

Feedback from users of electronic chart technology

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1. Abstract

Electronic Chart Systems have been used by mariners across the entire user spectrum without official standards or specifications for 10 years. In the last three years the debate has centred on chart data and the merits of differing cartographic technologies. There is little new that can be said for or against raster or vector technologies except what actual users might say, to support the requirements of their day-to-day operations.

Today, we approach a new stage as ENC's start to become available but only for limited areas. This in turn means that ENC's are capable of supporting the only approved electronic chart system, ECDIS, in a limited way. There is an urgent need for alternatives to ECDIS to cover those areas where ENC's will continue to be unavailable for the foreseeable future.

This paper therefore summarises feedback from users of RCDS and ECDIS-type systems to demonstrate the benefits which can be secured from official recognition of RCDS systems as the legal equivalent of paper chart navigation.

2. What is the navigator looking for?

It is so easy to forget that the end user is simply looking for a benefit. He is not concerned so much with the type of chart, the producer of it, the advanced nature of the system's capabilities and so on, as in how the system will help him perform his daily tasks, with improved safety and efficiency.

The real requirement for a navigation system could not be put more clearly than in the following statement:

(I want) "a reliable, accurate and continuously updated position related to charted features, with a simple method of ascertaining from the display the distance from perceived hazards without involving too much distraction from the task of conning the

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vessel. Plus a simple means of checking the accuracy of GPS position against other fixing methods”ⁱⁱ

and ...

“A reliable and simple to use passage planning tool”ⁱⁱ

3. The necessity for the “dual fuel” system

The “raster v vector” debate seems to have carried itself well beyond the fundamental needs of safe navigation, spreading confusion and uncertainty about different chart and system standards. As a consequence, many users are being needlessly denied access to efficiencies, safety checks, and better navigational strategies.

What is not made clear by the proponents of vector charts is that there is vector and vector - i.e. official ENC vector data produced to an international standard, and privately produced vector data produced to a proprietary specification. You may have heard the phrase “vector is best”. Well, which vector? There is only one approved vector chart, the ENC, and ENCs can only be issued by or on the authority of national hydrographic offices. And the irony is that the debate is often rendered irrelevant by the simple lack of ENC vector data. There are no commercially available ENCs as I write.

Meanwhile, there are available now safe, accurate and consistent Raster Nautical Chart (RNC) services developed to a product specification, and a detailed performance standard has been set out to control the navigation systems which use RNCs, known as the Raster Chart Display System (RCDS).

To recap briefly on the RCDS draft performance standard: it largely mirrors the already approved ECDIS specification, but it states that in areas where there are no ENCs available (currently the whole world, but in the future, parts of the world), then official updateable raster charts may be used to fill the gaps in the chart coverage. We all know that ENC data will not be available for the foreseeable future for those parts of the world where the original survey data is not good enough. New surveys would have to take place first, and there is limited funding for major new survey work.

So the “dual-fuel” system, using part ENC, part official raster charts, is now a necessity. And since RNCs for the non-ENC areas are already available, mariners are justifiably questioning the lack of

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approval for the RCDS specification with RNCs. Why wait, they ask, until some ENC's become available, when the ARCS part of the system is already available and would give them many safety and accuracy benefits over paper chart navigation?

The feedback I am reporting in this paper is from Marine Superintendents and senior Masters onboard SOLAS registered vessels using RCDS systems safely and with increasing confidence.

4. RCDS benefits

Two Hydrographic Offices, the UK HO with **ARCS** (since March 1996) and the Australian HO with **Seafarer** (since December 1997) provide charts to RNC product standards. My company along with others has been able to supply systems using Raster Nautical Charts for over two years. This has enabled a large number of systems to be supplied to a very wide range of vessel types and for mariners to get genuine long term experience in the use of such systems.

The experiences reported here fall into the following main areas and the paper will be divided accordingly:

- Charts
- Chart Correction
- Position plotting and monitoring
- Safety benefits and the removal of risk of human error
- Limitations

5. Charts

The following comments were made in support of the quality of ARCS:

(we like the) “accuracy of reproduction and clarity of display”ⁱⁱ

“The fact that (ARCS) are direct reproductions of their paper equivalent means that it is easier for the user to relate to them rather than to other possible electronic chart aids”ⁱⁱ

(we like) “the fact that all chart features are displayed with no option to remove layers of information”ⁱⁱ

“ARCS charts do not wear out and necessitate costly renewals on the issue of new chart editions”ⁱⁱ

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“There is nothing which the paper chart provides that is not provided for in some way by the raster chart, always assuming that the charts are issued by a hydrographic office.”ⁱ

“The display makes it easier to see small chart details, especially at night”ⁱⁱ

5.1 Physical chart availability

An obvious limitation of the paper chart is that it has to be physically delivered to its destination. In practice this means that vessels may have to navigate without the charts required for a new destination if they do not stop en route.

This safety issue is resolved by RNC; ARCS and Seafarer raster charts allow chart permits to be sent by voice, fax or e-mail, so that charts already resident on the library CDs held on board can be unlocked for use.

This benefit is recognised by trialists who have commented:

“Due to the ease with which new charts can be obtained via a chart permit one is less dependent on chart suppliers if one receives a sudden change of Voyage Orders to areas for which charts are not carried”ⁱⁱ

“Since one can obtain permits and user entry codes for additional charts whilst at sea, the shipowner does not need to carry such an extensive chart folio to cover all eventualities - he can add to them at sea if unexpected voyage orders are received”ⁱⁱ

An incident reported on by the Australian Marine Incident Investigation Unit highlighted that vessels are routinely trading without the necessary charts on board. This was in the context of the grounding last May of the Western Winner on Tiparra, South Australia, where the master of the Western Winner said that he had four sudden changes of orders in the loading port and claimed to be unable to obtain the necessary charts before proceeding to sea.

5.2 Chart management

There is a physical benefit to electronic chart management. Electronic chart data requires virtually no storage space and any of the charts, once installed into the system, can be viewed after a few keypresses. The following benefits are reported:

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“ARCS do not require bulky storage space on the bridge and the display can be located with the needs of the navigator as a prime consideration rather than where there is sufficient space for a chart table”ⁱⁱ

“automatic chart correction, organisation of electronic charts without physical effort / distraction, calling up charts for examination without physical effort / distraction”ⁱⁱ

“The changeover from chart to chart is less time consuming and there is no risk of error in transferring position”ⁱⁱ

“The ease of ... chart management”ⁱⁱ

6. Chart Corrections, Electronic Charts and the ISM code¹

All commentators highlight the automation of electronic chart corrections as a very substantial improvement in vessel safety management which alone should impel the adoption of the RCDS performance standard at the earliest opportunity.

“The most noteworthy advantage of an RCDS displaying ARCS charts is the ability to efficiently and accurately correct charts in a timely manner with little effort on the part of the operator”ⁱ

(RCDS provides) “a much more reliable and consistent method of chart correction compared to manual methods”ⁱⁱ

“There is a considerable time-saving with regard to chart correcting, the Update CD taking at the most minutes”^{iv}

“The chart update method saves many hours work for the navigator, reducing fatigue, and probably enhancing the quality of visual lookout since it is inevitable that a lot of manual chart correction is done during watchkeeping time”ⁱⁱ

(There is) “no risk of human error, inefficiency or ignorance of proper chart correcting procedures. This ought to be a very important plus-point for Shipowners since it fulfils their legal responsibility for having adequate chart management systems in place with minimum training costs”ⁱⁱ

¹ I am grateful to Captain Joshi of Teekay Shipping for his contribution to this section.

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Captain S K Joshi, Marine Superintendent of Teekay Shipping (Canada) Ltd, provided a summary of shipowners responsibilities:

“The ISM code is all about changing the safety culture present at sea and ashore. Historically the ships were blamed for everything that went wrong at sea. Today this is changing and there is a realisation that owners, managers or operators have to take some, if not all, of the blame for what goes wrong on the ships.

There is a long list of items where management is responsible for taking care of ships activities in a safe manner. A major responsibility is to supply the ship with up-to-date navigational equipment, including approved navigational charts for the area where the vessel is planning to navigate and adequately qualified and trained staff.

The ISM code expressly requires the management to provide the vessel with resources and personnel for safety and environmental protection. SOLAS Chapter V Regulation 20 requires that “all ships shall carry up-to-date charts ... necessary for the intended voyage”.

This brings us to two fundamental issues: firstly, the ship must have the charts onboard for the intended voyage and secondly there must be a reliable system for keeping the charts corrected at all times with the latest corrections available.

The major problem on ships trading world-wide is the sheer number of charts which must be corrected up-to-date from the latest Admiralty Notices to Mariners. It is an extensive task for any average second officer. In addition to his other duties (watchkeeping, cargo watches and provision of medical attention) he has to correct all charts and publications. In practice, this job is quite likely done in his own time. With on average over 3000 charts on a world-wide trading vessel, this job is not the most exciting or entertaining task in the world. Fatigue, boredom and the repetitive nature of the work take their toll on chart correction.

The reliability of chart correction is vital to the safe navigation of the ship. Yet the Master is unable to verify that the second officer has made appropriate corrections and maintained a proper log due to the sheer size of the task. There are three basic reasons for the unreliability of chart corrections. Firstly, due to work overload on the second officer, the job is done at the end of the day when he is tired so the corrections may not be applied accurately. Secondly, on a number of ships the second officer may be

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ignorant of the importance of chart corrections and is not trained in chart correcting. Chart correcting is not a subject in any syllabus for examinations nor is it taught in schools. It is learned on board by observing the senior officer doing the job. Thirdly, and most regrettably, the officer may be too lazy to correct the charts, instead making false entries in the log and in the left bottom corner of the chart without actually correcting the chart itself. Occasionally one comes across a second mate who does this at sea. The Master cannot physically check all the charts for correction. He has to delegate and rely on his officers.

Under Rule 7 of the ISM Code, development of plans for shipboard operations is an essential part of the Safety Management System. This includes identifying all operations affecting safety. These can be classified in four categories namely: normal, special, critical and emergency operations. Chart corrections fall under the critical category. The totality of corrections, accuracy of corrections and record keeping of corrections are all critical to the safe navigation of the ship. If one has to look into the functional requirements of Safety Management Systems (SMS) related to safe navigation of the vessel as a pro-active measure, there has to be a check list to ensure availability of an up-to-date corrected chart for navigation.

The foregoing discussion establishes the necessity for corrected charts under the ISM code. This can only be achieved with current reduced manning on ships by an automatic electronic process. This in turn is only possible with electronic charts (whether they are raster or vector is not of the greatest importance). The human element is avoided in electronic chart correction thereby increasing safety and saving a considerable amount of time to devote to other safety measures.

If there is an accident and the root cause is traced to inadequately corrected charts, the ship will be held to be unseaworthy.

This alone in my view should prove the case for compulsory use of electronic charts onboard in the near future.^{»iii}

7. Position plotting and monitoring

All navigators have the same fundamental requirement for accurate and, in the modern age, automatic plotting of position. Comments included:

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“Full navigational information is available at the position of control without the need to move to a separate chart table / chartroom.”ⁱ

“The risk of operator error in plotting positions is eliminated”ⁱⁱ

“instant real-time display of current position with up-to-the-minute course made good speed trend indication”ⁱⁱ

“Position relative to chart features, at that instant, is readily available to the navigator without the distraction, and time required, to plot a fix”ⁱⁱ

Fast ferry operators where vessels are moving at speeds over 40 knots and where position will have changed significantly in the time it takes to plot onto paper, commented in particular on:

“the ability to note at a glance any impending dangers relating to position”^{iv}

“the operator does not have to leave his chair to plot a position and combined with DGPS, approaching danger and potential manoeuvres to avoid traffic are much more easily identified”^v

7.1 Chart datums and offsets

The RNC product specification requires that the RNC provides a quality-checked shift from WGS84 to the RNC’s local datum. This enables GPS positions to be accurately plotted on non-WGS84 charts. (This is not a concern for ECDIS since all ENC data should be referenced to WGS84). This capability is a great benefit of RCDS which will have geodetic datum management built in because:

“It eliminates the need for the navigator to check each chart for datum corrections, and to apply the manual updates to the GPS receiver”ⁱⁱ

“It simplifies watch handover procedures in that less time is spent by the incoming OOW in checking his predecessor’s actions”ⁱⁱ

“It eliminates the risk of erroneous positions if the foregoing precautions have been forgotten or misapplied”ⁱⁱ

“It is very beneficial when changing charts in busy waters where safety considerations dictate that the time could be better spent monitoring the ship’s planned passage and traffic situation”ⁱⁱ

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8. Safety benefits and the removal of risk of Human Error

Several commentators highlighted direct safety benefits as follows:

“Because most of the inputting of courses etc is automatic there is much less risk of human error whilst inputting the route”ⁱⁱ

“The speed at which routes can be planned and modified, and then downloaded to printer and GPS receiver (as back-up in monitoring cross track error)”ⁱⁱ

“It is easier to check the planned route for hazards by just scrolling along the track without having to physically pull out the next chart”ⁱⁱ

“Courses are automatically calculated so there is much reduced risk of human error compared to the transfer of conventional passage plans to paper charts”ⁱⁱ

“Data concerning speed and course made good is available at the chart without having to consult different equipment for the information, thereby reducing workload on the navigator who is conning the vessel”ⁱⁱ

“(improved) ... position fixing capability of a navigational watch manned by ill-trained, inefficient, fatigued, or poorly motivated navigators - unfortunately a very real and important consideration nowadays”ⁱⁱ

“The automatic application of known datum errors to WGS84 means that the risk (with paper charts) of the user forgetting to apply these corrections is eliminated”ⁱⁱ

9. Limitations

9.1 Backup

“Due to the nature of the equipment (both hardware and software), the possibility of failure exists, which is not the case with the paper chart. The provision of a back-up system does, however, overcome these problems.”ⁱ

The draft RCDS performance standard has allowed for this and requires that “adequate back-up arrangements shall be provided to ensure safe navigation in case of RCDS failure”.

9.2 Look ahead

“Occasionally look ahead facility can be restrictive”ⁱ

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“The difficulties associated with portraying a large chart on a small screen .. makes it time-consuming finding the ‘out of immediate area’ features of the chart you wish to examine”ⁱⁱ

The foregoing points can be solved by the chart viewing software either through multiple chart windows (allowing small and large scale views to be displayed simultaneously) or by the system being capable of over-riding the normal vessel-centred display when necessary.

10. Conclusions

A number of the points made in this paper relate to the general benefits of an electronic system over paper, rather than specifically to the use of RNCs, but without the necessary approvals these users are unable to use RCDS to its fullest extent. And the vast majority of ship operators will not even purchase such systems, despite their benefits, whilst they are obliged to run full paper systems as well.

Those companies who are using RCDS are very positive about the safety and accuracy gains from using ARCS, and unanimous in their desire for the draft RCDS specification to be approved. Here are some comments in conclusion which pinpoint RCDS advantages:

“RCDS is a great aid to navigators in that it applies known errors, and given the automatic presentation of a reliable fix on a corrected chart display, will probably reduce the frequency of navigational error. This is an important point in an era when a large percentage of the world’s navigators are insufficiently trained”ⁱⁱ

“RCDS is also an incredibly efficient time saver for the navigator. Very few ships now are not under-manned in some respect and anything which reduces workload and fatigue of the navigator, and provides a more effective method of working, should be given very serious consideration.”ⁱⁱ

“At present, the 300 paper charts carried on each of our ships have to be corrected manually. The ARCS charts on board the same ships, however, are corrected each week from an Update CD issued by the UK HO. Provided the Update CD is loaded into the computer, which can be documented and takes about five minutes, the ARCS charts are automatically corrected. Indeed, one can justly argue that ARCS is not just the equivalent, but better than the paper chart, since one is no longer relying on hard-pressed ship’s officers to correct all their charts each week.”^{vi}

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“It was widely assumed within all sectors of the maritime industry that once an electronic equivalent of the paper chart was available, equivalency would be measured in terms of any improvement which was provided by the newly developed system. I believe that all interested parties would agree that the ARCS system, with back up provision, is in all ways at least equal to the paper chart, with the exception of correction facilities which are in themselves a demonstrable improvement.”ⁱ

For myself, I would like warmly to thank the small, but growing, band of users who are providing such thoughtful real-time testing of RCDS and giving the shipping industry in general, and my company in particular, such valuable feedback. The resulting improvements in systems and understanding of RCDS are due to these pioneering companies whose input will benefit the entire industry in the longer term.

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Appendix 1 Glossary of Terms related to Electronic Charting

ARCS	<u>Admiralty Raster Chart Service</u> - the UK HO proprietary RNC.
ECDIS	<p><u>Electronic Chart Display and Information System</u></p> <p>The performance standard for ECDIS approved by the IMO assembly in November 1995. The standards are defined in documents of the IHO and IEC: IHO Special Publication S-52 Provisional Specifications for Chart Content and Display of ECDIS; IHO Special Publication S-57 IHO Digital Data Transfer Standard IEC 1174 ECDIS Performance Standards.</p> <p>Note: The ECDIS standard is designed for use by vessels governed by SOLAS and requires data meeting the above standards which, at the time of writing (October 1997), is not commercially available.</p>
ECS	<u>Electronic Chart System</u> - a chart system which does not meet the requirements of SOLAS V/20 and is not defined by official standards.
ENC	<u>Electronic Nautical Chart</u>
EPFS	<u>Electronic Position Fixing System</u> GPS, Loran, Decca etc
HCRF	<u>Hydrographic Chart Raster Format.</u> This is the format developed by UK HO and used (at September 1997) by the UK HO for its Admiralty Raster Chart Service (ARCS) and the Australian HO for its Seafarer Chart Service. Other HOs are also expected to adopt HCRF.
IEC	<u>International Electrotechnical Commission</u>
IHO	<u>International Hydrographic Organisation</u>
IMO	<u>International Maritime Organisation</u>
NMEA	<p><u>National Marine Electronics Association</u></p> <p>NMEA 0183 version 2.01 is the standard which is defined to permit the ready data communication between electronic marine instruments, navigation equipment and communications equipment when interconnected via an appropriate system.</p>
RCDS	<u>Raster Chart Display System (RCDS)</u> means a navigation information system which can be accepted as complying with the paper version of the up-to-date chart required by regulation V/20 of the SOLAS Convention, by displaying RNC's, with position information from navigation sensors to assist the mariner in route planning and route monitoring, and if required display additional navigation-related information. A draft performance standard for RCDS is being considered by IMO.
RNC	<u>Raster Navigational Chart</u> means a facsimile of a paper chart. Both the paper chart and the RNC are originated by, or distributed on the authority of, a government authorised hydrographic office.
S-52	IHO standard which defines the presentation of chart data on an ECDIS display
S-57	IHO standard which defines the chart data format (DX90) and encoding for ECDIS

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SOLAS

The International Convention for the Safety of Life at Sea. Chapter V Safety of Navigation, Regulation 20, Nautical Publications requires that: “All ships shall carry adequate and up-to-date charts, sailing directions, lists of lights, notices to mariners, tide tables and all other nautical publications necessary for the intended voyage”

SOLAS does not apply to (Regulation 3 Exceptions):

- I. Ships of war and troopships
- II. Cargo ships of less than 500 tons gross tonnage
- III. Ships not propelled by mechanical means
- IV. Wooden ships of primitive build
- V. Pleasure yachts not engaged in trade
- VI. Fishing vessels

ⁱ Captain E W Lyons, Marine Superintendent, F T Everard & Sons Ltd (SOLAS I V Trial)

ⁱⁱ Captain David Picking, Master of Euplecta, Shell International Trading and Shipping Company Ltd (SOLAS I V Trial)

ⁱⁱⁱ Captain S K Joshi, Marine Superintendent, Teekay Shipping (Canada) Ltd

^{iv} Captain C Clare, Master, Stena Line Ltd

^v Captain A C Humphreys, Senior Master, Stena Line Ltd

^{vi} David Williams, Coastal Operations Manager, Shell (UK) Ltd