RAYDIST LOCATES BORING SITES FOR CHESAPEAKE CROSSING

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Raydist recently was used to quickly establish boring locations in open water across the mouth of Chesapeake Bay for a proposed bridge-tunnel project. The new facility will follow the route of the ferry from Little Creek, Va., to Kiptopeke Beach, Md.

For the first time Raydist equipment also was used in conjunction with subsurface sonar reflection equipment. The location work was done by Hastings-Raydist, Inc. of Hampton, Va. The sonar reflection survey work was done by Alpine Geophysical Associates, Inc., of Teaneck, N. J. All work was performed under the general supervision of Sverdrup and Parcel of St. Louis, the consulting engineers for the Chesapeake Bay Ferry Commission.

The proposed bridge-tunnel crossing is over 20 miles long and combines a tunnel under the main channel, a high-level suspension span, several smaller spans, and 12 miles of low-level trestle. Most of the roadway is 30 ft above the water.

To determine the depths of the various layers of sand, silt, mud, and rock, the thickness of these layers, and their physical characteristics, test borings were taken to depths of several hundred feet below the ocean floor. The sonar reflection survey along the proposed route permitted translating data from 24 borings to indicate subsurface conditions for the entire crossing. Use of Raydist speeded the location of towers for drilling and accurately located the subsurface soundings.

The DM Raydist System, a phase-comparison system of the latest type, offers exceedingly high accuracy and gives position data continuously and automatically in terms of direct range to two shore-based stations. The Raydist system used in the Chesapeake Bay operation consisted of two shore-based stations and duplicate Raydist position indicators mounted on the motorship *Robin*. One set was the newest transistorized Raydist equipment and the other was an older vacuum-tube system.

Each set of shipboard equipment included one unit incorporating all the electronic circuitry, two Raydist position indicators which were detachable and could be placed in any convenient location, a strip-chart recorder, and a battery power-supply. It was found that the most accurate control of the vessel was obtained when the captain was not required to observe the position indicators but was permitted to concentrate on maintaining a given heading. A small intercom set was used between the *Robin*'s bridge and the Raydist equipment located in the vessel's main salon by which means heading changes and the like were given verbally to the captain.

The two shore stations were about 21 miles apart spanning the mouth of Chesapeake Bay, one being located at Grand View, Va. (designated the Red Station) and the other at Oyster, Va., on the Cape Charles Peninsula (designated the Green Station). See Fig. 1*b*. (With this same base line, the Raydist system has been used to accurately determine the speed of ships operated beyond the Atlantic Shelf more than 100 miles seaward.) The stations were of the 100-watt type, altough the standard 10-watt equipment would have been entirely satisfactory for the purpose. The electronic components were enclosed in small, portable, weather-proof metal cases operated from conventional 110-volt power. The antennas were sectionalized aluminum guyed towers erected to a height of 100 ft. The operation of each station was entirely automatic, requiring no manual adjustments.

On the vessel, Raydist dials and a recorder continuously indicated and recorded the distance from the *Robin* to the two shore-based Raydist stations. To plot the position of the *Robin* on a standard Coast and Geodetic Survey chart of the mouth of the bay at any given instant, the observer had only to draw two circles on the chart with a compass. One circle, using the Grand View Station as the center, would have a radius equal to the dial reading from the red indicator. The second circle, using Oyster, Va., as the center, would have a radius equal to the dial reading on the green indicator. The intersection of these circles provided an accurate fix of the position of the boat. See Fig. 1*b*.

The fact that the Raydist Position Indicators operate automatically to give a direct reading of position is of special importance when operating on the water. Any unit or instrument that requires adjustment and manipulation or that requires aiming of a device toward some shore station in order to make a measurement would be totally worthless under the conditions of wind, tide and currents encountered along the North Atlantic coast in the wintertime. It would be impossible to hold a boat in a fixed position long enough to carry out such operations.

It was entirely practicable to calculate in advance the exact dial readings that the Raydist indicators would show when the ship reached the predetermined position—in this instance the spot at which one of the drilling towers was to be located. This permitted the *Robin* to go directly to the exact spot and to mark this spot with a buoy so that the drilling tower could be accurately positioned later.

The fact that the equipment also furnished a continuous strip-chart record of the position of the boat at all times throughout the operation was of particular value. This made it possible to return to any particular location at a later time if there was a need to check the data or to take additional samples.

The accuracy of Raydist is such that corrections were made for dropping the marker and buoy from the bow of the boat rather than from the point where the Raydist shipborne antennas were located. The accuracy of Raydist in this respect is much greater than that which it is practicable to incorporate in charts.

Each dial division of the Raydist position indicators represents a distance equal to a half wave-length of the frequency on which Raydist is

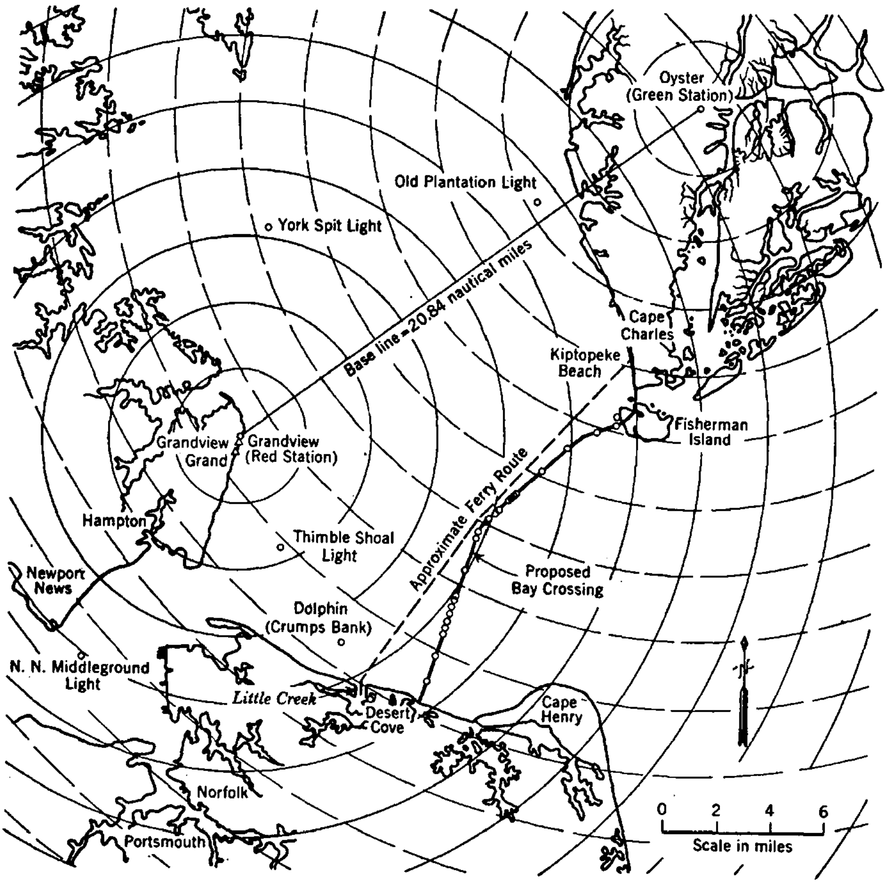

FIGURE 1*b*

(Below, left) Boring locations for a planned bridge and tunnel crossing of the mouth of Chesapeake Bay were established by Raydist, using observations on stations at Grandview, Va., and Oyster, Md.

operating. At the frequency used, the dials of the Raydist position indicators had a sensitivity of 18 in. per dial division. Repeatability was consistent to within a few feet, even under the widely changing atmospheric conditions that prevailed.

Raydist accuracies of 1 part in 5,000 or better can generally be expected under normal field conditions, and the accuracy can be considerably increased if special techniques are employed. While it was impossible under the circumstances to determine the absolute accuracy of the Raydist position data, it was possible, when weather permitted, to make optical checks of the boring-tower positions. These towers were generally found to be within 25 ft of the required locations.

It should be pointed out that effects of winds, tides and currents on the marker buoy at the time it is dropped overboard are the limiting factors in the accuracy obtainable, not the Raydist measurements. This was confirmed by the fact that when the positions of fixed objects such as light-houses were determined optically and by Raydist, the measurements agreed to within 10 ft day in and day out.

Even in these checks some error was unquestionably introduced by the problem of piloting the boat with safety close enough to lighthouses, docks and pilings to check their position with accuracy. In some cases, the position of fixed objects was determined by having the vessel record its position continuously as it followed several different lines directly toward the pile or lighthouse being checked. The paths of the ship were then drawn statistically to a large scale, and their intersection gave an accurate fix of the location of the object. One such evaluation of the position of a lighthouse, made to compare Raydist and optical data, is shown in Fig. 2*b*. The Raydist data checked with the optical within 10 ft.

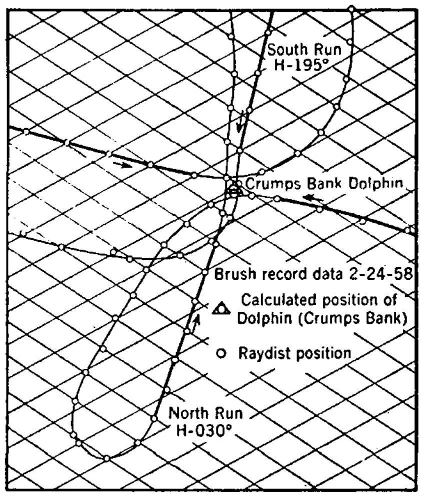

FIGURE 2*b*

Accuracy of Raydist was checked by observation on the Crumps Bank Dolphin. Raydist-equipped vessel approached on line from at least two directions in succession. Intersection of extended lines established position within 10 ft of that determined by best survey methods.

Sverdrup and Parcel furnished Hastings-Raydist, Inc., with a detailed boring plan showing the exact spots, in terms of coordinates on the Virginia grid system, specified to the nearest foot, at which each boring should be made. The distance from each boring location to each of the two shore station antennas was then calculated to the closest foot and a table prepared showing the two Raydist readings for each boring position. An individual large-scale diagram, or « drop plan », of each position was then prepared showing the desired boring position and the Raydist range circles in the immediate vicinity.

The pilot of the ship was given a heading that would bring the vessel to the approximate location selected. When in the general area where the buoy was to be dropped, the ship was navigated along one range circle which corresponded with the desired position. The pilot was given a bearing on this line and was continuously given information concerning the accuracy of his position on the line so that he could correct for wind, tides, and currents.

The second dial continuously indicated how far away from the intended tower location the vessel was. As the vessel approached the location, a « count down » was used, indicating the number of feet from the desired tower location. The pilot was continually given corrections if the vessel veered from the line. If the vessel did not pass over the precise spot, the run was canceled and the vessel circled and came back on line for a second approach. When both dials indicated that the vessel was directly over the selected point, an anchor and marker buoy were dropped. The vessel then circled once more to check the position. The buoy's anchor was used as the drilling site; the buoy merely located the anchor.

When the drilling tower was placed, a check on its position was made by Raydist, and if weather permitted, additional checks were made by optical means. The exact position data provided by Raydist enabled a tower to be returned to any position at a later date if studies indicated that further data were desirable.

SUMMARY OF STATISTICS

The entire survey of the proposed crossing route was completed in less than 45 days. Actual Raydist operations in positioning for 24 open-water borings involved only 17 days. A buoy could be placed over a new boring site within two hours after its being requested. The over-all positional accuracy, including maneuvering of the *Robin,* dropping the buoy, moving the platform into position and making it secure, was about $\pm$ 25 ft at sites up to eight miles from land.

The entire Raydist system was maintained and operated by two people. Both shore stations and the Navigator equipment aboard the *Robin* were completely automatic.

During the sonar towing operations, which required only 7 days including installation, calibration, operation, and removal of the equipment, a total distance of about 200 miles was covered.