The INTREPID part in developing OMEGA & NAVSAT Navigation.

by Byron Franklin QMCM (SS)

The *Intrepid* was a good ship to evaluate the new electronic equipment. The large navigation department enabled the evaluation of two new systems, which were completing for resources and money The Omega and the NAVSAT Systems. We had them installed in early 1971.

I remember coming out of our home port at Quonset RI. The Omega was very consistent in a plot that ran down Gould Island a half mile to the east of the ships plot. OMEGA's continuous fix was comforting compared to other navigation fixes that you would have to get, one at a time.

I was hoping for a NAVSAT fix to compare, visual, radar OMEGA and NAVSAT.

I at that time favored the OMEGA, because of the ease and continuous fix. Once we got clear and in deep water we had better than I expected, Omega running continuous and evaluated as good fixes.

(I was used to navigation with electronic equipment. My last ship was the Nuclear submarine SSBN 602 *Abraham Lincoln*. Her underwater navigation was all electronics, including inertial.)

While on the *Intrepid* I communicated regularly with Mr. Brown, the head of Navigation at the Hydrographic Center. I sent piecemeal information that I had collected on OMEGA and NAVSAT to Mr. Brown.

After some time my thoughts were changed about Omega, because of problems and errors that were easy to detect.

I didn't favor NAVSAT at first because of the infrequent NAVSAT fixes, my evaluation comparing NAVSAT and OMEGA changed my mind. I started collecting OMEGA data to find the problem. Other ships using OMEGA also were complaining about fix reliability, especially in the Mediterranean Sea.

I found a great flaw in the use of the only available three stations that we had to use, stations A-B-D. I found that we would get three point intersections, (that is considered an indication of a excellent fix) not near celestial, visible, radar fixes or Dead Reckoning. I concluded that the A/D and B/D both moved up north at equal distance allowing three point fixes when the ship is not near this OMEGA fix intersection.

I wrote an evaluation. Some of it had already been sent to Mr. Brown, at the HO.

I gave the write-up and supporting papers to the Navigator, he recognized the important and added to it, then to Captain, he sent it out to all Commanders.

I believe that this gave the NAVSAT a head start over OMEGA.

The following is the final report from the Intrepid without the Enclosures.

USS INTREPID (CVS-11)
FPO New York 09501

CVS11:02:ajh
10500
Ser 434
25 April 1973

From: Commanding Officer, USS INTREPID (CVS-11)
To: OMEGA Navigation System Project (PME 119), Naval Electronics Systems Command, Washington, D.C.

Subj: Two Year OMEGA Report (January 1971 - May 1973)

Encl: (1) Omega Report of USS INTREPID (CVS-11)
(2) C.O. INTREPID letter of 18 March 1971
(3) Commander NAVAL OCEANOGRAPHIC letter of 16 April 1971
(4) BALTIC MEDIAN ERROR PLOT
(5) BALTIC POLAR PLOT
(6) ATLANTIC MEDIAN ERROR PLOT
(7) ATLANTIC POLAR PLOT
(8) MED (INNER) MEDIAN ERROR PLOT
(9) MED (INNER) POLAR PLOT
(10) MED (CENT) MEDIAN ERROR PLOT
(11) MED (CENT) POLAR PLOT
(12) MED (DEEP) MEDIAN ERROR PLOT
(13) MED (DEEP) POLAR PLOT
(14) Barcelona MEDIAN ERROR PLOT
(15) Barcelona POLAR PLOT
(16) Malaga MEDIAN ERROR PLOT
(17) Malaga POLAR PLOT
(18) Genoa MEDIAN ERROR PLOT
(19) Genoa POLAR PLOT
(20) Augusta Bay MEDIAN ERROR PLOT
(21) Augusta Bay POLAR PLOT
(22) Athens MEDIAN ERROR PLOT
(23) Athens POLAR PLOT
(24) Malaga MEDIAN ERROR PLOT
(25) Malaga POLAR PLOT

1. Enclosure (1) represents a summary of USS INTREPID's experience with the OMEGA navigation system covering a period in excess of two years. It has been compiled and forwarded in the belief that it may be of potential value to OMEGA operators and managers alike.

R H Barker
R. H. BARKER

Copy to:
Commander Cruiser Destroyer Flotilla Twelve (w/o Enclosures 2-25)
Commander Sixth Fleet (w/o Enclosures 2-25)
Commander in Chief U. S. Atlantic Fleet (code J25) (w/o Enclosures 2-25)
Commander Naval Air Force U. S. Atlantic Fleet (w/o Enclosures 2-25)
Director Defense Mapping Agency Hydrographic Center

REPORT OUTLINE:

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VII. North Atlantic Deployment - 1972

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USS INTREPID OMEGA EVALUATION REPORT (1971 - 1973)

I. BACKGROUND.

INTREPID received the SRN 12 Omega and SRN 9 NAVSAT systems in January 1971. Three Quartermasters attended the Omega Operator Course in Norfolk. Since installation, INTREPID has been underway a large portion of the time covering a wide variety of operational areas in the Atlantic Basin and adjoining seas. These extensive observations, especially enhanced by the NAVSAT standard of precision, have revealed unusual OMEGA traits which are considered of potential value both to operators and system managers.

II. EARLY EVALUATION.

During early 1971, Omega was used in conjunction with NAVSAT. The latter proved to be extremely precise and reliable, with typical fix errors less than 500 yards. The disadvantage is the relatively infrequent fixes available (typically 10-20 usable fixes per day). On the other hand Omega provided continuous fixes with a median error of about 2 miles in the WESTLANT area.

III. CHART SCALE CORRESPONDENCE.

On 18 March 1971, the Commanding Officer wrote Commander Naval Oceanographic Office on the subject of Omega Charts (Enclosure 2). Enclosure (3) was received in response. Enclosure (2) suggested Bottom Contour series charts be extended for world wide coverage. Subsequent experience with "homemade" lattice overlays in BC series charts has proved the merit of this type chart, especially in areas of heavy operations such as the Mediterranean. Plotting error on the order of two miles is experienced from the use of VO and number 7501 series scale charts alone.

IV. UNUSUAL OMEGA LOP TRAITS.

During the ship's early experience it was regarded as curious that the Omega fixes were almost invariably points or near points, but nevertheless often disagreed considerably from the ship's known position as obtained by NAVSAT, visual, or radar.

It was further noted that proper resetting of lanes required knowledge of the ship's position within 4 or 5 miles, else a lane-induced error of 8 to 10 miles was the probable result. The navigator might well continue to receive point fixes and thus be unaware of the error.

Lane loss due to precipitation has continued as a significant, although somewhat controversial, nuisance.

V. BALTIC SEA. MAY 1971.

In April 1971 INTREPID deployed to Northern European waters. The Hawaiian station became weak shortly after transiting east of Bermuda. Stations A-B, B-D, A-D were utilized with good results transiting to Lisbon and North to the North Sea. While in the Baltic, Omega was of little assistance. New York was weak and intermittent while Norway was a nearby transmitter within approximately six hundred NM. Fixes had a median error of 8 NM in an approximate direction of 310 from ship's position. Large triangles as well as tight pin points were obtained. After leaving the Baltic, fixes improved and Omega was once again producing a median error of approximately 3 NM.

VI. LOSS OF LANE TRAIT.

After entering the Mediterranean in June 1971, Omega proved far less accurate. This was believed due to the sky wave correction not being available. Other problems included rain, or even heavy moisture, causing complete loss of signal and synchornization of the set. These signal loss periods were sometimes measured in days. This was the same problem that had occurred with less severity off the United States. A partial solution is to ensure the synchronization signal is ALWAYS to the strongest signal and to check synchronization often. Even then, while in the Mediterranean signal loss was considered too long and frequent for reliable use.

In mid-1972 NAVELEX emphasized via message and newsletter the significance of the trace recorder and interpretation of the "Phase Lock Fail" lights. Improved operator awareness proved beneficial. Nevertheless, overall experience since that time has been that the system is rendered inoperative by precipitation approximately five percent of the time, overall. Furthermore all evidence points to the culprit as rain's moisture, rather than electrical disturbances caused by lightning.

VII. NORTH ATLANTIC DEPLOYMENT - 1972.

Omega was not relied on extensively for navigation during most of the North Atlantic and Norwegian Operations during August - September 1972; however observations and evaluation of Omega continued. In latitudes of 60-70N off the Norwegian coast. only Hawaii and Norway were received. Hawaii was rarely usable. Once south of 60N and west of 5W, Omega again became reliable. Norway, New York, and Trinidad produced approximately 3 mile median errors.

VIII. CENTRAL ATLANTIC OPERATIONS - 1972.

The return transit to CONUS from Scotland in October 1972 produced outstanding Omega results. Extensive fleet operations in an area centered about 500 miles west of Ireland produced a median error of only 1.2 miles for 108 fixes, using a "homemade" lattice on a bottom contour chart. Two rainy days were encountered with no loss of synchronization.

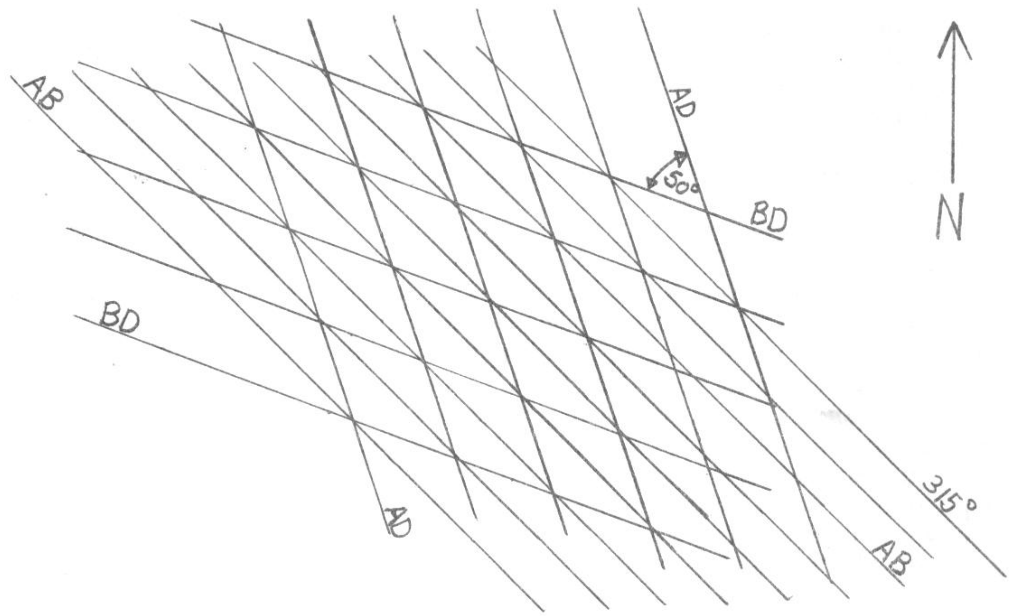
IX. MEDITERRANEAN 1972-1973.

Upon passing Bermuda during transit from CONUS to the Mediterranean in November 1972, Hawaii again weakened. Station pairs A-B, A-C, and B-C were used due to the unavailability of charts with the new North Dakota station. Hawaii was strong enough to produce a median error of some 3 miles across the central and eastern Atlantic. Homemade Omega lattices were constructed on bottom contour charts of the Mediterranean. Sky wave corrections for Norway, Trinidad, and North Dakota were newly available for the area. Once East of Gibraltar it was observed that point fixes were regularly produced in excess of seven miles to the Northwest of ship's known position. This phenomenon was reminiscent of that experienced in the Baltic during May 1971 and thereafter Omega fixes relative to the ship's known position were recorded as often as practicable for the purpose of evaluation and possible future use as a corrector.

After obtaining and analyzing some six hundred Omega fixes over a large portion of the Mediterranean, a consistent pattern of error became apparent. The common trait was the point fix several miles Northwest of known position. It was noted that the direction of error was quite consistent while the median magnitude increased from as little as 3 miles in the Western Mediterranean (e.g., Barcelona) to 17 miles in Sicily and 18 in Athens.

Following extensive analysis of the error pattern a tentative theory was formulated and is hereafter presented. The AB line of position (LOP) has proved reliable with a median error on the order of one mile. Its orientation is within approximately 2 degrees of 135/315 degrees throughout the Mediterranean area. Observed errors then are thus believed to originate from lines AD and BD. However, since A and B appear reliable in the makeup of AB, the suspected error source is station D (Dakota). It is noted that LOP AB almost precisely bisects the 50 degree angle of intersection between AD and BD (See figure 1).

Figure 1



Rhomboid Quilt Pattern Typical of Mediterranean

As a result, any error (skywave correction source or otherwise) in D moves both LOP's almost identical distances along the (valid) AB LOP. Hence the erroneous fix appears as a point, or virtually so, several miles NW of the actual position. Examination of the charts shows that each 1 percent of lane error in D results in a fix error of some 0.4 to 0.5 miles, depending upon area. Hence the 3 to 18 mile median fix errors observed correspond to station D errors on the order of only about 6 to 45 percent of one lane. It appears from the constant error direction that existing D skywave corrections are probably excessively positive by a like amount.

The insidious Omega characteristic is clearly the false point fix. This phenomenon is a rarity in the science of navigation since a large triangle would ordinarily be expected to alert the navigator to the possibility of such a gross error. A dual threat is thus presented. The unwary navigator may feel confident in his presumably well defined Omega position while his actual position is in error by a frightening magnitude. The other threat phase which follows is that the credibility of Omega, in the Mediterranean at least, is shattered. Nor are these threats idle speculation. The syndrome has been commonly revealed in discussions with navigators in other Omega equipped ships. Many consider Omega unusable in the Mediterranean pending operational status of the Japan station.

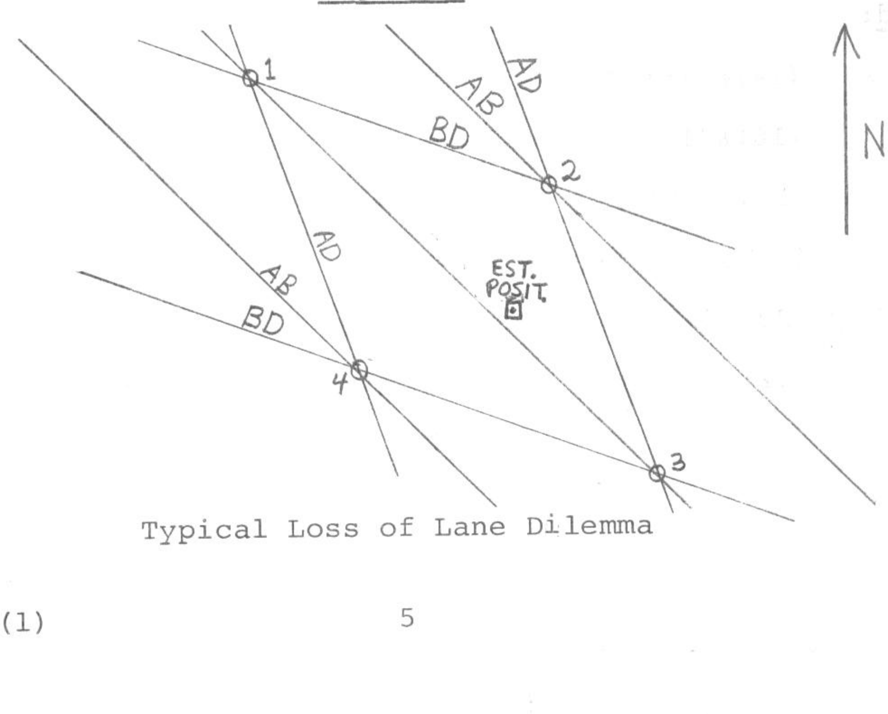
It is somewhat widely recognized that obtaining three LOP's from three stations is possible, but undesirable, since an error in one station affects two LOP's. The uniquely insidious nature on the Mediterranean phenomenon evidently stems from the combination of the unusual rhomboid quilt pattern formed by the three LOP's together with the error in station D. If these conditions did not exist, the erroneous point fix evidently could not.

Once the nature of the error in station D was correctly deduced, it became a simple matter to compensate for it and obtain reliable Omega fixes (more properly estimated positions). The technique was simply to apply an additional "I" correction to adjust the (apparent) fix the required distance Southeast and produce an Omega EP. The most straightforward and satisfactory technique is to reevaluate the magnitude of the "I" correction at every opportunity by comparing the (apparent) Omega fix to a known position. The latest "I" correction would then be used for hours or days in the same general area. This technique was used with excellent results during a four day transit from Crete to the Baelerics, throughout which the NAVSAT was unserviceable (due to loss of the 400 cycle precision generator). A corollary technique used with good success was to cross the AB LOP with other LOP's obtained by celestial, radar or fathometer.

X. SPECIAL MEDITERRANEAN LANE PROBLEMS.

When lane count is lost due to precipitation or other causes, extreme caution must be exercised in resetting. The three LOP's form an elongated rhombus oriented NW/SE (see figure 2).

Figure 2



Typical Loss of Lane Dilemma

The typical reset problem is illustrated by ship's best known position falling somewhere near the major axis of the rhombus with 4 surrounding intersections, all of which satisfy the displayed lane percentages. Intuition would normally lead the operator to select the closest intersection (either 2 or 4). However, such a choice is almost invariably erroneous. Experience has indicated that the AB lane can be reset with confidence, thus narrowing the selection to positions 1 or 3. Since the false fix is consistently NW, true lane count clearly corresponds to position 1. Hence the rule, "assume the false fix corresponding to proper lane count lies Northwest of the best known position."

XI. MEDIAN ERROR AND DIRECTION.

Table I lists observed Omega fix errors expressed as median range and approximate direction, using lines AB, AD, and BD.

Underway:

	ENCL.	PERIOD	LAT	LONG	TO	LAT	LONG	MEDIAN ERROR(NM)	BNG	FIXES
Baltic	(4)&(5)	MAY 71	57°N	11°E		55°N	18°E	8.0	310°	30
Atlantic	(6)&(7)	OCT 72	50°N	19°W		42°N	51°W	1.2	340	108
Med (inner)	(8)&(9)	DEC 72	36°N	03°W		40°N	04°E	3.0	340	63
Med (cent)	(10)&(11)	DEC 72	38°N	02°E		38°N	08°E	6.4	316	39
Med (deep)	(12)&(13)	DEC 72	39°N	04°E		36°N	19°E	7.4	316	59
										299

Anchored:

	ENCL.	PERIOD	LAT	LONG	MEDIAN ERROR(NM)	BNG	FIXES
Barcelona	(14)&(15)	DEC 72	41°N	02°E	3.0	319	64
Malaga	(16)&(17)	FEB 73	36°N	04°W	9.0	316	30
Malaga	(24)&(25)	APR 73	36°N	04°W	9.2	315	74
Genoa	(18)&(19)	FEB 73	44°N	09°E	8.0	318	51
Augusta Bay	(20)&(21)	FEB 73	37°N	15°E	17.0	318	22
Athens	(22)&(23)	FEB 73	38°N	23°E	18.0	317	103
							344
						TOTAL	643

XII. CONCLUSIONS.

(1) Omega is an excellent system which is steadily improving. Nevertheless it is still officially "experimental" and should be employed with appropriate caution.

(2) Fixes derived from only three stations should be regarded with suspicion, regardless of initial appearances.

(3) Precipitation remains a significant detriment with the present system of equipments, transmitter power, etc.

XIII. RECOMMENDATIONS.

(1) Continue periodic warnings (via Hydros or otherwise) of the experimental classification of Omega. Warn users of the "false point fix" danger, especially in the Mediterranean and elsewhere when using only three stations.

(2) Reevaluate the Mediterranean area skywave correction for station D. As an interim measure, caution users that LOP's AD and BD usually intersect well NW of actual position although line AB remains highly reliable.

(3) Reassess the extent of the precipitation problem in the Fleet. A questionaire to Omega ships is suggested.

(4) Reexamine chart production programs with an emphasis on utilization of bottom contour charts for common Fleet operating areas.