To the Graduate Council:

I am submitting herewith a thesis written by Jeffrey L. Rusher entitled "ES-3A Aircraft Navy Developmental Testing". I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Masters of Science, with a major in Aviation Systems Management.

Ralph D. Kimberlin

Dr. R. D. Kimberlin, Major Professor

We have read this thesis and recommend its acceptance:

Frank G. Collins

Dr. F. G. Collins

C. T. Paludan

Dr. C. T. Paludan

Accepted for the council:

C W Minkel

Associate Vice Chancellor and Dean of The Graduate School

ES-3A AIRCRAFT NAVY DEVELOPMENTAL TESTING

A Thesis

Presented for the

Master of Science

Degree

University of Tennessee, Knoxville

Jeffrey L. Rusher

May, 1995

ABSTRACT

The purpose of ES-3A Developmental Test phase IIID (DT-IIID) was to quantify technical mission systems characteristics, identify performance deficiencies based on Military Standards and Military Specifications, and determine whether the design and production characteristics of the integrated ES-3A Mission Avionics System (MAS) operating with Fleet Issue (FI) 2 mission software met the Tactical Electronic Warfare and Reconnaissance (TEW&R) mission requirements. The test and evaluation criteria for the ES-3A and associated mission avionics were based on specific parameters within various Military Specifications and Standards and the ES-3A Test and Evaluation Master Plan. The author of this thesis served the role as Lead ES-3A Systems Engineer for the Department of the Navy. The duration of the evaluation encompassed one full year, from 15 January 1993 through 28 January 1994, and included 75 flights totaling 268.7 flight-hours and over 1,500 ground testing hours. Specific evaluations performed and contained within this report include the following: Link-11 System; Communications System; Navigation System; Crew-Systems (Human Factors); OR-263 FLIR System; AN/APS-137 Radar System; and electronic support measures systems. During this phase of DT-IIID testing five enhancing characteristics were identified and should be incorporated in future ES-3A designs: C-11984/ARC AN/ARC-182 control head installed in place of the currently used C-10319/ARC ARC-182 control, which provides the ES-3A with the jam-resistant HAVE QUICK line-of-sight voice communications capability with the carrier battle group; the AN/ARC-156/206 Satellite Communications (SATCOM) system which provides the ES-3A with clear two-way over-the-horizon secure voice communications capability; incorporation of the AN/ARC-182 No. 1 Backup Communications Controller (BUCC); the accessibility and ease of utility of mission information layout via the software interface; and the ability of the

computer system to recover from power transients and power faults after software has been loaded. A total of 42 significant deficiencies were identified and documented with amplifying data, mission impact, and proposed recommendations.

During DT-IIID testing the ES-3A, using FI 2 mission software, demonstrated a substantial and significant improvement in the ES-3A's overall mission capability. FI 2 mission software adds significant new capabilities to the current ES-3A with the on-line operation of the MAS that could not be accessed with FI 1 mission software or controlled off-line. FI 2 mission software corrects and/or improves a number of FI 1 software limitations. Hardware corrections to be implemented in future engineering change proposals will be required to utilize Link-11, SATCOM and the ARC-182 No. 1 BUCC. Link-11, and AN/ALR-76 will require additional mission software improvements to enable the ES-3A to reach its full TEW&R potential. Specifically, the Link-11 system, while operational, is extremely operator intensive and should be improved in a subsequent mission software release. During DT-IIID the ES-3A met or exceeded all criteria set forth in the Test and Evaluation Master Plan. The ES-3A weapon platform performance utilizing FI 2 mission software exhibited excellent potential to successfully perform the TEW&R mission and will be fully satisfactory upon correction of the Part I deficiencies. With the continued implementation of Operational Safety Improvement Programs and development of new life-cycle mission software, the ES-3A will become an invaluable asset to carrier battle groups, joint commanders, and national policy advisors as an intelligence collection and exploitation platform. It is recommended the ES-3A proceed to fleet squadrons to enhance training, tactical development, and further development of the overall MAS.

TABLE OF CONTENTS

Page No.

INTRODUCTION

BACKGROUND

In the mid-1980 time frame, Naval Air Systems Command (NAVAIRSYSCOM) was tasked with replacing the retired U.S. Navy EA-3B Skywarrior Tactical Electronic Warfare and Reconnaissance (TEW&R) aircraft. The primary mission of the new replacement platform would be passive intelligence gathering. The platform would perform multi-mission roles including airborne command and control, over-the-horizon targeting, and battle management. The platform would be carrier-based, while utilizing advanced communications systems which would provide real-time threat assessments in support of both the U.S. Navy battlegroup commanders and theater strategists.

Lockheed Aeronautical Systems Company was awarded the contract and began modifying existing S-3A airframes to create the ES-3A. The modification included the addition of over 3,000 lb of avionics, including a complete redesign of crew stations 2, 3, and 4 of the aircraft. The prototype ES-3A (BuNo 159401), which first flew in Palmdale, California, on 15 May 1991, was accepted by the U.S. Navy on 8 August 1991, and developmental testing was begun at the Flight Test and Engineering Group, Naval Air Warfare Center Aircraft Division, Patuxent River, Maryland, on 26 August 1991. By mid 1994, the 16 ES-3A's were completed and fully integrated into the fleet, thus completing the EA-3B's replacement.

The author of this thesis has served as the U.S. Navy's Lead ES-3A Systems Engineer from 1991 to present. The author helped plan and coordinate new avionic system developments and integrations. Likewise, the author led the Navy Flight Test Engineering Group (FTEG) test and evaluation team, which consisted of military, civilian and contractor personnel. The author's duties during the test and evaluation phase included scheduling, coordinating, assisting and monitoring all ground testing, and in-flight evaluation and testing. Subsequently, the author reported the team's test results, conclusions, and recommendations to the sponsors, both orally and with published technical reports (references 1 and 2). As part of the developmental test evolution, the FTEG was tasked with conducting a Developmental Test phase IIID (DT-IIID), which encompassed the overall ES-3A mission avionics system integration. Many components of the ES-3A MAS are common to both the EP-3E ARIES II and S-3B avionics suites. The test and evaluation criteria for the ES-3A was based on specific parameters within various Military Specifications and Standards and the ES-3A Test and Evaluation Master Plan. Although standards and specifications are helpful in defining baseline evaluation criteria, the primary evaluation criteria was the evaluation of the capability of the specific avionic systems or the entire platform to perform and successfully complete the aircraft's electronic warfare and reconnaissance mission. Several system deficiencies discovered during previous test phases and published as Department of the Navy Yellow Sheet Reports are contained in reference 3, and were reevaluated during this test phase. Deficiencies identified during testing were assigned a Part I, Part II, or Part III priority as described in Appendix C. All new deficiencies discussed in this thesis are published Department of the Navy Yellow Sheets Reports contained in references 1 and 2.

PURPOSE

The purpose of this test was to quantify technical mission system characteristics, identify performance deficiencies, and determine whether the design and production characteristics of the integrated ES-3A operating with Fleet Issue (FI) 2 mission software met the ES-3A mission performance requirements, contractual agreements, and readiness for operational tests.

DESCRIPTION OF TEST AIRCRAFT

ES-3A AIRFRAME

The ES-3A is a high-wing, twin turbofan powered, carrier-based TEW&R aircraft equipped with folding wings, folding vertical fin, launch bar for catapult takeoffs, and a tailhook. It is a modification to an existing airframe (S-3A) using directed "off-the-shelf" MAS components common to the EP-3E ARIES II and the S-3B Viking. The airplane is powered by two General Electric TF34 high-bypass turbofan engines on pylons mounted under the wing, inboard of the wingfold stations. A detailed description of the ES-3A may be found in the ES-3A NATOPS Flight Manual (reference 4). The test aircraft BuNo 159391 was used during DT-IIID, and was representative of all production ES-3A's. Photographs and illustrations are contained in Appendix D.

ES-3A MISSION AVIONICS SYSTEM

The ES-3A has a distributed digital processing design. Three hardware-identical AN/AYK-14 standard Navy computers perform the central data processing functions. Three IP-1616 Multipurpose Displays (MPD's) provide the operators with MAS control input, system alerts, messages from stored data, tactical plots, vectors, tactical maps (TACMAP's), mission contact data, and scan-converted video from FLIR, radar, or the two Multistatic Signal Processors (MSP's). Interfaces used are two Navy Tactical Data Standard Army/Navy EW parallel ports, two Military Standard MIL-STD-1553B serial ports, and one 6 MHz Manchester encoded serial port. The AYK-14's contain both embedded software and software that is downloaded prior to the mission. The downloadable software and data are stored within the AYK-14 in nonvolatile core memory and in a bubble memory expansion unit. The Tactical Mission Programs used during ES-3A DT-IIID testing were FI 2 versions 7 and 8 (FI 2.7 and 2.8). The ES-3A also has communication systems for fleet standard connectivity, core navigation avionics including Global Positioning System (GPS), LTN-211 OMEGA and AN/ASN-92 Inertial Navigation System (INS), plus the S-3B common APS-137 radar, OR-263 FLIR System, and the increased capacity auxiliary power unit (APU).

DESCRIPTION OF EVALUATED MISSION SYSTEMS

LINK-11 SYSTEM

Radio frequency (RF) transmission of ES-3A Link-11 data is conducted via either high frequency (HF) or ultra high frequency (UHF) radio. The HF radio is an AN/ARC-153 which operates in a frequency range between 2.0000 to 29.9999 MHz. The ARC-153 is designed to operate in the upper, lower, and independent or diversity sideband modes. UHF radio transmissions are conducted via the AN/ARC-206 and are operated in a frequency range between 225.000 to 399.975 MHz in the upper sideband only.

The Data Terminal Set (DTS) is a modem that performs conversion of digital data from a computer or encryption device to a composite audio signal of phase modulated tones. The DTS also performs conversion of a composite audio signal of phase modulated tones to digital data suitable for use by a computer or encryption device. The ES-3A implements the picket, short broadcast, and data silent DTS modes of operation. The picket mode is a standard mode of operation that allows the ES-3A to automatically transmit available data upon net control station call-up. Short broadcast is a single transmission of all available data at the time of operator selection. Data silent inhibits the transmission of any Link-11 data. The DTS is a Rockwell Corporation TE-237P-11 version with the military designation CV-4158/A.

The KG-40A is the Link-11 encryption device.

The Data Terminal Interface Unit (DTIU) is a militarized 386-based computer that performs buffering and data conversion between the KG-40A and mission computer. The DTIU was incorporated to meet Naval Security Group automatic data processing red/black interface requirements. The DTIU is designed to accept track data in ASCII format from the mission computer, convert the data to the OPSEC 411 message format, and place the Link-11 messages in a buffer for transmission on the link. Conversely, the DTIU is designed to accept decrypted Link-11 messages from the KG-40A and convert the messages to the format required for processing in the mission computer. The DTIU's military designation is J4994/A.

COMMUNICATION SYSTEM

The ES-3A's communication system consists of two AN/ARC-182 UHF/VHF transceivers, an AN/ARC-156/206 UHF transceiver integrated for either line-of-sight or satellite communication (SATCOM) capability, and an ARC-153A HF radio set. The ARC-182 UHF/VHF radio sets and the ARC-156/206 UHF radio set are AM/FM combination radio sets. Channels are spaced 25 kHz apart for the two ARC-182's into the following frequency bands:

a. 30-88 MHz: FM communications with tactical ground forces.

b. 108-156 MHz: AM communications with commercial and international airway facilities (108 to 118 MHz in receive only).

c. 156-174 MHz: FM communications with mobile maritime vessels and selected emergency vehicles.

d. 225-400 MHz: AM/FM communications with tactical aircraft and tactical platforms.

Frequency band (d) also applies to the ARC-156/206 with channels spaced 25 kHz apart. The two ARC-182's and ARC-156/206 are capable of providing both plain and secure voice communications. The secure voice capability for each of these radios is provided by TSEC/KY-58 secure speech units. The ARC-153A provides long range communication in both plain and secure voice. The secure voice capability for the ARC-153A is provided through an Advanced Narrowband Digital Voice Terminal (ANDVT).

All radio sets are interconnected through the AN/AIC-37 Digital Communications Management System (DCMS). The AIC-37 DCMS is an airborne, solid-state audio/data distribution system that processes voice and/or data transmissions throughout the aircraft and provides an interface between digital and analog devices and the operator. The DCMS system uses a data bus to communicate between station operators and equipment. The time-division multiplexed data bus can process up to 84 audio sources where each source is characterized by a bandwidth of 200 Hz to 6 kHz.

The ARC-182 antenna system consists of two AS-3557/A blade antennas, one antenna on top of the aircraft and one antenna on the bottom of the aircraft. The ARC-156/206 antenna system consists of four antenna modes: top and bottom line-of-sight (LOS) communication antennas and high-angle and low-angle SATCOM antennas. Two AS-2668A/A blade antennas are utilized for LOS communications. One DMC34-3/B SATCOM antenna provides the high-angle and low-angle SATCOM antenna modes.

The ARC-182 Backup Communications Controller (BUCC) provides the aircrew with the capability to establish two-way radio communications in the event of a DCMS failure. The BUCC allows audio to be bypassed around the DCMS between the flight station intercommunications system (ICS) and the ARC-182 No. 1 radio. The ARC-182 No. 1 radio is powered on the essential bus, providing VHF and UHF transmit and receive capabilities. The addition of the ARC-182 No. 1 BUCC provides backup radio communications in case of a DCMS failure.

NAVIGATION SYSTEMS

ASN-92(V) Carrier Aircraft Inertial Navigation System

The ASN-92 is an inertial navigation system (INS) designed and manufactured by Litton Guidance and Control Division. The ES-3A aircraft used three of the five ASN-92 weapons replaceable assemblies: the Inertial Measurement Unit, the Power Supply Unit, and the Aircraft Navigation Computer Unit. This system configuration was similar to the ASN-92 configuration in the S-3A aircraft. A detailed description of the ASN-92 system components is contained in reference 4.

LTN-211 Omega Navigation System

Omega is a hyperbolic radionavigation system with eight ground stations transmitting very-low frequency signals. The Omega system provides continuous, all-weather position fixing capability. The LTN-211 Omega Navigation System (ONS), manufactured by Litton Aero Products Division, consists of three units: the Receiver Processor Unit, the Control Display Unit (CDU), and the H-field Antenna Coupler Unit located on the bottom of the aircraft, aft of the wings. The ONS was configured with software version 211-18-04. The system provides position, navigation, and guidance data necessary for long range navigation. A detailed description of the LTN-211 ONS is presented in references 5 and 6.

ARN-151(V)2 Global Positioning System

NAVSTAR GPS is a space-based radionavigation system providing position, velocity, and time information. The ARN-151 configuration for the ES-3A aircraft consisted of three components: the AS-3822/URN Fixed Reception Pattern Antenna (FRPA-3), the AN-7314/URN Antenna Electronics (AE-4), and the R-2332/AR GPS Receiver (RCVR-3A). Barometric altimeter aiding was provided to the receiver. The GPS antenna was mounted on the top center of the aircraft on an aluminum strip, between the two-piece cockpit canopy glass. Detailed descriptions of the three components are contained in references 8 and 9.

Navigation Control Display Unit

The Navigation Control Display Unit (NAV CDU) manufactured by Canadian Marconi served as the sole interface between the GPS and the operator. The CDU acted as the bus controller for the AYK-14 No. 3 mission computer, GPS receiver, and Military Standard MIL-STD-1553B bus and was capable of displaying various navigation parameters from all three of the independent navigation systems. The NAV CDU was configured with software version 169-662775-009 and also provided the operator with the ability to select the priority of the navigation heading source.

IP-1616 Multipurpose Display

The IP-1616 MPD provided the operator with alerts and messages and consisted of tableaus from Digital Data Converter stored data; a tactical plot composed of colored symbols, vectors, and lines; TACMAP's; mission contact data; and scan-converted video from the FLIR, radar, and MSP. All information was oriented to true north. Above each display was an off-line panel with switches that controlled power, brightness, and degaussing. Control of the MPD was through touchscreen and keyboard/trackball inputs.

AYK-14 No. 3 General Purpose Digital Computer

The AYK-14 No. 3 General Purpose Digital Computer (GPDC) served as the navigation mission computer and was configured with FI 2.7 mission software. The GPDC was responsible for functions such as status monitoring, range and bearing calculations between waypoints, and computer steering. Detailed information pertaining to the GPDC is available in reference 10.

APN-200 Doppler Radar

The APN-200 Doppler Radar set, manufactured by Teledyne Ryan Electronics, provided aircraft vertical, along- and across-heading velocities, and status indications. The Doppler-derived velocities were available for damping the ASN-92 and for INS in-flight alignment. A detailed description is available in reference 11.

OR-263 FLIR SYSTEM

The OR-263 FLIR system is a common module forward-looking infrared system originally developed for the S-3 aircraft. The OR-263 detects and processes incoming infrared radiation and produces a TV-like image for display to the aircrew. The system is comprised of three hardware components which include the sensor/turret assembly, control and servo electronics, and power supply video converter. The sensor/turret assembly is gyro-stabilized in pitch and yaw and can rotate 200 deg to the left and right of the airplane's centerline. Additionally, the system is gimballed inside the turret to operate between 0 and -84 deg elevation. The sensor/turret assembly is controlled automatically, via the FLIR "AUTO TREK" option, or manually via a trackball-controlled video presentation on the EW Combat Coordinator (EWCC), Electronic Support Measures (ESM), or Special operator's IP-1616 MPD's. The control and servo electronics unit provides elevation, azimuth, and logic power to ensure proper slewing of the sensor/turret assembly, and the power supply/video converter is designed to provide voltage for the subsystems, process TV camera video and synchronize the scan mirror and drive assembly. FLIR on-line operator menus are contained in reference 12. The OR-263 tested was production representative of the systems typically found in fleet installations. FI 2.7 mission software version was used during tests and was also representative of software that will be used with the FLIR system in the fleet.

ELECTRONIC SUPPORT MEASURES SYSTEMS

ALR-76 Electronic Support Measures

The ALR-76 Auto-ESM set is an automatic signal-to-emitter correlation and reporting system. Once downloaded with its initial program load software and initialized by the operator, the ALR-76 system will automatically set up search strategies; perform pulse sorting and tracking; and identify, correlate, locate, and report on signals-of-interest (SOI's). The ALR-76 generates audio threat warnings to operators over the DCMS. The ALR-76 creates and maintains an Active Interest List (AIL) of detected and processed signals such that an operator may review and edit detailed information on selected emitters. The operator has the ability to interrupt the automatic function of the ALR-76 and define receiver scan and search strategies via the IP-1616 MPD.

a. The ALR-76 system consists of two Frequency Converter/Narrow Band Receivers (FC/NBR's). Each FC/NBR is a dual-channel, double-conversion, fast tuning superheterodyne receiver. Signals are acquired and down-converted by the FC/NBR's from two four-element wingtip antenna arrays. The video signals are sent to the Signal Comparator for further processing. The signal comparator is the control processor of this system. The signal comparator performs the following functions: encode signal outputs from the receivers; pulse sorting and tracking; and identify, correlate, locate, and report on emitters by using a resident emitter Identification (ID) library and an amplitude DF system.

b. Control of the ALR-76 system is exercised by mission operators via commands entered on the IP-1616 MPD. The AYK-14(V) accepts the commands over the MIL-STD-1553B data bus and sends them to the ALR-76 signal comparator over a 6-MHz data bus. The ALR-76 uses internal application software to execute the commands and perform the ESM functions.

c. The initial program load for the ALR-76 system consists of application software and externally generated databases. The ID library database, used for emitter correlation, contains data on known emitters by frequency and ID number. The SOI lists eight groups with a maximum of 20 signal ID's each, and is used by the ALR-76 to define scan and search strategies.

AN/ALR-82 Receiver System

The ALR-82 is an operator controllable, high frequency, multiband crystal video RF receiver. The ALR-82 has the capability of receiving and processing six bands of RF inputs. Each band is amplified and converted to audio and video signals. Video output is available to stations 3 and 4 and the AN/USH-33(V)2. Audio output is sent to the DCMS. RF inputs received from ESM antennas are controlled by the operators at stations 3 and 4 via the Antenna Select Unit. The operators can select individual video band outputs for further processing or analysis via the ALR-82 Select Units.

AN/ALR-81(V)3 Countermeasures Receiving Set

The ES-3A is equipped with an ALR-81(V)3 Countermeasures Receiving set at stations 3 and 4. The ALR-81(V)3 provides RF signal reception and display for analysis and DF over the ESM frequency range. The ALR-81(V)3 uses fully synthesized RF tuners with low-phase noise combined with wide instantaneous IF bandwidths. The ALR-81(V)3 control capability, implemented through local (front panel) or remote (MIL-STD-1553B) access, is characterized by the following modes and displays:

a. Tuning modes and signal displays:

(1) Band scan mode and display,

(2) Sector scan mode and display,

(3) Multiple sector scan and display,

(4) Dwell mode and display,

(5) Manual tune mode with IF Pan and linear instantaneous frequency monitor (LIFM) displays.

b. Antenna modes and DF displays:

(1) Spin mode,

(2) Sector mode,

(3) Manual mode,

(4) Polar displays (fill, outline, and inverse),

(5) Rectilinear displays (fill and outline),

(6) 3-D raster display.

c. The directional AS-4148 Antenna receives RF energy in the ESM frequency range, providing RF inputs to the TN-613 RF Tuners through the onboard RF distribution (RFD) equipment. The AS-4148 includes four separate antennas: a vertically polarized two element log periodic antenna; a horizontally polarized, single element log periodic antenna; a horizontally polarized log periodic antenna; and a horizontally polarized dish and feed antenna.

d. The TN-613 Tuners convert the RF inputs to wideband 1-GHz, 160 MHz, and 70 MHz IF signals. The 160 MHz and 70 MHz outputs of the main tuner are applied to the C-12099 Antenna/Receiver Control, which includes demodulator circuits that converts the IF to video used for displays and to video and audio for associated analysis equipment. The C-12099 also provides wideband 160 MHz and 70 MHz IF outputs for associated equipment, and provides an auxiliary narrowband 70 MHz IF output. The auxiliary 70 MHz output is bandwidth limited by one of four selectable bandwidth filters. The 70 MHz wideband IF output of the auxiliary tuners is connected to the MD-1254A Multichannel Demodulator, which converts it to log video, linear video, and FM video for use by associated equipment.

e. The C-12099 Antenna/Receiver Control provides positional control for the AS-4148 Antenna (through the PP-8275 Power Supply), provides frequency control for the main and auxiliary tuners, and provides mode control for the MD-1254A Multichannel Demodulator. The C-11700 Converter Control (through the TD-1412 Multiplexer) provides control for the downconverter circuits in the AS-4148 Antenna when the AS-4148 is selected for low band operation via the C-12099.

f. In addition to providing control for the tuners, the antenna, and the multichannel demodulator, the C-12099 generates spectrum (signal activity versus frequency), IF Pan, LIFM, and DF displays. The displays are generated from video provided by the C-12099 demodulator circuits.

g. The TD-1412 multiplexes downconverter power and control signals provided by the C-11700 Converter Control onto one of the RF outputs of the AS-4148. It also extracts the RF from that antenna output and status signals from the downconverter from the multiplexed line. The RF is supplied to the RF distribution, and the status signals are supplied to the converter control. A bias tee in the AS-4148 Antenna strips the power and control from the multiplexed line and places the RF and downconverter control signals on that line.

AN/APS-137 RADAR SYSTEM

The APS-137 Radar System is a high-powered (0.5 MW) X-band ocean surveillance radar system featuring state-of-the-art technology. The APS-137 is currently in service in the S-3B and P-3C aircraft. The APS-137 consists of seven weapon replaceable assemblies (WRA's) listed in Table I, and has the following four modes of operation: periscope mode, used for small targets (<10 dBsm); short range detection, navigation/weather mode, used for land/water interface; weather detection and avoidance, surface search mode, used for long range surface target detection; and Inverse Synthetic Aperture Radar (ISAR) mode, used for imaging of surface/subsurface contacts. System changes incorporated for DT-IIID included the periscope and ISAR modes, along with new controls and displays. A detailed description of the APS-137 Radar System is contained in reference 12.

Table I

APS-137 RADAR SYSTEM WRA'S

Type Designator	Nomenclature
T-1203/APS-116	Transmitter
AS-3637/APS-137	Antenna
SN-546B/APS-137	Synchronizer/Exciter
PP-7813B/APS-137	Power Supply
R-2308A/APS-137(V)	Receiver/Pulse Compressor
C-11841/APS-137	Radar Interface Unit
CV-2041/APS-137	Signal Data Converter

SCOPE OF TEST

Ground and flight tests of the ES-3A airplane were conducted to evaluate the total airplane effectiveness for the TEW&R mission using FI 2.0 mission software. The ES-3A was operated from Patuxent River, and maintained by Force Warfare Aircraft Test Directorate (FWATD) personnel. The developmental test aircrew consisted of FWATD, Systems Engineering Test Directorate (SETD), and VX-1 personnel. Testing included over 1,500 hours of ground testing on the airplanes and the ES-3A Hot Mock-Up (HMU) bench laboratory, and 75 flights totaling 268.7 flight-hours.

LINK-11 SYSTEM

The ES-3A Link-11 system software and hardware was evaluated during ground and flight tests. Ground and flight testing was conducted using FI 2.8 mission software. Four flight tests totalling approximately 13.5 flight-hours were conducted concurrently with other mission system test flights. The flight tests were conducted in the Patuxent River restricted areas, between Patuxent River and warning area W-72, and in W-72. References 13, 14, and 15 define the minimum Link-11 performance requirements of the ES-3A. The flights were conducted within the limits described in reference 4.

COMMUNICATION SYSTEM

Flight tests consisted of four flights for a total of 16.0 flight-hours. During flight testing, ARC-153A HF functionality was evaluated as well as maximum LOS communications of the ARC-182 UHF/VHF radio sets, ARC-182 HAVE QUICK capability, and ARC-156/206 UHF radio set. The ARC-156/206 configured to the SATCOM mode was functionally evaluated for secure voice satellite communications at local latitudes.

NAVIGATION SYSTEM

Ground testing was conducted on aircraft BuNo 159404 and in the ES-3A HMU to evaluate the changes incorporated into FI 2 mission software. Ground testing consisted of functional checks. Omega signal reception was also evaluated during a ground test with engines turning. Flight testing conducted onboard aircraft BuNo 159404 consisted of computer steering tests to ensure there was no degradation of function and an Omega antenna pattern. The aircraft flew two dedicated flights totaling 5.2 flight-hours at Patuxent River. Additionally, INS carrier alignment tests were conducted concurrently with carrier suitability testing onboard the USS Washington. This test phase did not include navigation system accuracy tests.

OR-263 FLIR SYSTEM

A 3 hr ground Minimum Resolvable Temperature Difference (MRTD) test was conducted in a closed hangar environment to determine the FLIR resolution performance under ideal conditions. Two flights were conducted to collect Inverse Synthetic Aperture Radar (ISAR) data while the FLIR collected secondary visual ID data. Finally, four FLIR resolution flights totaling 8 hr were conducted against the Electro-Optics Test Target (EOTT) to determine airborne sensor resolution. The test envelope is reflected in table II. Test loadings and configurations for the FLIR tests were per reference 4. Ground and flight resolution test results were compared to the original baseline S-3A FLIR ground MRTD and flight resolution test results.

Table II

ES-3A FLIR TEST ENVELOPE LIMITS

Parameter	Limit Values
Altitude	1,999-27,000 ft
Airspeed	180-350 KIAS

ELECTRONIC SUPPORT MEASURES SYSTEMS

Ground and flight tests of the ES-3A airplane were conducted to evaluate effectiveness for the TEW&R mission. The ES-3A was operated from Patuxent River using FWATD maintenance personnel. Aircrew consisted of SETD, FWATD, and VX-1 personnel. Testing involved approximately four weeks of ground tests and seven flights totaling 35 flight-hours. The evaluation included the following:

a. ESM and Special systems ground tests consisted of sensitivity, probability of detection of SOI's, classification/identification of SOI's, recording capabilities, the ALR-92 MSP system and FI 2 mission software capabilities.

b. Seven flights of 5 hr each at the Chesapeake Test Range (CTR) in the W-386 airspace to determine the ES-3A's ESM and Special subsystems direction-of-arrival (DOA) accuracy, sensitivity, location/fix accuracy, and probability of detection of SOI's and ALR-92 MSP performance.

AN/APS-137 RADAR SYSTEM

The ES-3A APS-137 Radar System DT-IIID evaluation consisted of both ground and flight testing using FI 2.6 mission software. A total of 16 man-hours was required to conduct radar parameter testing at NAS, Cecil Field, Florida. The parametric checks included measuring transmitted frequency, transmitted power, transmitted pulse width (PW), transmitted spectrum, chirp bandwidth (BW), agile BW, pulse repetition frequency (PRF), receiver compressed PW, signal processing functional tests, and receiver sensitivity. Additionally, verification tests were conducted on the Diagnostic Self-Test (DST), Operational Readiness Test, and Built-in-Test (BIT). Sixteen additional man-hours were required for functional integration tests, software evaluation checks, and DST and BIT on the aircraft.

Eleven dedicated test flights totaling 53.0 hours were conducted with the radar system at altitudes of 5,000 to 25,000 ft AGL and in sea states of 0-2 ft. Flight testing included maximum detection range against fleet representative-sized targets (approximately 1,000 m^2 Radar Cross Section (RCS)), ISAR against cooperative fleet assets, ground mapping, antenna stabilization, range and azimuth resolution and accuracy, and off-line radar.

METHOD OF TESTS

LINK-11 SYSTEM

The ES-3A Link-11 performance was evaluated during ground and flight tests. A Link-11 net was established between ES-3A BuNo 159391 and the E-2C System Test and Evaluation Laboratory (ESTEL) located at the NAVAIRWARCENACDIV, FWATD, VAW Department, building 2044. The Link-11 HF and UHF radios and DTS were analyzed for acceptable operation using the Link-11 Monitoring System (LMS-11) located at the ESTEL. The LMS-11 provided real-time and post-flight information on data link radio and DTS performance relating to the requirements outlined in reference 14. Information provided by the LMS-11 included preamble, phase reference, tone phase errors, tone power levels, signal-to-noise ratio, control codes (start and stop), and address codes.

ES-3A software was exercised and evaluated for the capability to correctly transmit, receive, process, and display all applicable Link-11 messages in accordance with references 13, 14, and 15. A Link-11 software function test matrix was provided in reference 16. ESTEL operators monitored their displays to determine if the ES-3A transmitted the correct data. Conversely, ES-3A weapon system operators monitored the IP-1616 MPD's to determine if the aircraft correctly received processed data transmitted from the ESTEL. Data extraction was performed on the ES-3A by the Mission Avionics System audit trail device at the ESTEL.

COMMUNICATION SYSTEM

Ground tests consisted of receiver and transmitter specification conformance tests on the ARC-182, ARC-156/206, ARC-153A radio sets, and the ARC-182 No. 1 BUCC. Conformance tests verified receiver sensitivity, receiver distortion, transmitter output power, transmitter modulation, transmitter distortion, transmitter frequency accuracy, headset audio levels, and voice intelligibility. Transmit characteristics tests were conducted to verify modulation levels, distortion, RF output power, and frequency accuracy. The ARC-182 No. 1 BUCC plain and secure voice tests consisted of receive transmit audio distortion and sensitivity distortion, and the effects on voice intelligibility. Secure voice tests were conducted to verify that the KY-58 interface functioned properly. Functional ARC-182 HAVE QUICK tests were conducted to evaluate the ability of ARC-182 No. 1 and ARC-182 No. 2 to establish a HAVE QUICK communications link.

ARC-182 No. 1 BUCC receive audio distortion and sensitivity were measured using the HP 8656B signal generator and HP 8903A audio analyzer at a frequency of 243.00 MHz. The signal generator was used to provide a test signal level of -103 dBm. The test signal was amplitude modulated 30% at 1 kHz. With the radio and signal generator set to 243.00 MHz, distortion and sensitivity were measured using the audio analyzer.

ARC-182 No. 1 BUCC frequency accuracy, RF power out, and modulation were measured at a frequency of 243.00 MHz. Frequency accuracy was measured using the HP 8901A modulation analyzer. RF power out and modulation were measured using both the HP 8901A modulation analyzer and the HP 8903A audio analyzer. The audio analyzer was used to supply a 0.5 Vrms (closed circuit) audio signal to crewmember station No. 1's microphone input.

During functional ARC-182 HAVE QUICK tests the ARC-210 ground station was used to transmit and receive time-of-day (TOD) signals to and from both ARC-182 radios. Successful TOD transfer was demonstrated when a communications link was established.

ARC-182 voice intelligibility was measured on the aircraft at 313.0 MHz using STIDAS in both plain and secure voice. During transmit tests, a 0.5 Vrms (closed circuit) signal was supplied to the radio's microphone input using STIDAS. During receive tests, the STIDAS was used to externally modulate a -53 dBm input signal supplied by the signal generator to the radio.

ARC-182 No. 1 BUCC plain and secure voice transmit and receive intelligibility was measured on the aircraft at a frequency of 313.0 MHz using STIDAS. During transmit tests a 0.5 Vrms (closed circuit) signal was supplied to the radio's microphone input using STIDAS. During receive tests the STIDAS was used to externally modulate a -53 dBm input signal supplied by the signal generator to the radio.

Station-to-station ICS tests included the following measurements: audio bandwidth, audio distortion, audio levels, and voice intelligibility. Audio bandwidth and distortion were measured by injecting a signal level of 0.5 Vrms (closed circuit) at audio frequencies from 20 Hz to 100 kHz into the transmitting station's headset. Distortion and audio power measurements were taken across the 20 Hz to 100 kHz band. Voice intelligibility was measured using the STIDAS. STIDAS input and output levels were adjusted to standard microphone and headset levels. Frequency was varied in 100 Hz increments. Audio power was measured using the General Radio 1553 audio power meter and distortion was measured using the HP 8903A audio analyzer at the receiving station's (station 2) headset for each frequency until cut-off was achieved.

During SATCOM flight tests, the ground station used an ARC-210/KY-58 configuration with a Dorne and Margolin DM C101-3 high gain antenna for SATCOM. During LOS communications, the ground station used both an ARC-210 and ARC-182.

SATCOM performance was evaluated by establishing secure voice communications through the 100 deg W Continental United States Fleet Satellite with the ES-3A operating in restricted area R-4006. The ES-3A flew racetrack patterns with 4 nmi straight-and-level legs and a bank angle of 5 deg or less during turns. During racetrack patterns, the ES-3A established a KY-58 FM secure voice SATCOM with the ELS ARC-210/KY-58 SATCOM ground station and noted the quality of reception every 2 nmi during legs and every 30 deg during turns. Racetrack patterns took the aircraft flightpath parallel to the satellite LOS, which created more doppler effect. More emphasis and data collection was placed on the parallel look angles, which presented "worst case" scenarios. The ES-3A also flew clockwise orbits at a bank angle of 15 deg. During circular orbits, the ES-3A established SATCOM with ELS and noted the quality of reception every 30 deg. Both high angle and low angle antennas were used for racetrack patterns and the high angle antenna was used for circular orbits at altitudes up to 21,000 ft. During flight testing, quality of communications was manually recorded on flight cards both at the ground station and in the test aircraft. Audio signals were also recorded at both the ground station and aboard the test aircraft using a hand-held audio recorder.

HAVE QUICK counter-counter measures communication performance and maximum range flights consisted of the test aircraft flying an outbound and inbound radial from the ground station. The ES-3A flew at an altitude of approximately 28,000 ft ±1,000 ft along the 160 deg radial to a range of approximately 200 nmi. The aircraft started TOD on ARC-182 No. 1 and sent TOD to ARC-182 No. 2 and the ground station. Plain and secure voice HAVE QUICK communications were attempted with the ground station using both ARC-182's on HAVE QUICK I Training Network frequencies. Frequency ranges where communications were lost and regained were recorded manually on flight cards at the ground station and aboard the test aircraft. Audio signals were also recorded at both the ground station and aboard the test aircraft using a hand-held audio recorder.

NAVIGATION

Ground and flight testing using GPS was conducted when a minimum of four satellites were visible. Computer steering flight tests were conducted when the GPS receiver had acquired and tracked four satellites with a Geometric Dilution of Precision of less than 10. Satellite visibility predictions were made based on current almanac data obtained from the GPS computer bulletin board. Current constellation status was determined before and after each test flight via a telephone service provided by Falcon AFB, Colorado Springs, Colorado, and the USCG GPS Information Center.

An ONS antenna azimuth pattern was performed during one of the test flights. Omega Station B (Liberia) was off-air and Station E (La Reunion) was used for antenna calibration. Signal reception from the six remaining stations was evaluated, based on the station quality index displayed on the CDU. Station status was determined before and after the flight via a telephone service provided by the USCG Omega Navigation System Center.

OR-263 FLIR SYSTEM

MRTD ground tests were performed to determine the optimal FLIR resolution performance under controlled conditions. These MRTD measurements were used to predict in-flight resolution performance and served as a baseline of comparison for in-flight FLIR performance. The MRTD measurements (resolution as a function of delta temperature (ΔT)) were taken in a controlled environment (closed hangar) to minimize varying thermal effects. The FLIR was powered by ground external power. The resolution tests were conducted by the lead project engineer at ES-3A station 4. A low spatial frequency, 4 bar array pattern (large bars) was placed in the optical path of the FLIR at a set background temperature. The bar pattern was allowed to reach thermal equilibrium, then the temperature of the background was slowly raised. The FLIR and display controls were adjusted until 4 discrete bars were discernable. The next smaller 4 bar array was then inserted and the procedure was repeated. The detailed procedures for this test can be found in reference 17.

FLIR detection and recognition range tests were conducted against tactical targets to gather qualitative performance data in the flight environment. The acquisition flights and targets were coordinated with the APS-137 ISAR test flights and conducted as piggyback events on a not-to-interfere basis. The specific targets of interest were located in the local area and consisted of Navy fleet cooperative assets of various sizes. Throughout the flight tests, FLIR control adjustability and the length of time required to acquire the targets and aircrew workload were noted. Onboard recording of FLIR video was made during the flights and time-tagged with IRIG B time. The acquisition ranges were measured using the following method:

a. The aircraft approached and attempted to detect and identify the target using the APS-137 radar.

b. The radar target was "handed off" to the FLIR.

c. After the aircrew detected the target and obtained an adequate ISAR picture, the FLIR was assigned priority.

d. The aircrew determined if the FLIR resolution was adequate to detect and/or identify the target. The aircraft to target range was then obtained using the APS-137 radar.

FLIR resolution flight tests were conducted against the EOTT at night to gather technical performance data in the flight environment. The test was designed to determine FLIR resolution performance over a range of ΔT's and form the basis of calculated detection and recognition ranges. The test range maintained constant communication with the aircraft, and advised the pilot of local air traffic and the proper flight path. An area map of Webster Field, Maryland, can be found in reference 17, figure 3. A run-in line of 252 deg magnetic was used. All resolution flight tests were performed in negative or positive polarity, as formally discussed during the pre-flight briefing. In-flight FLIR level, gain, and focus, and display brightness and contrast were optimized on the target and surrounding terrain. The IR resolution target provided a 4 bar target, heated at a ΔT range between 1 to 8 ^{o}C. The detailed test method and procedures can be found in reference 17.

ELECTRONIC SUPPORT MEASURES SYSTEMS

The ground tests of the ES-3A ESM and Special systems took place in the EW Integrated System Test Laboratory (EWISTL). The testing consisted of: sensitivity, probability of detection of SOI's, classification and identification of SOI's, and recording capabilities as integrated in the ES-3A. The testing used the following simulators and test equipment: Multiple EW Emitter Simulator (MEWES), Enhanced Tactical EW Emitter Simulator (ETEWES), Communications Simulator (COMSIM), Wideband Signal

Simulator , Frequency Agile Signal Simulator, Hewlett-Packard HP 5372 Time versus Frequency Interval Analyzer and HP 8562 Spectrum Analyzer.

The objective of this test was to determine the sensitivity of the ALR-81(V)3 system in the Band Scan Mode as a function of the time to tune through the entire band. The Tuner 4-1 and the station 4 RFD were used for the test. The operator's ALR-81 IF bandwidth was set and linear video gain was selected with the linear gain knob set. The ALR-81's scan time was varied. The RFD preamp was set to the maximum gain setting. The predetermined test signals were used. The generated signals were injected into the RFD through the RF input jack at the antenna pedestal via coaxial cables. The MEWES provided a signal at one frequency at a level capable of being detected by the operator viewing the receiver's pan display. After the signal was detected, MEWES power was then decreased to a level below system sensitivity. MEWES emitter power was then increased in increments until the test signal was reacquired. After the signal was reacquired, the MEWES operator logged the MEWES output power. After the completion of the test, each emitter was brought up again at the MEWES output power at which the signal was detected and the actual MEWES output power was measured, using a spectrum analyzer, and logged in the data sheet. RF cable losses, path loss, and test antenna gains were recorded on the data sheet by the test engineer. Radiated sensitivity was determined by adding or subtracting the space losses and antenna gains from the recorded power level.

The ALR-82 sensitivity measurements were conducted using the MEWES. The ALR-82's sensitivity using the station 4 RFD with all six tuner bands routed to the station 4 ULQ-16 was tested. The ULQ-16's threshold and gain were set to the appropriate settings and the RFD preamps were set to their maximum gain settings. The threshold and gain settings of the ULQ-16 were recorded on the data sheet. The test signals had the following parameters: steady scan, 1,000 μsec pulse repetition interval (PRI), 1.0 μsec PW. The generated signals were injected into the RFD through the RF input jacks at the antennas via coaxial cables. The MEWES or COMSIM provided a signal at a specified frequency at a level capable of being detected by the ULQ-16 when the receiver's tuner was tuned to the test RF frequency. Detection by the ULQ-16 is defined as when the signal is processed on page one of mode 1 of the ULQ-16 display. After the signal was detected, MEWES power was then decreased to a level below system sensitivity. MEWES emitter power was increased in 1 dB increments until the test signal was reacquired. After the signal was reacquired, the MEWES effective radiated power (ERP) was logged in the data sheet. After the completion of the test each emitter was brought up again at the scenario ERP at which the signal was detected and the MEWES output ERP was measured using a spectrum analyzer and logged in the data sheet.

The performance of the ALR-76 AIL emitter display filters was tested. The AIL contains the following emitter filters: SOI list only filter, sector inhibit filter, and also switches that allow the operator to select whether or not to display threat signals, hostile signals, friendly signals, or unknown signals. An SOI list containing threat, hostile, and friendly emitters was loaded into the ALR-76. The ETEWES was then used to provide an emitter scenario containing threat, hostile, friendly, and unknown emitters at various angles around the aircraft. The filters were then activated on the ALR-76 AIL display, one at a time and in combination, and the results were noted and an evaluation of the ALR-76 AIL filters was made.

The ES-3A ESM systems flight tests were conducted on the CTR using emitters from CTR's EW Facility (EWFAC). All emitter frequencies were approved by the Mid-Atlantic Frequency Coordinator and all emitters met the EW Operational security requirements of OPNAVINST S3430.2A. CTR radars tracked the aircraft during all flights and CTR provided Time Space Position Information (TSPI) data to the test engineer at the completion of each flight. An I-band beacon was installed on the aircraft to facilitate more accurate radar tracking at long range.

The ES-3A sensitivity test flight profile were flown at altitudes between 24,000 and 30,000 ft and at maximum endurance airspeed. The pattern was then flown in reverse order. The flight involved a maximum number of orbit repetitions. The ALR-81(V)3 system sensitivity in the manual mode was tested using CTR EWFAC emitters that are readily power adjustable. The station 4 RFD was used by the operator. The operator's ALR-81 IF BW was set to 2 MHz, the IF Pan Width was set to 25 MHz, the linear video gain was selected, the linear video gain knob was set to the 3 o'clock position, and the audio gain controls were set to maximum. The ALR-81's IF Pan Gain control knob was set so that the noise level was just shown at the bottom of the display. The ALR-81's LIFM was selected. The RFD preamps were set to the maximum gain settings. ALR-81 antenna spin rates of 30 RPM, 60 RPM, 100 RPM, and 150 RPM were used. Selected emitters were radiated by CTR EWFAC and the power was set to maximum with the emitter antennas slaved to the CTR aircraft tracking radar. The ESM operator detected the test signal on the ALR-81 pan display while in the manual mode and center tuned on the signal, and reported the emitter number to CTR. CTR EWFAC personnel then began reducing the power level of the test emitter at a 3 dB per 5 sec rate. When the operator determined the signal was at the minimal discernible signal (MDS) threshold, it was reported to CTR, and the EWFAC operator recorded the power level and time. After a few seconds, the EWFAC operator began to increase the signal power at the same rate and the ESM operator again reported to CTR when the signal was at MDS threshold. CTR EWFAC combined the recorded MDS power levels and times, and the recorded TSPI data.

INTEGRATED ESM SYSTEM FLIGHT TESTS

The ESM location/fix accuracy test was conducted on the CTR using emitters from the EWFAC. The EWFAC radiated selected emitters throughout the test. The ES-3A proceeded to point "A" of the designated track and flew the profile from point "A" through point "D" at levels between 24,000 and 30,000 ft and at maximum endurance airspeed. Each location accuracy test flight involved a maximum number of track repetitions. At the beginning of the flight, the ESM operator created a Case for each test emitter on the IP-1616 MPD. The operator then recorded the parameters for each test emitter in case files, and entered the emitter number in the "ELNOT" field of each case file. The ALR-81's IF bandwidth was set to 25 MHz and the antenna scan rate was adjusted for each signal to optimize the signal, based on the test signal's scan rate. The operator then took a DF cut for the first emitter and recorded the fix position, if available, the time, and the emitter number taken from the case file display into the data card. The operator then retrieved the case file for the next emitter and took a DF cut for the emitter and recorded the results, and repeated the process. The operator attempted to obtain 5 to 8 DF cuts, and spread out between points "A" and "C". When the operator had recorded 5 to 8 DF cuts for an emitter, the operator created a new case for that emitter. The EW Combat Coordinator at Station 2 accessed the ALR-76 AIL menu on the IP-1616 and recorded the position, time, and emitter number for each test emitter on the data card. The EWCC then selected the REFRESH AIL touch panel area and repeated the process. The recorded data was compared to the known EWFAC emitter locations to determine location accuracy for the ESM subsystems.

The ESM system's ability to classify and identify emitters was evaluated using the emitters from the DF accuracy, sensitivity and location accuracy tests, and emitters of opportunity on the CTR by recording the results of the ESM system's analysis. The test was conducted concurrently with the other ESM flight tests. The ESM operator and the EWCC created a Case for each test emitter and as many emitters of opportunity as time allowed on the IP-1616 MPD's. The ESM operator used the ALR-81 and ULQ-16 and the EWCC used the ALR-76 to determine the ESM parameters of the emitters. Both the ESM Operator and EWCC recorded the parameters for each test emitter in the Case files and selected "New Ident" on the case file display. The EWFAC operator recorded the scenario, the emitter number and the true emitter characteristics on a data sheet. The recorded data from the aircraft was compared to the EWFAC truth data and known local emitter data to evaluate the ESM system's ability to classify and identify emitters.

RADAR SYSTEM

Ground testing, using FI 2.6 mission software, included radar parameter, functional, and BIT checks of the APS-137 Radar System. Ground tests were conducted on the APS-137 WRA's at the Aircraft Intermediate Maintenance Division, NAS, Cecil Field, Florida, using the AN/UPM-378 Peculiar Ground Support Equipment. Parameters tested, included transmitted frequency, transmitted power, transmitted PW, transmitted spectrum, PRF, chirp BW, agile BW, receiver compressed PW, signal processing functional tests, and receiver sensitivity. Additionally, system BIT software verification tests were conducted to ensure that the ES-3A was ready for flight radar tests.

Flight testing, using FI 2.6 mission software, was conducted in the Chesapeake Bay and Atlantic Coastal Warning areas at altitudes of 5,000 to 25,000 ft AGL and at airspeeds of 170-220 KIAS in sea states from 0 to 2 ft. Range and azimuth resolution testing was conducted using calibrated Luneberg lenses separated at the theoretical range and azimuth resolution limits of the APS-137. Antenna stabilization testing was conducted using large surface contacts and land masses as reference points to assess the effects of aircraft maneuvers on display presentation. Maximum range runs were conducted on targets-of-opportunity of approximately 1,000 m^2 RCS from beyond maximum theoretical range. ISAR runs were conducted against cooperative fleet assets of known location.

RESULTS AND DISCUSSION

LINK-11 SYSTEM

GENERAL

The DTS and HF and UHF radio protocol and signal quality performance was evaluated for compliance with reference 13 requirements. The specific items evaluated were preamble, phase reference, tone phase errors, tone power levels, signal-to-noise ratio, start and stop control codes, and address codes. LMS-11 displays were monitored to determine if the previously mentioned parameters were being correctly transmitted by the ES-3A. All parameters were within acceptable tolerances and satisfied reference 13 criteria.

HF Link-11 RF range performance was evaluated for compliance with reference 14 requirements. Tactical data transmissions were conducted between the ES-3A, operating at 28,000 ft, and the ESTEL out to a range of 190 nmi. At this range UHF voice communications were lost. Data transmissions to the reference 13 HF range requirement of 300 nmi were not attempted, as beyond LOS HF signal propagation performance is affected by atmospheric conditions. The atmospheric conditions are influenced by the time of day, sun spot cycle and activity, season, and latitude. Satisfactory operations to a range of 190 nmi indicate that the system was operating correctly and will provide satisfactory connectivity to the carrier battlegroup (CBG) participating units. Careful management of HF frequency selection to factor in critical operational parameters should facilitate successful ES-3A Link-11 operations with a maximum range of 300 nmi.

UHF Link-11 LOS range performance was evaluated for compliance with reference 14 requirements. Tactical data transmissions were conducted between the ESTEL and the ES-3A with a maximum range of 165 nmi. The capability to successfully conduct UHF LOS Link-11 operations will satisfy connectivity requirements with CBG Link-11 participating units.

The FI 2.8 mission software performance was evaluated for the capability to transmit and receive tactical data per references 13 and 15. A Link-11 net was established between the ES-3A and the ESTEL. The ESTEL acted as the net control station and the ES-3A was in the picket mode. Link-11 data was transmitted between the ESTEL and ES-3A in accordance with reference 16, Appendix A. Operator observations of data transmitted and received by the ES-3A during the missions indicated that reference 13 and 14 requirements were satisfied.

LINK-11 GROUND AND FLIGHT TESTING

During ground and flight testing of the ES-3A Link-11 system the operator could assemble only a single track prior to the arm-and-trigger validation-and-verification function. In many instances, it was found that several tracks of interest were in close proximity. The current implementation does not permit the operator to assemble multiple tracks prior to the arm-and-trigger functions on each separate track. This limitation requires excessive and time consuming operator compensation which distracts from the operator's situational awareness and decreases the overall Link-11 system effectiveness in passing time critical information. The inability to assemble multiple tracks prior to arm-and-trigger validation-and-verification functions is a Part II deficiency.

An excessive number of false Link-11 alerts were displayed to the operator and recorded by the alerts log during missions where Link-11 was active. The majority of the alerts were numbers 584 and 586, indicating a Link-11 sidetone problem. The alerts log was limited to three pages, and was quickly filled with the redundant erroneous Link-11 faults. The Link-11 alerts filled the log within 10-15 min from Link-11 activation, causing actual system faults to go unrecorded after the alerts log was filled. Recording of false Link-11 faults to the alert log renders the post-flight maintenance tool ineffective and unusable, as actual system faults go unrecorded. Excessive Link-11 alerts is a Part II deficiency.

During ground and flight testing, a two-way link using FI 2.8 mission software was established with the ESTEL. The IP-1616 MPD incorrectly displayed the Link-11 data rates. The options displayed on the MPD are "SLOW NORMAL", "SLOW LONG", and "FAST"; and should be reordered and displayed as "FAST", "SLOW", and "SLOW LONG", respectively. The selections were apparently transposed during the software coding and consequently displayed in the incorrect order. If the operator selects the "FAST" Link-11 data rates setup parameter, the system will actually operate in the "SLOW" data rate with long preamble. The incorrect display of the Link-11 data rates will lead to incorrect system configuration and Link-11 net connectivity failure, and reduces the operator's ability to effectively conduct the ES-3A mission. Incorrect display of Link-11 data rates on the IP-1616 MPD is a Part II deficiency.

The FI 2.8 mission software was evaluated for its utility in allowing the operator to "hook" high interest tracks. The Link-11 system did not allow the operator to "hook" a track-of-interest (TOI) and display amplifying data by entering the TOI's Link-11 track number (TN) into the IP-1616 MPD. The operator had to manually search through the track list pages for the TOI TN, "hook" the track, and perform the amplify track function. This process was very time consuming, even under a moderate Link-11 net track load. The ES-3A's inability to locate high interest tracks by Link-11 TN entry will require excessive operator action, detract from situational awareness, and reduces the capability to efficiently conduct the ES-3A mission. The incapability to locate high interest tracks by Link-11 TN entry is a Part II deficiency. The test team recommends providing the operator with an automatic track "hook" capability. The additional track "hook" capability would allow the operator to enter a TN into the IP-1616 MPD, which would initiate TOI amplifying data. Additionally, a function switch should be incorporated to trigger the system to automatically "hook" the TOI subsequent to TN entry into the IP-1616 MPD.

The "DISPLAY TRACK LIST" function was evaluated for its utility during Link-11 operations. When the operator enabled the "DISPLAY TRACK LIST" function to search for a particular Link-11 track, the "DISPLAY TRACK LIST" page listed only those Link-11 tracks that corresponded to the current geographical map display. As the geographical map area was decreased or increased, the "DISPLAY TRACK LIST" items (Link-11 tracks) would change to reflect the tracks displayed on the current geographical map. This implementation failed to provide the operator with an accurate listing of all active Link-11 tracks currently held in the system, degrading the operators situational awareness. The fact that "DISPLAY TRACK LIST" does not list all active Link-11 tracks is a Part II deficiency. The track list page should include all active Link-11 tracks in the system.

The initial step in the ES-3A operator's transmission of a Link-11 track is the assemble/assign process. During the assemble/assign process the operator highlights a specific track. Upon selection of the assemble/assign function by the operator, all track parameters relative to the highlighted track are amplified and presented for "last chance" operator modifications. When the operator performed the assemble/assign process while transmitting a FLIR track on the Link-11 net, the track identification parameter, one of many parameters, was modified by the operator. The source file for the particular track did not properly update to reflect the operator's intention, which was to modify the source file parameters. This resulted in the presence of conflicting data on the track, thereby severely degrading the operator's situational awareness. Failure of the Link-11 mission software to update the source file during the assemble/assign process is a Part II deficiency. A capability to simultaneously update the source file when a track is modified during the ASSEMBLE/ASSIGN process should be incorporated.

FI 2.8 mission software and the IP-1616 MPD were evaluated for their tactical utility. The mission software did not allow the overlay of Link-11 tracks while in the IP-1616 MPD radar or FLIR displays. This resulted in the display of an incomplete tactical picture. An option for simultaneous display of Link-11 tracks would provide the operator with a more complete tactical picture and enhance the operator's ability to evaluate radar or FLIR targets. Failure to simultaneously overlay the Link-11 tracks decreases the operator's situational awareness and decreases the ES-3A operator's ability to effectively and efficiently evaluate targets in the CBG outer air defense zone. The inability to overlay Link-11 tracks on the radar or FLIR displays (FW-402) is a Part II deficiency. An option should be incorporated to provide for simultaneous display or overlay of Link-11 tracks.

The ES-3A FI 2.8 mission software does not incorporate the capability to transmit or receive Link-11 M.11 D IFF/SIF messages on tracks other than the ES-3A itself. This data is extremely useful and significant for providing accurate identification information on Link-11 tracks. Additionally, the ES-3A has an APX-76 IFF interrogation and detection system onboard which could enable the ES-3A to forward additional tactically significant information to the battle group Link-11 net via the M.11 message. The failure to incorporate an M.11 transmit or receive capability on tracks other than ownship prevents the dissemination of significant tactical data to the remainder of the battle group and decreases the operator's ability to prevent Friend on Friend engagements. Failure of the Link-11 to transmit or receive type M.11D IFF/SIF messages is a Part II deficiency. The mission software should be modified to provide an M.11D transmit and receive capability on all tracks in the system.

The IP-1616 MPD was evaluated for its utility during ground and flight testing of the ES-3A Link-11 system. After the arm-and-trigger and validation-and-verification functions were enabled to transmit a Link-11 track, the IP-1616 MPD and keyboard locked-up for approximately 16-20 sec. The IP-1616 MPD and keyboard timeout occurred for each track reported on Link-11. In a track-rich environment where the ES-3A will be required to immediately report multiple tracks, the MPD timeout will seriously detract from the operator's situational awareness and the ability to effectively conduct the ES-3A mission. Excessive IP-1616 MPD timeout following arm-and-trigger and validation-and-verification function is a Part II deficiency.

The Link-11 track transmit function was evaluated for its operational utility. Transmitting a Link-11 track in the ES-3A required the activation of the assemble/assign track function, and the arm-and-trigger validation and verification (V&V) function. During assemble/assign, all necessary track edit and review functions, including the V&V, were completed by the operator. The arm-and-trigger software switch action is therefore unnecessary. The excessive operator software button activations required to transmit a Link-11 track consumes time unnecessarily, detracts from the operator's ability to efficiently transmit or report data, and reduces the operator's ability to effectively conduct the ES-3A mission. Excessive operator action required to transmit Link-11 track is a Part II deficiency which must be corrected as soon as practicable.

The "MONITOR SUMMARY" page was evaluated for its operator utility. During testing, the operator periodically enabled the "MONITOR SUMMARY" page and observed that the status page remained static during that period of observation. The operator was expecting the "MONITOR SUMMARY" page to be automatically updated or refreshed to reflect real-time monitoring of the system status. The operator was required to continuously enable the "MONITOR SUMMARY" software switch in order to refresh and display a current "MONITOR SUMMARY" page. The static, latent "MONITOR SUMMARY" page fails to provide the operator with current, accurate data to effectively conduct weapon system management, thereby decreasing the operator's situational awareness. Static, latent "MONITOR SUMMARY" page is a Part III deficiency which should avoided in future designs. The capability to automatically update the "MONITOR SUMMARY" page at a rate of once per 10 sec should be provided.

When the operator enabled the "DISPLAY TRACK LIST" page function, Link-11 TN's were not sequentially ordered. During voice inquiries and operator searches for particular tracks, the operator workload was significantly increased because of the non-sequential listing of the Link-11 TN's. Failure to provide a sequential track listing in the "DISPLAY TRACK LIST" page will result in increased operator workload. Failure to sequentially list tracks on the "DISPLAY TRACK LIST" page is a Part III deficiency. The capability to sequentially list tracks by Link-11 TN's on the "DISPLAY TRACK LIST" page should be incorporated.

During Link-11 operations, a Link-11 audit trail is written to the mission output tape to aid in post-mission procession. When conducting post-mission data analysis using the VQ Improved Processing and Enhanced reporting system, it was observed that the Link-11 audit trail data printout was difficult to read. Difficulty in reading the printout was caused by poor formatting and the insertion of extraneous characters in the printout data fields. Additionally, the reports were not separated by hard return or line break, causing confusion in establishing the end and beginning of each report. The reports were not formatted for page width and resulted in data being split between lines. The poor format resulted in a time-consuming and laborious post-mission review process. The poor format and difficulty in using the audit trail data printout will cause incomplete data analysis, and will result in a reluctance to review or make use of this data analysis tool. Poorly formatted and illegible audit trail Link-11 data printout is a Part III deficiency.

Tactical utility of the amplify (AMPLY) track function was evaluated during ES-3A Link-11 system ground and flight testing. When the operator "hooked" a Link-11 track and enabled the AMPLY track function, the TN of the participating unit (PU) with reporting responsibility was not automatically displayed to the operator. A majority of active Link-11 nets have multiple Link-11 PU's, with each PU transmitting track data. The ES-3A operator must be able to quickly ascertain the PU with reporting responsibility (R^2) on a particular track to correlate and validate other track information provided by that specific PU; therefore, the data should be automatically displayed. In those nets with multiple PU's, the ES-3A operator will be required to make voice inquiries to the Link-11 PU's to ascertain which unit has R^2, increasing operator workload. Failure to automatically display the participating unit track number during amplify track function (FW-406) is a Part III deficiency.

COMMUNICATION SYSTEMS

GROUND TESTS

ARC-182 BUCC RF power out was measured to be 17.2 W. RF power out met the requirements of reference 18, paragraph 3.6.1.14.1.2, in that the RF power was not less than 10 W for AM. RF output power for ARC-182 No. 1

BUCC is considered to be satisfactory and should allow for adequate two-way communications with the carrier battle group.

ARC-182 No. 1 BUCC transmit measured modulation levels exceeded 120% and did not meet the requirements of reference 18, paragraph 3.6.1.14.8.2.1, of modulation levels of at least 80%, but not more than 100%. High transmit modulation will cause a slight degradation of the transmitted audio signal and may contribute to poor voice intelligibility. High ARC-182 No.1 and No. 2 transmit modulation is documented in Yellow Sheet Report SY-263 of reference 3, and was also present using the BUCC.

ARC-182 No. 1 BUCC transmit measured distortion was 65.0% and did not meet the requirements of reference 18, paragraph 3.6.1.14.8.2.3, of distortion not greater than 5.0%. High transmit distortion will cause a slight degradation of the transmitted audio signal and may contribute to poor voice intelligibility; however, it should not substantially reduce the capability of the ES-3A to accomplish its mission. High ARC-182 No.1 and No. 2 transmit distortion in the ARC-182 is documented during previous testing and was also present using the BUCC.

ARC-182 secure voice communications in the VHF/UHF frequency band using the KY-58 secure voice unit was qualitatively evaluated during ground testing. VHF/UHF voice communications were established between an ARC-210 ground station and the aircraft. During the tests, resulting communications were loud and clear. When communicating with the carrier battle group using secure voice mode, the ARC-182 and KY-58 will provide satisfactory two-way secure voice communications.

Functional ARC-182 HAVE QUICK tests were conducted to test the ability of ARC-182 No. 1 and ARC-182 No. 2 to establish a HAVE QUICK link with an ARC-210 ground station using HAVE QUICK training net frequencies. HAVE QUICK radios must be able to transmit and receive the TOD, and must maintain synchronization of TOD to communicate. During ground tests, the ES-3A's ARC-182 No. 1 and ARC-182 No. 2 both successfully received TOD from a remote ARC-210 ground station. Subsequent HAVE QUICK communications between the aircraft and the ground station were loud and clear. Clear HAVE QUICK communications were also established when the ES-3A's ARC-182's were used to transmit TOD. The ES-3A's ability to communicate using HAVE QUICK is an enhancing characteristic, and should facilitate jam-resistant communications with the carrier battle group, and consequently, increase TEW&R mission effectiveness.

ARC-182 No. 1 BUCC plain voice transmit intelligibility was measured and did not meet the requirements of reference 18, paragraph 5.3.12.2, of 0.5 STI as presented in table III. Reduced plain voice transmit intelligibility may reduce the ability of the aircraft to adequately transmit a clear audio signal when communicating on the Backup Communications. Reduced plain voice transmit intelligibility is a Part III deficiency.

ARC-182 BUCC No. 1 plain voice receive intelligibility was measured and results are presented in Table III. ARC-182 No. 1 BUCC plain voice receive intelligibility did not meet the requirements of reference 18, paragraph 5.3.12.2, of 0.5 STI. Reduced plain voice receive intelligibility may reduce the ability of the aircraft to adequately receive understandable communications when communicating with the carrier battle group. Reduced voice intelligibility using the ARC-182 BUCC is a Part III deficiency.

Table III

ARC-182 NO. 1 BUCC SPEECH TRANSMISSION INDEXES

Transmit				Receive			
Plain		Secure		Plain		Secure	
AM	FM	AM	FM	AM	FM	AM	FM
0.35	0.36	0.37	0.37	0.30	0.34	0.42	0.43
0.34	0.34	0.34	0.39	0.33	0.33	0.44	0.44
0.27	0.36	0.38	0.34	0.33	0.35	0.42	0.43
0.34	0.33	0.37	0.36	0.34	0.32	0.43	0.44
0.35	0.35	0.38	0.35	0.31	0.32	0.41	0.43
0.28	0.34	0.36	0.37	0.31	0.34	0.42	0.43
Average				Average			
0.32	0.35	0.37	0.36	0.32	0.33	0.42	0.43

ARC-182 BUCC No. 1 secure voice transmit intelligibility was measured and results are presented in Table III. ARC-182 No. 1 BUCC secure voice transmit intelligibility did not meet the requirements of reference 18, paragraph 5.3.12.2, of 0.5 STI. Reduced secure voice transmit intelligibility may reduce the ability of the aircraft to adequately transmit a clear secure audio signal when communicating with the carrier battle group on Backup Communications. Reduced voice intelligibility using the ARC-182 BUCC is a Part III deficiency.

ARC-182 BUCC No. 1 secure voice receive intelligibility was measured and results are presented in Table III. ARC-182 No. 1 BUCC secure voice receive intelligibility did not meet the requirements of reference 18, paragraph 5.3.12.2, but is similar to the secure voice intelligibility on other Navy aircraft and should provide comparable secure voice performance. ARC-182 No. 1 BUCC secure voice receive intelligibility is satisfactory for the ES-3A mission.

Station-to-station ICS tests included audio bandwidth, distortion, and audio levels to determine voice intelligibility. Audio power and distortion measurements are presented in Table IV. During testing low frequency cut-off was established at 100 Hz and high frequency cut-off at 6,000 Hz. Audio bandwidth met the requirements of reference 19, paragraph 3.2.1.10, which requires the Digital Crewmember Interface (DCI) to have a fixed audio bandwidth of 100 to 6,000 Hz. Audio distortion was high at frequencies ranging from 100 to 3,000 Hz; however, usable communications were established. Station-to-station audio bandwidth is satisfactory for the ES-3A mission.

Table IV

DCMS AUDIO BANDWIDTH

Frequency (Hz)	Audio Output Power (mW)	Distortion (%)	Frequency (Hz)	Audio Output Power (mW)	Distortion (%)
100	20.0	30.0	3100	29.0	8.0
200	29.0	26.0	3200	29.0	4.0
300	30.0	27.0	3300	29.0	2.5
400	30.0	27.0	3400	28.0	2.0
500	30.0	28.0	3500	28.0	1.8
600	30.0	28.0	3600	28.0	1.8
700	31.0	27.0	3700	26.0	1.8
800	31.0	27.5	3800	25.0	1.9
900	31.0	27.0	3900	24.0	1.9
1000	31.0	28.0	4000	23.0	2.0
1100	31.0	28.0	4100	22.0	2.0
1200	31.0	28.0	4200	22.0	2.0
1300	30.0	28.0	4300	22.0	2.1
1400	30.0	27.5	4400	22.0	2.1
1500	30.0	28.0	4500	21.0	2.1
1600	30.0	28.0	4600	21.0	2.2
1700	30.0	28.0	4700	21.0	2.2
1800	29.0	27.0	4800	21.0	2.2
1900	28.0	26.0	4900	21.0	2.2
2000	25.0	24.0	5000	21.0	2.3
2100	25.0	17.0	5100	21.0	2.3
2200	25.0	16.0	5200	20.0	2.3
2300	25.0	16.0	5300	20.0	2.4
2400	25.0	17.0	5400	20.0	2.4
2500	26.0	17.0	5500	19.0	2.4
2600	25.0	17.0	5600	19.0	2.5
2700	26.0	16.0	5700	18.0	2.5
2800	27.0	15.5	5800	19.0	2.5
2900	28.0	16.0	5900	19.0	2.5
3000	28.0	14.5	6000	15.0	2.6

Station-to-station voice intelligibility was measured using STIDAS, and with crewmember station No. 1 configured as the transmitting station, and crewmember station No. 2 configured as the receiving station. Voice intelligibility was measured using STIDAS for volume levels one through nine. Three runs were conducted for each volume level. The measured station-to-station speech transmission indexes are presented in Table V. Station-to-station scores met the 0.5 Speech Transmission Index (STI) requirements of reference 18, paragraph 5.3.12.2 and will allow for understandable communications between crewmember stations. Station-to-station voice intelligibility is satisfactory for the ES-3A mission.

Table V

STATION-TO-STATION SIGNAL-TO-NOISE VOICE INTELLIGIBILITY

DCI Volume Level								
1	2	3	4	5	6	7	8	9
0.60	0.59	0.63	0.63	0.64	0.62	0.62	0.65	0.62
0.60	0.62	0.64	0.63	0.59	0.62	0.64	0.63	0.63
0.60	0.62	0.62	0.67	0.58	0.64	0.61	0.62	0.63

The antenna VSWR of the DMC34-3/B high-angle and low-angle SATCOM antennas was measured across the 225 to 400 MHz frequency band. The antenna VSWR of the high-angle antenna was measured at the input to the 90° hybrid and varied from 1.07:1 to 1.47:1, which meets the 1.5:1 maximum specification of reference 18. The antenna VSWR of the low-angle antenna varied from 1.13:1 to 2.35:1. The low-angle antenna VSWR exceeded the 2.0:1 specification of reference 18 from 394 to 400 MHz, but will not noticeably effect the ES-3A mission. The high-angle and low-angle antenna VSWR results are satisfactory for the ES-3A mission.

The RF transmission line loss of the AN/ARC-206 SATCOM antenna system was measured in the transmit mode. The line loss was measured from the transceiver to the input of the 90° hybrid for the high-angle antenna and from the transceiver to the input of the low-angle antenna. The transmit mode line loss varied from 1.7 to 2.4 dB to the high-angle hybrid and from 1.5 to 2.1 dB to the low-angle antenna. The high-angle line loss exceeded the 2.0 dB maximum line loss requirement of reference 18 above 297 MHz and the low-angle line loss exceeded 2.0 dB above 376 MHz. This specification non-compliance will not noticeably effect ES-3A mission performance and is satisfactory.

The RF transmission line loss of the AN/ARC-206 SATCOM antenna system was measured in the receive modes. The line loss was measured from the transceiver to the input of the 90° hybrid for the high-angle antenna and from the transceiver to the input of the low-angle antenna. With a pre-amp and filter in-line, the high-angle transmission line had a maximum gain of 27.6 dB and a 3 dB passband from 240 to 277 MHz. The low-angle receive transmission line also had a maximum gain of 27.6 dB and a 3 dB passband from 240 to 277 MHz. Reference 18 specifies 30$\pm$0.5 dB, minimum gain, from 240 to 280 MHz for the preamp. The receive mode transmission line loss/preamp gain results were slightly less than the minimum gain requirements of reference 18 because of the additional line loss in the cabling and bypass filter. The additional line loss is on the same order as the transmit line loss (approximately 2 dB). The receive mode line loss/preamp gain results were consistent with reference 18 and the SATCOM line loss/preamp gain results are satisfactory for the ES-3A mission.

FLIGHT TESTS

During SATCOM flight tests, the ELS Department ground station used an ARC-210/KY-58 configuration with a Dorne and Margolin DM C101-3 10 dB gain antenna for satellite communications. During LOS communications, the ELS ground station used an ARC-210 and an ARC-182.

During flight testing, satellite communications performance was evaluated. The ES-3A successfully established continuous two-way secure voice satellite communications during level flight. Further flight testing is recommended to determine SATCOM performance at increased and decreased look angles to the satellite.

ARC-182 No. 1 BUCC was tested on VHF plain voice communications on test frequency 123.35 MHz using the lower antenna. Plain voice communications were readable out to approximately 160 nmi. ARC-182 No. 1 BUCC did not meet the requirements of reference 18, paragraph D, part 2, which specifies that the ARC-182 provide intelligible communication to a range of 180 nmi for fixed wing aircraft. Although ARC-182 No. 1 BUCC did not meet the requirement, it will provide the aircraft with sufficient VHF ranges in the event of DCMS failure and is satisfactory for the ES-3A's mission.

ARC-182 No.1 BUCC UHF plain voice communications were readable out to approximately 180 nmi on test frequencies 262.8 MHz and 383.4 MHz. ARC-182 No.1 BUCC UHF secure voice communications were readable out to approximately 190 nmi. The maximum range capability of the aircraft's BUCC will provide the aircraft with sufficient VHF/UHF ranges in the event of DCMS failure and is satisfactory for the mission.

Plain and secure HAVE QUICK voice communications tests were conducted with the ARC-182 No. 1 using the lower antenna and ARC-182 No. 2 using the upper antenna. Secure voice HAVE QUICK was maintained out to approximately 190 mni for both ARC-182 No. 1 and ARC-182 No. 2. The maximum range capability of the ES-3A's ARC-182's in HAVE QUICK mode will provide the ES-3A with sufficient HAVE QUICK ranges and is satisfactory for the mission.

The utility and systems integration of the ES-3A was evaluated during flight testing of the communication suite. A single ARC-206 UHF radio is integrated into the communications system as a shared SATCOM, Link-11, and plain or secure LOS voice terminal. Two ARC-182 UHF/VHF radios are integrated into the communication suite to provide additional plain and secure LOS voice transmissions. During flight testing the ES-3A communication suite functioned properly in all modes; however, the communication suite could not be configured to operate simultaneously in SATCOM and Link-11 modes. As a result, the aircraft's mission had to be tailored or dedicated to either Link-11 or SATCOM operations. Limiting operations to either SATCOM or Link-11 will require the EWCC to make trade-off decisions in the dissemination of time critical tactical information. Additionally, the EWCC will be required to choose between either transmissions over the local Link-11 (GENSOR) net to support immediate battlegroup needs, or satellite communications to the theater commander over Sensitive Compartmented Information channels. The inability to configure the ES-3A communication suite to operate in both the SATCOM and Link-11 modes simultaneously is a Part II deficiency. The integration of an additional 100 W UHF radio should be considered, which will enable simultaneous Link-11 and SATCOM operation.

NAVIGATION SYSTEMS

GROUND TESTS

Proper interfacing between the NAV CDU and the GPS, INS, and ONS was verified. Communication between each of the three navigation systems and AYK-14 No. 3 was present, resulting in the appropriate information being sent to the NAV CDU. Proper communication will allow the pilot and copilot to use the NAV CDU to its full capability. The cockpit instrumentation interface is satisfactory.

The system initialization process was evaluated during ground testing. Initial position, date, time, and waypoints were entered into the INS CDU, the ONS CDU, and the NAV CDU individually for initialization. No means existed to crossfill the information between the CDU's, even though the same information was required by each CDU. The repetition of entering data provides the opportunity for data entry errors which will result in improper initialization and alignment, or in the aircraft flying to the wrong destination if the primary navigation source CDU is in error. The repetitive enter of data will also consume the aircrew's time in performing the same function three times, potentially delaying the aircraft launch. The inability to transfer information from one CDU to another is a Part III Deficiency.

The system initialization process was evaluated during ground testing. The three independent navigation system CDU's required different formats for initial position and waypoint entry. Initial position and waypoints in the INS and ONS required position information to be entered in degrees, minutes, and tenths of minutes. However, initial position and waypoints in the GPS on the NAV CDU required position information to be entered in degrees, minutes, and seconds. With each system requiring independent initialization and waypoint entry the operator was required to mentally convert the position information given in one format to another format to initialize the remaining system(s) and enter the positions into each CDU. The inconsistent formats require an unwarranted conversion that will promote incorrect data entry and introduce incorrect navigational tracks around hostile areas. The inconsistent formats for navigation position and waypoint format is a Part III Deficiency. The initial position format required by GPS on the NAV CDU should be changed to degrees, minutes, and tenths of minutes to meet the MAR, reference 8, of 0.1 minute precision for present position. MAR further requires waypoint positions to be precise to 0.01 minute.

FI 2 mission software changes to correctly display negative altitudes on the NAV CDU were verified. A large negative number was displayed in place of negative altitudes, regardless of the actual altitude. During the test, the altitude source was disabled to force GPS altitudes to be sent to the CDU, as the GPS searched for satellites. Negative altitudes from the GPS were displayed correctly. Correct display of negative altitudes will be required should the aircraft fly at an altitude deemed negative by the earth model in use. The software change to correctly display negative altitudes on the NAV CDU is satisfactory.

The NAV CDU designated waypoint capability was evaluated in the HMU. When entering a designated waypoint, the operator entered the aircraft track required to capture and depart the waypoint, whereas an undesignated waypoint was captured at a track determined by the shortest route to the waypoint. However, once a waypoint was designated with a track, it could not be undesignated. If the operator chose to re-use the waypoint as an undesignated waypoint, it was necessary to delete and reenter the waypoint. The inability to undesignate a designated waypoint presents the opportunity for error during waypoint reentry and will distract the aircrew's attention from more important duties. The inability to undesignate previously designated waypoints is a Part III Deficiency.

Agreement between the information displayed on the NAV CDU and the MPD Constant Display Area was verified on the aircraft during ground testing. Time, latitude, longitude, track, true airspeed, true heading, and altitude were in agreement when the same navigation source was selected for each display. Concurring information will prevent the aircrew from using extra time searching for non-existent system problems. The agreement between the NAV CDU and the MPD Constant Display Area is satisfactory.

The navigation source selection capability on the MPD for the station 3 and 4 operators was verified during ground testing. When AUTO was selected from the mission software Warmstart Menu, the mission systems were driven by the pilot's navigation source. This was indicated by the A-GPS, A-CAINS, A-LTN, or A-DR displayed in the Constant Display Area to represent pilot selected GPS, CAINS, LTN-211, or dead reckoning respectively. When GPS or LTN-211 was selected from the Warmstart Menu, the mission systems were driven by GPS or LTN-211 respectively, regardless of the pilot's selection. This permitted the station 3 and 4 operator to select the navigation system of choice, and when in AUTO, kept the operators informed of source changes made by the pilot. The ability for the station 3 and 4 operators to independently select a navigation source and be kept informed of the pilot's selection will permit more efficient system operation. The station 3 and 4 navigation source selection capability is satisfactory.

The IP-1616 MPD TACMAP was evaluated for presentation accuracy in the ES-3A HMU. The TACMAP provided a visual representation of the land and water masses of a particular area, and displayed many local preset points of interest and the waypoints currently in the waypoint database. The placement of the points of interest and waypoints were accurate relative to the displayed latitude and longitude lines. However, when the map was zoomed in, on-land waypoints near the edge of a land mass were sometimes displayed in the water. The inaccurate land mass representation on the MPD will cause inadvertent intrusions into hostile airspace and will cause confusion in distinguishing land-based emitters from sea-based emitters, degrading mission effectiveness. The inaccurate land mass representation on the IP-1616 MPD TACMAP is a Part II Deficiency.

The IP-1616 MPD navigation history log was evaluated in the ES-3A HMU for mission suitability. Latitude, longitude, altitude, heading, and the navigation source were automatically recorded every 90 sec and when the primary navigation source changed. Target fixes generated from other onboard sensors were relative to the aircraft position; therefore, frequent accurate position information was required to correlate sensor information to aircraft position to determine the actual target position. However, the 90 sec navigation parameters recording rate was not variable. If the timing of the history log entries cannot be varied to record additional information at key points along the flight route, valuable information will be lost, degrading mission effectiveness. The inability to vary the IP-1616 MPD navigation history log entry rate is a Part II Deficiency.

FI 2 mission software changes providing the option to use GPS with failed batteries as the primary navigation source was verified. The batteries were removed from the GPS receiver with power applied. The battery status changed to BAD, but the primary navigation source remained GPS because the receiver status was GO. Since GPS was able to run off aircraft power, batteries were not required for use; batteries were required only to retain almanac data and the cryptographic key. The ability to use GPS with failed batteries while the receiver status is GO will provide the pilot with continued GPS accuracy should the batteries fail in-flight. The software changes to select the primary navigation source relative to GPS battery status is satisfactory.

INS RF and umbilical carrier alignments were conducted during ground tests at Patuxent River and during flight tests onboard the USS

Washington. The RF alignments were successfully completed. Status indications on the CDU confirmed that the INS consistently entered fine align within four min and completed the alignments within 8.5 min. The umbilical alignment was also successfully completed on the ground, but not onboard the USS Washington. The cable used onboard the USS Washington was new and untested. The flight crew was unable to determine the cause of the incomplete alignment, and since cable alignments are required whenever the ship is under EMCON, no conclusion can be made about carrier alignments until umbilical alignments can be demonstrated. (RF alignments were not attempted onboard the carrier.)

FLIGHT TESTS

The number of Flight Display Interface System (FDIS) DEFECTIVE advisories was monitored throughout flight testing to evaluate the new advisory criteria implemented in FI 2 mission software. No more than two of these advisories were observed on any flight and the advisories were usually limited to start-up or shutdown. The large number of FDIS DEFECTIVE advisories noted in FI 1 mission software was annoying to the aircrew because the advisories were quickly followed by FDIS GO, and rarely indicated an actual fault. The new criteria more accurately indicated system status. The accurate display of FDIS DEFECTIVE advisories will keep the aircrew more informed of system status. The FI 2 mission software FDIS DEFECTIVE advisory display criteria is satisfactory.

The appearance of advisories specific to Dead Reckoning (DR) mode geographic correction (Geo Correct) was observed in-flight when the Geo Correct function was not available. Geo Correct allows the operator to update the aircraft position only when operating in DR mode. A reference position must be entered prior to Geo Correct activation. If activated via the CDU softkeys or control stick mark-on-top (MOT) button without the reference position entered, an "ENTER LAT/LONG" advisory was displayed on the CDU. This prompted the operator to enter the reference position into the Geo Correction page. If the pilot pushed the control stick MOT button in an operating mode other than DR mode, the "ENTER LAT/LONG" advisory was confusing and meaningless. This inappropriate advisory will confuse the pilot and distract his attention from more important duties. The display of advisories specific to the Geo Correct function when not using Geo Correct is a Part III Deficiency. The display of Geo Correct specific advisories should be restricted to operation in DR mode since Geo Correct is available only in DR mode.

FI 2 mission software changes to prevent premature waypoint capture were verified in-flight. Waypoint capture times ranged from 0 to 4 sec estimated time of arrival (ETA). Waypoint capture distances ranged from 0 to 0.1 nmi distance to go (DTG). Although the capture times were occasionally larger than desired, there was much improvement over the premature captures of the 10 sec noted in FI 1 mission software. However, since the distance was consistently within 0.1 nmi DTG, the software change met the criteria of 1.0 sec ETA or 0.1 nmi DTG. Timely waypoint capture will permit the aircrew to accurately locate targets. The software changes correcting premature waypoint capture is satisfactory.

During a pilot proficiency flight, the active waypoint window on the NAV CDU was monitored for uncommanded indication of an active waypoint. When the NAV select switch on the Flight Mode Selector (FMS) panel was in the TACAN or AWCLS position, the NAV/steering function should be inactive, indicated by INACTIVE displayed in the active waypoint window. When the NAV select switch was in the CMPTR position, the NAV/steering function should be active and either the name or number of the current waypoint or NO WPT should be displayed in the active waypoint window. During the flight the active waypoint window changed from INACTIVE to "2" for approximately 5 sec when the NAV select switch was in the TACAN position, on at least two occasions. The uncommanded display of an active waypoint by the NAV CDU indicates a malfunction in switch position reporting of the FMS to the navigation data converter/repeater (NDCR). The NDCR then forwards the position to the AYK-14 No. 3, which controls computer steering. During scenarios when FMS switch position reporting is unreliable, the position of the heading select/NAV switch can also be erroneously reported. When the FMS erroneously reports the positions of the NAV select switch and heading select/NAV switch while AFCS is engaged, uncommanded flight control inputs could result. Uncommanded waypoint activation is a Part III Deficiency.

The computer steering function was retested to ensure there was no loss of capability as a result of software changes. Waypoints were either designated or undesignated. Undesignated waypoints should be captured at a track determined by the shortest route to the waypoint. Designated waypoints should be captured at an operator-specified track. Designated waypoint capture was also required for figure-8 steering to work properly. During testing, neither designated nor figure-8 waypoints were captured by the system. The aircraft continuously flew around the waypoint as if searching for the waypoint, but never found it. When the pilot flew to the waypoint to manually capture it, the software still did not consider the waypoint captured and recalculated a distance to go of 5 nmi. The inability to capture designated and figure-8 waypoints will limit the use of the system for airways navigation and preclude the use of figure-8 steering. Without figure-8 steering, significant pilot attention will be required to fly a loiter pattern near a hostile border and limit the pilot's ability to perform other duties. The inability to capture designated and figure-8 waypoints is a Part II Deficiency.

During flight testing, the inability to quickly record the position of a target-of-interest (TOI) with a MOT type function was recognized. The NAV CDU does not have the ability to record the location of a TOI in an available storepoint for later use. The MOT function currently available is used only for position updating when operating in DR mode. This will cause the aircrew to miss or erroneously record the position of the TOI. The inability to rapidly record the position of a TOI with a MOT is a Part III Deficiency. The deficiency could be corrected by enabling the control stick MOT button to store marks as storepoints in the CDU, allowing for performance of a MOT from a CDU softkey labelled "mark-on-top" on the waypoint data page. The possibility of making the MOT position available to mission software for display on the TACMAP should also be investigated.

The inability to perform a geographic correction using the control stick was discovered during flight testing. The Geo Correct function allowed the operator to update the aircraft's position while in DR mode, based on a known reference position such as a landmark. The operator entered the reference position prior to pressing the ON TOP softkey on the Geo Correction page as the aircraft flew over the landmark. The AYK-14 mission computer then calculated and displayed the range and bearing to the landmark's entered position and replaced ON TOP with CONFIRM. The operator had 2 min to accept the update, based on this information, by pressing CONFIRM. If CONFIRM was not pressed, the function was ended, the position was unchanged, and CONFIRM reverted to ON TOP. If CONFIRM was pressed, the aircraft position was updated and stored in the CDU as a storepoint. Reference 20 states that this function should be performed by using the softkeys on the CDU or by using the ON TOP discrete input from the control stick's MOT button. However, the Geo Correct capability does not work properly when using the control stick. After the landmark's position was entered and the MOT button on the stick pressed, as the aircraft flew over the mark, ON TOP on the Geo Correction page did not change to CONFIRM. When that softkey was pressed for confirmation, new range, and true bearing were calculated from the aircraft's present position, which was no longer over the landmark, negating the mark performed with the stick. Additionally, if the pilot performed the mark, he had to remove his hand from the stick to push the ON TOP softkey. If the EWCC pushed the softkey at the pilot's mark, the combined reaction times would reduce the accuracy of the mark. All suggested options will introduce an error into the position correction and reduce DR accuracy. The inability to perform a geographic correction using the control stick ON TOP button is a Part III Deficiency. The software should be corrected to acknowledge the ON TOP discrete input from the control stick to allow geographic corrections. When using the stick, ON TOP on the Geo Correction page should change to CONFIRM after the MOT button has been pushed to allow confirmation via the CDU softkey. This deficiency established noncompliance with reference 5, paragraph 3.2.10.14, in that using the ON TOP discrete input fails to perform a geographic correction.

Uncommanded figure-8 leg track and leg distance changes were observed on the NAV CDU. Figure-8 steering commands aid the pilot in flying a figure-8 loiter pattern based on the leg track and leg distance from a given figure-8 waypoint. The figure-8 waypoint information was entered via the CDU's Figure-8 Data page or was a preexisting waypoint within the CDU waypoint database with leg track and leg distance added. Changing a waypoint into a figure-8 waypoint should not alter the original waypoint information on the CDU Waypoint Data page. During testing, a preexisting waypoint (waypoint No. 3), with a designated track of 060 deg was converted by the operator into a figure-8 waypoint with a leg track of 227 deg and a leg distance of 39 nmi. Time-to-go and distance-to-go was checked on the Waypoint Data page for waypoint No. 3. Waypoint No. 3's designated track had changed from 060 deg to 227 deg without operator intervention. Upon returning to the Figure-8 Data page, the figure-8 leg track had changed to 060 deg, which was waypoint No. 3's initially designated track, and the leg distance had changed to 0 nmi. The uncommanded figure-8 leg track and leg distance changes will cause the aircrew to fly an incorrect loiter pattern that may violate hostile airspace or fail to provide an adequate observation location. Uncommanded Figure-8 leg track and leg distance changes is a Part II Deficiency.

An Omega antenna azimuth pattern was conducted in flight in the local area. A cloverleaf pattern was flown on 12 equally spaced headings, relative to and including the great circle bearing to median SNR station F (Argentina). The ONS displayed the station quality index, which ranged from 0 to 40, for the three primary Omega navigation frequencies (10.2, 11.3, and 13.6 kHz). For navigation, any mix of stations and/or frequencies can be used if the signal quality index is above the threshold of 13 and geometry constraints are satisfied. The recorded station quality index and heading data indicated that signal reception was directional. Signal reception was stronger in the forward starboard and aft port quadrants (approximately). However, there was sufficient signal reception (station quality index above the threshold of 13) for navigation purposes. The sufficient ONS signal reception will permit continued reliable ONS navigation regardless of the heading the aircraft is flying. The Omega antenna azimuth pattern is satisfactory for navigation.

During flight testing of the LTN-211 ONS it was discovered that there was insufficient signal reception sensitivity to reliably accomplish the LTN-211's Lane Ambiguity Resolution (LAR) process. LAR is necessary to automatically correct unusually large errors in the ONS position that may result from either inaccurate initial position at takeoff, or because of extended flight periods without Omega signal reception. Analysis of signal and noise during the test period suggested that the degraded reception noted was consistent with wideband electrical noise generated within the ES-3A airplane. Since naturally-occurring atmospheric noise adds to aircraft-generated noise, and atmospheric noise is expected to be far worse at other times and places than during the ES-3A test, LAR in the ES-3A LTN-211 installation should be considered unreliable. Unreliable LAR capability will preclude accurate correction of ONS position should the airplane's GPS and CAINS be unavailable resulting in reduced navigation accuracy of the ONS. The insufficient signal sensitivity for reliable ONS LAR is a Part III deficiency.

The ONS software version was retested (Yellow Sheet Reports SY-28, SY-29 of reference 3) to determine if changes had been implemented to correct the deficiencies. Software version 211-18-04 remained the resident software, and no corrections had been implemented. The DT-IIIC Part II deficiencies, Yellow Sheet Reports SY-28, obsolescent ONS software; and SY-29, disabled ambiguity warning will remain open.

GPS cryptographic key acceptance was re-evaluated for consistency (Yellow Sheet Report SY-32 of reference 3). No loading problems were noted during DT-IIID testing with the 040 series receiver. Although the 020 series is known to have an inconsistency problem, all 020 series receivers have been removed from the supply system. The Part II deficiency, Yellow Sheet Report SY-32, inconsistent acceptance of the GPS cryptographic key has been corrected.

FI 2 mission software changes to correct the incorrect turn direction (Yellow Sheet Report SY-53 of reference 3) and agressive steering (Yellow Sheet Report SY-54 of reference 3) were reevaluated. Various waypoints were selected to create combinations of relative and true bearings less than and greater than 177 deg. Relative bearings less than 177 deg resulted in rights turns. Relative bearings greater than

177 deg resulted in left turns. Unfortunately, with the automatic flight control system (AFCS) coupled, the aircraft's angles-of-bank (AOB) were up to 55 deg were commanded, which exceeded the maximum recommended AOB of 45 deg. Additionally, the rollouts from the turns were unsteady. The continued aggressive steering indicates that the software corrections were not successful. The DT-IIIC Part II deficiency, Yellow Sheet Report SY-53, the use of incorrect bearing in computer steering software version 1.9 has been corrected. The DT-IIIC Part II deficiency, Yellow Sheet Report SY-54, aggressive steering will remain open.

FI 2 software changes to correct the loss of navigation data to the AYK-14 No. 3 mission computer (Yellow Sheet Report SY-118A of reference 3) and the spontaneous degradation of the AYK-14 No. 3 mission computer navigation source (Yellow Sheet Report SY-119 of reference 3) were evaluated. The AYK-14 No. 3 mission computer did not lose communication between AYK-14 No. 1 and AYK-14 No. 2 during testing. The aircraft position, heading, and altitude information continued to update on the MPD constant display area and navigation history log. No uncommanded navigation source changes or degradation for the mission systems operators were noted during testing. The operators maintained control of the source and were supplied with accurate heading reference information for DF's. Communication of navigation data between AYK-14 No. 1 and AYK-14 No. 2, and AYK-14 No. and the continuous operation of the primary mission computer navigation source are satisfactory. The DT-IIIC Part I deficiencies (SY-118A and SY-119) are corrected.

OR-263 FLIR SYSTEM

GROUND TESTS

An MRTD ground test was conducted to determine the baseline OR-263 FLIR resolution performance using the new displays under ideal conditions. Data was taken in the narrow field-of-view (FOV); the system would not transition into the wide FOV at the end of the test cycle. A spatial frequency (resolution) versus temperature (sensitivity) curve was then plotted to determine the ideal FLIR performance. The results of this test were compared with the original 1986 OR-263 resolution results of narrow FOV only (reference 21) collected with the S-3A installation to determine if the new displays affected the baseline FLIR performance in any way.

Comparison with the original S-3A data shows the new MAS displays did not cause any degradation in FLIR displayed resolution. The low spatial frequencies versus low temperature (high sensitivity) data comparison between the S-3A displays and the ES-3A display system were within 10%. It should be noted that the MRTD test is subjective and can be heavily influenced by the experience of the FLIR operator. The new MAS displays did not adversely degrade the OR-263 baseline S-3A FLIR resolution performance, as integrated into the ES-3A aircraft.

FLIGHT TESTS

Flight testing of the ES-3A OR-263 FLIR system, as installed in the ES-3A, was conducted using FI 2.7 mission software. During ground testing, the maximum manual azimuth slew rate obtained was 2 deg/sec. While conducting simulated ship identification flights on various targets of opportunity during flight tests, the poor azimuth slew rate of the FLIR severely limited the ability of the aircrew to accurately track the target throughout the aircraft maneuver. The inability to maintain a target track with the FLIR during ship identification flights will severely degrade the operator's ability to obtain accurate visual information when over-flying ships, reducing the ability to effectively conduct the ES-3A mission. The inability of the OR-263 FLIR to maintain a target track during ship identification flights is a Part II deficiency.

Flight testing of the ES-3A OR-263 FLIR system was conducted using FI 2.7 mission software. During ground and flight testing, the IP-1616 MPD's analog brightness and contrast controls were used, in conjunction with the FLIR software controls, in an attempt to optimize the FLIR display. The analog rheostats on the IP-1616 MPD had a very narrow dynamic range, which resulted in the controls being overly sensitive. Adjustments of the analog controls frequently resulted in the FLIR display being saturated, with no usable information available to the operator. The overly sensitive controls forced the operator to make numerous minute changes to obtain a good display image. The overly sensitive analog brightness and contrast controls of the IP-1616 MPD's will unnecessarily consume time and detract from the operators ability to efficiently operate the FLIR. The overly sensitive analog brightness and contrast controls of the IP-1616 MPD's is a Part III deficiency.

Four missions were flown against the EOTT to collect in-flight resolution data in a dynamic environment. Several OR-263 system failures and inclement weather (high humidity) prevented the collection of any in-flight resolution data. Based upon ground test data and FLIR imagery obtained during the ISAR flights, there is no indication that airborne resolution would be adversely affected by the incorporation of the MAS displays.

ELECTRONIC SUPPORT MEASURES SYSTEMS

GROUND TESTS

Sensitivity testing of the AN/ALR-81(V)3 in the Manual mode were conducted during DT-IIIC and the results of the tests can be found in reference 3. During DT-IIIC sensitivity flights the ALR-81(V)3 antenna spin rate was set. The purpose of additional Manual mode sensitivity testing during DT-IIID was to quantify the degradation to the ALR-81(V)3 sensitivity. Receiver sensitivity measurement tests were conducted by flying a specific track on the CTR and using variable power emitters from the CTR's EWFAC. The ALR-81(V)3 was operated in the Manual mode with intermediate frequency (IF) bandwidth and specified spin rates. The minimum discernible sensitivity was obtained for an antenna spin rate. Although degradation is incurred from the change of scan rate, the resulting sensitivity is still satisfactory for the mission.

Sensitivity tests were conducted to determine the ALR-81(V)3 sensitivity in the Band Scan mode at various scanning rates. ALR-81(V)3 sensitivity results in the Manual and Sector modes are presented in reference 3. The sensitivity measurement tests were conducted in the EWISTL by using the MEWES to directly inject RF signals into the ALR-81(V)3 Omni antenna. The ALR-81(V)3 was operated in the Band Scan mode with a specific IF bandwidth and with specific scan times. The measurements were combined with predicted antenna gains and the resulting predicted in-flight sensitivities for the various scan times. The small variation and overall good sensitivity gives the operator many options in setting up the ALR-81 scan. The ALR-81(V)3 band scan mode sensitivity is satisfactory for the ES-3A mission.

AN/ALR-82 sensitivity testing was conducted during DT-IIIC and the results are presented in reference 3. The purpose of the DT-IIID ALR-82 sensitivity testing was to determine the degradation in sensitivity caused by the selection of multiple ALR-82 bands for display on the AN/ULQ-16 Pulse Analyzer as opposed to a single band. The ALR-82 sensitivity measurement tests were conducted in EWISTL using the MEWES to directly inject RF signals into the Omni RFD antenna port. The MEWES provided a pulsed signal at a level capable of being detected by the ULQ-16. The MEWES output power was then recorded and combined with predicted antenna gains and the resulting predicted in-flight sensitivities for each RFD were determined. Minimal degradation allows the ESM operator to monitor multiple bands with the ALR-82 and ULQ-16 with only a slight loss of sensitivity. The ALR-82 sensitivity with multiple bands selected is satisfactory for the ES-3A mission.

INTEGRATED ELECTRONIC SUPPORT MEASURES SYSTEMS TESTS

The ESM probability of detection ground and flight tests were conducted in EWISTL using the ETEWES and on the CTR respectively. The test emitters were radiated to the ALR-81 spinning antennas and the ESM Omni antennas and hard wired into the ALR-76 antenna ports during EWISTL ground tests and radiated by CTR EWFAC during the flight tests. The tests consisted of radiating SOI's with and without geographic background scenarios, and determining the probability of the ES-3A ESM systems detecting the SOI's. The ESM operator used both the ALR-81 and ALR-82 with both the omni and spinning antennas. The ESM operator detections were counted if the operator logged the test emitter number with a corresponding time. The probability of detection was determined by dividing the number of detections by the number of opportunities. The integrated ESM system's probability of emitter detection is satisfactory for the ES-3A mission. Three Yellow Sheet Reports, SY-35, SY-37, and

SY-67 of reference 3, were verified as being corrected during this test. Yellow Sheet Report SY-38 of reference 3, excessive age-out time for some ALR-76 AIL entries, remains open.

During probability of detection testing, emitters were injected and radiated into the ESM system. Using ES-3A FI 2.7 mission software, the operator performed ALR-76 AIL updates for SOI's. Certain emitters generated multiple AIL entries with identical ESM parameters with the exception of RF. The generation of multiple AIL entries for a single emitter will cause the ALR-76 operator to needlessly task the ALR-81 operator to determine which AIL entry, if any, is correct. The multiple AIL entries for a single emitter will cause increased operator workload by requiring excessive time to sort, identify, and analyze AIL emitters. The multiple AIL entries for a single emitter presents false situational awareness and requires significant operator compensation, thereby degrading the capability of the ES-3A to perform the mission. The multiple AIL entries for a single emitter (FW-301) is a Part II deficiency.

Classification and identification tests of the ESM systems were conducted in EWISTL using the ETEWES. Signals were radiated into the receiver antennas and injected into the ALR-76 antenna ports, and the ESM parameters of the test signals were measured using the ULQ-16's and the ALR-76, and recorded as a case file in the mission software. The emitters used for the test included emitters exhibiting jittered PRI, staggered PRI, pulse group variations, CW, RF agility, frequency modulation on pulse, frequency scan, and high duty cycle. An evaluation of the recorded parameters compared to the actual test emitter parameters was conducted to determine the probability of the ES-3A classifying and identifying the emitter. Classification is defined in reference 4 as when a trained fleet EW Operator (EWOP), given appropriate audio and video characteristics, correctly determines the emitter's function. The integrated ESM system's probability of emitter classification and identification is satisfactory for the ES-3A mission. Two yellow sheet reports, SY-39 and SY-72 of reference 3, were verified as being corrected during this test. Yellow Sheet Report SY-66 of reference 3, incorrect calculation and display of ESM parameters in the Case File display, remains open.

ESM location accuracy testing was conducted during DT-IIIC testing and the results are presented in reference 3. The purpose of the ESM location accuracy that was conducted during DT-IIID was to evaluate the improved ALR-76 fixing software in FI 2.8 mission software. The ES-3A's ALR-76 emitter location accuracy was evaluated by flying a specific track and recording the emitter locations generated by the ALR-76 for the test emitters. As a stand-alone sensor, the ALR-76 location error does not provide sufficient accuracy to meet the TEMP requirement for passive targeting support; however, the ALR-81 mean emitter location error does. The ALR-76 emitter location accuracy is satisfactory for the ES-3A mission.

AN/APS-137 RADAR SYSTEM

GROUND TESTS

The APS-137 Radar System parameters were measured during ground tests to verify that the system was ready for flight evaluation. The radar parameters presented in Table VI met the specification requirements of reference 22 and are satisfactory for the ES-3A mission.

During ground testing of the APS-137 Radar System, the Video Frame Converter (VFC) within the Signal Conditioner Unit (SCU) had the voltage level set to the production level of 3.2 VDC. With the radar in the ISAR mode, but not transmitting, the expected white film of receiver noise was not present in the radar display image area. When analyzing the recorded video using the onboard video recorder, the receiver noise was plainly visible; however, the video recording input was received directly from the radar and was not processed by the SCU. The SCU VFC voltage level was subsequently increased to 3.8 VDC (maximum voltage available), at which time the expected receiver noise was visible in the radar display image area, resulting in satisfactory sensitivity in the ISAR mode. The increased voltage created an adverse side effect in the FLIR, causing the upper half of the gray shades to wash together, causing a loss of upper level sensitivity in the FLIR, thus precluding the operator from obtaining a valid ISAR image, and resulting in an overall reduction in mission effectiveness. The FLIR will be further evaluated during the FLIR DT-IIID testing. The unusable ISAR mode when the SCU VFC voltage is set to the recommended 3.2 VDC is a Part II deficiency.

Table VI

APS-137 RADAR SYSTEM MEASURED PARAMETERS

Parameter	Surface Search	Navigation/ Weather	ISAR
Transmitted Frequency (GHz)	9.6-9.7	9.5-9.8	9.5-9.7
Peak Power Output (kW)	566	566	423
Transmitted PW (μsec)	.56	.56	.56
Transmitted Spectrum	Satisfactory	Satisfactory	Satisfactory
PRF (Hz)	378	378	2025/508
Chirp BW (Mhz)	100	N/A	200
Agile BW (Mhz)	N/A	300	N/A
Receiver Compressed PW (nsec)	A.12	N/A	12
Receiver Sensitivity (dBm) ($P_{fa}=10^{-5}$)	-95	-95	-95

FLIGHT TESTS

During flight testing of the APS-137 Radar System, the operator placed the Target Designator Symbol (TDS) over a TOI to obtain range and bearing information to the TOI. Simultaneously, the operator required a change in radar parameters to optimize the radar display. The only methods currently available to the operator to disable the TDS (enabling the cursor) are the touch panel, function key methods, or to roll the cursor over to the menu selection on the side of the radar display and depressing the "enter" key. The touch panel and function key methods are both extremely cumbersome. Because of the excessive time required to disable the TDS, the range and bearing information to the TOI was lost. Additionally, because the cursor is disabled when the TDS is enabled, as is during an autotrack, no means are available to the operator to acquire the latitude and longitude or range and bearing to any target. Normal mission operations require constant updates of the TOI's position, which becomes more difficult when a TOI is located within a dense operational environment, and will increase the workload of the operator and could result in the loss of the TOI's on the radar display, degrading overall mission effectiveness. The incapability of the APS-137 Radar System to provide a separate TDS and cursor is a Part II deficiency.

During flight testing of the APS-137 Radar System, the operator selected manual antenna tilt to optimize a TOI at 50% of the current range scale. The operator then selected autotilt, and the radar display became unusable, except at the outer ranges of the display. It was determined that the unusable radar display was caused by the antenna tilt algorithm driving the antenna up several degrees. The ES-3A autotilt algorithm computed the optimum antenna tilt angle based on range-to-horizon, which resulted in incorrect tilt angles for the TOI's in the center of the current range scale. Of note, the current S-3B autotilt algorithm optimized the antenna tilt angle based upon the current TDS position, providing the aircraft with a system more tactically advantageous. The ES-3A radar operator was required to use the manual antenna tilt control, an intensive and time-consuming action, to optimize the displayed TOI, causing the possible loss of TOI detection while using the manual tilt to optimize the display, and resulting in an overall reduction in mission effectiveness. The incapability of the autotilt function to optimize the radar display based on current TDS position is a Part II deficiency.

During flight testing of the APS-137 Radar System, the radar operator selected the autotilt function while the aircraft was above 5,000 ft AGL. During the flight, the aircraft's altitude dropped below 5,000 ft AGL, disabling the autotilt function. However, an autotilt condition was still indicated on the radar display. The operator received no indication that the autotilt function was no longer activated. Radar antenna tilt control was lost until the operator selected manual antenna tilt control. Because the antenna tilt angle remained at the last commanded angle above 5,000 ft AGL, and the relative tilt angle between the aircraft and target had changed, the radar display was degraded in that targets were lost from the display, and will cause increased operator workload and confusion, and possibly the loss of targets of interest, resulting in an overall reduction in mission effectiveness. The nonfunctional APS-137 autotilt function below 5,000 ft AGL is a Part II deficiency (FW-313).

During flight testing of the APS-137 Radar System, the radar operator selected manual antenna tilt control and optimized the radar display. When a TOI was located, the TDS was placed on top of the TOI, and the autotrack mode was selected. After processing the acquired TOI, the operator deselected the autotrack mode. The TOI was lost, because the antenna tilt control remained in autotilt, which reinitialized the radar antenna tilt angle to the horizon, rather than returning to the previously selected manual antenna tilt control mode. With the antenna tilt control mode in autotilt, the display was not optimized due to the ineffective autotilt algorithm, and the operator had to reselect manual antenna control to optimize the display and reacquire the TOI, resulting in an increased workload and overall reduction in mission effectiveness. The incapability of the APS-137 to revert to the previous antenna tilt control setting after deselecting the autotrack function is a Part II deficiency.

During flight testing of the APS-137 Radar System, the radar operator selected the autotrack function to track a TOI. During the run-in to the TOI, range and bearing information to the TOI was being displayed with continuous updates. When the operator changed to a smaller range scale, the TDS disappeared from the radar display and erroneous range and bearing information was displayed. The TOI remained displayed in the same location, but the radar was no longer locked on the TOI, and the TDS was not on the TOI. Additionally, after automatically or manually recentering the display, the range and bearing information were again erroneous, with the TOI displayed in the original geographic location and the TDS not on the TOI. Both anomalies were repeatable. The operator had to disable the autotrack function to reacquire the TOI, causing the operator to lose track of the TOI, precluding the aircraft from maintaining contact and tracking TOI's in a dense operational environment. The loss of current TDS position during range scale changes or recentering of the display is a Part II deficiency (FW-319).

During flight testing of the APS-137 Radar System, the radar operator evaluated surface contacts on the radar display in the ground stabilized reference mode. When the aircraft symbol had tracked near the edge of the radar display, the operator changed range scales in the SURFACE SEARCH mode, which required approximately 15 to 30-sec for the radar display to refresh and for surface contacts to reappear. The display origin (aircraft location) presented on the original screen was transferred to the refreshed screen off-center at the same location near the edge of the display, but with an additional offset caused by the aircraft's movement during the screen refresh. To view the entire radar display at the new range, the operator initiated a display recenter action, which, again, required an approximate 15 to 30-sec delay as the screen was refreshed. Because two display refreshes and the associated waiting periods were required with the change of range scales and origin recentering while operating in the ground stabilized reference mode, the display remained unusable for a significant portion of time. The unusable display will require that the operator take the additional step of recentering the display, which will result in an increased operator workload, a temporarily unusable radar display, and an overall reduction in mission effectiveness. The incapability of the APS-137 Radar System to automatically recenter with range scale changes is a Part II deficiency.

During flight testing of the APS-137 Radar System, the radar operator tracked a TOI until a good contact was detected, and then a radar fix was initiated. Because no fix overlay function was available on the radar video display, the operator accessed the TACMAP menu, which displays the location of the new fix. After reselecting the radar menu, approximately 15 to 30-sec was required for the radar video to build in the Surface Search mode, which will cause a loss of time and situational awareness while the operator transitions to the TACMAP menu for updates, and will result in increased operator workload and an overall reduction in mission effectiveness. The incapability of the APS-137 Radar System to overlay fixes on the radar display is a Part II deficiency.

During flight testing of the APS-137 Radar System, the TDS was placed on a TOI. During a typical TEW&R mission, the targeting information on the TOI is sent to the battle group for incorporation into the Navy Tactical Data System (NTDS) tactical plot. The desired format for NTDS data is latitude and longitude of the TOI. With the TACMAP off, the only data available is range and bearing from the aircraft to the TOI. In order for the operator to obtain the latitude, longitude, range, and bearing to the TOI at the same time, the TACMAP must be on. With the TACMAP on, the display becomes cluttered with unnecessary TACMAP information that is overlaid on the radar information, causing a cluttered radar display and will result in an overall reduction in mission effectiveness. The unavailability of latitude and longitude data of TOI's when the TACMAP is off is a Part II deficiency.

Maximum detection range flight tests were conducted in the Atlantic Coastal warning areas against targets of opportunity of approximately 1,000 m^2 RCS. These targets consisted of Group III Commercial/Auxiliary and LPH-7 (USS Guadalcanal) from approximately a stern-on aspect. Once location, course, and speed were verified visually via a MOT. Run-ins were conducted at 25,000 ft AGL, with the aircraft descending slightly throughout the run. Initial detection ranges were noted, also the point where probability of detection (P_d) exceeded 50% (0.5). Range and bearing calls were verified using the TACMAP initiated during the MOT of Group III contacts or the TACAN position of LPH-7. Aspect of contact was determined by known location, course, and speed of contact. The APS-137 Radar System performance was excellent. All targets detected were in excess of the requirements of reference 22. The radar mode selected was at the discretion of the radar operator, although the navigation/weather mode was generally preferred to the surface search mode due to the quick integration time. Detection performance did not differ between navigation/weather and surface search modes. After the surface search mode integrated the target for display presentation, the target detection was similar to navigation/weather. The maximum detection capability of the APS-137 Radar System as configured in the ES-3A aircraft is satisfactory for the ES-3A mission and should provide operational users with long range standoff detection capabilities against surface targets.

Antenna stabilization flight tests were conducted at test altitudes of 7,500 to 12,500 ft AGL at normal cruise speed. Tests were conducted in the Atlantic Coastal warning areas using large surface contacts and land masses such as Cape Hatteras, NC, as baseline targets. With the radar presentation optimized, the aircraft commenced the pitch and roll maneuvers listed in Table VII, using a standard rate coordinated turn. The operator noted the effect of the maneuver on the radar display. The results of these tests are summarized in Table VII. Some degradation occurred at 15 deg climb, 20 deg right roll, and 30 deg left and right roll, but did not preclude target detection. The APS-137 Radar System antenna stabilization performance is satisfactory for the ES-3A mission within the envelope of normal NATOPS pitch and roll maneuvers.

Table VII

APS-137 RADAR SYSTEM ANTENNA STABILIZATION TEST MATRIX

Maneuver	Scan	Optimum	Degraded	Lost
5 Deg Climb	Full	X		
5 Deg Dive	Full	X		
5 Deg Left Roll	Full	X		
5 Right Roll	Full	X		
10 Deg Climb	Full	X		
10 Deg Dive	Full	X		
10 Deg Left Roll	Full	X		
10 Deg Right Roll	Full	X		
15 Deg Climb	Full		X	
15 Deg Dive	Full	X		
15 Deg Left Roll	Full	X		
15 Deg Right Roll	Full	X		
20 Deg Left Roll	Full	X		
20 Deg Right Roll	Full		X	
25 Deg Left Roll	Full	X		
25 Right Roll	Full	X		
30 Left Roll	Full		X	
30 Right Roll	Full		X	

Range and azimuth resolution testing was conducted in the Chesapeake Bay restricted areas at a test altitude of 5,000 ft AGL, at normal cruise speed, and an initial range of 25 nmi. Test targets consisted of four 10 m^2 Luneberg lenses mounted on stabilized spar buoys and rafts. The lenses were placed at theoretical separation distances for range and azimuth resolution for the APS-137 Radar System. Range resolution runs were conducted in both the navigation/weather and ISAR modes. The lenses used for the navigation/weather runs were separated by approximately 300 ft, and the lenses used for the ISAR runs were separated by approximately 9 ft. Azimuth resolution runs were conducted in the navigation/weather mode against lenses at 3,400 ft separation (theoretical maximum range for detection is 13.5 nmi). The aircraft began its run at an initial range of 25 nmi and continued inbound until the lenses of interest were broken out on the radar display. The mark was radioed to the CTR, which was providing truth data for relative lens location. The aircraft was equipped with a tracking beacon for improved accuracy. Some data calls were time-late, due to operator workload. Performance of the system met theoretical standards, and when using the B-Scan window with its improved display resolution and signal processing, theoretical values were exceeded. Results of the range resolution testing were 8.5 nmi average detection breakout in ISAR mode and 6.0 nmi average detection break-out in navigation/weather mode. The azimuth resolution detection breakout occurred at 13.9 nmi average in the navigation/weather mode. The range and azimuth resolution of the APS-137 Radar System is satisfactory for the ES-3A mission of detecting targets in close proximity to one another.

Range and bearing accuracy tests were conducted in the Atlantic coastal warning areas at altitudes of 15,000 to 25,000 ft AGL at normal cruise speeds. These tests were conducted using cooperative U.S. Navy ships as contacts. With no CTR tracking available, individual ship's TACAN's were used to provide position information on the contact. The TACAN provided range and bearing to the contact from the aircraft. On-board navigation equipment was used on the aircraft to verify the TACAN data. When a MOT was initiated, the ship's position was entered into the aircraft TACMAP, along with an estimated target course and speed. The data points corresponded with the TACAN information. Additionally, the radar target range and bearing readouts corresponded with the radar target position information. The range and bearing accuracy was checked during ground testing and found to be within the manufacturer's specifications. The standard used to determine mission suitability of the range and bearing accuracy is presented in reference 22. Table VIII contains a summary of the range and bearing accuracy data collected during flight testing. The range and bearing accuracy of the APS-137 Radar System as installed in the ES-3A aircraft is satisfactory for the mission of surface target detection and localization.

Table VIII

RANGE AND BEARING ACCURACY TEST DATA

Contact	Aircraft Data		TACAN Data		Error	
	Bearing (deg)	Range (nmi)	Bearing (deg)	Range (nmi)	Bearing (deg)	Range (%)
LPH-7	278	69.0	283	68.5	-5.00	+0.7
LPH-7	285	95.0	286	92.5	-1.00	+2.6
LPH-7	322	75.5	327	74.0	-5.00	+2.0
LPH-7	349	82.0	350	79.0	-1.00	+3.7
LPH-7	239	30.0	244	30.0	-5.00	0.0
LPH-7	338	93.8	338	93.7	0.00	+0.1
LPH-7	252	151	253.1	152.2	-1.10	-0.8
LPH-7	247	138	248.9	138.9	-1.90	-0.6
LPH-7	258	165	258.0	162.1	0.00	+1.8
LPH-7	253	161	253.8	161.7	-0.80	-0.4
LPH-7	248	159	249.6	159.0	-1.60	0.0
DD-963	265	40	265.1	40.0	-0.10	0.0
DD-963	024	120	024.0	120.0	0.00	0.0
DD-933	220	123	222.2	124.7	-2.20	-1.4
DD-963	220	107	222.0	108.0	-2.00	-0.9
DD-963	220	110	220.0	112.0	0.00	-1.8
FFG-16	279	56.7	272.0	56.8	7.00	-0.2
FFG-16	279	45.6	274.2	45.9	4.80	-0.7

The ground mapping capability of the APS-137 Radar System was qualitatively evaluated in the Atlantic Coastal warning areas using the navigation/weather mode at test altitudes of 15,000 to 25,000 ft AGL, at normal cruise speeds, and using land masses as reference points. The capability of the APS-137 to detect land/water interfaces, surface contacts, inlets, lighthouses, and channel markers were evaluated. Land/water interfaces were visible at display limits at all times, and in all range scales. The ground mapping capability of the APS-137 Radar System as installed in the ES-3A is satisfactory for the mission.

During ground mapping testing, detection capability against fully developed weather systems was to be evaluated. However, due to schedule and environmental limitations, testing was not accomplished. Further testing is recommended during FI 3.0 software version testing to determine the weather detection and avoidance capabilities of the APS-137 Radar System in the ES-3A.

The off-line radar capability of the APS-137 Radar System was qualitatively evaluated in the Atlantic Coastal warning areas at test altitudes of 15,000 to 25,000 ft AGL, at normal cruise speeds. The off-line radar mode is similar to the navigation/weather mode except that the only controls available to the radar operator are manual antenna tilt, range scale, and receiver gain. The display is oriented in North Stab. Profiles were similar to those used in the ground mapping evaluation in navigation/weather mode. Display presentation was qualitatively compared to those in the navigation/weather mode. No degradation was noted in the display presentation. The off-line radar capability of the APS-137 Radar System as installed in the ES-3A is satisfactory for the mission.

During the off-line radar portion of the APS-137 Radar System flight testing, the radar operator was evaluating the display presentation when several small targets, not previously detected, appeared on the display. The small contacts had been masked by the higher intensity range rings and became visible as the aircraft changed position. The range ring intensity is not adjustable in off-line radar. During AYK-14 computer off-line mission operations, small targets being masked by the range rings in off-line radar will cause a delay in acquisition time, and will result in the lost contact of TOI's and a reduction in AYK-14 computer off-line mission effectiveness. The incapability of the APS-137 Radar System to detect small targets masked by range rings in off-line radar is a Part III deficiency.

The ISAR mode was evaluated in the Atlantic Coastal Warning Areas at test altitudes of 20,000 to 25,000 ft AGL, at normal cruise speeds. Targets used consisted of cooperative fleet targets. The targets included the USS Guadalcanal (LPH-7), the USS Spruance (DD-963), and the USS Clifton Sprague (FFG-16). Pre-flight briefings with the Operations Officers of each ship gave approximate location at the beginning of each test. Once the aircraft was airborne, secure communications were attempted to obtain current position information. However, all attempts were unsuccessful, and clear voice and TACAN were used to obtain positional information. When positive contact was established, the aircraft made one pass to visually verify the proper contact. The aircraft then moved to an initial standoff range of 200 nmi to begin the first run-in. At the completion of the first run, an initial range of 100 nmi was used to facilitate an increased number of runs. When possible, the runs were configured to allow an oblique bow or oblique stern aspect for optimum image quality. Some data runs were accomplished in bow-on, stern-on, or beam aspects, to show variation in image quality as a function of aspect angle. Image quality was based on apparent ship length, superstructure location, mast numbers and location, and major features such as gun mounts and radar flashes. Most of the runs resulted in image quality capable of target classification to the Perceptual Class, while the optimum runs resulted in image quality capable of target classification to the Gross Class. Fine Class classification was not attempted during the flights, but was possible in the post-flight data analysis. In addition to the cooperative fleet targets, many Commercial/Auxiliary class contacts were imaged and identified to the Gross

Class. Image quality was identical at both long ranges (150 nmi) and short ranges (20 nmi). The ISAR capability of the APS-137 Radar System as installed in the ES-3A was satisfactory for the mission of long range surface target classification.

During flight testing of the APS-137 Radar System, another method used to verify the TOI during the ISAR runs was the radar-to-FLIR handoff. The handoff aligns the FLIR antenna to the radar antenna, which is searchlighted while in the ISAR mode. The radar-to-FLIR obtained very successful results during the flight testing at an average range of 20 nmi, giving the flight crew additional verification that the correct TOI was being imaged. The radar-to-FLIR handoff is an enhancing characteristic.

During flight testing of the APS-137 Radar System, the operator selected the ISAR mode and the proper image was displayed. While evaluating the displayed image, the aircraft experienced dynamic yaw motion of approximately one-half pedal. The aircraft motion degraded the displayed image to a point where it became unusable. The operator was unable to regain the image with any of the available controls. The image returned only after the aircraft motion was stabilized. During a normal TEW&R mission, the radar operator uses the ISAR mode to assist in target classification, and should the pilot input yaw motion, the ISAR mode will become unusable, which will result in a loss of time when classifying targets and an overall reduction in mission effectiveness. The unusable ISAR mode during dynamic yaw flight control inputs is a Part III deficiency.

During flight testing of the APS-137 Radar System, the operator selected the ISAR mode and a TOI was imaged. After the TOI was imaged, the operator selected the freeze image function for more detailed image analysis. Before the image froze on the radar display, varying delays of approximately 2-sec were encountered, during which time the optimal target image was lost. During normal mission operations, a 2-sec delay will require the operator to "lead" the image to allow for the optimal image quality to be frozen on the display, requiring additional time to optimize the image due to the increased chance of freezing an unclear ISAR image, and result in an overall reduction in mission effectiveness. The incapability of the APS-137 Radar System to instantaneously freeze an image in the ISAR mode is a Part II deficiency.

During flight testing of the APS-137 Radar System, the operator selected the ISAR mode to image a TOI. The resultant image was in one quadrant of the four-quadrant mode with the detail reduced because of the image size reduction. A full-size TOI image is necessary to obtain detailed information to aid in target recognition, as the display size is approximately one-quarter that of the S-3B aircraft. The operator had to select the expand single quadrant function by rolling the cursor over the appropriate quadrant on the menu side of the radar display and select the expand single quadrant function, and will require increased time to obtain a full-size image on the radar display and result in an overall reduction in mission effectiveness. The incapability of the APS-137 Radar System to default to a single quadrant with four quadrants selectable in the ISAR mode is a Part III deficiency.

During flight testing of the APS-137 Radar System, the operator established an autotrack on a TOI. The ISAR mode was then selected from the autotrack. With a good image displayed on the radar display, a "lock-off" indication was displayed in the Radar Constant Display area, but did not adversely effect the image quality. When the operator exited the image mode, a "lock-on" indication was displayed on the Radar Constant Display (RCD) and the TDS was still in place over the TOI. The successful "lock" indication displayed and the TDS remaining in place was attributed to the software querying the status of autotrack, which was disabled while in the ISAR mode. During mission operations, the "lock-off" indication will cause the operator confusion in determining whether the radar is locked on the proper target, and will cause the operator to attempt to regain a target when the target already exists, resulting in the loss of the actual TOI and an overall reduction in mission effectiveness. The "lock-off" displayed when ISAR mode is selected with good autotrack is a Part II deficiency.

During flight testing of the APS-137 Radar System, the ISAR mode was selected and a TOI was imaged. The operator then selected the Range Search function to center the returns in the A-Scan window to the optimum point, at which time the Stop command was given. A delay of approximately 2-sec was encountered before the display stopped, requiring the operator to repeat the function in the opposite direction to center the returns. During normal mission operations, the operator will be required to attempt to anticipate the delay (which is not consistent due to varying levels of bus traffic) and "lead" the function to have the returns at the optimum position in the A-Scan window, and will require additional time for the operator to optimize the image due to the increased chance of stopping the Range Search function at a less than optimum position, resulting in an overall reduction in mission effectiveness. The incapability of the APS-137 Radar System to instantaneously stop the Range Search function in the ISAR mode is a Part II deficiency.

Throughout the flight test period, radar video and audio was recorded for post-flight data analysis. The integration of the recorder controls in FI 2.0 mission software proved easy for the crew to control. During the post-flight data analysis of the radar video, the TEAC RO-570 video recorder installed in the aircraft was used for detailed image analysis. The test aircraft had a modified recorder that also recorded ICS audio with the video, which proved to be beneficial in the data analysis, as the analyst could reconstruct the scenario as the crew viewed it. A separate deficiency has been written against the recorder to include the audio recording on all fleet aircraft. The integration of the recorder controls in FI 2.0 mission software is an enhancing characteristic.

CONCLUSIONS AND RECOMMENDATIONS

Significant progress has been made in the correction of previously identified deficiencies with the introduction of FI 2 and through engineering efforts. The ES-3A, using FI 2 mission software and Engineer Change Proposal (ECP) 420 corrections, demonstrated a substantial and significant improvement in the aircraft's overall mission capability. FI 2 mission software adds significant new capabilities to the current ES-3A with the on-line operation of systems that previously could not be accessed with FI 1 mission software or controlled off-line. Additionally, FI 2 mission software corrects and or improves a number of FI 1 software limitations. Hardware corrections to be implemented in ECP-420 will be required to utilize the Link-11, SATCOM, and the Backup Communications Controller. There remain areas in the Link-11 and ALR-76 systems in which the mission software should be improved to allow the ES-3A to reach its full potential.

The ES-3A aircraft, using FI 2 mission software, demonstrated an excellent potential to perform the TEW&R mission during DT-IIID testing. The ES-3A weapons system's improved operational utility should perform satisfactorily during the next phase of operational testing, and it is recommended that the ES-3A proceed to the next phase of testing.

LIST OF REFERENCES

LIST OF REFERENCES

1. FW-1R-94, ES-3A Aircraft Navy Development Test DT-IIID, Report of Test Results, of 30 Sep 1994.

2. FW-S9R-94, ES-3A Aircraft Navy Development Test DT-IIID (U), Report of Test Results, of 30 Sep 1994.

3. SY-S7R-93, ES-3A Aircraft Navy Development Test DT-IIIC (U), Report of Test Results, of 9 Aug 1993.

4. ES-3A NATOPS Flight Manual, NAVAIR 01-ES3AAA-1, of 15 Oct 1993.

5. MIL-N-81604C(AS), Military Specification AN/ASN-92(V) Inertial Navigation Set, of 3 Dec 1976.

6. ONS Technical Description, Litton Aero Products, Woodland Hills, CA, of Jun 1979.

7. ONS Operators Guide, Litton Aero Products, Woodland Hills, CA, of Apr 1981.

8. NAVAIR 16-30ARN151-1, Satellite Signal Navigation Set AN/ARN-151(V), of 8 Aug 1990.

9. ICD-GPS-059 Rev B, GPS User Equipment Interface Control Document for MIL-STD-1553 Multiplex Bus Interface, of 8 May 1990.

10. Program Design Specification for ES-3A Fleet Issue 1 and Fleet Issue 2 AN/AYK-14 Navigation Software, SofTech, Inc., Fairborn, OH, of June 1990.

11. Preliminary Operation and Maintenance Instructions for AN/APN-200, Teledyne Ryan Aeronautical Company, Report No. 79064-2, of August 1970.

12. ES-3A Weapon Systems Manual, NAVAIR 01-ES-3AAA-1.1 Preliminary, (U) of 15 March 1993

13. MIL-STD 188-203-1A Interoperability and Performance Standard for Tactical Digital Information Link (TADIL) A of 8 Jan 1988.

14. Navy Tactical Data Systems Model 4 Link-11 Operational Specification 411.2 Change 5 (U) of 6 Jan 1989 (U).

15. Navy Tactical Data Systems Model 4 Link-11 Operational Specification 411.2 Change 5 Appendix D ES-3A Description Report (U).

16. NAVAIRWARCENACDIV Patuxent River ES-3A Link-11 Project Test Plan of 1 Sep 1993.

17. NAVAIRWARCENACDIV, Patuxent River, FTEG Foward-Looking Infrared Radar (FLIR) Project Test Plan of 9 March 1994.

18. MIL-R-85664(AS), Military Specification for the Receiver-Transmitter Radio RT-1250A/ARC-182, of 3 Jun 1985.

19. System Specification for Digital Communications Management System (DCMS), of 18 Oct 1988.

20. MIL-STD-1472C, Human Engineering Design Criteria for Military Systems, Equipment, and Facilities, of 2 May 1981.

21. AT-2R-85, Evaluation of the OR-263/AA Forward Looking Infrared (FLIR) System for the S-3A Aircraft, of 06 Jan 1986.

22. Test and Evaluation Master Plan No. 396 (revision 2), of 29 Aug 84.

GLOSSARY

GLOSSARY

AFCS	Automatic Flight Control System
AIL	Active Interest List
AMPLY	Amplify
ANDVT	Advanced Narrowband Digital Voice Terminal
AOB	Angle-of-Bank
APU	Auxiliary Power Unit
BUCC	Backup Communications Controller
BW	Bandwidth
BIT	Build-in-Test
CBG	Carrier Battlegroup
CDU	Control Display Unit
COMSIM	Communications Simulator
CTR	Chesapeake Test Range
ΔT	Delta Temperature
DCI	Digital Crewmember Interface
DF	Direction Finding
DCMS	Digital Communications Management System
DOA	Direction-of-Arrival
DR	Dead Reckoning
DST	Diagnostic Self-Test
DTIU	Data Terminal Interface Unit
DTG	Distance-to-Go
DTS	Data Terminal Set
EOTT	Electro-Optics Test Target
ECP	Engineering Change Proposal
ERD	Effective Radiated Power
ESM	Electronic Support Measures
ESTEL	E-2C System Test and Evaluation Laboratory
ETEWES	Enhanced Tactical EW Emitter Simulator

ETA	Estimated Time of Arrival
EWCC	EW Combat Coordinator
EWFAC	EW Facility
EWISTL	EW Integrated System Test Laboratory
EWOP	EW Operator
FC/NBR	Frequency Converter/Narrow Band Receiver
FDIS	Flight Display Interface System
FI	Fleet Issue
FMS	Flight Mode Selector
FOV	Field-of-View
FWATD	Force Warfare Aircraft Test Directorate
Geo Correct	Geographic Correction
GPDC	General Purpose Digital Computer
GPS	Global Positioning System
HF	High Frequency
HMU	Hot Mock-Up
ICS	Intercommunications System
ID	Identification
IF	Intermediate Frequency
INS	Inertial Navigation System
ISAR	Inverse Synthetic Aperture Radar
LAR	Lane Ambiguity Resolution
LIFM	Linear Instantaneous Frequency Monitor
LMS-11	Link-11 Monitoring System
LOS	Line-of-Sight
MDS	Minimal Discernible Signal
MEWES	Multiple EW Emitter Simulator
MOT	Mark-on-Top
MPD	Multipurpose Display

GLOSSARY (Cont'd)

MRTD	Minimum Resolvable Temperature Difference
MSP	Multistatic Signal Processor
NAV CDU	Navigation Control Display Unit
NAVAIRSYSCOM	Naval Air Systems Command
NDCR	Navigation Data Converter/Repeater
NTDS	Navy Tactical Data System
ONS	Omega Navigation System
P_d	Probability of Detection
PRF	Pulse Repetition Frequency
PRI	Pulse Repetition Interval
PU	Participating Unit
PW	Pulse Width
R^2	Reporting Responsibility
RCD	Radar Constant Display
RCS	Radar Cross Section
RF	Radio frequency
RFD	RF Distribution
SATCOM	Satellite Communication
SCU	Signal Conditioner Unit
SETD	Systems Engineering Test Directorate
SOI	Signal-of-Interest
STI	Speech Transmission Index
TACMAP	Tactical Tap
TEW&R	Tactical Electronic Warfare and Reconnaissance
TDS	Target Designator Symbol
TOD	Time-of-Day
TOI	Target-of-Interest
TOI	Track-of-Interest
TN	Track Number

GLOSSARY (Cont'd)

TSPI	Time Space Position Information
UHF	Ultra High Frequency
V&V	Validation and Verification
VFC	Video Frame Converter
WRA	Weapon Replaceable Assembly

DEFINITION OF DEFICIENCIES

DEFINITION OF DEFICIENCIES

Part I indicates a deficiency, the correction of which is necessary because it adversely affects:

a. Airworthiness of the aircraft or system.

b. The capability of the aircraft or system to accomplish its primary or secondary mission.

c. The safety of the crew or the integrity of an essential subsystem. In this regard, a real likelihood of injury or damage must exit. Remote possibilities or unlikely sequences of events shall not be used as a basis for safety items.

Part II indicates a deficiency of lesser severity that a Part I which does not substantially reduce the capability of the aircraft or system to accomplish its primary or secondary mission, but the correction of which will result in significant improvement in the effectiveness, reliability, maintainability, or safety of the aircraft or system, or requires significant operator compensation to achieve the desired level of performance; however, the aircraft or system being tested is still capable of accomplishing its mission with a satisfactory degree of safety and effectiveness.

Part III indicates a deficiency which is minor or that appears too impractical or costly to correct in this model but which should be avoided in future designs. Included are violations of specifications for use by the contract negotiator in final settlement of the contract.

PHOTOS AND ILLUSTRATIONS

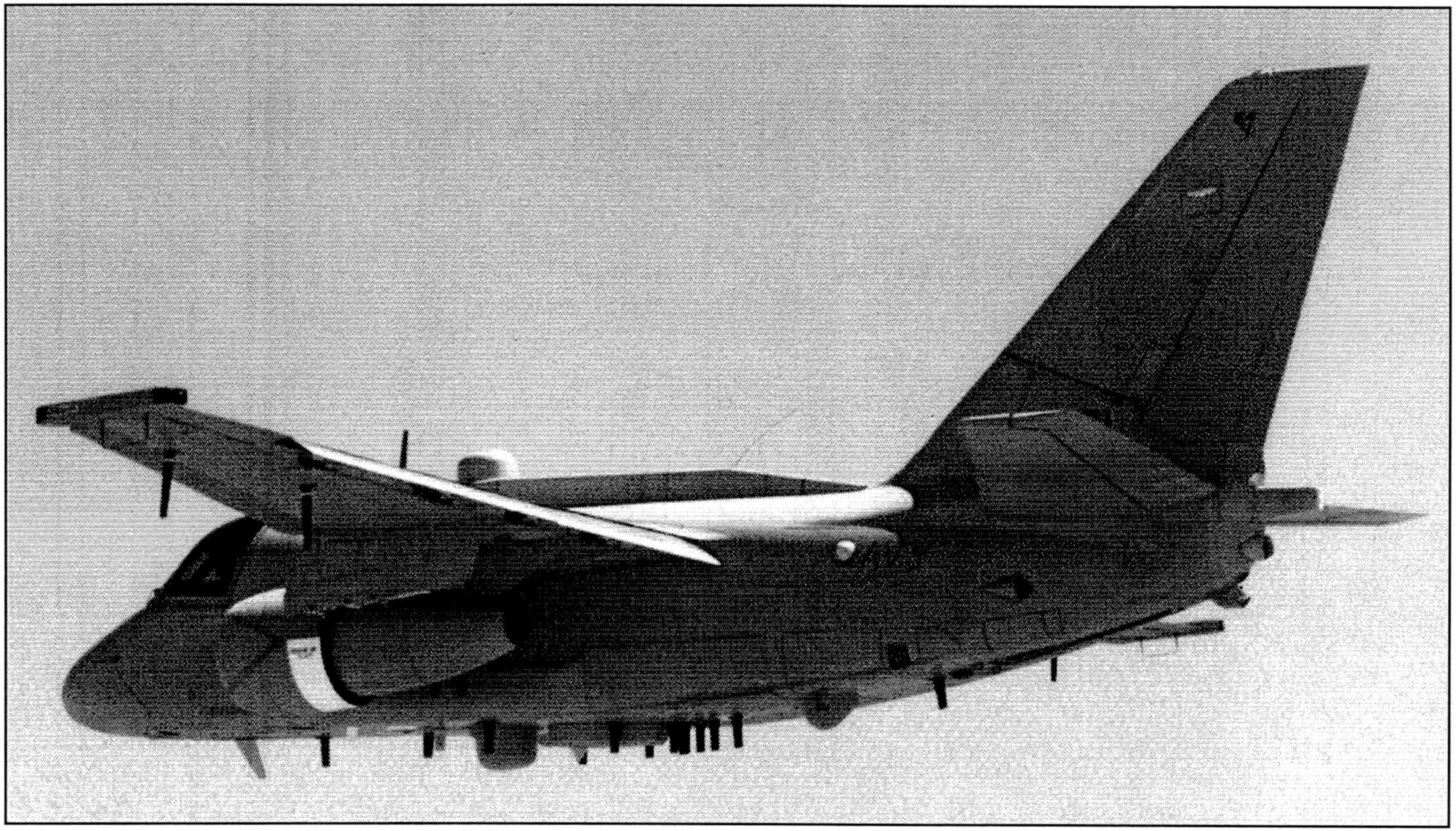

Figure 1
NAVY ES-3A AIRCRAFT BUNO 159401

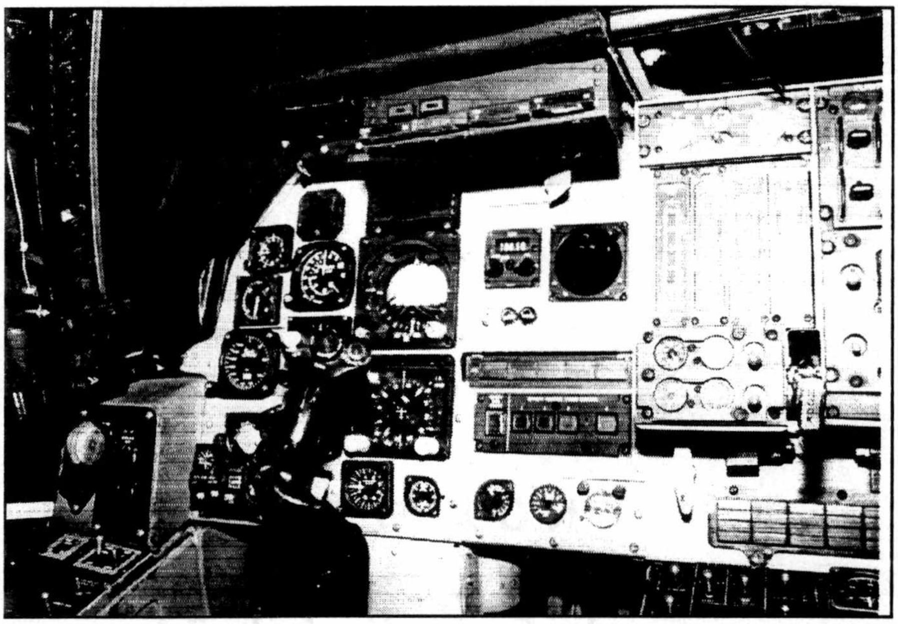

Figure 2
ES-3A PILOT STATION

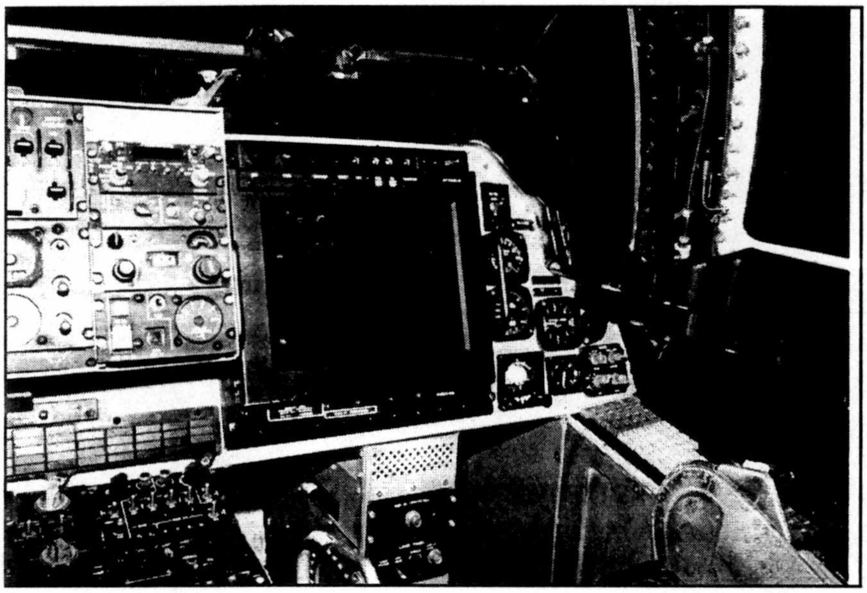

Figure 3
ES-3A EW COMBAT COORDINATOR STATION

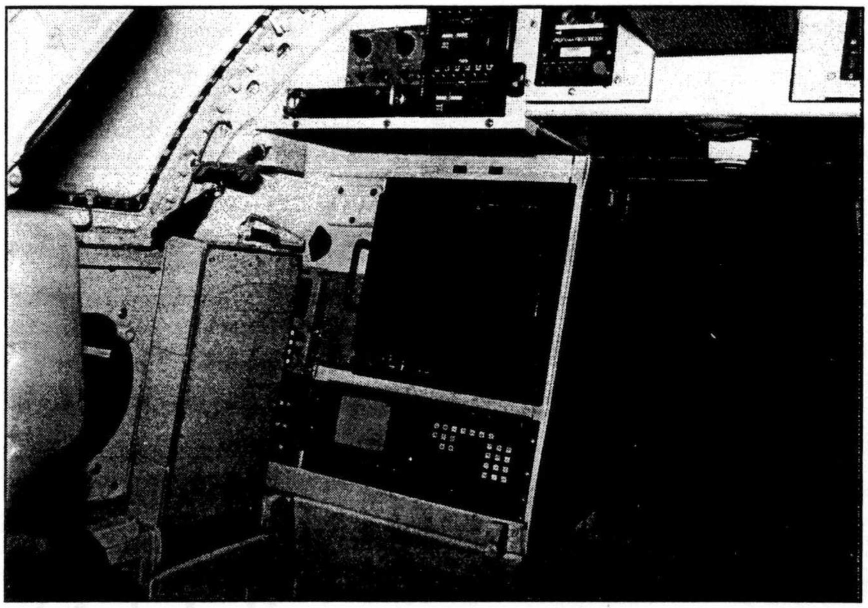

Figure 4
EW OPERATOR STATION 3

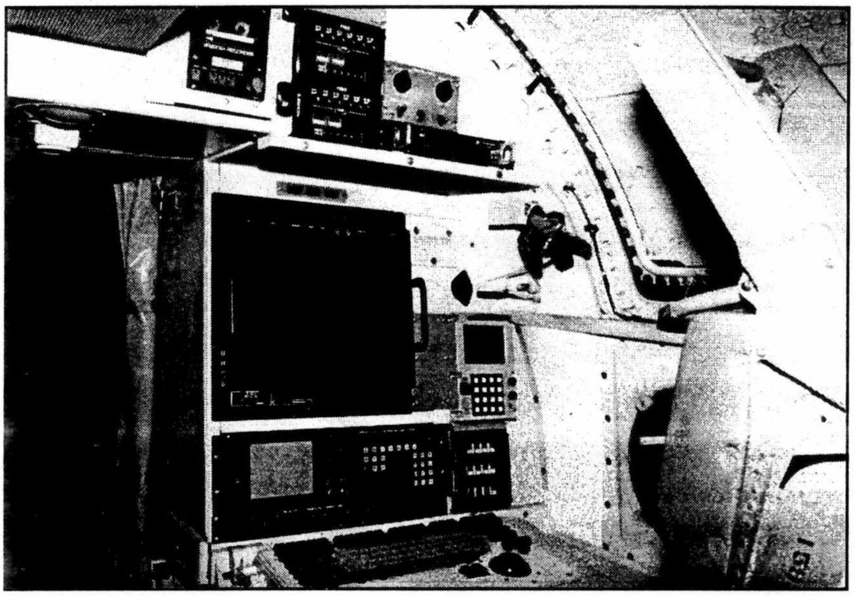

Figure 5
EW OPERATOR STATION 4

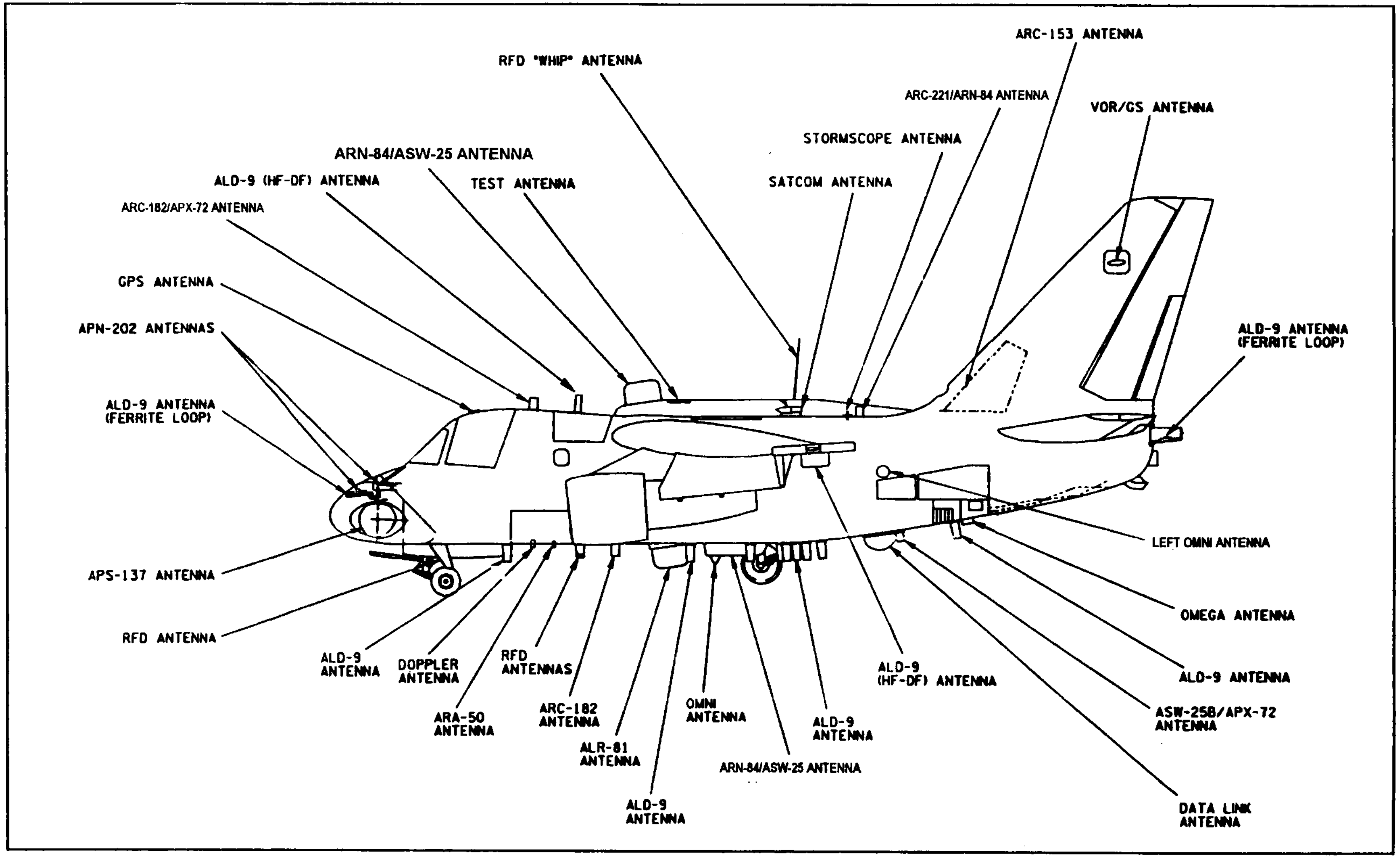

Figure 6
ES-3A ANTENNA LOCATION
VIEW LOOKING AT SIDE OF AIRCRAFT

VITA

Jeffrey Lee Rusher was born in Charlotte, North Carolina on January 2, 1962. He attended elementary school in the Derita (Charlotte suburb) Area School District and graduated from North Mecklenburg High School in June 1980. The following September he entered North Carolina State University, and in May of 1985, he received the degree of Bachelor of Science in Electrical Engineering. In 1985, Jeff began work at the Naval Air Warfare Center, Aircraft Division, Patuxent River, Maryland. In 1990, he was selected for and completed the Aviation Systems Curriculum at the United States Naval Test Pilot School in 1991. Jeff enrolled in the Masters of Science program at the University of Tennessee, Knoxville in 1991 where he intends to receive a Masters degree in Aviation Systems Management.

He is presently employed as an electrical engineer at the Naval Air Warfare Center, Aircraft Division, Patuxent River, Maryland.