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SWATH SOUNDING INITIATIVES IN CANADA

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Abstract

Over the past 50 years, the hydrographic community has progressed from the humble leadline for single spot depths to sophisticated multibeam sounding systems capable of charting the entire seafloor. Canada now extensively uses this technology in its surveying operations. There are many benefits to using the latest swath systems, especially in the coastal margins and inland waters where, for instance, channel monitoring and dredging raise safety, economic and environmental issues. Utilizing multibeam systems reduces survey time, extends bottom coverage and contributes to conserving survey resources.

Multibeam systems are expensive and the complexity of the system often requires high maintenance. In addition the software used for acquiring, processing and displaying the collected information is still maturing. Data cleaning algorithms to accommodate data collection rates that at times exceed 3000 data points per second are required.

Canada has been dealing with those aspects of swath sounding for a decade now. Continuous research and development in the subject gave berth to new technologies and new acquisition and processing techniques. This paper summarizes the Canadian experiences in swath sounding and discusses its future developments and direction within the Canadian Hydrographic Service.

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1. INTRODUCTION

The Canadian Hydrographic Service (CHS) has been using multibeam sounding systems since 1988. At that time, the CHS was operating, in terms of high density acquisition systems, a couple of multi-transducer sweep systems [1]. It is now operating one of the latest state-of-the-art multibeam sounding systems. In doing so, the CHS saw its acquisition rate increase from 330 soundings/sec. to over 3175 soundings/sec. The major work load switched from data collection to data processing with the challenge of keeping the acquisition to processing ratio as large as possible (ideally 1:2). Throughout the Canadian swath sounding experience, numerous research projects were initiated from chasing sources of error such as the ones generated by the motion sensor to developing new algorithms for the detection of bathymetric outliers. In this effort to improve the swath sounding technology, the CHS reinforced its relations with academic and private institutions as well as with other national and international state agencies in initiating new partnerships and collaborative agreements.

While gaining experience and developing further the swath sounding technology, rules changed for hydrographic surveys. Economic belt tightening and organization restructuring forced the CHS to revise its priorities in terms of swath surveying. Focus was given to shipping lanes and harbours. Channel monitoring, which is economically sensitive and where full bottom coverage is of paramount importance, is seen as one of the major hydrographic applications for multibeam sounding systems in Canada. The St. Lawrence seaway is an important entry for transportation of goods into North America and consequently is important for its economy. At the same time, Electronic Charts and Display Information Systems (ECDIS) have entered the shipping market, requiring the Hydrographic Office (HO) to provide their products in digital format. The use of an ECDIS for navigating in harbours and for berthing necessitate an increase in sounding density that can only be cost-effective if provided by swath surveys.

2. A CHRONICLE OF CANADIAN SWATH SOUNDING ACTIVITIES

This section presents a short review on the swath sounding activities that have occurred in Canada since the purchase of the first multibeam echosounder. Details on the acquired equipment is given. Several research projects were initiated, leading to the development of new tools and techniques to collect and process swath sounding data. The efforts of the R&D program opened numerous collaborative initiatives and joint surveys, through alliances of public and private organizations. These activities are summarized here to show that, above all, the partnering became an important mechanism for exchanges of knowledge and for fruitful development.

2.1 The Arsenal

The Canadian Hydrographic Service purchased its first multibeam echosounder, a Simrad EM100, in 1988. The first project to use multibeam echosounders, called the "Canadian Ocean Mapping System" (COMS) was designed to operate Simrad EM100's on semi-submersibles called DOLPHIN's. A mother ship, also equipped with an EM100, accommodated the DOLPHIN's.

Originally, three Simrad EM100's were purchased. One was installed on the CSS "LOUIS M. LAUZIER" [2] and another on a DOLPHIN. The "LOUIS M. LAUZIER" operated its swath sounding system for two years before being remobilized to Lake Ontario for other scientific missions. The EM100 was transferred to the new vessel CSS "MATTHEW" to perform surveys on the continental shelf. This EM100 still serves on the CSS MATTHEW. The second EM100, installed on the DOLPHIN, is currently operated by a Canadian company, Geo-Resources Inc (GRI), of St. John's, Newfoundland through a partnering agreement. The third system is used as a stand-by.

In 1991, a Simrad EM1000 was acquired and installed on the NSC "FREDERICK G. CREED" [3]. This installation was designed for coastal and inland waters surveys. Soon it became obvious that the EM1000 was not adequate for very shallow water surveys. The CHS issued a Request For Proposal to deliver a new shallow water multibeam sounding system. The requirements called for a fully integrated system to be installed on a 9.5 metre hydrographic launch (Fig. 2.1). Simrad won the competition and supplied CHS with three new EM3000's. A fourth system has since been acquired with plans to purchase a fifth. All of the EM3000's will be operated from small hydrographic launches [4].

The CHS is now equipped with a variety of swath sounding systems that can be used separately or in combination to perform various types of surveys (hydrographic, cable route, harbours and harbour approaches, geophysical and geological surveys, etc). The following tables summarizes the general characteristics of the CHS swath sounding arsenal.

Table 2-1
Current Simrad multibeam echosounder used by the CHS.
General characteristics

Multibeam Echosounder	No. of Beams	Swath Width (°)	Beam width (° along X ° across)	Depth Range (m)	Motion sensor
EM100	32	100	6.6 X 3	-390	TSS 335B
EM1000	60	150	3.3 X 3	-990	POS/MV 320
EM3000	127	120	1.5 X 1.5	-199.9	POS/MV 320

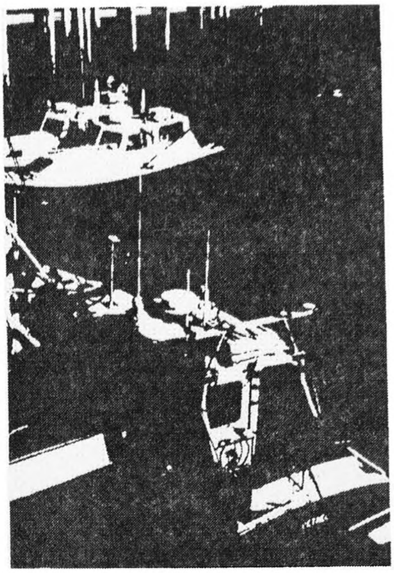

FIG. 2-1.- CHS launches equipped with Simrad EM3000 multibeam echosounder. The frontward one was temporarily equipped with an array (triad) of GPS antennae, to conduct squat assessment trials

Table 2-2
CHS multibeam echosounders and their platforms

	Platforms	LOA/Beam/ Draught (m)	Max. Survey speed (kn)	Crew/ Hydro.	Multibeam Echosounder
Vessels	CSS Matthew	1.52380952381	10	1.77777778	0
	NSC Frederick G. Creed	0.77097505669	17	1.33333333	0
Launches	Plover	4.52380952381	11	1	0
	Puffin	—"—	"	"	0
	Petrel	—"—	"	"	0
	Revisor	2.77161862528	12	0.5	0
Semi-submersible	DOLPHIN	3.7619047619	12	1	0
Spare	—	—	—	—	0

2.2 Research and Development

Well before the acquisition of its first swath sounding system, the CHS had been involved in hydrographic research work as well as taking part in major engineering projects with private companies. The advent of shallow water multibeam echosounders started a new era of research activity within the CHS and its partner companies. A number of papers were written and presented at major hydrographic and oceanic conferences. The principal development projects that occurred in the past decade are briefly described here.

2.2.1 Canadian Ocean Mapping System

The Canadian Ocean Mapping System is a modified version of a CHS model employed many years ago. The principle involves steaming survey platforms in parallel, usually with a mother ship, so as to increase the sounding coverage area during favourable survey conditions. This concept began on the east coast offshore surveys where long range positioning systems such as Decca and Minifix were used to position the mother ship. The smaller launches were positioned from shorter range systems aboard the mother ship while they conducted sounding operations. In the modern version, the DOLPHIN (Deep Ocean Logging Platform with Hydrographic Instrumentation and Navigation) has replaced the survey launch. The DOLPHIN is equipped with GPS positioning, Simrad EM100 multibeam and a sophisticated control and data relay system that allows the mother ship to both manoeuvre the DOLPHIN and log data collected by the DOLPHIN [5]. The advantages to this type of system are many. The DOLPHIN is unmanned and therefore can extend the data collection time tremendously, only having to stop for fuel replenishment. Also, the DOLPHIN is capable of sailing submerged below the wave action. This provides a very stable platform and reduces the amount of noisy data collected. It also allows the DOLPHIN to sail in much rougher conditions than a surface vessel of comparable size. Timely data processing can be accomplished aboard the mother ship as the data is transferred via a telemetry link from the DOLPHIN. When a number of DOLPHIN's are operated in parallel, very wide areas of the ocean floor can be surveyed in one swath taking advantage of favourable weather conditions and narrow time windows.

Soon after COMS was underway, the national survey priorities shifted from offshore surveys to the inshore areas where this type of operation is much less effective. In order to maintain the technology, the Canadian government entered into a partnership with Geo-Resources Inc. This company, based on the east coast of Canada in the province of Newfoundland, has been using the DOLPHIN with the Simrad EM100 [6] to conduct both hydrographic and geologic surveys for the public and private sectors. There has been interest from the military establishments and modified DOLPHIN's (ORCA) are now deployed with the US Naval Oceanographic Office.

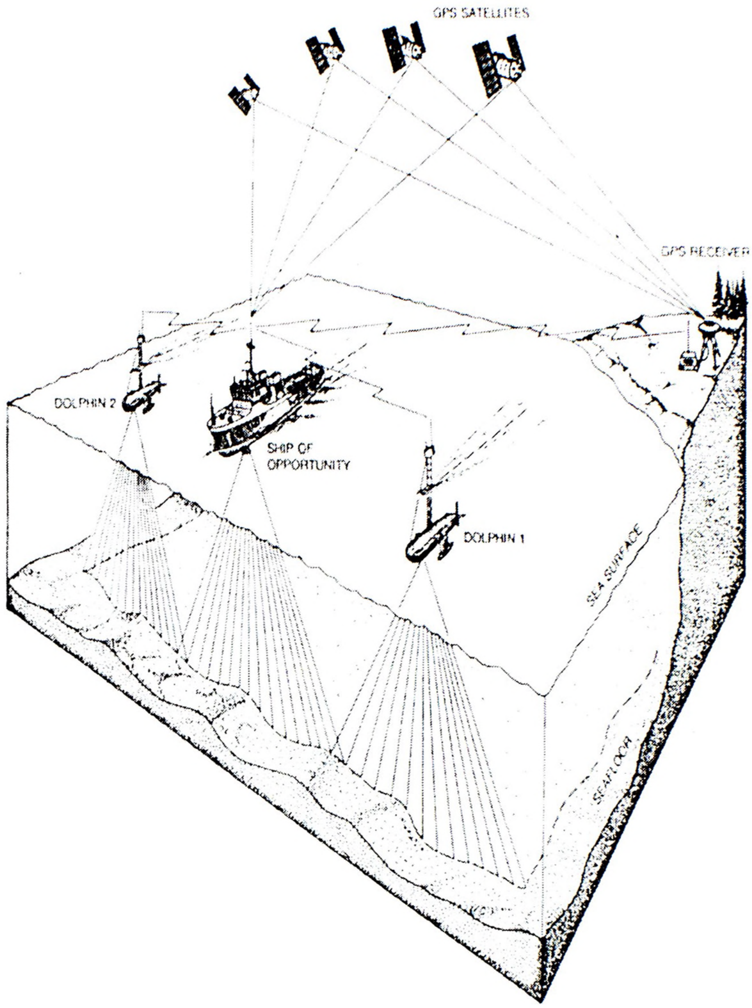

FIG. 2-2.-The concept behind the COMS project: using two or more DOLPHIN, along with a swath sounder equipped mother vessel, to more effectively survey the seafloor (from PEYTON [1992]).

2.2.2 The Ocean Mapping Group

The Ocean Mapping Group (OMG) of the University of New Brunswick, now well known worldwide, was created in 1988 to encourage and maintain advanced research in ocean mapping in Canada. Its mandate*, "to develop innovative methods for the management, processing, depiction, and interpretation of ocean mapping data", satisfy well the national needs. The OMG, of faculty and staff and with the fervor and determination of interested graduated students, works on innovative projects in

* from the OMG web page : http://www.omg.unb.ca

computer science, engineering (surveying, electrical) and geology that contribute to the ocean mapping evolution. The research activities associated with hydrography and swath sounding form an important faction within the OMG's curriculum, mastering:

- The development of advanced software tools for real-time and post-processing of swath map bathymetry and sidescan sonar imagery.
- Interactive 3-D visualization of large multiparameter data sets.
- Quantitative high-resolution acoustic profiling for seafloor classification.
- The Hydrographic Ground Truthing Experiment -- an experiment that takes advantage of the 15 metre tidal range of the Bay of Fundy to evaluate the capabilities and limitations of modern acoustic mapping systems.
- Developing techniques for minimizing sounding errors -- evaluating sources of error such as roll and refraction and looking at new techniques (multi-antenna DGPS systems) for minimizing these errors.
- Development of "On-The-Fly" ambiguity resolution techniques to allow differential GPS to be used for measurement of tides, ship motion and ground-truthing.

One of the latest ongoing projects is the investigation of multibeam sonars for fish stock assessment, a project supported by the CHS. Similar research is being done on the west coast, at the Institute of Ocean Sciences where the CHS - Pacific Region is located.

The OMG, through the recommendations of the US/Canada Hydrographic Commission, offers training in swath surveying. The Multibeam Sonar Training Course, held in St. Andrews (N.B., Canada) every year since 1993, has became very popular within the hydrographic community. The 1998 course will be held at Patricia Bay (B.C., Canada), followed by the 1998 Candian Hydrographic Conference.

The industrial chair in Ocean Mapping was founded to further support research work in ocean mapping as well as to bring a means for promoting partnering amongst academic, industrial and governmental institutions in the subject. The chair that started with five sponsors now counts up to fourteen members from Canada and abroad.

2.2.3 The Development of the "Hydrographic Data Cleaning System"

When the CHS began to acquire high-volume bathymetric data sets, it quickly realized that the post-processing software would require upgrading. In 1988, the CHS contracted the Ocean Mapping Group to investigate error detection and correction associated with the processing of swath and sweep data [7]. Based on this study, the CHS initiated a development project, having the OMG develop a suite of software for cleaning high-volume bathymetric data. The Hydrographic Data Cleaning System (HDCS) was compiled on Unix platforms, using Xwindows and a Motif environment. It features automatic and interactive cleaning tools for attitude, navigation and bathymetric data collected by a variety of hydrographic acquisition systems [8]. The internal data structure was designed to keep all field observations. This was done in order to help decision making in the cleaning process and to be used by adaptive filters in automatic detection of outliers. The use of statistical surfaces and georeference bathymetric representations, within the application, help detect spurious data and system biases.

The project was designed to have the HDCS integrated into a broader commercial package, the Hydrographic Information Processing System [9] (USL). A beta version of this package was released in 1992. The ability to export cleaned data sets as CARIS work files and to create various types of DTM and 3D views is also part of the package. Additional development has followed since the first release, including the incorporation of the OMG SwathEditor, acoustic backscatter editing and mosaicing functionality and a calibration module.

2.2.4 Motion Sensor Trials

It has been observed [10] that time delay and scaling errors in attitude data produce roll errors that can strongly degrade the accuracy of the outer beams. Horizontal accelerations in cornering can also affect attitude measurements from the vertical reference unit (VRU) which will also result in erroneous depth measurements [11]. Hence a series of motion sensor trials were carried out between 1992 and 1995 in order to analyze and report on this source of error. An extensive experimental campaign on the CSS "MATTHEW" took place to assess the performance of different sensors [12, 13]. This CHS development project was done in collaboration with the Geological Survey of Canada and various "Motion Sensor" manufacturers. This work in finding a solution to motion sensor artifacts led to the development of a new instrument package, the GPS-aided inertial navigation system POS/MV [14].

When the Applanix POS/MV motion sensor became available, CHS undertook a series of trials to evaluate this sensor as a replacement unit in the multibeam program. During 1994, an evaluation was made of this unit on 3 different classes of vessel in the CHS fleet. These vessels were the CSS "MATTHEW", a conventional survey ship, the NSC "FREDERICK G. CREED", a swath vessel, and "HELLDIVER", a 10.4 metre survey launch. Results from both the small launch and conventional survey ship trials indicated that the POS/MV's attitude data are unaffected by manoeuvres such as speed changes, radical course changes and short period vertical motion. The "MATTHEW" trials, using a Simrad EM100, showed that repeated sounding over a reference surface while manoeuvring through speed changes, zig zags and 90° course changes resulted in depth errors at 100 metres that are well within the International Hydrographic Organisation (IHO) standards. Examination of the outer beams with the middle beams indicated that the differences for the outer beams was only 2-4 cm greater than the middle beams.

Several problems did show up during these trials together with some factors that the multibeam operator should be aware of while using the systems under certain conditions. The first problem occurred with the "HELLDIVER" where results showed that the bottom had step like changes. These steps were produced from trim changes in the vessel as the observers moved about and changed the vessel attitude. It appears that the motion sensor could not correct for long term trim changes due to the implementation of a heave algorithm that uses a high pass filter operating on vertical acceleration. This was an inherent trait of the POS/MV and is being corrected by the addition of an optional module using Real Time Kinematic / On The Fly (RTK/OTF) GPS [personal communication with Applanix].

The second problem was observed on the "FREDERICK G. CREED" during high speed (16 knots) turns. This was identified as roll compensation and was referred to as *ribbing* due to its characteristic pattern. Subsequent analysis [15, 16] determined that some of the error was due to hull flexure as the pontoon struts deflected under high side loading. This did not seem to account for all of the error and it has been concluded that other factors may be present that are causing problems. One of these factors may be the transducer on the "FREDERICK G. CREED" as it moves upward in the water column during high speed turns. This could present problems for the refraction algorithm as the refraction gradient is high near the surface. The high refraction gradient near the surface may also cause problems for small vessels that have relatively shallow drafts. Another factor that may have to be considered is co-ordinate frame transformation errors. It is critical that the offsets between sensors be measured as accurately as possible. This applies to all vessels having offset sensors for position, attitude and depth.

2.2.5 Development in the Assessment of Sound Velocity Profiles

Sound velocity profiling is a critical element in the successful deployment of a multibeam survey. If a survey area is comprised of water that exhibits a constant velocity from the surface to the seafloor then one velocity cast will suffice for the entire area for the duration of the survey. We all know that this is not realistic, that in real life the velocity profile varies from the surface downward, from area to area and from one time period to another. The problem then is to measure these changes with enough frequency, both spatially and temporarily, to ensure that any error introduced by misapplying velocity profiles is kept within reasonable limits [17].

If we take for example the Simrad EM3000 multibeam system, the velocity profile information is used for two purposes. The first is the determination of the departure angle of the individual beams from the transducer. It is critical that this angle be correct; otherwise the beam intersection with the seafloor will be displaced by the angular error. Shallow water multibeam transducers are designed to be mounted on vessels that have very shallow drafts. This places the transducer high in the water column and into the area of the steepest velocity gradient. Any vertical displacement of the transducer from vessel heave, pitch or squat will change the velocity value at that location. In the worst case, this could move the transducer between fresh and saline water within vertical movements of little more than a few centimetres. There have been a number of ideas put forward to measure or detect changes in velocity at the transducer face. Some of these include a pressure sensor at the face, a temperature sensor at the face, a water sampler at the face that would direct water into a container with a velocity profiler but none have been implemented at this time. In addition to the hardware, software will have to be incorporated into the system to analyze the data and make the appropriate changes in the velocity value. Work continues in this area.

Velocity profiling is also used to correct for ray bending as the beam passes through the water column. If we examine the ray bending case then we must be concerned with changes in velocity profiles due to such events as tidal mixing, estuarial inflow, external temperature effects (hydro-electric cooling water outflow) and water layering among others. There are several methods of overcoming these problems. The simplest is to ensure that sufficient velocity casts are made in order to identify all of the changes. These profiles must then be input into the ray bending algorithm to ensure that true depths are calculated. Another method involves real time, on line velocity profiling employing several different techniques. Brooke Ocean Technology (BOT) in Dartmouth, Nova Scotia, Canada, in co-operation with CHS, has developed a velocity profiler deployment system that can be mounted on the after deck of a survey vessel. This system will continuously raise and lower a profiler while underway. Real time data is fed into the data collection system via a hardwired link. This system will provide timely data for adverse conditions such as those listed previously. There are some drawbacks with this technology, however. It is difficult to use in shallow water where there are steep bottom gradients. Those who have used any type of towed submersible will appreciate this problem. The other major drawback for shallow water use is the need for a large vessel as the system is relatively large and heavy. This precludes its use on our 9.5 metre launches.

The other technique employed by BOT is a fixed mooring system. The movement of the water is used as the energy source to ratchet a velocity profiler (or any other sensor) up and down the mooring line. A telemetry link can be used with this system to broadcast the data to the survey vessel. Careful deployment of several profilers would allow a survey vessel to work in areas of continuously changing velocity profiles and still receive continuous real time velocity information that could be fed directly into the data collection system. For a full description of the deployment systems with pictures, refer to the BOT Internet site at >http://Fox.nstn.ca:80/~afurlon/<.

2.3 The Partnering

Partnering is a the new way of doing business. This is especially true for government agencies and the Canadian government is no exception. CHS has entered and will continue to enter into ventures with private industry and academic institutions. This has come about primarily because of belt tightening and the limited resources that are available to all participants. The government has found it advantageous to use the expertise, development skills and marketing available in the private and academic worlds while business has come to realize that the backing of established government agencies can be their entry into markets otherwise restricted for whatever reasons. Government agencies also become the testing and evaluation sites for the newly developed tools. True partnerships, where both sides make a contribution and where both sides are aware of the conditions and ramifications and are willing to work together, are usually successful.

Partnering in swath sounding activities in Canada began with the COMS project and with the OMG's Hydrographic Ground Truthing Experiment. Partnering is the raison d'être of the Canadian initiative called National Action Committee on Ocean Mapping (NACOM) that put together industrial, academic and governmental agencies to work on a multitude of projects in ocean mapping. Partnering is used for joint surveys between the CHS, the OMG, NOAA and the U.S. Geological Survey as in the Stellwagen Bank project [18] and between CHS, OMG and the U.S. Office of Naval Research in the New Jersey Margin project of the STRATAFORM program (see http://pccad.msrc.sunysb.edu/). CHS is about to enter into a partnership with Universal Systems Ltd. (USL), Fredericton, New Brunswick, Canada to develop a new generation of hydrographic data processing software. This will include modules for single beam as well as multibeam data and will exploit the Oracle SDO technology for data management.

Partnering is not entered into blindly. The CHS has been an important player in supporting and facilitating Canadian ocean mapping initiatives among the private and academic sectors. The CHS, as well as its partners, see these agreements as a means for developing cost effective techniques and technologies. Furthermore, the CHS should be a catalyst for joint ventures and at the same time a mediator for the way these collaborative agreements are being conducted. The CHS recently organized a workshop to further define Partnering Guidelines for ocean mapping in Canada.

3. NEW DIRECTIONS FOR FUTURE SWATH SOUNDING ACTIVITIES

There are a number of new directions that CHS multibeam sounding activities will go in the coming years. One of these will be our ability to take advantage of the ECDIS capabilities combined with the vast amount of data collected from multibeam to develop new looks for the nautical chart. Other areas, new to CHS but being used by other agencies such as the US Army Corps of Engineers, are channel monitoring and pre/post dredge surveys. The St. Lawrence River and the associated Seaway system monitoring and dredging programs will be carried out with the aid of multibeam surveys. GPS technology will allow all of our future surveys to be independent of tidal monitoring stations through the application of RTK/OTF. This may also lead to the seamless datum that has been discussed for the last several years and allow smooth transitions between charts on the ECDIS. Key to all of the future activities will be our ability to "process" the vast amounts of data that will be collected by each system. Improved post-processing packages are being developed by a number of manufacturers including Universal Systems Ltd., an industrial partner with the Canadian government.

3.1 New Look for Nautical Charts

Our business as an HO is the production of nautical charts for the maritime community. CHS as well as the other HO's have done a commendable job up to the present, given the data that was available, but it is now time to look to the future. Present day multibeam systems are capable of producing over 3000 soundings per second, covering what most people would consider to be 100% of the seafloor. It is this data that will enable HO's to present the seafloor in any manner that the mariner wishes to view it. ECDIS can have the capability of displaying soundings, contours, shaded relief detail, statistics, quality control data and a host of other information either stand alone or draped over the bathymetry. It will be the job of hydrographers, cartographers and the ECDIS manufacturers to produce these displays and present them to the maritime community. From these prototype charts will emerge the best and in some cases the most spectacular views of the information needed by the mariner. A practical application of this technology might be for visualizing, in 3 dimensions, a vessel as it sails through a dredged channel. The navigator would see the hull in relation to the side slopes and the bottom of the channel. This could also apply to the large scale or super scale charts that have been requested by the shipping industry for docking. Rather than have text information in the form of soundings on these charts, the bathymetry could be represented graphically. There are many more ideas that could be explored but it will require some imagination on the part of the chart makers and a lot of input from the end users. Technology is no longer holding back the development of new and innovative charting presentations.

3.2 Swath Sounding Applications for Channel Monitoring and Dredging

The St. Lawrence river is an important entry route for commercial shipping into North America. There are up to 300 nautical miles of waterway between Québec City and Kingston (Ont.). It is a water way that needs to be monitored and dredged to maintain a safe depth for the passage of cargo vessels. Between Québec and Montréal, 110 square kilometres of channel must be surveyed for pre and post dredging operations. The vertical and horizontal accuracy required for this kind of survey is more stringent than that for regular hydrographic surveys because depth measurements will be used to compute volumes to be dredged. Since the charges for the removal of material are based on the volume and on the extent of the feature to be dredged, it is essential to get the most accurate depth measurements. To date, sweep systems have been used to survey the St. Lawrence channel, with a depth accuracy of 15 cm (95% confidence level) or better. When the first multibeam systems were purchased by the CHS, the overall accuracy obtained did not meet the above requirements. The "CREED" EM1000 multibeam did not comply either [19]. With the development of the shallow water swath systems, such accuracy's can be obtained [20] provided that heave and sound velocity errors are minimized. The survey program for the St. Lawrence channel, using these new EM3000-equipped launches, could certainly be done more rapidly and more cost-effectively. The maintenance for small launches would also be much less than that of a larger vessel such as the "F.C.G. SMITH" [21] not mentioning the gain in maneuverability and operation costs.

3.3 Vertical Referencing from RTK GPS Positioning

We know that corrections for water levels can be an important source of error in the bathymetric error budget [22, 19], 19. It is also true but to a lesser extent for other vertical variations such as heave, squat and transducer draft [23]. With the advent of RTK, GPS positioning can help reducing these sources of error. The heights obtained from an RTK positioning system and referred to a seamless datum would provide excellent water level corrections because it is observing in situ the vertical changes caused by tide, hydrodynamic effects and river slope. Such heights would also monitor the long period changes in the vertical location of the transducer with respect to the water surface as squat and draft changes from water and fuel consumption. RTK positioning is not by itself appropriate for heave measurements because the low sampling rate would not be sufficient for monitoring rapid vertical changes that occur on small platforms such as launches. Nevertheless, it can be used as an aid with GPS-based inertial attitude sensors to improve the heave measurement.

There is an ongoing project in Canada to provide long base line RTK GPS positioning for the St. Lawrence River [24, 25]. This project has been initiated to supplement RTK positioning for the survey platforms that operate in the St. Lawrence Seaway between Québec City and Montréal. The obtained antenna heights will be referred to a newly defined seamless chart datum. Knowing the static offset on the platform and with the use of the attitude data from the motion sensor, the RTK GPS data would be integrated directly into the system to reduced the depth measurements to chart datum. By doing so, errors coming from squat, static draft and co-tidal corrections are eliminated.

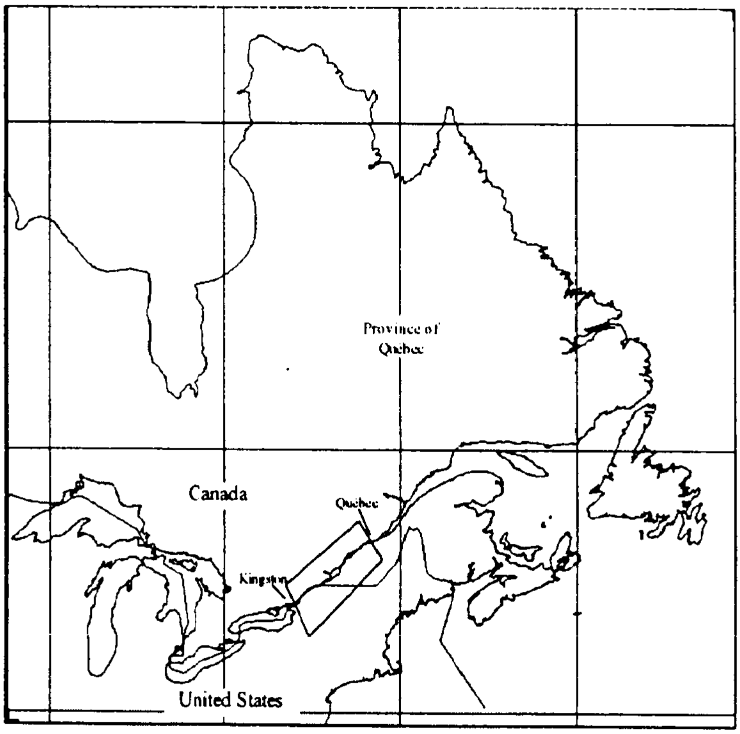

FIG. 3-3.- The St. Lawrence seaway, between Québec city and Kingston (encircled), 300 miles of maintained channel.

If this pilot project proves that the technology is reliable, the service would be extended to supply vertical positioning for commercial shipping. In the meantime, there is a development project to integrate the technology into shallow water multibeam sounding systems to increase overall accuracy.

3.4 Development of new Post-Processing Packages

Industry has been forging ahead with data acquisition technology to such an extent that the development of data processing tools is lagging behind. There is a growing awareness that the present data processing packages are not adequate to deal with the huge amounts of data being collected. A number of manufacturers have begun development of new algorithms for automated data cleaning with the latest trend to providing online, near real time data processing. Data thinning is being considered in an effort to reduce the storage requirements and data processing time. Many software manufacturers have provided the capability to reprocess the raw data to account for poor calibration estimates.

It is becoming increasingly more difficult to detect anomalous values in the very large data sets being logged by the multibeam systems without visual aids. Past practice has relied to a large extent on the human brain putting the data into context but that is no longer possible. 2D and 3D views, with the aid of such techniques as tiling and bining are required to produce images that can identify this errant data. Rendering, artificial sunlit views, colour contouring, point and identify are but some of the techniques that are being incorporated into the software.

Often times, users would like the option of having several different packages available. Each may have strengths in areas that the other doesn't. Relational Data Base Management Systems (RDBMS) may provide a solution to allow for the interaction of these different software packages. RDBMS such as Oracle SDO that optimize data storage and retrieval are gaining ground on the traditional databases and flat file methods of data handling. There are a number of advantages to using an RDBMS with the data processing packages. No longer will it be necessary to open the entire flat file and sequentially search for particular data points. The program can extract data from the database by immediately going to the data location and retrieving the information. This translates into faster retrieval times and reduced storage requirements. With the proper tools, the user can structure new queries to perform operations that normally require the software manufacturer to program into the software. This will allow much more flexibility for the user and independence from specific software programs. The Structured Query Language (SQL) or other suitable feature will provide the tools for quality control (QC) functions. QC personnel will now have the capability of using the same software as the data processing people with the addition of their own specialized QC query routines.

4. Conclusions

We have entered a new age of hydrography. Much as in the past when we progressed from leadline to acoustic echosounder, we must now find new ways of applying the multibeam technology. Total bottom coverage will open up waterways presently restricted because of depth uncertainties. Commercial shipping will see increased revenues as more confidence is gained in loading vessels to operate with less underkeel clearance. Pipeline routing will be made much more economical as the companies can visualize the seafloor and determine bottom characteristics from the data collected with multibeam. Litigation will be reduced for dredge contracts as precise measures of material removed will be available from multibeam surveys. The list goes on and on, all to justify our invesment in swath sounding technology.

The next decade will see other flourishing activities associated with swath sounding in Canada. The CHS will focus more on shallow water operations which brings a whole new set of challenges. New post-processing tools and techniques will be developed to serve the shallow water ever increasing requirements. Fisheries geomatics is also evolving and the uses of multibeam echosounder for biomass assessment and fish habitat mapping are other potential applications that are being considered. Partnering is now a common word in our working environment and it will be a key player in future collaborative developments and joint surveys.

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