PCA completed, Block 30/35 LRIP kit-proof complete (2)
Jan	1997	E 767 completes six-month flight test and FAA certification
3Q	FY97	Start Block 30/35 support capability I-level
4Q	FY97	RSIP IOT&E, Milestone III
2Q	FY98	RSIP Kit #1 delivery, Block 30/35 RAA/IOC
3Q	FY98	RSIP trial installation start
4Q	FY98	RSIP trial installation completed
Mar	1998	Delivery of first two E767s to Japan
early	1999	Delivery of second two E 767s to Japan
3Q	FY99	RSIP Kit #2 delivery, RSIP FOT&E completed
3Q	FY00	RSIP Kit #3
3Q	FY00	RSIP Kit #4 & 5 delivery, RSIP IOC
4Q	FY00	RSIP Kit #6 delivery
2Q	FY01	RSIP Kit #7 - 9 delivery
Jun	FY01	RSIP IOC
4Q	FY01	RSIP Kit #10 - 12 delivery
3Q	FY01	Last Block 30/35 Mod induction, Block 30/35 FOC
1Q	FY02	Blk 30/35 FOC
2Q	FY02	SATCOM DAMA MND, Comm projects EMD start, ATC compliance EMD start

Worldwide Distribution

France. France has procured four aircraft and will upgrade them to RSIP standard.
Japan. Japan is procuring four E-767 AWACS.
NATO. NATO has procured 18 AWACS aircraft.
Saudi Arabia. Saudi Arabia operates five AWACS and is upgrading to RSIP standard.
United Kingdom. Britain has a fleet of seven AWACS aircraft.
United States. The US Air Force maintains 34 AWACS aircraft.
Italy, **Turkey**, and **South Korea** are interested in AWACS or some other AEW&C platform.

Forecast Rationale

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

AWACS can often be on the scene within hours and adapted to the mission requirements of most contingency operations. Adding new communications and electronic surveillance equipment will expand the possibilities for the *Sentry* Mission. When teamed up with JSTARS and UAVs, AWACS is an indispensable command asset and resource manager.

Aircraft compatibility among all users means anyone can respond to meet a mission need, so a mix of aircraft would not make too big a difference. Even US aircraft versions vary significantly within the Fleet. 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 COTS developments. The massive improvement in processing power will generate significant operational capability improvements.

It is an effective weapons control, air traffic management, threat warning, and general surveillance/ monitoring system. The current radar and system upgrades expand this effectiveness significantly. In Operation Desert Storm, planners proved that using multiple AWACS aircraft in a coordinated team was most effective in combat operations.

Based on the proven abilities of E-3s in the Persian Gulf, interest in acquiring AWACS has increased, but affordability prevents many from ever being able to acquire it. By switching to the commercial procurement procedure, the Pentagon can reduce the cost of AWACS for international purchasers. Still, the aircraft will be affordable only to large, rich nations, and release of the superstar technology will be tightly controlled.

The introduction of the Boeing 737-based Multi-Role Electronically-Scanned Array (MESA) aircraft will significantly impact this situation. It incorporates new technology to create an AEW&C platform with capabilities approaching that of AWACS, but at significantly lower purchase and operational cost. Most nations that have been interested in AWACS will probably take a long, hard look at MESA.

Radar and computer system upgrades ensure that AWACS will be the premier battle management system for at least another decade. The upgrades capitalize on technological advances and incorporate changes needed to ensure that AWACS can perform in the expected future environment.

There has been sporadic talk about switching to space-based sensors. But this is a long shot, especially since Congress killed FY01 funding for the space-based radar program. The idea was revived for FY02; but it will be decades before AWACS is fully retired.

After the Radar System Improvement Program is completed and operational, many follow-on upgrades and improvements will be accomplished by enhancing computer and ancillary equipment.

New combat concepts and uses of AWACS ensure that there will be further demands on the tried-and-true sensor. Maritime surveillance to support the Navy's Cooperative Engagement Capability, improving data fusion, and inclusion in a tactical cruise and ballistic missile defense network are new ways to capitalize on what the aircraft can do, and at the same time bring operations into line with today's operational concepts.

Spare parts production, maintenance requirements, and upgrades will continue throughout the decade. The Radar System Improvement Program and Block 30/35 enhancements are sustaining the effort. The Japanese procurement may eventually be boosted by additional E-767 purchases. Saudi Arabia, South Korea, Italy and Turkey are interested as well.

The government of Korea canceled its letter of offer for a planned AEW&C procurement of AWACS, when, because of political considerations, it put US$14 billion in acquisitions on hold as part of a major budget reduction. Other potential buyers are finding it hard to justify the cost of AWACS, and some nations are beginning to acquire smaller versions such as the Embraer EMB-145 AEW&C selected by Greece, and the Boeing MESA platform selected by Australia and Turkey. These platforms are less manpower-intensive, more readily maintained, and significantly less expensive than the large versions of AWACS.

Although the E-767 is being marketed aggressively, technology makes it possible to approach the capabilities of AWACS in smaller platforms, especially if the command and control function is moved to ground stations where powerful COTS computers can be used to process radar data linked from the airborne sensors. This may be fiscally and tactically attractive to the potential AEW&C users of tomorrow.

Even when a replacement system begins to come online, AWACS will see many more years of life in the international community, possibly with some of the US aircraft renovated for use by nations that cannot afford the newest technology.

Impact of the War on Terrorism. When terrorists attacked the nation on September 11, everything seemed to turn upside down. 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.

Something had to be done. Most immediate was rescue and recovery, then retaliation, immediate 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 in a flurry of bipartisanship and outrage 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 FY2002 defense budget, and Congress put off debate on many contentious issues to head off divisiveness at a critical time for the nation. Although budget restrictions were lifted (such as not dipping into the Social Security surplus), the money pot was far from unlimited, especially with the nation's economy reeling, so spending goals needed to be prioritized.

In addition, Congress passed a measure (HR 2510) granting executive agencies the power to buy needed goods quickly in emergencies. The law was originally written in 1950 to provide supplies during the Korean War and would have expired September 30. It gave the President the ability to provide loans and financial guarantees for supplies during war or civil emergencies and applies primarily to the Department of Defense and Federal Emergency Management Agency (FEMA).

First and foremost came funds to support immediate recovery and response. US$15 billion was budgeted to help the nation's airlines and for other economic recovery initiatives, including from US$60 to US$75 billion for economic stimulus. There would be ongoing expenditures for force deployment, law enforcement and intelligence operations, as well as to boost stocks of fuel, munitions, and consumables needed in the War on Terrorism. How long this effort would continue was uncertain.

The Secretary of Defense invoked fiscal provisions available under the Feed and Forage Act to handle emergency costs resulting from the terrorist acts. The Feed and Forage Act allows the Military to incur obligations in excess of available appropriations for clothing, subsistence, fuel, quarters, transportation and medical supplies. It also authorizes deficit spending to cover the costs of additional members of the Armed Forces on active duty-beyond the number for which funds were provided in DoD appropriations. (This authority requires congressional notification and does not permit actual expenditures until Congress appropriates the required funds. Such notification was quickly accomplished.) The Department of Defense last invoked the Feed and Forage Act in fiscal 1996 for force protection measures in Saudi Arabia, following the attack on Khobar Towers. While it was invoked at that time, it was not used.

The emergency spending measure (HR 2888 – Public Law PL 107-38) gave the administration nearly free rein to spend half the money appropriated. The added US$20 billion would be provided through later appropriations measures.

Of the initial US$20 billion, approximately US$10 billion was to be made available to the President immediately, with an additional US$10 billion after 15 days. Of that, the DoD would get roughly half, about US$4.25 billion. This would be used primarily for intelligence, command and control, repairs to the Pentagon, and initial response to the crisis.

Once the DoD takes care of emergency and immediate operational needs, planning for the mid-term will begin. Many programs are at a critical point, while others are at a point where changes will difficult to make. Although there is little doubt defense spending will increase over the next several years, how much and for what is going to be in doubt for a while.

The President indicated he planned to boost the defense budget by at least US$10 billion per year over the next five years (exclusive of the operational costs of the War on Terrorism), and initial indications were that Congress would support this. But 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 some 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 some 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 counterterrorism will surface.

The *Quadrennial Defense Review 2001* was delivered to Capitol Hill September 30, 2001. The report was long on philosophy but short on numbers, disappointing those who hoped it would give definitive details on the size and makeup of the future military. 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. The FY02 budget was in the final stages on Capitol Hill and guidance for FY03 had already gone to the Services. These could be adjusted, but the most impact on budget planning would be in FY04 and beyond. Besides dealing with ongoing plans, these budgets will be adjusted 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. 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 to be deferred or ended. Anti-terrorism operations and an increased emphasis on homeland defense (such as Combat Air Patrols over select US cities) will increase spare and repair parts requirements. This will in turn increase the percentage of defense funding for Operations & Maintenance accounts.

At this stage, understanding the various influences and possibilities is more important than trying to predict just what will happen. This makes it possible to better understand the implications of the rapidly changing operational situation on specific programs.

There is little to no chance that the situation will prompt new production of AWACS. The time it would take for new aircraft to be fielded and 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 manageable OPTEMPO/ PERSTEMPO for US assets possible.

Communications and datalink enhancements will be evaluated and promise significant improvements for the E-3s. The ability to communicate around the battlefield as well as efficient "reachback" is important for modern operations. Heavy use will increase the need for depot maintenance and overhaul, with an associated increase in the need for parts and replacement subsystems.

The Boeing Company sent top executives to lobby Congress for help in weathering economic difficulties resulting from the September 11^{th} terrorist attacks by creating a multibillion-dollar market for several of the company's commercial aircraft in FY2002 legislation. The plan would be to select the Boeing 767 aircraft as the next generation of Air Force tanker and position the 767 to become the military's airborne surveillance platform of the future. The company's 737 aircraft would become the new medical evacuation aircraft.

Under a plan that had the support of top members of the Senate Appropriations Committee, the Air Force would lease over the next decade 100 converted 767s as part of a scheme to begin replacing the fleet of 136 aging KC-135E tankers – the workhorses responsible for refueling combat aircraft in Kosovo and in the current Afghan conflict. The phased leasing idea would enable the Air Force to begin acquiring the planes quickly, while spreading out the annual costs and avoiding having to tap into the strained aircraft procurement budget.

Some officials noted that the leasing plan would cost US$16 billion to US$20 billion through 2012. The idea ran into strong objections from some officials at the Congressional Budget Office and at the House and

Senate budget committees who contend it is a ruse that adds to long-term costs and violates a 1997 budget agreement. Some congressional analysts said the smaller 757 might be a better candidate as the KC-135 replacement because it could fit into existing hangars.

The idea could bear fruit for the tankers and medevac aircraft. The Pentagon is considering re-establishing the original requirement for at least 19 JSTARS aircraft, using a new airframe (such as 767) instead of rebuilt 707s. It is unlikely that the USAF will go for new AWACS using current or even the upgraded radar and operator suite. At some point, however, if officials can find the money for more AEW&C aircraft the idea of mounting a MESA "Top Hat" system on a 767 airframe. This would provide the newest sensor and aircraft technology in an aircraft that can handle a larger contingent of operators and controllers.

In the House version of the FY02 defense bill, Congressman Norm Dicks (R-Wash.) used his influence to add US$150 million to demonstrate the feasibility of converting one 767 into a tanker. He added US$190 million for a test of the 767 as a platform for the next generation of multipurpose airborne surveillance planes, replacing both AWACS and JSTARS. As of press time, the conference committee had not yet reconciled the differences between the House and Senate bills to create the final legislation which would be voted on.

Ten-Year Outlook

No further production expected; modifications continue.

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