

Contour

CANADIAN HYDROGRAPHIC SERVICE

SUMMER 1994



Photo courtesy of Port of Montreal

IMPROVING TRANSPORT TO THE PORT OF MONTREAL

by Jean-Luc Bédard, Harbour Master

The Port of Montreal is situated on the shortest route between the industrial heart of North America and Europe. Thanks to its privileged location, its excellent intermodal transportation links, its modern facilities and its many other advantages, the port handles as many, if not more, containers and a greater variety of merchandise by way of the North Atlantic than any other

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CONCERTED EFFORTS KEEP ECDIS ON COURSE

by Lee Alexander, Ph.D.

The following highlights are from a report by Lee Alexander, Project Manager, Integrated Navigation Systems, U.S. Coast Guard Research and Development Centre, to the U.S. Hydrographic

Conference, Norfolk, Virginia, April 1994.



The Maritime Safety Committee (MSC) of the International Maritime Organization (IMO) approved for adoption the IMO ECDIS Performance Standard in May 1994 with formal adoption by IMO expected in September 1995. In the interim, IMO

has disseminated the ECDIS Performance Standard requesting member governments to expedite the production of electronic navigation charts (ENCs), to establish the associated updating service, and to ensure that manufacturers conform to the performance standards when design-

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Fisheries and Oceans Pêches et Océans

Canada

Port of Montreal

port in eastern North America.

But competition is fierce: the port of Montreal is not the only one serving the vast hinterland of central Canada, the

Midwest and the American north-east. To meet the challenge of competition from other east coast ports and to stimulate port activity, the Port of Montreal Company and other stakeholders in its port system are doing everything possible to offer their customers a quick, reliable, efficient and economical service. In terms of actual economic impact, port activity currently generates \$1.2 billion a year and 14,000 jobs, directly and indirectly.

In our view, electronic navigation represents an excellent way to improve the service we offer the customers we are trying to attract from far and wide. Thus we are happy about the efforts made by various parties, both individually and collectively, to install state-of-the-art navigational aids on the St. Lawrence. In particular, we support the work accomplished in this area by the Canadian Hydrographic Service, the Canadian Coast Guard and the Pilots.

The St. Lawrence and new technologies

The Electronic Chart Display Information System (ECDIS) provided to commercial navigation, clearly facilitates access to the port of Montreal. It makes navigation safer, makes passage easier in all weather to the ports of the St. Lawrence, even on winter nights, and improves the dissemination of nautical data to navigators as well as to our customers.

The Pilots who travel the St. Lawrence must guide ships that are larger and larger through a channel whose width has not changed in 20 years. It is becoming more pressing for them to use navigational aids that are more precise and reliable in all kinds of weather.

From mid-April until the beginning of December, St. Lawrence Pilots can rely on lighted navigational buoys but then these are removed because of ice.

Even though there are no navigational aids for four to five months a year, ships have been travelling the St. Lawrence year round for more than 30 years. Moreover, ocean traffic is as dense in winter as it is during other seasons, mainly because of regular shipping service and the system of "just in time" management.

In winter, the lighted floating aids are replaced by unlighted spars. Unfortunately, these have a tendency to slip under moving ice and it is difficult to detect or identify them, especially at night. That is why, when moving through the channel, St. Lawrence Pilots use terrestrial navigational aids, including among others, alignment lights and radar distances. These two kinds of aids, however have a tendency to lose some of their effectiveness in bad weather. It is hardly surprising, therefore, that in winter, navigators are reluctant to travel at night through a narrow channel, with only minimal navigational aids, if weather conditions are not ideal.

All of these constraints can result in delays, and can complicate the planning of arrivals and departures, as well as coordination with cargo transfer activities—and affect the demand for dockers and railway work teams, and the scheduling of long-haul trains. These constraints can also reduce the efficiency of the transportation network, which can entail significant financial losses affecting the competitiveness of the St. Lawrence ports. On the other hand, better navigational aids—effective in all weather—will allow us to increase productivity.

Because of financial and environmental constraints, we may have to wait several years before the shipping channel can be altered. It is important to make the best use of the existing channel's capacity to maximize shipping load. Therefore,



we need to be able to count on effective tools that will allow us to access the most current data and make informed decisions.

Over the past year, many kinds of information display devices that can be installed on board ship have been developed. The cooperation of all interested parties, including among others, the Pilots, the Canadian Coast Guard, the Canadian Hydrographic Service, the ports and the maritime companies, has made it possible to create a basic infrastructure for electronic navigation in the St. Lawrence.

In support of this, the Canadian Hydrographic Service has moved quickly to offer basic electronic charts geared to criteria established by Pilots, who are the principal users on the St. Lawrence. For its part, the Canadian Coast Guard has installed Differential Global Positioning System (DGPS) stations covering the St. Lawrence and giving commercial navigators access to a precise positioning system. Once these basic infrastructure elements are fully in place, it will be possible to do the necessary tests to ensure that integrated navigation systems respond to the Pilots needs. The tests will also enable Pilots to become familiar with the system.

The electronic chart should be the basis for the development of a true marine geomatics approach making it possible to distribute current data to users. These data could be useful both to mariners and land-based employees of shipping companies who, for example, have to plan a voyage. The electronic chart should become a fundamental support tool for navigation and a



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source of useful information for those who plan the loading and movement of ships.

Step by step

The cooperation of the various interested parties has made it possible to establish quickly the basic infrastructure that integrates the DGPS and the visual display of a vessel's position on an electronic chart. It has also made it possible to establish the Coast and Ocean Water Level Information System (COWLIS), which allows us to read and disseminate, in real time, information about water levels all along the St. Lawrence. This system could eventually be directly linked to the electronic chart. Given the many aspects of this program, this first stage in the process for integrated navigation has been accomplished in record time.

Though the integrated navigation system offers many advantages for a port like ours, it must still be used by seasoned mariners who know the territory and have the necessary practical experience. It is another aid to navigation, which in the short term, will ensure better service to shipping on the St. Lawrence. This system must be easy to use so that navigators can adapt to it easily, and thus enable us to quickly reach our goals. It must also be reliable enough to gain the confidence of navigators.

Our regular shipping lines are interested in the concept, and have begun to acquire the necessary materials. However, the number of ships so equipped represents only a very small percentage of the total traffic. The users of the system, such as the Pilots of the St. Lawrence, will thus have few opportunities to familiarize themselves with integrated navigational systems.

The lack of infrastructure could create serious obstacles to the interactive capabilities we are looking for.

It would certainly be desirable to promote the maximal use of the system by navigators. Ideally, Pilots should bring their own integrated

navigational equipment on board vessels that are not already equipped. The use of a portable system would have many advantages:

- it would offer users the highest possible level of interactive capability;
- it would make navigation safer for all commercial vessels travelling on the St. Lawrence;
- it would offer economic advantages to all ships; and
- it would further improve the system by increasing the number of users.

Cooperation has made it possible to launch a private sector project to develop portable devices. But we cannot stop there. We must now establish a true marine geomatics infrastructure to allow all users, on land as well as on the river, to get quick access to current data.

We already have the basic technology and the means of communication. All that remains is to establish the priorities for the integration of the technologies and to continue the existing collaboration to establish an integrated system that will allow us to offer better service.

The St. Lawrence presents some unique advantages for the establishment of an integrated electronic navigation system and marine geomatics infrastructure which can offer real economic benefits to every active ship owner on the river. The installation of such systems also ensures increased maritime safety, easier access and, in the long term, maximal exploitation of the capacities of the channel.

These economic benefits should stimulate the development and rapid integration of the different components required for integrated navigation and marine geomatics. We can thus be in the vanguard and maintain our reputation with the international maritime community.



Photo courtesy of Port of Montreal



CRAZY-QUILT PATTERN OF STANDARDS FOR ECDIS/ECS

by Mortimer Rogoff

Introduction and Background

Everyone agrees that standards are desirable—they introduce order and reason into what otherwise might be a chaotic situation. But if you examine the current situation in the matter of standards for Electronic Chart Display and Information Systems (ECDIS) and Electronic Chart Systems (ECS) you probably wonder if standards make for order or for confusion. There is a continuing proliferation of standards that apply to these systems, and we haven't seen the end yet.

The first ECDIS standards appeared in 1989, when the International Maritime Organization (IMO) approved the professional Performance Standard, advising member nations to make sea trials that would test the new standard, and proposing that it become final in 1993. IMO has adhered to that schedule, and its Safety of Navigation Subcommittee did recommend in September of 1993 that a Performance Standard for ECDIS be approved by the Maritime Safety Committee (MSC) and the Assembly of IMO. MSC has approved the new standard—in May of 1994—and final approval by the Assembly is expected in November of 1995.

During the same period, the International Hydrographic Organization (IHO) was at work establishing standards for the display and chart database portions of ECDIS. Committees were set up within IHO, some con-

sidering the details of the database and the format by which digital data could be exchanged between Hydrographic Offices, others working on the content of that database and on the appearance of ECDIS displays aboard ship. In addition, IHO joined forces with IMO in a Harmonization Group of ECDIS (HGE), that was given the assignment to create the IMO Performance Standard.

IHO has produced a series of standards documents that are referenced within the IMO standard, and thus are part of the complete ECDIS standard documentation. This coupling by reference has resulted in an exceptionally "dense" standard for ECDIS, because each paragraph

of section in the IMO standard brings with it corresponding layers of the IHO standards.

But that is not the end of the depth of standards. The International Electric Commission (IEC) is preparing its own ECDIS standard whose principal function is to establish a group of tests which, if performed properly will demonstrate compliance with the provisions of the IMO standard (and, of course, with the relative provisions of the IHO standards).

But even that is not the end of the standards story. ECDIS has spawned ECS. The latter is the variation that does not purport to be the legal equivalent of the paper chart, but simply acts as an aid to navigation. ECS has begun to create its own coterie of standards. The Radio Technical Commission for Marine Services (RTCM) is presently completing an ECS Performance Standard, and there is even discussion within IMO for the purpose of deciding whether or not to produce "guidelines" (a variation on the concept of standard) for ECS.

Given this rambling, raucous, background of standards, the question to be answered is whether or not the mariner is well-served by these layers of words that are intended to say what ECDIS and ECS must do—and what it must not do—to be properly qualified to bear the name. Or, one wonders why so much energy and effort is being poured into this matter of defining the ECDIS/ECS family of systems.

Actually, there is a purpose behind these efforts, and this will be explored in the sections that follow.

The present set of standards

Just to establish the present status of applicable standards and their sources, the following paragraphs established the relationship between those preparing standards, and what the standards cover.

The IMO performance standard for ECDIS

This standard covers the functions to be performed if the system is to qualify as an ECDIS. This standard covers such topics as:

- Display of information
- Updating of chart information
- Chart scales
- Display of other navigational information
- Display mode
- Colours and symbols
- Display requirements
- Route planning, monitoring and recording
- Connections with other equipment
- Performance tests, alarms and indications
- Back-up arrangements
- Power supply

International Conference on Electronic Charts

The International Conference and Exposition for Electronic Chart Display and Air and Shipborne Information Systems was held in Copenhagen, Denmark on May 24-26, 1994.

120 delegates from 15 countries heard 20 papers on Electronic Chart related issues. Significant concerns at this date in the development of the technology appear to be:

- supply of data by Hydrographic Offices
- updating services.

The IHO specifications for chart content and display aspects of ECDIS (Publication S52)

This standard covers the following topics:

- Cartographic framework
- ENC content and display
- ENC data structure
- Minimum performance requirements in relation to the ENC
- Updates
- Minimum configuration

The IHO Provisional Colour and symbol specifications for ECDIS (Publication S52, Appendix 2)

This standard covers the following topics:

- General considerations
- Specifications for lines, symbols, alphanumerics
- Specifications for colours
- Specifications for the CRT display screen
- Colour tables
- Provisional presentation library

The RTCM recommended standards for Electronic Chart Systems (ECS)

This standard covers the following topics:

- General requirements
- Display of chart information
- Provision and correction of chart information
- Messages and warnings
- Display of additional information
- Presentation modes
- ECS database content
- Colours and symbols
- Display requirements
- Operating modes
- Calculation precision

IEC publication 1174 "Electronic Chart Display and Information System (ECDIS)"

This publication is still in its early formative stages. Completion is not expected until 1996. Its content will be detailed tests to be performed related to virtually every provision of the IMO Performance Standard for ECDIS.

IHO specifications for updating the Electronic Chart (Publication S52, Appendix 1)

This publication is still being drafted by a Committee of IHO. When completed it will define methods of preparing and disseminating official updates to electronic charts by various means.

The purpose of the standards

Although there is a wealth of detail in these completed, provisional, and preliminary standards, it is possible to see an underlying purpose and value in them. The motivating force behind all of them is maritime unity. ECDIS and ECS both represent a basis for avoiding groundings and successful maneuvering away from potential collisions. Unfortunately, their close relationship to the nautical chart has presented a challenge, if not a barrier, to early implementation. It is, and has been necessary to assure the content, validity, and quality of the chart features being displayed so that they match the content, validity and quality of the paper nautical chart. It is for this reason that such a complete array of standards and tests are being developed. Regulatory authorities are attempting to assure the maritime community that using an electronic chart is as safe as using a paper chart. This degree of attention is also aimed at the admiralty courts who, in the future, will be asked to accept evidence derived from electronic charts as being equal to that normally available from paper charts. No court has yet ruled on the admissibility of such evidence, but the attempt is being made now to make its acceptance a likely probability.

There is a probability to precedent for a new electronic system to be given the scrutiny being experienced by ECDIS and ECS. Electronic systems, be they direction finders, depth finders, gyrocompasses, radar, bridge-to-bridge radios, or position finders such as Decca, Loran or GPS have not been asked to prove their legality. They have been accepted as aids to navigation, contributors to safety, and they meet their own standards of performance. But they are not the final authority as is the nautical chart. The data obtained from these sensors can be checked and cross checked with other data in order to properly assess a developing critical situation. But there is virtually no way to check the chart. It has to be accepted as the basic authority on the bridge; the electronic chart, if it is to be the substitute for the paper chart, has to meet the same test of quality and validity.

These factors and considerations probably explain the ex-

IEC meeting

The International Electrotechnical Commission, had previously established a working group to write a technical standard establishing tests and checks that prove whether a specific piece of equipment meets the required IMO standard for ECDIS.

This group met in Norrköping, Sweden at the end of May this year and will meet again in London on September 12-14, 1994 to continue preparation of IEC documents required for type approval.

tence of the multitude of standards being developed for ECDIS and ECS.

The Missing Standard

It's hard to believe that there may be missing standards. In reality, there are some gaps. An important omission lies in the electronic chart equipment installed on SOLAS Convention vessels that is not using a government produced database. Thus the equipment, which may be in full compliance with the performance requirements of ECDIS, is actually appearing as ECS because of missing or unavailable government data. There is no standard available or in preparation that covers this situation. Since large vessels are the most likely to be carrying hazardous cargoes in large quantities, the absence of these standards can represent a safety hazard. This gap should be filled.

What the future holds

All of the standards discussed above will be completed during the next few years. They will then become the basis for regulations, including mandatory carriage of ECDIS and ECS in many countries of the world. There is not doubt that these standards will provide the users and regulators in the maritime community with the assurances they need that they are actually improving safety. It is easy to see that during the previous and present era, when such standards were missing, that ECDIS and ECS

played no role in improving the safety of shipping operations. It is a safe bet that the approval of this set of standards will encourage their use. When that happens we can look forward to achieving the full promise offered by this major improvement.

Mortimer Rogoff is President of The Digital Directions Co., Inc., Washington, D.C.

International Conference on Maritime Law and the Electronic Chart

The NOAA's Coast and Geodetic Survey and the Maritime Law Center of Tulane University will host the 2nd International Conference on Maritime Law and the Electronic Chart in New Orleans, March 12-14, 1995.



Photo: CHS Archives

INTEGRATING DGPS WITH ELECTRONIC CHARTS

by Jean-Pierre Leroux

The Pilots of the Central St. Lawrence have acquired a working knowledge of the Differential Global Positioning System (DGPS) allowing us now to anticipate the benefits to maritime companies that invest in this new technology.

The system allows the specialist of 'navigation in confined waters' to offer higher quality services. Used with the radar marking

method well known to pilots, the DGPS is an excellent tool for confirming the position of ships. For that matter, the integration of the DGPS with an electronic chart system is making it possible to locate a ship in relation to the parameters of the chart, and this, in both good and bad weather, by day and by night.

The advantages are numerous:

- the information portrayed by the video image, like the radar image, will no longer be hampered by interference because of bad weather or ice;
- it will be possible at any moment to see the position of the ship on the bridge;

- the addition of another aid can only improve the safety of navigation;
- in confined waters, more ships will be able to travel in poor visibility and on winter nights; and
- assuming the quality is acceptable, the superimposition of the radar image on the screen provides an anti-collision function to the system. In fact, this image will confirm the position of the vessel, an obligatory and indispensable reference for the pilot. The use of several aids reduces the risk of errors, after all, no single aid is infallible.

The integration of radar with a positioning system using electronic charts still involves a potential danger: in the event of a breakdown, the pilot would be deprived of two navigational systems. In the inter-

ests of safety, therefore, there should be separate and independent navigational instruments on the bridge.

Piloting in confined waters is based on a knowledge of local conditions, confirmed by many observations of surrounding waters, the shore and the navigation instruments. Standardized methods of navigation among the whole range of maritime traffic in a region would improve safety and efficiency. With this objective in mind and since not all ships have the same equipment, a portable DGPS could make navigation between Québec and Montreal faster, safer and more effective.

Jean-Pierre Leroux is President of the Corporation of Pilots of the Central St. Lawrence.

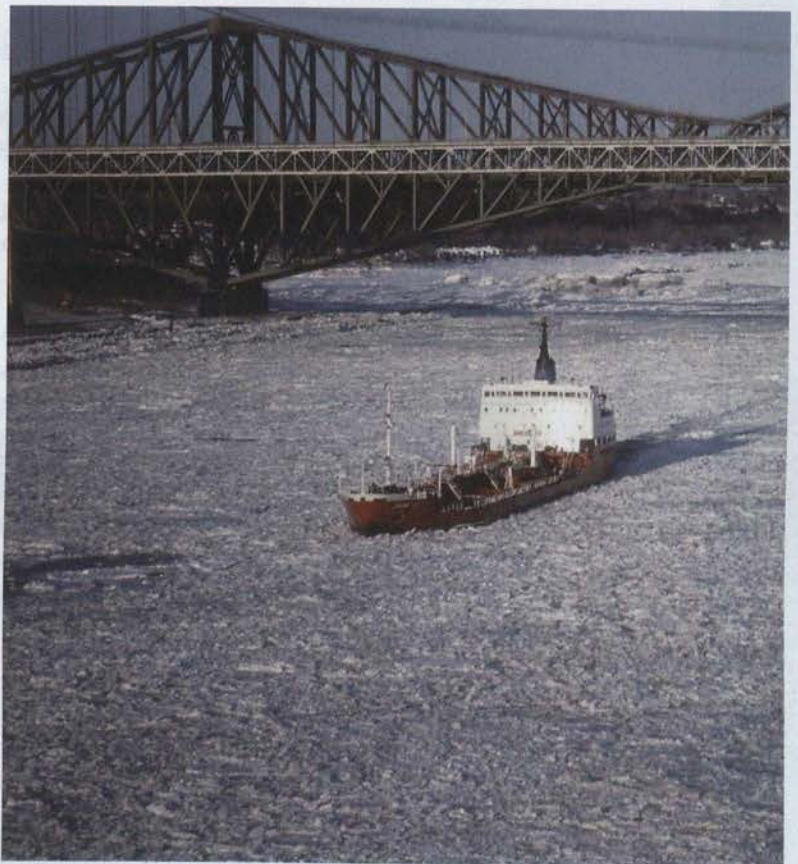
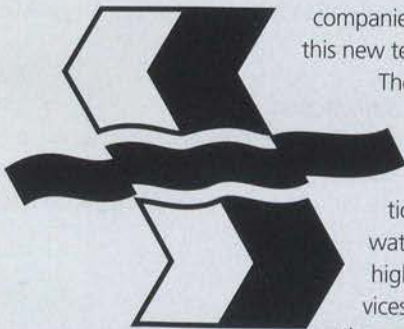


Photo: CHS Archives

FEASIBILITY STUDY FOR QUALITY MANAGEMENT IN CHS



Purpose

This study was conducted to investigate the feasibility of implementing a quality management system (QMS) for the electronic charting function in the Canadian Hydrographic Service (CHS). The study was jointly funded with Industry Canada. Industry Canada's interest in the study involves showing how ISO 9000 registration can help Canadian industry become more competitive and could provide opportunities for introducing international quality requirements in government contract procurement.

Approach

The study followed these steps:

- ISO 9000 awareness seminars were conducted for CHS staff and for a number of contractors involved in some aspects of electronic charting.
- Site visits and discussion groups helped to obtain feedback and data from participants.
- Electronic charting production activities were assessed against ISO 9000 requirements.
- Requirements were identified for implementation of ISO 9000 in CHS.

A number of issues were raised by staff and suppliers. Generally, the response from was very positive.

The options for implementation that were considered involved the functional scope (electronic charting functions), the institutional scope (Headquarters, Regional Offices, Nautical Data International, and suppliers) and the selection of an ISO 9000 model (ISO 9001, 9002 or 9003).

Recommendation

The Study team concluded that the CHS should implement ISO 9001 for CHS electronic charting production, with a functional and institutional scope that covers electronic charting production processes across the board (i.e., covers Headquarters, Regional Offices, Nautical Data International and suppliers). The electronic charting quality management system, once in place, should be registered with an accredited Canadian registration organization.

Advantages

The advantages of introducing an ISO 9000 registered Quality Management System (QMS) include:

Increased Efficiencies

The establishment of a QMS will provide the infrastructure for an improved organization which actively promotes efficiencies in the production processes. The process of documenting procedures will naturally open opportunities for streamlining and integrating existing activities.

Customer Satisfaction

It will assure clients that products are developed, produced and distributed using the best known management practices including standards of operation and quality checks.

Litigation

It will be essential to have a QMS which ensures and proves that state-of-the-art professional practices are in place at all stages of the ENC production process.

Cost Savings

Generally, quality management means doing things right the first time, and that in itself is a saving. However, redundant activities and duplication of efforts are less likely to occur when an appropriate system is followed.

Implementation

It is anticipated that implementation will involve approximately 450 person days of CHS staff time, over an 18 month period.

The first year would be devoted to introducing, developing and implementing the system. The second year would be utilized in pursuing formal registration.

It is preferable to require suppliers, especially software developers, to comply with ISO 9001. The contract review and purchasing elements of a CHS ISO 9000 registration offer benefits to all parties. But the option of supplier registration could be made voluntary, if suppliers are not ready or able to commit to implementation within the same time frame as CHS. However, for manufacturers of the complete ECDIS product, as installed on ships, registration to ISO 9001 would clearly provide the necessary quality assurance needed to achieve market advantages and better defense against litigation.



Photo: CHS Archives

Today's technology and yesterday's data

ANY RISK INVOLVED?

Two CHS hydrographers, Rob Hare and Peter Kielland, answer this question in the following article. According to the authors, when it comes to the marine environment, ships face two main risks—running into another vessel and running aground.... To avoid grounding, ships need to know their position and the depth of water below the keel at all times during their voyage. But what is the probability of grounding one's vessel? The authors contend that mariners assess the following factors—the accuracy of their present position and course-made-good and the accuracy of the bathymetry portrayed by the chart image. In the article, the authors deal with the second factor in risk assessment—the accuracy of the bathymetry or seafloor model presented on paper charts and in electronic charts (ECs).

HOW ACCURATE ARE SEAFLOOR MODELS?

*Rob Hare and
Peter Kielland, CHS*

Depth information is represented by both points and lines on navigational charts. Examples of point data are depth soundings, examples of line data are depth contours. The combination of these two data types is a graphical attempt to represent the shape of a three-dimensional surface—the seafloor or bathymetric surface. The limitations of the traditional paper chart medium make it difficult to represent accurately the true shape of the seafloor.

Today the EC provides far more flexibility for displaying the shape of the seafloor and its spatial uncertainty—if that uncertainty has been estimated. We need to know the horizontal position accuracy of depths as well as the accuracy of the depths themselves. We also need to know the risk that shoals may have been missed between the measured soundings. If the survey was done using a leadline, there is a chance shallower depths exist between any two soundings along the same surveyed line, and an even greater risk that they might exist in the large areas between the sounding lines.

For surveys carried out using echosounders, the depth information obtained along the surveyed line is nearly continuous because the portion of the seafloor which is ensonified is overlapped by adjacent sound pulses. The unsurveyed seafloor between the surveyed lines may still be shallower or deeper. Only multibeam echosounder technology can provide total sea floor coverage and thus eliminate this

uncertainty. However, that technology is still new and very expensive so a complete picture of the seafloor is a not yet available.

So how can we assess the accuracy of the data we have?

We first have to assess the accuracy of the point data, then estimate the chances of a hazard existing where we have not measured. Once this is done, a way must be found to present this information to mariners so they can assess their navigational risks.

Assessing point data

The horizontal accuracy of point data is generally ± 1 mm at survey scale (scale at which data was acquired) 95% of the time—better if digital analytical methods are used to derive the soundings in conjunction with Differential GPS positioning. Even for data collected using older technology, the accuracy remains high. Accuracy suffers, however, whenever documents are manipulated or data transferred such as in the digitizing process. Other errors can be introduced with any human manipulation of the data.

The vertical accuracy of soundings depends on the accuracy of the method used to measure the depths, the tidal information used to reduce the depth to low-water datum, the corrections for the survey vessel draft and squat, correction for the velocity of sound in water, whether vessel heave was removed from the depths by using a heave compensator and other error sources.

In Canada, the standard for depths less than 30 metres shown on charts and field sheets is considered to be ± 0.34 metres 9 times out of 10. Such standards are difficult to meet in offshore areas with-

out the use of heave compensators because of the continuous 1 to 2 metre ocean swells.

In summary there are many factors which can potentially degrade the accuracy of both positions and depths of the soundings used to produce electronic charts (ECs).

What's between the lines?

Contours produced from soundings will be affected by all of the errors discussed above as well as errors due to interpolation where no soundings were taken. Contours are arbitrary two-dimensional representations of the bathymetric surface. The measured depth soundings merely sample this surface at discrete points in space. What is the best depiction of this surface? Ideally we would interpolate a dense grid of depths which models the entire bathymetric surface and at the same time estimate the uncertainty of each of those gridded depths (see figure 1).

CHS is developing a software package which does just that. The software (called "Hydrostat") uses statistically derived information about the roughness of the bottom together with the spacing of the measured soundings to estimate the likelihood of something undetected. The prototype software thus produces not only a gridded model of the seafloor but also estimates of the depth's uncertainty at every point. This "surface of uncertainty" is what we refer to as the seafloor model's "stochastic surface".

Portraying the risk on an EC

The EC's display flexibility and computational capabilities can exploit this information to help mariners to

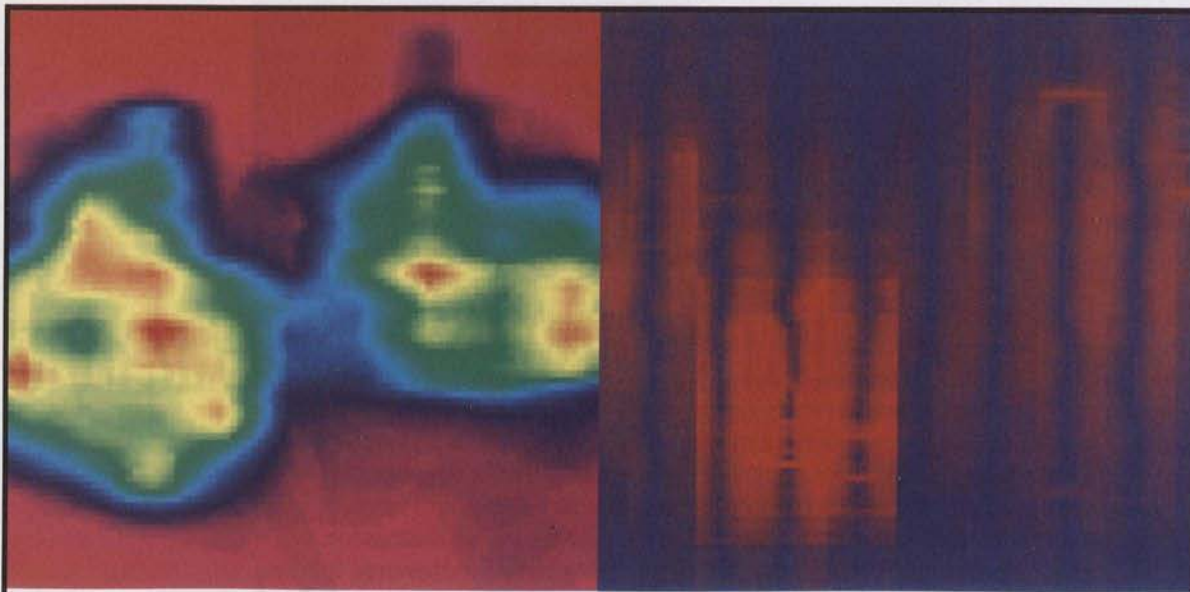


Figure 1

Figure 1 illustrates how this display technique might appear on an EC. The seafloor model of a shoal on the left was gridded by Hydrostat using typical CHS survey data collected using a single beam echo sounder. The colours correspond to depths between 5 and 85 metres. What's really interesting is shown by the image on the right ... the shoal model's stochastic (or error) surface. We can clearly see how confidence in the image is greatest along the sounding tracks and degrades as we move into the interpolated zones between measured profiles. We can also clearly see how the sea floor model is estimated to be much more accurate in the smooth area surrounding the shoal structure than on the much rougher shoal structure itself.

better assess the risk involved in using the bathymetric data. The stochastic surface provides the information needed to display the seafloor plus any errors right on the EC system. There are various display options available to portray this information.

Raster chart images

Many modern electronic charts (ECs) are based on raster chart images. These raster images are "dumb" due to the fact that the value of each pixel in the image represents only the colour of a scanned paper chart. In contrast, Hydrostat estimates actual depths at each pixel site as well as accuracy information about each of these depths. These depth values can be displayed by the EC using a Colour Look Up Table and thus transform the interpolated depth matrix into a 3D

"intelligent" raster image. Location represents 2 dimensions (X,Y) and depth or error provides the 3rd dimension (shown by colour). See figure 1.

There are other display benefits inherent to exploiting a gridded seafloor model within an EC. A mariner could select a colour encoding scheme tailored to the specific navigational task at hand. For example, if a vessel's current draft were 8.6 metres, at the click of a button all points on the display with depths shallower than 8.6 metres could be made red and all points deeper than 8.6 metres could be made green. This would provide a very simplified "go, no-go" EC image based on the user's needs. Alternatively, the user-defined 8.6 metre depth contour could be rapidly computed from the depth

image and drawn over a more conventional chart background.

Another interesting display option might be to apply tidal corrections directly to the computed depth image. The current tidal reduction could easily be subtracted from the value of all grid cells in the displayed depth image. This modified depth image (or any depth contours extracted from it) could thus be animated by the changing tide thus providing a "present real depth" EC display.

Charting uncertainty

We can assess the envelope of uncertainty around the most probable location of the contour by adding the error surface (thereby shoal-biasing the model) or by subtracting the error surface (thereby deep-biasing the model). A thicker envelope indicates greater uncer-

tainty in the seafloor model. These contour envelopes thus provide the mariner with a means to better assess where to steer to avoid grounding.

Figure 2 was computed by Hydrostat using soundings surveyed by CHS at a scale of 1:10000. If those soundings had been of different accuracy and/or different density, the width of the contour envelope would have varied accordingly. Since the width of the envelope is tied directly to the viewing scale selected, survey data cannot be abused by an over-confident navigator. Whether the shoal is viewed at 1:10000 or 1:1,000,000, its inherent depth uncertainty is correctly scaled on the EC display. The image portrays all the spatial information needed to better assess the risks when passing near the shoal it depicts. Current EC capabilities already can warn navigators of impending grounding; by shallow biasing the bathymetric information we add an extra level of insurance.

Interpolated depth images have another useful characteristic for Electronic Charting. By simply pointing on any pixel within the image,

the numerical depth at that location could instantly be displayed (by translating the colour of the pixel back through the Colour Lookup Table to the actual interpolated depth). Another use of this graphical link to the gridded depth data could permit a navigator to lay out a course onto the EC screen and simultaneously view a high resolution depth profile along that track (displayed in another window).

The format of an interpolated depth image also permits it to be viewed as a 3D "wire mesh" model. When animated with DGPS position and heading, this 3D view would simulate the view over the vessel's bow as if the vessel were "flying" above the seafloor. Using the EC of the future could thus become an even more flexible and dynamic experience. These are just some of the exciting possibilities in the near future for ECs.

To risk or not to risk? That is the question

Mariners have at their disposal today a navigational tool more powerful than anything that has existed in the past. The integration

of precise positioning using DGPS with underlying hydrographic digital data in an EC enables the mariner to perform more complicated maneuvers than may have been attempted in the past. The accuracy of the data used to support such maneuvers will depend on the collection methodology used before it was digitized to support the EC.

Among its many capabilities the EC can offer a way to portray the risk associated with depth information throughout the voyage if the survey data has been geostatistically modeled.

Mariners are cautious folk by their very nature however, the pressures of today's competitive marketplace require more risk assessment than ever. To manage those risks without compromising the safety of the crew, the cargo, or damaging the environment, the mariner must know what the level of risk is for any given situation.

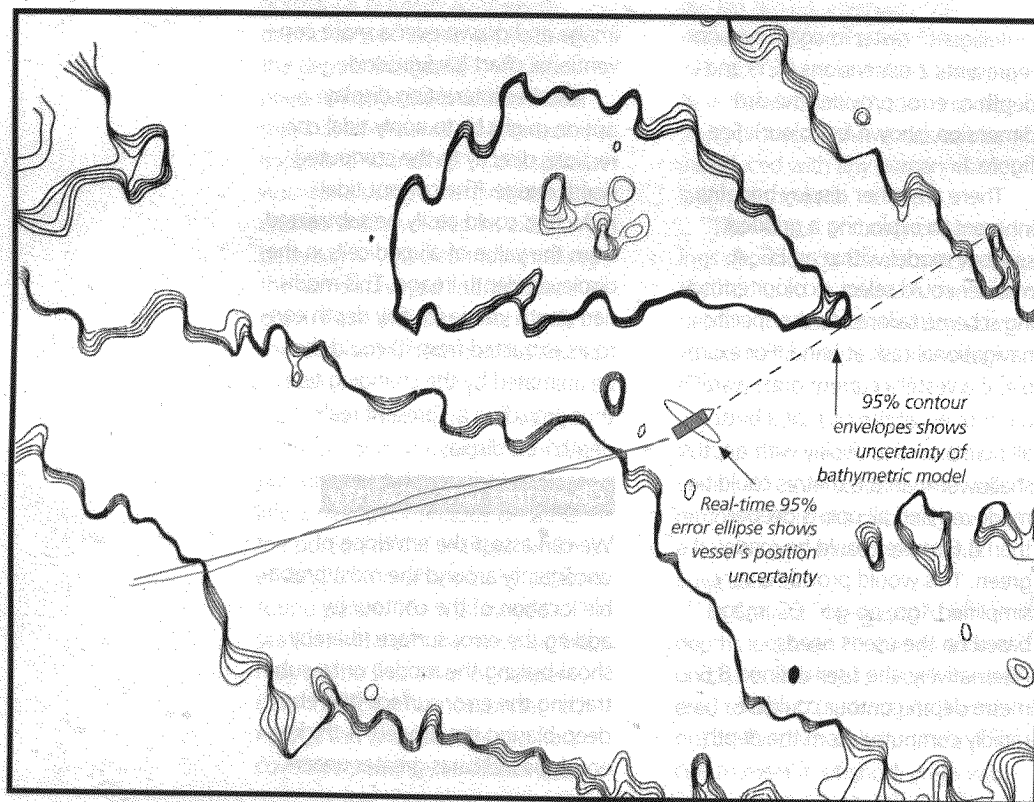


Figure 2
Combining the two data types



FROM SEXTANT TO MULTIBEAM ECHO SOUNDER

Some of the information on today's charts dates back to the British Admiralty surveys performed more than 100 years ago. The technology used then to position depths was the sextant which remained in use until the 1960's. Leadlines were used to measure depths at points along surveyed lines between sextant positions up until the introduction of echo sounders in the 1930's.

Echo sounders enabled continuous depth profiles to be measured directly under the survey vessel's track. This virtually eliminated interpolation errors along the survey vessel tracks however, the zones between the survey lines remained unsurveyed.

Recently multibeam sounders have been introduced which enable whole swaths of acoustic data to be collected on both sides of the vessel tracks. Provided the survey lines are run close together, the sea floor can thus be fully ensonified and all interpolated errors eliminated. It is hoped that eventually multibeam echo sounders will be used for all surveys as they cover 100% of the sea floor. However, these echo sounders are very expensive (CHS

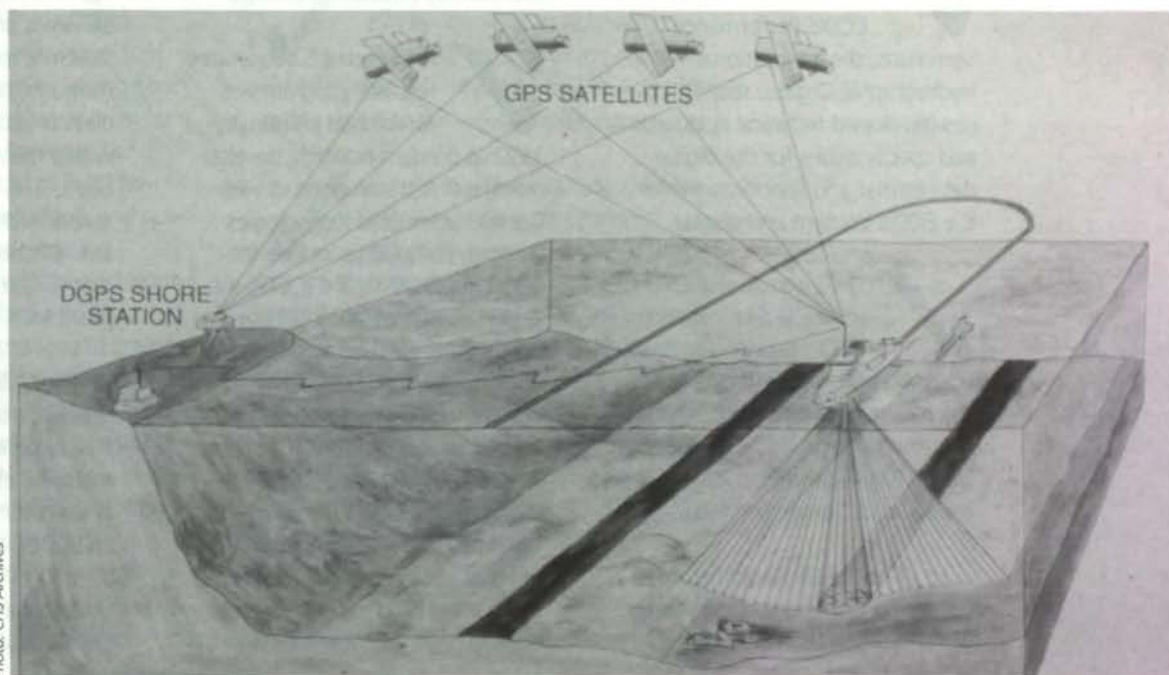
has 5) and only a small percentage of Canadian waters have been surveyed using this technology.

Electronic positioning systems were introduced in the 1960's to position survey launches relative to shore-based horizontal control marks until the 1990's when the Differential Global Positioning System (DGPS) came into being.

Depths were collected in fathoms and feet until Canada changed to the metric system in the 1970's. Much of today's electronic chart data has been converted to metric from older sources.

Most surveys since 1991 have been performed using a horizontal positioning reference frame, compatible with GPS, called North American Datum 1983 (NAD '83). Prior to that, surveys were carried out using NAD'27, a datum more suited to land-based positioning methods for the North American continent only and containing some large regional distortions. Positions obtained on NAD'27 must be converted to NAD'83 for use with GPS.

Field sheets and charts are now being prepared digitally, whether through digitally-collected source material or by digitizing the historic field sheets and charts. But the latter process can introduce additional errors into the digital data.





continued from page 1
ECDIS on course

ing and producing Electronic Chart Display Information systems (ECDIS).

✓ In conjunction with the development of IMO ECDIS Performance Standards, the International Hydrographic Organization (IHO) has developed technical standards and specifications for the digital data format and specifications for the ECDIS content and display.

✓ The International Electrotechnical Commission (IEC) is working to develop type approval specifications for the methods of testing and required test results for an IMO-compliant ECDIS. These specifications are expected by September 1995.

✓ The US Radio Technical Commission for Maritime Services is working to

develop a voluntary, industry-wide standard for an electronic chart system that would supplement the paper chart. The ECS would have to be used with an up-to-date chart from a government authorized HO.

✓ The USCG's evaluation of ECS includes determining the trade-offs between using government HO provided raster data and vector data that is provided by private companies.

✓ A Canada-US cooperative research program was established in February 1992 to conduct research, development, test and evaluation of electronic chart-related technologies. Program participants include the Canadian Coast Guard (CCG), the Canadian Hydrographic Service (CHS); the Coast and Geodetic Survey (C&GS) and, the United States Coast Guard (USCG).

The program, based largely on the CHS Pilot Project, has now expanded into a comprehensive series of at-sea operational trials being conducted onboard commercial and government vessels with the

objective of developing the infrastructure and standards necessary for the safe use of ECDIS as an aid to navigation in North American waters. Vessels in the Great Lakes, Pacific Northwest, St. Lawrence and Maritime coastal waters equipped with ECDIS are demonstrating that it is an aid in grounding and collision avoidance.

Other testing includes the use of marine training centres in British Columbia, Quebec and the Maritimes as well as the the ship-simulator facility at the Centre for Marine Simulation, St. Johns, Newfoundland, to evaluate the human factor aspects of ECDIS design and operation.

✓ Through its Electronic Chart Pilot Project the Canadian Hydrographic Service is providing for the infrastructure required to produce, maintain, disseminate and update electronic charts. In partnership with a manufacturer and a major client, CHS has adopted a pragmatic approach—providing minimum level Electronic Navigation Charts that will be upgraded to IMO-compliant level.

The CHS is also conducting trials related to colours and symbols as well as general issues such as commonality, effectiveness and flexibility in operator control and operation of an ECDIS.

Canada has developed an ENC product specification and has estab-

lished a partnership with Nautical Data International Inc. to market data for raster and vector electronic charts and other GIS applications.

✓ The US National Ocean Service will produce digital raster versions of its nautical charts this year by scanning unscreened black and white film positives of colour separates used in the paper chart process. The raster charts will be individually issued on 3.5" floppy disks and collectively on CD-ROMs for regional coverage using the services of a partner in the private sector.

✓ The US ECDIS Testbed Project administered by the Marine Policy Center of Woods Hole Oceanographic Institution is currently focussed on three main tasks:

- evaluation of the Defense Mapping Agency digital data standard to meet IHO S-52 standards and IMO standards;
- development of additional system functionality for towboat and surveying operations on the lower Mississippi River for the US Army Corps of Engineers; and
- investigation of a number of input formats, user interface procedures and outputs to perform routine updating.

✓ In Germany, the Baltic and North Sea ECDIS testbed project (BANET) is progressing to create a regional database from which ENC's will be produced. Likewise, Norway plans to establish an electronic chart centre as a regional data centre covering the North Sea and the Baltic Sea. Norway is currently establishing cooperative agreements with the Hydrographic Offices (HOs) in the region and is seeking certification to ISO-9000 quality standards. Plans are being made to

expand the US-Canada updating trials to include participation in Germany's BANET Project. In this manner, both European and North American ECDIS manufacturers and vessels will be provided a standardized ENC product. This would facilitate voyages between northern Europe and North America. Involving Norway's ENC is also a possibility as is the possibility of the Japan Maritime Safety Agency participating in the joint US-Canada ECDIS updating trials.

✓ In the United Kingdom, the HO has announced an Admiralty Raster Chart Service to provide digital (raster) CD-ROM versions of Admiralty paper charts and a weekly updating service.

✓ Future initiatives include: developing very large scale charts for manoeuvring and docking; producing high accuracy (GPS-qualified) charts; providing more primary and secondary positioning sensors; overlaying information on ECDIS for ice navigation; integrating related real-time data such as water levels and current flows; integrating ECDIS and vessel traffic service for busy and congested ports; and, outfitting USCG cutters with some combination of ECDIS and ECS.



Photo: CHS Archives

ECDIS RESEARCH AT THE CENTRE FOR MARINE SIMULATION

by Captain Robert Mercer

Evaluation of the findings in the latest series of ECDIS-related studies has now been completed at the Centre for Marine Simulation (CMS) in St. John's, Newfoundland, Canada. Commissioned by the Canadian Hydrographic Service (CHS), this study was conducted under the Electronic Chart Pilot Project. Following collection and analysis of data, a draft report was presented to CHS.



Photo by G. Fox, Marine Institute Public Relations

Captain Mercer reviews the ECPINS 9000 features with project participant Captain Brian O'Neill prior to the start of a simulator run.

The purpose of the study was to replicate and extend the results of Smith, Gonin, et al (1993). One of the specific questions addressed was from a mariner's perspective: Which of three navigation options is optimal: traditional paper charts, ECDIS, or ECDIS with radar overlay? This study extended previous work by making the experimental task more difficult, and involving more traffic and varying visibility conditions.

A number of unique capabilities make CMS's ship simulator ideally suited for this type of research. The simulator consists of a large modern ship's bridge which is mounted on a six-degree of freedom motion platform, and is equipped with state-of-the-industry equipment. It has an extensive capability to realistically reproduce environmental conditions such as wind, waves, current and fog. Added to this is the specific design feature which allows video,

audio and electronic recording of all activities on the bridge. The motion and visual systems combined with realistic environmental effects and advanced modelling techniques for ship models, make the CMS simulator a highly valuable research facility.

An ECPINS 9000 manufactured by Offshore Systems Ltd of Vancouver was the ECDIS system used in this study. CHS provided the system for the duration of the study. The ECPINS 9000 was interfaced to the simulator's radar system to provide radar overlay features and to the positioning systems to provide DGPS simulation. Each of the six mariners who participated in the study all reported that they had no previous experience with ECDIS. Two training sessions were held prior to the start of data collection in order to ensure that the participants were familiar with the ECDIS and other ship's equipment.

Collection of data was accomplished by requiring each participant to execute all of the six prepared scenarios. This provided a total of 36 runs, during and after which data was collected. All six prepared scenarios used the same planned route into Halifax Harbour; however, the traffic patterns were altered in each scenario in order to prevent the participants from anticipating events as each scene developed. In addition to the different traffic situations, each scenario was run using a different combination of navigation option, visibility and weather conditions.

Analysis of the data shows support for the hypothesis that Navigational Performance is improved with the use of ECDIS for route monitoring. Participants stayed closer to the planned track when using ECDIS and even closer still when radar video was superimposed on the ECDIS. Significant differences in closest point of approach while passing target vessels indicates that the participants may have had a better situational awareness in terms of their vessel in relation to

other vessels. An increase in the number of helm orders adds strength to the idea of an increased awareness of position in relation to a planned route.

Examination of the data also indicates a reduction in workload when ECDIS is used as a route monitoring device. As expected, participants reported spending more time on navigation related tasks during paper chart runs. *It is, however, interesting to note that the addition of radar overlay does not appear to have any additional effect on the workload when compared to the effect of ECDIS alone.* This may be due to a number of factors and certainly warrants further investigation.

No significant differences were found for collision avoidance workload. This was evident for both scenario and visibility. It may have been due, in part, to the experimental design, where, in a harbour approach, the inbound and outbound routes are well defined, thus reducing the requirement for collision avoidance action. Future research using similar research design should look specifically at traffic monitoring rather than collision avoidance.

The results of this study have made a significant contribution to the growing body of knowledge related to the human interaction with ECDIS. It is evident from this study and from questions yet unanswered that further research into this new technology is required. Discussions have already started between the Canadian Hydrographic Service and the Centre for Marine Simulation on Phase II of the project. Phase II is scheduled for completion by March 31, 1995, and will build on the results of Phase I as well as address additional areas of concern.

Captain Robert Mercer was the co-ordinator for this project at the Canadian Centre for Marine Simulation.

PILOTS IN TRAINING AT IMQ

by J. Proteau,
Institut maritime du Québec

The Institut maritime du Québec (IMQ) offered pilots of the St. Lawrence a training seminar on integrated electronic navigation last February 15, 16 and 17. Organized in cooperation with the Canadian Hydrographic Service (CHS), the Canadian Coast Guard (CCG) and the Corporation of Pilots of the Central St. Lawrence, this training was provided at Québec City, Trois-Rivières and Montreal. As well as permitting the transfer of knowledge, the training helped this technology make further inroads in the maritime milieu of Québec. More than half of the

Corporation's 120 pilots took part in this first training event.

Training presents a number of challenges—defining the needs, devising a program that responds to those needs in terms of content and teaching materials. This particular training focused on the adoption of new methods of work, and the understanding of new concepts brought about by the introduction of new technology—the electronic chart.

Training in the field of integrated electronic navigation added two new dimensions to deal with: it had to adjust to a developing technology, and it required a body of skills that IMQ has not yet completely mastered.

Adjusting to a developing technology

In addition to acquiring new knowledge and skills, the participants had the opportunity to collaborate in the development of this new technology. Having mastered the system's fundamentals, principles, limits and modes of operation, the participants reported on their experience in using the technology. Their feedback will help us define the parameters of a device to adequately meet the needs of navigation on the river.

That is why the training fell within the context of a research program whose goal was to evaluate the needs related to integrated electronic navigation on the St. Lawrence. Defining the research program as well as the training program in close collaboration with the pilots resulted in a program closely tied to the implementation of the system, and hastened the acceptance of the new technology by the pilots.

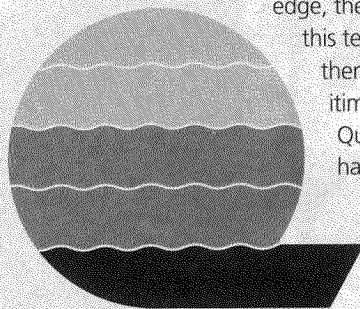
A diverse set of skills

Integrated electronic navigation systems involve the marriage of electronic charts and various kinds of data from the Differential Global Positioning System (DGPS) concerning water levels, weather conditions and other factors within a state-of-the-art information system. It thus requires from its users, a set of skills that they likely have not yet developed. To quickly put in place a complete training program emphasizing the interdependence of the different components of the system, the IMQ had to count on the expertise of the CHS with regard to electronic charts and water levels, and on that

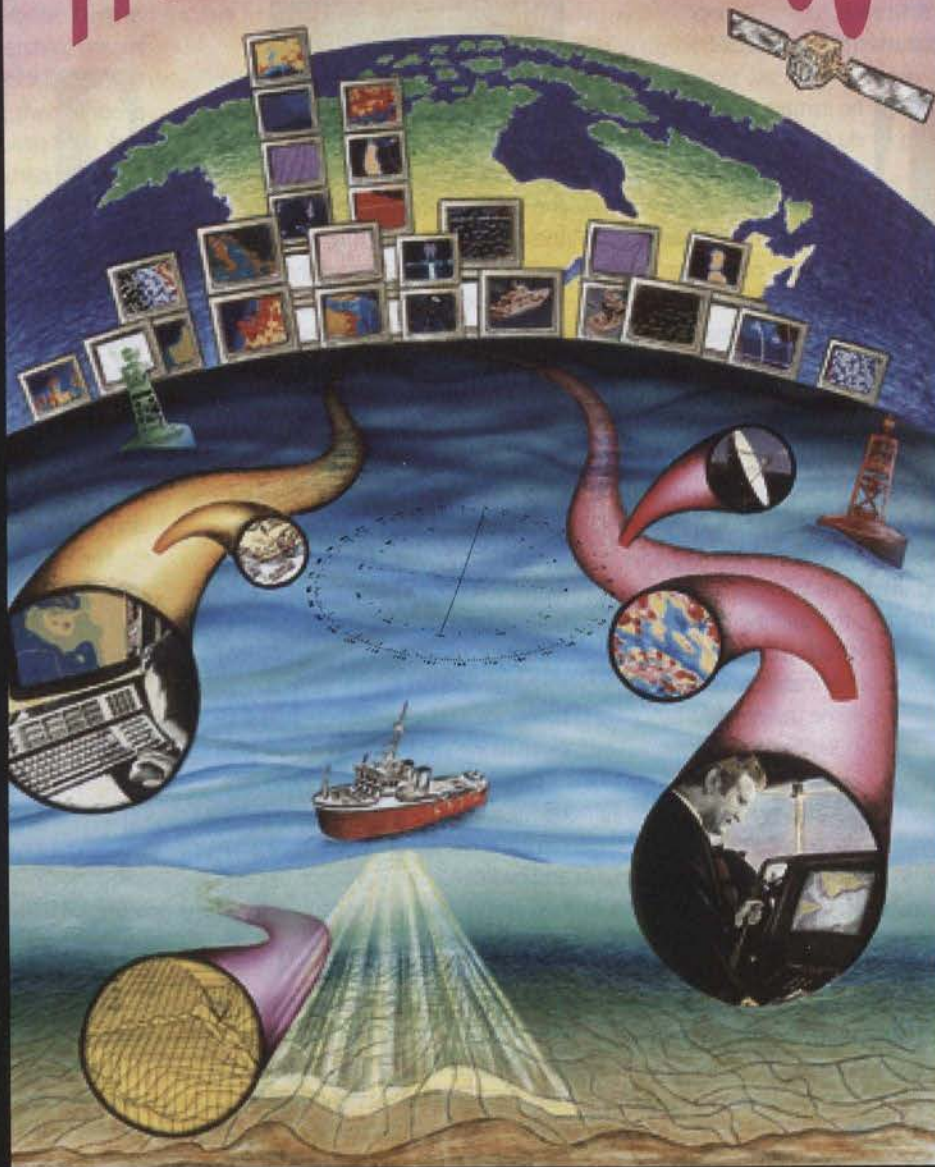
of the Canadian Coast Guard with regard to data from the DGPS. Due to this collaboration, the training program was put together within very tight deadlines. At the same time, the participation of the CHS and the CCG brought them closer to the users and helped sensitize them to the pilots' expectations. In the context of a developing technology, close contact between the various stakeholders is crucial. The success of the training has encouraged the partners to collaborate on more projects in the field of electronic navigation as well as in other domains.

This partnership will be maintained throughout the coming year and even expanded with the participation of new collaborators. Other information and training seminars will be given, the knowledge and skills acquired and the data collected will be put to good use in other projects—perhaps even in the development of a new portable integrated navigational device. Moreover, with the aim of keeping up the momentum at all levels, the IMQ is already studying the possibility of creating a genuinely integrated electronic navigation simulator.

For the IMQ, the marriage of training and technological development constitutes a stimulating challenge. This project is evidence of the IMQ's intent to extend its mission to include applied research through collaboration with its various partners in the maritime community. In fact, this intent has already been translated into action with the completion of some 20 technology transfer projects since 1989. The results attained so far have encouraged us to continue this approach.



HYDROCOMM '95



February 15, 1995

Satellite technology will be used to broadcast the presentations simultaneously to all sites where participants at each site will have a real-time communications link to both speakers and participants at other sites.

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Le 15 février 1995

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CANADIAN COAST GUARD LEADING WITH HIGH STANDARDS

by Fred Forbes

The Canadian Coast Guard was the first fleet user of electronic charts with precise positioning. It's a fact they are proud of and they plan to stay ahead by introducing a radiobeacon—based differential global positioning system (DGPS) navigation service to Canada.

The fully operational GPS space element, to be available in 1995, will comprise 24 satellites in semi-synchronous orbit in six orbital planes. GPS Standard Positioning Service (SPS) will provide worldwide, continuous positioning with a 95% accuracy of 100 meters and a 99.99% accuracy of 300 meters.

DGPS is a regional enhancement that improves navigation and the accuracy of positioning over the standard GPS and increases the integrity of the GPS signals.

Radiobeacons are already used for marine landfall and direction-finding. This coverage generally matches the area of validity of DGPS corrections and the use of existing beacons simplifies the frequency allocation process. And with DGPS receivers now widely available and affordable, their use is expected to increase.

Using CHS' DGPS equipment, Canada's first test transmissions from radiobeacons were initiated on the West Coast in April 1992. Point Atkinson and Race Rocks have been broadcasting ever since. They have proven popular with area mariners and have given exposure to two Calgary companies, Novatel (receivers) and Nortech Surveys (software).

The CCG has since installed 9 more test transmissions as part of an active DGPS test bed project across Canada.

Because these transmissions are not yet monitored as the final production versions will be, they are not to be used in operational situations.

The CCG is presently planning for the implementation of a national marine DGPS service. If funding is received, a system of 25 stations is planned with implementation to start in 1995 and be completed by the end of 1998.

Canadian coverage of DGPS will be prioritized according to traffic volumes and navigation risks. The St. Lawrence Seaway and River to Les Escoumins and major east and west coast ports are the first priority. The second priority stations cover Georgian Bay, more areas on the east and west coasts and the upper St. Lawrence River. Third priority sites include more remote coastal waters and the Gulf of St. Lawrence.

Until the operational system is validated, coverage from each radiobeacon will be defined as the area where the DGPS signal strength is sufficient (probably 75 microvolts/metre). Except in the very noisiest conditions, area users will be able to receive transmissions at much lower signal levels.

The DGPS service is being designed to provide an accuracy of 10 metres or better 95% of the time. All DGPS transmissions will be monitored and controlled by the CCG. The DGPS Integrity Monitor (IM) will monitor numerous parameters including the transmitter power output, the correctness of the DGPS data, GPS geometry and position accuracy. Out-of-tolerance limits will be set within the monitor and alarms and messages to the user and/or the control station will be generated if these limits are exceeded to warn users within 10 seconds of the occurrence.

The Coast Guard have also set themselves a reliability goal of 99.7% which means that a particular station will be on the air and broadcasting proper corrections in any one-month period, at least 99.7% of the time! To ensure that goal is met, there will be complete equipment redundancy and hot backups at every DGPS site as well as overlap between stations.

Fred Forbes, Marine Technical and Support Services Directorate, Canadian Coast Guard, Ottawa

Working seminar on precise navigation systems and electronic charts

The Canadian Shipowners' Association, the Canadian Hydrographic Service and the Canadian Coast Guard are sponsoring a working seminar on Precise navigation and Electronic Charts. This two-day event will be held at the offices of The Port of Montreal on February 1 and 2, 1995.

The three program sessions will cover

- international activities, IMO and IHO activities and developments in Norway
- North American activities, CHS, CCG, NOAA and USCG
- Canadian industry views.

CHANGES IN NAVIGATION NOT NECESSARILY PROGRESS

by Captain John Anderson,
CSS J. P. TULLY

A burning question for a navigator at any time, in any age. Safety at sea is a growing concern, prompted mainly by environmental concerns, people being more aware of environmental degradation and finding it unacceptable.

Where does the risk stem from? The bulk of the world's small craft, fishing boats, work boats etc. pose a negligible hazard to the environment. The risk stems nearly entirely from deep water cargo ships, carrying large quantities of heavy fuel, crude oil and toxic chemicals.

Public concern fuels advancements in safety, but the solution to the problem must be commercially viable if it is to be adopted. The ship owner may have to pay for improved safety; the cost will be passed on to the consignee; but he may also benefit by reduced insurance premiums, so there is a net gain in the public domain.

In the last half century, the main improvements to navigational safety include the echo sounder, Loran, Decca, Omega, satellite systems culminating in GPS. Earlier the D/F and the gyrocompass, and the log made significant contributions.

What was it like before these improvements? Under an overcast, at night, or in poor visibility, navigation was strictly dead-reckoning; for soundings the ship was hove-to and the lead used. In confined waters and fog, frequently the ship was anchored or hove-to until conditions improved. This wasn't the Dark Ages, it was common practice less than fifty years ago, and is of course totally unacceptable in today's business environment.

A great number of technological advances have occurred in shipping, yet still the accidents occur. The IMO has introduced a variety of regulations and standards all intended to improve safety at sea, in every aspect, not just naviga-

tional. The problem however remains, there will always be some accidents.

Concurrent with the technological advances have been drastic reductions in the size of ships' crews and increased use of "Flags of Convenience". Also, more and more, these crews come from whatever nation can supply the cheapest labour, generally poorly educated, frequently unable to converse properly in the language of the officers running the ship—at best, poorly trained, frequently totally inexperienced.

Have traditional practices changed? In my experience, yes they have, and frequently not for the better. The more one relies on instruments the less one tends to make visual checks. Eyes coupled with experience and sound judgement, in my opinion, are the best asset a navigator has. Recently I made a number of trips around the British Columbia coast aboard cargo ships of a variety of nationalities. Not once did I see a Mate take a visual fix. The few fixes taken were a cursory range and bearing by radar. By and large the Mate ensured the Pilot had a reasonably regular supply of coffee, and took very little interest in the progress of the ship, relying entirely on the Pilot. Four years ago for Third Mate I had a young man with a new WKM Cert., an excellent chap. Today, not yet with a Master's Cert., he is Chief Officer of a 40,000 ton cruise ship. I'm sure he will do well, but is it the way things should be? Twenty or thirty years ago such a ship would likely have had two Mates in a watch, a Master's Cert. in each watch, a great deal of accumulated experience. On deck there would have been a larger number of experienced seamen than is the case today.

Electronic aids are undoubtedly wonderful, they are also boring to use, easily breed complacency, and do not involve the watch keeper as deeply in the job as more traditional "hands on" methods.

An what of training? We have STCW, which theoretically has all seafarers trained to the same standards. More and more of the training takes place ashore, the sea time requirements are ever more

lenient, as are the rules governing what qualifies as sea time.

Every maritime disaster produces a crop of statistics, and very predictably human error is at the top of the list for causing the disaster. Of course it is, why shouldn't it be? ships are run by humans, the electronics are no more than aids.

The current philosophy seems to be to throw enough technology at the problem and the problem will go away. Will we ultimately have a wheelhouse full of gadgets with a taylor's dummy in charge? Not very long ago, when a ship dropped the land astern it was an eminently self-sufficient community; modern ships are ever more dependent on the shore and on the "world-wide services of the ABC Electronics Co.". Coupled with the ever smaller crews, ships are less flexible, less able to respond to an emergency of any kind. In any disaster a larger crew can deliver a more versatile response to the emergency that a smaller crew. Ship owners and managers should be more accountable, for the simple fact is modern ships are frequently less able to respond to emergency situations.

As mentioned earlier there is a tremendous volume of legislation aimed at shipping in general, and safety in particular. I am left with the impression that all too frequently it doesn't improve the operation of the ship, but merely is quoted at length after the accident.

There has certainly been a great deal of change in navigation, I'm not sure if it has all been progress though. People run ships, the gadgets are only aids. The IMO and national administrations have a great fascination with technical improvements. The maritime community, and the general public would be better served if existing rules were better enforced, electronics viewed in their proper perspective as just aids, and more emphasis placed on ensuring that highly trained, well educated and experienced people are running today's ships.

Contour

CANADIAN HYDROGRAPHIC SERVICE

WINTER 1994

ENC PRODUCTION: FULL SPEED AHEAD

by Paul N. Holroyd,
Chief, Electronic Charting, CHS

For the Canadian Hydrographic Service (CHS), an organization strongly rooted in the production of traditional paper charts, the last three years have brought about monumental and exciting change. The speed with which the structure and direction of CHS were permanently altered to produce electronic navigation charts (ENCs) underlines CHS's commitment to meeting client requirements.

Much of what exists today is new. And it was done without a model for CHS to imitate. From having no electronic navigation charts three years ago, CHS now has well over 300 ENCs in use on over 30 Electronic Chart Display Information System (ECDIS) installations in Canada alone.

CHS was able to respond quickly to client requirements because of collaboration between its offices across Canada and with industry partners involved in data conversion, marketing and licensing, ECDIS manufacturing, and software consulting. CHS also ensured clients and government organizations such as Canadian Coast Guard, Environment

continued
on page 2



Complex chart display



Simplified chart display



Fisheries
and Oceans

Pêches
et Océans

Canada

continued from page 1

ENC Production

Canada and National Defence have been involved.

National Standards

There are three central standards governing the construction of ENC's.

The first, the *ENC Product Specification*, describes the content of an electronic chart data set. CHS realized that merely digitally replicating paper charts resulted in cluttered ECDIS displays and overburdened ECDIS memory and storage capacity. In order to meet ENC delivery deadlines and yet provide data suited to the needs of clients and the requirements of ECDIS, a review of data requirements was necessary. By consulting with clients and ECDIS manufacturers, the most critical ENC data was identified. This data essentially was the shoreline, channel limits, one bathymetric contour, and navigation aids.

ENC's meeting this absolute minimum content became known as "Level 1" ENC's. Successive visits to the topic of ENC content have broadened this definition substantially, into what became the ENC Product Specification.

The current ENC Product Specification allows CHS to focus on only the most essential data when new ENC's are required to meet tight deadlines, and to digitize more features as time permits. In time, as the inventory of ENC's grows and stabilizes, the content requirements will be standardized and there will be fewer optional data.

The second standard, the *Digital Chart File Standard (DCFS)*, describes the organization of the digital file, including thematic layering, polygon labeling, feature coding and header content.

The third standard is the *Data Model*. The current data model is

the CARIS format and related exchange format, NTX, as well as a derivative called ALL, or ASCII Lat/Long.

CHS as a virtual organization

ENC's are produced nationally by CHS with the work being done by all offices working together, as well as with industry partners. Using network technology, CHS can move an ENC from site to site, right across Canada, in a matter of minutes. The Internet provides many of its business partners equal accessibility.

It starts in the regions

Four regional production teams work with private sector data conversion companies to convert paper chart information into digital form through a combination of raster scanning and vectorization and table digitizing. The method chosen depends on time constraints, available resources and the quality of the source material. In some cases, digital files already exist and these are used in ENC production as well.

The regions perform initial quality control, incorporate the latest Notices to Mariners and build topological data structures to meet the Digital Chart File Standards. The files are then transferred to Ottawa electronically.

Regions also update the digital files on an on-going basis, to reflect Notices to Mariners updates. When a digital file is updated, the whole file is again sent to Ottawa and reprocessed completely. This method, referred to as "brute force updating", is seen as a preliminary technique. CHS is investigating alternative approaches to the entire updating issue.

Ottawa finalizes

To ensure all ENC's produced by CHS are consistent nationally, staff

in Ottawa from the Electronic Charting Division, Quality Control and Services, and the Notices to Mariners section of Nautical Publications and Distribution work as a team.

Files arriving in Ottawa are placed in a digital "in-basket" and entered manually in a "History File" which records the arrival of the ENC, the originator, the dates and types of transactions performed, and a list of clients. When a file arrives, an e-mail message goes out that lets the regional team know that the file was received in Ottawa and that lets the Ottawa team know that a file has arrived for processing.

A quality control check is performed on the file and the results are recorded on a spreadsheet colloquially referred to as a "Report Card". These report cards are sent to the regions and the digital files are repaired either in the region or in Ottawa, depending on the nature of the work required.

Once the ENC has passed the DCFS check, it can be customized. The file resolution is adjusted from 2500 dpi to 250 dpi to better suit ECDIS. This results in smaller files and better ECDIS performance yet with minimal change to the data. Nevertheless, this operation quite often results in errors in polygon topology, so some topological reprocessing and correction is required.

Data superfluous to the ENC Product Specification is stripped out and any insets, continuations and compartments are separated and made into individual ENC's.

After a final check using a non-CARIS PC-based system, final corrections are applied and the ENC then goes through a release procedure.

Just prior to the release process, a unique five-digit product number is assigned to the ENC, in order to



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give these new and unique products their own identity.

During the release procedure, a detailed summary of the contents of the ENC is created, including the geographic and projection parameters of the file, magnetics information, approximate chart accuracy, and the last Notice to Mariners applied to the ENC. There is also a description of each feature found on the ENC, the feature code, an indication of the data type of the feature, the thematic layer the feature belongs to, and an associated depth value, if applicable.

The entire package is then reviewed and formally recommended for release by the respective Chiefs of Electronic Charting, Notices to Mariners, and Quality Control. Approval for release is the responsibility of Director of Marine Cartography and the Dominion Hydrographer.

Once released, the file is available to Nautical Data International (NDI) for licensing and distribution to CHS clients. The ENC is delivered to the client in either binary NTX format or in a simplified version of NTX called ALL, which is in ASCII format with latitude/longitude coordinates.

Longer term

A data management system CIDAS (Compusult Integrated Data Access System) will soon provide a national basis for the management of ENCs and other digital products such as bathymetric maps and raster charts. CIDAS uses ORACLE to manage meta-data, CARIS for graphics operations, and components of the Internet to link CHS sites together. It will automate many of the currently

manual transactions including quality control checking against the DCFS. It will also provide links to other CHS data bases, resulting in better information integration.

Eventually CHS will switch to the IHO standard S-57 format and distribute data in the DX-90 format, based on IHO cells. Development of a CARIS Object Manager is well underway and over 20 ECs have been converted to DX-90 and distributed to two alpha test sites.

Finally, ChartNet is another project CHS and its business partners are undertaking to improve the infrastructure for collaborative production, quality control, licensing and distribution of digital products in a wide area network environment.

PENETRATING THE MARKETS

*Editorial by M.J. Casey,
Chief, System Development, CHS*

December 1994 saw C-MAP, the multinational electronic chart supplier, join forces with Nautical Data International Inc. (NDI), the private sector chart production and distribution partner of the Canadian Hydrographic Services.

This strategic alliance is key to satisfying the growing demand for high quality digital charts for electronic navigation systems. It encompasses all aspects of the market: production and distribution of ENCs, cooperation with Hydrographic Offices, sharing of technology and standardization of electronic chart usage. As part of the agreement, C-Map has acquired an equity position in NDI.

CHS has long recognized that ECDIS is a fundamental breakthrough in navigation safety and efficiency and has re-tooled its organization to be able to respond to any client wanting good data for Canadian waters. CHS sees this private sector alliance as a positive move towards integration of electronic chart services and cooperation between HOs and industry.

The recently announced partnership between C-Map and NDI brings together global distribution and sales networking; expertise in data conversion, data management and benchmarking; access to European and the Pacific Rim markets; exchanges of ideas and information; an international infrastructure for updating; commercial possibilities re large scale data; and greater product diversification.

This latest business arrangement does not alter the original CHS/NDI agreement but builds on that understanding of our mandate from the business perspective including the need for strong partnerships involving CHS staff in the quality analysis and quality control process of ENC production. It bodes well for the future of ENCs and ECDIS.

CHS MAKES CRUISING A PLEASURE



The Yorktown Clipper is a 78-metre vessel, owned by the Clipper Cruise Line which is based in St. Louis, Missouri. It carries a crew of 39 and 138 passengers, and has an average draft of only 8.3 feet allowing close inshore access. When the decision was made to equip the Yorktown Clipper with an ECPINS system from Offshore Systems International, CHS was requested to provide a long list of Canadian and US charts, including the Caribbean.

*by Dave Jackson,
CHS Pacific Region*

The request for charts was first received in CHS Pacific region in January 1994. Had this been an order for paper charts as are most requests, it simply would have been processed. Given, however, that this request was for electronic charts and that these charts were required in four months time, it generated much discussion with the client to refine and supplement the chart list making sure we understood exactly what they needed. This discussion provided the client with a much better understanding of what data was available and the limitations on some of the older data.

Production

A total of 48 charts were required in two batches, the first for May 1

and the second for May 20. Of these, digital files existed for 29 with the other 19 available in hard copy only and needing to be digitized. Given the tight deadlines, it was not possible to complete all charts to the same full content level so another standard was developed defining 3 levels of data content.

Level 1 contains high water, significant low water areas and rocks, a single depth contour, aids to navigation, any other significant navigational dangers and a few geographic names. Level 2 adds more bathymetric and supplemental data. Level 3 reproduces the equivalent paper chart content.

For Level 1 files, production consisted of digitizing, editing, building topology, plotting, checking, applying digital standards, rechecking and then dispatching to HQ for further checking, customizing and forwarding to NDI for distribution. Levels 2 and 3 files required digitizing and editing to update and complete data content before proceeding to topology building, and then following the same steps for Level 1.

The need for people and hardware was a constant problem. At the beginning of the project, only 2 people knew how to build topology - a considerable amount of on the job training was undertaken. The three worktables available were in constant use.

Recurring minor problems were handled in-house by electronic and other technicians.... worn wiring producing a shower of sparks over a work table or another table that had been taken out on board ships and which was causing inaccuracies of 1 to 2 mm.

The combination of tight deadlines and

continued
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LISTENING AND LEARNING

by Julian Goodyear

The following comments are based on a preliminary analysis of ECDIS user responses. A comprehensive review of the pilot project feedback will be featured in the next issue of Contour.

Since September 1992, the Canadian Hydrographic Service Electronic Chart Pilot Project has been a positive vehicle for the development of Electronic Charting technology. Although this was not the beginning of electronic charting for CHS, it marked the beginning of a formal program to put into place the ways and means of supplying the shipping community with the required tools to do their job.

The CHS, in conjunction with the equipment manufacturer and users attempted to test the system in real operational situations in a wide variety of environmental conditions. To date approximately 20 vessels have been included in the study. These include bulk/ore carriers, passenger/vehicle ferries, Coast Guard buoy tender/ice breaker, fisheries surveillance vessel, cruise ships and a petroleum products carrier (tanker).

During the course of the Pilot Project systems were in use on both east and west coasts of Canada and the United States, in the

St. Lawrence River and in the Great Lakes - in all types of weather conditions, areas of dense traffic in harbours, narrow fairways and coastal passages.

Feedback from the Pilot Project was gleaned in several ways including a survey distributed to each of the vessels involved and soliciting information on: 1) vessel bench-

mark information; 2) chart display; 3) system functionality; 4) electronic chart updating; 5) personal history (of user), and, 6) a section for general comments.

Each bridge officer was requested to complete the questionnaire after one-month's use of ECPINS. The vessel's master provided the completed questionnaires to the CHS Pilot Project Officer. As well, the survey was supported by a written report from a company representative (usually a captain).

Feedback from the approximately 200 hands-on users was instrumental in implementing changes along the way. As each system was installed on the various vessels, alterations already included could be reviewed by the next set of users.

Preliminary results indicate that the mariner's level of confidence in the electronic chart system increases with continual use. Early in the project it was necessary to install standard navigating techniques whereby mariners could compare "old and proven" methods to check the information displayed on the system. As one well-seasoned master pointed out, "bridging the leap of faith from parallel rules and dividers to this new technology is an absolute necessity during the transition period".

Initially the user comments pertained mainly to functionality and chart content. At that point in time, the ENC content consisted of all information portrayed on the standard paper chart.

The feedback results were consistent: a full paper chart representation was considered unreadable and in fact most information was considered clutter. It also became apparent early in the program, that by digitizing full paper chart con-

tent, delivery schedules for ENCs could not be met. With the help of working mariners we were able to focus on the minimum real content data set needed and by omitting information traditional to the paper chart, such as topographic contours, social details of cities, railway junction lines, and any detail not observable from sea, a tremendous efficiency was achieved.

The working strategy became "give the user the basic data they need right now and fill in incrementally to meet the growing, still largely undefined, longer-term user need".

The number one concern for mariners using any electronic chart system appears to be a comprehensive passage planning utility. Over and over we heard of shortcomings in voyage planning that mariners considered essential for enroute monitoring. Although progress was made during the initial phase of the pilot project, a flexible, user-friendly, all encompassing passage planning routine still requires considerable consultation between system manufacturer and mariner.

Approximately 80% of the vessels involved had radar overlay installed on the system. Feedback on this function indicated that less than 5% used the radar overlay for collision avoidance, however 50% of the users used it as a check on positioning. Also, the majority of users indicated that radar echo definition needs to be improved and that ARPA-type information on ECDIS would be very useful.

Once underway with ECDIS, bridge officers considered Course Made Good information to be the most critical navigation information, combined with the ability of

continued
on page 6

Continued from page 2

Listening and learning

the system to enlarge chart data. For the first time, mariners have the ability to manipulate chart data. For data providers such as CHS, this means two new demands have to be met: 1) display options and 2) customized views. Feedback is clear, mariners want large scale information for docking and maneuvering. In case after case, unhindered by machinery constraints, mariners zoom in naturally to a scale of approximately 1:500.

Continued from page 4

CHS makes cruising a pleasure

lack of experience in raster scanning supported the use of tried and true technologies so we pressed on. Two charts were raster scanned and although the results were positive, the many fitting problems caused delays.

On the other hand, the topology building process was greatly accelerated by developing some command files driven by a batch menu and this meant that the project was completed on time. The command files string together a lot of topology programs which saved a

lot of time and running them in batch overnight eased demands on the central processing unit.

A multi-disciplinary team of 8 people, including field and cartographic staff, worked on the project for 4 months and they were given priority for use of the digitizing table, computer terminal, photo-mechanical and other resources.

Questions for the future

Some charts used in the production of ENC's are old. One chart used was drawn in 1945 and is based, in part, on even earlier surveys. Merely digitizing this data is not good enough. Issues such as resurveying or adjusting the positional accuracy of existing field data, recompiling it and digitizing it to produce more

accurate chart data are all becoming critical to the production of digital data for use with highly accurate positioning systems.

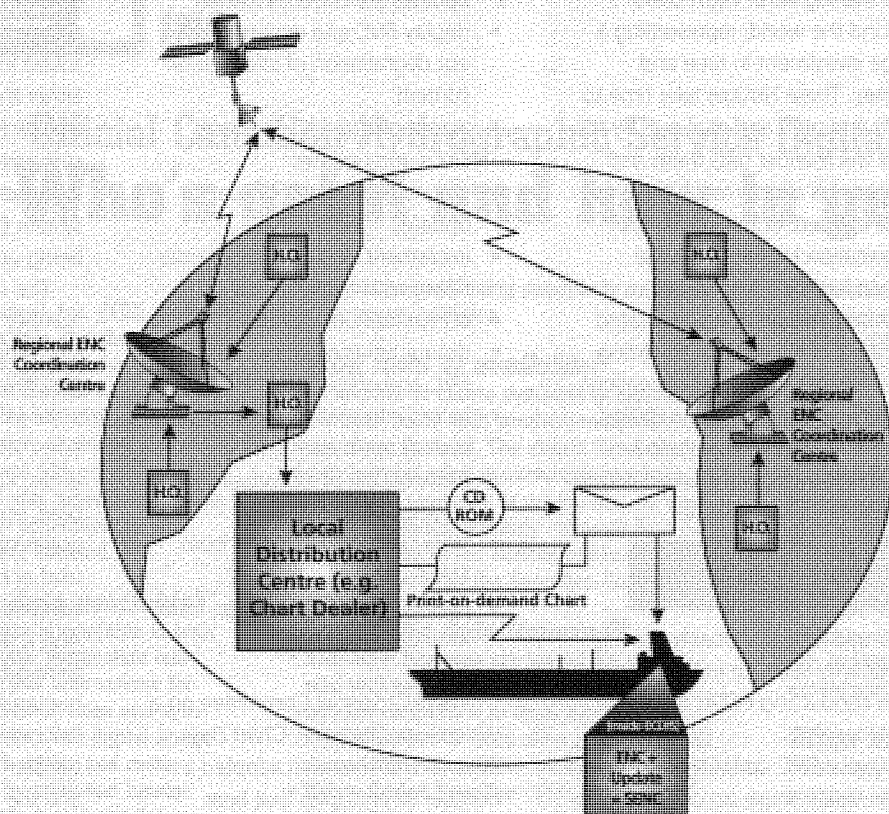
When high priority projects such as this one cause reallocation of people and other resources, its impact is felt throughout the organization. In this case, reprints and reruns of paper charts had to be produced instead of new editions. A fully integrated chart production program that produces both ENC's and paper products simultaneously is anticipated.

Julian Goodyear is an Electronic Chart Pilot Project Officer, CHS.

The CHS leads the world in ENC production. The cost of being a pioneer has been high, but everyone agrees it has all been worthwhile and, because of this, the CHS is in a good position to face the next set of challenges.

International Conference on Maritime Law and the Electronic Chart

The NOAA's Coast and Geodetic Survey and the Maritime Law Center of Tulane University will host the 2nd International Conference on Maritime Law and the Electronic Chart in New Orleans, March 12-14, 1995.



Updating charts

HIGH PRIORITY FOR ALL HOS

by S. Grant and M. Casey, CHS

First the paper...

Updates, chart corrections, hand amendments, notices - they are all part of keeping charts up to date. Broadly speaking, this is done in just two ways. Either the owner does it personally or the charts are purchased fully up to date. CHS' policy has been the same for decades. With the exception of pleasure craft charts, only up-to-date charts are shipped. Each chart is individually hand corrected to be up to date to the latest Notice to Mariners. No reliable way has ever been found to automate this process. The alternative is for each owner to hand correct his own chart. Many ship owners see this approach as advantageous because the charts are on board faster, enriched with personal or proprietary information, and the personnel are available to do the corrections - "the curse of the Third Mate".

It's considered a curse because the task involves sorting through past notices to extract the ones relevant to their particular voyage, deciding on what changes and how, and then doing them. It is laborious and error prone and not too many people enjoy it.

*Illustration:
A simplified
Worldwide
Chart Data
base system*

Notices to Mariners are also expensive. In Canada, 14,000 Notices are mailed every two weeks to a mailing list of chart users around the world, representing a huge investment in time and money. These Notices take time to draft and print and mail out. By the time the mariner gets them and updates his charts, much time may have elapsed. In this age of the Information Highway, people expect faster performance.

Many people view automated updating and ECDIS as heralding that new era - no hand corrections, no mail outs, error-free updating, short time delays, automated, hands-off transparent updates delivered to the ship en route.

And now the electronic chart...

ENC updating is probably the highest priority issue for most countries now conducting ECDIS tests and developments.

Digital ENC updating is expected to be faster, more accurate and less time consuming for the mariner. In addition to the Notices to Mariners referred to above, there are additional updating services such as Radio Navigational Warnings, Notices to Shipping, and supplementary services such as the United States' Navigation Information Network (NAVINFONET). NAVINFONET is digital but the data can be printed only so although it is more easily accessible via telephone link by ships at sea using INMARSAT, it is still equivalent to a printed notice.

For ECDIS users, it is important to note that bandwidth has already been allocated on INMARSAT's Enhanced Group Call (EGC) SafetyNet facilities for ENC updates, thereby opening the door to a worldwide ENC updating capability.

Both the International Hydrographic Organization (IHO) and the International Maritime Organization (IMO) have established specifications and performance standards for the updating characteristics ECDIS and ENCs should have. They should :

- facilitate simple and reliable updating
- enable assurance that ENC and updates are correctly loaded
- display ENC and updates without degradation of information content
- accept official IHO standards ENCs and updates
- automatically apply official updates
- implement update without interfering with display in use
- accept manual updates
- distinguish manual updates from ENC and official updates
- record information about updates such as application time, etc.
- allow review of individual official updates on demand
- store updates separately from ENCs
- distinguish official updates from local updates

The IHO Special Committee on a Worldwide Electronic Chart Data Base (WEND) has also adopted a number of principles that bear directly on ENC updating. They call for the establishment of technically and economically effective updating solutions. They want the hydrographic offices providing the source data to be responsible for ensuring that issuing agencies are advised of update information in a timely manner and that issuing agencies provide timely ENC updates to the mariner. As well, the updating information should be available worldwide with member states being responsible for the preparation and provision of digital data (including updates) for all waters of national jurisdiction.

This Committee also adopted a regional centre concept for the management and dissemination of ENCs and updates. (see chart on page 7).

The *IHO Guidance on Updating* the ENC identifies six entities involved in the process: the originator of navigational information (the source provider, usually an HO); the issuing authority (the regional ENC coordinating centre under the

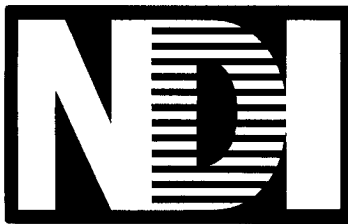
WEND model); the distributor who packages and disseminates updates to all users or a group of users; the receiver, usually the mariner onboard ship or via telecom receiver linked to the ECDIS; the applier, either the mariner keying in the update information or the ECDIS software processing the update information; and the SENC (or the system ENC), the ECDIS data base being used for navigation.

The *Guidance* also looks at a number of features of ENC updating. What media will be used to display the update information, what is the efficiency of update operations, security of transfer procedures, validity of the updated data base, etc.. It describes three categories of updating service — scheduled at regular intervals, on demand, and emergency service. And it discusses manual updating, semi-automatic updating requiring human intervention to establish the link between the media used to transfer information and the ECDIS, and the fully-automatic updating where the update reaches the ECDIS directly from the distributor without human intervention.

ENC updates are also grouped according to how they aggregate the information. Sequential updates contain only new corrections since the previous update. Cumulative updates contain all the individual sequential updates since the last new edition of the ENC. Compilation updates are like the cumulative updates except that all the individual updates are compiled into a single all-inclusive ENC update.

The *Guidance* also offers specific guidance to the Hydrographic Office, the Issuing Authority, the Distributor, the ECDIS Manufacturer and the User to define a minimum capability for updating the ENC. The roles and responsibilities of the various players are described and a wealth of detailed guidance is given.

The report shows how complex ENC updating is going to be - from the technical aspects of producing,



**NAUTICAL
DATA
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Official Canadian Hydrographic Service Digital Data Who's got it and how to get it.

Who's got it?

Nautical Data International, Inc. (NDI), a private sector firm, is the sole distributor and licensor of digital data products for the Canadian Hydrographic Service (CHS). NDI coordinates the licensing and delivery of data products to a wide variety of clients in the electronic navigation and GIS communities around the world. NDI also assists the CHS in establishing production schedules for new products, based on client demand.

In what form is data available?

Digital hydrographic data is available in both vector and raster formats. Vector data consists of positional data and instructions for the construction of polygons, lines and symbols. Raster data consists of a digital image of the paper chart. Both vector and raster data are accompanied by plain-text header files containing complete descriptive information about the content and organization of the data product.

- **Vector data** is produced in **NTX format** (compatible with the CARIS system developed by Universal Systems Ltd. of Fredericton, New Brunswick). NTX data can also be exported in **ASCII Lat/Long (ALL) format**, **DXF**, **SIF**, **DLG**, **COGIF**, **PIP** and **TRAN**. Note that DXF, SIF, DLG, SIF, COGIF, PIP and TRAN data will not contain the full symbology of the original NTX file. In the near future CHS ENC data will be produced in **DX-90/S-57** format to conform to international standards. NDI can assist you in converting data to suit a wide variety of commercial GIS systems.

- **Raster data** is produced in **interim Hydrographic Standard Raster Product (iHSRP)** format consisting of an ASCII text file header and a raster image corrected to the appropriate chart projection. The preferred raster image format (e.g. **TIFF**, **BMP**, **WMF**, etc.) may be selected at the client's discretion. Raster data is produced at a resolution of 254 dots per inch.

How do we deliver?

The data products can be delivered in a wide variety of physical formats, including floppy disk, DAT and other tape formats, CD-ROM, etc. Data can also be delivered via InterNet to clients with InterNet sites or accounts. Due to the large size of many data files, the files are

often compressed using commonly available compression software.

What data is available?

The number of charts available is increasing on a daily basis, with production scheduled to meet client demand. The charts listed further down indicate what is currently available and what is currently in production. As they become available, officially released data sets are also listed in the Notices to Mariners published regularly by the Canadian Coast Guard.

How is the data licensed?

- **End-user licences** are issued for clients who will use the data in-house, and who will not circulate it to third parties. This type of licence is most often granted to GIS users with a specific in-house application.
- **Value-Added Reseller (VAR)** licences are most often issued to manufacturers of Electronic Chart Systems who wish to convert the data for use with their systems and distribute the data to end-users.
- **Experimental licences** are most often granted to clients who wish to test data for new or unusual applications, and who agree not to distribute the data product.

How can vector data be used in common GIS systems?

Vector data in NTX format can be used directly with the CARIS GIS system, and in other systems with appropriate conversion routines. Vector data in ALL format can be used with systems accepting ASCII Lat/Long data. Vector DXF files can be used with most common GIS systems, although the symbology of the file is not maintained. Please note that vector DXF data files cannot be loaded directly into AutoCad unless a dummy shape table is constructed. CHS vector digital data will soon be available in DX-90/S-57 format.

How is data made available for electronic chart system end-users?

There are over seventy manufacturers of EC and ECDIS systems world-wide, and most systems use proprietary data formats, media and software systems. This makes it impossible for NDI to package and distribute data to the EC end-user. End-users, including recreational boaters and commercial users, should contact the manufacturer of their system for

information on obtaining official CHS digital chart products. The manufacturer should then contact NDI for information and sample data for conversion to their proprietary format.

What if the data is not available in digital form?

In cases where digital data is not available, but analog data exists in the form of field sheets or paper charts, it is possible to negotiate an agreement whereby the end user or a contractor can digitize the data to CHS specifications. Digitizing agreements are undertaken between the end user and the CHS. NDI can facilitate the negotiation of a digitizing agreement.

What does CHS/NDI data cost?

Costs vary because digital hydrographic data exists in standard and customized forms. It is the policy of NDI and the CHS to maintain data pricing as low as possible to facilitate growth of the user community. Contact NDI to determine the cost of licensing the data you need.

To place an order or get more information?

Call NDI: **1-800-563-0634** (Canada)

or **1-709-576-0634**

Fax: **1-709-576-0636**

Internet: info@ndi.nf.ca

Be prepared to provide the following information:

- **ENC reference number or CHS chart numbers;**
- **your intended use of the product;**
- **the digital format you require;**
- **the media format and method for delivery; and,**
- **invoicing information.**

You will then be issued a licence based on the intended use. On return of the signed licence and a purchase order, the data product will be shipped to you.

NDI Products List

January 31, 1995

| Paper Chart Ref. No. | TITLE | ENC No. | Paper Chart Ref. No. | TITLE | ENC No. |
|-------------------------------|--|---------|----------------------|---|---------|
| Vector charts released | | | | | |
| 1221 | Pointe de Moisie à/to Île du Grand Caouis | 79028 | 3711 | St. John Harbour | 70041 |
| 1226 | Baie-Comeau | 79048 | 3728 | Milbanke Sound and approaches/et les approches | 70044 |
| 1226 | Quais/Wharves Cargill-Reynolds | 79050 | 3738 | Sarah Island to Swanson Bay | 70047 |
| 1226 | Île aux Oeufs - Mouillages/Anchorages | 79052 | 3738 | Sarah Island to Swanson Bay - Heikish Narrows Inset | 70048 |
| 1233 | Cap aux Oies à/to Sault-au-Cochon | 79021 | 3739 | Swanson Bay to/à Work Island | 70049 |
| 1233 | Saint-Joseph-de-la-Rive | 79022 | 3740 | Work Island to/à Point Cumming | 70051 |
| 1233 | Saint-Jean-Port-Joli | 79024 | 3741 | Otter Passage to Bonilla Island | 70052 |
| 1234 | Cap de la tête au chien à/to Cap aux Oies | 79029 | 3742 | Otter Passage to McKay Reach | 70065 |
| 1234 | Port de Gros-Cacouna | 79030 | 3747 | Browning Entrance | 70055 |
| 1234 | Pointe de la Rivière du Loup | 79031 | 3772 | Grenville Channel - Sainty Point to Ormiston Point | 70056 |
| 1234 | Pointe-au-Pic | 79032 | 3772 | Grenville Channel - Baker Inlet Entrance | 70057 |
| 1234 | Saint-Simeon | 79033 | 3772 | Grenville Channel - Ormiston Point to Baker Inlet | 70129 |
| 1234 | Cap-à-Laigle | 79034 | 3773 | Grenville Channel - Baker Inlet to/à Ogden Channel | 70058 |
| 1235 | Pointe au Boisvert à/to Cap de la tête au chien | 79035 | 3785 | Namu Harbour to Dryad Point | 70059 |
| 1235 | Escoumins | 79036 | 3785 | Kliktoati Harbour Inset | 70060 |
| 1236 | Pointe des Monts aux/to Escoumins | 79037 | 3785 | Namu Harbour Inset | 70061 |
| 1236 | Godbout | 79038 | 3934 | Approches to/ approches à Smith Sound and/et Rivers Inlet | 70131 |
| 1236 | Baie Verte | 79039 | 3934 | Darby Channel | 70132 |
| 1236 | Matane | 79040 | 4001 | Gulf of Maine to/à Strait of Belle Isle including/y compris Gulf of St. Lawrence/Golfe du Saint-Laurent | 76030 |
| 1236 | Rimouski, Point-au-Père | 79041 | 4011 | Approches to/approches à Bay of Fundy - Northeast Portion/Partie Nord-Est | 76019 |
| 1310 | Port de Montréal - Repentigny à/to Montréal-Est | 79001 | 4024 | Baie des Chaleurs aux/to Îles de la Madeleine | 79075 |
| 1310 | Quai Alexandra | 79002 | 4025 | Cap Whittle à/to Havre-Saint-Pierre et/and Île d'Anticosti | 79043 |
| 1310 | Port de Montréal - Montréal-Est à/to Pont Victoria | 79080 | 4026 | Havre-Saint-Pierre et/and Cap des Rosiers à/to Pointe des Monts | 79044 |
| 1310 | Cap-Rouge à/to Saint-Romuald-d'Etchemin | 79081 | 4045 | Sable Island Bank/Banc d'Île de Sable to/au St. Pierre Bank/Banc de St-Pierre | 76090 |
| 1313 | Batiscan au/to Lac Saint-Pierre | 79014 | 4047 | St. Pierre Bank to Whale Bank/Banc de Saint-Pierre au Banc de la Baleine | 76091 |
| 1313 | Port de Trois-Rivières | 79015 | 4114 | Campobello Island | 76033 |
| 1313 | Port de Bécancour | 79016 | 4114 | Eastport Harbour | 76034 |
| 1314 | Donnacona à/to Batiscan | 79017 | 4116 | Dipper Harbour | 76012 |
| 1315 | Québec à/to Donnacona | 79020 | 4116 | Musquash Harbour | 76013 |
| 1316 | Port de Québec | 79003 | 4118 | St. Mary's Bay | 76024 |
| 1317 | Sault-au-Cochon à/to Québec | 79025 | 4118 | Meteghan | 76025 |
| 1317 | Québec à/to Beauport et/and Saint-Michel | 79082 | 4118 | East Sandy Cove | 76026 |
| 1337 | Lac Saint-Pierre | 79009 | 4118 | Grand Passage | 76027 |
| 1338 | Lac Saint-Pierre à/to Lavaltrie | 79010 | 4118 | Petit Passage | 76028 |
| 1338 | Port de Sorel | 79011 | 4118 | Waymouth | 76029 |
| 1338 | Lanoraie | 79012 | 4124 | Petite Passage, Letang Harbour, and/et Black's Harbour | 76022 |
| 1339 | Lavaltrie à/to Longue-Pointe | 79013 | 4124 | Seal Cove and approaches/et les approches | 76023 |
| 1409 | Canal de la Rive Sud | 79042 | 4201 | Halifax Harbour - Bedford Basin | 76001 |
| 2257 | Clapperton Island to/à John Island | 73044 | 4202 | Ocean Terminals | 76004 |
| 2299 | Clapperton Bay to/à Meldrum Bay | 73059 | 4203 | Halifax Harbour - Black Point to/à Point Pleasant | 76002 |
| 2310 | Caribou Island to/à Michipicoten Island | 73087 | 4227 | Country Harbour to/au Ship Harbour | 76061 |
| 3419 | Esquimalt Harbour | 70138 | 4237 | Approches to/approches à Halifax Harbour | 76009 |
| 3481 | Approches to/approches à Vancouver Harbour | 70072 | 4237 | Sambro | 76010 |
| 3490 | Sand Heads to/à Tilbury Island | 70015 | 4429 | Havre-Saint-Pierre et les approches/and approches | 79004 |
| 3490 | Tilbury Island to/à Douglas Island | 70128 | 4429 | Havre-Saint-Pierre | 79005 |
| 3493 | Vancouver Harbour - Western Portion/Partie Ouest | 70073 | 4432 | Îles de Mingan | 79026 |
| 3494 | Vancouver Harbour - Central Portion/Partie Centrale | 70123 | 4845 | Renews Harbour to/à Motion Bay | 76070 |
| 3494 | Second Narrows | 70124 | 4845 | Bay Bulls and/et Witless Bay | 76071 |
| 3499 | Roberts Bank | 70002 | 4845 | Lumley Cove | 76072 |
| 3539 | Discovery Passage | 70017 | 4845 | Fermeuse Harbour | 76073 |
| 3543 | Cordero Channel | 70019 | 4920 | Petit Rocher Wharf | 76267 |
| 3543 | Dent and/et Yuculta Rapids | 70020 | 4920 | Quai/Wharf Belledune | 76268 |
| 3543 | Greene Point Rapids | 70021 | 4920 | Shippegan Harbour | 76269 |
| 3543 | Haydon Bay to Cooper Reach | 70133 | 4920 | Bathurst Harbour | 76270 |
| 3544 | Johnstone Strait - Race Passage and/et Current Passage | 70022 | 4954 | Chenal du Havre de la Grande Entrée | 79084 |
| 3544 | Topaze Harbour | 70023 | 4954 | Quai/Wharf Mines Seleine | 79085 |
| 3546 | Broughton Strait | 70025 | | | |
| 3546 | Alert Bay | 70026 | | | |
| 3546 | Port McNeil | 70027 | | | |
| 3547 | Queen Charlotte Strait - Eastern Portion/Partie Est | 70028 | | | |
| 3548 | Queen Charlotte Strait - Central Portion/Partie Centrale | 70031 | | | |
| 3548 | Blunden Harbour | 70032 | | | |
| 3548 | Port Hardy | 70033 | | | |
| 3549 | Queen Charlotte Strait - Western Portion/Partie Ouest | 70034 | | | |
| 3550 | Approches to Belize Inlet | 70036 | | | |
| 3711 | Jackson Narrows | 70037 | | | |
| 3711 | Coghlan Anchorage | 70038 | | | |
| 3711 | Klemtu Passage | 70039 | | | |
| 3711 | Nowish Cove | 70040 | | | |
| Raster charts released | | | | | |
| Paper Chart Ref. Number | TITLE | Scale | | | |
| 3481 R/M | Approches to/approches à Vancouver Harbour | 25000 | | | |
| 3494 R/M | Vancouver Harbour - Central Portion/Partie Centrale | 10000 | | | |
| 1412 R/M | Lac Saint-François - Partie Est/Eastern Portion | 25000 | | | |
| 1436 R/M | Whaleback Shoal to/au Summerland Group | 25000 | | | |
| 1437 R/M | Summerland Group to/à Grindstone Island | 25000 | | | |
| 1439 R/M | Carleton Island to/au Charity Shoal | 30000 | | | |
| 2011 R/M | Belleville Harbour | 6000 | | | |
| 2017 R/M | Kingston Harbour and approaches/et les approches | 15000 | | | |
| 2055 R/M | Frenchman's Bay | 10000 | | | |
| 2165 R/M | Wheatley Harbour | 4000 | | | |

| Paper Chart Ref. Number | TITLE | Scale |
|-------------------------|---|-----------------|
| 3441 R/M | Haro Strait, Boundary Pass and/et Satellite Channel | 40000 |
| 3463 R/M | Strait of Georgia - Southern Portion/Partie Sud | 80000 |
| 3512 R/M | Strait of Georgia - Central Portion/Partie Centrale | 80000 |
| 3513 R/M | Strait of Georgia - Northern Portion/Partie Nord | 80000 |
| 3717 R/M | Approaches to/approches à Skeena River | 25000 |
| 3526 R/M | Howe Sound | 40000 |
| 3540 R/M | Approaches to/ approches à Campbell River | 10000 |
| 3745 R/M | Gardner Canal | 73050 |
| 3809 R/M | Carpenter Bay to/à Burnaby Island | 37500 |
| 3865 R/M | Englefield Bay and Vicinity | Various/variées |
| 3960 R/M | Approaches to/approches à Portland Inlet | 40000 |
| 4201 R/M | Halifax Harbour - Bedford Basin | 10000 |
| 4202 R/M | Halifax Harbour - Black Point to/à Point Pleasant | 10000 |
| 4529 R/M | Fogo Harbour, Seal Cove and approaches | Various/variées |

Vector charts in production

| | | |
|------|--|--|
| 1411 | Canal de Beauharnois - Lac Saint-Louis au/to Lac Saint-François | |
| 1412 | Lac Saint-François - Partie Est/Eastern Portion | |
| 1413 | Lake St. Francis/Lac Saint-François - Western Portion/Partie Ouest | |
| 1414 | Lake St. Lawrence - Eastern Portion/Partie Est | |
| 1415 | Lake St. Lawrence - Western Portion/Partie Ouest | |
| 1416 | Iroquois Lock to/à Prescott | |
| 1417 | Prescott to/à McDonald Point | |
| 1436 | Whaleback Shoal to/au Summerland Group | |
| 1437 | Summerland Group to/à Grindstone Island | |
| 1438 | Grindstone Island to/à Carleton Island | |
| 1439 | Carleton Island to/au Charity Shoal | |
| 2000 | Lake Ontario/Lac Ontario | |
| 2006 | Upper Gap to/à Telegraph Narrows | |
| 2011 | Belleville Harbour | |
| 2017 | Kingston Harbour and approaches/et les approches | |
| 2018 | Lower Gap to Adolphus Reach | |
| 2042 | Welland Canal - St. Catharines to/à Port Colborne | |
| 2043 | Lower Niagara River and approaches | |
| 2048 | Port Credit | |
| 2058 | Cobourg to Oshawa | |
| 2060 | Main Duck Island to/à Scotch Bonnet Island | |
| 2061 | Scotch Bonnet Island to/à Cobourg | |
| 2064 | Kingston to/à False Duck Islands | |
| 2067 | Hamilton Harbour | |
| 2077 | Lake Ontario/Lac Ontario - Western Portion/Partie Ouest | |
| 2085 | Toronto Harbour and approaches/et les approches | |
| 2086 | Lake Ontario - Toronto to/à Hamilton | |
| 2100 | Lake Erie/Lac Érie | |
| 2110 | Lake Erie - Long Point Bay | |
| 2120 | Niagara River to/à Long Point | |
| 2121 | Long Point to/à Port Glasgow | |
| 2122 | Pointe aux Pins to/à Point Pelee | |
| 2123 | Pelee Passage to/à la Detroit River | |
| 2200 | Lake Huron/Lac Huron | |
| 2201 | Georgian Bay/Baie Georgienne | |
| 2221 | Harbours in/Havres dans Georgian Bay - Midland Harbour | |
| 2225 | Approaches to/approches à Parry Sound | |
| 2228 | Lake Huron - Southern Portion | |
| 2235 | Cape Hurd to/à Lonely Island | |
| 2239 | Port Severn to/à Hope Island | |
| 2243 | Batean Island to/à Byng Inlet | |
| 2244 | Alexander Passage to/à Beaverstone Bay | |
| 2245 | Beaverstone Bay to/à Lonely Island and/et McGregor Bay | |
| 2250 | Bruce Mines to/à Sugar Island | |
| 2251 | Meldrum Bay to/à St. Joseph Island | |
| 2258 | Bayfield Sound and approaches/et les approches | |
| 2259 | John Island to Blind River | |
| 2273 | South Baymouth Harbour and approaches | |
| 2274 | Cape Hurd to Tobermory and Cove Island | |
| 2282 | Cape Rich to/à Cabot Head | |
| 2284 | Parry Sound and approaches | |
| 2286 | Georgian Bay to Clapperton Island | |
| 2289 | Giants Tomb Island to/à Lone Rock | |
| 2291 | Goderich to/à Chantry Island | |
| 2292 | Chantry Island to Cove Island | |
| 2297 | Duck Islands to de Tour Passage | |
| 2298 | Cove Island to Duck Islands | |
| 2300 | Lake Superior | |
| 2301 | Passage Island to/à Thunder Bay | |
| 2302 | St. Ignace Island to/à Passage Island | |

| Chart Ref. No. | TITLE | Scale |
|----------------|---|-------|
| 2303 | Jackfish Bay to St. Ignace Island (to be cancelled by NC 2334 and 2335) | |
| 2304 | Oiseau Bay to Jackfish Bay | |
| 2307 | Coppermine Point to Cape Gargantua | |
| 2308 | Michipicoten Island to Oiseau Bay | |
| 3440 | Race Rocks to/à d'Arcy Island | |
| 3441 | Haro Strait | |
| 3442 | North Pender Island to/à Thetis Island | |
| 3443 | Thetis Island to/à Nanaimo | |
| 3473 | Active Pass | |
| 3476 | Approaches to/approches à Tsehum Harbour | |
| 3495 | Vancouver Harbour - Eastern Portion/Partie Est | |
| 3513 | Strait of Georgia - Northern Portion/Partie Nord | |
| 3526 | Howe Sound | |
| 3545 | Johnstone Strait - Western Portion/Partie Ouest | |
| 3679 | Quatsino Sound | |
| 3720 | Idol Point to Ocean Falls | |
| 3727 | Cape Calvert to Goose Island Including Fitz Hugh Sound | |
| 3734 | Jorkins Point to/à Sarah Island | |
| 3743 | Douglas Channel | |
| 3746 | Petrel Channel and approaches/et les approches | |
| 3902 | Hecate Strait | |
| 3955 | Plans - Prince Rupert Harbour | |
| 3956 | Malacca Passage to/à Bell Passage | |
| 3957 | Approaches to/approches à Prince Rupert Harbour | |
| 3958 | Prince Rupert Harbour | |
| 3959 | Hudson Bay Passage | |
| 3960 | Approaches to/approches à Portland Inlet | |
| 3964 | Tuck Inlet | |
| 4006 | Newfoundland/Terre-Neuve to/à Bermuda | |
| 4117 | Saint John Harbour and approaches/et les approches | |
| 4210 | Cape Sable to/à Pubnico Harbour | |
| 4233 | Cape Canso to/à Country Island | |
| 4240 | Liverpool Harbour to/à Lockeport Harbour | |
| 4241 | Lockeport to/à Cape Sable | |
| 4244 | Wedgeport and Vicinity/et les Abords | |
| 4846 | Motion Bay to/à Cape St. Francis | |
| 4906 | West Point à/to Baie de Tracadie | |

Raster charts in production

| Paper Chart Ref. No. | TITLE | Scale |
|----------------------|---|-----------------|
| 1202 | Cap Éternite à/to Saint-Fulgence | 37500 |
| 1209 | Rivière Saguenay - Saint-Fulgence à/to Rivière Shipshaw | 18000 |
| 1223 | Chenal du Bic et les approches/and approaches | 24000 |
| 1229 | Plans - Péninsule de Gaspé | Various/variées |
| 1411 | Canal de Beauharnois - Lac Saint-Louis au/to Lac Saint-François | 25000 |
| 1414 | Lake St. Lawrence - Eastern Portion/Partie Est | 25000 |
| 1438 | Grindstone Island to/à Carleton Island | 25000 |
| 2000 | Lake Ontario/Lac Ontario | 400000 |
| 2006 | Upper Gap to/à Telegraph Narrows | 30000 |
| 2007 | Belleville to/à Telegraph Narrows | 30000 |
| 2018 | Lower Gap to Adolphus Reach | 30000 |
| 2043 | Lower Niagara River and approaches | 20000 |
| 2048 | Port Credit | 5000 |
| 2049 | Whitby Harbour | 5000 |
| 2050 | Oshawa Harbour | 5000 |
| 2053 | Port Hope Harbour | 5000 |
| 2054 | Cobourg Harbour | 5000 |
| 2058 | Cobourg to Oshawa | 72400 |
| 2060 | Main Duck Island to/à Scotch Bonnet Island | 77700 |
| 2061 | Scotch Bonnet Island to/à Cobourg | 73240 |
| 2064 | Kingston to/à False Duck Islands | 61528 |
| 2067 | Hamilton Harbour | 12000 |
| 2069 | Bay of Quinte - Picton to/à Presqu'île Bay | 60588 |
| 2077 | Lake Ontario/Lac Ontario - Western Portion/Partie Ouest | 100000 |
| 2086 | Lake Ontario - Toronto to/à Hamilton | 50000 |
| 2100 | Lake Erie/Lac Érie | 400000 |
| 2110 | Lake Erie - Long Point Bay | 50000 |
| 2120 | Niagara River to/à Long Point | 120000 |
| 2121 | Long Point to/à Port Glasgow | 100000 |
| 2122 | Pointe aux Pins to/à Point Pelee | 100000 |
| 2123 | Pelee Passage to/à la Detroit River | 100000 |
| 2181 | Harbours in Lake Erie/Havres dans le Lac Érie | Various/variées |
| 2200 | Lake Huron/Lac Huron | 400000 |
| 2228 | Lake Huron - Southern Portion | 120000 |

| Paper Chart Ref. No. | TITLE | Scale | Paper Chart Ref. No. | TITLE | Scale |
|----------------------|--|-----------------|----------------------|---|-----------------|
| 2260 | Lake Huron/Lac Huron - Sarnia to/à Bayfield (to be replaced by 2260-C) | 80000 | 3857 | Louscoone Inlet | 18257 |
| 2261 | Lake Huron/Lac Huron - Bayfield to/à Douglas Point | 80000 | 3858 | Flamingo Inlet | 18247 |
| 3000 | Juan de Fuca Strait to/à Dixon Entrance | 1250000 | 3859 | Tasu Sound | 24340 |
| 3001 | Vancouver Island - Juan de Fuca Strait to Queen Charlotte Sound | 525000 | 3860 | Harbours on the west coast of Graham Island | Various/variées |
| 3424 | Approaches to/approches à - Oak Bay | 10000 | 3863 | Port Chanal | 18258 |
| 3440 | Race Rocks to/à d'Arcy Island | 40000 | 3864 | Gowgaia Bay | 18254 |
| 3441 | Haro Strait, Boundary Pass and/et Satellite Channel | 40000 | 3865 | Englefield Bay and Vicinity | 36600 |
| 3442 | North Pander Island to/à Thetis Island | 40000 | 3932 | Rivers Inlet | 40000 |
| 3443 | Thetis Island to/à Nanaimo | 40000 | 3933 | Portland Canal and/et Observatory Inlet | 80000 |
| 3461 | Juan de Fuca Strait - Eastern Portion/Partie Est | 80000 | 3962 | Mathieson Channel - Northern Portion/Partie Nord | 40000 |
| 3473 | Active Pass, Porlier Pass and/et Montague Harbour | Various/variées | 3964 | Tuck Inlet | 20000 |
| 3490 | Fraser River/Fluve Fraser - Sand Heads to/à Douglas Island | 20000 | 4002 | Golfe du Saint-Laurent/Gulf of St. Lawrence | 750000 |
| 3491 | Fraser River/Fluve Fraser - North Arm | 20000 | 4016 | Saint-Pierre to St. John's | 350000 |
| 3493 | Vancouver Harbour - Western Portion/Partie Ouest | 10000 | 4023 | Northumberland Strait | 300000 |
| 3495 | Vancouver Harbour - Eastern Portion/Partie Est | 10000 | 4025 | Cape Whittle à/to Havre-Saint-Pierre et/and Ile d'Anticosti | 300000 |
| 3499 | Roberts Bank | 15000 | 4117 | Saint John Harbour and approaches/et les approches | 15000 |
| 3513 | Strait of Georgia - Northern Portion/Partie Nord | 80000 | 4202 | Halifax Harbour - Point Pleasant to/à Bedford Basin | 10000 |
| 3514 | Jervis Inlet | 50000 | 4203 | Halifax Harbour - Black Point to/à Point Pleasant | 10000 |
| 3526 | Howe Sound | 40000 | 4230 | Little Hope Island to/à Cape St. Mary's | 150000 |
| 3534 | Plans - Howe Sound | Various/variées | 4237 | Approaches to/approches au Halifax Harbour | 40000 |
| 3535 | Plans - Malaspina Strait | Various/variées | 4306 | Strait of Canso and/et Southern approaches/les approches Sud | 25000 |
| 3536 | Plans - Strait of Georgia | Various/variées | 4307 | Canso Harbour to Strait of Canso | 37500 |
| 3538 | Desolation Sound and/et Sutil Channel | 40000 | 4308 | St. Peters Bay to Strait of Canso | 37500 |
| 3539 | Discovery Passage | 40000 | 4320 | Egg Island to West Ironbound Island | 145000 |
| 3540 | Approaches to/approches à Campbell River | 10000 | 4374 | Red Point to Guyon Island | 74474 |
| 3541 | Approaches to/approches à Toba Inlet | 40000 | 4375 | Guyon Island to Flint Island | 75733 |
| 3543 | Cordero Channel | 40000 | 4416 | Havre de Gaspé | 12000 |
| 3544 | Johnstone Strait - Race Passage and/et Current Passage | 25000 | 4451 | Îles-de-la-Madeleine | 110655 |
| 3545 | Johnstone Strait - Western Portion/Partie Ouest | 40000 | 4462 | St. George's Bay | 75200 |
| 3546 | Broughton Strait | 40000 | 4485 | Cap des Rosiers à/to Chandler | 75000 |
| 3547 | Queen Charlotte Strait - Eastern Portion/Partie Est | 40000 | 4520 | Orange Bay to Cape Bonavista | 286000 |
| 3549 | Queen Charlotte Strait - Western Portion/Partie Ouest | 40000 | 4523 | Little Bay Arm and approaches, Beaver Cove Head to Goudies Cove | Various/variées |
| 3550 | Approaches to/approches à Seymour Inlet and/et Belize Inlet | 40000 | 4524 | Botwood Harbour | 9000 |
| 3555 | Plans - Vicinity of/Proximité de - Redonda Islands - and/et - Loughborough Inlet | Various/variées | 4526 | Lewisporte | 9000 |
| 3559 | Malaspina Inlet, Okeover Inlet and/et Lancelot Inlet | 12000 | 4529 | Fogo Harbour, Seal Cove and approaches | Various/variées |
| 3602 | Approaches to/approches à Juan de Fuca Strait | 150000 | 4530 | Hamilton Sound - Eastern Portion/Partie Est | 40000 |
| 3606 | Juan de Fuca Strait | 110000 | 4531 | Carmarville to Bacalhao Island and Fogo | 40000 |
| 3625 | Scott Islands | 80000 | 4535 | Greenspond Island to Cape Freels | 25000 |
| 3640 | Clayoquot Sound, Lennard I. to Estevan Pt. | 77500 | 4536 | Valleyfield Harbour and approaches | 10000 |
| 3648 | Clayoquot Sound - Northwest Portion/Partie Nord-Ouest | 36488 | 4545 | Smith and Random Sounds - Eastern Part | 36000 |
| 3651 | Scouler Entrance and/et Kyuquot | Various/variées | 4548 | Plans on the east coast of Newfoundland | Various/variées |
| 3662 | Nootka Sound to/à Esperanza Inlet | 75000 | 4560 | Indian Bay to Wadham Islands | 75000 |
| 3664 | Nootka Sound | 40000 | 4569 | Cape Bonavista | 25000 |
| 3671 | Barkley Sound | 40000 | 4578 | Clarenceville and approaches | 12000 |
| 3682 | Kyuquot Sound | 36676 | 4582 | Plans in Notre Dame Bay | Various/variées |
| 3711 | Plans - Vicinity of/Proximité de Princess Royal Island | Various/variées | 4585 | Green Head to Little Bay Island | Various/variées |
| 3719 | Inlets in Campania and Princess Royal Islands | Various/variées | 4591 | Pilly's Island Harbour - Halls Bay and Sunday Cove | Various/variées |
| 3724 | Caamano Sound and approaches/et les approches | 71594 | 4592 | Little Bay Island to League Rock | 24400 |
| 3727 | Cape Calvert to Goose Island Including Fitz Hugh Sound | 73584 | 4593 | Sunday Cove Island to Thimble Ticks | 24500 |
| 3728 | Milbanke Sound and approaches/et les approches | 76557 | 4594 | Thimble Ticks to Bagg Head Including New Bay | Various/variées |
| 3736 | Kitimat and/et Kemano Bay | 12000 | 4595 | Bay of Exploits - Sheet I (North) | 24500 |
| 3737 | Loredo Channel including/y compris Loredo Inlet and/et Surf Inlet | 77429 | 4596 | Bay of Exploits - Sheet II (Middle) | 24600 |
| 3739 | Swanson Bay to/à Work Island | 35574 | 4597 | Bay of Exploits - Sheet III (South) | 24600 |
| 3740 | Work Island to/à Point Cumming | 35467 | 4598 | Bay of Exploits - Sheet IV (Northeast) | 24650 |
| 3741 | Otter Passage to Bonilla Island | 72860 | 4599 | Bay of Exploits - Sheet V (Southeast) | 24600 |
| 3743 | Douglas Channel | 73032 | 4617 | Newfoundland-Placentia Bay - Red Island to Pinchgut Point | 37500 |
| 3746 | Petrel Channel and approaches/et les approches | 39070 | 4619 | Presque Harbour to Bar Haven Island and Paradise Sound | 37500 |
| 3753 | Plans in the Vicinity of Pitt and Banks Islands | Various/variées | 4817 | Bay Bulls to/à St. Mary's Bay | 150000 |
| 3772 | Grenville Channel - Saintry Point to Baker Inlet | 36225 | 4846 | Motion Bay to/à Cape St. Francis | 60000 |
| 3781 | Dean Channel - Cousins Inlet to Elcho Harbour | 36507 | 4848 | Holyrood and/et Long Pond | Various/variées |
| 3784 | Kwakshua Channel to/à Spider Island and/et Namu Harbour | 36760 | 4951 | Îles-de-la-Madeleine - Partie Sud/South Portion | 60000 |
| 3794 | Portland Canal - Stewart | 12000 | 4952 | Îles-de-la-Madeleine - Partie Nord/Northern Portion | 60000 |
| 3807 | Atli Inlet to Selwyn Inlet | 37500 | 4954 | Chenal du Havre de la Grande-Entrée | 15000 |
| 3808 | Juan Perez Sound | 37500 | 4955 | Havre-aux-Maisons | 10000 |
| 3811 | Harbours in Queen Charlotte Islands | Various/variées | 4956 | Cap-aux-Meules | 10000 |
| 3854 | Tasu Sound to/à Port Louis | 141935 | 4957 | Havre-Aubert | 10000 |
| 3855 | Houston Stewart Channel | 20000 | 4980 | Blanc-Sablon | 15000 |

Natural Resource maps released (1.250)

14928, 14938, 14948, 14954, 14956, 14958, 14962, 14964, 14966, 14968, 14972, 14974, 14976, 14978, 14982, 14984, 14986, 14988, 14996, 14998, 15020, 15030, 15032, 15038, 15040, 15042, 15046, 15050, 15052, 15054, 15056, 15062, 15064, 15066, 15070, 15072, 15074, 15080, 15082, 15777, 15779, 15783, 15785, 15787, 15789, 15792, 15794, 15796, 15798, 15881, 15890, 15892, 15894, 18508, 18518, 18600, 19304, 19306, 19308, 19316, 19318, 19326, 19328, 19338, 19400, 19402, 19404, 19406, 19410, 19412, 19414, 19416, 19418, 19420, 19422, 19424, 19426, 19428, 19430, 19432, 19434, 19436, 19438, 19440, 19442, 19444, 19446, 19448.

Example of the IHO General Guidance for manufacturers

Data Integrity

The ECDIS should be able to process ENC updates without degradation of the information content of the ENC or ENC update. For example, all information regarding attributes, logical relationships, geometry and topology must be accounted for.

Verification of Application

The ECDIS should provide a method to ensure that updates have been correctly applied to the SENC. Those updates are either integrated into the SENC display or are a temporary layer of information that was entered manually.

Integrated/Non-integrated Updates Distinction

Updates should be clearly distinguishable on the display. Once accepted, integrated updates should be indistinguishable from the ENC data. Non-integrated updates (e.g. those entered manually) should be orange. It should be possible on demand to review a previously installed update.

Storage Separation

ECDIS should store all updates separately from the ENC.

Recall for Display

It should be possible to display selectively any previously accepted integrated Update Set which has been applied to the current ENC Edition of Data in the SENC.

Compatibility

ENC updates will comply with the ENC product specification to be developed by the IHO.

Non interference

ECDIS should be able to receive updates without interfering with its current operation.

Log file

ECDIS should keep a record of updates, including time of application and identification parameters (i.e. set, cell, and individual update number) through a logfile. The logfile should contain, for each update applied to or rejected by the SENC, the following information:

- date and time of application/rejection;
- complete identification number of update which includes: identification of Issuing Authority, sequence number of Update Set, Cell Identifier, Edition number of ENC involved, Update Sequence Number within the Cell;
- any anomalies encountered during application;
- type of application: manual/ automatic.

Update out of Sequence

The ECDIS should warn the user when an update is out of sequence. Provision should be made to allow updates to be applied even if out of sequence.

disseminating and incorporating the updates and keeping track of all the administrative details to the organizational infrastructure needed to ensure that a ship anywhere in the world can obtain updates for its ENC.

ENC updating experience and planned activities

ENC updates via INMARSAT Standard C, cellular and land based telephone have been successfully used in several projects such as the Canadian ECDIS Testbed; the North Sea Project and the Seatrans Project in Norway; the Hamburg Ferry ECDIS Testbed in Germany; the Netherlands ECDIS Project; the US ECDIS Test and Evaluation Program; and the CHS Electronic Chart Infrastructure Program.

Some technical details warrant evaluation. Software packages for generating official IHO data format have only recently become available and updating experience will be needed to ensure no deficiencies exist.

Canada, Germany, Japan, Norway and the United States have agreed to exchange data sets and ENC update data to tighten up the standard. Other countries have also agreed to exchange ENC update data sets and to test the update process in the laboratory and at sea. Questions regarding the size of the updating data files for different types of updates, the effect of data compression techniques and the contribution of new emerging technologies are also being studied.

A promising new process used by the software industry to update its customers' application software is the "Binary Patch". Its update data file is small and applicable to both software and data. Tests are being carried out to determine any drawbacks and to ensure IMO and IHO requirements are met.

Canada

Canada is committed to the creation of the infrastructure, data and standards to routinely support

ECDIS by 1997. A specific project to build, by March 1996, a prototype infrastructure for keeping ENC's up to date, was started in April 1994. The project is looking closely at infrastructure and quality issues, the requirements of the various stakeholders and the products, systems, procedures needed to meet national and international standards. Alternative ENC updating methods are being evaluated and several sea trials have been scheduled. This work is being done in close cooperation with the United States, and in the near future, Germany and Japan. In 1995, Canada will report on major Infrastructure Issues and HO/CG/User Requirements; look at the communications and protocols surrounding the distribution of updates on land and at sea, in both scheduled and on demand modes; investigate the use of binary patch technology and if possible, incorporate it into the updating infrastructure; and, lay the groundwork for a preliminary updating infrastructure based on IHO specifications.

Germany

Germany has been gaining experience from ECDIS research and development for 8 years. At present the Baltic and North Sea ECDIS Testbed (BANET) project is managed by the Shiphandling and Ship Simulation Facility (SUSAN) in Hamburg, with Germany's Federal Maritime and Hydrographic Agency (BSH) and the Hydrographic Offices of Finland, Sweden, Denmark (Baltic Sea area) as well as Netherlands and the UK (North Sea). The project data base, composed of the data contributions of the participating HOs, is operational and will be used for producing ECDIS updates. ECDIS equipment has been installed onboard the ferry "Finnjet" and will be installed onboard the ferry "Hamburg" for sea tests, including updating. The IHO Data Transfer Standard will be used for updating and for all other data exchange. It is planned, after completion of BANET in mid 1995, to continue updating

experiments at sea onboard a BSH research vessel including tests using INMARSAT C/EGC.

Japan

Japan plans to publish its ENC before March 1995 and is now assessing the necessity of specially designed printed Notices to Mariners for manual updates; the practicality and reliability of semi-automatic updates (e.g. floppy disk) by means of Feature Updating; and updating via telephone and/or satellite links.

Norway

Norway has been actively involved with all aspects of ECDIS for many years. The first INMARSAT Standard C Electronic Chart update messages were sent from Norway to the research vessel "Lance" during the North Sea Project and were applied, fully automatically, to the SENC within the Canadian EC Testbed that was onboard. The Electronic Chart Centre in Stavanger is currently establishing a North-European data-base service in a joint effort with the North-European Hydrographic Offices. An updating service is a vital part of the technology developed to support this service. Norway plans to establish one of the first Regional ENC Coordinating Centres for North Europe by 1996.

United States

The United States ECDIS Test and Evaluation Program, a four-year effort jointly managed by the US Coast Guard (USCG) and the Coast and Geodetic Survey of the NOAA, is closely coordinated with similar work in Canada and other countries. Most recently, the USCG, with participation from NOAA, conducted sea trials on updating an ENC. Manual and automatic updates were successfully demonstrated at sea using IHO data. Other tests planned for the fall will look at infrastructure planning for the US to support ENC updating and investigation into the "Binary Patch"

update method. In 1995, the USCG will conduct a feasibility study to determine if, and to what extent, the USCG Aids to Navigation (ATON) Database is capable of supporting ENC updating requirements for Local Notice to Mariners (LNTM). It will also develop an engineering tool to investigate the capabilities and limitation of various IHO standards for ECDIS.

Conclusion

Although a number of lower level technical issues still need to be resolved, the results to date indicate that ECDIS updating requirements as set forth in the IMO Performance Standard for ECDIS are achievable and continued international cooperation will minimize the delay.

OCEANS OF EXPERIENCES



Ross Douglas retired December 31, 1994, as Dominion Hydrographer of the Canadian Hydrographic Service. He was Dominion Hydrographer from 1987 to 1994. Contour is proud to present to its readers a last interview with Ross Douglas as DH.

As Head of the Canadian Hydrographic Service (CHS), Ross Douglas has been in the thick of changes most of us just hear or read about... A government organization providing an underpinning to safe navigation for the very busy and lucrative shipping industry, recreational boating market, and national defence — the CHS has been driven by quality and innovation in its products and managing its

accountability to the public.

"This has meant effecting change inside the organization — by helping Government share our vision and by continually building a committed and flexible work force. CHS has always had a very strong role in bringing about change inside the system — perhaps being so close to our clients has forced us to stay on the leading edge and find ways of helping the bureaucracy respond to Canadians needs. Effecting change outside the organization has meant building partnerships, alliances, and staying in touch with clients."

During his tenure Mr. Douglas has retooled CHS, helped Canadian businesses compete globally, outsourced traditional in-house services, introduced new concepts

such as just-in-time training and formed strategic alliances with other countries and key partners that make CHS a world leader in hydrography.

In the last few years alone we have witnessed a world in which the shipping and boating sectors have gone from a total reliance on paper charts to embracing electronic charts and many other digital data based products. This has forced a disproportionate need for change in a very condensed time frame.

"The biggest challenge has been to change the mindset," explains Douglas. "With paper charts, we provided a static product but when technology took over, we had to provide a dynamic product line —

continued on page 12

CHS and Government Policy



Oceans of experiences

clients now define and redefine what they want, giving us specifications for products to suit their needs".

"As soon as we became a data organization, we had to change, and that of

course raised a lot of different issues for us such as converting all our analogue data to digital formats, and inspiring an even more flexible work force at the very time of immense change in the public service." We saw many opportunities...

Skills mix important

"The first issue was skills. Between 1989 -90, we assessed all our people and undertook a training program to move the basic skill set from the two distinct groups of cartographers and field surveyors to a more flexible and effective group of hydrographers. It cost a lot and meant only urgent work was done but it paid off in spades.

"We were gearing up for changes we anticipated having to meet by the year 2000 but in 1993-94, all of a sudden, we had a crisis. There was an urgency for electronic charts but most of our data could not be used in black boxes. Mariners want to call up information in seconds, they want to plan

their route with it, they want large scale data for docking, they want integrated radar information, they want simplified data, supplemented with non-traditional (to charts) information and they want it customized too.

Meeting client needs

"It was our partnership with Canada Steamship Lines (CSL) that really got us going. They had new electronic chart systems and needed data fast. While CSL was very accommodating and agreed to use rudimentary data, it soon became a win-win situation for them as well as for our the pilot project — it forced CSL to specify their requirements and to provide feedback allowing a very focused and timely development approach."

Managing electronic chart data added yet another set of issues to be dealt with. Digital data doesn't fit into a file drawer the way paper charts do, integrating survey data from the 60's with data from the '90's isn't as easy as it seems despite the capabilities of today's technology. Another opportunity for CHS...another partnership and voil88 Oracle MD now meets the world's needs in dealing with complex data integration problems.

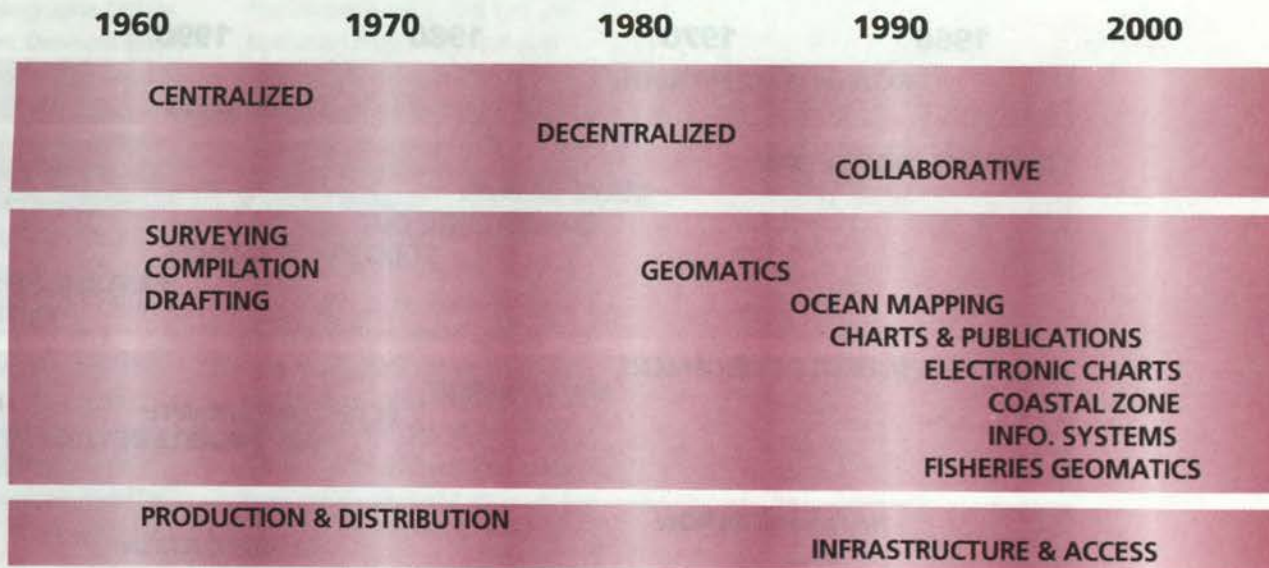
Marketing CHS products

There is now a much broader set of clients than CHS has served in the past. Digital data which can be manipulated and integrated is in great demand by mariners, manufacturers of small and large systems, environmental assessors, fishermen and fisheries scientists, oceanographers, engineers, geologists, geophysicists, biologists, and others.

"Our existing network of dealers works well in providing products to the traditional paper chart users. But the customization and distribution of digital data is more involved. Once again alliances with industry will make products available in a much shorter time frame than we can provide from CHS directly". A quality control process originating in CHS and involving industry will further ensure that CHS standards are met at each stage in the production and customization process.

But CHS expertise extends beyond hydrography and providers of data. The organization has over the last dozen years gained a reputation as an economic partner, a facilitator and a project manager for international projects. With skilled and professional staff we can assess and evaluate emerging technologies and their uses and assure successful

CHS Organization



delivery and implementation of programs worldwide. "We have always worked closely with industry, cooperated... never competed We keep them well informed, they always know what is going on internationally and we do everything we can to include Canadian industry in developments such as our current work with Lavelin in Egypt and with Universal Systems Ltd. in Spain.

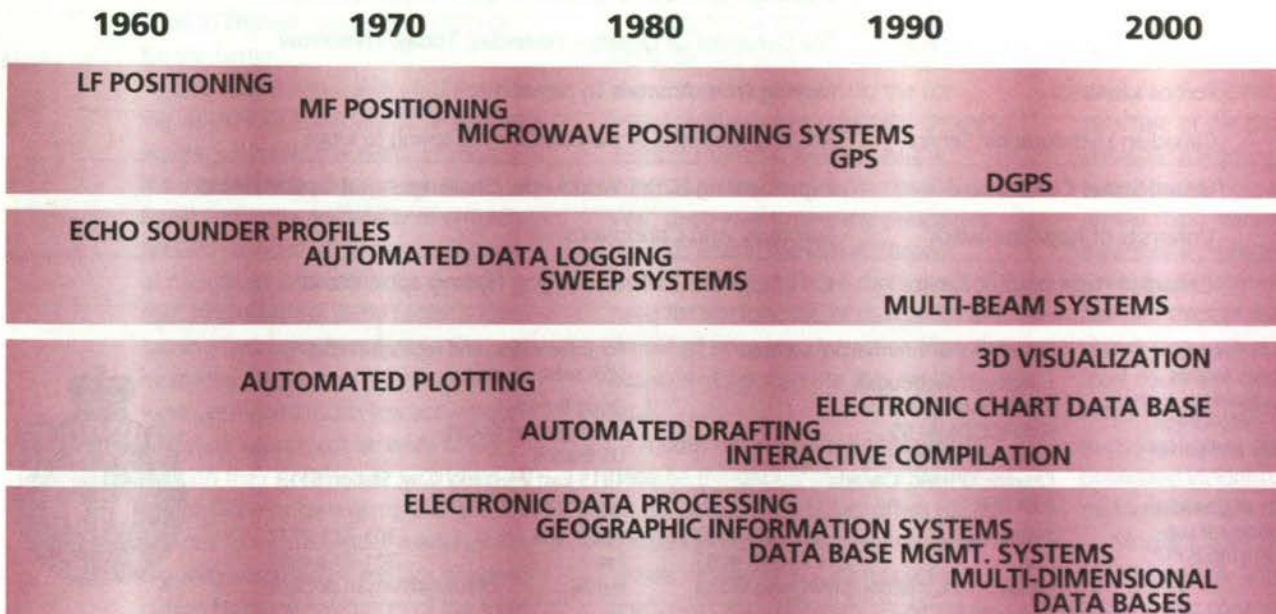
CHS' work with Canadian universities is well known. Most recently, CHS sponsorship of and continued cooperation with the Chair on Ocean Mapping at the University of New Brunswick has improved Canada's capability to map 100% of the ocean floor. They are at the forefront in many aspects of ocean technology, including processing large volume, multibeam data sets, bottom classification, volumetric mapping and biomass or fish mapping, so important in this era of endangered fish stocks worldwide.

Within two short and very busy years, CHS has retooled, downsized and is producing not one but two distinctly different product lines. It has increased its involvement with clients, provided new mechanisms for Government to deliver products and services, is generating royalties

and is providing professional advice and training worldwide... and its not over yet!

"The CHS of the future will be much smaller but it will survive and continue to play a leading role in hydrography world-wide. Our working relationship with industry is really making a big difference for us and we will continue to nurture it. Whether — digitizing data, re-licensing Electronic Charts, providing traditional paper charts or developing new technology , surveying or training, Industry is already directly involved in our production and delivery processes. Together with client participation and our committed and more flexible work force, the job gets done :"

CHS and technological change



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Canadian Hydrographic Symposium 1995

WHERE IS TECHNOLOGY TAKING HYDROGRAPHY?

Preliminary Program

| | | |
|------------------------|-------------------------------|---|
| Stephen Macphee | Dominion Hydrographer | Welcome and Introduction |
| Ross Douglas | Canadian Hydrographic Service | 35 Years of Hydrography - Reflections On Adapting To Change |
| Captain John Pace | Canada Steamship Lines | Electronic Charts - The Course To Go |
| Lesley Southwick-Trask | Proactive Consultants Ltd. | The Human Side Of Organizational Change |
| Victor Glickman | British Columbia Government | Beating the Bush: Begging, Borrowing, Buying And Blending Other People's Data |
| Fosco Bianchetti | C-MAP | Meeting The Need For Electronic Chart Data - Worldwide |
| Ray Chapeskie | Canadian Hydrographic Service | The Dynamics Of Quality - Yesterday, Today, Tomorrow |
| Jean-Luc Bédard | Port of Montreal | Moving From Artwork To Network |
| Jullian Goodyear | Canadian Hydrographic Service | Reaping the Fruits of the Labour — Learning to Cope |
| Dr. Lee Alexander | United States Coast Guard | Implementing ECDIS Worldwide: Challenges And Opportunities |
| Dr. David Wells | University of New Brunswick | Summary And Conclusions |
| Neil Anderson | Canadian Hydrographic Service | CHS Response To The Changing Hydrographic World |

Satellite technology will be used to broadcast the presentations to sites simultaneously and participants at each site will have a real-time communications link to both speakers and participants at other sites.

Information on addresses of Canadian sites and on-line registration are supported via INTERNET (anonymous FTP site): ftp.chshq.dfo.ca

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For information and registration for USA sites, contact:

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OPPORTUNITIES FOR PROGRESS IN NAVIGATIONAL PRACTICE

by Rear Admiral Nigel Essenhigh,
Hydrographer of the Navy (UK)

Captain John Anderson ("A Matter of Opinion", *Contour*, Summer 1994) raises some interesting and important issues regarding the growing concern over safety at sea. The pressure to reduce operating costs and meet increasingly tight deadlines is as prevalent in the world of the fighting ship, of which I have some experience, as it is in the mercantile marine, so graphically illustrated by Captain Anderson. When the full cost of a maritime accident is considered, and today this can run to billions of dollars, those responsible for operating ships at sea must seize every opportunity to reduce risk and enhance safety.

Whilst I too am tempted to explore the areas of manning, training and bridgemanhip, I will confine myself in this short article to the practice of navigation and the role modern technology can play in improving both navigation standards and safety. In particular, I will concentrate on GPS and the electronic chart, for together these developments offer the best opportunity for many years to change navigational practice for the better.

GPS now offers continuous positioning, anywhere in the world, of sufficient accuracy to meet the needs of most mariners outside pilotage waters. Increasingly, the availability of differential GPS services will permit a precision of navigation undreamt of a decade ago. However, this same factor is also causing hydrographers quite a headache since many older surveys were positioned much less accurately, and chart users must be wary when plotting their positions in such areas. Whilst this may be a glimpse of the obvious to most *Contour* readers, I am regularly surprised by the lack of appreciation by many navigators of the true

significance of chart datum and source data information.

If GPS has removed much of the doubt over "Where am I?", then GPS coupled with a system displaying an electronic chart should offer greatly enhanced peace of mind. The advantages of having the ship's position continuously displayed on the familiar surface of the chart can be directly measured in terms of ships' officers spending less time "heads down" in the routine processes of navigation and more time "heads up", concentrating on their primary tasks of avoiding collision and controlling the vessel's progress. Traditional methods of fixing and plotting can only give a historical position, from which can be derived an estimate of present and future whereabouts and then only after certain plotting functions and calculations have been completed. By comparison, GPS and navigation systems using electronic charts provide virtually real time and continuous display of position as well as automatically generating estimates of future movement, all this being achieved with minimal input from the navigator. The advantages of continuous positioning will be most noticeable when under helm or in a close quarters situation. In a warship there are considerable benefits to be had since continuous positional accuracy integrated into the command and weapons systems is critical in modern maritime warfare. As the emphasis shifts away from classical Cold War, deep water maritime campaigns towards littoral warfare in "brown water", there is an even more pressing need for the function of navigation to be simplified since any distraction from the business of fighting the ship could be fatal.

It does not stop there of course, because the display of radar information on systems such as ECDIS offers further benefits in terms of monitoring other vessels' movements with respect to one's own ship, all clearly displayed in

relation to the constraints of the water depth, traffic lanes, navigational hazards etc. Matching the chart to the radar display will also aid the identification of buoys, lights, anchored vessels and other features sighted visually or on radar. Conversely, objects such as buoys which are out of their charted position can be rapidly spotted. Decision-making is aided by the ability to quickly clarify a confusing, cluttered radar picture in dense shipping and difficult navigational waters, particularly when this task might otherwise occupy an officer for several minutes using traditional plotting methods. And for those who are not yet ready to place their trust implicitly in GPS, many electronic chart systems offer the ability to compare positions obtained from other navigational aids, including radar ranges and visual bearings, or to revert entirely to such methods in the event of GPS equipment failure.

However, benefits to the mariner do not accrue just from GPS and a chart display but also from the inherent nature of digital chart data. In developing the Performance Standards for ECDIS and the S-57 Transfer Standard for Digital Hydrographic Data, the IMO and IHO have ensured that ECDIS offers not just "equivalence" with the paper chart but considerable enhancements to safety and efficiency. Built into the very structure of the data is the ability to generate a warning when certain conditions are satisfied, such as the approach on the ship's track of shoal water, by means of a predetermined safety depth. Similarly, divergence from the pre-planned track or the proximity of a regulated area such as a traffic separation zone could also generate warnings. If either feature had been available to ships involved in certain recent, well-publicized incidents, it is arguable that misfortune might have been avoided.

Strictly speaking, such "intelligence" is only available with vector digital data, such as that conforming to the S-57

continued from page 15

A matter of opinion

standard, but this is expensive to produce and there is little yet available from the world's Hydrographic offices. There is, however, an increasing amount of chart data in raster form, an example being ARCS, the Admiralty Raster Chart Service, produced by my own Office. Whilst raster data does not comply with IMO/IHO standards for ECDIS, and therefore cannot at present relieve SOLAS ships from the duty of carrying paper charts, it can when used in appropriate equipment provide much of the additional functionality inherent in vector data. For instance, the use of ARCS with a vector "overlay" highlighting limiting danger lines can provide warning when approaching a hazard, and the overlay of radar information is also possible. Another safety-enhancing feature is the automatic reconciliation of the chart horizontal datum with the WGS-84 datum on which GPS positions are based, thus relieving the mariner of another computational exercise and another opportunity to "get it wrong".

Whilst raster-based systems are unlikely to offer the full functionality of ECDIS, they offer distinct advantages in displaying familiar-looking data, which is cheap and readily available, in a way which relieves the pressures on ships' officers and enhances safety. As such, they provide a more user-friendly navigational tool than does the paper chart. Let me hasten to add that ARCS is just one offering from my digital repertoire. I also intend to produce an IMO/IHO-conforming Electronic Navigational Chart service from 1997.

My final point concerns the updating of charts by Notices to

Mariners, that tiresome, time-consuming but essential task which usually falls to the Second Mate or a warship's navigator, both hard-pressed men as a result of their primary duties. We all know that in many less well-run vessels, the chart correcting task is skimped, ignored altogether, or carried out incompetently. Even in a well-run ship the sheer volume of the task will lead to the occasional error or omission. With both ECDIS and ARCS, pen and ink chart correction is a thing of the past and all the risk associated with the human element is eliminated. Correction is carried out automatically, and all the master needs to know is that he is using the latest correction disk. As a bonus, the corrected chart will always appear in pristine condition.

My aim here has been to set out what I see as some of the benefits available from modern technology. The future will see more developments, with the availability of digital databases offering every conceivable piece of navigational information, including Sailing Directions, Tide Tables, etc. By eliminating routine, repetitive tasks and distractions such systems allow officers to devote more time to their primary role, that of ensuring the safety of the ship.

But we must not get too carried away with all this. Such systems involve fundamental changes to the way we navigate and control vessels, and these changes must be recognized in the way the bridge is manned and organized, and in the development of standard procedures. This requires careful thought and formal training if we are to get the best out of these systems. There is still much to be done by the IMO, IHO and other international bodies to ensure that the proper standards are put in place, and can be effec-

tively monitored. The scope for data piracy and the production of poor-quality products is far higher with digital chart information than with paper, and there must be a concerted effort to stress the importance of using official data produced by national hydrographic offices, and to keep it updated.

So, whilst I have considerable sympathy for Captain Anderson's concerns which reflect those of many of us who have spent much of our lives at sea, I see great potential in adopting new technology to make a real contribution to safety at sea. However, to gain full advantage from what is now on offer, those of us with experience of the old order will have to encourage progress towards new navigational practices. This will require us to accept that the emphasis on establishing position, formerly the key to the navigator's art, is altered to place increasing priority on using the information which can now be generated automatically. Some of our old primary skills will become fallback methods—the new skills will be equally, possibly more demanding but different. As Captain Anderson rightly concludes and so will I, this will need, "highly trained and well educated people" to run ships.