EXPERIENCE WITH MINIATURE RAYDIST

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June 1966

A 10-watt miniature Raydist positioning system has been in use on hydrographic surveys of the U.S. Naval Oceanographic Office for about two years. When properly used, it has proved most satisfactory.

The 10-watt miniature Raydist is a highly portable, battery powered, positioning system employing transmitter and receiver units at each of two shore sites and transmitter, receiver, readout and recorder units in the mobile site. When calibrated, the readout (navigator) and the recorder (EPSCO Recorder) on the mobile user (ship) will indicate the distance of the ship from each shore site graduated in lanes, tenths, and hundredths. Lane width, which varies with operating frequency, is approximately 50 metres.

The Raydist is a dual-channel phase comparison system. The signal of each channel undergoes a complete 360° phase shift when the distance from the ship's antenna to the corresponding shore site antenna changes by one lane. If lane count is lost in either channel momentarily, the equipment will resynchronize. However, an error corresponding to any number of full lanes may have been introduced (decimals resynchronize correctly). The green channel is slaved to the red channel in such a manner that green lane count can be lost without affecting red lane count. However, if red lane count is lost, an error is introduced in green lane count.

The minature system is extremely sensitive to overland transmission, and great care must be taken in selection of the shore sites to ensure a clear, overwater path between the two stations. If possible, the ground should be level or gently sloping for a considerable distance behind the site. Shore sites free of foreign objects should be selected as close to the water as possible. The antennas should have a good ground plane. Any conductor in the vicinity can act as a parasitic element, introduce phasing, and cause erroneous results. It is well to remember that a non-conductor can become a conductor when it rains. With one 10-watt Raydist net used, a fractional change in the baseline length was noted during rainy weather.

Two methods of calibration are used with the miniature Raydist system. One method uses an electronic distance measuring device to determine the distance from the electrical center at the red station to electrical center on the mobile user a short distance off the station. This distance is translated into red lane count and compared with a simultaneous red Raydist reading. At the same time, a reading is made of the green rate, which should give a rough check on the inter-station distance. The same procedure is repeated at the green station. Several comparisons are usually made off each station.

In the other method of calibration, the user vessel crosses the line between the two shore stations about midway between them and determines the minimum reading to each station. The sum of the red and green readings, translated into metres, is compared with the geodetic distance between the shore stations. Then the vessel crosses the extension of the line between the stations behind each station. Here the difference between the red and green readings provides the so-called baseline distance. Crossing behind the green station gives the inter-station distance in terms of red lanes, and any difference between this and the geodetic distance is applied as a correction to the red rate. Crossing behind the red station provides a correction for the green rate. After the correction is applied, the calibration should be repeated.

The first method of calibration provides an independent check on the system operation. The method works well with a vessel large enough to be a more or less stable platform, but it is very difficult to use in a small boat if there is much of a sea running. The second method will provide a consistent system, but one which is not necessarily correct.

The relatively narrow lane width causes operational problems. Loss of lane count from momentary loss of signal or a burst of RFI is common, and the only positive means of resolving lane count is to recalibrate. A calibration buoy must be used with caution as its position must be known within half a lane (or about 25 metres). A buoy with a considerable scope of chain might be out of position by this much. The shipboard antennas are normally placed as high on the masts as possible. In a heavy sea, the rolling of the ship may introduce errors in dial readings approaching half a lane. Lane count loss, if it occurs when the dials are hunting due to the ship rolling, is often difficult to detect.

Raydist frequencies used are in the 1.6 and 3.5 megacycle band. Operations were generally conducted in areas near highly populated areas, shipping channels or during adverse propagation conditions. At best, the low power of the miniature Raydist results in a poor signal to noise ratio. Atmospheric static bursts, primary frequency interference from distant stations, harmonic RFI from near stations or brute force RFI from own ship's transmitters or merchant ships passing nearby frequently caused the Raydist dials to spin out of calibration. In one area, it was necessary to change frequencies and have new plotting sheets prepared. In another area, it was necessary to suspend survey operations from 2200 to about 0200 daily.

The secret of reliable Raydist performance is to attain the maximum signal to noise ratio. Any corrective action that will improve receiver or transmitter performance, improve antenna patterns, reduce transmission losses, or increase transmission efficiency will enhance the signal level and thus Raydist reliability. With only 10 watts of power to begin with, there is little margin for losses, especially in a noisy environment.

A test was made in September 1965 on the Patuxent River in Maryland to evaluate two unusual modes of operation of the Mini-Raydist. One was the use of floating platforms for the shore stations, and the other was the use of the net by several users.

Navoceano One was outfitted as the mobile master station. Two Navy picket boats were outfitted as floating shore stations. They were anchored bow and stern approximately 3/4 mile distance offshore at Cedar Point and Cove Point, giving an inter-station distance of approximately five miles. The floating stations were positioned by sextants. The soundboat calibrated by the baseline, and baseline extension crossings method, and the correct number of lanes were inserted in the receiver. Wave action on the anchored stations was such that the boats rolled and pitched considerably, enabling an excellent evaluation of the anchored stations to be made. *Navoceano One* simulated running sounding lines to check repeatability of the system, at a distance of 7-9 miles from the slave stations. Repeatability was excellent. The weather was overcast and the sea was rough. The picket boats were pitching and rolling with such force that both their antenna tips broke off.

The shore stations were established on two points of known geodetic position. The picket boats were then outfitted as mobile masters and they, along with *Navoceano One*, made up the multiple user system for the next operation. *Navoceano One* calibrated the net and placed lane count on a buoy. The picket boats proceeded to this buoy to get proper lane count. The baseline or inter-station distance for this exercise was five miles. Different exercise patterns were executed in order to attempt to lose the signals on one or more of the sounding units. Parallel lines were run from one to five miles apart. Sharp turns were made, with no loss of signals. At one time, picket boat No 1 lost lane count, but it was discovered that its antenna had slipped downward in its telescope sleeve, about 25 % of its length, making its signal much weaker; this along with possible weak batteries caused it to lose signals. Correct lane count was passed to it by *Navoceano One*. On one occasion, picket boat No 2 was anchored 1 500 feet from red station, and *Navoceano One* still tracking signals very well at 11 miles away with but two lane losses; these were recovered by checking recorder tapes.

Both evaluations were successful, and both modes have since been used in the field, on actual survey work, without difficulty.

In the multi-user mode, the following frequencies were used :

One user :		3308.4	kHz
Two users :	1st :	3308.370	kHz
	2nd :	3308.450	kHz
Three users :	1st :	3308.370	kHz
	2nd :	3308.450	kHz
	3rd :	3308.560	kHz

It was found in actual practice that better results were obtained if both the users were approximately the same distance from the shore station. If the distance from the red station, for example, to the nearer boat is N; and the distance from the red station to the farther boat is F, then the ratio N/F should lie between 1/2 and 1/5 for best results.

This is not to say that another ratio will not work. In the case mentioned above, when one user was 1 500 feet and the other 11 miles, the ratio is 1/44. This is an exceptional case, and not to be expected often.

The useful area of a mini-Raydist net can be determined, approximately, from a simple diagram. Arcs swung from each shore station define a large lens-shaped area as shown in figure 1. Then with the two apexes as center, swinging arcs with the inter-station distance as a radius defines a small lens-shaped area lying between the two shore stations. Here the system should not be used for positioning, as the lines of position intersect at very small angles and the fixes are weak. Elsewhere in the large lens-shaped area, the angle of intersection of the two lines of position is good (more than 30°) and the distance to the farthest station is not too great for stable reception.

This coverage diagram (figure 1) shows the most useful part of the net; however, the system can be used anywhere where signals can be received satisfactorily. Fixes are good where the lines of position intersect at angles of more than 30°. Lines intersecting at angles between 30° and 15° give acceptable fixes, but lines intersecting at less than 15° give weak fixes and should not be used.

The distance between the shore stations should not exceed 20 miles, except under exceptionally favorable conditions. In areas with high noise level, the maximum should probably be reduced to about 15 miles. The shore stations must be so situated that the line joining them does not pass over or graze the land. Actually, if the antenna is erected on shore, the line must pass over the land between the antenna and the shoreline. This distance should be kept to a minimum. The site should be selected so as to be as free as possible from signal contamination. This is vitally important in areas of high noise level. The electrical center of the shore station should be positioned to third order accuracy. The net must be calibrated with care. Provision should be made for convenient recovery of lane count.

If the mini-Raydist net has been set up with care, and a good calibration made, good results can be obtained. The procedures suggested have been found to give good results under normal (rather poor) conditions. Under exceptional conditions, almost anything can be made to work, after a fashion.

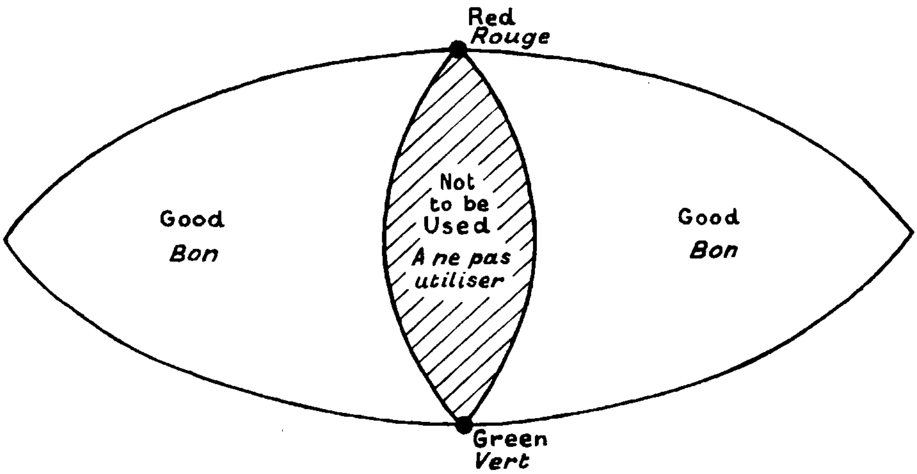

FIG. 1. — Mini-Raydist coverage area.