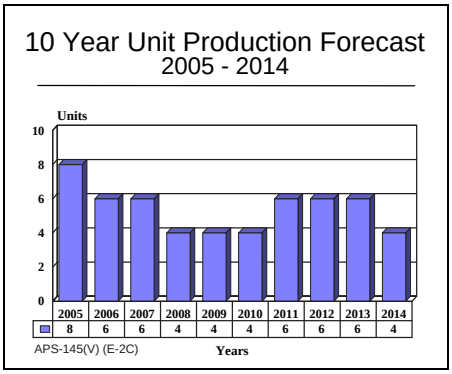
E-2C Hawkeye - Archived 1/2006

Outlook

- Surveillance/ABC2 for U.S. fleet
- Cooperative Engagement Capability, new displays, and increased computer power among changes being fielded by the Navy
- Outyear production will have new antenna



Orientation

Description. The advanced airborne surveillance radar for the E-2C Hawkeye, the Navy's all-weather, carrier-based tactical warning and control system aircraft.

Sponsor

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Status. In service, with ongoing logistics support.

Total Produced. Through 2004, an estimated 243 E-2 aircraft had been produced.

Application. Carrier- and land-based Fleet support.

Price Range. Approximately $3 million for the radar subsystem. The antenna system, including the radome, costs over $1 million. The unit cost of a full Hawkeye 2000 has been put at $71.63 million.

Contractors

Northrop Grumman AGS&BM Systems, http://www.is.northropgrumman.com, 2000 NASA Blvd, PO Box 9650, Melbourne, FL 32902-9650 United States, Tel: + 1 (407) 951-5447, Fax: + 1 (407) 951-6876, Prime

Technical Data

	Metric	U.S.
Dimensions		
Rotodome	0.76 x 7.32 m	2.5 x 24 ft
Antenna weight	772 kg	1,700 lb

Characteristics

APS-145(V) Radar	
Frequency	400 to 450 MHz (in 16 selectable bands)
Peak power	1 MW
Pulse width	13 µsec
PRF	300 pps (3 variables to reduce "blind speed" problems)
Scan rate	5 rpm
Beam	7 deg x 20 deg
Radar range	350 nm (large target); 145 nm (cruise missile)
Target capacity	2,000 simultaneously
E-2C	
Speed	300+ knots (552 kmph)
Ceiling	30,000 feet (9,100 m)
Crew	5
Sortie duration	4.5 hr, typical

Design Features. The E-2C Hawkeye has been the Navy's carrier-based surveillance aircraft for decades. An improved version of the radar suite combines the basic radar and a new antenna system known as the Total Radiation Aperture Control-Antenna (TRAC-A) into a configuration that enables the E-2C to maintain its effectiveness in heavier jamming.

The APA-171(V) antenna system is housed in a rotating radome mounted on top of the aircraft. An Identification Friend or Foe (IFF) array is incorporated into the radome. A three-channel rotary joint was replaced by an eight-channel unit to permit more access to antenna signals, providing automated cues to the operators on the best radar mode for different jamming levels and directional information on the jamming sources (directional information aids interception by battle group fighters). The radar and automated data processing can handle more than 600 tracks.

A key to the Navy's Group 2 Upgrade program was the APS-145(V) radar. Design improvements increased operating range by 40 percent and surveillance space volume by 96 percent, and the improvements made it possible to monitor, track, and display more than 2,000 tracks simultaneously.

The APS-145(V) has sophisticated electronic counter-countermeasures, and its adaptive signal processing provides effective target detection and tracking in complex target environments. The advanced radar incorporates automatic performance optimization that adapts to operating conditions over varied terrain. It monitors the radio frequency environment and selects the clearest operating frequency.

Other improvements included additional anti-jam antennas and an enhanced high-speed processor that doubles the E-2C's Group 1 processor capability. The new computers use parallel processing to boost speed and capability, while seven-color displays present 2,000 tracks on an 11-inch flat-panel screen, a significant improvement over the old monochrome system. With the new displays, operators have more flexibility in overlaying maps and displaying data in moveable windows.

The upgrade included IFF improvements. Range was extended to accommodate the radar's longer-range operation. Automatic interrogation is possible, and a jamming strobe alerts operators to ECM attempts. Enhancements to the Group II E-2C will make it possible for the Hawkeye to remain in service beyond 2015.

Hawkeye 2000. The Hawkeye 2000, the latest generation E-2C, features improved situational awareness and provides over-the-horizon communications and non-organic data access. Hawkeye 2000 has enhanced theater missile defense capabilities and the ability to generate a better theater composite tactical picture with Cooperative Engagement Capability (CEC) improvements.

The baseline Hawkeye 2000 includes the APS-145(V) and improved IFF system, a Joint Tactical Information Distribution System (JTIDS), GPS, and a CAINS II navigation system. The core of the new Hawkeye is a new open architecture central mission computer featuring COTS technology. DEC 2100 333 MHz processors will have a 9-GB removable cartridge memory and identical ACIS 9 GHz workstations. The new processors are half the volume and one-third the weight of the original L-304 computer.

New 17-inch, color, flat-screen, AMLCD-based displays will provide better performance with a 180-pound weight savings, reduced power requirements, and improved reliability compared to the current vacuum-tube displays in use. They have higher resolution and brightness, as well as improved life and lower life-cycle costs. There is a requirement for up to 150 of the new Group II Enhanced Main Display Units (EDMUs).

A satellite communications system makes wideband secure voice, narrowband secure voice, and DAMA/ non-DAMA operations possible. Future growth to full data capability is planned. The aircraft will be equipped with a reduced-weight, 700-pound CEC system, and a 2-inch by 54-inch, 700-pound, end-fire array antenna will be installed in an aerodynamic fairing on the underside of the Hawkeye 2000 to support data communications. Other aircraft improvements include a new vapor cycle upgrade to improve equipment cooling.

Advanced Hawkeye Radar Modernization Program. This is considered a two-generational leap in radar technology for the E-2C. The design will give the Navy far greater threat detection capabilities over land and water, and greater range and precision than the systems in today's Fleet. It will provide an enhanced airborne command and control capability, making it a major node in the Navy's FORCEnet information/decisions grid. The modernization program will provide and integrate key information and surveillance data, fuse decision data, and provide control and communications capabilities.

The Advanced Hawkeye will have a new cockpit. Going beyond the single-purpose "glass" cockpits of modern aircraft, Northrop Grumman engineers are designing displays that will allow either the pilot or the copilot to participate as a fourth mission system operator. Navy operator input has been obtained to guide these designs using the substantial simulation laboratory and demonstration capabilities available to the E-2 program. Other features of the Advanced Hawkeye include terrain avoidance systems and global air traffic management system enhancements.

The SDD contract was awarded to Northrop Grumman in August 2003, and will focus on reducing production and total operational support costs. For example, some of the structures on current Hawkeyes are built from individual sheet metal parts. These structures will be replaced by single-piece machined parts to reduce both cost as well as time needed to construct the subassemblies and mate fuselages. Two-level maintenance concepts, coupled with automated system test capabilities, are being explored to reduce total ownership costs.

The Radar Modernization Program (RMP) is a ground and flight prototype test demonstration and risk mitigation of multiple technologies. It initiates the application of new radar technologies to modernize the primary sensor of the E-2C weapon system to provide a definitive littoral surveillance capability integral to the Navy's Theater Air Missile Defense (TAMD) Integrated Warfare Architecture. Key technologies to be integrated are space-time adaptive processing, electronically scanning array, solid state transmitter, and high dynamic range digital receivers. The resulting detection system will provide a substantially improved overland performance, enhancing all current required mission areas while simultaneously contributing to the emerging TAMD mission requirements. The impact of the dominant battlefield awareness provided by this improved airborne early warning system will substantially contribute to the development of a Single Integrated Air Picture.

The RMP also supported the UHF Electronically Scannable Antenna, which was realigned from RMP Littoral Surveillance for the E-2C. FY02 was the last year of funding for this effort.

E-2 Radar Modernization funding ended in FY03 with $10.376 million.

Operational Characteristics. The E-2C Hawkeye, the Navy's all-weather, carrier-based tactical warning and control system aircraft, provides all-weather airborne early warning and command and control functions for the carrier battle group. Additional missions include surface surveillance coordination, strike and interceptor control, search-and-rescue guidance, and communications relay. An integral component of the carrier air wing, the E-2C uses computerized sensors to provide early warning, threat analyses, and control of counteraction against air and surface targets. During operations in Kosovo, E-2Cs operated more as battle managers than airborne early warning platforms.

The E-2C has been the Navy's AEW command post for over 30 years, and it is the only carrier-based airborne early warning command post in the world. The sensor can monitor a surveillance area of 6 million cubic miles. Automated features, which reduce operator workload, optimize radar performance without the need for operator intervention.

Over land, the radar can track aircraft over most terrain, and ground vehicles when the target density is relatively low. At sea, the APS-145(V) can track all significant naval targets (large ships, fast patrol boats, and stationary platforms) in most sea states.

High-altitude flight allows the battle group radar horizon to extend well beyond that of surface ship sensors, a significant part of naval tactical planning. The system automatically modifies track processing as required to maintain track integrity at land-sea interfaces. Beyond-the-horizon targeting has made the Hawkeye the sensor heart of the Navy's Cooperative Engagement Capability program.

E-2C Hawkeye

Source: U.S. Navy

Variants/Upgrades

APS-120/125(V). The original radar.

APS-138(V). This early variant introduced the low-side-lobe antenna known as TRAC-A (Total Radiation Aperture Control- Antenna). It was first delivered in late 1982.

APS-139(V). The Navy developed hardware/software changes to the APS-125/138(V) as part of a two-phase Update Development Program, adding improved surface detection in high sea state/clutter, improved counter-measures, and an automatic channel monitor/select capability. Modifications to the tactical software program included increased active track capability, display prioritization, and new radar controls.

APS-145(V). UDP Group II modifications to the APS-139(V), or combined Group I/II modifications to the APS-138(V), created a system redesignated the APS-145(V). It is replacing the older radars. Over-land performance is said to equal the E-3 AWACS radar, and it retained a superior over-water search capability. The APS-145(V) was designed to operate in the Western European electronic environment without undue disruption to friendly users of the frequency spectrum.

Tactical software modifications made as part of the E-2C Block Update II, the Radar Update II, extended the sensor's range and automatic processing capability. This block upgrade affects 50 aircraft.

Mission Computer Upgrade (MCU). This upgrade replaced the L-304 processor with a DEC 2100 333 MHz COTS processor. The new computer is half the weight and one-third the size of the replaced system, with an order of magnitude improvement in performance.

Advanced Control Indicator Set (ACIS). The new, state-of-the-art, COTS tactical workstation leveraged technology from the UYQ-70(V) Advanced Display System. It has a high-resolution, flat-panel display.

Cooperative Engagement Capability (CEC). A co-operative engagement processor, digital distribution system, and steerable end-fire antenna were installed. Onboard sensor data are inputted to the Fleet CEC network.

Satellite Communications. The HF, VHF, UHF, JTIDS communications suite has been expanded with a fully integrated satellite communications terminal to extend Hawkeye operations beyond line-of-sight. It was planned for growth to full data capability.

Vapor Cycle Upgrade. This is a new, environmentally friendly cooling system for the onboard electronics.

Group II Enhanced Main Display Units (EDMU). New 17-inch color flat-screen AMLCD-based displays will provide better performance with a 180-pound weight savings, reduced power requirements, and improved reliability compared to the current vacuum tube displays in use. The EDMUs will provide higher resolution and brightness, as well as improved life and lower life-cycle costs. There is a requirement for up to 150 of the new displays.

Advanced Hawkeye Radar Modernization Program. This RDT&E effort began in FY98 and applied new radar technologies to modernize the primary sensor of

the E-2C system to provide a definitive littoral surveillance capability integral to the Navy's Theater Air Missile Defense (TAMD) Integrated Warfare Architecture.

Key technologies to be integrated are space-time adaptive processing, electronically scanning array, solid-state transmitter, and high dynamic range digital receivers. The resulting detection systems are being designed to provide an improved over-land performance while contributing to the emerging TAMD mission requirements.

The improved detection and longer range performance should increase performance in all environments. Multisensor integration will enable operators to use information from many sources: radar, IFF, CEC, Link 4, Link 11, Link 16, and satellite data feeds. This will help create a Single Integrated Air Picture (SIAP) fused information. The result is a clear, coherent picture of the battlespace.

In January 2002, the Navy awarded Northrop Grumman a contract for Pre-Systems Development and Demonstration (Pre-SD&D) for the E-2C Hawkeye Radar Modernization Program. The 12-month contract would advance the design of the mission system and define the physical architecture of the system, produce preliminary weapon system specifications, and provide associated program plans.

L-3 Communications Randtron Antenna Systems will provide the next-generation antenna to replace the current TRAC-A antenna and rotary coupler. In addition to increased performance, the new antenna will be lighter than the current hardware.

The full SDD contract was awarded in August 2003. It called for modifying two Hawkeye 2000 aircraft to the AEH configuration.

Program Review

Background. The Navy issued the initial APS-125(V) contracts in 1972. The analog portions of the original APS-120(V) were replaced by digital components, resulting in greater sensitivity in the detection of targets in noise and clutter with a reduction in the number of false alarms. Improved electronic counter-counter-measures (ECCM) characteristics were also incorporated.

The APS-125(V) was installed beginning with production E-2C aircraft No. 34 to provide fully automatic overland detection and improved ECCM characteristics. The changes involved substituting line-replaceable units to reduce space and weight. This kit installation program was completed in 1983.

In 1988, an improved APS-139(V) radar was installed to upgrade the Hawkeye to Group I configuration. This was enhanced to Group II in 1991 with the APS-145(V) radar, a new IFF system, an L-304 enhanced high speed processor, new tactical displays, JTIDS, and a GPS system. APS-145(V) installations began in 1991.

In 1986, Lockheed used the APS-138(V) to develop a surveillance version of the P-3 Orion, the P-3B AEW&C. The U.S. Customs Service procured four of the P-3B AEW&C. The Customs Service had previously borrowed U.S. Navy E-2Cs to meet its anti-narcotics surveillance requirements, but required an aircraft with longer range and on-station time. As a result, the Customs Service took delivery of its first Blue Eagle aircraft in September 1988, six months ahead of schedule. The second delivery took place in April 1989.

In June 1989, the U.S. General Accounting Office issued a report on the drug interdiction P-3B AEW aircraft. The findings indicated that the radar performance was as specified, but the P-3B (when compared to the E-2C) was less costly to operate per square mile of area covered because of the higher cruising speed and longer endurance. The P-3B had at least twice the in-flight endurance of the E-2C.

The DoD terminated the E-2C production line for the U.S. Navy in FY93, a year earlier than originally scheduled, citing a declining defense budget. The Navy had planned to seek six E-2Cs in FY93. Without continued production, the Navy would be forced to proceed with massive upgrades and reworking of the shop-worn Hawkeyes.

In April 1994, the Navy reversed its production termination decision and announced that it was considering buying another 16 E-2Cs after 2000, in addition to an extra 20 aircraft it was purchasing between 1995 and 2000. The Navy had determined that procurement of the new-production E-Cs was more cost-effective than a massive upgrade of the existing fleet.

In 1993/94, Northrop Grumman and the Navy became engaged in a series of additional upgrades. Enhancements included a new mission computer, an improved APX-100 IFF, a GPS system, a satellite communications terminal, the Joint Tactical Information Distribution System (JTIDS), new workstation-based mission displays, and the integration of a Cooperative Engagement Capability (CEC).

In mid-1997, Japan requested the modification and upgrade of 13 E-2C Update Group II Mission Suite retrofit kits, to include the APS-145(V) (Category XXI) radars to replace APS-138(V) radars in service. A February 9, 1998 *Commerce Business Daily* notice revealed a $31 million basic ordering agreement for E-2C Group 0 to II Upgrade Kits and Installation Data Packages for the government of Japan.

In 1997 and 1998, the Navy demonstrated the E-2C's ability to acquire over-the-horizon targeting information and relay that information to ships within a battle group. Such enhancements established the E-2C as the airborne link in the Navy's CEC system, which fuses sensor and weapon systems data from several ships to act as a single distributed anti-air warfare net.

Beginning in 1998, the aircraft carried an improved IFF system, new mission computer, new workstations, an ASN-139(V) navigation system, flight control upgrades, and a cooling system upgrade.

The first flight of the new Hawkeye occurred on April 11, 1998, the first in a series of contractor short-term test flights at Northrop Grumman's St. Augustine (Florida) facility. Following Navy acceptance of the test results, the aircraft was flown to the Patuxent River Naval Air Station, Maryland, for an in-depth evaluation of the Hawkeye 2000 system.

In mid-1999, the Navy approved multiyear procurement of 22 E-2C Hawkeye 2000s. This buy generated an order for 22 APS-145(V) radars from Northrop Grumman to Lockheed Martin, a contract valued at between $100 million and $140 million.

A July 1999 notice from the Pentagon announced that the Taipei Economic and Cultural Representative Office in the U.S. was considering a possible purchase of two E-2T Hawkeye 2000E aircraft, two APS-145(V) radar, two T56-A-427 engines, two OE-335/A antenna groups, two mission computer upgrade/advanced control indicator sets, two passive detection system upgrades of software laboratory, spare and repair parts, support equipment, supply support, publications, personnel training and training equipment, U.S. government and contractor engineering and technical services, and other related logistics support. The estimated cost of the effort was put at $400 million. Northrop Grumman was selected as the prime contractor.

In October 1999, Northrop Grumman delivered two E-2C Hawkeyes to the Navy, bringing the total of newly manufactured or remanufactured Hawkeyes delivered in 1999 to eight. One was a new-production Group II, the 183rd produced. The second was a Fleet aircraft modified with the New Mission Computer Upgrade and advanced control indicator set workstations that was to be used in the Navy's OPEVAL in 2000.

In a March 2000 issue of *Commerce Business Daily*, the U.S. Customs Service announced that it intended to negotiate a sole-source contract with Lockheed Martin for four complete APS-145(V) radar system upgrade kits, plus associated spare parts. These radar system upgrade kits would be used to convert the APS-138(V) radars in the Customs Service's P-3 AEW aircraft No. 1 through No. 4 to the APS-145(V) configuration. The updated radar would be fully integrated with the existing TRAC-A rotodome antenna system, TPX-54(V) IFF interrogator, and an updated VME-based computer processing, tracking, and display system as previously accomplished on the P-3 AEW #5 and #6 aircraft.

The April 21, 1999 issue of *Commerce Business Daily* carried the announcement of a $4 million contract to purchase two APS-145(V) radar systems to be installed in two P-3 airborne early warning (AEW) aircraft. System spares were included.

During the Dubai 2000 International Aerospace Exhibition in November 1999 in the United Arab Emirates, Northrop Grumman's Integrated Systems and Aerostructures sector announced a teaming with the U.S. Navy to upgrade E-2Cs with production mission systems based on the Hawkeye 2000 configuration for countries that procured them through FMS. Northrop Grumman would take the aircraft and add the latest mission systems and radar, significantly upgrading the nation's AEW&C capability for less than the cost of a new Hawkeye 2000.

The U.S. Navy plan to upgrade its Hawkeye fleet created this opportunity. Because of the different environments of carrier-based versus land-based operations, the U.S. found that it was not cost-effective to upgrade its fleet of E-2Cs, and decided to procure new-production Hawkeye 2000 aircraft instead. The land-based airframes in service with allies have significant service life left, making upgrades economically feasible. This plan makes it possible for users to acquire advanced AEW systems and benefit from Navy-funded upgrades. It would also improve interoperability between the Navy and its allies.

The first production Hawkeye 2000 was delivered to the U.S. Navy in October 2001. In April 2002, the third Hawkeye 2000 production aircraft was delivered to the Navy, one month ahead of schedule.

Egypt and Japan announced a desire to upgrade to Hawkeye 2000 standard. Egypt would replace the APS-138(V) with the APS-145(V), upgrade the mission computer, and add new work stations. The contact was valued at $138 million. Work on the first Egyptian aircraft was scheduled to begin in late 2002.

In November 2000, Japan ordered two additional upgrade kits and associated services to upgrade its fleet to Hawkeye 2000. The contract to upgrade the entire fleet was put at $400 million, with plans to complete the upgrades over five years, with the first modified E-2C planned for 2004. The modifications would take place at Kawasaki Heavy Industries, Gifu, Japan. Because Japan flies its E-2Cs from land bases, the aircraft have twice the life of U.S. Hawkeyes. These upgrades should bring the service life of Japan's fleet to 2020.

In September 2002, the United Arab Emirates requested the sale of five refurbished E-2C aircraft upgraded to Hawkeye 2000 configuration, including five APS-145(V) radars and five OE-335/A antenna groups, plus engines, support equipment, and other ancillary requirements. Value of the contract is estimated to be $400 million.

In October 2003, the first of the new 17-inch color, flat-panel AMLCD-based displays was delivered for Group II E-2Cs.

Also in October 2003, L-3 Communication's Randtron Antenna Systems Division was awarded a $65 million contract by Northrop Grumman to provide the next-generation Airborne Early Warning radar antenna for the Advanced Hawkeye. Procurement of a full 75 aircraft could bring the value of the contract to over $300 million.

PE#0204152N, E-2 Squadrons. E-2C Improvements provided pre-planned product improvements for the evolution of E-2C airborne warning system capabilities in support of naval warfare command and control requirements. It developed a Mission Computer Upgrade, applying ongoing developments in data processing and target detection, which will relieve current bottlenecks in signal and processing.

Project 0463, E-2C Improvements. E-2C Improvements provides pre-planned product improvements for the evolution of E-2C airborne warning system capabilities in support of naval warfare command and control requirements. It has previously funded developments for the modification replacement of selected weapon replaceable assemblies of current installed subsystems. This has resulted in a new capability configuration referred to as Group II aircraft. The program has developed a Mission Computer Upgrade (MCU), applying ongoing developments in data processing and target detection to relieve current bottlenecks in signal and data processing. The MCU will permit incorporation of additional functional capabilities to satisfy evolving operational requirements (e.g., CEC, and satellite communications), and permits the evolutionary growth of a combat identification and TAMD capability.

In FY03 through FY09, funding will provide for evaluation of technology for new emergent systems and subsystems. This initiative allows for data collection and the evaluation of new technologies in the context of emerging missions and requirements including theater air and missile defense, ballistic missile defense, littoral warfare, combat identification including specific emitter identification, multisource integration, Airborne Battlefield Command and Control, and SIAP, as well as parts and system obsolescence.

Emphasis will be on participation in exercises to assess capabilities against emerging threats, identify deficiencies and solutions, and demonstrate ground/ airborne identified technologies.

E2321, Radar Modernization Program. The Radar Modernization Program (RMP) was a ground and flight prototype test demonstration and risk mitigation of multiple technologies. It initiated the application of new radar technologies to modernize the primary sensor of the E-2C weapon system to provide a definitive littoral surveillance capability integral to the Navy's TAMD integrated warfare architecture.

Key technologies were space-time adaptive processing, electronically scanning array, solid state transmitter, and high dynamic range digital receivers, with the resulting detection system providing a substantially improved overland performance, enhancing all current required mission areas while simultaneously contributing to the emerging TAMD mission requirements. The impact of the dominant battlefield awareness provided by this improved airborne early warning system will substantially contribute to the development of a single integrated air picture.

These technologies and the resultant equipment demonstrated in the ground environment in FY99 was tested from FY01 through FY03. The PE funded RMP pre-engineering and manufacturing development in FY01 and FY02, integrating RMP advanced development hardware into the NC-130H test bed aircraft and including flight test and data analysis of the advanced development system.

Emphasis was on flying qualities testing, NC-130H processing suite design and fabrication, integration and check of the processing suite, RMP flight testing, and tracking analysis. Added modification and flight testing of the NC-130H would be conducted under PE#0604234N, for risk reduction in the core RMP Program. The last funding was in FY03.

PE0604234N, E-2 Advanced Hawkeye. The Advanced Hawkeye will replace the existing E-2C fleet. The AHE program develops, demonstrates, tests, and procures the replacement of the APS-145(V) radar system and other aircraft system components that modernize the E-2C

weapon system to maintain open ocean mission capability while providing the U.S. Navy with an effective littoral surveillance and TAMD capability.

Key radar technologies are space-time adaptive processing, electronically scanning array, solid state transmitter, high dynamic range digital receivers and IFF/radar aperture integration. The resultant detection system will provide a substantially improved overland performance by correcting current sensor shortfalls and enhancing all current required mission areas, while simultaneously contributing to the emerging TAMD mission requirements.

The AHE program also upgrades or replaces aircraft system components that are either obsolete or becoming unsupportable, upgrades or replaces other aircraft systems as required to support the radar upgrade, and improves the producibility of the weapons system. The impact of the dominant battlefield awareness provided by this improved airborne early warning system will substantially contribute to the development of a single integrated air picture.

These technologies were demonstrated in a ground environment in FY99 and continued to be refined through FY03. This PE was utilized for RMP pre-system development and demonstration in FY03, followed by SD&D beginning in 4Q FY03.

The program quickly ramps up in FY04 and FY05 to support a Preliminary Design Review (PDR) in 1Q FY05 and a Critical Design Review in 1st Qtr FY06. The program plan will begin E-2 AHE Pilot Production in FY07 (long lead on four aircraft), begin the production phase with a low-rate initial production Milestone C decision in FY09, and achieve Initial Operational Capability in FY11.

PE 0204152N, E-2 Squadrons, also supports the radar risk reduction effort on the NC-130H test bed aircraft. Two multiyear procurement E-2C aircraft will be modified to provide RDT&E assets for the AHE program.

In FY03, developers conducted Pre-System Development and Demonstration and award/extended the contract to Northrop Grumman. They began E-2 AHE system architecture trade studies, requirements analysis, radar system demonstration/validation, producibility enhancement, and life cycle costs reduction efforts. IFF system integration and demonstration/validation of other mission avionics systems were also conducted.

Also in FY03, developers entered into SD&D for the E-2 AHE program to conduct engineering and development efforts in preparation for System Functional Review for the AHE weapons system. Engineering and development efforts were conducted in preparation for Preliminary/Critical Design Reviews. Funding in FY04 was $282.219 million, with $562.949 budgeted in FY05.

The rest of the effort included a variety of support efforts for the development.

DOT&E FY2002 Report

E-2C Advanced Hawkeye

There are currently two E-2C configurations in the Hawkeye procurement program: Hawkeye 2000 (HE2K) and the Advanced Hawkeye (AHE).

HE2K is an umbrella term for multiple improvements to the Group II E-2C, each of which is a separate program. The key objective of this series of modifications is the integration of Cooperative Engagement Capability (CEC). The integration of CEC into the E-2C will increase the air surveillance, detection, and tracking capabilities of the battlegroup.

The improvements include the replacement of the current mission computer with a commercial off-the-shelf (COTS) computer (Mission Computer Upgrade (MCU)) and replacement of the control and display consoles with COTS workstations (Advanced Control Indicator Set); the integration of the airborne variant of the CEC system; an upgraded cooling system; UHF Satellite Communications; replacement of the current Passive Detection System with an Electronic Support Measures system; and development of a Mission Information Transfer System.

To carry and employ CEC, the E-2C required increased mission computing and display capabilities, as well as an offset in weight and volume. These modifications will be incorporated into new E-2C aircraft production. The Navy also plans to retrofit these improvements into older E-2C aircraft. An upgraded inertial navigation system has also been added.

The AHE program entered System Design and Development in June 2003. This program will replace the E-2C's radar with a UHF Electronically Scanned Array radar via the RMP. This radar is intended to provide significantly increased detection performance over the current radar, particularly in overland and littoral operations.

The AHE includes a number of other modifications including an upgraded Identification, Friend or Foe system, a modernized tactical cockpit, a new intercom system, upgraded electrical generators and power distribution system, an upgraded liquid cooling system, and ARC-210 and Multi-function Information Distribution System upgrades. Additionally AHE will incorporate mandated safety improvements including Crash Survivable Flight Incident Recorder, Terrain Approach Warning System/ Ground Proximity Warning System, Collision Avoidance System, and Integrated Material Diagnostic System. Finally, CEC software modifications will be required by RMP.

TEST & EVALUATION ACTIVITY. MCU follow-on test and evaluation (FOT&E) will be conducted in parallel with the CEC E-2C operational evaluation now scheduled for 3QFY04.

RMP has completed a series of test flights using the radar technology demonstration system developed for Mountain Top installed on a C-130.

DOT&E approved the AHE Test and Evaluation Master Plan (TEMP) in June 2003.

During FY03, there was no E-2C HE2K operational testing but E-2C HE2K developmental testing continued.

The E-2C upgrades were reviewed and are not covered product improvement programs requiring LFT&E. This determination was based on multiple factors, including the intended role and missions of the aircraft, combat experience to date, and concept of operations.

Due to its importance to fleet air operations, the survivability of the E-2C will be evaluated for expected combat missions. The Navy has developed a comprehensive survivability evaluation plan to ensure the needed data and information are available.

TEST & EVALUATION ASSESSMENT. The MCU TEMP approval memo, signed July 27, 2000, called for an update to the TEMP within 90 days to define MCU FOT&E, which will include Electronic Support Measures and Satellite Communications. This TEMP has yet to be formally submitted to DOT&E.

The E-2C survivability program is adequate to evaluate the survivability of the aircraft.

Advanced Hawkeye radar risk reduction flight-testing was performed at the Naval Air Warfare Center Aircraft Division, Patuxent River, Maryland, on the NC-130H aircraft from December 2002 - June of 2003. The Advanced Development Model radar system used during the demonstrations at the Pacific Makaha Ridge Facility in 1997 and 1999 was integrated into the NC-130H. Specific risk reduction objectives included evaluation of space time adaptive processing operation in critical operational environments and conditions and radar system performance. The system was operated in overland and littoral environments that included ground traffic, clutter, jamming, and casual electromagnetic interference. Radar system assessment included controlled target detection range performance in clutter and jamming environments and system accuracy. Initial analysis of flight test data indicates the program met all system risk reduction objectives and achieved all predicted performance capabilities.

A critical aspect of E-2C AHE operational testing will be joint interoperability, an area that was unresolved in the MCU operational evaluation. The Joint Air and Missile Defense Organization is coordinating significant resource investment by OSD in a 2010 theater air and missile defense architecture. In addition to AHE, this effort includes other upgrades, such as the Block 40/45 upgrade to the E-3 and new platforms, such as the Joint Land Attack Cruise Missile Defense Elevated Netted Sensor. Additionally, the Single Integrated Air Picture System Engineering Task Force is coordinating an effort to improve the quality of the air picture available to the Joint Forces Air Component Commander and to the forces conducting and fighting the air battle through improvements in the available data links. Joint interoperability will be key to OSD achieving its theater air and missile defense goals. Therefore, testing the joint interoperability of the participating platforms will be a critical part of their OT&Es.

Funding

U.S. FUNDING

	FY04		FY05		FY06(Req)		FY07(Req)	
	QTY	AMT	QTY	AMT	QTY	AMT	QTY	AMT
RDT&E (USN)								
E3051 E-2 Adv *Hawkeye*	-	343.3	-	597.0	-	609.2	-	526.9
Procurement (USN)								
E-2C	5	379.8	5	425.9	2	238.1	2	245.4
E-2C Mods	-	55.5	-	23.6	-	49.1	-	13.7

	FY08(Req)		FY09(Req)		FY10(Req)		FY11(Req)	
	QTY	AMT	QTY	AMT	QTY	AMT	QTY	AMT
RDT&E (USN)								
E3051	-	623.5	-	280.5	-	TBD	-	TBD

All $ are in millions.

Recent Contracts

(Contracts over $5 million.)

Contractor	Award ($ millions)	Date/Description
Northrop Grumman	6.0	Jan 2003 – Order against a previously awarded basic ordering agreement for E-2T training for the government of Taiwan under the FMS program. To be completed June 2005. (N00019-00-G-0280)
Northrop Grumman	9.7	Feb 2003 – Ceiling-priced delivery order against a previously awarded basic ordering agreement for a Hawkeye 2000 export avionics package, which will improve the radar systems, IFF system, receiver and transmitter navigation system, and mission computer for a Japanese E-2C aircraft under the FMS program. Completed October 2003. (N00019-00-G-0280)
Northrop Grumman	5.8	Fixed-price order against a previously issued basic ordering agreement for 164 spares to support the 15-ton vapor cycle for the French E-2C. Completed October 2004. (NN00019-00-G-0280)
Northrop Grumman	1,932.0	Aug 2003 – CPFF for System Development and Demonstration (SDD) of the Advanced Hawkeye. The SDD phase will consist of modifying two E-2 Hawkeye 2000 aircraft to the E-2 AHE configuration. Complete December 2012. (N00019-03-C-0057)
Northrop Grumman	7.4	Aug 2003 – FFP order against a previously awarded basic ordering agreement for initial spares to support two E-2 Hawkeye 2000s for the Taiwan Air Force under the FMS program. To be completed June 2005. (N00019-00-G-0280)
Northrop Grumman	108.7	Dec 2003 – Estimated value mod to previously-awarded advance contract for FY04 procurement of one Hawkeye 2000 (HE2K) E-2C aircraft and one trainer TE-2C aircraft, including support, long-lead, etc. To be completed September 2007. (N000129-03-C-0044)
Northrop Grumman	13.6	Dec 2003 – FFP order against previously-awarded basic ordering agreement for integrated logistics support and sustaining engineering for E-2C aircraft owned by Egypt, Taiwan, France, Japan, and Singapore under FMS. Completed December 2004. (N00019-00-G-0280)
Northrop Grumman	576.5	Jan 2004 – Modification to convert a previously undefinitized multiyear contract action to a definitized multiyear contract for FY04-FY07 procurement of three Hawkeye 2000 aircraft and five trainer E-2C, as well as associated equipment and support. In addition, one HE2K and one E-2C trainer will undergo SDD modification. To be completed September 2009. (N00019-03-C-0044)
Northrop Grumman	18.2	May 2004 – FFP contract for procurement of one E-2T Hawkeye 2000 tactics trainer for the government of Taiwan under FMS. To be completed September 2006. (N00019-04-C-0058)
Lockheed Martin	12.7	Jul 2004 – Ceiling-priced order under a basic ordering agreement for the acquisition on 21 different parts in support of the APS-145(V). To be completed November 2005. (N00383-03-G-002F, 5006)

Contractor	Award ($ millions)	Date/Description
Northrop Grumman	25.5	Jul 2004 – Fixed-price order against a basic ordering agreement for two E-2 upgrade kits for the government of Japan under FMS. Kits include the mission computer upgrade, advanced control indicator set, and navigation upgrades. To be completed December 2006. (N00019-04-G-0001)
Northrop Grumman	6.6	Oct 2004 – FFP order against previously issued basic ordering agreement for installation of SATCOM into three French E-2C aircraft under FMS. To be completed October 2006. (N00019-04-G-0003)

Timetable

Month	Year	Major Development
Oct	1960	First flight
Jan	1964	E-2C operational
Feb	1974	APS-125(V) operational
Mid	1976	Initial deliveries for production aircraft
	1982	APS-125(V) production completed
	1987	Last APS-138 delivered; U.S. Customs Service orders first Lockheed P-3 AEW&C
	1988	USN begins APS-145(V) integration on E-2C
	1989	APS-145(V) production initiated
	1991	APS-145(V) IOC, deliveries begun, first flight of EC-130V
Mar	1992	Taiwan initiates E-2C procurement (4 aircraft)
	1993	First Group 2 E-2C squadron activated at Miramar NAS, operational evaluation started
	1994	End of production on current aircraft orders, MCU Milestone II, start of CEC testing, Taiwan E-2C rollout
	1995	Restart of production for CEC aircraft, Taiwan E-2Cs arrive in country
Mar	1995	France initiates two aircraft procurement
	FY96	First CEC developmental units received
Aug	FY97	MCU LRIP
	FY98	CEC LRIP, Radar Modernization Program start; Japan initiates upgrades
Apr	1998	First French E-2C delivered, first Hawkeye 2000 flight
2Q/3Q	FY98	MCU Qual tests
3Q	FY98	MCU DT/OT-IIB
	1999	End of Group 2 upgrade program, Egypt initiates upgrades
1Q	FY99	MCU TECHEVAL/OPEVAL begun, multiyear procurement started
2Q	FY99	MCU DT/OT-IIB, MCU FRP
Apr	1999	French contract for third aircraft
3Q	FY99	MCU TECHEVAL/OPEVAL completed, Hawkeye 2000 retrofits/production begun
Sep	1999	First APS-145(V)-equipped P-3 delivered to Customs Service
4Q	FY99	MCU DT/OT-IIC, TECHEVAL
Dec	1999	Taiwan initiates fifth and sixth aircraft purchase, Egypt announces upgrade to APS-145(V)
	FY00	Flight test Radar Modernization technologies
2Q	FY00	MCU DT-IIC
3Q	FY00	MCU DT-IID/TECHEVAL
4Q	FY00	MCU OPEVAL, Airborne CEC TECHEVAL
4Q	2001	MCU FRP
	FY02	Hawkeye 2000 IOC, Advanced Hawkeye development to begin
May	FY02	UESA contracts awarded
2Q-3Q	FY02	JSCEIT MSI integration data collection

Month	Year	Major Development
2Q-4Q	FY02	MSI Phase 1 development
	2003	Third French E-2C delivered
1Q	FY03	MSI Phase 1 S&T Demo
1Q-4Q	FY03-04	IPAD Development
1Q-4Q	FY03-05	SIAP Blk 0
1Q-3Q	FY03-08	MSI Phase II FQT
3Q	FY03	ABC2 FBE K
3Q-1Q	FY03-04	MSI Phase 1 FQT
1Q-4Q	FY04-06	ABC2 Development
2Q	FY04	MSI Phase 1 Deploy
3Q	FY04	AODS S&T, IPAD Demo
3Q-3Q	FY04-06	MSI Ph II JCEIT
4Q-4Q	FY04-05	AODS FQT
4Q	FY08	MSI Phase II transition to AHE
Advanced Hawkeye		
3Q	FY03	Milestone B
1Q	FY04	Software Functional Review (SFR)
1Q	FY05	PDR
1Q	FY06	CDR
1Q-2Q	FY05-07	Development Test A-123 & NC-130
4Q	FY07	SDD, Systems Installation
3Q-4Q	FY07-09	Development Test SD&D #1 and #2
4Q	FY08	Operational Assessment
2Q	FY09	LRIP I start

Worldwide Distribution

The APS-125/138/139/145(V) series radar is the mainstay of the Grumman E-2 airborne early warning aircraft. In addition to being used on carrier-based squadrons of the **U.S. Navy**, the radar and aircraft are employed by the U.S. **Coast Guard** in limited numbers, while the **Customs Service** operates three P-3Bs equipped with the APS-125.

The international E-2C users are:

Egypt. The Egyptian Air Force operates a fleet of five Group 0+ Hawkeyes and has plans to upgrade to the APS-145(V) and Group II Mission Suite.
France. The French Navy is procuring two Group IIs and one Hawkeye 2000. The Group II aircraft will eventually be upgraded to Hawkeye 2000. They have announced an intent to acquire one more for delivery in 2006.
Japan. The Japan Defense Forces operate 13 Group 0 E-2Cs originally equipped with APS-125/138s. They are upgrading to Hawkeye 2000.
Singapore. Singapore has four Group 0 E-2Cs and is considering a major upgrade effort.
Taiwan. The Republic of China has completed an FMS order for four APS-145(V) radars plus a significant spares order to equip its Group II E-2C aircraft. In mid-1999, officials announced the possible sale of two additional E-2T Hawkeye 2000E aircraft.
The **United Arab Emirates** plans to purchase five refurbished E-2Cs upgraded to Hawkeye 2000.

Forecast Rationale

The Hawkeye has been the backbone of Fleet AEW&C for decades. The carrier-capable E-2C is less expensive and less labor-intensive to operate and maintain than the E-3A AWACS, and can be acquired by nations that cannot afford to buy or support AWACS. In addition, an export license has been more likely to be approved than for the E-2C than the E-3A.

One or more E-2Cs are constantly airborne during carrier battle group operations. It is the Navy's only airborne command and control asset, the only one the Fleet can bring with it. If a battle group is close to hostilities or to a contingency operation, the E-2C can be on the scene to perform AEW missions before AWACS can be deployed. The naval strategy of

prepositioning carrier battle groups in areas of anticipated conflict puts the Hawkeye on the front line first. The FY94 Defense Appropriations Bill (PL 103-139) required the Navy to develop a viable airborne CEC component, so planners were able to justify and receive funding for new-production aircraft.

Mission computer upgrades made advances in radar capability possible. The L-304 could not fully support the APS-145(V) or expanded AEW operations. CEC's distributed processing made it possible to do much of the heavy-duty processing on ships with advanced computer resources. But the aircraft mission computer had to keep pace with the increase in processing sophistication if the E-2C was to carry its share of Fleet operations. The new mission computer made an order-of-magnitude improvement in capability possible with a system one-third the weight and half the volume of the older system. Flight tests of the new computer began in 1997 and proved the new hardware and software to be mission-capable. LRIP took place in August 1997.

The Pacific Rim forces have been lucrative markets for the Hawkeye, since the E-2 is considered ideal for operations in that area. Its rugged airframe makes it tough enough for operating from small local airstrips. Small crew size and system maturity (hence reliable, low-maintenance operations) lessen the strain on already scarce resources. The larger E-3 would have to operate from a single airfield, create an impossible drain on skilled technicians, and be a complete budget-buster for most forces.

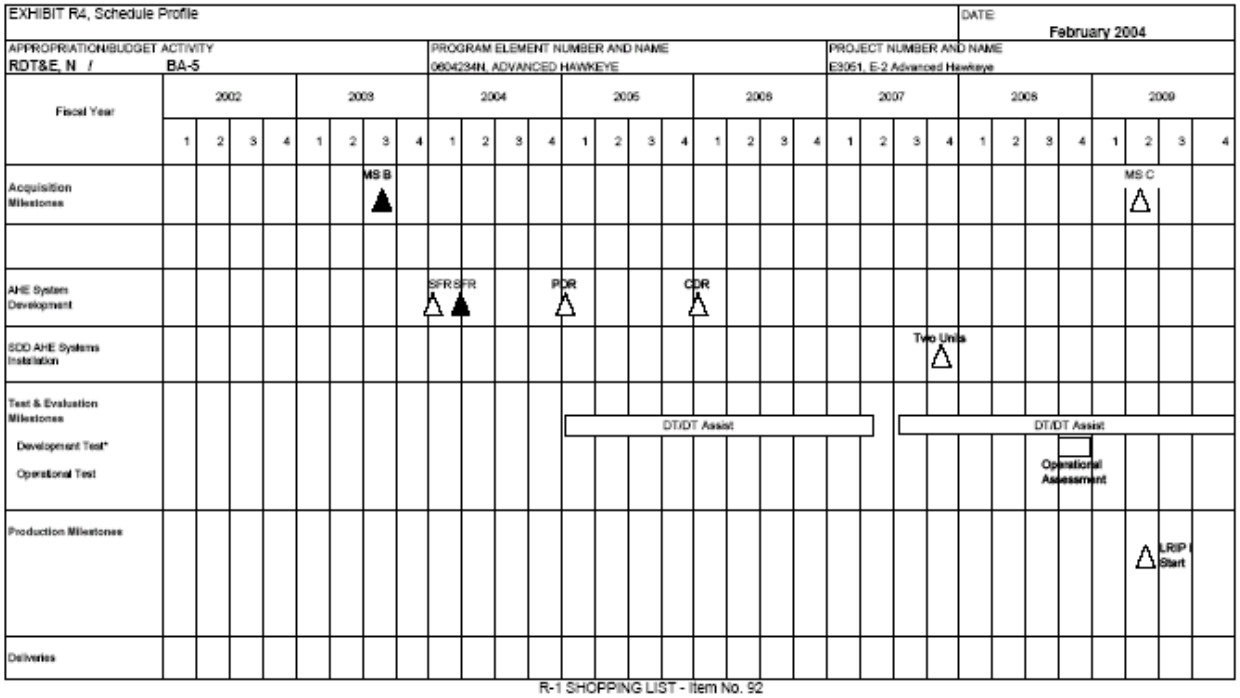
The production line will support both new production and upgrade kits to bring current aircraft to the Group II standard. Budget issues resulting from the anti-terrorism efforts may affect that schedule. Plans call for transitioning to five CEC-configured squadrons by 2006. There will be no mixed squadrons; transition to CEC will be all aircraft at once.

The SDD Advanced Hawkeye award will build on a proven airplane and capitalize on advancing technology. The switch to an active array radar will result in increased performance and capability. There will also be significant improvements in reliability and maintainability of the E-2. Pre-SDD efforts have focused the engineering and refined the expectations for the Advanced Hawkeye.

Ten-Year Outlook

ESTIMATED CALENDAR YEAR PRODUCTION

			High Confidence Level				Good Confidence Level			Speculative			
Designation	**Application**	**Thru 04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**Total 05-14**
AEH RADAR	*ADVANCED HAWKEYE* (USN)	0	0	0	2	4	4	4	6	6	6	4	36
APS-125/138	Prior Prod'n:	27	0	0	0	0	0	0	0	0	0	0	0
APS-139/145(V)	Prior Prod'n:	167	0	0	0	0	0	0	0	0	0	0	0
APS-145(V)	E-2C (FRANCE)	5	1	0	0	0	0	0	0	0	0	0	1
APS-145(V)	E-2C (VARIOUS EXPORT)	15	2	2	2	0	0	0	0	0	0	0	6
APS-145(V)	E-2C HAWKEYE 2000 (USN)	23	5	4	2	0	0	0	0	0	0	0	11
APS-145(V)	Prior Prod'n:	6	0	0	0	0	0	0	0	0	0	0	0
Total Production		243	8	6	6	4	4	4	6	6	6	4	54



R-1 SHOPPING LIST - Item No. 92

* DT/DT Assist in FY05/FY06 and 1Q-2Q of FY07 includes NC-130A-123/ab integration dedicated for weapon system development and air vehicle testing.

* DT/DT Assist in FY07-FY09 includes efforts for weapon system development and air vehicle testing on SD&D #1 and SD&D #2 aircraft.

* Schedule updated from Feb 03 submission to reflect a more clearly defined and discretely identified test evolution developed in cooperation with COTF and DOT&E in progress to MS B in June 2003.

Source: U.S. Navy