ABSTRACT

The Naval Air Systems Command formed the Air Systems Electromagnetic Interference Corrective Action Program (ASEMICAP), which is designed to stop the progressive deterioration of combat capability caused by rising electromagnetic environmental effects (E\textsuperscript{3}) in fleet aircraft. The two major efforts in implementing this goal are, (1) the E\textsuperscript{3} class evaluation (i.e., performing intrasystem and intersystem EMC/EMI tests) of specific aircraft class/type currently deployed in the fleet, and (2) the Quick Reaction Investigation of fleet E\textsuperscript{3} problems, which provides for a team of highly experienced and qualified EMC engineers to solve urgent E\textsuperscript{3} problems in the fleet. This paper discusses the results of one class evaluation effort. These results are considered typical and demonstrate the intent of the program.

INTRODUCTION


This NAVAIRSYSCOM program has two major goals which are: (1) the E\textsuperscript{3} class evaluation of specific aircraft class/type currently deployed in the fleet; (2) the quick reaction investigation of fleet E\textsuperscript{3} problems. This paper addresses only the class evaluation effort.

E\textsuperscript{3} CLASS EVALUATIONS

The E\textsuperscript{3} evaluation project is the most significant portion of the ASEMBICAP which evaluates the adequacy of the E\textsuperscript{3} control design of various aircraft that are now in the fleet. The problems found on each aircraft evaluated will be assigned criticality categories which will assist in supporting Engineering Change Proposals (ECPS). In addition, the results will be analyzed to determine where state-of-the-art E\textsuperscript{3} design techniques are deficient. The deficiencies will be renewed and investigated under the Electromagnetic Compatibility Aerospace Research and Development (EMCARD) program.

The steps taken to accomplish a specific class evaluation are:

- Define aircraft type/model including specific Bureau number.
- Submit request for a fleet full mission capable configured aircraft.
- Compile a list of the avionic suite, Electromagnetic (EM) problems, ECPS and waivers/deviations.
- Predict EM problems and compare with existing problems.
- Prepare a detailed evaluation procedure with pass/fail criteria.
- Perform evaluation.
- Analyze evaluation results.
- Document results.
- Class Evaluation Board reviews results and recommends disposition.

Twenty aircraft were selected as candidates for the class evaluations. The aircraft selected were the F-14A, CH-53D, A-4M, CH-46, S-3A, A-7E, E-2C, EC-130Q, A-6E, SH-3H, P-3C, AV-8C, EA-6B, SH-2F, FA-18, LAMPS MK III, CH-53E, AV-8B, RF-4B, and TAV-8A.

This effort was started in 1979 with the establishment of a class evaluation board and the preparation of a fleet aircraft class evaluation project plan. The class evaluation board has a chairman (NAVAIRDEV/CEN/20P3) and nine members as shown in Figure 1. The members are NAVAIRTESTCEN, NAVSURFWPNCEN/Dahlgren, NAVSURFWPNCEN/White Oak, NAVAIRENGCEN, ECAC, Naval Safety Center, Naval Weapon Center, Naval Air Force Atlantic, and Naval Air Force Pacific. Specific responsibilities have been assigned to the various members and are detailed in the fleet aircraft class evaluation project plan. The project plan was originally issued 9 January 1980 and has subsequently been updated.

The project plan has the general procedures for the class evaluations. Each aircraft class evaluation includes:

- Pre-evaluation E\textsuperscript{3} inspection
- Electrical inspection
- Intrasytem
(1) Bonding
(2) Equipment functional compatibility (intrasytem)
(3) Emissions survey (including emission control/EMCON)
d. Intersystem
   (1) Electromagnetic Vulnerability

PRE-EVALUATION $E^3$ INSPECTION

This inspection is performed to document the equipment onboard versus the avionic suite, and verify the full mission capable configuration. Any action required to obtain missing equipment and to repair or replace malfunctioning equipment is expedited.

ELECTRICAL INSPECTION

An electrical inspection is performed to detect the evidence of improper maintenance, corrosion and wear of electrical avionics system wiring in accordance with MIL-W-5088 requirements. In addition, the inspection also addresses connectors, areas of possible lightning damage, radome conductive coatings, antenna conditions, P-Static discharge devices and canopy conditions.

BONDING

Measurements are performed utilizing resistance and impedance levels specified by MIL-B-5087B. The results are recorded on data sheets for the following areas:
   a. Avionics bay shelves to airframe
      (1) Shelf to rack
      (2) Rack to equipment
   b. Racks/consoles to airframe
      (1) Console to control box instrument
      (2) Rack to equipment
   c. Instrument panel to airframe
   d. Antenna mount to airframe

EQUIPMENT FUNCTIONAL COMPATIBILITY

An evaluation of the operational Electromagnetic Compatibility of the aircraft is performed. All susceptible equipments are operated as victim equipment in all modes, while the source equipment are operated one at a time, then simultaneously. Outputs and displays of the victims are monitored for possible malfunction or indications of interference while being subjected to all aircraft sources. All data are logged by identification of the source and victim, measured levels of undesirable response, indications or malfunctions and the Electromagnetic Interference (EMI) frequency where applicable. The test combinations used to determine EMI effects for the equipment functional compatibility evaluations are:
   a. Signal to override
   b. Crosstalk (circuit isolation)
   c. Background noise level
   d. Receiver background noise level
e. Receiver to receiver
f. Transmitter to receiver
g. Transmitter to active devices
h. Transmitter to passive devices
i. Receivers to active devices
j. Receivers to passive devices
k. Active devices to passive devices
l. Active devices to receivers
m. Electrical power system transients
n. Electrical/electronic subsystems transients
o. Simulated mission

EMISSIONS SURVEY

The emission survey measures the frequency and field strengths of signals and spurious radiation from the aircraft electrical and electronic subsystems and equipments. Measurements are taken for unintentional emitters intentional emitters and simulated mission emissions. Measurements of all unintentional emitters are made to determine compliance with emission control (EMCON) requirements.

ELECTROMAGNETIC VULNERABILITY

This evaluation determines the susceptibility of all aircraft equipments, the malfunctions of which could affect safety of flight or cause mission abort. The aircraft is exposed to the EM environments encountered during typical mission scenarios by using frequencies and levels outlined in MIL-HDBK-235 for guidance. EM environments include those due to own force ships and aircraft. Aircraft equipments are exercised solely and jointly as would occur during typical mission conditions. Specific evaluation phases include the following:

a. Pre-flight checks on ships' power
b. Pre-flight checks with engines turning
c. Simulated launch and land with engines turning
d. Completion of mission scenario with aircraft exposed to typical air and surface emitters

The data is recorded as to susceptibility threshold, frequency, and field strength calculated or measured at the victim equipment.

ACTUAL TEST RESULTS

The first fleet aircraft class evaluation was conducted from July to October 1980 at two different sites. The sites were the Grumman aerospace corporation anechoic chamber at Calverston, Long Island, New York and the Naval Air Test Center, Patuxent River, Maryland.

Both functional compatibility and EMV evaluations were accomplished. The subsystems and equipment operating modes and frequencies were optimized to permit a complete evaluation consistent with program constraints.

The functional compatibility evaluation uncovered twenty-four (24) interactions in the anechoic chamber. Of the 24, only twelve (12) were proven to exist in flight. These 12 interactions were analyzed and assigned the following deficiencies:

a. One Part I Deficiency
b. Six Part II Deficiencies
c. Five Part III Deficiencies

The categories of deficiencies are as follows:

a. Part I - EMC problems that could result in loss of life, loss of vehicle, mission abort, costly delays in launches, or unacceptable reduction in systems effectiveness.
b. Part II - EMC problems that could result in injury, damage to vehicle, or reduction in system effectiveness that would endanger success of mission.
c. Part III - EMC problems that result only in annoyance, minor discomfort, or loss of performance that does not reduce desired system effectiveness.

Only the Part I deficiences were submitted for Engineering Change Proposals (ECPS). Four of the interactions were resolved by preparing and submitting to the fleet a frequency selection plan. The other interactions have been made a part of the Naval Air Systems Command's Electromagnetic Compatibility Aerospace Research and Development (EMCARD) program. Information on these interactions also has been made available for the development of new equipment in the form of more rigid specifications.

The Electromagnetic Vulnerability (EMV) evaluation was conducted at the Naval Air Test Center, Patuxent River, Maryland, by the Naval Surface Weapons Center, Dahlgren, Virginia. There were a total of forty-six (46) aircraft subsystems and equipments evaluated for EMV. Of these 46 evaluated, nineteen (19) were affected by EMV. These 19 interactions were analyzed and assigned the following deficiencies:

a. Two Part I Deficiencies
b. Nine Part II Deficiencies
c. Eight Part III Deficiencies

d. Completion of mission scenario with aircraft exposed to typical air and surface emitters

As for the functional compatibility evaluation interactions, only the two Part I deficiences were submitted for ECP action. Information on the Part II and III deficiencies have been given to the fleet operators and to equipment designers and developers.

CONCLUSIONS

This class evaluation has provided a detailed evaluation of a fleet aircraft weapons systems. The results have produced information leading to corrective action being taken to eliminate the most critical, Part I, deficiencies. Fleet operators have been informed of the less serious problems and will follow the appropriate procedures to eliminate those problems. All of the test results will be input to the EMCARD program so that design techniques can be developed that will obviate these and similar problems in future design efforts. The aircraft class evaluations provide the experimental data with which to corroborate or disprove the analytical methods being utilized and developed in the laboratory.