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UNITED STATES COAST GUARD

ADDRESS REPLY TO:
COMMANDER
11th COAST GUARD DISTRICT
706 TIMES BLDG.
LONG BEACH 2, CALIF.

EVC

J15-2
13 October 1961

From: LCDR ROBERT S. HALL (4076), USCG
To: Commandant(EEE)
Via: Commander, Eleventh Coast Guard District(e)

Subj: OMEGA Steering Committee Meeting, 9-10 October 1961; report on

Ref: (a) Comdt(EEE-4) ltr 22 Sept 1961, file J15-2/14-7

1. An OMEGA Steering Committee Meeting was held on 9-10 October 1961 at Naval Electronics Laboratory, San Diego, California. Enclosure (1) is the agenda of the meeting, and enclosure (2) is a list of personnel present.

2. The only classified aspect of the OMEGA system is its application to submarine navigation with respect to depth of signal reception, navigational accuracy while submerged, and details on the submarine evaluation. These aspects are classified CONFIDENTIAL. Enclosure (3) contains all the classified discussion and comments.

3. The following is a summary of the presentations by the various committee members and the ensuing discussions. It is felt that probably a portion of the information may already be available at Headquarters.

A. History of OMEGA Evaluation:

Enclosure (4) is a summary of various stages of the system development. The first OMEGA station was near San Diego at a previous Radux site. It was paired with a station at Haiku, Hawaii in mid 1958. In the available frequency band 10-14 KC, the frequency of 10.2 KC was selected. Higher frequencies would result in greater propagational instabilities, reduced ranges, and smaller lane widths; lower frequencies would increase the size of the transmitting antennas required and would encounter higher atmospheric noise levels. The effective system bandwidth is less than .05 cps. The Haiku site utilizes an antenna in a valley on the eastern side of Oahu. Its six top-loading elements are supported from the mountains surrounding the antenna on three sides, and in turn they support the vertical portion. With about 100 KW into the antenna, 3KW are radiated. Antenna resistance is about one ohm. The receiving site is located at the north end of Oahu and connected to Haiku by telephone line. To obtain a 4500 mile baseline for evaluation, a transmitter was installed at Forestport, N.Y. to utilize the tower there which had previously been employed for Cytac. This tower is a very poor radiator because of the low loading provided by the top loading elements which are brought near to ground level. This station uses

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the same type transmitter as Haiku, an AN/FRA-31, but the radiated power is only 200-300 watts with 30-40 KW into the antenna. The receiving antenna is located 18 miles away and connected by telephone line.

Since San Diego is almost on the Haiku-Forestport baseline, a third station more advantageously located was needed. A tall antenna was already located at Balboa, Canal Zone and used by NBA to transmit time signals. It has six 600 feet towers supporting the outer ends of the top loading elements and provides much better loading than at Forestport. The OMEGA station was placed in operation early in 1961, and the antenna is used on a time-shared basis between OMEGA and the time signal. The radiated OMEGA signal is about 2 KW. NBA transmits time ticks on 18 KC for 4 seconds. The fifth tick is suppressed while the OMEGA transmitter and additional loading coils are connected to the antenna by relays for 1.2 seconds. This transmitter is also an AN/FRA-31. These transmitters are considered capable of saturating any antenna that can be built, and thus are considered operational equipments. Increasing system power will be dependant on improving the transmitting antennas.

An evaluation has been completed in the Gulf area in which two fixed monitors and a mobile monitor on the CGC BLACKTHORN were employed. Of the data that has been reduced so far, some 60 fixes, the results are considered very good. A slide prepared some weeks ago showed the first twelve fixes reduced. Ten of them fell within a 1/2 mile radius of the Lorac fixes used as standards, one was between 1/2 and 1 mile, and one between 1 and 1½ miles. Here, as elsewhere at sea, the big problem was to have a reference system at least 10 times more accurate than the one under test in order to insure that any errors introduced by the reference navigation system did not substantially contribute to the test errors. The Lorac was believed to have an accuracy in the test area of between 100 and 200 feet. Two men who had been on the BLACKTHORN commented on the fine cooperation of the Commanding Officer, CDR ABNEY.

Summarizing the NEL sea trials, the OMEGA accuracy with respect to Lorac for all periods monitored was found to be 0.8 mile. For daytime results only, accuracy was 0.5 mile. Accuracy at a fixed Gulf Coast shore site was 0.4 mile. Additional tests at La Paz, Mexico--on the southern tip of Baja California--indicated a fixed site error of 0.4 mile although the crossing angles of the two lines of position were very poor. At sea in the La Paz area, the OMEGA fixes were more accurate than any other navigational aids available.

lower ambiguity?

Results of monitoring tests in Florida have not yet been evaluated and a report was not available for the meeting.

There is only one experimental aircraft monitoring equipment. This has been tested in the air only twice for short periods, but it appeared to function well. On the bench simulated signals representing aircraft velocity of 1200 knots did not cause the receiver to lose sync. Reading accuracy is 1/50th to 1/100th of a lane. The receiver utilizes a 24 inch vertical antenna. It weighs 50 lbs, but no attempt at miniaturization was made in its construction. It uses diodes and transistors but not printed circuits, although such circuits could well be employed. There have been four reports published on this receiver, and a fifth one will be submitted in two months. NRL is considering development of a portable receiver having a volume of 0.8 ft^3, weighing 20 pounds, and being battery operated.

B. Miscellaneous Facts and Comments:

OMEGA is a general navigation system with a range of 5000 miles from a transmitting station. Minimum usable distance is about 300 miles. It involves phase difference measurements, resulting in lane widths of about 8 miles at 10.2 KC. It has an absolute geographical accuracy of 1/2 to 1 mile, and a relative accuracy for station keeping of 0.1 mile or better. Increased experience with diurnal propagation variations and geographic area errors will permit more accurate mapping and provide necessary day-night and seasonal corrections.

Enclosure (5) contains a comparison of the accuracy, coverage, and cost between Loran A, OMEGA, Loran C, and Transmit systems. It was the opinion of LCDR EDELSON, Program Manager from BuShips, that OMEGA was competitive with Loran A for general navigation, but not with Loran C for precision navigation, and that the program should be pushed as a general navigation system not a precision navigation system. He felt that if OMEGA were installed worldwide, Loran A could be phased out. I pointed out that the Coast Guard has found difficulty in discontinuing navigational aids once established, unless the superceding system was not only better but more inexpensive to the user. EDELSON felt that Loran-C would continue to be relied upon for special purpose high precision navigation in the 25% of the world's area for which it afforded coverage, but that OMEGA would complement Loran-C by affording somewhat lower accuracy over the entire globe.

Prospective customers for OMEGA are: submarine navigation, position keeping for Pacific and Atlantic Missile Range vessels, Hydrographic Office for offshore surveying, Time and Frequency people by greatly extending VLF coverage, Lofti satalite program studying VLF propagation, and special purpose VLF time-shared communications such as passing target acquisition information to missile range stations.

A total of twenty OMEGA navigational receivers have been procured or are on order from IT&T. The Type I receivers were NEL designed for monitoring at a fixed site. They were fabricated by IT&T. The Type I is continuously tunable from 8.2 to 15.2 KC. The receiver read-out gives the lane number plus the percent of the lane occupied. It can accommodate 80DB differential signal. All of these equipments have been delivered. A Digital Data Converter has been built which takes the analog output from the Type I receiver and converts it to digital form for processing. Three of these have been delivered. The IT&T Type II receiver is identical in cabinet appearance. Both are about 2 feet wide, 18" deep, and five feet high. The RF unit is different from the Type I, being fixed tuned at 10.2 KC. It has higher gain, and a zero velocity servo unit for use on moving vehicles up to about 30 knots. It has an automatic synchronization feature that should work at S/N ratios down to 1/3, and after being placed in sync the receiver is designed to maintain sync for S/N ratios down to 1/30. Two of these Type II's are now at NEL undergoing acceptance tests, four more are promised for delivery by IT&T within 1 month after conclusion of the current labor strike, then four more at weekly intervals.

A study has just been completed by IT&T of an analog hyperbolic-to-geographic coordinate converter that would work on either Loran or OMEGA. Design has just been started and delivery should be in June-July 1962.

It appears to be feasible to multiplex OMEGA with a VLF communications system, and since the expense of VLF antennas is so great this may offer a real savings. The Balboa installation is actually doing this now. For a worldwide OMEGA system, a transmitting cycle of 10 seconds is currently envisioned, with each station on the air about one second. At each site the remaining 9 seconds could well be used for high rate communication purposes. An antenna designed strictly for OMEGA would have a very narrow bandwidth unsuitable for high rate communications. However, if the antenna were designed with a broader bandwidth for communications, it would be quite satisfactory for OMEGA also.

Mr. Frantz of Sperry brought a proposal to the meeting covering the addition to the Type II receiver of an adapter to facilitate synchronization and make it faster and easier. The proposal employs a coherent detector, making first a coarse sync and then a fine sync. A Type II receiver with a cold oscillator and a S/N ratio of 1/3 now takes about 15 minutes to get in sync if the operator can receive by radio a WWV reference time signal or has a chronometer accurate to within 1/2 second. Lacking both of these aids but being able to see at least one OMEGA transmission on the monitor scope, the operator can gain sync within 15 minutes.

A set of the five OMEGA charts which have been prepared to date are forwarded as enclosure (6).

C. Future Evaluation Program:

Commencing 11 October 1961, NRL personnel will depart on a flight stopping at Thule, Keflavick, Bodo, Miltonhall, England in a WV-2 aircraft. It will stop in each location for 3 to 4 days to monitor the triad, utilizing both the experimental aircraft receiver and a Type I receiver for comparison purposes. Enroute, the aircraft receiver will monitor the transmissions. Dual channel TI recorders will be employed to record results. A second test flight will commence about 1 November 1961 from Washington DC down the west coast of South America, cross the continent about Santiago, Chile, and return along the east coast of South America. An additional flight is in the proposal stage to cross the Pacific to Honolulu, the Philippines, and Australia.

Results?

A modification to the IT&T receivers is being built that will enable them to monitor and record the field strength of each transmitting station concurrently with other navigational tests. The first such modification unit will be available the first of December, and additional units will be available monthly thereafter.

Operational Test and Evaluation Forces, Pacific are in charge of a forthcoming shipboard evaluation aboard the ORISKANY, KING, and MAHAN. Type II receivers will be employed. Tests will be in the Pacific. Additional tests aboard the COMPASS ISLAND in the Atlantic and Gulf areas will be conducted. Evaluation will cover:

Accuracy--geographic, relative position (static), and rendezvous (dynamic)

Reliability including performance when jammed

Operational suitability including compatability with Naval Tactical Data System

The exact start of these tests will depend on the outcome of the current strike at IT&T which in turn governs dates of delivery of the Type II equipments. Two Type II receivers are now at NEL, San Diego. An IT&T engineer is finishing acceptability tests on them since they had been shipped from the factory early to avoid the strike. In preparation for the OPTEVFOR evaluation, NEL will conduct a 5 day training school for the navigators and quartermasters operating the receivers, and a 2 to 3 week school for the technicians maintaining them. Both these schools will start in late October 1961. Philco and NEL instructors will also be aboard the test vessels for further personnel instruction.

school ✓

One Type I equipment is scheduled for the use of the BLACKTHORN in its moored weather buoy support program from mid December 1961 through January 1962. A Type I receiver will monitor at the CG Base, Mobile during the COMPASS ISLAND tests in the Gulf through 15 December 1961.

The Pacific Missile Range is interested in using OMEGA for positioning their range vessels along the 120th meridian in the vicinity of the equator. Present navigation in that area is quite unsatisfactory. PMR has already tried a sonobuoy system, but it was not satisfactory in the deep water due to propagational unknowns. PMR will get two Type II receivers in January-February 1962 for two of their range ships. NEL will provide personnel to accompany the ships long enough to evaluate OMEGA for the purposes of this test.

At this point I commented on the similar Coast Guard problem with maintaining Ocean Station vessel position on Station November. NEL personnel were very interested in this matter and were happy to know that the Coast Guard maintained a continuous patrol at a fixed point well located in the triad over the entire year. They felt that with a given vessel out on patrol only one month, this would facilitate putting an NEL man aboard for one trip of reasonable duration. They inquired as to where the Ocean Station vessels were berthed. Later in the conference when the schedule for receiver utilization was presented, I found that LCDR GREMER had scheduled a Type II receiver for the Eleventh Coast Guard District about 1 February 1962, for the Twelfth District on 1 March, and for the Thirteenth District 1 April 1962. Since I had received no information as to the Coast Guard's attitude toward OMEGA or its evaluation, I did not pursue the matter further or comment as to whether the ships could actually be employed for such tests. However, in view of the BLACKTHORN's services, it appeared that the Coast Guard was cooperating in the program.

D. Long Range Plans:

Dr. J. A. PIERCE of Harvard felt that for an operational system a radiated power of 10KW should be aimed for, but that a minimum power of 5 KW would be acceptable. Using a globe, Dr. Pierce and NEL and NRL personnel tentatively layed out a global OMEGA system based on existing land and very rough politics. They concluded that stations at the following six positions would provide good coverage:

Tokyo; southern New Zealand: Mauritius Islands: someplace in Argentina, Uruguay, or Argentina in the vicinity of Montevidio: La Paz, Mexico (or San Diego if this were not available): and northern England.

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LCDR R.S.HALL(4076),USCG to
Commandant(EEE) via C11CGD

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They felt the Coast Guard would probably be most familiar with site survey procedures and politcal complications because of their loran experience. If by January-February 1962 the evaluation indicates a successful system, the Coast Guard will probably be requested to initiate a siting program. It seemed to be the feeling of NRL and NEL personnel that the Coast Guard would also be requested to operate the system.

4. It was of interest to note that LCDR GREMER of NEL, who is the OMEGA program coordinator at that command, was also the officer with whom I worked in the Border Field interference study. I was inclined to discuss with him, but did not, the relative importance to NEL of possible radio interference from a Coast Guard Loran Station at Border Field and the stategic need in January 1961 for leaving temporarily unfulfilled, pending the OMEGA evaluation, the Navy and Air Force's requirement for additional navigational aids south of San Diego. If OMEGA for any reason is not accepted as a system, it will be interesting to see if the NEL objection to the loran station decreases.

5. This letter may be reduced in classification to UNCLASSIFIED upon removal of enclosures 3, 4, and 5.

R. S. HALL

ENCL: (1) OMEGA Steering Committee Agenda
(2) OMEGA Steering Committee
(3) Classified OMEGA Discussion
(4) Classified OMEGA System
(5) Classified OMEGA Summary
(6) OMEGA Charts(5)(Under Separate Cover)

FIRST ENDORSEMENT on LCDR R.S. HALL OMEGA REPORT dtd 13 Oct 1961, J15-2

13 October 1961

From: Commander, Eleventh Coast Guard District
To: Commandant(EEE)

1. Forwarded. Approved.

R. N. WILLIAMS
By direction

Enclosure (3) to LCDR R. S. HALL OMEGA report 13 Oct 1961, file J15-2

The following discussion at the OMEGA Steering Committee meeting of 9-10 October concerned submarine evaluation of the system which is classified CONFIDENTIAL.

1. Enclosure (4) to the basic letter contains statements that reception of OMEGA was possible while submerged to a depth of 50 feet or from beneath polar ice caps. Actually no tests have been made to confirm this claim which is based on theoretical calculations and optimistic hope. Two tests of an OMEGA Type I receiver aboard the submarine BAIA were unsuccessful. The first was unsuccessful because of a high level of 60 cycle and harmonic pickup in the loop antenna system. The second test revealed a partially defective loop antenna--a high impedance leak. It has also been found that the loop's movement through the water induced noise in the loop. A third test is slated to commence 12 October for two days on a concurrent basis with other exercises. It is expected that only preliminary information will be obtained. Since OMEGA has only a B priority, it is anticipated that numerous higher priority commitments will continue to limit submarine testing.

2. The higher gain in the Type II receiver was inserted for submerged signal reception. The loop coupler in the submarine also amplifies the signal before relaying it to the receiver.

ENCLOSURE (4) to LCDR R.S.HALL letter dated 13 Oct 1961, file J15-2

OMEGA - A VLF NAVIGATION SYSTEM

...REMENT SC 4407 & 54 04301
...BUREAU OF SHIPS
...NAVAL ELECTRONICS LAB
...SYSTEM STUDIES NAVAL RESEARCH LAB
...COMPUTATIONS HYDROGRAPHIC OFFICE

...S TECHNICAL EVALUATION CONTINUES SATISFACTORILY.

KEY:
ESTIMATED SCHEDULE
CONTRACT AWARD — DELIVERIES — ALLOWED EVALUATION — OPTEVFOR EVALUATION

STAGE	1952	1953	1954	1955	1956

RADUX

1952 DAY OR NIGHT PHASE STABILITY OF 40 KC TRANSMISSIONS OVER LONG DISTANCES DEMONSTRATED BY NEL

RADUX 40 KC EXPERIMENTAL NAVIGATION SYSTEM DEMONSTRATED 1954. ACCURACY 5 MILES. SHELVED BECAUSE GREATER ACCURACY REQUIRED & COST OF WORLD WIDE SYSTEM OF 36 STATIONS

RADUX-OMEGA

40 KC ABANDONED, VLF SUPERIOR

OMEGA

FEASIBILITY STUDY

TRANSMITTER INSTALLATION — HAIKU — FORESTPORT — BALBOA — COMPLETE ENGINEERING CHECKOUT OF ALL OMEGA STATIONS

RECEIVER DEVELOPMENT — MOTOROLA — ITT CO.

PROPAGATION STUDY & SYSTEM EVALUATION — WORLD WIDE INSTALLATION CONTINGENT ON RESULTS OF OPTEVFOR EVALUATION

CURRENT DATE

FLEET DELIVERY

1957	1958	1959	1960	1961	1962	1963

FUNDING MILLIONS OF DOLLARS

	FY 59 & Prior	FY 60	FY 61	FY 62	FY 63
RDT&E	4.090	1.400	1.415	1.425	1.330

MISSION AND DESCRIPTION

OMEGA is a ground reference, long range (5000 - 6000 miles) electronic aid to navigation of the hyperbolic type utilizing time shared sequential transmission of very low radio frequencies (10 - 14 KC). A line of position is established by a "Fine" phase comparison of CW signals from any two stations. The intersection of two lines of position determines a fix. Within a circle passing through three transmitting stations, position accuracy is less than one half mile (standard deviation) for ships, and less than two miles for aircraft. The low frequencies permit submerged reception at antenna depths of up to 50 ft. Navigation by submarines completely submerged beneath polar ice caps is feasible. 6 to 10 transmitting stations will be required for world wide coverage. The system is all weather, can be used day or night, and will have universal unclassified application. Special classified, anti-jamming, anti-deception techniques will be provided for wartime use. Can be used as a world wide time and frequency standard broadcast.

RDT&E 24
10 Sep 1961

Enclosure (5) to LCDR R S. HALL letter dated 13 Oct 1961, file J15-2

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SPC-4

COMPARISON

PRINCIPAL PARAMETERS FOR MODERATE AND HIGH ACCURACY NAVIGATION SYSTEMS

	LORAN-A	OMEGA	LORAN-C	TRANSIT
Accuracy	2 MILES	0.5 MILES	0.1 MILES	0.1 MILES
Coverage	selected areas (10%) full time	world wide full time	selected areas (25%) full time	world wide periodic
Cost				
ship's equipment	$1,800	$20,000	$40,000	$100,000
Installation	$75 million (60 stations)	$50 million (7 stations)	$ 95 million (27 stations)	$ 88 million (Boosters Satellites. Shore support)
per square miles covered	$3.75	$0.25	$1.90	$0.45
Annual Operating	$1.2 million	$3.5 million	$13.5 million	$ 4 million