

**11th CSPCWG/1st NCWG Meeting
Rostock, Germany, 27-30 April 2015**

Paper for Consideration by CSPCWG/NCWG

The Future of the Paper Chart

Submitted by:	Australia, New Zealand
Executive Summary:	This Paper summarises activities and discussions related to the increasing use of ENC and ECDIS as the primary navigation product for SOLAS vessels and the possible impact of this on the future of the paper chart as a primary navigation product.
Related Documents:	<ol style="list-style-type: none"> 1. CSPCWG9 Minutes – 10.2: Discussion on INT charting; 2. CSPCWG10-13.1A_Future_of_Paper_Charts [presentation]; 3. HSSC5-INF7_Future_demand_for_paper_nautical_charts; 4. Next Generation Paper Chart [by Ian Halls – International Hydrographic Review May 2014]; 5. HSSC6-INF1 – Australian experiences from deriving paper charts from ENC.
Related Projects:	IHO MS Chart Producing Authorities – Chart Portfolio's; Paper chart and ENC consistency.

Introduction / Background

As Hydrographic Offices (HO's) move increasingly towards ENC as the main focus of navigational chart production, there have been proportionally increasing questions asked in regard to the continued investment by Hydrographic Offices in paper charts. This increasing focus on ENC is in relation to:

- The increasing uptake of ENC and ECDIS (and the generally corresponding reduction in paper chart requirements) by mariners;
- The incremental mandating of ECDIS on SOLAS class vessels by the IMO (complete mandation by 2018);
- The evolving expectations and skills of the current and future mariner; and
- The development and implementation of the e-Navigation concept.

In addition, further emphasis is being placed on the ability of HO's to maintain multiple nautical chart product streams in an environment of at best static or, more commonly decreasing, national resources (in terms of personnel, budget and nautical cartography experience).

A major factor in this regard will likely be the continuing divergence of the construction and content of paper charts and ENC's to provide the best information for the mariner in regard to the way that the products are used in the planning and operational environment. These constraints and evolving issues for HO's will be the subject of additional Papers for CSPCWG11/NCWG1.

Initial discussions regarding the possible future of the paper chart took place on an informal basis at CSPCWG9 in Seoul, South Korea in November 2012 (ref (1)). This was followed up with a presentation by the CSPCWG Chairman at CSPCWG10 in Wellington, New Zealand in January 2014, which prompted further discussion within the Working Group but no substantive recommendations (ref (2)). Concurrent to discussions within the CSPCWG, related discussions have taken place and Papers written which raise additional issues related to this subject.

Two of these Papers have been included as Annexes to this Paper (ref (3) and (4)) to inform and promote discussion at CSPCWG11/NCWG1. Additional comments related to the discussions at CSPCWG10; and some additional issues that have been recently raised within the IHO or discussed within the Australian Hydrographic Office (AHS) and Land Information New Zealand (LINZ), are also included in the Analysis/Discussion section of this Paper.

Analysis / Discussion

The following analysis is based on the presentation from the CSPCWG10 meeting in Wellington, New Zealand in January 2014. The relevant slides from this presentation have been included for reference,

and the initial notes made by the Australian delegate to the meeting, expanded on as a result of further discussion by Australia and New Zealand, included beneath each slide.

In addition to the information below, the Papers contained in the Annexes should be read in order to promote further discussion at CSPCWG11/NCWG1. It should be noted that these Papers have been used as reference information to inform and contribute to the discussions that have taken place in the AHS, and are not to be interpreted as the national Australian position as to the future of the paper chart.

Factors influencing requirements

- What requirement beyond 2018?
 - National application of SOLAS?
 - Extend beyond SOLAS definitions?
 - Port State and Flag State views?
 - Will paper be ‘illegal’ as regulated carriage compliant? If not, how may it live on? Eg ECDIS back-up, planning, context overview
- Communities not impacted by SOLAS – significance, obligations, best practice, priorities?
- Do Paper Charts remain in your long-term plans?

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Overall, this needs to be considered from a HO perspective in terms of the question “who are our charts intended for?”. The Vision of the IHO (as taken from the IHO web site home page (<http://ihonet.int>) is “... to be the authoritative worldwide hydrographic body which actively engages all coastal and interested States to advance maritime safety and efficiency and which supports the protection and sustainable use of the marine environment”. Is it intended that this Vision extend beyond the requirements of SOLAS? It must be stressed here that the provision of an adequate charting service (including ENC coverage) is the responsibility of the coastal State, and not the IHO. However this does not mean that the IHO cannot “engage” with coastal States in developing guidance as to what constitutes an adequate charting service in regard to the classes of vessels taken into account.

In order to ensure consistency of nautical chart service carriage requirement for the international mariner the views of Port and Flag States should be similar if not the same, otherwise the mariner will be subject to the possibility of different requirements dependant on the jurisdiction of the waters in which they are navigating. This has already been reported to be a reality as some coastal States have insisted on mandatory carriage of paper charts, even where the vessel satisfies the IMO chart backup requirement through installation of an “independent” 2nd ECDIS. The IHO should have the role in defining this “consistent view”. While the IHO has done this extremely well with the INT paper chart concept, there may be scope for expansion given the advent of a multi-product environment. While the WEND concept is attempting to provide a similar baseline for ENC for the international mariner, this has been treated to now in isolation from the INT paper chart concept.

The question as to whether paper charts should be continued to be (at some point in the future) a primary navigation product in terms of SOLAS V/9 is a decision for the IMO. However the question is whether the IHO has a role in informing the IMO to assist in making this decision? Consider that if the paper chart is not considered a primary navigation product then it would follow that paper charts would not be considered to be an adequate back-up to ECDIS.

From an AHS perspective the paper chart remains in our long term plans (AHS Hydrographer comments December 2013, re-enforced December 2014), however it should be noted that at this stage there has been no discussion with the Australian Maritime Safety Authority (AMSA) on this topic. The AHS is continuing to transition (from March 2014) from a process of ENC as a derivative of the paper chart to the paper chart as a derivative of the ENC. The intent is for a paper chart to be compiled from a corresponding ENC source within a period not exceeding 2 weeks (for comments related to the Australian

experience to date refer to Paper HSSC6-INF1 – Australian experiences from deriving paper charts from ENC). Due to the potential, however minimal, for a catastrophic failure in the ECDIS, or issues with GNSS receivers or gyro compass interaction within ECDIS, we consider that paper charts in some form will continue to be considered to be a prudent back-up for the mariner. From this perspective we do not see any motivation for the IMO at this stage to remove the status of the paper chart as an “official” navigational product.

Production Questions?

- Optimising efficient production systems (>5 years) for:
 - Production from a product-neutral hydrographic database (with product tagging, portrayal)
 - Print from ENC
 - Print by HO, distributor, user on board, method (eg litho, ePOD)
 - Unit costs of paper charts – user demand, supportable?
- Define minimum content requirement for safety?
- Define maximum content for usability?
- Official status, safety & quality assurance, liability?

Many “mature” HO’s have already, or are in the process of, transitioning to a “product neutral” hydrographic database for source product data storage and management. The transition from the paper chart to the ENC as the primary HO nautical charting product will focus increasing pressure on producers to derive their paper charts from ENC; or ENC and paper chart concurrently from a single source, with minimal resource application in order to save money and time.

AHS comment from CSPCWG10: “Very good point in regard to determination of maximum content in order to not overburden the mariner with information (note UK observations in CSPCWG10-INF3)”.

Core familiarity of the user (ENC, Paper)

- Cartographic principles - common or different?
- Symbology – sufficiently similar or different:
 - Same features portrayed the same
 - Different features portrayed distinctly different
 - Are all symbols intuitive and unambiguous?
 - Impact of conditional symbology?
 - Is there a symbology gap - review and modify?
- Does format constrain best portrayal
 - are differences necessary, essential?
 - Paper ‘push’ v ENC ‘pull’

It can be considered that the fundamental cartographic principles for ENC and Paper Chart are not different, and further considered that these fundamental principles will never diverge. However, as further feedback is received from mariners in the use of ENC in ECDIS (including AHS nautical cartographer participation in an IMO recognised ECDIS training course), it is becoming more obvious that the general principles of nautical cartography for ENC require refinement to adapt to the way that ENC data can best be utilised by the mariner. This includes ENC scheming and optimum ENC display scale according to purpose; ENC content and associated encoding rules; and maintenance regime (see further comments for the following slide).

It is important to note that the technological advances in standards relevant to ECDIS hardware and software, including portrayal standards relevant to improving display resolution of the ECDIS screen, is a long way behind the rest of the technical world. These technological advances, particularly in terms of the improved clarity of symbols on the ECDIS screen, has the potential for an increasing correlation between paper chart and ECDIS symbols, although compromises may need to be considered in some cases for paper chart symbols. Where possible, the IHO must strive to achieve consistency between the information displayed on the ECDIS and the information portrayed on a paper chart, even if the content is by necessity not consistent. It is anticipated that the recent re-structure of the HSSC Working Groups, and the anticipated role of the NCWG in taking on the role of developing symbols for use in ECDIS in addition to the paper chart (to be discussed at CSPCWG11/NCWG1), will significantly improve this consistency.

AHS comment from CSPCWG10: "Very good point in regards to ENC distribution, which will likely be much more interactive in terms of the mariner requirement given the advances in satellite data transfer technology; and innovations in ENC packaging; licensing (access); and distribution as developed and implemented by ENC Service Providers".

Chart design questions?

- Scale of portrayal – retain, modify, reduce?
- Numbers – less?
- Content – retain, change, reduce?
- Maintenance regime – same or less?
 - NM, updates, frequency
 - ENC in advance; by design or requirement?

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It is considered that this is where the largest divergence between ENC and paper charts will occur. ENC is not constrained by scale, geographic extent (only by data volume) or paper size (only by file size), and has more flexibility in terms of the way that the data can be presented to the mariner.

Recent discussions within the AHS have been initiated from nautical cartographer attendance at an IMO approved ECDIS training course. Attendance involves cartographers participating as observers in the course with Masters, Navigators, Pilots, Tug Captains, and Port Administrators, utilising interactive variable ship bridge simulators consisting of a "standard" integrated navigation bridge system (3-person configuration consisting of ECDIS (Master), Con (Navigator) and Radar (Pilot)) with published "official" ENC's for the ECDIS and as a Radar overlay/underlay. This has facilitated considerable feedback and discussion within the AHS as to how our ENC data is used by the mariner, and how the structure and content of our ENC's can be improved to facilitate this usage. The resultant amendments to our ENC scheming and content specifications has resulted in some significant departures from the format and information that is provided in the "corresponding" paper chart. As discussed at CSPCWG9, the medium-

term future of the paper chart may be to provide a smaller scale “overview” to what the mariner is using within the confines of the ECDIS monitor to provide a wider, more complete indication of situational awareness. If this proves to be the reality, this may be achieved adequately through filtering and printing ENC data for the appropriate area at an appropriate scale, which may be a function of route planning.

In terms of maintenance, producers and distributors of ENC should be working towards the concept of the promulgation of “real time” Updates, and in terms of the paper chart this perhaps should not be discounted, perhaps through leveraging off the ENC Update transmission process? Looking at the ENC Update process and its impact in terms of mariner requirement, the AHS is beginning to move away from “product-centric” projects aimed at initial promulgation of safety-related and other navigationally significant information via the Notices to Mariners (and ENC Update) process, with full inclusion of other hydrographically relevant source information on an opportunity basis. The intent is to move to more “data-centric” projects which, in addition to the Notices to Mariners/ENC Update process, will involve full inclusion of all hydrographically relevant information in ENC’s as part of the flow of source data through the AHS. This will result in more frequent publication of New Editions of ENC’s containing all the latest hydrographically relevant information available to the AHS. The possibility to implement this is directly related to the ENC service provision and ECDIS data updating process, given that the provision of New Editions of ENC are part of most ENC service agreements (no additional cost to the end user) and requires minimal time and effort by the end user (mariner) to load into the ECDIS.

Discussions within the AHS regarding the structure and content of ENC based on mariner feedback, and the relationship between product updating mechanisms (paper chart Notices to Mariners/New Edition and ENC Updates/New Editions) has resulted in questions as to the definition of “consistency” between the information contained on ENC’s and corresponding paper charts. This is the subject of a separate Paper submitted to CSPCWG11/NCWG1.

Impacts?

- ENC stands independent
 - Full costs of generation / compilation – content, selection, quality assurance
 - Lower cost base or not?
 - Views of / endorsed by national safety agencies?
 - Modify ENC to support paper as bi-product?
- Paper chart undermined – safety, maintenance, user perceptions, less activity?
- Likely divergence of Paper and ENC, including NM updating regime – acceptable?
- Mariner – better served?
- MS’ capabilities (Capacity Building) – Paper cf ENC

The Australian experience to date is that, whatever product is a derivative of the other, it is not too much an issue in regard to resources required, but only on which product the product data content decisions are made. ENC still needs a major effort in terms of cartography to best present the information to the mariner (sounding selection, contouring, topography, etc) and has the added issue of variable display scale (SCAMIN), which the AHS has actually used to its advantage in terms of varying paper chart scale content. Additionally, it has been generally conceded by most producers that the paper chart will be a “subset” of the information provided in the “corresponding” ENC (although not in terms of essential content). In terms of the ability for the future mariner to safely navigate on the paper chart, this is not as much an issue of presentation or content (the paper chart has been considered a very safe product on which to navigate for a very long time), but more the mariner knowledge (training, etc) in using the paper chart utilising traditional terrestrial navigation techniques. With different delivery mechanisms, it seems obvious that ENC Update delivery and paper chart NM delivery will increasingly diverge, although that

does not mean that this should be automatically conceded – investigations should be conducted as to how NM promulgation could leverage off ENC Update distribution.

Additional Considerations:

In addition to the above comments in relation to Paper CSPCWG10-13.1A, AHS and LINZ discussions have identified the following considerations that should also be taken into account when considering the future of the paper chart:

- The possible “look” of the Paper chart in the future – printing a paper chart directly from an ENC (refer to Annex B).
- The “economic reality” – having to do more (maintaining multiple product streams) with the same or less (in terms of budget and human resources).
- The “skills reality” – decreasing skills in nautical cartography (in particular related to paper chart presentation) world-wide. This is the subject of a separate Paper submitted to CSPCWG11/NCWG1.

Conclusions

Hydrographic Offices are now required to maintain portfolios of paper charts and ENC's in an environment of static, if not decreasing, economic and human resource availability. While advances in spatial database technology have greatly assisted in regard to generating multiple product streams from a single source database, the continuing evolution of ENC's in accordance with the way that mariners navigate using ECDIS will likely result in an increasing divergence between paper chart and ENC product streams. Hydrographic Offices will be increasingly seeking economies in their nautical chart production and maintenance processes, and with ENC beginning to gain ascendency for mariners at the expense of the paper chart, there will be increasing pressure to achieve these economies through cessation of what may be seen by the Hydrographic Office (or national maritime safety authority) as a redundant product stream.

From the above analysis and the Papers included in the Annexes below, the following are some questions that can be raised (there may be others!):

- Should the IHO be providing a clearer indication to HO's as to whom nautical charts are intended for (if more than just compliance with the requirements of SOLAS V/9), or should this be purely a decision for HO's? [NOTE: This question should take into consideration the intent of the Vision of the IHO.]
- Do we agree that as long as the IMO continues to include the paper chart as a primary (“official”) navigation product (which by extension includes the paper chart as an approved back-up to ECDIS), HO's should have a responsibility to continue to provide a paper chart service?
- Should there be an investigation carried out to determine whether the INT charting scheme could be extended to take into account mariners operating in a multi-product environment?
- Does the IHO have a role in informing the IMO at some time in the future as to the continuing relevance of the paper chart as a primary navigation product?
- Is there a role for the paper chart in the future to provide the mariner with a smaller scale and wider “overview” in order to assist with situational awareness? If yes, could a “printout” of an ENC satisfy this requirement?
- Can a better maintenance regime be established for the paper chart that leverages off the ENC Update process?
- What will be the future impact of ECS (Electronic Chart Systems) that can utilize ENC data on the “non-SOLAS” (recreational) mariner, and how does this impact on the question of the future requirement for paper charts (refer Annex A)?
- Should the IHO investigate the requirement for a new Product Specification in S-100 for generating paper chart plotable files (content (i.e. minimum content) and portrayal) directly from ENC (refer Annex B)?
- What is meant by the term “consistency” in regard to ENC and paper chart content? [NOTE: This is the subject of a separate Paper for CSPCWG11/NCWG1.]

Recommendations

This Paper and its Annexes are intended to facilitate discussion within the CSPCWG/NCWG in order to enable the development of a discussion/position Paper for the HSSC outlining options for the possible future of the paper chart as a primary navigation product.

It is recommended that the questions posed in the Conclusions above, as well as any other questions raised from the analysis above, be discussed and a small NCWG Project Team established to develop a Position Paper including an IHO position regarding the future of the paper chart for the next generation of mariners. The recommended timeframe for this Project would be for the Project Team to have a draft Paper prepared for NCWG2, with the aim of the NCWG approving a final Paper to be presented at HSSC8 (November 2016). These recommendations are aimed at addressing Work Item A16 of the NCWG Work Program.

Justification and Impacts

Investigation and recommendations from the IHO regarding the future of the paper chart may assist Hydrographic Offices and national maritime safety authorities in taking a consistent approach in regard to assessing the future relevance and purpose of the paper chart as a primary navigation tool for their national waters. Such guidance should be considered equally important for international waters.

Ultimately, taking a consistent approach with regard to the future of the paper chart will be of benefit to the mariner.

Action required of CSPCWG

The CSPCWG is invited to:

- a. **Note** this Paper.
- b. **Discuss** the analysis provided in the Paper and Annexes, and conclusion derived from this information.
- c. **Agree** to the establishment of a NCWG Project Team to further develop a position paper for an IHO perspective on the future of the paper chart.

Annexes:

- A: HSSC5-INF1 – Future Demand for Paper Nautical Charts.
- B: International Hydrographic Review, May 2014 – Next Generation Paper Chart (by Ian Halls, AHS).

HSSC5-INF1

**5th IHO-HSSC Meeting
Shanghai, China, 4-8 November 2013**

Information Paper for consideration by HSSC

Future demand for Paper Nautical Charts

Submitted by: Australia

Executive Summary: Australia has conducted an analysis of ongoing demand for paper charts beyond completion of transition to mandatory use of ECDIS and ENC in 2018. The study identified that demand for Australian paper charts is likely to decline by two thirds to three quarters of current levels. The analysis is likely to be broadly applicable and of interest to other Member States.

Related Documents: Nil

Related Projects: Nil

1 Introduction / Background

ENC coverage

1.1 Australia has completed initial ENC coverage and has a portfolio equivalent to the coverage provided by paper charts. Coverage consists of 862 ENC across five navigation purpose bands. The equivalent paper nautical chart portfolio consists of 464 paper charts. Most ENC were developed from paper chart content, but within this process, all paper charts were brought into metric units of measurement and referenced to WGS84, with numerous new and recent surveys added, and older surveys on unknown datums re-referenced by ships and survey teams, or reconnection to new geodetic frameworks. Over 95% of charts are now also referenced to Lowest Astronomical Tide.

1.2 The ENC are arranged in a regular geographic grid to assist in future data management and, with the exception of ports (and a very few others), do not follow the limits of paper charts. The alpha-numeric identifier of each Navigation Purpose 1 to 4 ENC refers to the latitude and longitude of the SW corner of each ENC. Despite the regularity of the grid, content is trimmed as necessary to avoid overlaps with ENC from adjoining producer nations. A comparison of the ENC and paper chart schemas is shown on the following page and clearly shows the relative simplicity of the regular grid schema.

1.3 Australian ENC are available for international mariners via the IC-ENC network, while the local AusENC service caters for smaller commercial and recreational vessels operating entirely within Australian and Papua New Guinea (PNG) waters.

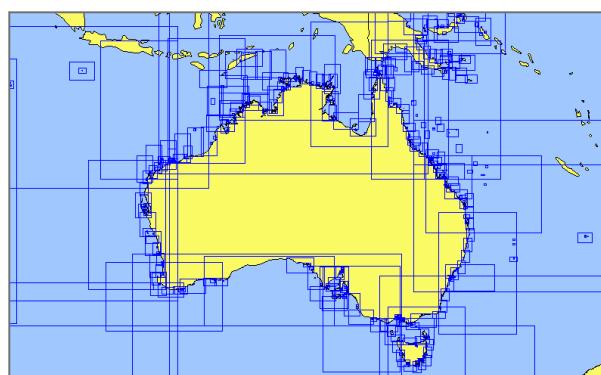
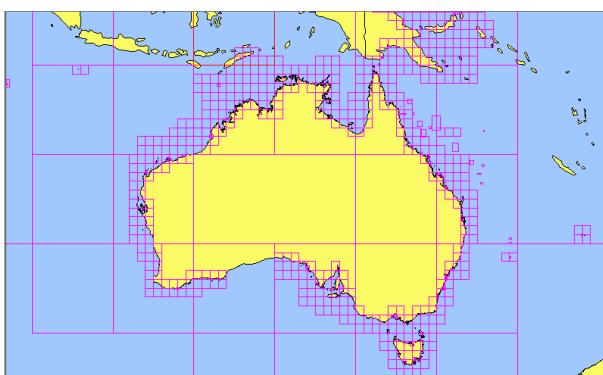


Figure 1 – extracts from the Australian Chart Index (online catalogue) showing limits of Band 1 to Band 5 ENC and paper charts for the equivalent area

Projecting future demand for paper charts

1.4 Considerable debate has been undertaken within the AHS regarding the future of paper charts. To ensure a degree of objectivity a study was undertaken to identify the future demand for paper charts once all vessels required to adopt ECDIS and ENC have completed the transition.

1.5 Australia distributes paper nautical charts via the following methods:

- International chart distribution agents located outside Australia. Any vessel purchasing an Australian chart outside Australia must be planning on undertaking an international voyage, with 90% bought for vessels that will be adopting ECDIS and ENC. Only 10% of sales of Australian charts by these agents are for use in small vessels. The selected Australian paper charts reproduced by the UKHO for international shipping fall into this overall category and are likely to be similarly affected by the ECDIS transition. UKHO reproductions were not included in the study out of respect for potential commercial sensitivities, but are likely to be affected similarly.
- Major national chart distribution agents within Australia. These distribution agents were consulted closely to determine the relative volume of sales to their various user segments. These include:
 - International and other nationally regulated vessels, the latter including commercial vessels operating entirely within Australian waters and subject to laws which specify various chart carriage requirements – an estimated split of 20% and 33% of their total sales respectively.
 - recreational vessels, including power vessels, cruising and racing yachts – known to be 47% of total sales by these agents.
- Local chart distribution agents. These agents cater for recreational vessels only – known to be 100% of their sales. In addition to official charts in one or more formats, they also sell licensed charts and small electronic chart systems. These agents consider their demand to be reasonably stable as the various vessel owners to which they sell paper charts have had access to electronic alternatives for over a decade and have no specific requirement to buy official paper charts, but are choosing to do so anyway. Racing yachts have detailed requirements to carry paper charts specified in race rules; there are no plans for this requirement to be changed in the near term as paper charts are considered essential in the event of power or systems failure.
- Direct distribution. Royal Australian Navy ships and a variety of Government authorities are supplied charts directly by the Australian Hydrographic Service. Significantly, Navy ships which have transitioned to a full dual-ECDIS arrangement are still required to carry a reduced emergency folio of paper charts sufficient to return to (but not enter) port.

1.6 Assumptions were:

- International shipping will meet mandatory requirements for carriage of ECDIS and ENC and, on balance, are highly unlikely to maintain a full portfolio of paper charts as their IMO approved full back-up arrangement. Feedback indicates this decision is based primarily upon cost, as ENC can be used on multiple systems, whereas a combination of ENC and paper charts approximately doubles the cost of charts for any given area and, for larger areas of coverage, can significantly outweigh the cost of a second ECDIS.
- The IMO (and therefore the Australian Maritime Safety Authority) will continue to consider official paper nautical charts as a suitable backup to a single ECDIS; by inference, they will be expected to exist and, if used, maintained and kept available for immediate use1.
- International shipping may choose to carry an emergency folio of paper charts, even if they have a dual-ECDIS arrangement. While unlikely, this contributes to the highest predictable demand which the AHS must be

prepared to meet. For the Australian Charting Area, the Navy emergency folio2 has been used as the model for vessels which may choose to carry a small portfolio of charts while familiarity with ECDIS grows. Exclusion of any tertiary emergency folio by international shipping results in the lower predicted residual demand for paper charts.

- Regulated domestic commercial shipping may choose to carry an emergency folio of paper charts but have no specific requirement to do so. As above, for those choosing to do so, the Navy emergency folio has been used as the model. Exclusion of any tertiary emergency folio by commercial shipping results in the lower predicted residual demand for paper charts.
- Recreational demand is substantially stable – owners have been free to make their choices and have had significant opportunity to do. The price, durability and battery life of tablet computers may gradually influence demand, but has been assumed to have no immediate effect.

1.7 Paper chart demand for the period July 2011 to June 2012 has been used as a baseline for projections. This was the last full year before the start of the roll-out of mandatory ECDIS / ENC carriage requirements.

	2011-12 Paper Chart demand	Projected change	Residual demand (highest)	Residual demand (lowest)
International shipping via international distribution agents	98,119 *	Shift to ECDIS / ENC, retain or not retain emergency folio of paper charts	20,860	Nil
International shipping via major national distribution agents	11,625	Shift to ECDIS / ENC, retain or not retain emergency folio of paper charts	2,471	Nil
National commercial shipping via major national distribution agents	17,437	50% or 80% shift to ECDIS / ENC	8,718	3,487
Navy	24,921 **	Shift to ECDIS / ENC, retain emergency folio of paper charts	6,728	6728
Recreational vessels via major national distribution agents	25,772	Stable, no change	25772	25772
Recreational vessels via local distribution agents	6,334	Stable, no change	6334	6334
<hr/>				
Total	184,208		70,883	42,321
Percentage of current demand	100%		38%	23%

* total includes 20860 already identified as useful for including within the emergency folio, plus 77259 other charts

** total includes 6728 already identified as useful for including within the emergency folio, plus 18193 other charts

2. Analysis / Discussion

2.1 While some of the assumptions may not prove strictly correct, the overall trend is significant. Implications include:

2 While the Royal Australian Navy has a specific list of Australian paper nautical charts intended to permit ocean transit and general coastal navigation in the event of total failure of the primary and secondary (backup) ECDIS, neither the IMO or AMSA has a requirement for a tertiary backup arrangement.

- **Update regime** Given that the vast majority of users beyond 2018-2020 will be recreational, what effect could this, or should this have on update regimes for paper charts and the alignment with update services for ENC?
- **Chart Schemes.** Given that the vast majority of users beyond 2018-2020 will be recreational, or carrying charts for emergency use only, will this be an opportunity for Member States to reduce or refine the number of paper charts in their schema? Should international guidelines be developed to meet these new circumstances to drive consistency, or should this be done in isolation? Does the strong trend to satellite based positioning and away from terrestrial fixing mean overlaps between adjoining charts will no longer be required?
- **Chart specifications.** Does the projected shift heavily in favour of ENC warrant or present opportunities for revisions to symbology on and specifications for paper charts?

3. Conclusions

3.1 This paper has been submitted for information only – Member States may draw their own conclusions regarding the applicability of this study to their own particular circumstances.

4. Justification and impacts

4.1 This paper has been submitted for information only. However, Australia has recognised the expected shift and is actively developing new organisational and production arrangements to permit paper charts to be derived from ENC product level datasets.

4.2 If Member States agree that this study is generally applicable to most nations producing paper charts, then this may form part of considerations regarding future priorities and work items for various IHO technical working groups. In particular, this paper is referenced in a separate submission regarding possible future work items for CSPCWG.

5. Action required of HSSC

5.1 The HSSC is invited to:

- Consider and discuss this paper.
- Note that while the specific predictions may not be directly transferable to other Member States, the overall trend is likely to affect most Member States to a generally similar degree.

Next Generation Paper Chart

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Abstract

Throughout the ages, the navigation chart has adapted to meet the requirements of the mariner to ensure safety of navigation. The portrayal of chart information and its physical presentation on manuscript materials have also changed through innovation and human factors. In more recent times, the work of the International Hydrographic Organization (IHO) has established various standards to provide consistency to charting products to meet a truly global requirement. The transition from a manuscript to a digital electronic navigation world continues at a rapid pace. A new generation of users are more familiar and comfortable with electronic technology. One of the challenges facing the IHO is the future of the paper nautical chart. The ongoing need for paper charts is not the issue discussed in this paper. What is discussed, however, is the portrayal of chart data and the way in which paper charts may be generated in the future. The issue requires careful consideration to reduce Hydrographic Office (HO) production burdens, maintain relevance and meet the customers' expectations.

"In matters of style, swim with the current; in matters of principle, stand like a rock."
Thomas Jefferson.

1. A Tale of Portrayals

From the very earliest recordings of sailing directions (periplo), to the 15th and 16th century portolans of the Venetians and Genoese, through to the current paper nautical charts, the depiction of chart detail has been an art form to serve a multitude of navigation purposes. The description and portrayal of real, fictitious, cosmological and embellished detail, was subject to the current school of thought, the imagination of the cartographers, the dominant cultural influences, the artists and the adventurers. Improvements in navigation methods and technology, the ages of discovery and enlightenment and more understanding of the real world combined with innovative charting practices and tools, have influenced the portrayal of information and the physical construction of navigation charts as supposition gradually retreated in the face of knowledge.

1.1 Paper Charts

The depiction of the current paper nautical chart is the result of some decades of cooperative standardisation effort championed by the IHO and described in the Regulations for International (INT) Charts and Chart Specifications of the IHO (known as S-4) (IHB, 2013(a)). This publication provides the framework for modern paper chart construction, colours, symbology and supporting textual information (Figure 1). S-4 is supported by a number of technical specifications such as INT1 (Symbols, Abbreviations and Terms used on Charts), INT2 (Borders, Graduations, Grids and Linear Scales) and INT3 (Use of Symbols and Abbreviations).

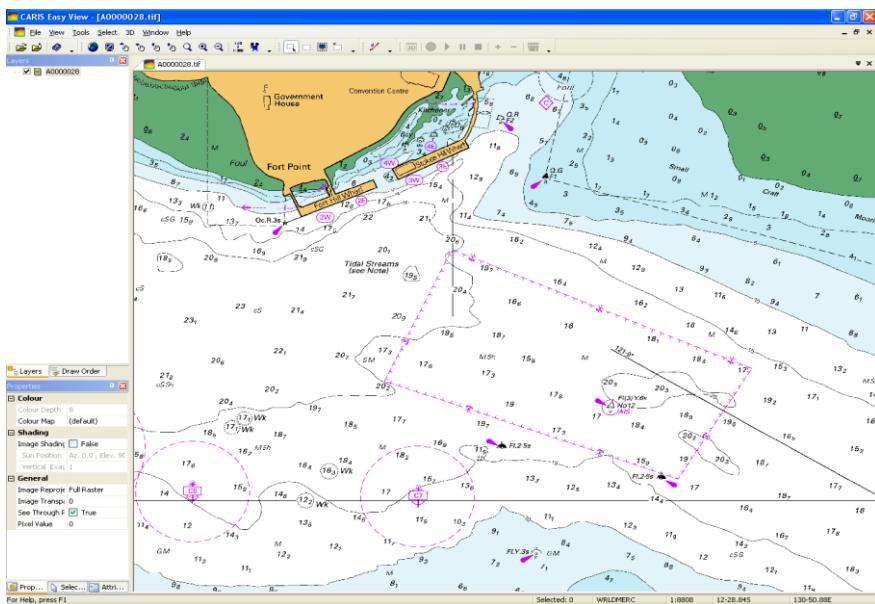


Figure 1. A typical INT1 paper chart portrayal

Extract of Chart Aus 28 Copyright Commonwealth of Australia (2008). Used with permission of the Australian Hydrographic Service.

Whilst the IHO has adopted Karte 1 (INT1) produced by the German Federal Maritime and Hydrographic Agency (BSH, 2011), a single, global specification for paper chart symbology has been elusive with many individual HOs developing their own version of INT1 (e.g. UKHO Chart 5011, NOAA U.S. Chart No. 1, Canada Chart No. 1, etc.). Fortunately, these documents basically follow the IHO INT1 content and structure, and include additional symbols and abbreviations that have been locally adopted within a national context. The key issue is that a mariner looking at charts produced by different HOs can interpret the charted features correctly through generally adopted portrayal standards.

The S-4 specification is maintained by the IHO's Chart Standardization and Paper Chart Working Group (CSPCWG). The CSPCWG has a set of defined objectives, operating procedures and guiding principles within its Terms of Reference (IHB, 2013(b)). Due to the diligence of the working group members over many years and the implementation of modern, advanced chart production software, S-4 and INT1 are mature specifications. Changes to S-4 are relatively minor and are implemented to support new charting requirements (e.g. Archipelagic Sea Lanes and various sensitive areas).

1.2. Electronic Charts

With the development of electronic charting in the late 1980s, the IHO soon realised that S-4 and its technical components (INT1 and INT2) would not satisfy computerised chart display for the Electronic Chart Display and Information System (ECDIS). For this reason, a new data portrayal specification needed to be developed. The Specifications for Chart Content and Display Aspects of ECDIS (S-52), describes the technical requirements for information display, symbology, environmental condition colour palettes, display screen configurations and various calibrations. S-52 includes Annex A - the Presentation Library (PL) (IHB, 2010(a)), and is maintained by the IHO's Digital Information Portrayal Working Group (DIPWG). The objective of this group is to maintain the IHO's specification for colours, symbols and display rules used to show Electronic Navigation Chart (ENC) information on ECDIS in a safe and ergonomic manner (see Figure 2). The membership of these working groups reflects wide international cooperation and this resulted in the general global acceptance of their resultant work.

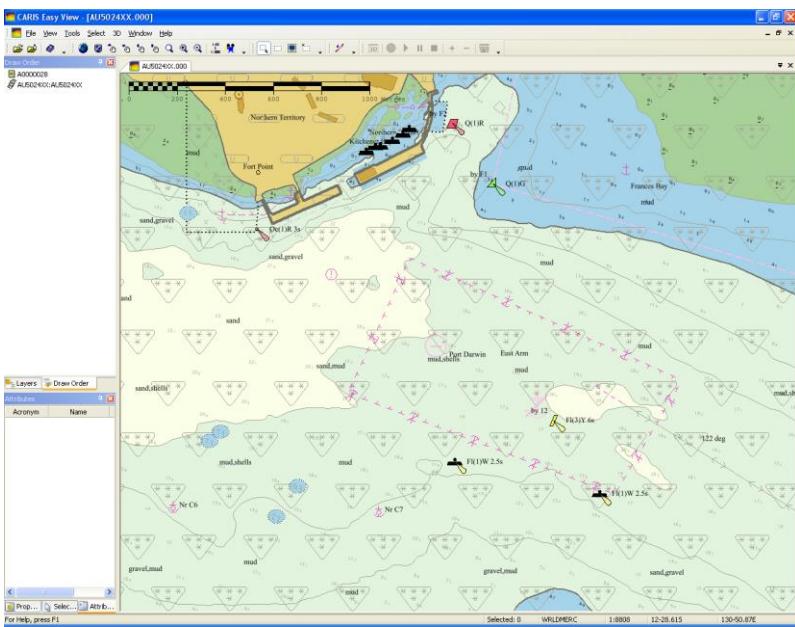


Figure 2. S-52 portrayal of the same area depicted in Figure 1
Extract of ENC Cell AU5XX24 Copyright Commonwealth of Australia (2008). Used with permission of the Australian Hydrographic Service.

Rather than being a paper-based portrayal specification such as INT1, the PL is provided in a machine-readable format so that electronic chart manufacturers can use it in their technology. The use of a standard set of symbology instructions should minimise the interpretation of symbology rules. This unfortunately is not always the case and a number of system manufacturers have either implemented the library with their own coding interpretations or developed their own libraries creating inconsistency issues with ENC data portrayal (Mohasseb, 2013). Through intensive stakeholder engagement, the IHO and ECDIS manufacturers continue to address and improve these interpretations with the aim of minimising encoding and portrayal variation and ambiguity.

2. The challenge of two chart worlds

In the late 1980s when ECDIS was first conceptualised and the early systems were being prototyped, there was much speculation about the future of the paper chart. It was not uncommon to hear early statements that paper charts would not exist beyond 2000. It has hard to believe that after 20 years, the paper chart is still a preferred navigation tool by many mariners.

The continued preference for the paper chart in an ever-increasing electronic age is the result of a number of factors:

- Users are familiar with long-used, paper chart products. Often user's charts are marked up with historical routes or other important information;
- HOs have taken a long time to achieve a satisfactory level of ENC coverage. This has meant that HOs need to produce and maintain multiple products, often using multiple production systems that compound complex issues in production and maintenance workflows, training, competency and technology and data refresh;
- The legislative process of the International Maritime Organization (IMO) has taken many years to mandate compulsory use of ECDIS resulting in a slower uptake of ECDIS technology and the necessary formal training of mariners to appreciate the technology and gain the necessary competencies;
- Official ENC data is used predominantly in type-approved ECDIS on large ships. A significant market segment doesn't require ECDIS technology (e.g. recreational users, fishing, small commercial vessels). For these users, official ENCs, non-official vector charts, raster charts and paper charts can all be used to meet their requirements;
- Many mariners are so familiar with the paper chart that a change in presentation, functionality and trust in technology can be difficult to embrace;
- The variety of cheaper electronic charting systems (ECS) product offerings, the varying levels of data quality and competitive business interests lead to a confused electronic chart market-place.

3. Paper charts and Safety Of Life At Sea (SOLAS) Convention

The adoption at the IMO's Maritime Safety Committee 86th session (MSC86) of the amendments to SOLAS (IMO, 1974) regarding mandatory carriage for ECDIS equipment for ocean-going ships has an important impact on the future need for paper nautical charts (see Figure 3). Under the SOLAS revisions, the decision must be made either to fit vessels with dual or single ECDIS. Both must comply with the ECDIS performance standard and will require a back-up plan whose demands will vary between flag States. In the dual-ECDIS case, bridge staff will be able to significantly reduce (in some cases down to zero) their use of paper charts. In the single-ECDIS case, they will likely keep the paper chart as backup.

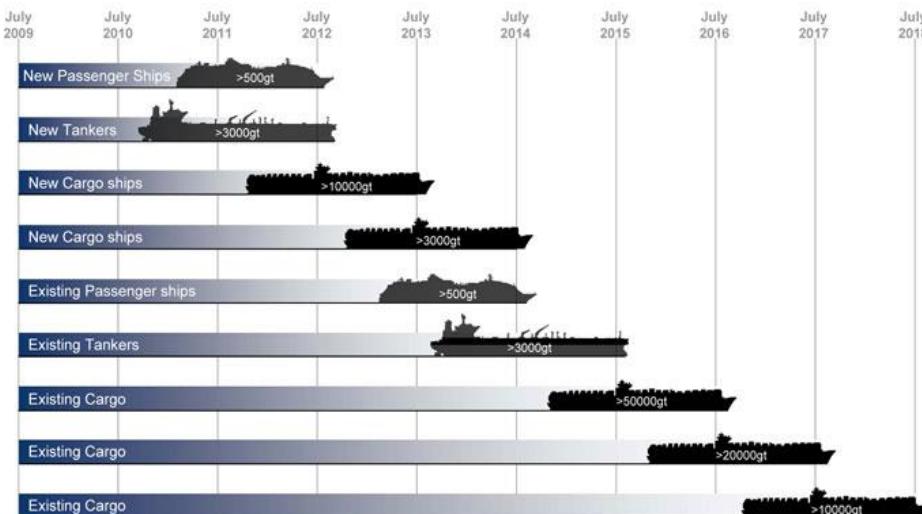


Figure 3. ECDIS Compliance Dates for SOLAS (UKHO, 2013)

In Australia, the Australian Maritime Safety Authority (AMSA) released Marine Notice 7/2012 outlining Guidance of ECDIS for ships calling at Australian Ports. In accordance with IMO resolutions, AMSA considers the following will meet the back-up requirements for ECDIS (AMSA, 2012):

"An independent, fully compliant second ECDIS unit, connected to ship's main and emergency power supply and connected to systems providing continuous position fixing capability; or

Adequate and up to date paper charts (including relevant large scale charts) necessary for the intended voyage."

The IHO describes a nautical chart in S-66 (IHB, 2010(b)) as:

"Nautical charts are special purpose maps specifically designed to meet the requirements of marine navigation, showing amongst other things depths, nature of the seabed, elevations, configuration and characteristics of the coast, dangers, and aids to navigation. Nautical charts provide a graphical representation of relevant information to mariners for executing safe navigation. Nautical charts are available in analogue form as paper charts, or digitally as electronic charts."

A key component of nautical charting world-wide is standardisation of portrayal. This is emphasised in IMO SOLAS Chapter V Regulation 9, para. 3 (IMO, 1974):

"ensure the greatest possible uniformity in charts and nautical publications and to take into account, whenever possible, relevant international resolutions and recommendations."

4. The Future of Paper Charts

Given the changes to the implementation of ECDIS, what is the future of the paper chart? In a 2011 article, the then UKHO CEO, Mike Robinson, expressed a view that paper charts would still be used for many years, even if they were only used in a "get me home" scenario. Despite a prediction that the sale of UKHO digital charts will exceed the sale of paper charts around 2018, there will still be a requirement to provide paper chart products to meet the varied usages and this will continue to be a production and maintenance issue for all HOs (Robinson, 2011).

In a world that is rapidly changing in technology (*in matters of style, swim with the current*), along with a technically-savvy younger generation of users, it is time to look critically at what the paper chart represents and how it can be

provided in different ways to a changing user-base without compromising navigational safety (*in matters of principle, stand like a rock*).

4.1. Official ENC-Derived Paper Charts

If a paper nautical chart is to exist in the future, what should it look like? Is it practical or economically feasible for HOs to continue to publish paper chart products with different portrayals? Will this be confusing to the market place?

Irrespective of the ENC/paper chart equivalency, many HOs can produce INT1 paper charts fairly easily from an ENC source. The primary hydrographic software vendors all provide an INT1 paper chart output. Hence, there is no impediment to this capability continuing. However, as uptake of ENCs continue, can users be expected to put up with two different portrayals of the fundamental navigation data? An alternative approach is for HOs to publish paper charts with a predominantly S-52 (ENC) presentation and transition away from the traditional INT1 portrayal.

To assist in the adoption of electronic charts, the author believes that there is merit in considering the need to transition INT1 paper chart portrayal to a S-52 style portrayal. From a practical production aspect and debatably a customer perspective, it makes little sense to retain two separate product portrayals. In a small and limited customer market, the major HO production software vendors all support S-52 portrayal in their symbol libraries. All of the software systems are relatively mature and whilst they can support both INT1 and S-52, a transition to one portrayal specification can utilise the best of both specifications (e.g S-52 for colours and symbols, INT1 for graticules, marginalia, title blocks and text, etc.). As part of the IHO's S-100 family of product specifications, S-4 could/should be replaced by a new S-10x Product Specification: ENC-Derived Paper Chart.

4.2. User-generated Non-official paper charts

In the world of "apps", it should be possible for users to create and print their own ENC-derived charts. These charts can be plotted from the users own ECDIS or ECS technology where the ENC data has already been purchased. In this case the plot could be generated from the System ENC (SENC) or from the purchased ENC product. HOs will need to consider a pricing model for the ENC to include some level of cost recovery for user-sourced plotting. Chart agents and other value added resellers may also provide a plotting service.

5. S-100 Product Specification for a ENC-Derived Paper Chart

The traditional paper chart specifications are well described through S-4, INT1 and national variants. However, for the portrayal of ENC data on a paper format, it is recommended that a new S-10x product specification within S-100 be developed and managed either by a sub-group of one of the current IHO portrayal working groups or by a new technical working group. The purpose of the new product specification is to establish the minimum requirements for the portrayal of ENC data on a manuscript format whilst maintaining an appropriate level of maritime navigation safety. In developing such a specification, a number of issues need to be considered.

5.1 Data portrayal

S-52 specifications were designed for computer displays and not paper output. Hence, the ENC portrayal will not be aesthetic to the eye from a traditional paper chart user perspective. New symbols would need to be added to account for cartographic features such as a compass rose. With increased uptake of ENCs, users should be more familiar with ENC portrayal and so over time, portrayal interpretation issues should also reduce. To assist mariners with ENC portrayal, the UKHO has already issued the ECDIS version of INT1 - NP5012 Admiralty Guide to ENC Symbols used in ECDIS (UKHO, 2012).

5.2 Paper Plot Layout Elements

Certain "elements" need to be included in the plot layout to assist the mariner using the derived paper chart:

Graticule: Simplified latitude and longitude grid/graticule

Scale bar: Simplified scale bar

Marginalia: Plot date, ENC EN/ER update status, Geographic extents, Producer agency ENC cell names used as the source, copyright and disclaimer statements.

Scale: The scale of the plot will be determined by various user-defined options – paper size, area coverage, etc. Some warning notation may be required if the inappropriate navigation usage or ENC scale is used for plotting. This may be similar to the "overscale" warning currently shown on ECDIS displays.

Available data: Where ENC coverage is not fully available, the paper plot may contain Raster Nautical Chart (RNC) content. The ENC content should always take precedence and some rules will be required to stop users from plotting RNC versions of the large portions of paper charts.

Data Content: similar to S-52, a minimum content of ENC data (e.g. Base) is required. The user should then have the ability to add extra content to the display.

Projection: At a certain scale, the output plot should be projected to aid the intended usage. For large scale situational awareness, a UTM projection may be best. For scales smaller than 1:75,000 where the chart may be used for course plotting and navigation, the plot should be output in a Mercator projection.

Colours: S-52 provides various colour palettes. For paper chart plots, the "bright-day" palette is likely to be the preferred colour palette.

Symbology: S-52 supports a simplified and traditional symbology palette. The user should be able to select the palette they are most familiar with. Some additional cartographic symbols will need to be developed.

Explanatory/Cautionary Notes: These notes are provided to assist the mariner to interpret potential navigational issues (e.g. chart omissions, dangers, etc.) or provide advice on where to find additional information (e.g. maritime boundaries). In the ENC, these notes are provided as text and/or picture files. Rather than plot the note content on the paper copy, the user could be given the option to print any relevant files separately.

6. Plotting Services

HOs can continue to provide plotting services for official paper charts. In many cases, chart plotting is now undertaken using Print on Demand (POD) technology rather than offset lithographic printing. POD provides options for plotting charts as either traditional INT1 portrayal or ENC-derived portrayal at large formats. Most users do not have access to large A0 plotters. Hence, large format plotting, from an economic perspective will remain with the HO, any contractors or potentially chart agents or specialist service agencies. Most users will only have access to A3/A4 printers at most. The challenge for using A0 plotters on vessels is the maintenance of consumables (i.e. inks and paper) which can be bulky, messy, expensive and susceptible to temperature and humidity.

7. Legal Issues

If a paper chart is plotted from the official HO-published ENC or RNC data, or from an approved SENC, and it has been output using the minimum required portrayal settings, it should be deemed suitable as an official and legal product. Some criteria may need to be established to ensure that the plotted output is legible in terms of scale and colours (rather than a grayscale printout).

8. Conclusions

The increasing adoption of ENCs and the changes in mandatory carriage requirements for SOLAS vessels will result in mariners using a product that has significant portrayal and capability departures from the traditional INT1 paper chart and derived raster navigation products currently in the market place. Should users have to put up with multiple navigation chart portrayals or should there be only one product portrayal based predominantly on the ENC with additional portrayal functionality to provide "cartographic representations"?

The author does not question the ongoing need for paper charts - only how paper chart content should be portrayed to users. At all times the principle of safety of navigation cannot be compromised, but this doesn't preclude looking at opportunities to streamline the production or to simplify the provision of derived paper products from an official ENC source. There is no doubt that such considerations will spark debate. However, from experience of witnessing the battle that some HOs had with the ECS entrepreneurs of the early 1990s, the IHO needs to decide if this really is an issue and be on the front foot in defining an appropriate specification. Otherwise, industry will dictate the capability.

The opinions expressed in this paper are those of the author and do not necessarily reflect those of the Hydrographer of Australia or the Royal Australian Navy.

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