E-2C AIRBORNE EARLY WARNING (AEW) HAWKEYE 2000

Navy ACAT ID Program

Total Number of Systems:	75
Total Program Cost (TY$):	$2.4B
Average Unit Cost (TY$):	$320M
Full-rate production:	2QFY01 (MCU)
	2QFY04 (CEC)

Prime Contractor

Northrop Grumman—Integrator
Johns Hopkins—CEC and ACIS software
Raytheon Systems Corporation—CEC hardware
Lockheed Oswego—ESM
Raytheon & Compaq—MCU
Allied Signal—15 ton Vapor Cycle

SYSTEM DESCRIPTION & CONTRIBUTION TO JOINT VISION 2010

Hawkeye 2000 is an umbrella term for multiple improvements to the Group II (Joint Tactical Information Distribution System and APS-145 radar equipped) E-2C. Improvements include the addition of: (1) the Global Positioning System receiver; (2) an environmentally friendly, 15 ton vapor cycle system; (3) Ultra-High Frequency (UHF) Satellite communications (SATCOM); (4) replacement of the current mission computer with commercial-off-the-shelf computer (mission computer upgrade [MCU]); (5) new commercial-off-the-shelf workstation (Advanced Control Indicator System [ACIS]) display positions; (6) replacement of the current Passive Detection System (PDS) with an Electronic Support

Measures (ESM) system, and (7) integration of the airborne variant of the Cooperative Engagement Capability (CEC) system.

Hawkeye 2000 modifications contribute to ***dominant battlespace awareness*** for the theater commander. The integration of Cooperative Engagement Capability, UHF SATCOM, increased functionality Electronic Support Measures, and a higher capacity mission computer support the exchange and fusion of on- and off-board intelligence, sensor, and command and control information. The addition of Cooperative Engagement Capability will allow E-2C to fully participate in the netted Cooperative Engagement Capability data link; and UHF SATCOM will be able to support beyond-line-of-sight reception and transmission of indications and warning, surveillance, and command and control information. The addition of the Global Positioning System will support precise target and friendly force location and synchronized operations through a common time and navigation reference. The replacement of the Passive Detection System with Electronic Support Measures will provide improved emitter identification, automation, and system reliability. These improvements will enhance E-2C as an integral command and control component of carrier battle groups, joint Service, and Coalition operations—providing increased ***information superiority*** and more robust active participation in the integrated, in-depth theater air and missile defense, thereby achieving ***full-dimensional protection***.

BACKGROUND INFORMATION

Hawkeye 2000 is the most recent of a series of modifications aimed at improving the capability and sustainability of the E-2C airborne early warning platform. Modification of the aircraft with these new capabilities will occur incrementally and not in a block upgrade. The modifications will be incorporated into new E-2C aircraft production (approximately four annually) and retrofitted into older E-2C aircraft.

The key objective of Cooperative Engagement Capability modification is to provide the Navy with an airborne Cooperative Engagement Capability on the E-2C to extend sensor detection and provide an airborne relay of ship-based Cooperative Engagement Capability data. In order to accommodate an airborne Cooperative Engagement Capability suite, the E-2C required increased mission computing and display capabilities and an offset in weight and volume to carry the estimated 500-750 pound Cooperative Engagement Capability suite. The replacement of the analog mission computer provided the necessary space and replacement of the three-mission crew displays, and the old computer provided the majority of the needed offset in weight. The airframe also required significant modification to the underside to install the Cooperative Engagement Capability antenna and aerodynamic fairings. Additionally, an increase in the capacity of the avionics cooling (vapor cycle system) was also required to suppress additional heat generated by the Cooperative Engagement Capability equipment and new digital mission computer and displays. Finally, replacement of the cooling system was also necessary to address environmental issues.

During 2QFY99, the program office selected Lockheed Martin of Oswego, NY, to produce the Electronic Support Measures system for E-2C. This system will replace the Passive Detection System and provide improved emitter identification, automated controls, and reliability. This upgrade is being developed as a logistics engineering change proposal because parts for the current Passive Detection System are no longer available.

All Hawkeye 2000 modifications are being developed in parallel. Problems in the development of one modification can ripple through to others. For example, the overrun in allocated mission computer

timing and sizing during the re-host of all E-2C mission functionality into Ada impacts the budget allocated for integrating Cooperative Engagement Capability.

TEST & EVALUATION ACTIVITY

The Hawkeye 2000 TEMP was disapproved by OSD in April 1996 due to insufficient detail on the planned series of upgrades for E-2C and testing that was to validate system performance. The Navy was asked to provide additional information on the many Hawkeye 2000 improvements and their interdependencies. A draft Mission Computer Upgrade TEMP was submitted in March 1997 for OSD coordination and returned with comments on April 21, 1997. The Navy is revising the Mission Computer Upgrade TEMP. A separate E-2C TEMP annex to the Cooperative Engagement Capability TEMP has been approved by DOT&E. There is no capstone TEMP to address Hawkeye 2000 modifications other than the Mission Computer, Advanced Control Indicator System, and Cooperative Engagement Capability. However, a capstone TEMP is necessary to address the interdependencies of all concurrent upgrades comprising Hawkeye 2000.

During FY99, twenty-nine combined DT/OT flight missions were conducted on an E-2C modified with the new mission computer and Advanced Control Indicator System workstations. The implementation software contained incremental additions to E-2C mission functionality, however integration of Link-16 communications will not be available for test until FY00. Both the Mission Computer and Advanced Control Indicator System hardware and software were modified during the year to improve computing and display power.

Government Formal Qualification Testing (FQT) of the Mission Computer software was initiated during 2QFY99 at the Northrop Grumman plant.

The single E-2C equipped with the airborne AN/USG-3 Cooperative Engagement Capability system conducted 51 DT and combined DT/OT flight test missions during FY99. This aircraft is also equipped with the Mission Computer Upgrade and Advanced Control Indicator System, but the hardware and software configuration is one version behind the configuration of the primary Mission Computer Upgrade test aircraft. Missions included weeklong operations with Cooperative Engagement Capability-equipped Land Based Test Sites at Wallops Island and Dam Neck as well as a Cooperative Engagement Capability-equipped surface ship. The same E-2C is equipped with the new SATCOM system and a number of missions were flown to evaluate that integration.

DOT&E is working with Commander, Operational Test and Evaluation Force and the developer to develop an operational test strategy. An operational assessment of the Cooperative Engagement Capability-equipped E-2C was conducted in 1QFY00. Electronic Support Measures are expected to be available for flight test during FY01.

TEST & EVALUATION ASSESSMENT

Mission Computer and Advanced Control Indicator System

Flight operations demonstrated the increasing hardware stability of the new MC. Uncommanded halts that force a reboot of the software program have been reduced to approximately two to three per flight mission. ACIS displays exhibit a variety of problems including sensor/track correlation, different track counts, and widely varied system time between the three workstations in E-2C. Most of the serious

tracking correlation inconsistencies appear to have been corrected during 4QFY99, and the Navy is planning to certify the Mission Computer Upgrade system for control of aircraft. Flight testing also revealed deficiencies with air control Link-4, surveillance, command and control Link-11, and the Passive Detection System software implementations.

Government FQT was terminated after it was determined the software was too immature to be evaluated. The team had opened over 320 software trouble reports. The software supporting the data links (Link-4, Link-11, and Link-16) was not available for FQT. Largely due to the problems reported by the FQT team, the MC schedule and OPEVAL was delayed by one year from 1QFY00-1QFY01.

UHF SATCOM

FY98 flight testing indicated the presence of a slight airframe shudder during initial acceptance testing of the first E-2C modified with Cooperative Engagement Capability and the new UHF SATCOM antenna. Data analyses and additional flight tests during FY99 isolated the shudder to the new UHF SATCOM antenna—the "dunce cap" on the top of the E-2C radar rotodome. Flight tests with a redesigned antenna produced no appreciable improvement and engineering analysis continues.

Cooperative Engagement Capability Integration

The Cooperative Engagement Capability equipped E-2C demonstrated the ability to enter the Cooperative Engagement Capability network, relay and exchange air track information with the Land Based Test Sites and Cooperative Engagement Capability equipped AEGIS cruiser, the USS *ANZIO*. During five one-week tests, in which E-2C was tasked to fly one mission daily, there were two Cooperative Engagement Capability hardware failures, both in the same Cooperative Engagement Processor component. A changed board in the processor corrected that discrepancy for the May and June tests. Overall mission availability during these missions neared 70 percent and non-availability was largely due to non-Cooperative Engagement Capability related aircraft problems, 15-ton vapor cycle system failures, and incorrectly loaded cryptographic variables.

Data recording instrumentation system failures and slow data reduction/analyses are the primary impediments to determining the adequacy of Cooperative Engagement Capability message exchange. It appeared from observation of the real-time ground-based network displays that Cooperative Engagement Capability data from E-2C provided vastly increased situation awareness for the Land Based Test Sites and USS *ANZIO*. The data allowed surface sites to view E-2C-generated air tracks over 250 miles distance and use E-2C sensor data to build composite track files.

The E-2C test aircraft was plagued with a number of non-system under test problems during the test period, including air surveillance radar performance, cracked windshield, and faulty landing gear.

The new vapor cycle exhibited a variety of discrepancies including seizures, icing, and incorrect failure mode indications. Every in-flight failure of the vapor cycle forced E-2C crew to power down mission systems such as the radar and Cooperative Engagement Capability and, at times, change E-2C patrol altitude.

The Advanced Control Indicator System displays exhibited operating inconsistencies similar to those noted in Mission Computer Upgrade test missions. During the July 1999 Land Based Test Sites test week, one display representing one third of the mission operator capacity, was entirely inoperative.

Based on the immaturity of the overall E-2C system demonstrated through June 1999 and the problems associated with on-board Cooperative Engagement Capability track data recording, the developer delayed entry into DT-IIC by two months from July 1999 until September 1999. Completion of DT-IIC is an entrance criterion for the OT-IIA-2 Operational Assessment, also scheduled for September 1999. OT-IIA-2 was delayed a month because of Hurricane Floyd.

CONCLUSIONS, RECOMMENDATIONS, LESSONS LEARNED

Parallel engineering development and testing of modifications such as the Mission Computer Upgrade, UHF SATCOM, and Cooperative Engagement Capability, place increased burdens on test resources such as E-2C test airplanes, test personnel, data recording, reduction, analyses systems, and the hardware under test. Concurrent with the increased utilization, the developer must convince the supporting operations and logistics infrastructure to increase the priority for these test resources in order to maintain schedule.

Deceptively basic supporting modifications, as indicated by the vapor cycle system and the aerodynamic design of the UHF SATCOM antenna, can affect testing and schedule of the primary modification, in this case, Cooperative Engagement Capability integration.