THE AIR FORCE ELECTRONIC COMBAT TEST PROCESS

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ABSTRACT

The Air Force Electronic Combat Office was tasked, by the Chief of Staff, Air Force, to implement a disciplined test process for development and modification of electronic combat systems. This tasking has resulted in the development and implementation of the Air Force (AF) Electronic Combat (EC) Test Process. This paper answers four questions: (1) Why do we need an AF EC Test Process?; (2) How does this process relate to the current acquisition development process?; (3) What is the AF EC Test Process?; and (4) Where do we go from here? These questions are answered by providing: (1) Background information on the need for improving the way we acquire and test EC systems; (2) information on the relationship of the AF EC Test Process to current Department of Defense (DoD) policy, procedures, and guidelines; (3) a description of the AF EC Test Process; and (4) a conclusion.

Why do we need an AF EC Test Process?

In 1988, the Chief of Staff, Air Force, tasked the Air Force Systems Command to lead an ad hoc group to investigate his concern that the Air Force lacked a structured EC test process. This group examined the EC systems development process and determined that there was a problem in the acquisition and testing of EC systems. A partial summary of these findings (Ref 1) follows:

- a. An institutionalized and

disciplined process does not exist for the development and upgrade of EC systems.

- b. It is difficult to correlate data collected from contractor and Government-owned test facilities.

- c. Utilization of test resources lacks discipline among programs.

- d. A common modeling architecture does not exist.

Deficiencies such as these and others suggest that we do need to establish a disciplined process for acquiring and testing EC systems. The AF EC Test Process has been developed to address these deficiencies. It provides a structured approach in designing the test, conducting the test, evaluating the results, and feeding the results back into the system development process. The AF EC Test Process will aid all Air Force organizations involved in developing, modifying, and testing EC systems to overcome these deficiencies and instill a disciplined approach to developing and fielding EC systems.

How does the AF EC Test Process relate to the current acquisition development process?

It is structured to support the acquisition and modification of EC systems within the framework of DoD policy, procedures, and guidelines for conducting acquisition programs. Particularly, it falls under the Acquisition Management System as defined in DoD Directive 5000.1 (Ref 2). It is applied during each of the five major acquisition phases and milestone decision points as detailed in DoD Instruction 5000.2 (Ref 3) and shown in Figure 1.

FIGURE 1. ACQUISITION MILESTONES AND PHASES

What is the AF EC Test Process?

It is an iterative process, as illustrated in Figure 2, of conducting: (1) pretest analysis to predict EC system performance; (2) test sequences under progressively more rigorous ground and flight test conditions; (3) post-test analysis and evaluation of operational effectiveness and suitability; and (4) feedback of test results to the system development process. It is accomplished during each phase of the Systems Acquisition Process, starting with the Concept Exploration and Definition Phase and progressing through the Operations and Support Phase until the system is removed from the AF inventory.

One of the key tools needed for addressing the identified deficiencies is a common computer simulation capability. Development of this capability involves the development of an EC digital system model (DSM), development of Defense Intelligence Agency validated reference threat packages (RTPs), e.g., models, and a digital computer simulation architecture. The EC DSM models the proposed EC system design. It is developed as part of the systems engineering process to support analysis and testing. The digital computer simulation architecture, being developed by the joint service CROSSBOW-S Committee, is the key to achieving a common computer

simulation capability. This architecture will provide a common environment between the EC DSMs and RTPs to simulate their interactions. The common architecture will ensure that all future models are compatible with each other and with the RTPs.

The AF EC Test Process concept follows the following six steps:

a. Derive test requirements. Test requirements are derived from system development and deployment activities. Due to the complexity of EC system and threat interactions, computer simulation techniques are used to aid in the analysis of system requirements, design, and specification activities. Computer simulation of postulated combat scenarios is used to predict battle and engagement outcomes in terms of the same measures of effectiveness (MOEs) that would be used to evaluate operations once the system is deployed. Then, a system-specific design, specification, and production configuration is evolved and tested through technical performance parameters (TPPs) that translate system performance requirements into technical performance specifications.

b. Conduct pretest analysis. Computer simulation can be used to support

FIGURE 2. AF EC TEST PROCESS CONCEPT

pretest analysis activities before a test sequence is run in a hardware-in-the-loop (HITL) laboratory or on an open-air range. The focus of pretest analysis is to determine what test conditions should be run in the test sequence. Pretest analysis is also used to predict the results of the test in terms of events that will occur and to predict values for system performance and technical performance parameters. Proper application of computer simulation in EC pretest analysis can save time and money by determining: (1) How to design the test scenario (e.g., what test conditions to run); (2) how to set-up the test environment; (3) how to properly instrument the test; (4) how to man and control the test resources; (5) how to best sequence the test trials; and (6) predict outcome values that can be used to analyze test results. As the system matures and standard test trials are defined, this step may often be deleted because previously conducted test trials can be simply repeated in order to demonstrate that performance requirements have been achieved. Computer simulations used in supporting pretest analysis should be common with those used in the system engineering

process during system development.

c. Conduct testing. More complicated testing of the developmental EC system is progressively conducted in five categories of EC test facilities shown under the test sequence in Figure 2. As system development progresses from brassboard, through prototype, to production systems, both hardware and embedded software undergo a sequence of tests. These tests are conducted at the various facilities to establish demonstrated values for system performance and technical parameters.

d. Process test data. Data (e.g., antenna patterns, time responses, tracking, telemetry, firing events, operator logs) measured in various test facilities must usually be processed into a form suitable for analysis. For example, time-space-position-information on aircraft flight profiles must be smoothed and tracking errors must be calculated by comparing threat pointing angles to a ground truth reference over the time domain of the test. Once processed, time correlated measurement values can be used

to conduct a post-test evaluation of results.

e. Conduct post-test analysis. Post-test analysis consists of comparing measured data against predicted results and other effectiveness and suitability evaluation criteria. Where differences between measured and predicted values are found, the analysis must determine if the difference is due to lack of fidelity in any of the simulators used, flaws in the test design, or in the system's achieved performance. If a threat simulator is found to be at fault, it is updated to reflect the correct threat definition and the trials repeated. If the test design is the source of the difference, the test may also need to be restructured and rerun. The post-test analysis is considered complete when all test objectives have been analyzed, demonstrated values have been documented, and processed data on the test is archived in the Performance Data Archive (PDA). The PDA is another tool that has been developed to ensure that system performance reporting is accomplished for EC system development programs. The PDA contains all data required for an audit trail from system concept definition through the life of the system. It provides a data record to track refinements on system requirements and maturity, to keep decision makers informed, to support effectiveness studies, and to support modification programs after the system has been fielded.

f. Report results. The final step in the EC test and evaluation sequence is to report the results back to the system Program Manager, Program Executive Officer, Milestone Decision Authority, and users so they can be acted upon.

To illustrate how the AF EC Test Process concept works, let's look at the Engineering and Manufacturing Development Phase (Phase II) test and evaluation sequence, shown in Figure 3. The Phase II test and evaluation sequence follows:

a. Derive test requirements. The Test and Evaluation Master Plan (TEMP)

developed during Phase I, should have established test requirements and identified required test resources to accomplish Phase II testing. The TEMP, Phase I PDA, and Phase I EC DSM will be used during pretest analysis to structure the upcoming test and predict test results for later analysis.

b. Conduct pretest analysis. Before testing of the production prototype begins, the EC DSM, from Phase I, is updated to include changes from the Development Baseline. In addition, the computer simulations and input files are retrieved from the Phase I PDA and updated to reflect changes in scenarios and threat parameters. The computer simulations should then be run, as required, to support pretest analysis in order to structure new test trials and update the values predicted for system performance and technical performance parameters.

c. Conduct testing sequence. The Phase II test sequence should begin in the contractor's plant using his test facilities in a test and fix sequence. This will confirm that performance thresholds, capable of being tested in the contractor's system integration laboratory (SIL), have been achieved and enable the contractor to correct any identified hardware and software problems. Once the systems components have been tested in the contractor's facilities, they can be shipped to Government test facilities for more rigorous evaluation.

d. Process test data. As required, data obtained from contractor test results should be processed into a form suitable for post-test analysis. Test results should be reflected in the EC DSM.

e. Conduct post-test analysis. As higher quality test data from the production prototype system becomes available, post test analysis should begin to focus on establishing demonstrated values for key system performance parameters and critical technical performance parameters. At this point, test data, coupled with data stored in the PDA, should permit a

FIGURE 3. PHASE II TEST AND EVALUATION SEQUENCE

more precise statistical analysis of actual system performance and effectiveness. This will establish confidence levels for the values and aid in the development of algorithms for Level II and Level III analysis models for future applications.

f. Report results. At this point, test results from the contractor SIL testing should be reflected in the PDA and EC DSM to begin the process again in preparation for HITL testing.

If further testing is required, a pretest analysis should be conducted again to prepare for the next test sequence. In this example the following four test sequences would remain to be conducted, with the appropriate pretest and post-test analyses performed before and after each sequence:

a. HITL testing. The production prototype components are usually tested in Government HITL test facilities before the system is installed in a testbed or dedicated test aircraft for open-air range testing.

This ground testing should focus on confirming that problems identified in Phase I testing have been fixed, performance thresholds can be achieved, and on optimizing countermeasures versus HITL threat simulators. Because a complete system is available for this testing, compared to just critical components available during Phase I testing, this is the first opportunity to conduct integrated system effectiveness tests.

b. Measurement facility testing. Phase II measurement facility testing should establish values for technical performance parameters for installed antenna patterns, platform signatures, direction finding, component reliability under various ground stress tests, and decoy trajectories.

c. Installed ground testing. Installed ground testing is normally the first opportunity to evaluate EC system performance operating on an aircraft platform. This ground testing is conducted

to evaluate the integrated performance of EC sub-systems as part of an integrated avionics suite. A prime purpose is to test the system's electromagnetic compatibility with other systems on the aircraft.

d. Open-air range testing. Open-air range testing, during Phase II, provides the first opportunity to establish achieved values of key system performance and technical performance parameters of the production prototype. It will normally begin with one-on-one scenarios and progress to multiple threat scenarios as operationally realistic as possible using the available threat simulator resources, ranges, and range instrumentation.

When all test sequences are completed the EC DSM and threat computer simulations should be further calibrated and refined with correlated test data. This will permit the determination of technical performance parameters and measures of effectiveness values characterizing the system's full performance range and effectiveness providing the capability to extend results to other test conditions and for different scenarios in support of a Milestone III decision. This test data along with cost and operational effectiveness analysis results will be used to demonstrate whether Phase II exit criteria have been met.

The results of the Phase II testing provide the data required to establish demonstrated values for the system Production Baseline and technical performance parameters. This test data, along with a description of the test conditions, should be stored in the PDA. The updated PDA provides an audit trail for the Engineering and Manufacturing Development Phase of testing, leading into Phase III testing.

Where do we go from here?

First, we must complete the development of the digital computer simulation architecture and make it available to contractors and Government organizations involved in EC test and evaluation. Second, we must ensure that EC DSMs are developed for all new system developments and

current system developments and modifications, where practical. Third, Test Managers and Responsible Test Organizations must ensure that resources are utilized in a well organized and structured approach by identifying required test resources and shortfalls in test resources. Fourth, Program Managers must ensure that a Performance Data Archive is established and maintained throughout the life of the system. When these tasks are being accomplished on each program we will have solved the deficiencies identified in the Ad Hoc Group Report. The AF EC Test Process (Ref 4) provides the framework for implementing this process.

REFERENCES:

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