

E-3 AWACS RADAR SYSTEM IMPROVEMENT PROGRAM (RSIP)



Air Force ACAT IC Program

Total Number of Systems:	33 airborne 3 ground test/ development
Total Program Cost (TY\$):	\$895M
Average Unit Cost (TY\$):	\$14.7M
Full-rate Production:	4QFY97
FOT&E	3QFY98-2QFY00

Prime Contractor

Boeing Corporation (Integration)
Northrop Grumman (Radar Development)

SYSTEM DESCRIPTION & CONTRIBUTION TO JOINT VISION 2010

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 Airborne Warning and Control System (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 mission of E-3 AWACS is to provide airborne surveillance and airborne warning, and command, control, and communications for strategic and theater operations. AWACS is the primary airborne command and control element of the Theater Air Control System. It operates in every major theater in the world and passes information, via data links and voice, to other air vehicles and command and control facilities. The E-3 AWACS is a commercial Boeing 707-320C airframe modified with a distinctive radome that houses an identification friend-or-foe system and an AN/APY-1 or AN/APY-2 radar capable of detecting aircraft and cruise missiles, particularly at low altitudes. In addition, the E-3 is equipped with general and specialized mission computers, multi-purpose displays, and clear and secure

multiple-voice and data link communications. The United States acquired a total of 34 E-3s, one of which is a dedicated test and development aircraft (Test System 3 or TS-3) operated by Air Force Materiel Command at Boeing Field. One E-3 was lost in an accident. Of the remaining 32 E-3s, four are assigned to Pacific Air Forces and 28 are assigned to Air Combat Command. NATO, Great Britain, France, and Saudi Arabia also operate E-3s, each with configurations different from the U.S. aircraft.

The E-3 RSIP will enhance surveillance capability and provide air commanders with improved 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. First deployed operationally in 1977, the E-3 has become the centerpiece of the theater air control system, performing early warning, air surveillance, combat identification, aircraft monitoring, fighter control, and battle direction missions. AWACS has been employed in support of joint and multinational operations as part of the overall theater air control system and autonomously in advance of deployment of ground-based command and control systems.

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 (JTIDS) 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. Block 30/35, the most recent system upgrade, adds a 360-degree-coverage passive Electronic Support Measures (ESM) system to support detection and identification; incorporates a Global Positioning System navigation capability; replaces the Class 1 JTIDS terminal with a Class 2H (High-Power Amplifier, modified) terminal; and increases memory capacity of the central mission computer to support ESM and JTIDS.

RSIP, the modification program currently on DOT&E oversight, replaces 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 is also designed to increase reliability and maintainability of the modified components. The RSIP modification to increase the E-3's radar sensitivity, including the development of new waveform and processing algorithms, is planned to restore target tracking standoff ranges delivered in 1977 that were decreased by the reduction in radar cross-section signatures of fighters and airborne cruise missiles. 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.

TEST & EVALUATION ACTIVITY

The U.S. RSIP IOT&E started with its first sortie on August 3, 1995, and was suspended almost immediately when a mishap damaged the radar components. Investigation showed that RSIP software did not have an automatic safety feature, which existed in the pre-RSIP software, to prevent power from going to the radar when a particular non-RSIP relay failed. The radar was repaired, the software was modified, and IOT&E resumed with the first sortie successfully completed on October 12, 1995. The

scheduled six-sortie IOT&E was again suspended because of serious performance deficiencies observed during IOT&E. IOT&E resumed for the third time in August 1996; it was 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. Piggybacking on previously planned activities reduced by approximately 40 percent the number of AWACS and test target sorties necessary to accumulate required data. This approach also reduced test duration by approximately six months.

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.

DOT&E has been actively involved in identifying test issues and reviewing data during FOT&E. IOT&E involved testing the RSIP-modified AN/APY-2 radar found in the TS-3 test aircraft and one-third of the USAF operational fleet. FOT&E includes the first testing of an RSIP-modified AN/APY-1 radar system. Two-thirds of the U.S. fleet are equipped with the AN/APY-1 radar. Also, RSIP FOT&E provides the opportunity to test a complete production-representative ESM system with RSIP.

The first FOT&E sortie took place on April 8, 1998, using a pre-RSIP AN/APY-1 equipped E-3. This provided a performance baseline of the pre-RSIP AN/APY-1 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 will continue until at least 500 hours of suitability data from the 552nd Air Combat Wing's normal use of the aircraft is collected. Current projections indicate that data collection will be complete in 2QFY00.

TEST & EVALUATION ASSESSMENT

DOT&E analyzed the data from both U.S. and NATO IOT&Es and from combined DT/OT, including post-IOT&E testing. Testing confirmed that the RSIP-modified radar is capable of meeting current system-level performance requirements and is substantially more effective than the pre-RSIP radar it is intended to upgrade. RSIP is capable of tracking smaller radar cross-section targets at longer ranges than its predecessor. RSIP is also far more effective when operating against electronic countermeasures.

The RSIP-modified radar provides significant improvements in several areas of suitability. The improvements in man-machine interface are a quantum leap forward from the previous system. Additionally, in-flight repair time, diagnostic effectiveness, fault detection, fault isolation, and built-in-test "cannot duplicate" rates were all system successes. There have been no critical failures of RSIP hardware. However, the issue of software maturity plagued RSIP throughout testing prior to Milestone III. This is most evident in Mean Time Between Failure and Mean Time Between Critical Failure Rates, both of which fell well short of system goals. Despite this, the RSIP-only component break rate met requirements, and the overall radar break rate is comparable to the pre-RSIP operational fleet break rate.

The only negative impact to current system capabilities was to the Beyond-the-Horizon (BTH) radar mode. The U.S. crews indicated that they experienced a degraded ability to use the BTH mode effectively, although NATO crews reported no difference. The apparent cause of the change to BTH operations has been isolated to software. A software change has been made, and U.S. crews are in the process of determining the effectiveness of the fix and their preferences for tuning the BTH radar mode for operational use. There is insufficient test data available to make a final determination as to whether the BTH software change corrected the problem. That determination, and final selection of primary and alternate BTH operational modes, will be made after additional test flight data is gathered.

The initial FOT&E sortie flown in April 1998 provided baseline target detection and radar performance data for the AN/APY-1 equipped E-3. This aircraft was subsequently modified with the RSIP upgrade, and the May 20, 1999 dedicated RSIP FOT&E flight collected data against which to compare the baseline data. Observations of the pre- and post-RSIP sorties indicate that the RSIP-modified radar performs better than the pre-RSIP radar; however, final analysis of the data from the post-RSIP sorties is not yet complete.

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.

Software maturity remains the highest risk item in the RSIP program. Data collection continues, and observations during FOT&E sorties indicate that the software maturity and operational suitability of the RSIP-modified E-3 continue to improve.

The AWACS Y2K program has completed awareness, assessment, renovation, and validation phases. A total of nine Y2K fixes have been implemented and tested. Most were relatively minor ground system date formats. The radar hardware and software do not use date codes; there are no RSIP or pre-RSIP Y2K issues. The prime contractors have submitted their final assessment reports. A DoD Inspector General audit concurred with the assessment and completeness of the AWACS Y2K program approach. The Air Force Program Executive Office certified AWACS as Y2K compliant on November 19, 1998. AWACS will also participate in additional DoD-wide Y2K interoperability testing in 1999.

CONCLUSIONS

The E-3 RSIP is operationally effective. Although a final determination has not been made regarding RSIP suitability, RSIP does provide significant improvements to the current system in many areas, and corrective actions are being pursued in the areas where deficiencies have been discovered. In the future, DOT&E will report on RSIP along with other E-3 AWACS improvements and upgrades.

RECOMMENDATIONS

Additional modifications should be made, and FOT&E flights continued, until it is determined that the BTH problem has been corrected to the satisfaction of the U.S. crews.

Software maturity and significant improvement to Mean Time Between Failure and Mean Time Between Critical Failure should be verified during FOT&E prior to the full fielding of RSIP.

LESSONS LEARNED

Re-hosted radar software, combined with the new RSIP code, resulted in inadequate protection of aircraft radar hardware under certain operating conditions. Improved ground testing and design of new hardware interlocks were needed to ensure aircrew and aircraft safety. New procedures have been implemented to prevent further problems.

Software designed to ensure that RSIP met pulse-Doppler detection requirements inadvertently degraded the long-range detection and tracking performance of the BTH radar. This issue reinforced the need for thorough, ongoing compatibility testing for all system software changes.

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 tests will use this same approach, leveraging existing activities wherever practical.

Agreements on test concepts and objectives during all phases of test must be thoroughly understood and documented. Key personnel changes in developer, user, and tester organizations resulted in intensive discussions to revalidate previously agreed to post-IOT&E and FOT&E test requirements. Possession of an updated TEMP and B-LRIP report identifying FOT&E issues and the outlining of a test strategy was instrumental in retaining the scope of testing during numerous personnel changes.

