HARBOR SURVEY OPERATIONS USING CUBIC AUTOTAPE

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ABSTRACT

A Cubic Model DM-40 Autotape provided horizontal control for the hydrographic survey of an approximately one mile square area of Port Royal Bay, Bermuda. A U.S. Navy LCM 6 with an over-the-side mounted transducer served as the survey platform.

Survey lines were run east and west with north-south cross-check lines. Course corrections were obtained from a real-time plot of Autotape data.

The survey required approximately 65 miles of survey line and was completed in six survey days.

INTRODUCTION

The U.S. Naval Oceanographic Office (NAVOCEANO) is frequently required to conduct hydrographic operations in small harbors or along isolated coastal areas. Specialized hydrographic ships or boats are usually not available for such operations, and it is necessary to use local boats or military craft. Since installation of survey equipment aboard such platforms must be accomplished quickly and with no damage to the boat, a portable positioning system is required.

The Cubic Autotape has now replaced the sextant, hydrodist and azimuth instruments in many NAVOCEANO harbor survey operations. Autotape requires fewer operators, simplifies communications, produces data which are easy to plot, and usually requires fewer geodetic stations than the more traditional control systems.

Port Royal Bay, Bermuda (figure 1) is typical of small harbor areas to be encountered throughout the world and presented a good operational test for the Autotape system.

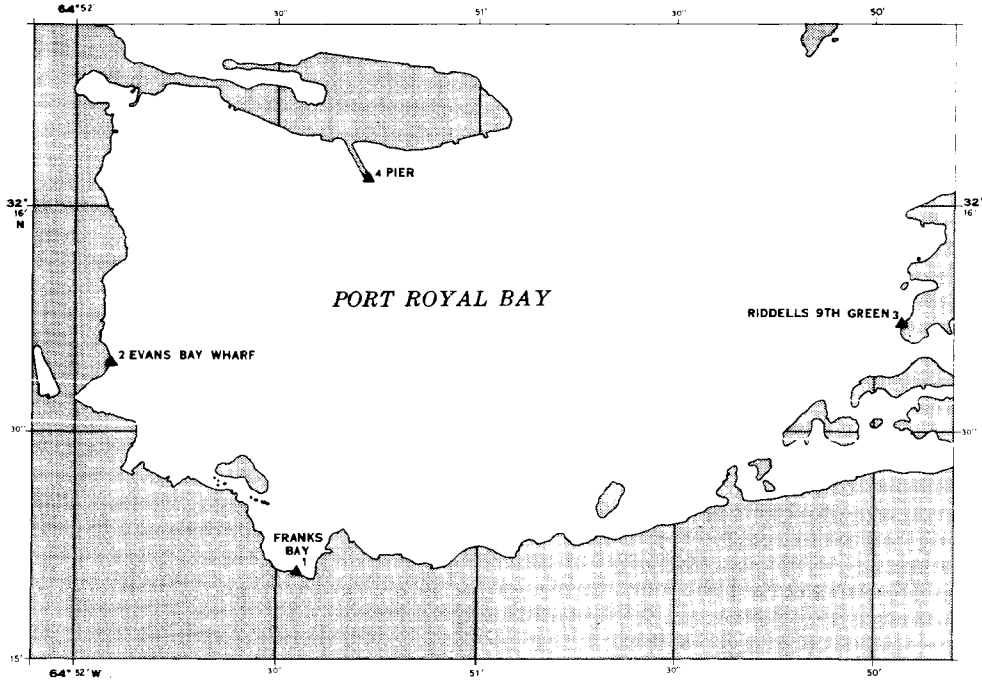

FIG. 1. — Survey Area.

AUTOTAPE SYSTEM DESCRIPTION

The Cubic Model DM-40 Autotape gives positions by the measurement of ranges from an interrogator unit to two responder stations. Range (distance) measurement capability is based on the principle that radio frequency modulation applied to an electromagnetic wave propagated through space exhibits a phase delay proportional to the distance traveled and the modulation frequency (*). The Autotape computes range by measuring the phase delay between the instantaneous output of the modulation signal generator and a signal which has traveled from the interrogator to the responder and back. Ranging frequencies of approximately 1 500 kHz, 150 kHz and 15 kHz are modulated on a 3 000 MHz carrier.

The manufacturer reports a maximum range of 100 kilometres, and an accuracy of about $\frac{1}{2}$ metre ($\pm$ 0.5 metre $\pm$ 10 ppm $\times$ range (**), when index of refraction corrections are applied). Known distance range checks by NAVOCEANO indicate that $\pm$ 1 metre for individual readings is probably to be expected under most circumstances.

The Autotape measures slope distances and must have line-of-sight between the interrogator and each responder. The manufacturer reports that the maximum range of the system will be reduced by half for each

(*) Operating Manual for Cubic Model DM 40 Autotape : Cubic Corporation, San Diego, California.

(**) ppm = pulses per minute.

10 metres of semi-dense foliage in the path. The system is not significantly affected by fog or rain.

The two ranges are displayed in metres on the interrogator panel and can be recorded on a number of peripheral devices. The range display reads to 9999.9 metres and updates each second during normal operations. There are optional settings which give 10 cm resolution and a 2-second update, or a coarse setting which gives 1 metre resolution.

The interrogator is normally attached to an omni-antenna giving 360 degrees of horizontal and 10 degrees of vertical coverage. The responders have horn antennas providing 60 degrees horizontal and 10 degrees vertical coverage.

Two-way voice communication between the interrogator and responder is built into the system. Power requirements are 8 amps at 12 volts DC for the interrogator and 6.5 amps at 12 volts DC for the responders. Adequate power sources are critical for successful operation of the Autotape. NAVOCEANO has found it prudent to obtain new heavy-duty batteries for each operation and to recharge the batteries after not more than 8 hours operation.

The interrogator, which is the heaviest system component, weighs 25 kilograms. Each responder weighs 10 kilograms and each responder antenna 12 kilograms. Responder antennas are mounted on tripods and are easily plumbed over geodetic stations. The entire system can be assembled in fifteen to twenty minutes. An additional 15 minute warm-up period is required prior to the start of survey operations.

FIELD OPERATIONS

Four responder stations (fig. 1) were selected near the shoreline of Port Royal Bay. These were kept at low elevations to avoid the need for slope corrections. Since the ranges involved were short, no curvature induced line-of-sight problems were encountered. Stations 1 and 2 were used for surveying the north side of the bay, and stations 3 and 4 were used to complete the south side.

The interrogator was carried aboard a U.S. Navy LCM 6 which served as the survey platform. The omni-antenna was mounted directly over the transducer as shown in figure 2.

An optional digital printer was connected to the interrogator to provide a permanent record of the measured ranges. Since this printer required 120 volt 60 cycles power source it was connected to a separate 12 volt battery and converter.

Navigational plotting sheets were constructed at a scale of 1/5 000 using the geodetic positions of the responder stations. Although the sheets for the Port Royal Bay survey were laid out by use of a PDP-9 computer program, they can be field constructed. The plotting sheet lines (figure 3) are simple concentric circles centered on the responder station locations.

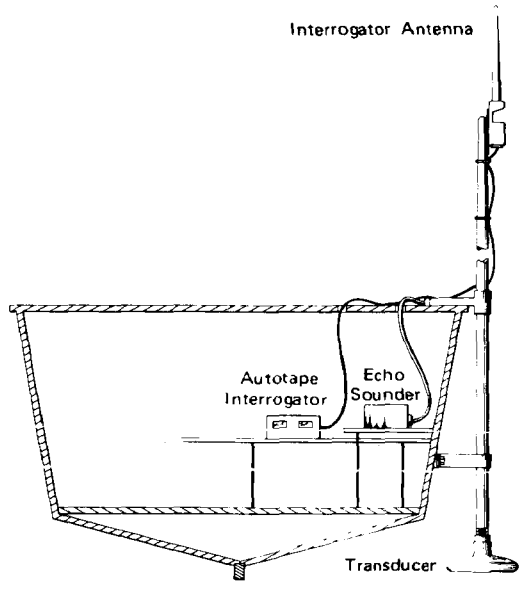

FIG. 2. — Equipment installation.

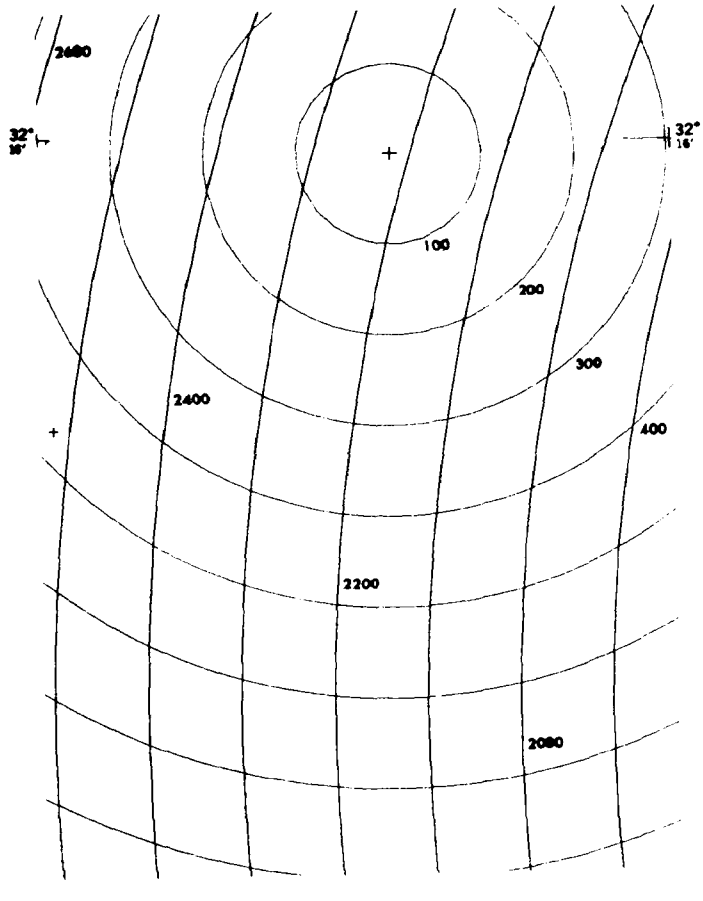

FIG. 3. — Plotting sheet segment.

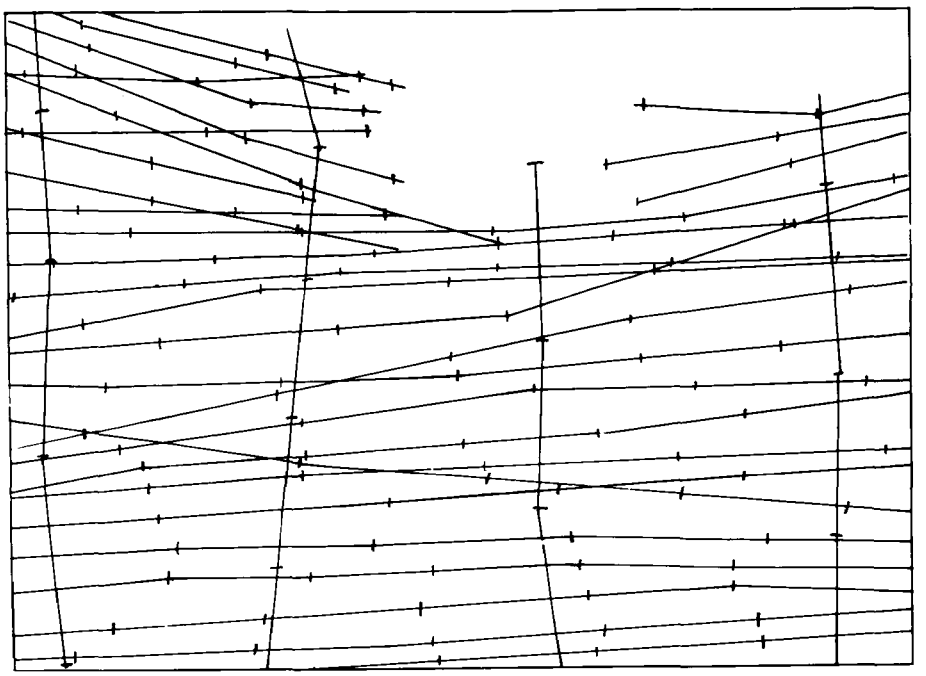

FIG. 4. — Portion of track sheet.

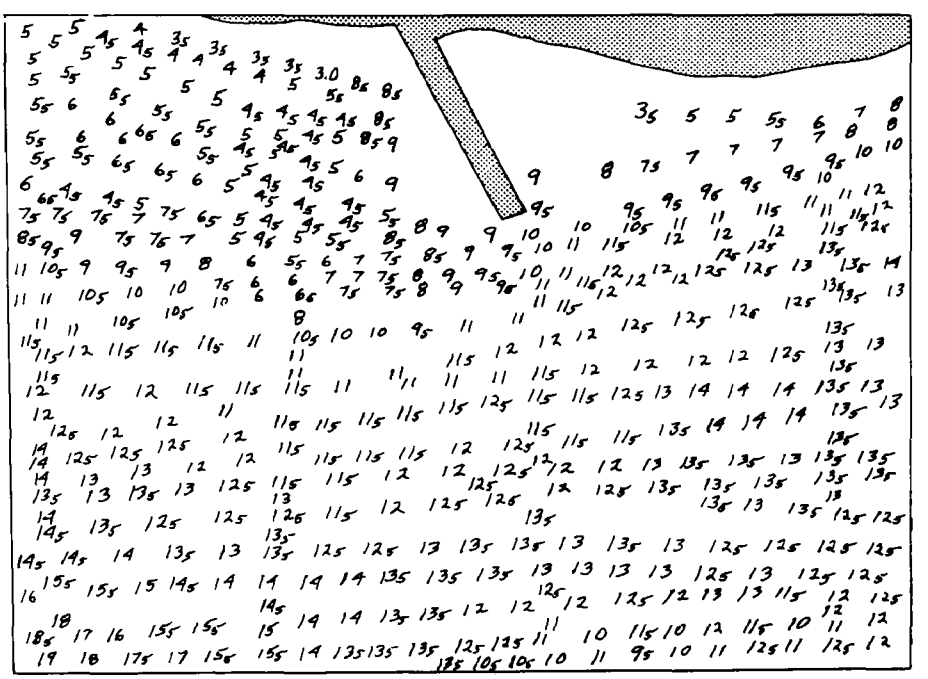

FIG. 5. — Portion of sounding sheet.

Two men were required to handle the plotting, recording, and annotating of the Autotape output. One man marked the time fixes on the printer tape and recorded the ranges in a sounding journal. Another individual plotted the positions on the navigation plotting sheet. The major part of the boat's course was laid out on parallel east-west lines with approximately 0.5 cm between lines.

The speed of the LCM was maintained at approximately 4 knots. This slow speed allowed the plotter to keep up with the boat's progress and maintain a reasonable spacing of position fixes. Fixes were recorded and plotted every minute (figure 4). Soundings were later added to the track at 15 second intervals (figure 5) (*).

Once the responders are positioned and activated, it is not necessary to keep an operator on the station. During the Port Royal survey, an operator was kept at each station to provide security and to turn the antennas in the event that the 60° horizontal limit of the responder antenna was exceeded.

The positions of five mooring buoys in Port Royal Bay were determined using the Autotape. This operation was quickly accomplished by bringing the interrogator antenna next to the buoys on the windward side and recording the ranges.

RESULTS

Six survey days were required to obtain the 65 miles of survey data. There were no malfunctions of the Autotape during the survey. The equivalent of one day's survey data was discarded due to navigation problems unrelated to Autotape operation. As the boatswain became familiar with the survey procedure, the track lines became straighter and most of the survey proceeded very smoothly.

Autotape represents a significant improvement over previous harbor survey control methods. It is easy to install and operate and can be used with a wide variety of survey platforms. The voice communication feature eliminated the need for radios during the Port Royal survey.

A limitation of the system, not encountered at Bermuda, is caused by the presence of reflective objects in the measurement area. Reflections from such objects as steel bridges and large buildings will show up as variations about the correct value of Autotape readings. Although the geometry of the responder locations can sometimes be adjusted to avoid reflections, it is sometimes impossible to cover certain areas of a planned survey due to the reflection problem. Interference from transmitters on frequencies near the Autotape frequency can also cause failure of survey operations.

(*) Soundings shown are unedited and have been modified to facilitate inclusion in this report. For corrected hydrographic information, see the latest H.O. charts (published by the U.S. Defense Mapping Agency).