The electronic chart – Present status and future problems

Author

A. J. Kerr, R. M. Eaton, and N. M. Anderson[1]

Preamble

This manuscript is a reprint of the original paper previously published in 1986 in The International Hydrographic Review (IHR, https://ihr.iho.int/): Kerr, A. J., Eaton, R. M., and Anderson, N. M. (1986). The electronic chart – Present status and future problems. *The International Hydrographic Review, 63*(1), 97–105. https://journals.lib.unb.ca/index.php/ihr/article/view/23424

This paper was presented at the Fifth International Congress of the International Association of Institutes of Navigation, Tokyo, Japan, October 1985. It is published in the *Journal of Navigation* (U.K.), Vol. *39*, No. I, 1986 and reproduced here with permission.

1 Introduction

Interest in the use of video displays for nautical chart presentation has increased rapidly during the last two years. Eaton et al. (1984) at the Second International Hydrographic Technical Conference provided a list of ten different systems already in production. Oshima (1985) speaking at a Workshop on the subject in Canada, earlier this year, mentioned that some 4000 Japanese fishing boats and 150 merchant vessels now carry electronic charts of varying degrees of complexity.

The electronic chart is in reality simply the output end of an integrated navigation system which brings together different navigation sensors, in particular the combination of radar imagery, with the digitized chart data. The idea of integrating chart and radar data goes back to the 1950's (Dickson, 1952) and was one of the objectives of the "Manav" Integrated Navigation System (Millar & Hansford, 1983). However, at that time the technology had not reached a state by which digital data could be handled so easily.

Outside the marine field, video display technology has been developing even faster in the aviation industry (Bernard, 1983) where crowded airways and the speed of modern aircraft, particularly military aircraft, make fast and accurate navigation decisions an urgent necessity. Electronic map displays are now being seriously considered for automobile navigation (Shuldiner, 1985) although it is contended that, for navigating ground vehicles, recorded voice instructions are more effective than a map display (Streeter & Vitello, 1985).

At present it appears that the marine developments are being pursued most actively in Japan (Oshima, 1985) and the United States where electronic charts have been developed for harbour navigation (Rogof, 1985) and for the navigation of naval hydrofoil vessels (Puckett, 1983). There is also considerable activity in Canada where one company has used electronic charts for navigating oil industry vessels in the Arctic and is now actively engaged in developing systems for ferries (Ridgewell, 1985). In the United Kingdom an experimental system for the use of fishing vessels has been developed (Coates et al., 1984) and an interesting and futuristic approach is being taken in the Netherlands in the design of the "ship 90" complete with a "bridge 90" (van Opstal, 1985). Aside from these primarily government efforts, several commercial developments are also underway in Europe. These include a market research study by the International Management Institute in Geneva to examine the future of the electronic chart as a product.

Although navigators and hydrographers may be fascinated by the display technology of the electronic chart, it is becoming increasingly clear that this may be less difficult than the development of the data bases and questions of legality and finance. The development of suitable data bases of chart information is far from simple and the matter of the smooth exchange of digital data is now being actively ad-

[1] Canadian Hydrographic Service (Atlantic Region), Bedford Institute of Oceanography, Dartmouth, N.S. B2Y 4A2, Canada

dressed by the International Hydrographic Organization (IHO) through its CEDD (Committee on Exchange of Digital Data) Committee (IHB, 1984). At this stage, some manufacturers of electronic charts are simply digitizing information directly from the paper charts and this brings into question legal matters such as copyright and the overall responsibility for the quality of the data that will be presented to the navigator. Hydrographic offices are concerned about the impact of the electronic chart on their future activities, and the North Sea Hydrographic Commission has established a working group to examine the issues. It is evident that the approach to the provision of digital data is not uniform. It is reported that the Japanese Hydrographic Office plans to provide the private sector with digital chart data from May 1985 (Oshima, 1985) and that in the United Kingdom the Hydrographic Office is digitizing charts of the south coast of England as a test set. Apparently, in Sweden, a commercial firm is providing digital data by digitizing the government charts itself. Obviously, some policies for international standardization, quality and marketing must be developed very soon.

The updating of electronic charts has been recognized by Hammer (1984), Eaton et al. (1983) and others from the start as an important matter to be resolved. Obviously, if a commercial company digitizes a chart and does not simultaneously develop a system to continuously update it, the product will not be acceptable to the navigator. Various approaches to the matter have been proposed, from transmitting Notices to Mariners to be manually inserted into the chart file aboard, to the prophecy of Rear Admiral R. Morris, now being actively examined in Canada, that the entire updated chart will be transmitted directly to the navigator by satellite (Mukherjee & Anderson, 1985).

Fundamental to all thought on the electronic chart is whether or not it will partially or completely replace the paper chart. At this stage, there are some who will argue that the electronic chart is but a diagram providing only essential tactical information for the navigator, while there are others who argue that once the navigator has started using the electronic chart, the paper one will be left to gather dust in the chart drawer.

2 Technology

The technology central to the electronic chart has already been described in detail by Eaton et al. (1983) and elsewhere and need only be summarized here. In the first place the navigator must be precisely positioned relative to the charted information. Various electronic systems, such as Loran C, are available for this. It is expected that GPS may be used at some future date. Processing of navigational data and presenting it in the form of off course corrections and way point navigation is already commonly available for many electronic receivers. The charted data must be provided in digital form and then displayed. This introduces the matter of the density and type of information needed.

One problem of the paper chart today is its increasing clutter (Kerr, 1985) and the electronic chart provides a way to avoid this by being selective in the data required. For instance, a supertanker will be primarily interested in depths greater than 20 metres whereas a small yacht will be interested in depths less than 5 metres. Ideally, the electronic chart should have available a complete hydrographic data base from which selected data, such as depth contours, may be drawn, but at present limitations in data base management and memory capacity have inhibited this total flexibility. Present examples of electronic charts have been designed for specific classes of users. The ability to change scale and projection at will is a potential feature of the electronic chart, so that as a vessel approaches a port from seaward, the navigator can call up an increasingly larger scale and more detailed display. This zoom capability may be provided, at its least sophisticated, as a set of specific frames or, in a more elaborate manner, as a continuous change of scale.

There has been considerable interest in the cartographic presentation of the new medium. The video game industry has demonstrated the amazing capabilities of symbolization and animation. This capability is available to the electronic chart manufacturer and a decision to be made is whether to copy precisely the existing paper chart or to branch out into new symbols. At present, work is going on in the Deutsches Hydrographisches Institut (DHI) to study the simulation of electronically drawn symbols as near copies of the paper chart symbols. Certainly the electronic medium offers capabilities, such as flashing symbols, to direct the navigator's attention which are not possible on a paper chart. The ability to select colour has proved a particularly fascinating subject to persons involved with the electronic chart. Theoretically, the active presentation of colours on a video display offers a great choice of options and cartographers have often noted the psychological implications of colour (Samson & Poiker, 1985) such as red as a danger signal. In spite of these theories, it appears that experienced mariners tend to prefer the colours that they are used to on the paper chart. Electronic chart manufacturers to date have exercised a free choice in colour selection and interesting designs have developed. However, it is important that the designs be standardized soon, as without doubt there is a danger in having no uniformity.

The superposition of the radar display is a key feature of the electronic chart. The ability to provide the navigator with a single display showing both static chart data and mobile targets, such as other ships, was recognized as essential under the economic studies of the "Manav" project (Millar & Hansford, 1983). The ability to do it elegantly has only been allowed by the development of video systems and greatly facilitated by the advent of raster scan con-

verters and the availability of digital radar displays in matrix format. True motion displays have been used in many of the electronic charts to date with which the observer's vessel moves across the display, but as the vessel approaches the edge of the chart the frame automatically moves forward. However, alternative displays such as centering the display on the ship are equally possible. The manner in which the radar returns have been displayed on the electronic chart, with respect to colour and suppression, has varied in the designs.

The International Hydrographic Organization has now spent many years in reaching a uniform standard of paper chart presentation (Newson, 1983) and it is clear to many that the development of standards for the electronic chart, both in its display and data exchange format, must be given high priority. At the same time, it must be recognized that we are dealing with a new medium with exciting possibilities and its potential should be explored before we tie ourselves firmly to set standards (Luder & Barber, 1984). As an approach to examining these possibilities and other aspects of the electronic chart, the Canadian Hydrographic Service has contracted a commercial company (Universal Systems Ltd., Fredericton, New Brunswick) to develop an Electronic Chart Test Bed with which to examine the options. The company, which has expertise in developing interactive cartographic systems, will utilize a large electronic display controlled by a MicroVax II computer. While this system may be more powerful than those that will actually be needed in future electronic charts, it will allow the process to be modelled by testing different approaches to chart framing, to scale zooming, to colour choice, and to the design of symbols. It will also permit experiments to be made with different approaches to data bases.

3 Data bases

It is nearly twenty years since some national hydrographic offices started developing computer assisted chart production systems, although it is less than five years since the majority of these offices have been confident enough in their system to use them on a production basis. It is now clear that the digital era has arrived and the digital chart files are growing daily. In some countries, hydrographic data is also being regularly collected in digital form. There is an increasing awareness that some form of data base management is urgently required and that, since there is a need to exchange this data internationally, some common formats are needed.

To date, the digital data required for the electronic charts has been obtained by digitizing the paper charts, but it should be recognized that a paper chart includes only a fraction of the total survey data collected. It is a fairly general rule of hydrography that charts are always published on a smaller scale than the scale of the survey from which they are derived. This means that an electronic chart should only be permitted to enlarge the scale up to a maximum of the scale from which the data base is drawn, which at present is the largest scale chart. This presents a difficulty for those companies which might wish to display very large scale charts of ferry terminals and other critical areas. Since a strength of electronic charts is that they can provide special versions for different types of users such as fishermen, yachtsmen or VLCCs, it is necessary that the data base includes all the data from which to make the selection. For instance, a chart for a fisherman engaged in trawling will require the full detail of the bathymetry and not the selection of soundings required for normal commercial navigation.

The simple and straightforward approach is obviously to digitize the largest scale paper charts, but a better and more flexible approach, if the data base management system can handle it, is to provide some carefully assembled collection of all the data available. In the Canadian Hydrographic Service experimental work is being carried out to develop what is termed a digital Qualified Data Base (QDB). This is the development of a unique set of digital data, based upon the largest scale charts, but includes all the survey data available for that area but with all overlaps reconciled. The present approach has been to contour the areas in detail and then to digitize this very dense selection of contours. However, this dependence upon contours may inhibit one potential of the electronic chart which is to add tidal height to the soundings in real time to provide actual depth to the navigator. The significance of the QDB, as opposed to providing digital records of all data, is that the data has already been qualified and is therefore more amenable to selection and presentation to the navigator.

4 Legal aspects

Considerable attention has already been given to the legal consequences of introducing this new product. Developments to date, in which the electronic chart is being provided by a commercial manufacturer from digital data that they have obtained from national hydrographic offices, promise to change the legal responsibilities significantly. In some countries, where special charts for yachtsmen and fishermen have been produced commercially from data derived from government sources, the national hydrographic offices appear to have abdicated any legal responsibility. However, as far as is known, this has yet to be tested in the courts. In meetings of the North Sea Hydrographic Commission Working Group it was a general first opinion that, both morally and to meet the stated expectations of the users, the hydrographic offices should remain responsible for the data which they provided.

Mukherjee and Anderson (1985) have discussed some of the legal issues associated with the electronic chart. Of particular importance is the subject of copyright. Some national hydrographic offices have copyrighted their charts while others have not. The

https://doi.org/10.58440/ihr-29-a16

purpose of copyrighting and its effectiveness need to be examined. Mukherjee (1985) has noted that copyright has a moral and a commercial aspect. Copyrighting is essentially the right to prevent others copying one's creative work and, in Canada, at least, a chart is interpreted as a creative work. The reasons for exercising this right in terms of the chart may be to prevent the production of inferior products and thus the tarnishing of the reputations of a hydrographic office, or associated with this, a means to prevent the release of an unsafe product which might result in the producer of the original chart being held legally responsible. Yet another reason, and certainly the one of concern to commercial organizations, is the loss of revenue when a product is copied and sold. The revenue available from the sale of charts can be considerable, although most national hydrographic offices wil1 point out that these revenues do not even approach the overall cost of surveys and cartography. Nevertheless, if these revenues were lost there would be concern by national governments, particularly in these days of interest in cost recovery.

The introduction of the electronic chart poses some new questions on the matter of copyright. First of all, it has been suggested that the electronic chart is simply software and there is considerable general interest in the copyrighting of software. The copyrighting of software has been through considerable examination in the courts and arguments have been presented and refuted that software must be in human readable form and that source and object codes may not be covered. The distinction between programs which control a process and the actual data does not seem to have been made, but going back to the basic definitions it cannot be argued that data is a creative work but rather it is something, in our case a chart, that has been produced from the data that is subject to copyright. These fine distinctions must clearly be left to the lawyers, but it must be argued here that if hydrographic offices are to control the use of their data or their charts, they must insist on copyrighting.

Another legal matter which is becoming of increasing concern to hydrographers is their liability for the products for which they are responsible. The situation regarding the paper chart has a considerable history in the courts and is reasonably well established, but the increasing use of commercial contracts for both survey and cartographic work by national hydrographic offices promises some changes in the legal position. Essentially, even if the work is carried out under contract, provided it is properly supervised, the hydrographic office remains responsible. While the manner in which the contract is described may have a bearing, if the contractor does something in an unsupervised fashion, then he will find himself legally liable. The manner in which the data is provided by the hydrographic office to a commercial manufacturer of an electronic chart is presumably, therefore, the causative factor in the matter of legal liability. If a manufacturer simply digitizes data off a chart without permission and produces an electronic chart, then the manufacturer rather than the hydrographic office will presumably be responsible for any errors that are made. If, on the other hand, the hydrographic office digitizes the data itself, and this is faithfully displayed by the electronic chart manufacturer, then the former will remain legally liable. It can be appreciated from these assumptions, if they are correct, that if a hydrographic office feels that it has a moral responsibility for its data, and to meet the stated expectations of users, it must ensure that it can supervise every step of the production of the electronic chart. It is this concern which turns us back again to the importance of copyright.

5 Administration

Hammer (1984) has observed that there are three communities of interest associated with the production and use of electronic charts. The first of these are the government hydrographic offices, which provide the data and normally digest this into the paper chart form. Then there are the "value-added" producers which take the data or digitize the charts and turn them into the electronic chart and, finally, there are the navigators who use the charts. To date, in the case of paper charts, the governments have served as regulators and have accordingly been responsible for the product throughout. It appears that there are several approaches that can be taken for the centre link. In Japan, the Hydrographic Office has taken up the responsibility of digitizing its own charts. It may be noted that this has not been the total chart, but selected information from it. It is their plan that these data will be sold through the Japanese Hydrographic Association, at the very modest cost of $20 per chart. It is not known how the Hydrographic Office provides updates to the digital chart files or how it assures itself that the presentation of the data is without error or distortion. At least one American company makes its own digital tapes from the government charts, which are not copyrighted. The company has proposed that it could produce hard copy overlays to give the National Ocean Survey in order that it could check the accuracy of the electronic chart.

At present, the manufacturers of the electronic chart hardware must either digitize their own data tapes or, in the case of Japan and possibly now the United Kingdom, obtain the tapes directly from the hydrographic offices. There is another scenario that has been proposed by the Norwegian Hydrographer, in which an organization be established to obtain and sell the digital data, acting as an additional middleman. These organizations could be commercial or part govern mental. It has been suggested that such organizations could be licensed by the hydrographic offices to carry out this function. They would be financially self-supporting, buying the rights to digitize charts from different national hydrographic offices and then selling the chart tapes to the electronic chart manufacturers. These bureaux have been proposed on a regional basis and would be

more readily controlled than all the hardware manufacturers, which appear to be proliferating. Arrangements could be made between the bureaux and national hydrographic offices to ensure the quality of the digital data. The bureaux would also relieve the latter of the digitizing task. If the electronic chart develops to such an extent that it replaces the paper chart, the royalties paid by the bureaux to the hydrographic offices would provide some compensation for this lack of revenue. It is far from clear how data from a more raw state could be accessed and at this time it is perhaps realistic only to consider the digitization of the largest scale charts.

Supervision of the actual output of the electronic chart may still present a problem as there is no guarantee that the manufacturer will choose to display all the data or that the resolution of the display will permit a clear depiction of the data. Hydrographic offices would, for instance, not be happy to see their charts displayed at a larger scale than they were drawn. It may be necessary for electronic chart systems to be accredited in some way either directly by the hydrographic offices or by the bureaux and to advise mariners that they were at their own risk unless they used a properly licensed system. However, in this it must be surmised that the manufacturers are as anxious to sell a good product as are the hydrographic offices.

Finally it may be asked what part the International Hydrographic Organization has to play in these developments. Over many years it has advocated a free exchange of chart data between countries. It has also advocated international standards. Does it now have a part to play in the establishment of digital chart bureaux? Possibly the Regional Commissions of the IHO might be responsible for setting the standards and licensing the bureaux. Certainly the IHO has already shown its concern for the legal questions concerning the electronic chart by going to the International Maritime Organization (IMO) to ask its opinion.

6 Conclusion

While we are already well launched on the technical road to producing electronic charts, there are still some important issues to be faced at an administrative level. First is the question of updating and how this can be achieved; there is then a question for standards: then there is a question of legal responsibility and. finally, there is the matter of how the data will be administered. Are we to see the demise of national hydrographic offices as producers and sellers of nautical charts or will they become managers of hydrographic data bases only with the data being converted into digital form and kept updated by special bureaux and the charts in electronic form by commercial companies? At this stage the majority probably believe that there will always be a requirement for the paper chart and that electronic charts are but a diagrammatic presentation forming part of an integrated system. However, the business aspects of the electronic chart bear as much watching as the technological advances.

References

Bernard, M. (1983). New display systems for the next generation of civil aircraft. *Journal of Navigation*, *36*(3).

Coates, R., Dye, K., and Knox, K. (1984). An electronic chart display for fishing vessels. *Journal of Navigation*, *37*(3), pp. 374–379.

Dickson, J. H. (1952). Radar chart matching devices, *Journal of Navigation, V*(4), 1, pp. 331–344.

Eaton, R. M., Anderson, N. M., and Evangelatos, T. V. (1983). The electronic chart. Proceedings of the Canadian Hydrographic Service Centennial Conference, Ottawa, April 6–8, 1983.

Eaton, R. M., Anderson, N. M., and Evangelatos, T. V. (1984). The electronic chart. Proc. 2nd International Hydrographic Technical Conference.

Hammer, J. L. (1984). The electronic chart. *The Hydrographic Journal, 33*, pp. 49–50.

International Hydrographic Bulletin (1984). NSHC Workshop "Automated Chart Production". *I. H. Bulletin*, p. 318.

Kerr, A. J. (1985). Navigation chart design. *Journal of Navigation*, *38*(1), 56 pp.

Luder, C. B. and Barber, P. J. (1984). Redundant color coding on airborne CRT displays. *Human Factors*, *26*(1), pp. 19–32.

Millar, J. C. and Hansford, R. F. (1983). The "Manav" integrated navigation system. *Journal of Navigation, 36*(1).

Mukherjee, P. K. (1985). Proceedings of Workshop on Electronic Chart. Bedford Institute of Oceanography (unpublished).

Mukherjee, P. K. and Anderson, N. M. (1985). Copyright, safety and the electronic chart: Towards new directions in navigation. Proc. of the First Biennial Canadian Hydrographic Conference, Halifax.

Newson, D. W. (1983). International standardization of nautical charts. Proceedings of the Conference of Commonwealth Surveyors. Paper No. E4, 16 pp.

Oshima, S. (1985). Hydrographic Department, Japan. Proceedings of Workshop on the Electronic Chart. Bedford Institute of Oceanography (unpublished).

Puckett, L. (1983). Hicans – Navigation for high speed ships. *Navigation, 30*(2), pp. 107–122.

Ridgewell, B. (1985). Offshore Systems Ltd., Vancouver. Proceedings of Workshop on Electronic Chart. Bedford Institute of Oceanography (unpublished).

Rogof, M. (1985). Navigating with full-color electronic charts. Proceedings of Auto Carto 7, Washington.

Samson, L. and Poiker, T. K. (1985). Graphic design with color using a knowledge base. Canadian Cartographic Association, Annual Meeting, Fredericton.

Shuldiner, H. (1985). Computerized navigator for your car. *Popular Science*, pp. 65–67.

Streeter, L. A. and Vitello, D. (1985). How to tell people where to go: Comparing navigational aids. *Int. Journal of Man/Machine Studies*.

van Opstal, L. H. (1985). Hydrographer, Royal Netherlands Navy. Proceedings of Workshop on Electronic Chart. Bedford Institute of Oceanography (unpublished).

https://doi.org/10.58440/ihr-29-a16