# The Status and Future of the Electronic Chart

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There is still fierce debate in the international community regarding the use and standards of electronic chart data and equipment. Whilst the standards for ECDIS are now virtually complete and type-approved equipment will be entering the market during 1998, there is currently no IMO/IHO compliant ENC data service from any national hydrographic office. It is expected that it will be 1 to 2 years before there is any appreciable quantity of ENC data supported by a proper update service. It will be many more years before ENC data becomes available to match the present coverage of paper charts, but we can expect that most major routes and the port entries of the majority of the world's trading nations will be available within a few years. This situation is examined, together with the ideas that IMO is considering to improve the availability of official electronic chart data. In addition, the distribution of electronic charts is discussed and the future trends in navigation that will occur with the availability of ECDIS equipment and related data are explored.

1. INTRODUCTION. The relatively short history of electronic charting, still in its 'teenage years', has always been beset by uncertainty and confusion. Unfortunately this is still the fact today, although a lot of effort is being expended to rectify the situation. Much of the problem is related to the need to get international acceptance for a standard that would meet the requirements of member countries of the International Maritime Organisation (IMO) and the International Hydrographic Organisation (IHO) for a system which would have the integrity and accuracy to replace the use of paper charts. Getting such international acceptance has taken a notoriously long time, perhaps exacerbated by being in a field related to computing, in which the technology is moving rather faster than the traditional speed of legislation. IMO and IHO refer to the approved system as the Electronic Chart Display and Information System (ECDIS).

2. ECDIS. At their 19th Assembly in December 1995, IMO adopted the ECDIS Performance Standard under Resolution A.817.[1] This states that 'ECDIS with adequate back-up arrangements may be accepted as complying with the up-to-date charts required by regulation V/20 of the 1974 SOLAS Convention'. The drafting of Resolution A.817 was delegated to a joint committee of IMO and IHO specifically set up for the task – the Harmonisation Group on ECDIS (HGE). Unfortunately this was not the end of the matter because the Performance Standard referenced certain IHO documents defining technical aspects of the data format and other matters, which at the time were not complete. Also, following normal procedures for IMO-defined radio and navigation equipment, the Performance Standard needed to be amplified by the International Electro-technical Commission (IEC) into a document suitable for ultimate use by



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equipment manufacturers and marine type-approval authorities. The IEC document has now passed through its first phase of international voting and can be expected to become an International Standard in the Spring of 1998 as IEC 61174.[2] In parallel, the IHO documents have been progressed and are now mainly in place.

Thus, during 1998 we can expect type-approved ECDIS equipment to come onto the market and, 'with adequate back-up arrangements' be used as a replacement for paper charts. What constitutes adequate back-up has now also been defined by IMO in a more recent resolution.[3] Although there are certain ambiguities in this resolution it can be expected that most administrations will allow back-up solutions based on the following options:

(i) The carriage of an additional type-approved ECDIS;
(ii) Reversion to paper charts on failure of the ECDIS;
(iii) Reversion to a non-ECDIS electronic chart system meeting certain minimum requirements and utilising data issued with the authority of a national hydrographic office.

The subject of back-up is explored more fully in Reference 4.

3. STATUS OF OTHER ELECTRONIC CHART SYSTEMS. During the development of the IMO Performance Standard for ECDIS, IMO made it clear that there were two groups of electronic chart equipment and related data. Systems which would meet the evolving Performance Standard were to be referred to as ECDIS; systems which did not were called Electronic Chart Systems (ECS). Only the former could be used to replace the paper chart; ECS must only be used in conjunction with paper charts (or an ECDIS). Unfortunately many marine manufacturers ignored the distinction and tended to call their own electronic chart system an ECDIS, whether it was designed to meet the emerging standard or not. Even today much advertising concerning electronic chart products is very misleading, continually adding to the confusion of the mariner. Electronic chart equipment can only be used as a replacement for paper charts if the equipment is proven to have met the requirements of the IMO Performance Standard (effectively type-approved to the IEC61174 standard) *and* is displaying chart data conforming to Edition 3 of the IHO S57[5] data standard *and* such data has been issued 'on the authority of government-authorised hydrographic offices'. Data conforming to this standard is known as the Electronic Navigational Chart (ENC).

Recognising that there would be a long period prior to the finalisation of the ECDIS and S57 standards and potentially an even longer wait for national hydrographic offices (HOs) to issue properly maintained ENC data, a number of private companies and certain HOs were prompted to develop alternative electronic chart data systems. Data from private companies will not be further discussed here, suffice to say that some of it is good, some of it is appallingly poor and very little is maintained to be in step with official HO Notices to Mariners (NTMS). What is of particular interest are the developments arising from two major HOs – the Admiralty Raster Chart Service (ARCS)[6] from the United Kingdom HO, and the BSB format issued with the authority of the US National Oceanographic and Atmospheric Administration (NOAA).[7]

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As opposed to the vector data format of ECDIS, both of these systems utilise raster data. In essence they are computer-displayable 'photographic' images of existing paper charts. The relative simplicity of data creation and update of raster format electronic chart data has led to the rapid availability of chart data from both organisations. The in-built geographical referencing of these systems allows specifically designed electronic chart equipment to overlay data simply and accurately, such as own-ship's position, radar tracked targets, planned route, ship's track, etc, but does not allow some of the advanced features of ECDIS. In particular, the ability of an ECDIS system automatically to alert the navigator of all charted dangers in both route planning and route execution modes is not possible with raster systems. (Some raster chart display equipment allows the navigator manually to create areas on the chart which will sound an alarm should the vessel be about to enter them).

The success of the ARCS and BSB formats has added to the confusion in the market. They do not comply with the IMO ECDIS Performance Standard, but they are issued on the authority of recognised national hydrographic offices which give the same assurance of the data as they do for the equivalent paper chart. Some other HOs are beginning to issue charts in one or other of these formats. They have most of the advantages of paper charts, enhanced by the nature of the computer format, but they are not ECDIS. The IMO/IHO HGE has been asked to decide whether such formats, issued with the authority of national HOs, can be used as an equivalent to the paper chart. This has resulted in the development of a draft raster chart standard by the HGE, known as Raster Chart Display System (RCDS). Both ARCS and the BSB data formats would comply with the requirements of such a standard – which also has clear functional demands on the chart display equipment. As yet no agreement has been reached on whether systems conforming to this standard can be given paper chart equivalency.

Both the UKHO and NOAA recognise that RCDS is not equivalent to, nor as good as, ECDIS, but nevertheless offers a better capability than paper charts, provided there is appropriate back-up. They cite many successful trials and the reported safe use by numerous professional mariners. The UKHO, supported by many nations, argue that the adoption of RCDS actually helps the introduction of ENC data and ECDIS. Readily available RCDS data could be used until a specific area has proper ENC coverage. The long timescales associated with the introduction of a useable world series of ENC charts would inhibit other than specialist use, if the mariner has to rely on a mixed use of paper charts and ENC data only. Other nations argue that the RCDS format has not properly been proven to be safe and its adoption might lessen the resolve of HOs to generate ENC data. Several manufacturers are trialing ECDIS-compatible equipment capable of additionally displaying ARCS, BSB and other chart formats, in so-called multi-fuelled systems. IMO and national maritime administrations will have to decide whether the mariner needs to use paper charts in parallel with these other formats.

4. DISTRIBUTION OF ELECTRONIC CHART DATA. To date, the distribution of raster and vector electronic chart data from national hydrographic offices has followed fairly conventional avenues, being made available to the professional mariner by direct collection from a chart agent, by post or by other

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courier service. For instance ARCS charts are distributed on CD ROM. Once a week an update CD is issued which contains data to 'correct' all ARCS charts issued by the UKHO. A combination of UKHO chart agents and ARCS equipment suppliers make these disks available to vessels.

During the next year HOs will start making ENCs and their updates available, possibly on a mixture of CD ROMs and $3\frac{1}{2}$ inch floppy disks. The old regime, where HOs freely let other HOs have access to their own data to convert into paper charts, does not extend into the digital age. Members of the IHO have agreed that if an HO wishes to use another HO's data, bi-lateral agreements need to be set-up and royalties agreed. In practice this will mean that a complete world series of charts is unlikely to be available from a single source. The IHO has envisaged that a series of Regional Electronic Navigational Chart Co-ordination Centres (RENCs) will be set-up, responsible for issuing data from a group of regional HOs and possibly also issuing data from other RENCs. To date only one major RENC has been formed, known as the North Europe RENC, which seems to be gaining credence among many European HOs, extending even to the Mediterranean. This RENC will attempt to ensure that at least Northern Europe is covered by a co-ordinated set of ENC data and would hope to issue ENCs from other HOs around the globe.

It is unlikely that shipping companies trading internationally will wish to deal with numerous HOs and RENCs to get their electronic chart data, when they can presently get a world series of paper charts from a single agency. Thus chart agents, new and old, are also likely to be very involved in the supply of raster and vector electronic chart data, perhaps fully integrated with a paper chart service, particularly during the extended years of transition from a paper to a digital environment.

The digital nature of electronic chart and update information makes the eventual transmission of such data using various telecommunications and satellite channels a certainty. Whilst the bulk transmission to a vessel of numerous complete charts is currently unfeasible due to the cost and channel capacity of existing services, it is becoming cost-effective to be able to transmit update information and even the occasional chart. Such services could also carry data to print out paper chart correction tracings on the vessel. With the advent of Low and Medium Earth Orbiting Satellites (LEOs and MEOs) a complete transmission service of electronic charts and their updates may be possible in just a few years. Such transmissions will become part of a totally integrated digital information service to the mariner.

It will be interesting to see how such a future will evolve. For instance, with high integrity, high capacity, global transmissions it could be possible for vessels to download only the latest copy of the chart information relevant for that part of the voyage. Unfortunately the mariner cannot therefore look forward to a huge cost reduction even with only one copy of a chart on board the vessel at any one time – the hydrographic offices will still be wanting to defray a significant proportion of their operating costs!

5. THE USE OF ECDIS EQUIPMENT AND ENC DATA. The mariner will clearly get immediate benefit from the use of official ENC and RCDS data. The data

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will have accuracy and integrity standards at least as good as paper charts. Proper updates will be available, at least matching the quality of existing NTM services. Updates at sea, as noted above, will become the norm, allowing the vessel to be immediately notified of the latest navigational information. Vessels unexpectedly diverted to another port or to another route because of safety or commercial reasons will be able to get quick access to charts that are not normally carried by that vessel, avoiding dangerous or expensive delays. Route planning will be enhanced and considerably simplified. Route execution may be performed to a higher degree of accuracy, ensuring higher standards of safety and potentially saving fuel worth thousands of dollars per voyage. ARPA-tracked targets from the radar can be automatically displayed as vectors on the chart. These vectors can often give the mariner a better understanding of the intentions of surrounding vessels, when directly and immediately compared with the charted information.

'Raw' radar overlays on both ECDIS and RCDS data displays are already available on some manufacturers' equipment, using sophisticated display technology to avoid obscuring essential charted information. This can give enhanced correlation of radar returns with charted radar observable features. Errors in the primary (or integrated) position fix are quickly noted on such equipment should radar returns from charted objects no longer co-locate. In the future, radars will become available which will use ENC data for deriving radar mapping information, which currently has to be laboriously compiled by the mariner, sometimes inaccurately. Multi-functional equipment, which can act as an integrated navigation system, radar display, electronic chart or as a combined display, will become common. These will greatly enhance the 'availability' of the critical navigation functions of the vessel, allowing a multi-display bridge to be automatically and instantly reconfigured if a malfunction occurs in any of the bridge display equipment.

IMO are currently formulating standards for Automatic Identification Systems (AIS). Special equipment will be fitted to vessels that transmit their own navigational and vessel information in response to interrogating signals from port authority systems or other vessels. This information will be displayed on electronic chart and radar displays, enhancing the visibility and intentions of all vessels. AIS symbols are already included in the ENC symbol library. Port authorities are considering whether they could additionally transmit preferred routes and other data for individual vessels, which could be displayed on a future ECDIS.

In the more distant future ENC data will become integral to highly intelligent collision avoidance systems. Systems are currently being demonstrated which give the mariner early advice on the actions needed to avoid collision with other vessels in crowded waters. Prototype Collision Avoidance Advice Systems (CAAS) already take into account the desired course of the vessel, the IMO collision regulations and the handling characteristics of the vessel. Research is now in hand to enhance the usefulness of such equipment by taking into account ENC data. Thus buoyage systems, traffic separation zones, shallows and other hazards will additionally be taken into account by the expert system contained within the equipment. Whilst the research is directed towards advice systems it could, in principle, be used as the basis for the fully automatic control of vessels. With high

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integrity DGPS, automatic radar tracking enhanced by AIS and better ship prediction and control models, it is quite possible to foresee that such systems could become, in the more distant future, safer than traditionally manned vessels.

6. CONCLUSIONS. Despite the agony and protracted timescales that have occurred in getting official status for electronic charts and the seemingly interminable wait for data, the light is now visible at the end of the tunnel for a revolution in the safe navigation of vessels. New 'multi-fuel' chart displays, type-approved to the IMO ECDIS standard and able additionally to display other data standards, will be coming onto the market during 1998. There will be a rapid introduction of services to transmit electronic chart update information directly to vessels. Many future improvements to navigational practice can be foreseen once there is a wide availability of ENC data.

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## KEY WORDS

1. Maps/Charts. 2. Electronic. 3. Displays. 4. Sea.

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