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## ECDIS: Past, Present and Future

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### Introduction

Electronic chart technology is taking the Hydrographic and Marine Navigation communities by storm. From its beginnings two decades ago it has progressed to the point where Electronic Chart Display and Information Systems (ECDIS) are now on the verge of being recognized with the same status and authority as the paper chart on the ship's bridge. In this paper the history of electronic charts is briefly reviewed to set the stage for the three main thrusts that are underway today: (1) completion of international standards, including defining

tests and procedures to certify equipment, data and updates; (2) developing and implementing the national and international infrastructures to rapidly and efficiently disseminate ECDIS data and updates world wide; and (3) creating ECDIS data, known as the Electronic Navigational Chart (ENC), for all the main shipping lanes of the world. The paper concludes with a look at the future of electronic charts and the impact they may have on a variety of hydrographic and marine related activities.

### Background

In Canada, electronic chart technology had its beginning in the late seventies when several companies involved in hydrographic surveying for the petroleum industry developed specialized navigation systems that utilized rudimentary graphics and integrated navigation systems to navigate ships accurately in confined waterways.

In the early eighties, Hydrographic Offices (HOs) in Europe and North America became interested in this emerging technology. A series of Electronic Chart Workshops on both sides of the Atlantic, starting in 1982 at the University of New Brunswick, reflected the growing interest. Today, electronic chart sessions and demonstrations are common at all major marine conferences.

In conjunction with academic studies, several HOs participated with the private sector in at-sea trials and demonstrations of Electronic Chart testbeds with the aim of introducing the technology to the marine community and obtaining feedback. HOs were interested primarily in evaluating the difficulties associated with defining, compiling and maintaining an Elec-

tronic Chart Database. At-sea trials included: the Canadian Hydrographic Service (CHS) testbeds from 1985 to 1988 in Halifax Harbour, the North Sea Project onboard the M/V *LANCE* in November 1988, followed by the Seatrans Project onboard the M/V *NORNEWS EXPRESS* in 1989/90.

The International Maritime Organization (IMO) and the International Hydrographic Organization (IHO) began discussions centered around electronic charts in the mid eighties, with the aim of initiating standards for the industry.

In 1989, acknowledging rising concerns regarding Canada's ability to prevent or respond to a major maritime oil spill, the Canadian Federal Cabinet initiated the Public Review Panel on Tanker Safety and Marine Spills Response Capability. The panel, chaired by Mr. David Brander-Smith, Q.C., delivered its final report in 1990. Among many recommendations was the following:

*"[to] expedite development of electronic charting technology and the required infrastructure, then introduce regulations requiring the use of electronic charts on all tankers in Canadian waters"*

In response to this recommendation, an electronic charting strategy was developed by CHS with the following mission statement:

*"To demonstrate to a broad spectrum of potential users, suppliers and benefactors the utility of electronic chart systems and to acquire real-world operational experience in servicing the related evolving national and international digital market."*

In order to address the many questions electronic chart technology would generate, a key element of the strategy included the actual testing of operational systems. In order to simulate the expected conditions, the strategy called for a number of systems to be deployed across the country, in a variety of commercial vessels for extended periods of time. The CHS Electronic Chart Pilot Project was designed to identify the stresses and strains of the everyday creation, maintenance and day-to-day delivery of data to a broad clientele.

In June, 1992 Offshore Systems Ltd. (OSL) was awarded a contract by CHS to use OSL's latest Electronic Chart Precise Integrated Navigation System (ECPINS) in CHS's Pilot Project. The belief was that the international standards being developed would lead to modification of the *Canada Shipping Act* which governs the use of such systems onboard vessels operating in Canadian waters. Hence, the CHS, the official purveyors of all charts in Canada, had a requirement to develop a mastery of the production and control of electronic charts.

### International Standards

Electronic Charts are categorized by IMO into two main groups: Electronic Chart Display and Information System (ECDIS) and Electronic Chart System (ECS).

The first, ECDIS, must meet the Performance Standards that were developed by the IMO/IHO Harmonization Group on ECDIS (HGE). This standard, approved by the Maritime Safety Committee in May 1994 was submitted to the nineteenth Assembly of IMO and adopted as an Assembly Resolution in November 1995. As defined in the standard, ECDIS is "a navigational information system which with adequate back-up arrangements, can be accepted as an equivalent complying with the up-to-date charts required by regulation V/20 of the 1994 SOLAS Convention". When the IMO, IEC and IHO standards, type approval specifications, etc. are finalized, then the installed ECDIS achieves full equality with the paper chart. Of course, this includes the availability, and installation of a chart updating facility, as well as the employment of government produced chart databases.

By displaying selected information from an electronic navigational chart (ENC) and positional information from navigational sensors, ECDIS should "assist the mariner in route planning and route monitoring, and if required, display additional navigational information". As an automated decision aid capable of continuously determining a vessel's position in relation to land, charted object, aids-to-navigation, and unseen hazards, ECDIS represents an entirely new approach to maritime navigation and piloting.

In conjunction with the development of IMO Performance Standards for ECDIS, the IHO has developed technical standards related to the digital data format to be used and specifications for the ECDIS content and display. IHO Special Publication No. 57 (IHO S-57) is the IHO Transfer Standard for Digital Hydrographic Data. It includes a theoretical data model, object catalogue and data encoding guide. IHO Special Publication No. 52 (IHO S-52) is the IHO Specification for Chart Content and Display Aspects for ECDIS. It includes four appendices related to updating, color and symbol specifications, data quality and a glossary of ECDIS-related terms. Both S-57 and S-52 are referenced in, and are therefore part of, the IMO Performance Standards for ECDIS.

At the request of IMO, the International Electrotechnical Commission (IEC) is working to identify and describe the necessary performance tests and checks for ECDIS equipment to certify that it is fully compliant with the IMO Performance Standard for ECDIS. Scheduled completion date of the IEC ECDIS Performance Standard (IEC Publication 1174) is summer/fall of 1996. However, some of the IHO Standards that form the foundation of the IMO Performance Standard are still under development; the IHO ECDIS Updating document, for example, is only classified as Guidance at the moment and is due for a major rewrite in the near future when a number of ECDIS Updating trials underway around the world, including Canada, are completed. Also, the specification for an adequate backup for ECDIS has not yet been developed and, once it has, an IEC test procedures document will also have to be developed. Therefore, formal adoption by IEC will not likely occur before late 1997 at the earliest.

Electronic Chart Systems (ECS) comprise the second group of electronic chart equipment and include all electronic charts which do not comply with the ECDIS standard. These are not acceptable by IMO as a paper chart equivalent and paper charts will therefore still have to be carried. ECS is a combined apparatus, as is ECDIS. It involves the combination of an electronic chart with a positioning system, displaying the vessel's position and track, along

with the buoys, lights and hazards. It is intended to be an aid to navigation like radar, GPS, echo sounder, speed log, etc. ECS takes many forms; equipment is supplied to be suitable for the whole range of vessels: from small yachts to super tankers. As a result, the range of ECS equipment varies from small plotters to very sophisticated systems.

The United States Radio Technical Commission for Maritime Services (RTCM) issued its standard for ECS in 1994. The RTCM standard calls for ECS to be capable of executing basic navigational functions, providing continuous plots of own ship position and providing appropriate indications with respect to information displayed. The Standard allows for the use of either raster or vector data. However, many of the functions found in ECDIS will not be available in ECS which is classified as an aid-to-navigation that must always be used with an up-to-date chart from a government authorized HO.

In addition, at the last meeting of IMO/IHO HGE, the chairman asked the members to prepare ECS guidelines for submission at the next meeting.

### ENC Production

At the time of the grounding of the Exxon Valdez less than 10% of CHS charts were digital and none were suitable for use by ECDIS. To-day approximately 300 charts (30% of the CHS inventory) are digital and are being distributed to ECDIS users and manufacturers by our commercial partner Nautical Data International (NDI), St. John's, Newfoundland. Furthermore, about 250 charts (25% of the CHS inventory) have been raster scanned by NDI on behalf of the CHS and are being maintained and distributed by NDI.

Canadian ENC production has been driven largely by user demand as shipping companies have made fleet purchases of ECDIS equipment and demanded CHS approved ENC's to use in them. Lacking the resources to meet this initial demand the CHS consulted users to define a minimum content standard for safe navigation which was used during a first round of digitizing. To-day the content level of most of these charts has been upgraded to the point where

they are nearly compliant with the IHO S-57 product specification. Furthermore, most of the major tanker routes in Canada are now completed or are well underway. This process has been very enlightening for both mariners and hydrographers alike in that it has forced them to assess exactly what is required for safe and efficient navigation, not only with ECDIS, but on paper charts as well. The close cooperation and consultation that now exists between mariners, shipping companies and the CHS means that we are focusing our efforts on meeting client needs rather than meeting internally defined production target levels.

Initially all CHS ENC's were created and distributed in the CHS proprietary NTX format. Indeed, most CHS ENC's are still maintained and distributed in NTX but that is about to change. Over the past several years as the IHO DBWG has developed the S-57 Transfer Standard for Digital Hydrographic Data, Version 2, the CHS has actively participated in that development and has, as much as possible, ensured that our ENC's (in NTX format) are as compatible with the IHO standard as possible. Also, software has been developed by CHS in conjunction with Universal Systems Ltd., Fredericton, NB, to interactively convert ENC's from NTX to S-57. At present about 80% of the conversion is automatic and 20% requires human intervention. Eventually the process is expected to be about 95% automatic. A test is presently underway to convert a contiguous set of ENC's between Montreal and Quebec as well as other sites in the Great Lakes. A preliminary test version of S-57 (Version 3) is expected to be released in April 1996, with a final release later in the year, and the CHS conversion software is being upgraded already. The CHS target is to distribute ONLY S-57 data by 1997.

Mariners and shipping companies in increasing numbers are discovering the economic and safety benefits of ECDIS. For example, the Canadian Ship Owners Association has stated that the entire Great Lakes Fleet on the Canadian side will be ECDIS equipped by late 1997. However, shipping companies that operate globally face a more difficult problem since not all HO's are tackling ENC production as aggressively as

Canada. Indeed, only a handful of HO's (Japan, Norway, France and Canada) are digitizing their charts in any numbers. Shipping companies who want to use ECDIS globally must therefore rely on commercial ENC providers or ECDIS manufacturers in areas not presently serviced by HO's. Given the global movement towards smaller government, HO's who delay their ENC production programs will have great difficulty dislodging the private sector once it has demonstrated its capacity, efficiency and the quality of its products.

### ENC Distribution

Another area that has attracted international attention is the need to address the administrative, technical, financial and legal aspects of distributing ENC's and ENC Updates worldwide. To meet this need, the IHO formed the Worldwide Electronic Navigational Chart (WEND) Committee in 1992. The Committee developed a set of principles and a Conceptual Model which consists of several Regional ENC Coordinating Centers (RENC's) around the world that would accept data from HO's. They would then be responsible for integrating the individual HO's data and subsequent updates and providing a service to international shipping. In principle the mariner would be able to obtain ENC's and updates from anywhere in the world through a communications network linking all the RENC's. Progress in implementation of this model has stalled because many HO's have been unable to divert their diminishing resources away from their traditional paper products.

It isn't clear how the global distribution of ENC's will unfold. The situation is made more uncertain with the strong commitment to produce Raster data by the United Kingdom Hydrographic Office (UKHO) and the intention of the United States Defense Mapping Agency to distribute their chart data in their Vector Product Format. Indeed, an initiative being lead by the UKHO proposes a Raster Chart Display Standard (RCDS) along similar lines to the ECDIS Performance Standard that (a) recognizes that ECDIS is much more than the equivalent to the paper chart and (b) that a system conforming with RCDS is actually 'equivalent' to the paper chart. RCDS could be

adopted by the Marine Safety Committee of IMO within the next year. Certification standards similar to the IEC 1174 for ECDIS would then need to be developed by IEC and certification agencies would need to gear up to start testing equipment. Given their experience with ECDIS standards these agencies probably could repeat the process for RCDS quite quickly. RCDS certified systems could be replacing paper charts on ships bridges in a very few years. What impact will this have on the global expansion of ECDIS? Given that it is relatively easy and inexpensive to raster scan paper charts and that RCDS certified systems could be as much as an order of magnitude cheaper than ECDIS, the negative impact on ENC production and therefore ECDIS use globally could be significant.

The CHS has undergone a significant change in both attitude and work procedures in the past 5 years as a result of its commitment to meet the demands for ENCs by Canadian ECDIS users. The CHS has gone from a paper oriented organization that thought in time scales of 1 - 2 years to produce a new product to an organization that produces new Electronic Chart products in 1 - 2 months. Documents that used to spend weeks or months travelling back and forth between Headquarters and the Regional offices are now mailed electronically in seconds. The re-engineering and changes in attitude that are taking place in the CHS are having beneficial effects on our paper products as well. But, we still have a long way to go!

At present, ENC updating in Canada is achieved by total file replacement. While not the desirable final solution, it works surprisingly well with turn-around times of a few days to a few weeks. Major initiatives are underway in Canada and elsewhere to test and evaluate the IHO Guidance on ENC Updating and eventually turn it into an international standard. ENC Updating, ENC Quality Indication and ECDIS Backup are the three major outstanding "holes" in the international ECDIS Standards that need to be 'plugged'.

### The Future of ECDIS

The future of ECDIS in Canada is bright because nearly a half the CHS charts are digital and available for use in ECDIS.

However, internationally the future of ECDIS depends on several factors, the most significant of which is the lack of ENCs. This lack, in turn, is suppressing demand for ECDIS with the result that interest in setting up an infrastructure to distribute ENCs and updates has stalled. Given the international trend toward smaller government it doesn't seem likely that the production of ENCs will dramatically increase in the near future. The introduction of the RCDS will only exacerbate the problem.. Mariners in increasing numbers are discovering the economic and safety benefits of ECDIS and are continuing to exert pressure on HO's to produce more ENCs. Where they can't get 'official HO data' they are reluctantly settling for commercial data which probably exists in greater quantity than the total of HO data worldwide. However, commercially developed data doesn't have the authority or legality of 'official HO data', so, when it is being used, the paper chart is still the only legal navigation document on the ship's bridge.

The Canadian and US Coast Guards are forging ahead with the implementation of DGPS networks in all coastal waters of North America. The 3-5 metre accuracy available from this system can only be exploited with an ECDIS like system. And, as mariners use these systems with these accuracies they are discovering new and better ways to operate their vessels. ECDIS systems are being used for docking and Canada Steamship Lines was given approval to operate in the St. Lawrence River last year after the buoys were removed for the winter. Normally removal of the buoys signals the end of shipping for the winter. ECDIS is also influencing the way mariners and navigation service providers (typically Coast Guards) approach the safe and efficient management of shipping. For example, they are asking if as many buoys and lighthouses are needed and how should Vessel Traffic Services (VTS) function in the future? A related development, known as Automated Information Systems (AIS) could have ships broadcasting their positions over dedicated radio links and ECDIS systems using this information to display all ships in the vicinity, even when they can't be seen by radar because, for instance, they are around a bend in a river.

There is no doubt that ECDIS, DGPS and rapid global digital communications, supported by ever faster and smaller computers and higher resolution video displays will continue to revolutionize marine navigation for many years to come. We live in interesting times!

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