EVALUATION OF LORAC FOR CONDUCTING SPEED AND MANŒUVRING TRIALS OF NAVAL VESSELS

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Abstract. — The evaluation of Lorac Radiolocation System was authorized by the *Bureau of Ships* and was conducted during the period 10-14 June 1957 off Cameron, Louisiana, by staff members of the *Taylor Model Basin* and *Lorac Service Corporation.* Measurements of the speed and turning characteristics of a test vessel were made independently with Lorac and with the Navy tactical shore station equipment. This report contains a comparison of the test results with comments on utilization of Lorac in conducting trials on naval vessels.

Introduction

The purpose of the project was to conduct an evaluation of the Lorac system of radiolocation to determine its suitability for accurate derivation of the path and speed of a ship during various manœuvres.

It is taken for granted that readers are already acquainted with the principle of Lorac, which is a system for determining positions by measuring the phase difference of radio waves (*).

Original plans for the tests called for operations in the vicinity of offshore oil well platforms approximately 20 miles south of Cameron, Louisiana. On visiting the platforms it proved impractical to land equipment and shore station personnel due to sea conditions at the time. The actual tests were conducted in a different location as described in a succeeding section of this report.

Instrumentation

The Lorac D-Network was selected for use during the tests since its location was the best available to service the area in which the Navy tactical

(*) IHB Special Publication 39 (Radio Aids to Maritime Navigation and Hydrography).

stations could be set up. Standard Lorac equipment of the type used by oil companies in the test area was used. The Lorac equipment consisted of three transmitting stations which transmitted signals from permanent locations on shore to a mobile receiver installed in the test vessel. Additional shipboard equipment consisted of an indicator which provided a continuous indication of the Lorac readings and a printing unit which recorded the data at equal time intervals or on demand. The stability of the network was monitored by a mobile receiver operated ashore in the vicinity of the test area. The test vessel was the M.V. *Lorac,* an 87-foot boat capable of speeds up to about 9 knots.

The Navy tactical shore station equipment was used to obtain test data for comparison with the Lorac data. Two shore stations, each consisting of an azimuth head with a camera attachment, were set up on the beach to measure the angle between the baseline and the test vessel. The stations were located approximately 10 143 feet apart. Each shore station operator tracked the test vessel manually with the aid of a telescope attached to the azimuth head, and photographed the azimuth scale simultaneously at regular time intervals. Radio communications between the two shore stations and the test vessel were used to correlate collection of the test data.

Methods and procedures

The speed trials were conducted by having the shore station observers establish a line of sight at right angles to the baseline between the stations and by steering the M.V. *Lorac* on a course parallel to the baseline. When the first line of sight was crossed, time was started and when the second line of sight was crossed, time was stopped. Simultaneous bearings were taken every sixty seconds during these runs.

The elapsed time required to traverse the known distance between shore stations was used to compute the average speed for the run. The bearings obtained at sixty-second intervals provided data for computation of speed variations during the run.

Lorac readings and time were taken approximately at the beginning and at the end of the run for determining the average speed for the run. Readings were taken also at known intervals during the run for use in computation of variations in speed.

The tactical trials were conducted by having the shore station observers continuously track the path of the vessel and record the bearings at regular time intervals. Time signals were transmitted by radio from the vessel to the shore stations every ten seconds during the approach to the manœuvre and every thirty seconds during the manœuvre. Data were collected simultaneously by the shore station operators and by the Lorac operator.

Presentation of trial results

The results obtained for the speed trials from the shore stations and from Lorac are presented in table 1 for comparison. A comparison of the data obtained during the tactical trials is presented in figures 1 to 6

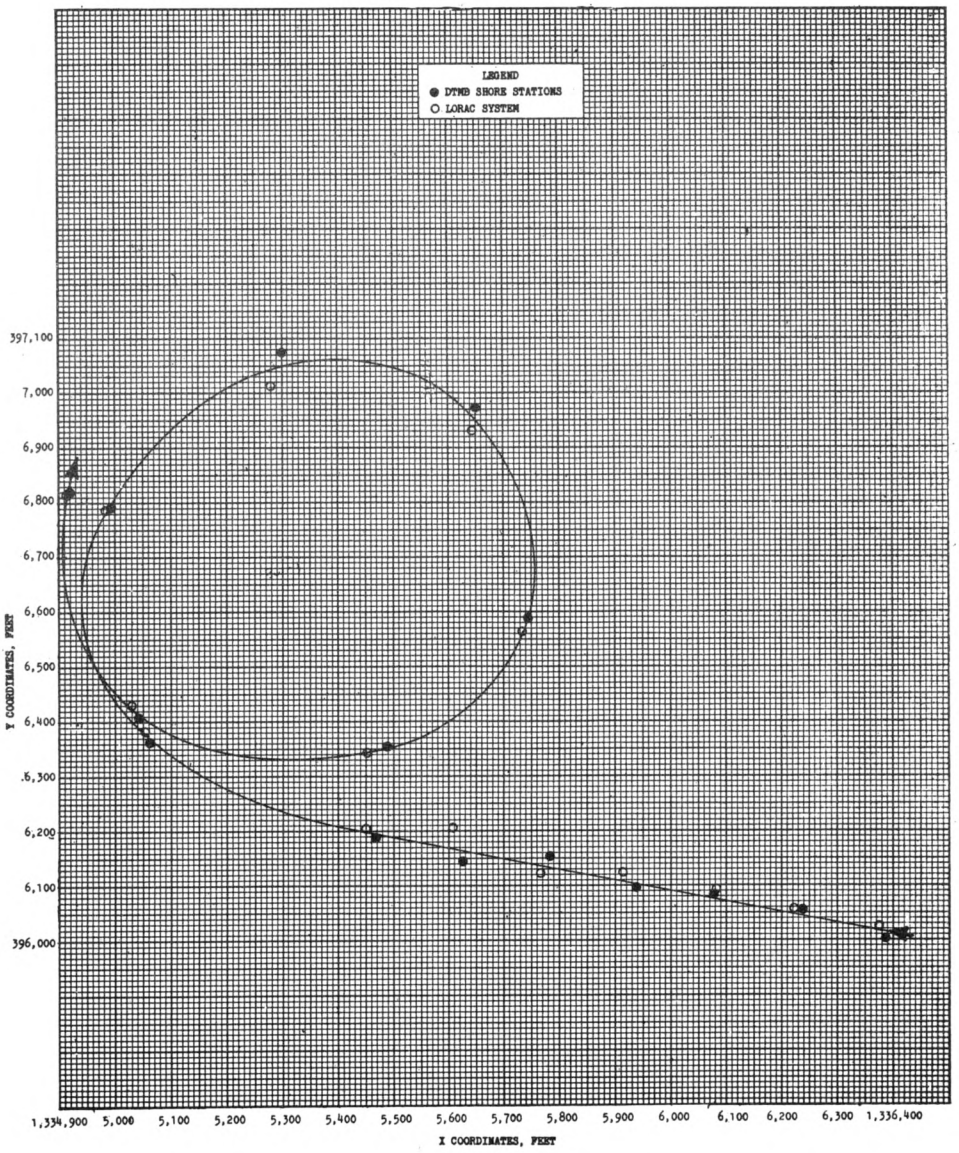

FIGURE 1

inclusive. Additional details on the Lorac equipment and on the data obtained by the contractor are contained in a report (*).

Discussion of results

A comparison of the speeds as shown in table 1 indicates that it is possible to obtain accurate speed data with Lorac. It will be noted that

(*) *Final Report of Field Tests of the Application of the Lorac Radiolocation System to Demonstrate its Application to the Conduct of Full Scale Standardization and Tactical Trials of Ships*, R. J. PUCHATY, Lorac Service Corporation, 10 June 1957-14 June 1957.

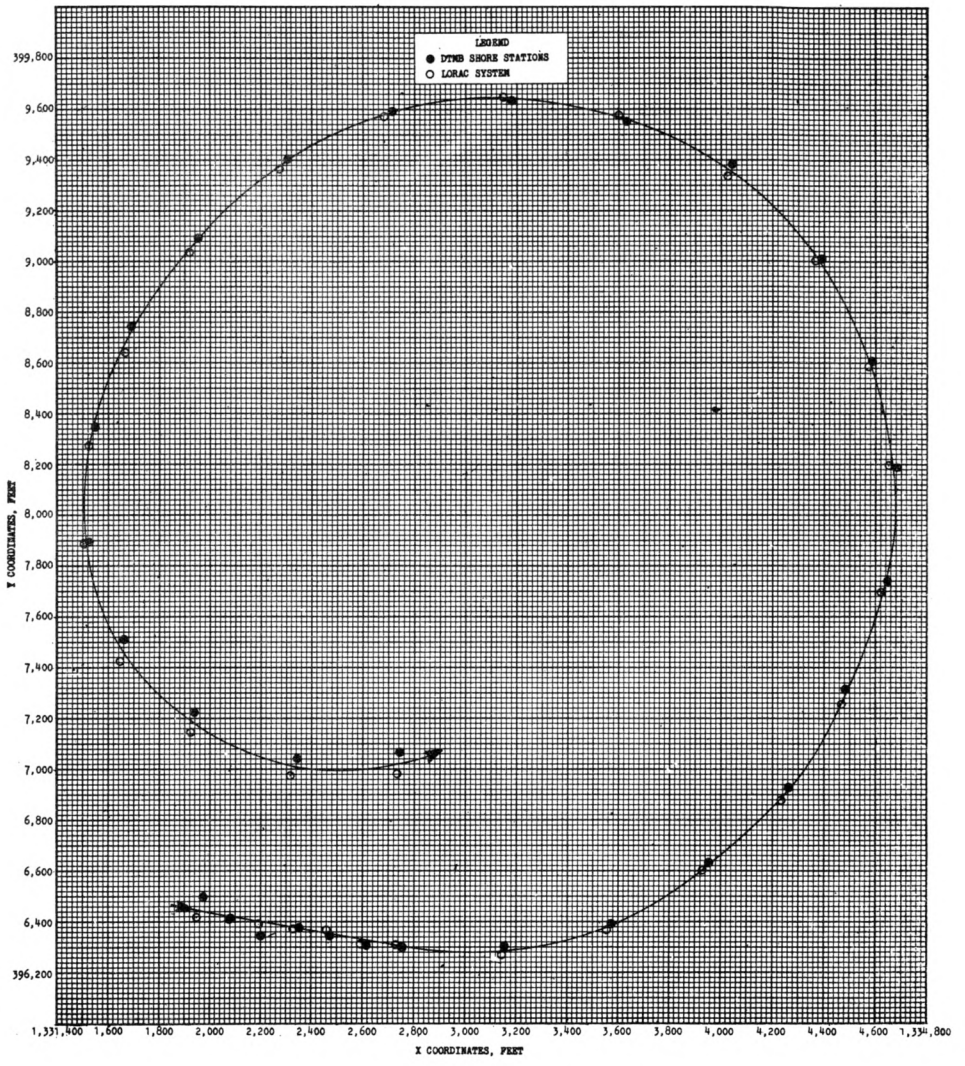

FIGURE 2

comparative data were obtained only over a nominal speed range of 6 to 9 knots.

The method of obtaining speed data from shore stations is not usually employed in Navy trials and is not considered the most accurate method obtainable. A more desirable procedure would be to operate the vessel over a measured course having markers at each end and to station two or more observers on the vessel to operate precision timers for measuring the time required to travel a known distance.

An area in which both Lorac and the Navy shore stations could be utilized had to be selected for the tests. This area was not the location in the Lorac network best suited for the operation of Lorac equipment. It is quite remarkable, in view of the test conditions, that the speeds as measured by the two systems were in such close agreement. On 10 of the 12 runs

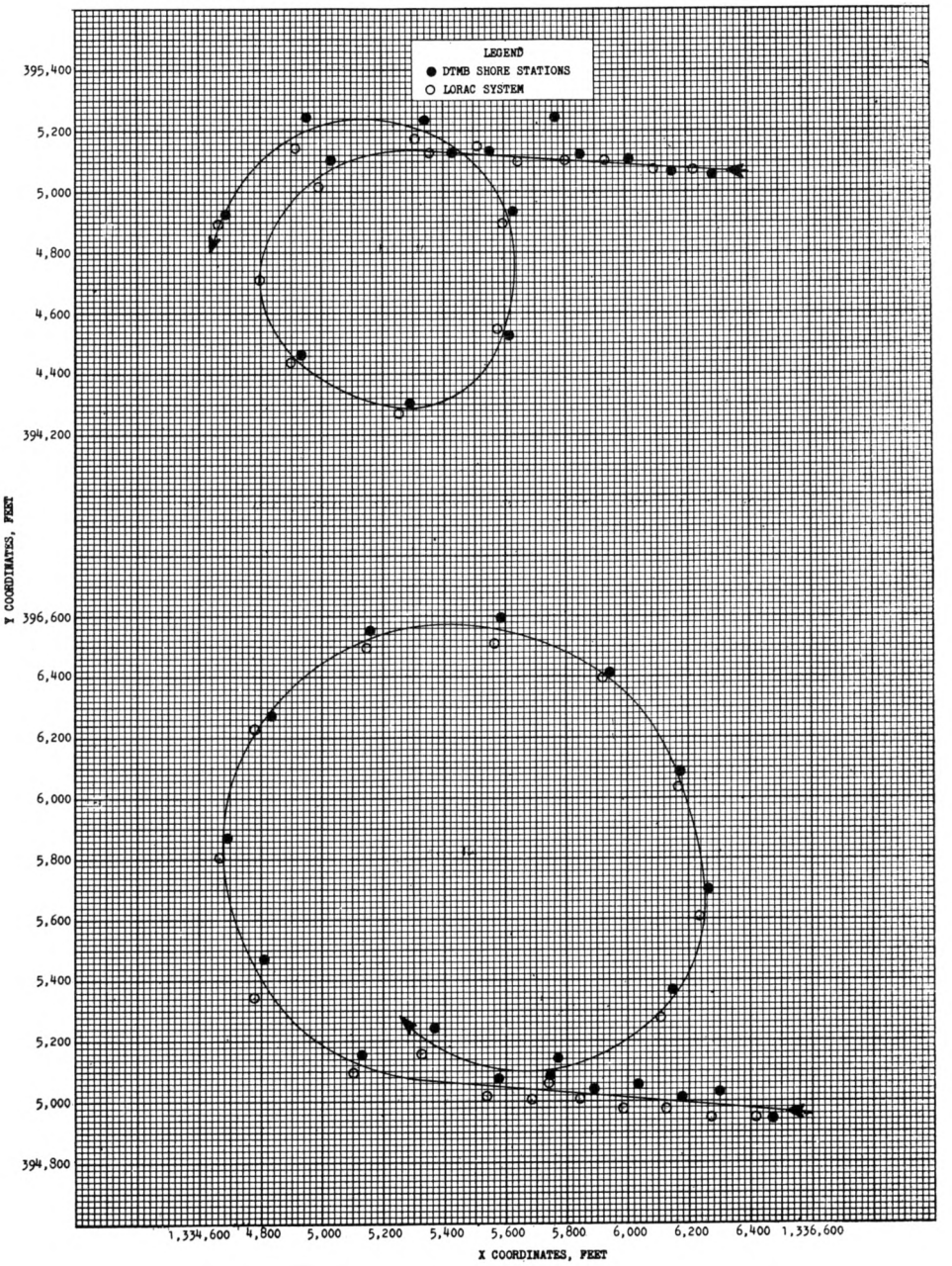

FIGURE 3

conducted the speeds measured by Lorac were within 0.05 knot of the speeds obtained by the shore stations.

The turning circle data, figures 1 to 6 inclusive, indicate good agreement between Lorac and the shore stations. The location in which this phase of the trial had to be conducted had a greater detrimental effect on the accuracy of Lorac than it had on the shore station accuracy. The

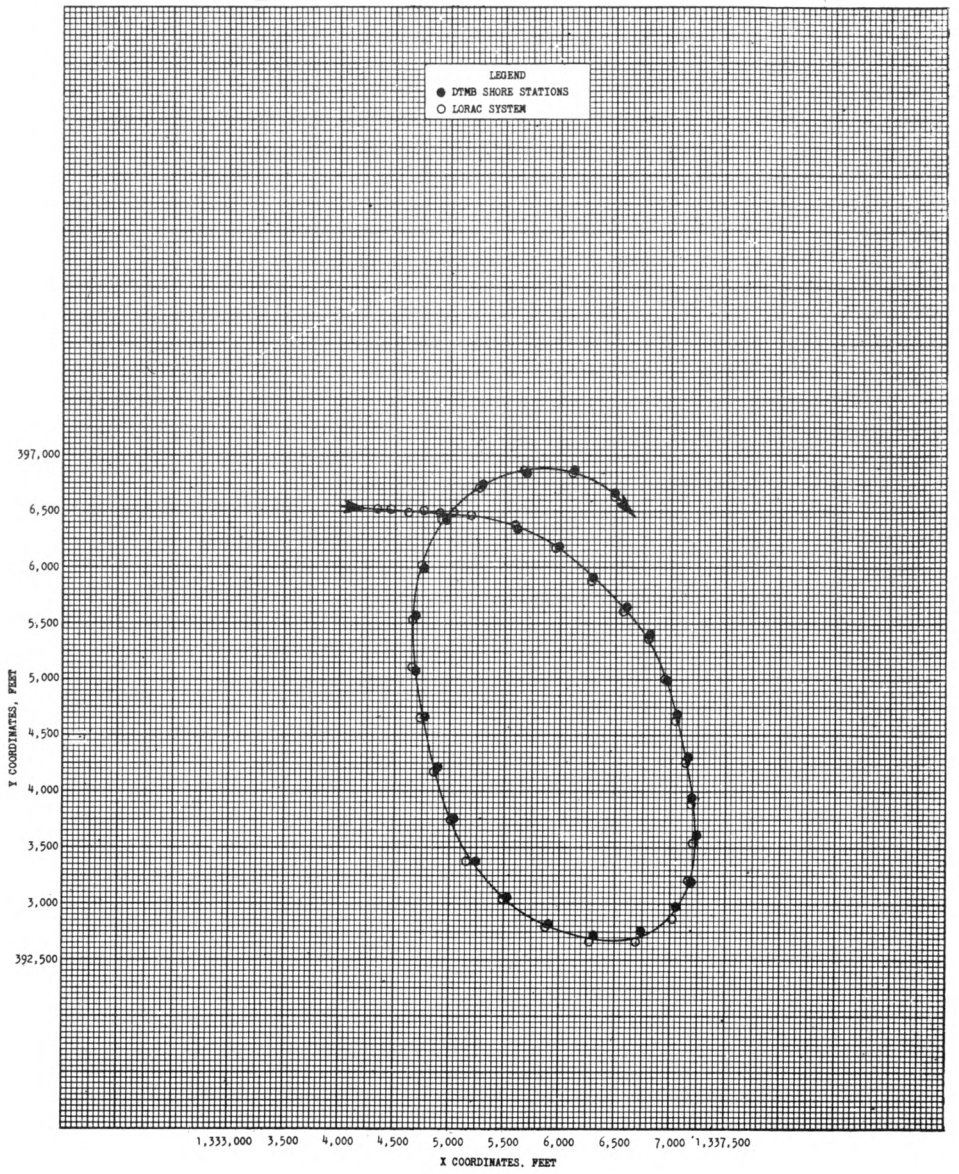

FIGURE 4

deviation between the points plotted in the figures was expected since it was known that Lorac accuracy in the x direction was about five times that in the y direction in the portion of the Lorac network utilized for the test runs.

Conclusions and recommandations

The Lorac results reported herein were prepared by the Lorac Service Corporation working independently of the Model Basin after the tests were

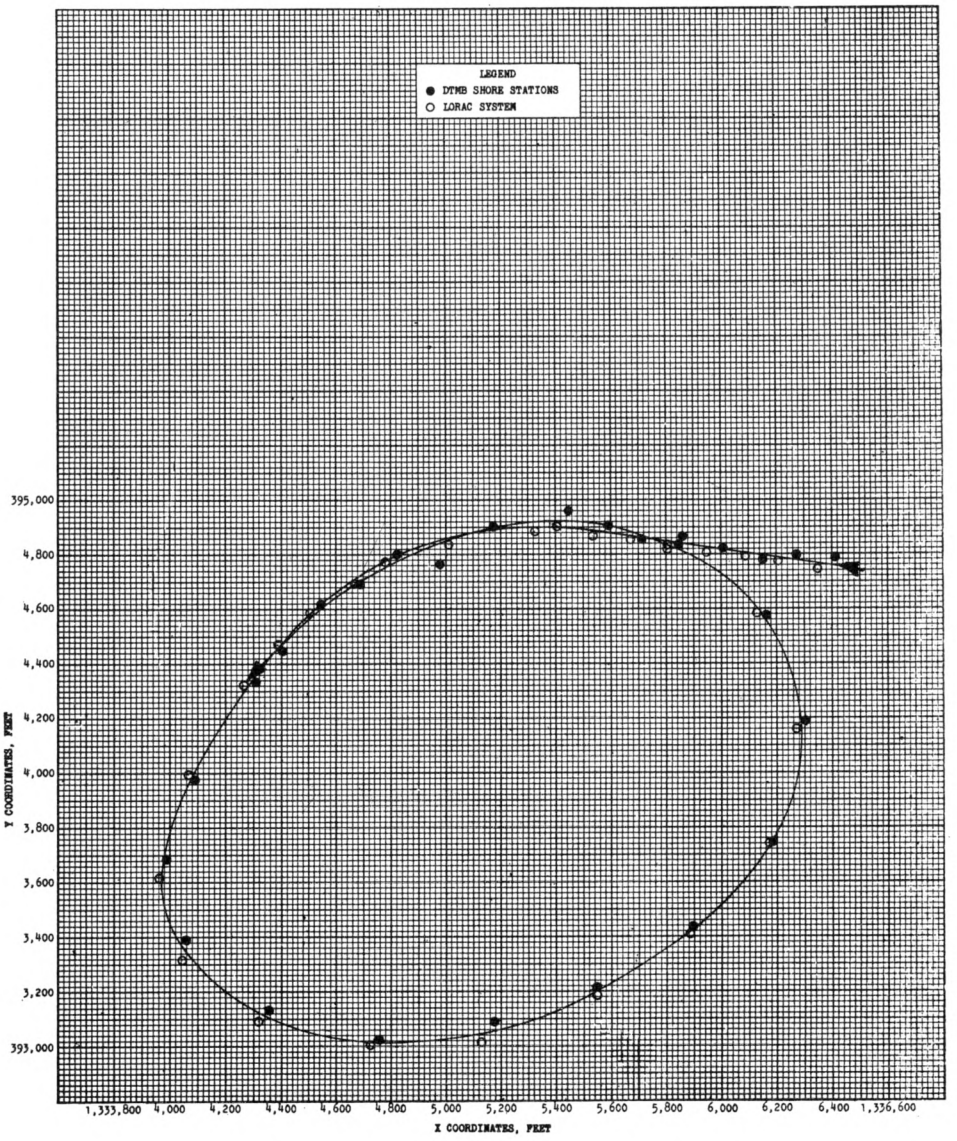

FIGURE 5

conducted, and these results were in agreement generally with the results obtained from Model Basin equipment. Although there is agreement between the two measuring systems, it is believed that the scope of the evaluation tests was insufficient to determine the suitability of Lorac for testing of naval ships. Tests should be conducted on a naval vessel to obtain more comprehensive data. These tests would provide the opportunity to investigate the possibility of interference from various types of electronic navigation and communications equipment aboard ship. Interference of a

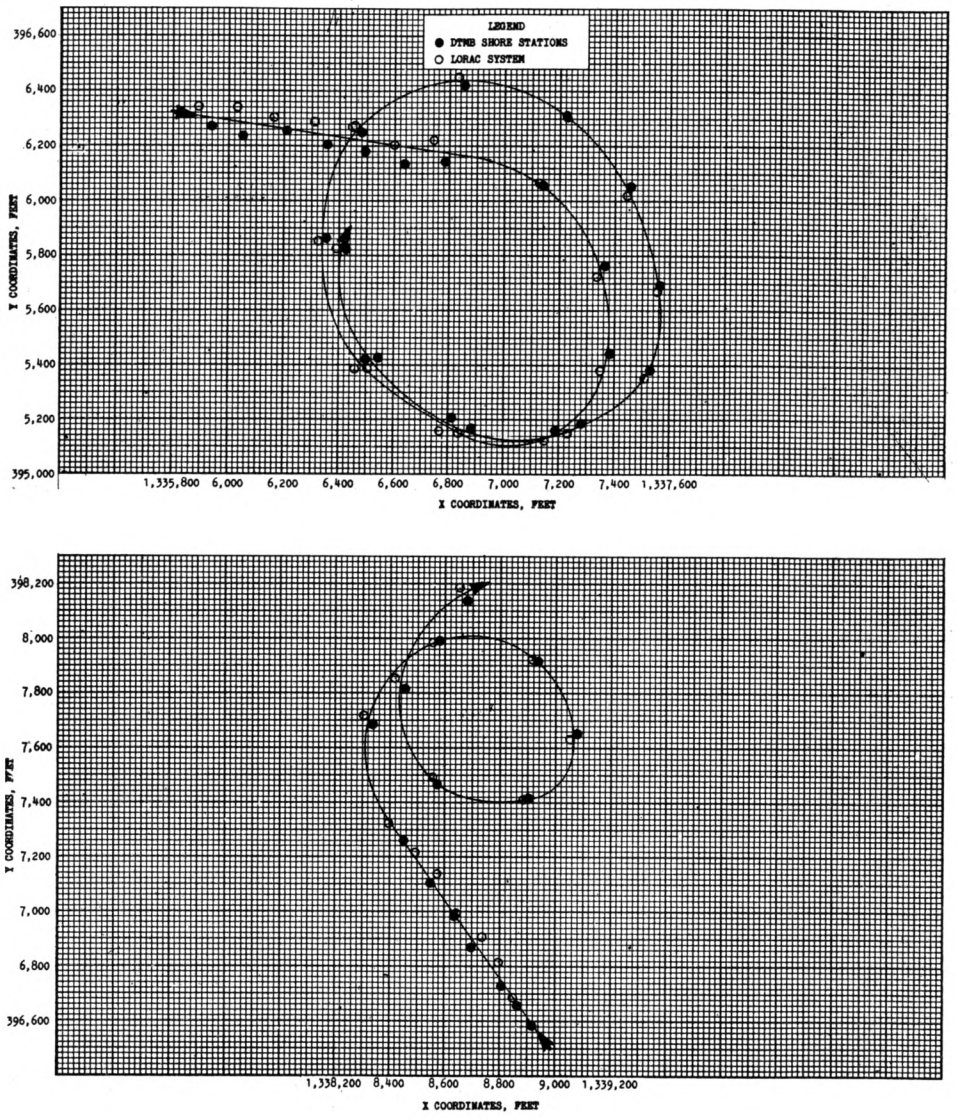

FIGURE 6

ship's superstructure, the effects of rolling and pitching motions, the problem of setting the initial Lorac readings on a larger ship, and the performance of Lorac at more realistic speeds should also be investigated. The proposed tests would require establishing a temporary Lorac network in the vicinity of a measured course in order to obtain comparative data by existing methods.

There are several factors to be considered in determining the advisability of establishing a permanent Lorac network to replace the measured courses and portable shore stations presently used for Navy trials. A discussion on establishing a Lorac network and utilization of Lorac equipment for testing naval vessels is contained in the appendix below.

TABLE 1

Comparison of speeds measured by Lorac and by shore stations

Speed by Lorac	Speed by Shore Stations
8.25 knots	8.23 knots
8.95	9.05
8.14	8.07
8.34	8.33
8.75	8.75
8.16	8.13
8.72	8.67
8.26	8.28
6.32	6.29
7.19	7.20
8.76	8.81
8.31	8.30

APPENDIX

UTILIZATION OF LORAC FOR TESTING NAVAL VESSELS

Shore installation

The establishment of a Lorac network would require installation of at least three transmitting stations on land to service a predetermined test area at sea. The aerials for these stations should be permanently installed and must be fixed at exact geographic locations. It would be preferable if the transmitting stations were also installed permanently and serviced with commercial electric power. It would also be necessary to establish one point geographically within the offshore network for use as a reference marker for the Lorac receiver. This point would be used in setting the initial readings of the shipboard indicator and as reference for checking the operation of the equipment during the trials.

Inasmuch as the contractor deemed it necessary to monitor the network during the evaluation trials, it is considered advisable to provide with the initial equipment a monitor receiver which would be used to check the stability of the network.

Shipboard installation

The equipment required for installation aboard the test vessel consists of the receiver, indicator, power supply, digital recorder, and an aerial. The instruments are portable and can easily be installed or transferred from one ship to another. In making an installation aboard ship it would be advisable to mount the aerial on the ship's mast in order to minimize interference from the superstructure.

Conducting a test

All test data concerning the speed of the ship for a measured time and the path of the ship during a manœuvre are collected aboard ship and correlation with the transmitting stations is not necessary. After the transmitting stations are placed in operation, the station operators make sure that the equipment continues to operate properly throughout the trial period. The complete network is monitored by a monitor receiver to detect any malfunctioning that may influence the test data.

The data are collected in the form of simultaneous readings of two phasemeters (indicators) and a time reading. Preliminary readings may be made by visual observations, but the actual test data are obtained from a printer which tabulates the readings on a time basis.

In order to permit reduction of the indicator readings to usable form it is necessary to set the indicator to a known reading prior to collecting any test data. The normal procedure in setting the initial readings after the equipment is put in operation is to move the test vessel to the reference marker located in the network. The indicator is then set to the calculated readings as determined by the geographic location of the reference marker.

Another possible method of making the initial settings is based on the fact that one of the phasemeters in the indicator should indicate zero when the shipboard receiver crosses a baseline, or baseline extension, between the centrally located transmitter and another transmitter. Thus one phasemeter could be set to zero by having the ship cross the baseline between the centre station and one of the end stations. The other meter would be set to zero as the ship crossed the baseline joining the centre station and the other end station. The practicality of setting the meters by this method will depend on the shoreline of the area and upon the configuration of the three transmitting stations. This method also involves precise navigation of the vessel to determine the location of the ship with respect to the baseline.

During the trial period the ship should return to the reference marker or to the baselines once each day as a check on the performance of the equipment. Should the equipment be de-energized while the ship is in motion, it would be necessary to reset the initial readings as previously described. It is permissible, however, to secure the equipment after the ship has tied up to a pier at the end of a day's testing provided meter readings were taken after the ship was berthed. In this case the equipment could be placed in operation and the meters reset to the same readings before the ship departed from the pier.

Data reduction

The Lorac indicator readings represent the ship's position in a hyperbolic grid which must be constructed for the network. The grid layout depends on the geographic locations of the three transmitting stations and on the frequencies utilized by the network. A change in indicator reading denotes a change in position which can be reduced to terms of distance travelled in a given time.

During the evaluation tests it was not possible to convert the indicator readings to terms of distance while the tests were being conducted. The method employed by the contractor was to forward the readings to the home office where the data were reduced by electronic computers. At the present time there are no means available, other than plotting the data points on the grid, to reduce the data in the field. While the graphical method would give an indication of the trial results, it is not considered of sufficient accuracy to permit an evaluation of the results while the trials are in progress. Often the results of a shipboard test are used as a basis for further testing or for eliminating proposed tests, and preliminary test results must be available aboard ship within a few minutes after a trial run is made.

In order to utilize Lorac equipment, it will be necessary to design and manufacture a portable computer to reduce the data in the field to usable form. This computer should be installed aboard the test vessel. It would be possible, but somewhat impractical, to install a computer at one of the permanent transmitting stations. A shore-based computer would introduce the problem of transmitting the data from the test vessel to the computer station and transmitting the results from the computer back to the test vessel for evaluation during the progress of the trials.

Also to be considered in the data reduction is the fact that corrections are made for various factors that are known to influence the data. Among these factors are the weather and atmospheric conditions, the terrain over which the signals are transmitted, and the network stability. The network used during the evaluation tests has been in service for some time, and it is evident from the test results that the contractor has devised an accurate method of reducing the data to final form. The scope of the tests did not include the data reduction methods, but it is known that the initial readings were adjusted for propagation effects and for network stability. It is assumed that these adjustments were minor and that preliminary test results could be obtained in the field without making any adjustments to the data.

Operating personnel

Each transmitting station will require an operator. The monitor receiver would also require an operator. These operators should be men with a background in servicing electronic equipment. Amateur radio operators also may be trained as transmitter station operators. A graduate electronics engineer should serve as a network supervisor. Personnel without experience in operating Lorac stations will require a minimum of two weeks' training by the manufacturer.

A technician familiar with instrumentation could operate the shipboard equipment without difficulty. Servicing the shipboard equipment would require an experienced electronics technician.