E-3 AIRBORNE WARNING AND CONTROL SYSTEM (AWACS)

Radar System Improvement Program

Air Force ACAT IC Program		**Prime Contractor**
Total Number of Systems:	33 airborne	Boeing
	3 ground test	Northrop Grumman
Total Program Cost (TY$):	$895M	
Average Unit Cost (TY$):	$14.7M	
Full-rate production:	4QFY97	

Block 40/45 Upgrade

Air Force ACAT ID Program		**Prime Contractor**
Total Number of Systems:	33 airborne	Boeing
Total Program Cost (TY$):	TBD	
Average Unit Cost (TY$):	TBD	
Full-rate production:	FY07	

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 AN/APY-1 or AN/APY-2 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 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 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 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 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.