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Form Approved
OMB No. 0704-0188

AD-A263 067



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2. REPORT DATE FEB 22 1993		3. REPORT TYPE AND DATES COVERED FOLLOW-ON OPERATIONAL TEST REPORT	
4. AUTHOR(S) LT TONY BOEX		5. FUNDING NUMBER PR 643/0302	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) COMPTON FOR 7970 DIVEN ST NORFOLK VA 23505-1448		8. PERFORMING ORGANIZATION REPORT NUMBER SER 643/0302 FEB 22 1993	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) OPNAV (N6/N88) WASHINGTON DC		10. SPONSORING/MONITORING AGENCY REPORT NUMBER N/A	
11. SUPPLEMENTARY NOTES NONE			
12a. DISTRIBUTION/AVAILABILITY STATEMENT NONE		12b. DISTRIBUTION CODE	
DISTRIBUTION STATEMENT A Approved for public release Distribution Unlimited			
13. ABSTRACT (Maximum 200 words) OPERATIONAL EVALUATION FOR CARRIER SUITABILITY OF AN/ARN-151 GPS RECEIVER. TEST CONDUCTED ON ES-3A FOR RELIABILITY, MAINTAINABILITY AND AVAILABILITY. FOUND SATISFACTORY IN ALL THREE AREAS.			
DTIC SELECTED APR 21 1993 S B			
14. SUBJECT TERMS GPS		15. NUMBER OF PAGES 6	
		16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT

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DEPARTMENT OF THE NAVY
COMMANDER OPERATIONAL TEST AND EVALUATION FORCE
7970 DIVEN STREET
NORFOLK, VIRGINIA 23505-1498

3980 (190-04-OT-IIIC)
Ser 643/

FEB 22 1993 0302

From: Commander, Operational Test and Evaluation Force
To: Chief of Naval Operations

Subj: FOLLOW-ON OPERATIONAL TEST AND EVALUATION OF THE NAVSTAR
GLOBAL POSITIONING SYSTEM AIR INTEGRATION/INSTALLATION
PROGRAM (OPNAV REPORT SYMBOL 3960-12)

Ref: (a) Test and Evaluation Master Plan 190-4 (Rev 1) of 11
May 92
(b) Test and Evaluation Master Plan 190-4 (Rev 1) Change 1
of 15 Jun 92
(c) COMOPTEVFOR ltr 3960 (934-2-OT-IIIB/190-4-OT-IIIC) Ser
631/C052 of 22 May 92
(d) CNAWCAD Patuxent River, MD 051339Z Aug 92
(e) Navy GPS User Equipment Air Set Maintainability/Built-
in-Test Assessment Test Report of 28 Sep 89
(f) ASD memo of 13 Sep 91

1. Summary. This is a report of COMOPTEVFOR's first phase of follow-on operational test and evaluation (OT-IIIC), as defined in references (a) and (b), of the Global Positioning System (GPS) as installed in the ES-3A, performed under CNO Project 190-4. The purpose of the evaluation was to determine the reliability, maintainability, and availability of the AN/ARN-151 GPS User Equipment, as installed in the ES-3A, in an aircraft carrier environment. The GPS user equipment (UE) is determined to be operationally suitable. Approval for extension of application to platforms which require catapult launches and arrested landings is recommended.

2. Background. The ES-3A integration of the GPS is designed to provide precise navigation positioning data, accurate velocity and time data and to enhance night/adverse weather mission capability. Additionally, GPS provides a sole means of navigation capability for flight in the National Airspace System (NAS), by emulating the current Tactical Air Navigation system. The GPS UE required for aircraft integration consists of a receiver processor unit, an antenna system and a control display unit. The AN/ARN-151(V) receiver acts as the GPS system receiver and associated avionics are integrated into the on-board mission computer.

3. Program History

a. OT-IIB (A-6E) was conducted from September 1985 to March 1986. The system was operated by fleet personnel and maintained by contractor personnel. COMOPTEVFOR concluded that the NAVSTAR

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Notes:

1. MFHBCF_{GPS} was calculated using the formula:

$$\text{MFHBCF}_{\text{GPS}} = \frac{\text{Total Number of Flight Hours}}{\text{Total Number of Critical GPS Failures Discovered During System Operations}}$$

Where, critical GPS failure is any fault, failure, malfunction, or degradation of any component or function which prevents successful accomplishment of the mission task. Critical failure determination was based on Appendices A and B (proposed ES-3A Mission Essential Systems Matrix of reference (c), current fleet doctrine, and the operational test director's operational experience.

2. O-level MTTR_{GPS} is the mean time to complete corrective maintenance on all critical hardware failures. It is the average time to self-test, remove and replace faulty weapons replaceable assemblies, exclusive of access time.

3. I-level MTTR_{GPS} is the mean time to test, isolate, remove, and replace the faulty shop replaceable assembly (SRA).

4. A_{GPS} is a measure of availability of the GPS, and was computed using the following formula:

$$A_{\text{GPS}} = \frac{\text{GPS Uptime}}{\text{GPS Uptime} + \text{GPS Downtime}}$$

Where, GPS Uptime is that amount of time where the ES-3A Mission Avionics System (MAS) is indicating that a usable GPS signal is being received. GPS downtime is that total time that the system was operating and during which the computer indicates a source other than GPS is providing primary positional information to the MAS.

c. Limitations. The following limitation affected testing, but did not impact the resolution of COIs and did not preclude the formulation of conclusions concerning operational suitability: The GPS was not tested in all operational environments. Testing took place at electronic warfare ranges and in-theater. Data was correlated to all operational environments.

6. Critical Operational Issues. COIs were resolved as follows:

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<u>Critical Operational Issue</u>	<u>Resolution</u>
Reliability	Resolved (SAT)
Maintainability	Resolved (SAT)
Availability	Resolved (SAT)

7. Results and Discussion. Operational suitability test results are:

a. Reliability. The GPS system installed in the ES-3A was operated for 355.3 flight hours with zero mission critical failures (criterion: ≥ 500 hours). Since the same GPSs were tested during the ES-3A's Technical Evaluation (DT-IIIC) the reliability data reported in reference (d) has been considered in determining overall system MFHBCF_{gps}. Table (1) lists the number of flight hours logged during both the DT and OT phases of testing, by aircraft.

Table 1. U. Reliability

<u>AIRCRAFT</u>	<u>DT-IIIC</u>	<u>OT-IIIC</u>	<u>TOTAL HOURS BY AIRCRAFT</u>
JA-770 (159401)	177.5	164.9	342.4
JA-771 (159404)	24.7	190.4	215.1
TOTAL HOURS BY PHASE OF TESTING	202.2	355.3	557.5

There were zero system failures during DT-IIIC. Based on the cumulative number of flight hours logged during DT-IIIC and OT-IIIC, as well as the reliability demonstrated by GPSs integrated into various other air platforms, there was no reason to suspect that the reliability will be significantly less than 500 hours.

b. Maintainability.

(1) No critical failures occurred at the O-level (criterion: ≤ 20 minutes). Repair of one critical failure induced during a maintenance demonstration (M-demo) required a total of 6 minutes to complete. Only one maintainability demonstration was conducted because this was a remove and replace

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assembly at the O-level. The procedures were found adequate.
The M-demo was assessed as satisfactory.

(2) No critical failures occurred at the I-level (criterion: ≤ 60 minutes). Repair of 28 mission critical faults induced during a maintainability/built-in-test assessment (reference (e)) required a total of 10.6 hours to complete, for an $MTTR_{GPS}$ for I-level of 22.8 minutes. The AN/ARN-151 (V) receiver is the only GPS component installed in the ES-3A that is capable of being repaired at the Intermediate Maintenance Activity.

c. Availability. The demonstrated A_{GPS} was >0.99 (criterion: $\geq .95$) based upon 355.3 flight hours of GPS uptime in 355.3 total flight hours of GPS uptime and no downtime.

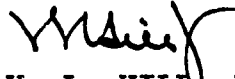
8. Operational Considerations. GPS Receiver (P/N 622-8078-020) did not accept cryptographic key on any attempt to load it. Although not an objective of this test, this effectiveness problem was detected during testing. Without the crypto key, the GPS cannot operate with full precise position service (PPS) capability. PPS provides accurate navigation in 3 dimensions to within 16 meters spherical error probable. This capability is defined as a requirement in accordance with the minimum avionics requirements (MAR) promulgated by the Assistant Secretary of Defense (reference (f)). Without the cryptographic coding the GPS will be subject to degraded navigational accuracy as well as degraded capability to reject interference, jamming, spoofing and meaconing. As a work-around for testing purposes, the batteries of the receiver were removed. This procedure erases the internal memory but allows the cryptographic key to be loaded. The GPS then requires a cold start. A GPS cold start forces the receiver to search for satellites without almanac data. The cold start process requires in excess of 20 minutes to reacquire GPS position data. A normal start requires approximately 2 minutes. The excessive time of a cold start could prevent a GPS solution from being available to the aircrew in the event of an alert launch. This problem appears to be unique to the 020 receiver, but not unique to the ES-3A. It has also occurred on the E-2C equipped with the 020 receiver. It has not been observed in the later 030 and 040 receiver integrations. OT-IIIC was not intended to resolve MAR compliancy in the ES-3A. This will be verified during FOT&E.

9. Conclusions. The GPS UE, as installed in the ES-3A, is operationally suitable.

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10. Recommendation. Extension of application for the AN/ARN-151(V) GPS system is recommended for platforms in the aircraft carrier environment (i.e., catapult launches and arrested landings).

11. Other Recommendations. Ensure correction of cryptographic key loading problem discussed in paragraph 8.


V. L. HILL JR.

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