THE ST. LAWRENCE RIVER CHANNEL OPERATIONS

Shallow-water Survey in Canada

Canada is the second largest country in the world, with a shoreline measuring approximately 243,800km, more than six times the circumference of the Earth. The Canadian Hydrographic Service (CHS), established in 1883, is divided into four regions better to serve this immense territory. Shallow-water surveys take place in all four regions; however, one of these has the most intense operations: the St. Lawrence channel in the QuÃ©bec Region. The Canadian Hydrographic Service based at Maurice Lamontagne Institute, in collaboration with the Canadian Coast Guard, is working to improve the efficiency and accuracy of these shallow-water survey operations. This paper presents the latest improvement made with implementation of RTK GPS in a fully operational mode and looks at what is planned for the future.

The St. Lawrence River in Canada connects the Atlantic Ocean with the Great Lakes. This provides a navigable waterway beginning on the shores of North Eastern North America and stretching some 3,750 kilometres into the continentâ€™s interior, providing a crucial element in the vitality of commerce and economy for Canada and the United States. Thousands of vessel transits and many millions of metric tons of cargo are recorded and shipped every year through this very important navigational system. The St. Lawrence River channel, a 320 kilometre-long section of this waterway, is heavily navigated. For part of this section, a 210-kilometre stretch mainly situated between QuÃ©bec City and MontrÃ©al, the channel is restricted and depths are constantly maintained by dredging operations. Although hydrographic surveys are performed yearly from mid-April to the end of November, the channel is open all year round, despite ice conditions in winter.
Shipping traffic is important and is managed to avoid congestion. Dredging operations along the channel provide depths of 10.7m to 12.5m, depending on river section. These operations are essential and are conducted on a regular basis. Winter in this part of the world produces particularly harsh conditions that must be addressed in order to maintain the channel; surface-ice formed in winter moves around and flows downstream in spring. Boulders and debris of various size may be moved by the ice (this is called â€˜glacielâ€™) and alter the depth in some areas.

The Survey Vessels
CHS, using Canadian Coast Guard (CCG) vessels of the Department of Fisheries and Oceans (DFO) conducts bathymetric surveys to accurately determined water depth. In the early spring, each survey boat is calibrated and survey operations begin. First, changes in depths that have occurred over the winter, particularly those caused by boulders, are rapidly detected in order to prepare for dredging operations. Then the usual pre and post-dredging sounding operations are conducted, in addition to regular maintenance surveys to monitor the rate of changes in depth.
Three survey vessels are in constant use. At the moment these are all equipped with sweep systems using Navitronics (RESON) echo sounders; two are catamaran (two hulls) and the small one is a regular mono-hull launch. The largest is the *F.C.G. Smith*, 35m long, equipped with two arms and carrying 33 transducers (see Figure 1). The medium one, GC-03, is approximately half the length (18.5m) of the largest. Finally, the small launch is 8 metres long and carries six transducers (see Figure 2).

Water Level Reduction
Previous methods of reducing water levels required intensive on-site manual labour and the accuracy was subjective and limited by sea-state conditions. Water-level reduction applied to bathymetric soundings was done with an application called â€˜AutomarÃ©eâ€™, using a linear interpolation model. With this water level is obtained at the position of the survey vessel on the basis of water-level readings obtained at two or three tide staffs. Tide staffs are 3m or 6m long, depending on the tide amplitude on the river. The staff is levelled prior to each survey to eliminate errors caused by wave action that shifts it. An operator on a launch or on land reads the water level and transmits the value to the ship by radio link. This technique is relatively reliable but requires favourable weather conditions and the use of a couple of people. In fact, waves higher than 30cm affect the accuracy of the water-level reading and thus the accuracy of the sounding. Also, the linear interpolation model is basic and cannot predict the real movement of the water level or local hydrodynamic effects between staffs.
In the summer of 1996, deployment of the DGPS permanent CCG infrastructure network combined with current technological context opened the door to the use of an Ã”On-the-FlyÃ• (OTF) method of real-time positioning (GPS phase ambiguity resolution in kinematic-relative positioning mode). When applied to bathymetric surveys of the channel on the St. Lawrence River the OTF approach could eliminate tide staffs and tide gauges used to reduce bathymetric soundings to the reference datum of nautical charts (chart datum). The elimination of sixty to seventy tide staffs along the channel would represent low-cost gain in productivity and efficiency.
CHS, CCG, the private sector and teaching institutions involved in geomatics have been working together for some years to implement DGPS-OTF technology for hydrographic surveys on the St. Lawrence River channel. The project was divided into six distinct modules:

- development and testing of RTK software
- development and realisation of seamless datum
- development and implementation of communication system
- development and implementation of hydrographic integration solution for RTK values
- development of independent water-level information system, Le SystÃ¨me de PrÃ³vision et dâ€™Interpollation des des Niveaux Eau(SPINE) based on a One-Dimension (One-D) hydrodynamic model of the St. Lawrence
- general benchtesting (see Figure 3).

Evaluation

In a joint CHS-CCG project, GPS/OTF and SPINE technologies were subjected to intensive evaluation campaigns from 1999 to 2002. The results of these campaigns were positive and demonstrate the benefits related to the use of these technologies, especially for shallow-water surveys in a river like the St. Lawrence channel. In 2002, the GPS/OTF method was used as the backup system for water-level reductions of the soundings on the channel. In 2003, the GPS/OTF method was the primary system and the tide staffs were used only as backup. We were very satisfied with the results; in the 2004 season there has been no reinstallation of tide staffs and the GPS/OTF method of reducing the water level is, along with the SPINE integrity system, now the official primary system used.

The OTF solution offers many advantages for surveys because it allows optimisation of surveying and dredging techniques. In the current context of shipboard integration, it allows an assessment of water levels at the shipâ€™s actual position and is not an interpolation. Using SPINE as part of the solution is also important as this provides an interpolated water level at the shipâ€™s actual position and therefore allows a comparison between the various proposed methods of obtaining water levels and tide staffs, when in place.

Future Projects

Needless to say, the combined use of OTF and the hydrodynamic model approach will substantially reduce the operational costs of shallow-water bathymetric surveys on the St. Lawrence River channel. Benefits of using this technology will now be extended to other uses and projects, such as the determination of squat for deep-draught vessels and the production of dynamic digital charts.

In the continual race to improve efficiency whilst reducing costs we constantly face new challenges. Last autumn we began a project to evaluate the use of MBES technology against multi-transducer technology in shallow-survey operations on the channel to see if similar or better results could be obtained. Costs would be reduced substantially by replacing the largest catamaran by one or two smaller MBES vessels like our launch *Guillemot*, equipped with an Em-3000 from Kongsberg-Simrad.