A Guide to Planning a Hydrographic Survey

By Anne Lafrance, Algonquin College, Survey Technician Graduate

SUMMARY

The steps involved in planning a hydrographic survey are described in this report as an aid for anyone wanting to plan a survey and to view the overall aspects involved in planning.

The topics covered are the preliminary information required before the survey, the methods for the operational plan, the selection of equipment, the selection of personnel, and a financial evaluation of the risk involved.

I conclude that there is a lot of work involved in planning a hydrographic survey and many aspects are interelated.

1. INTRODUCTION

There are many purposes for hydrographic surveys, such as resource recovery, navigational safety, evaluation of coastline erosion, site location for submarine cables and pipelines, as well as many more. Some of these surveys are done nearshore while others are done on the open ocean. Since there are many different types of hydrographic surveys, this report will offer a general guide to planning one.

A hydrographic survey requires planning for many reasons. It is more costly than a land survey because of the special equipment required to detect important features that are underwater (1). The main reasons are to ensure adequate accuracies, to reduce costs and to establish the organization. The optimal survey plan will provide high accuracy data at a low cost and will benefit many users (2). It is important that the plan be flexible enough to allow for delays due to inclement weather, equipment breakdowns, and other unavoidable circumstances. Other reasons would include establishing goals and objectives (3), ensuring consistency (4), positioning the vessel properly in the horizontal plane, obtaining the correct permit for restricted areas (5) and preparing the crew. All of which adds to the total cost of the survey. With proper planning, unnecessary costs, delays and inefficient work will be avoided, or at least minimized.

The primary objectives of a hydrographic survey are to provide charts showing the topographic configuration of underwater features whether they are natural or man-made. With the increase in use of the earth's bodies of water over the past 50 years, there has been an increase in demand for hydrographic charts and services. There has also been an increase in demand for quality work with less spending, due to financial cutbacks.

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2. PRELIMINARY INFORMATION

The preliminary information covers all of the information that can be gathered about the area to be surveyed. All of this information can be acquired in the office or by research. It comprises what the client provides and all of the information that has been established already.

2.1 Client Specifications

The client specifications include all the information that the client requires from the survey and the information that the client may already have. There are many types of clients that would require a hydrographic survey. Different clients have different purposes. Most, like government agencies and the industries such as, fisheries, oil and gas, offshore mining and shipping (6,7,8), will commission the survey as well as use the end results . An oil and gas company will require charts and specific details of an unsurveyed area for exploration and resource extraction.

Others will use the finished product; like people with recreational purposes such as, boating, fishing and diving. Someone wishing to tour the Rideau River and canal systems from Ottawa to Kingston would require a nautical chart of the area in order to safely navigate through.

When the client is familiar with the requirements of a survey, the specifications are supplied. If not, then they must be determined. The client may specify the accuracies for the horizontal and vertical controls (explained in section 3.2), accuracies for the data, the scale of the chart, the total coverage of the area and the time available. The client must provide the budget limitations, if any. Since the weather cannot be predicted it should be discussed before hand who pays for the lost time due to the weather (11).

2.2 Reviewing All Existing Information

Reviewing all existing information will help determine the specifications not provided by the client or to further enhance the specifications the client has provided. This information would include all that can be gathered from researching the various sources available such as, the libraries, government documents, private businesses, county offices and reconnaissance if gaps are found (12). All sources should be studied, including all previous survey work of the area. The main purposes for this review of information is to avoid repetition (13) and to ensure that information will not be lacking.

If the area to be surveyed is virgin, then a reconnaissance should be done. This would require gathering information in the field by doing a preliminary survey of the area. It will also be necessary to determine where control points should be established. If the area has been previously surveyed but has been done some time ago, then a reconnaissance would determine if the control points are still intact and visible from the survey vessel.

Hydrographic charts of the area should be viewed to provide sounding depths and depth variations (5). This will aid in the selection of equipment. Aerial photographs viewed stereoscopically and topographic maps provide detailed information about natural and man-made features for the survey area, and may be used to determine control stations (5).

Sailing directions, and tidal and current tables (14) are published and should be consulted. As well, information on boating restrictions in channel locations, areas of restricted vessel use, prevailing wind directions (5), and normal and storm wave heights (5,14) should be gathered.

Examination of the site in the office, using maps, charts, auxiliary publications, such as sailing directions, photos and reconnaissance work, will aid in locating existing and establishing new control points (15).

3. OPERATIONAL PLAN

The operational plan is the organization of the methods involved in the survey. The first item to be determined is whether it is a nearshore or offshore survey that is required. Then the methods needed to accomplish the survey can be determined. The choice of methods depends on the amount of work to be done, the size and shape of the area involved, the amount of time available, the budget and the amount of data to be collected. You must determine the position-fixing technique, the horizontal and vertical controls, the sounding procedures and the data processing and presentation procedures. It is also necessary to determine the type of vessel, the tidal gauge selection, the final presentation of the data and the most suitable scale and projection (14).

The limits of the area to be surveyed are set based on the user requirements, charts, chart schemes and future use of the data. It is important to maintain consistency throughout the survey, to employ methods which have a system of self checking (4), and to consider systematic errors in the chosen method(s) (4).

3.1 Position-Fixing Techniques

Position-fixing is the location of the survey vessel in the horizontal plane when a measurement is made. The manual method involves the basic principals. The required equipment would include theodolites, sextants and a larger field crew (16). Techniques for this method would include two simultaneous sextant angles observed from the vessel, intersection from two theodolite stations ashore; a known range line and single angle (18); constant vessel velocity (19); and intersecting range lines (20). The electronic method involves more sophisticated equipment and a smaller crew (16). Techniques for this method would include EPF (electromagnetic position-fixing) and GPS (global positioning system), through the use of satellites.

3.2 Horizontal and Vertical Control Procedures

The horizontal control consists of a network of shoreline stations. These stations must be located in such a way as to satisfy the position-fixing method (22). As well, these control stations must be visible from the survey vessel (22). The basic control consists of a primary network of widely spaced horizontal and vertical control points which will be used to control all other surveys in the area (23). These should also be tied into at least two existing geodetic government monuments (23), which provide an accuracy control for all of the other points.

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The vertical control involves the correction for water levels under non-tidal conditions and for tidal variations (24), and is termed the reduced sounding. This control must be related to the desired datum or reference level (24). This aspect involves water levels and tidal gauging.

Echo-sounders are generally used for depth measurements for all surveys nowadays; however, lead lines can be used as a backup. Constant monitoring of the transmission returns and notes of anomalies should be incorporated in the survey (24). Accuracies in acoustic measurements in seawater depend on salinity, temperature and density which vary daily, seasonally and with rainfall (25). Echo-sounders should be calibrated at the beginning and end of each day's work (25).

Tidal gauging involves the observation of tidal variations from the vertical datum, throughout the sounding (26). A tidal pole or recording tidal gauge is required to obtain the necessary information during the sounding operation (26).

3.3 Sounding Procedure

A series of equally spaced sounding lines over the area to be surveyed is the most economical way for seabed coverage (27). Spacing between sounding lines, their orientation with the shoreline, the frequency of sounding along each line, direction in which the sounding lines are running and the appropriate scale are to be considered (27). The variation of depths in the survey area should be known in order to determine the spacing of individual soundings. These variations are dependent on bedrock and superficial geology as well as the number and size of offshore bars (27).

Then it should be determined if sweeping on shoal examinations are required. This is the additional sounding done in order to locate underwater features in areas not covered by the original sounding plan (29). Since the hydrographer does not know the water depths until the survey is completed, this is done last (29).

3.4 Data Processing and Presentation

The selection of computational procedures, data gathering, filing, processing and presentation are determined. Proper coordinate grid and datum plane must also be selected (23). Data is generally collected electronically and is digitally processed on systems such as CARIS (Computer Aided Resource Information System) (31). However, there is also the manual option, where the sounding plan is plotted on a stable medium such as Mylar to the desired scale. The accurate location of all shore stations and each sounding line is plotted on the Mylar prior to commencing the field work (32). The sounding details and tidal observations are recorded in the field (32). If a constant recording echo-sounder is used, the tidal observations are marked directly on the trace (32). It is important to review all of the data gathered and to plot the data before leaving the survey site in order to determine if an acceptable survey has been performed (32). Therefore, provisions should be made for plotting onboard or at a nearby office site (32). The new technology of electronic charts allows for the display of information on board ships electronically on a screen. Provisions should be made for safeguarding the data, so that it will be available for future use. The recording of the data should be understandable by any trained person (23).

4. THE EQUIPMENT

The equipment is all the necessary instruments and accessories required for the survey. The selection of the equipment will be based on the type of survey and techniques decided on. Different techniques require different equipment. Consider the instruments and their standard deviations of measurements (34). Establish the limits of error, using your knowledge of the equipment, the procedure, error propagation and personal experience (23). All equipment should be checked for proper working performance, prior to the survey (14,23). Arrange for backup of essential equipment (23) or for repairs (10) of equipment. This is especially necessary for offshore surveys, due to the increased cost of wages, expenses and unproductive time.

Lead lines are valuable for calibrating echo-sounders and for a backup (24) if there is a problem with the echo-sounder. Sextants, another echo-sounder and batteries are also valuable backup equipment. However, this type of equipment is for older methods of surveying. Now, all data collection and processing is done electronically.

Equipment would be required for position-fixing, sounding, data plotting and processing. For nearshore surveys, an echo-sounder, a multibeam sonar system such as Simrad EM-100 (36) or airborne lidar systems would be among the necessary instruments. For offshore surveys, COMS (Canadian Ocean Mapping System) (36), or a sidescan sonar such as GLORIA would be required. Some methods require Global Positioning Systems (GPS) or airborne lidar systems, like LARSEN 500 (36). Both types of surveys utilize swath technologies. Other equipment possibilities would include theodolites, gravitometers, and EDM devices (10).

5. LOGISTICS

The logistics is the organization of the supplies and services. Whenever there is a hydrographic survey to be done, there are always pesky details to determine. The further away the survey site is from civilization, such as a site in the Arctic, the more complicated the logistics become and the more the costs increase (10).

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5.1 Transportation

One of the main logistical concerns is the transportation of people and equipment. Transportation is required to get the personnel to the survey site while equipment can either be sent with the personnel or sent ahead. You must also consider your transportation to the control points on the shore either by truck or helicopter. Finally, there is the transportation to the survey site of the appropriate survey vessel.

The size and specifications of the vessel will depend on the type of survey and the techniques in which the survey will be accomplished. Safety should be the first consideration (38). Proper weight distribution, cruising speeds to return safely in case of a storm (38), proper handrail adjustments where the hydrographer can securely stand to work, and proper life saving devices, such as rafts, life jackets and lifesavers are all important features to keep in mind. Adequate fire fighting devices, ability to anchor (38), minimal deck openings, and smooth motion are also important safety considerations. Good working facilities and low operation costs should be considered after safety (38). Speed and manoeuvrability at low speeds (24,38), visibility to take angles, minimal vibrations from the engine (24,38), provisions for instruments, protection of instruments (38) and sufficient space for plotting (24) are also important factors.

Other considerations would include the purpose of the survey, weather conditions, wave heights, room for all personnel as well as food and supplies, ability to cook, sleeping quarters, sufficient electrical power at the required voltages for all equipment, and compatibility of fuel capacity (24).

In all cases, planning transportation should be designed to minimize travel time and distances (39) and, therefore, costs.

5.2 Accommodations

Another important logistical concern is the accommodations required during the the survey. If the survey is of a coastal nature and the crew returns to shore at the end of the day, sleeping arrangements could be made at the local motel (22,31). Provisions should also be made for office space for data processing (22,31). If the survey is offshore, then accommodations could be provided on board the vessel. As well, arrangements for office space near the launch site, should be made. This is to process data and to ensure that the specifications of the survey have been adequately met.

5.3 Food

All portions of food for all of the personnel for the whole duration must be determined. Allow for extra portions due to unavoidable delays. The choice of food should meet the nutritional requirements of the personnel. The method of packaging should also be considered in order to minimize space usage.

5.4 Time Estimation

Once the techniques required for the data collection and processing are determined, the time schedule should be set out. A breakdown of each day's work should be laid out to determine the length of time required to complete the survey. When the availability of the equipment and the survey vessel has been determined, the starting date and estimated completion date can be determined. This will also be beneficial for budgeting. Once the dates are known, the survey can be planned day by day. This will enable the daily breakdown of costs to be determined more efficiently. As well, extra time should be allocated for delays such as poor weather conditions. Should there be an unavoidable delay and there is extra time available, there will be little or no affect on the cost of the survey.

6. PERSONNEL

The personnel will be determined by the type of survey and techniques decided on. The number of people required and the necessary qualifications must be determined. Cooperation between the survey personnel and the support personnel is essential (41).

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6.1 Survey Personnel

The size of the survey crew will depend on the number of people needed for the techniques chosen. As well, the level of qualification of each individual and experience required for these techniques are important considerations. The individuals should be familiar with the overall tasks of the support personnel, as well as have a thorough understanding of hydrographic surveying principles (41). Each person should be able to carry out more than one key survey function (42). The hydrographer in charge, the hydrographers and the survey technicians make up the survey personnel.

6.2 Support Personnel

The support personnel is the group of people required for the survey, whose duties are not survey related. This would include the captain, the seamen, a cook, and electronic technicians if it is an offshore survey. You should also consider hiring local residents who are familiar with the area (42).

7. RISK EVALUATION

The risk evaluation is the breakdown of costs and the determination of whether these costs will fit into the available budget. The objective of this section is to meet all the criteria at an acceptable cost. All financial requirements must be estimated.

The main factors to consider are:

1. The equipment cost, whether purchase or rental.
2. The operational cost, some methods are more complicated and therefore are more costly.
3. The equipment maintenance: some equipment requires more maintenance or repairs are more costly.
4. The supporting equipment cost, some methods require more sophisticated equipment.
5. The time consumption, some methods require more time.
6. The training, some methods require more highly trained individuals.

After the breakdown has been determined, that is, all costs accounted for, and a total has been attained, compare it to the available budget to see if it is a feasible survey. Cost can be reduced by decreasing the area coverage if the client specifications allow for this. If the budget allows for it, extra time should be allotted in case of unavoidable delays.

8. CONCLUSION

To review, planning a hydrographic survey, or any survey for that matter, involves a lot of work. There are many steps to follow: gathering of preliminary information, determining survey methods and techniques, along with data processing and presentation, choosing equipment, selecting personnel, and evaluating the budget. As well, there are many decisions and selections to make, and many cannot be made until other decisions or selections have been made. One must call upon many years of experience in order to make the appropriate decisions or selections.

In short, each survey has different specific requirements which are determined mainly from the client specifications. With so many options, it is impossible to provide a more specific guide to planning a hydrographic survey.

Anne Lafrance is a 1994 survey technician graduate from Algonquin College in Ottawa. She is also a student member of the Institute of Survey Technology of Ontario. Anne's resume is on file with ISTO's Resume Referral program and anyone seeking to employ her may contact ISTO.

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