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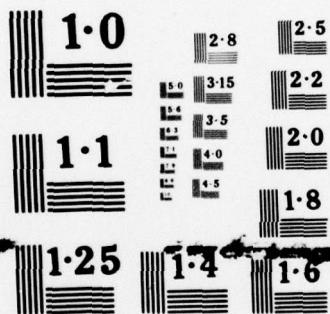
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C-118 WEAPON SYSTEMS MANAGER

TECHNICAL REPORT

PACIFIC AREA EVALUATION OF A COMMERCIAL OMEGA

NAVIGATION SYSTEM INSTALLED IN

A VC-118 AIRCRAFT.
Supplement I.

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CLIFTON G. WRESTLER, JR.

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Encl: (1) C-118 WSM 1-78 Supp I, Pacific Area Evaluation of a Commer-
cial OMEGA Navigation System Installed in a VC-118 Aircraft

1. During reference (a), an evaluation of a commercial OMEGA
Navigation System (ONS) installed in a C-118 aircraft was authorized.
Reference (b) reported the results of the evaluation in the Conus,
Atlantic, Mediterranean, and Caribbean. A supplemental evaluation was
deemed necessary for the Pacific Area due to variations in the
geographic locations and power output of the ground based transmitters.

2. Enclosure (1) gives the results of the evaluation, recommendations
for UNS implementation and concludes the evaluation of a commercial ONS
in the VC-118 aircraft.

F. G. Mitchell
F. G. MITCHELL

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Pacific Area Evaluation of a Commercial OMEGA Navigation
System Installed in a VC-118 Aircraft

By
Clifton G. Wrestler, Jr.

- Ref: (a) "Evaluation of a Commercial OMEGA Navigation System Installed in the C-118 Aircraft." C-118 Weapon Systems Manager Technical Report number C-118 WSM 1-78, Sep 1978
(b) C-118 Weapon Systems Manager spdltr Code 0515/CGW/271 of 12 Sep 1978
(c) Federal Aviation Administration circular AC 120-31
(d) Aeronautical Radio Incorp. specification ARINC 580
(e) Aeronautical Radio Incorp. specification ARINC 599
- Encl: (1) Pertinent Configuration Differences
(2) Received Signal Strength
(3) Navigation Accuracy

INTRODUCTION AND PURPOSE

1. The results of the evaluation of a commercial OMEGA on a C-118 aircraft operating over the Atlantic were reported in reference (a). A supplemental operational evaluation has been conducted using a Litton Aero Products OMEGA Navigation System (ONS), LTN201, installed in VC-118B BUNO 128424. The purpose of these tests, as delineated in reference (b), was to evaluate the position accuracy and the received signal strength in the Pacific operations area. This report presents the test results and the operational problems encountered.
2. The LTN201 installation in the VC-118 was similar to the installation reported in reference (a), with one major difference. The location of the control display unit (CDU) was installed in the control pedestal between the pilot and the co-pilot. Pertinent installation/configuration differences are listed in enclosure (1). The antenna location was determined by using the skin mapping results reported in reference (a) and verifying adequate signal strength with the actual ONS prior to installation.
3. During the evaluation, the received signal strength data were recorded near the waypoints. Adequate signal strength was available for the ONS to accomplish navigation. However, the overall average signal strength was 15.6% lower in the Pacific area as compared to results reported in reference (a). Additional results are found in enclosure (2).

Enclosure (1)

4. Data were collected using electronic/celestial fixes and mark-on-top fixes. The data using mark-on-top fixes was of primary interest for this evaluation. Data collection was a team effort between the pilots and the navigator due to the location of the CDU. In VC-118 aircraft, there is no navigator's ditching station within the navigator/radio operator compartment. Therefore the CDU had to be located accessible to the pilots in order to obtain mark-on-top data during approaches and landings. In addition to collecting data, the pilots had to compute the true airspeed (TAS) from the indicated airspeed, air temperature and altitude, and input the ONS during the flight, especially during approaches and landings. Since TAS inputs via the keyboard are time-consuming, inputs could not be entered continuously thereby incurring some loss of accuracy.

5. The mark-on-top data points showed an average error of 3.80 nautical miles with a standard deviation of 2.280. The ONS was accurate to within 7.0 nautical miles in better than 90% of the samples, even though the TAS had not been continuously updated. The electronic/celestial data points showed an average error of 6.24 nautical miles. Additional data is found in enclosure (3).

6. During the evaluation period, the squadron was required to report all failures. The occurrence of the following incidents were recorded: two relane incidents, three nonprecision updates, and two ambiguity conditions. The receiver processor unit was changed once unnecessarily due to a software error. Additional training for the crew precluded the operator from entering into the software problem area during the remainder of the evaluation. Not enough flight hours were accumulated during the evaluation to make an accurate point estimate on the reliability of the ONS hardware.

7. The additional capability of the ONS was used to evaluate wind conditions. This information was used to fly closer to desired track than is possible using hourly or even semi-hourly LORAN and celestial fixes.

Conclusions and Recommendations

8. The LTN201 installed in the VC-118 aircraft operating in the Pacific area had an average error of 3.80 nautical miles which meets the minimum navigation performance standards of references (c), (d), and (e). At all times, there were four stations (minimum of three required) with signal-to-noise ratios suitable for navigational use. Therefore, the LTN201 or another commercial ONS with similar mechanization and accuracy will meet the long range overwater navigation requirement for VC/C-118 aircraft in the Pacific, Atlantic, Caribbean, and Mediterranean.

9. It is recommended that the C-118 ONS training syllabus and operation manuals should be developed/structured to conform with NATOPS Standards.

Pertinent Configuration Differences

Ref: (a) C-118 Weapon Systems Manager Technical Report, C-118 WSM 1-78
of Sep 1978

The significant aircraft configuration differences between C-118 aircraft reported in reference (a) and VC-118 aircraft used for this portion of the evaluation and the OMEGA Navigation System installation differences are tabulated in Table 1.

TABLE 1

	<u>C-118 BUNO 131609</u>	<u>VC-118 BUNO 128424</u>
Driftmeter Instl	Yes	No
Loran C	No	Yes
Nr of 400HZ Inverters	2	6
Control Display Unit (CDU) Location	Navigator's Station	Cockpit Control Pedestal
Manual TAS Input	Vernier Syncro	CDU Keyboard

The ONS Program provided for this evaluation, LTN201-3-9-25, is the same program developed for commercial airlines flying the Micronesia Islands. This program uses signals from stations up to 9500 NMI vice 8000 NMI range used in the program utilized for the evaluation reported in reference (a). This change in range increases the number of stations available for navigation provided the signal strength is adequate.

Enclosure (1)
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Received Signal Strength

Ref: (a) C-118 Weapon Systems Manager Technical Report, C-118
WSM 1-78 of Sep 1978

The received signal strength data were recorded near the waypoints for the three frequencies of each station as a ratio of signal to noise. For statistical purposes, the lowest signal to noise ratio (SNR) for the three signals from each station is taken as the value for the station. This procedure gives a pessimistic value for signal quality.

The 105 SNR readings reduced to percent of samples with a minimum value of SNR and for a minimum number of stations are given in Table 1. The range limitation on use of signals is for navigation computational purposes and is excluded from the data in Table 1.

TABLE 1

Percent of samples for a given SNR and number of stations.

Minimum SNR (db)	Number of Stations					
	2	3	4	5	6	7
+20	82.86	36.19	14.29	0	0	0
+10	89.52	46.67	20.95	.03	0	0
+ 5	97.14	71.43	44.76	20.00	0	0
0	100.00	90.48	72.38	40.00	.05	0
- 5	100.00	100.00	92.38	77.14	22.86	.02
- 9	100.00	100.00	100.00	97.14	94.29	60.00

The above SNR's are substantially less than the comparable values given in reference (a). The percent reduction in signal quality for a given number of stations is shown in Table 2. Thereby resulting in an overall average reduction in signal to noise ratios of 15.6% for the Pacific area.

TABLE 2

Percent reduction in signal to noise ratio for Pacific area by number of stations.

Percent Reduction	Number of Stations					
	2	3	4	5	6	7
	2.02	8.36	17.46	21.89	39.48	49.46

Enclosure (2)
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Navigation Accuracy

The majority of the data points were gathered while flying over the vast expanse of the Pacific Ocean. Approximately 100 flight hours were logged during flights from Hawaii to Conus, Midway, Guam, Philippines, Japan, and Korea. The data collected were divided into two groups; mark-on-top fixes and electronic/celestial fixes according to the accuracy with which the position of the aircraft is known. The visual mark-on-top data taken over surveyed targets is the most reliable since the geographic position of the aircraft is known. The fixes obtained by electronic/celestial means are less accurate due to errors associated with the position fixing accuracy associated with electronic/celestial means and with facilities available.

The position fixing accuracy test results are shown in Table 1 for all fixes by category. The mark-on-top data is affected by the true airspeed not being continuously updated and the fact that these data points, for the most part, were taken during landings.

The sample probability distribution for mark-on-top fixes is shown in figure 1 and for electronic/celestial fixes is shown in figure 2.

TABLE 1

	<u>Position Fixing Accuracy</u>		<u>Number Samples</u>
	<u>Average Error</u>	<u>Std Deviation*</u>	
Mark-on-top fixes	3.80	2.280	21
Electronic/celestial fixes	6.24	5.006	76

*A normal distribution was assumed in computing standard deviation. A normal distribution assumption for errors is an approximation to other statistical distributions used in ONS test result reporting. Naval Air Test Center Technical Report WST-74R-74 of 24 June 1974 refers.

Enclosure (3)
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FIGURE 1. NAVIGATION ACCURACY: PROBABILITY DISTRIBUTION FOR MARK-ON-TOP DATA SAMPLE

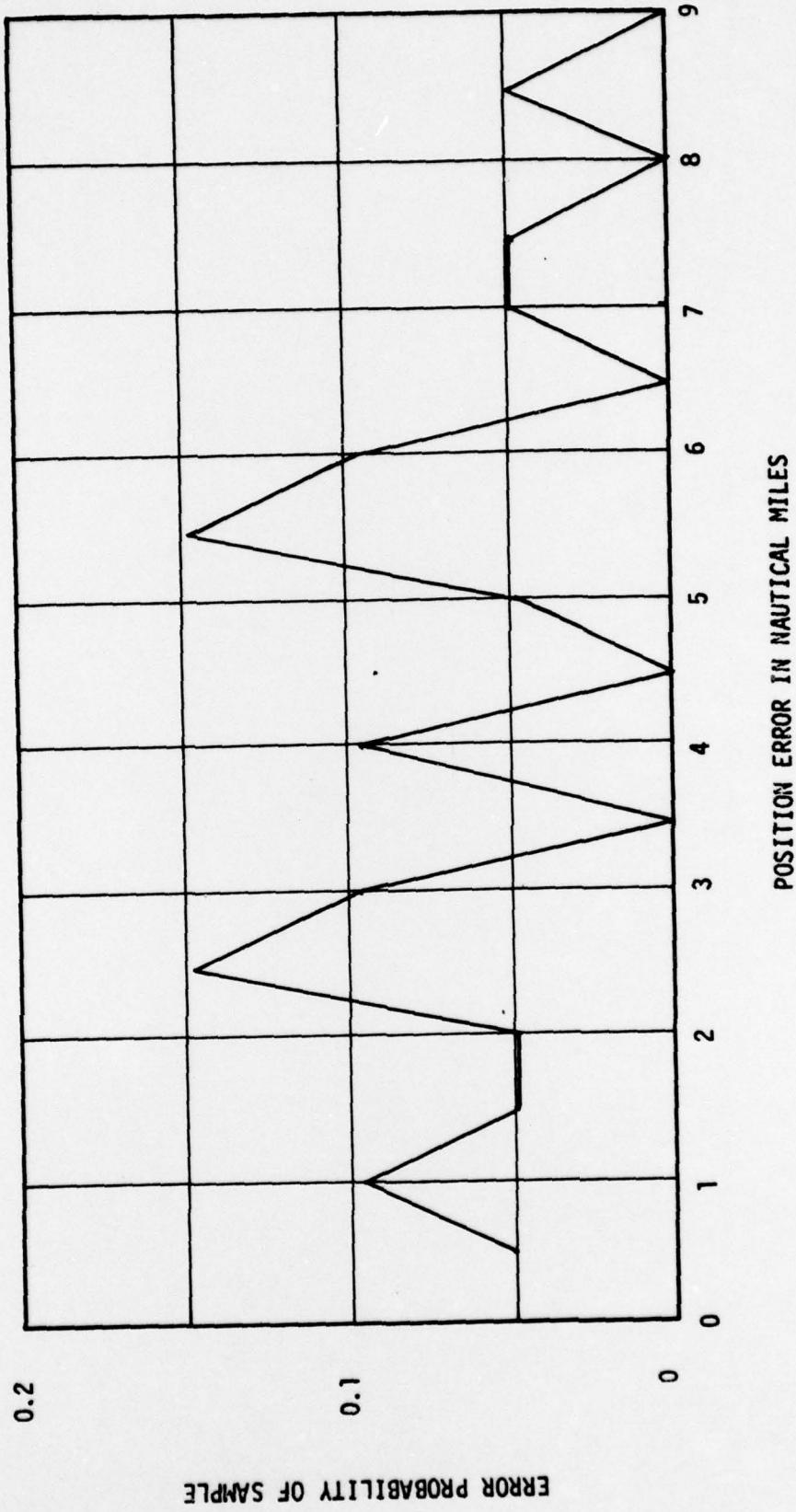


FIGURE 2. NAVIGATIONAL ACCURACY: PROBABILITY DISTRIBUTION FOR ELECTRONIC/CELESTRIAL DATA SAMPLE

