

E-3 Airborne Warning and Control System (AWACS) Block 40/45

Executive Summary

- The Air Force Operational Test and Evaluation Center (AFOTEC) completed the IOT&E for the E-3 Airborne Warning and Control System (AWACS) Block 40/45 Modification during 2010. DOT&E and AFOTEC evaluated the system as operationally effective but not operationally suitable. Key deficiency areas included reliability and training. In addition, the Block 40/45 ground-based and deployable support systems were not available and operational testing of these elements was deferred to the FOT&E.
- The E-3 Block 40/45, designated E-3G, modifications include incremental updates to the business-grade commercial mission computing systems in the aircraft, ground support systems, and application software to address diminishing manufacturing resources, correction to deficiencies identified through testing and operational use, and to add enhancements. AFOTEC used E-3G hardware version 1.0 for IOT&E and version 3.0 for some FOT&E events. The Air Force has fielded both versions.
- The Air Force conducted the following test events:
 - E-3G FOT&E began during 4QFY15, in accordance with the DOT&E-approved Test and Evaluation Master Plan, with the collection of suitability data on the version 3.0-configured E-3G aircraft.
 - Cold weather operational testing during 2QFY16.
 - A cybersecurity Cooperative Vulnerability and Penetration Assessment (CVPA) and a comparative operational assessment of maritime surveillance and tracking in 3QFY16.
 - An operational deployment and observation of the deployed performance and suitability of the E-3 Block 40/45 and Deployable Ground System during a Red Flag Large Force Exercise in 4QFY16.
- Observations and emerging results from these events indicate that Block 40/45 version 3.0 with mission computing software version 11.1 has deficiencies related to multi-source track integration, maritime tracking, cybersecurity vulnerabilities, and software reliability.
- The Air Force halted completion of FOT&E during the Operational Test Readiness Review largely due to adverse pretest predictions provided by AFOTEC. Instead, AFOTEC was requested to observe employment during a Red Flag Exercise and provide feedback on required improvements to prepare for FOT&E.

System

- E-3 AWACS is built on a Boeing 707 airframe. The AWACS crew employ a surveillance radar and Identification Friend or Foe (IFF) system located in the rotodome above the airframe. Additionally, the E-3 AWACS' communications



- suite includes ultra high frequency, very high frequency, high frequency radios, satellite communications; and Link 16 and Link 11 tactical datalinks. The E-3 AWACS Block 30/35 upgrade included an Electronic Support Measures (ESM) system – passive detection of electronic signals – mounted on the cheeks of the airframe, under the nose, and in the tail.
- The Block 40/45 upgrade, designated the E-3G, replaces the mission computing system with open-architecture, commercial off-the-shelf hardware including servers and 15 mission crew interactive operator workstations. Also, the Block 30/35 Air Operations Computer Program has been replaced by the Block 40/45 mission computing software program; a set of local area networked, open architecture programs. The human-computer interface is built on the Windows operating system and licenses the Raytheon Solipsys Tactical Display Framework.
- The E-3G's mission computing system provides the capability to automatically fuse all on- and off-board sensor inputs to provide a single track for each air, sea, and land entity using a multi-sensor integration algorithm. The upgrade is also intended to provide:
 - An update to the E-3 AWACS Link 16 and satellite communications capabilities
 - Software to automatically refresh the onboard database
 - An updated mission system health monitoring tool
 - Improved interfaces and controls of the onboard ESM system
 - Improved mission planning and post-mission processing capabilities
- Also, the E-3G upgrade will include a deployable ground support system to enable deployed crews to conduct mission planning and post mission processing with a central data processing center for data storage and retrieval.

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- The first six Block 40/45 E-3s are planned to have three different mission computing configurations. The Air Force plans to use the configuration of the seventh Block 40/45 E-3 to upgrade the next 11 jets.
- The AWACS Block 40/45 requires several new ground support systems, including the mission planning system, which the contractor delivered with the first upgraded aircraft. The contractor delivered a deployable mission planning system in support of Initial Operational Capability and trainers for maintenance personnel and mission crew.
- The Air Force is developing new communications and combat identification capability upgrades for the E-3 AWACS that will require integration with E-3G's mission computing system, the human-computer interface software, or both. These upgrades will improve and enhance data communications capabilities; tactical datalink management; and surveillance and identification operations.

Mission

Joint/Combined Forces Air Component Commanders use AWACS-equipped units to:

- Provide airborne early warning, airborne air surveillance and identification, air operations battle management, and beyond line-of-sight capabilities.
- Provide command and control of offensive and defensive counter-air and counter-sea operations, and strike missions including dynamic targeting, close-air support, suppression of enemy air defenses, and strategic attack.
- Manage air refueling operations, combat search and rescue missions, and special operations missions.

Major Contractor

Boeing Corporation – Seattle, Washington

Activity

- The Air Force did not conduct any developmental testing for Block 40/45 hardware configuration version 3.0. There are no dedicated test E-3 aircraft or government laboratories. DOT&E and AFOTEC leveraged operational and training flights from the 552nd Air Control Wing to collect data and were provided dedicated aircraft and aircrew by the 552nd Air Control Wing for the maritime tracking test.
- AFOTEC started suitability data collection with the first operational E-3G version 3.0 during 4QFY15 and will continue through 4QFY16 until the required mission computing operating hours are collected.
- During 2QFY16, AFOTEC conducted a cold weather suitability assessment with the deployment to Eielson AFB, Fairbanks, Alaska. The test was incomplete due to non-Block 40/45-related airframe and surveillance radar failures, which prevented take-off for the planned operational mission. Consequently, the elapsed time for bringing the Block 40/45 mission computing system on-line after a cold weather take-off, could not be measured.
- During 3QFY16, the Air Force conducted a CVPA of E-3G version 3.0 and supporting mission planning, software verification, and training ground systems to assess the system's performance in the presence of a realistic cyber threat.
- During 3QFY16, AFOTEC, with support of the 552nd Air Control Wing, conducted a test over the Gulf of Mexico to characterize E-3G maritime surveillance tracking performance. The comparative test employed a legacy E-3 Block 30/35 and an E-3G version 3.0 conducting surveillance of the same overwater track production area.
- AFOTEC observed and collected data during a 3-week hot weather (daytime temperatures in excess of 110 degrees Fahrenheit) deployment to a Red Flag Large Force Exercise conducted from Nellis AFB, Nevada. To assess operational

employment, this test included two E-3G version 3.0 aircraft and Deployable Ground Support System version 3.0—downsized system with more computing capacity—to provide mission planning, rehearsal, and post-mission recording review.

- The Air Force Program Executive Officer (PEO) did not certify the system as “ready for Follow-On Operational Test and Evaluation (FOT&E)” after AFOTEC highlighted deficiencies observed during IOT&E and other events that had not been resolved. The PEO requested AFOTEC utilize the data collected during the Large Force Exercise Red Flag 16-3 to identify deficiencies to be corrected prior to any re-planned FOT&E of Block 40/45.

Assessment

- Observations and emerging results from the FY16 tests indicate that the E-3G version 3.0 has difficulty in combining various on- and off-board sensor data into a coherent single track on a consistent basis. Analysis of air and maritime and ESM sensors to assess and characterize current system performance for single track is ongoing.
- DOT&E could not collect data on E-3G mission computing start time and operating capability during cold weather operations due to aircraft mission cancellations. Additionally, the Deployable Ground System was not available to be deployed to the cold weather operating base. This metric remains unresolved.
- Based on the data collected during the 3-week cybersecurity vulnerability test, the E-3G version 3.0 and supporting Block 40/45 ground systems are highly vulnerable to cyber threats and not survivable.
- Block 40/45 tracking of sensed maritime objects, ships, and platforms, is less effective than the predecessor Block 30/35

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aircraft, although both systems demonstrated deficiencies compared to truth data supplied by the Coast Guard.

- The E-3G version 3.0 hardware reliability trend indicates it may meet the post-IOT&E revised threshold requirement for hardware mean time between failure. System deficiency reports and software performance are being reviewed and compared with the revised threshold requirement for software reliability. The ESM sub-system, which experienced some hardware and software modification for Block 40/45, is not reliable due to a combination of legacy, built-in test false alarm, and Block 40/45 problems.
 - Insufficient cooling resulting in Deployable Ground System version 1.0 overheating and failure was a critical deficiency identified during the operational deployment to the Caribbean Sea. In contrast, the Deployable Ground System version 3.0 performed well while deployed to Nellis AFB for the Red Flag Exercise and relying on room-modified, dedicated air conditioning ducts. It experienced only one required reboot during the 3-week deployment.
 - The E-3G demonstrated several operational deficiencies during Red Flag Large Force Exercise, including inaccurate track quality data processing and inconsistent IFF response displays to the operator.
 - Due to the program deficiencies and the PEO's decision to not certify AWACS Block 40/45 as "ready for FOT&E," AWACS Block 40/45 is delayed approximately 2 years while the program manager works to develop resolutions.
2. Modify the mission computing software and refine technician training to reduce the incidence of induced critical failures during Block 40/45 mission computing startup.
 3. Develop software modifications to improve aircrew ability to control the automated tracking capability.
 4. Review and update the planned training syllabus for both aircrew and maintenance personnel with information learned during the IOT&E.
 5. Conduct FOT&E of Block 40/45 using the first Block 40/45 configuration that will be installed on more than two aircraft. The FOT&E should include an operationally representative deployment in a stressful tracking and combat identification environment.

Recommendations

- Status of Previous Recommendations: The Air Force has satisfactorily addressed one of the previous recommendations. The Air Force still needs to:
 1. Complete and update aircrew and maintenance checklists and technical orders to address the new failure modes discovered during IOT&E.
1. Identify the Block 40/45 mission computing hardware and software for E-3G aircraft and ground configurations for the new FOT&E and update the Test and Evaluation Master Plan accordingly to include a description of the planned verification of correction of deficiencies.
 2. Plan to conduct a second CVPA and a cybersecurity Adversarial Assessment as part of the new FOT&E.
 3. Plan to test the integration of new E-3 developmental communications and combat identification capabilities, including Next Generation IFF interrogation system, E-3 AWACS Radar Electronic Protection, Internet Protocol Enabled Communications, Combat Identification (also known as System R), and Communications Network Upgrade, with the Block 40/45 mission computing system and Primary AWACS Display (as appropriate) as part of the FOT&E.
 4. Plan to complete the test of mission computing during cold weather employment.

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