Future Vision of the Paper Chart

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TABLE OF CONTENTS

ACRONYMS

AHS – Australian Hydrographic Service
AML – Additional Military Layer
BSH – German Hydrographic Service
CBSA – Canada Border Services Agency
CCMEO – Canada Centre for Mapping and Earth Observation within NRCAN
CHS – Canadian Hydrographic Service
DEM – Digital Elevation Model
DFO – Department of Fisheries and Oceans
DNC – Digital Nautical Chart
DND HSO – Department of National Defence Hydrographic Services Office
ECDIS – Electronic Chart Display and Information System
ECS – Electronic Chart System
ENC – Electronic Navigational Chart
EPOD – Electronic Print-On Demand (UKHO)
EPOD – Enterprise Product-On-Demand (NGA)
GIS – Geographic Information System
HO – Hydrographic Organization
HPD – Hydrographic Production Database
IHO – International Hydrographic Organization
IMO – International Maritime Organization
ISO – International Organization for Standardization
MDF – Minimum Deployment Folio
NGA – National Geospatial-Intelligence Agency
NOAA – National Oceanic and Atmospheric Administration
NRCAN – Natural Resources Canada
NTM – Notice to Mariner
NTS – National Topographic System
POD – Print on Demand
RNC – Raster Navigation Chart
RTCM – Radio Technical Commission for Maritime Services
SOLAS – Safety of Life at Sea
UKHO – United Kingdom Hydrographic Office
WMS – Web Map Service

ABSTRACT

To continue providing the highest quality and most appropriate products and services for safe navigation, the Canadian Hydrographic Service (CHS) has undertaken internal research to begin examining the future vision of the paper chart in Canada.

This report aims to provide a framework for discussion at both the national and international tables. Results collected from a number of consultations are explored and suggestions are presented for the CHS to consider adopting. The predominant themes that are addressed include mariner requirements for safe navigation, production paradigms for the CHS to potentially implement, as well as product evolution and suggested changes. Acknowledging that marine navigation is moving towards primarily using electronic systems over the use of paper charts, the options presented are designed to align with this shift. The final recommendations indicate a number of potential options for the CHS to consider implementing in the short term, the medium term, and over the long term time horizon.

EXECUTIVE SUMMARY

Over the last number of years, revenues from paper chart sales have been decreasing as chart users are shifting more towards the use of electronic navigation systems. Nevertheless, the effort required to produce paper charts remains both work intensive and expensive. Accordingly, the CHS recognizes the need to review its current methods of production and distribution to evaluate how to best move forward in the upcoming years. In assessing the future of the paper chart the goal is to increase efficiencies within the CHS while continuing to provide quality charts that meet the needs of mariners.

Consultations took place with two broad groups; Canadian chart users as well as hydrographic organizations (HOs) and Canadian/American organizations involved in chart or map production and distribution. A range of topics were addressed such as chart format and content, printing and distribution options, and requirements for safe navigation, current uses for paper charts, global and domestic production practices, and products and services offered by chart/map producing organizations. This report presents the feedback gathered from chart users and organizations with similar functions to the CHS, provides ideas for improving current systems in Canada, and aims to promote dialogue on the subject both domestically and internationally.

Input gathered on mariner preferences and external practices allowed for a discussion on key ideas to consider putting into practice in the Canadian context. Working groups and internal CHS committees reviewed and provided comments for inclusion in the final report. Outside organizations consulted with were also given the opportunity to review their respective contributions and statements attributed to them in the report. After incorporating all of the third party reviews, the final report was drafted to be used for internal research purposes.

Conversations with chart users brought to light that most of the respondents feel that paper charts still play a key role in promoting safe navigation. Paper charts may be less frequently used for primary navigation yet they continue to be widely used as a redundancy, such as in cases of power failure, lost satellite signal, or in emergencies. They have also proven to be a vital tool for training basic principles of safe navigation including the fundamentals required for electronic navigation. The predominant changes requested from the chart user respondents were on improving access to or availability of paper charts and increasing the range of custom print options. At this time, the notion of going paperless was not seen as a feasible or safe option though mariners recognize that this may be inevitable in the future.

In consulting with outside organizations, it became clear that the CHS is leading the way in many areas of chart production yet can also benefit from adopting certain innovative practices from other chart and map providers. Understanding what is being offered by other organizations can help the CHS to determine what changes could be made in Canada. The use of Print on Demand technologies have been implemented or are in

the process of being implemented by all of the outside organizations consulted with. Most of the chart and map providers have venders responsible for the sale and distribution of their paper charts and most require charts to be printed or provided directly from the HO to meet carriage requirements; for the most part even those that offer free data and products or allow users to download from their homes do not accept these as legal documents. Many of the chart/map providers offer a wide range of custom products and chart formats. A limited number of HOs have recently started adjusting their production methodologies to an ENC first concept, making ENCs the driving force for production with paper charts considered a derivative product. Most HOs consulted with, however, still retain paper charts as the primary product, creating electronic products such as RNCs and ENCs later in the production stream. The legal requirements surrounding the use of paper charts still represent a major component to be addressed not only in Canada but within the IMO and the IHO as well.

The Discussion section of the report ties together findings from the chart user and chart/map provider consultations with respect to how they can be applied in Canada. Mariners' requirements for safe navigation were addressed including an assessment of chart content, the role of charts as primary or backup navigation, and using paper charts for training purposes. The production models of other chart and map providers are assessed with the emphasis placed on shifting towards electronic navigation, and establishing minimum deployment portfolios and options for automation were considered. The evolution of charting products are explored by discussing legislation, international expectations for electronic navigation by 2018, and the use of cell based production, providing free products, creating printed ENCs, and general improvements to printing and distribution.

Suggestions have been made for potential options that could be implemented in the short term, the medium term, and the long term. Many options could be implemented simultaneously and in conjunction with one another. Efforts to assess the future of the paper chart are still in the early stages of discussion within CHS as well as the broader HO community. Given that this report serves as a preliminary effort within the CHS to begin addressing the future of the paper chart, there will be further work that will need to be accomplished following this project. All of the potential options presented in this report are suggestions established during the creation of the report and will not necessarily be adopted by the CHS.The ideas generated and presented throughout this report will however provide a foundation from which to build off of and hopefully create a better understanding of what possibilities exist for shaping the future of nautical charts offered by the CHS.

INTRODUCTION

With changing technologies available to hydrographic organizations and shifting demands for the types of products sought after by mariners, the Canadian Hydrographic Service (CHS) recognizes that its means of production and distribution of paper charts needs to be re-evaluated. Overall, paper chart usage and sales have been declining every year as more vessels/mariners transition to electronic navigation. In beginning to address this issue, this report aims to provide a framework for dialogue on moving forward with the necessary changes within the CHS to ensure that high quality and appropriate charts are offered to mariners.

To begin assessing this change, consultations with domestic chart users as well as chart and map providers were completed; this included gathering information from numerous hydrographic organizations (HOs) and other agencies within Canada. This provides a strong context from which to understand what today's chart users want in the products available to them and what types of charts and distribution options are being offered to mariners across the world.

Re-emerging themes and prominent ideas from the consultations with chart users were pulled out and summarized. Chart and map provider responses were broken down into key topics and statements were attributed to the HO or agency that made them. The connection was drawn between ideas shared by the chart users and information provided by the chart/map providers on potential improvements that could be made in Canada. Final suggestions are made on action that could be taken within the CHS in the short, medium, and long term.

BACKGROUND

EVOLUTION AND CURRENT FRAMEWORK

The CHS is a scientific organization within the Department of Fisheries and Oceans Canada (DFO) that, since 1883, has been responsible for the surveying, measuring, and describing of Canada's waterways, including its oceans, seas, rivers, and lakes. The data collected is used to produce nautical charts. Currently the CHS offers 946 charts that cover all three of the country's coastlines and its major inland waterways. These charts are distributed to the public by over 800 dealers across Canada and the world.

The United Nations plays a pivotal role in maritime safety through the International Maritime Organization (IMO). The IMO is made up of 171 member states, which have collaboratively developed international conventions, such as the Safety of Life at Sea (SOLAS). SOLAS was brought into force in 1914 and has been regarded as one of the most important international treaties regarding maritime safety (IMO, 2016). For domestic shipping, the SOLAS convention is often used as a framework to developing custom legislative requirements which are country specific.

In Canada, the *Canada Shipping Act, 2001, Charts and Nautical Publications Regulations, 1995* also stipulates vessel navigation requirements; this includes the requirement that all vessels in Canadian waters must carry and use the most recent editions of nautical charts and the relevant publications. According to SOLAS amendments in 2002, paper products may be replaced by electronic means if legally accepted back up is in place. Nevertheless, at the present time paper charts and publications remain the minimum requirement for back up navigation in many countries across the world (Primar Stavanger and IC-ENC, 2004).

With the continual evolution of vessel design, marine transportation needs and survey technology, nautical charts have had to adapt in order to meet changing demands. With the first launch of NASA satellites capable of assisting navigation in 1970 and the increased development of computers, marine navigation underwent a major revolution (NASA, 2012). In the early 1990s the first Raster Navigation Charts (RNC) started appearing and by the mid-1990s they were being used in conjunction with systems that allowed for electronic navigation (Weintrit, 2009). Currently there are multiple product lines including paper charts, raster navigation charts (RNC) and the electronic navigational charts (ENC)[1].Throughout its history, the CHS has been internationally recognized as being one of the most advanced hydrographic organizations. As such, the CHS strives to be a world leader in identifying new tools and techniques appropriate for meeting the needs of mariners as the demand for charts evolves.

[1] For the purpose of this report, all non-paper charts will be referred to as electronic navigation or electronic systems.

ISSUE AND MOTIVATION

The challenge with paper charts is that despite a unified production environment, the effort required to produce them remains highly intensive and costly. This issue is compounded by the fact that the demand for paper charts is continually declining, subsequently decreasing revenues. This raises the question of at what point the effort to produce paper charts exceeds the benefits derived from maintaining the product line?

In the face of declining paper chart revenues, decreasing resources (i.e. allocated budget), and increasing costs, the status quo for paper chart production needs to be reviewed. The project undertaken by the CHS evaluates and reports on the future vision of the paper chart, including topics such as format (e.g. size, layout, look/feel, content), printing options (e.g. CHS, super dealers, commercial printers, users), as well as the type of products and the methods of delivery used by other organizations.

The goal of the project is to determine if the methods of production and distribution of paper charts currently offered align with the needs of today's mariners. Any changes to be implemented should ideally contribute to making CHS processes less work intensive and less costly. In striving to improve operational efficiency, future efforts should maintain the high level of quality currently offered while allowing the CHS to maximize its staffing and financial resources.

The CHS aims to identify key areas for improvement and changes that can be made to meet the shifting demand. The project is comprised of three phases: (1) an examination of external domestic and international practices as well as chart user requirements, (2) an internal CHS review and dialogue, and (3) the creation of a report with the results, discussion of findings and suggested options for the future. This work serves as an effort to gather industry feedback, generate ideas, assess viable options and provide a framework for the CHS to consider in the upcoming years.

METHODS

PARTICIPANTS

The majority of participants contacted for consultations were researcher selected. The selection was based on readily available contact information with CHS Director and Supervisor recommendation. In an effort to make participation as broad and encompassing as possible, the participant list was left open ended and added to as internal and external recommendations were provided. Additionally, a focus was placed on contacting organizations rather than individuals in order to solicit a wider perspective on the questions posed. Nonetheless, participant responses do not necessarily represent the view of the organization or agency as a whole but rather is a single perspective at a given time. Some participants represented their own views and others spoke on behalf of a larger number of people that had shared input on the CHS questions. Once consultations had begun, a handful of self-selected individuals identified interest in submitting comments after hearing of the project; these comments were also included in the project analysis.

The list of participants is divided into two main groups, chart providers and chart users (Appendix A). The chart providers consisted mainly of HOs but also included other governmental agencies responsible for delivering products similar to charts (e.g. topographic maps). The HOs contacted are all active member states of the International Hydrographic Organization (IHO) and play a considerable role in shaping policy at the international level. They also have a good rapport with the hydrographic community and have similar policies and technology as the CHS. Consultations with domestic chart users included an array of governmental, commercial, and recreational organizations. Many of the chart user respondents had multiple years of experience using CHS paper products and most had a breadth of sea going time in different capacities. Consultation with a limited number of newer mariners also took place.

CONSULTATION QUESTIONS

The questions discussed during consultation are structured to be qualitative in nature, focusing on the paper chart from its creation to actual employment at sea. Two overarching sets of base questions were drafted; one for chart and map providers and the other for domestic chart users (Appendix B). There are two organizations that are not typical HOs but could be considered chart providers so questions were modified to be more applicable. Most questions were designed to be open-ended to encourage the participant to elaborate with as much or as little detail that they felt necessary.

Chart provider questions focus on the topics of legislation, distribution, physical format, content, efficiency and digital production. These broad topics are further broken down into sub-questions to better engage participants regarding specific aspects of the paper chart and its future.

Chart user questions focus on the topics of usage, minimum requirements, current level of satisfaction, potential improvements, presentation changes and the shift to electronic options. These topics encourage users to offer their insights into CHS paper products and think outside of the classic and historic presentation of paper charts to what the future might hold.

DATA COLLECTION

Twenty-two structured telephone consultations serve as the primary method of data collection for this project; twenty of the consultations took place with one researcher and two of the consultations were done by an alternate researcher. In addition to the telephone consultations, one HO submitted written responses in place of a phone call, amounting to twenty three responses to the CHS questions collected. One of the HOs provided both written feedback and participated in a phone consultation, and five brief unprompted emails from individual domestic chart users were received.

Initial contact with each of the participants was made via email, informing participants of the project background, goals, and the questions to be discussed over the telephone. Consultations occurred over a period of six weeks (Dec 7, 2015 – Jan 18, 2016) involving seven chart providers and fifteen domestic chart users. For the purpose of note taking and analysis all conversations were recorded and the responses documented in note form; each recorded conversation and transcribed notes were reviewed by a second person. Before each consultation began, participants were reminded that the conversation was being recorded and at any point they could request that their statements remain confidential (for internal CHS purposes only).

A preliminary report was distributed to internal committees (i.e. CHS Executive Committee, Hydrographic Operations Committee, Client Liaison and Marketing Committee), a working group (i.e. Hydrographic Production Working Group), and select individuals involved in national and international efforts to assess the future of the paper chart to provide comments and feedback on the report findings and discussion. Chart and map providers that engaged in the consultation process were sent a document with all statements attributed to them isolated from the report for their review, confirmation of accuracy, and clarification on specific points; the feedback received was incorporated into the final report.

DATA ANALYSIS

Responses from each respondent group are divided into the major themes discussed during the consultations. All analysis is reserved for the Discussion section of the report to maintain strict separation between respondents' views and the interpretation of the authors. This report contains information known at the time of its drafting and may not represent a complete outlook of the current and anticipated practices attributed to any of the chart and map providers discussed, including those within Canada. Additionally, only data pertinent to examining the future of the paper chart was requested from the

consultation participants, therefore, only a snap-shot of all of the products, services, and processes offered by the chart/map providers are included.

The results from the chart user consultations are conveyed in the Client (Chart User) Input section. Predominant ideas that were either voiced by multiple respondents or that presented a particularly pertinent example, from the perspective of the CHS, are included. The primary focus of the conversations with chart users was to understand the general consensus of today's mariners and to help shape the future of navigational products for the nautical community as a whole. Reoccurring views and widely made suggestions are presented to demonstrate the areas of most pressing concern according to the chart user respondents. For the most part, feedback is not directly attributed to individuals or specific agencies but rather grouped into broader statements and collective views. Perspectives that were overtly individualistic or solely represented the personal opinion of one user and were not shared by other respondents were not included.

While some of the feedback collected was not directly pertinent to this project it is of value to the CHS as a whole and should not be lost. The value added from the consultations (not discussed in this report) resulted in the creation of a secondary document where a list of further opportunities for improvements (OFI) was compiled.

Results from the consultations with chart/map providers are communicated in the Chart and Map Provider Practices section of the report. Responses are explicitly attributed to each organization to clearly differentiate the current practices and products of each. Chart/map providers were predominantly asked the same questions with a couple specific to individual organizations. Each respondent had varying levels of information to offer therefore the amount of detail provided varies from one respondent to the other; this includes certain sections that do not contain any response from a given organization where a question was not pertinent or information was not obtained.

The Discussion section includes analysis and interpretations of both chart users and providers responses. Keeping at the forefront the notion of looking to the future of the paper chart, the discussion focuses on the application of various ideas in the Canadian context and options most likely to assist the CHS in responding to shifting market demands. Concepts of importance to navigational safety through the chart users lens are discussed. Potential modernizations to the CHS production and distribution are explored through reference to the current or anticipated practices of other chart/map providers. Lastly, considerations for the potential evolution of the paper chart are outlined. There are opportunities for the CHS to grow and evolve and this section provides a discussion on how such change could take place. Key points from this section are used to make recommendations in the Potential Options section.

In support of the consultation results/ discussion in this report and as an aid to future efforts on this subject, a brief Literature Scan has been generated and is located at the end of the report.

CLIENT (CHART USER) INPUT

There are many factors that contribute to quality navigation products and to the safety of navigation. Discussing the key factors with chart users is critical to the evolution of relevant and innovative navigation products. The following sections represent the thoughts that chart users have shared regarding the paper chart and its potential future.

MINIMUM REQUIREMENTS FOR PAPER CHARTS

To assess potential changes to the paper chart, understanding what mariners require at the minimum is key. This section indicates some of the basic requirements currently held by individual's navigating in Canadian waters.

Of the fifteen chart user participants, the large majority did not consider any of the current chart content to be non-essential and would not support any elements being removed. Most users felt that the majority of elements on the paper charts are used at some point or another and therefore it could be damaging to remove content. The limited number of suggestions that were made on potentially superfluous content were based on specific uses of paper charts to a given individual but were not widely held views across the other respondents. For example, a couple chart users stated that topographical information was not crucial for meeting their needs for safe navigation yet others explicitly indicated the opposite in that topography was essential to their use of charts. As such, no specific elements of charts could be identified as generally non-essential to all mariners.

A common statement regarding charts was that more detail is always preferable; four chart users specifically said that they would like to see more information on the charts, such as bathymetric overlay. Numerous respondents indicated that large scale, detailed charts were essential to safe navigation. It was stated that areas where one is more likely to encounter danger requires more detailed charts; therefore a minimum requirement for safe navigation for many of the respondents was to have large scale charts for areas such as harbours, ports, and coastal areas.

In recent years, the Royal Canadian Navy transitioned to a new system referred to as a Minimum Deployment Folio (MDF) where Navy vessels are no longer required to carry paper copies of all pertinent charts to a given voyage. Rather, only those required to get safely back into friendly port (home waters) in the event of catastrophic electronic system failure or enemy action (e.g. an electromagnetic pulse [EMP]) are carried; the MDF would be extended to specific areas of operation in the case of wartime requirements.

PRIMARY NAVIGATION AND BACKUP REDUNDANCIES

Learning whether paper charts are being used as a primary source for navigation or serving a secondary function can help the CHS determine an appropriate evolution of the product based on its present-day use. This section elucidates the paper chart's current utility and provides examples on its various uses.

All participants strongly indicated that paper charts are a widely used resource for backup navigation. Only a very limited number of respondents suggested that they or their colleagues use paper charts for primary navigation. Participants' responses suggested that most are either strictly using electronic navigation or a combination of electronic as a primary tool and paper as a redundancy. The impression is that very few mariners are using paper charts exclusively; nevertheless, there are still some who rely on them very heavily.

It was repeatedly iterated that paper charts are essential in cases of power failure, in locations where there may be intermittent satellite signal, during emergency scenarios, and under duress such as in cases of search and rescue. Nearly all participants stated that not having paper charts on board is an impediment to navigational safety in any of the aforementioned instances. Furthermore, a frequently made comment was that paper charts are of particular use in new, unfamiliar, or congested areas. This is as a result of it being easier to view the entire area and get a better overview of what to expect along the course on a paper chart versus on a small screen.

Increasing numbers of newer mariners are using electronic means of navigation, including ENC and RNC, over the use of paper charts. While there are a large number of seasoned mariners that continue to use and prefer paper charts, some of the participants suggested that over the next ten to twenty or even fifty years there may be even fewer people using paper products, eventually rendering them a non-essential product. However, at present, the overarching view drawn from the consultations is that mariners remain unconvinced that electronic systems of any type are completely infallible and thus do not believe that the nautical community is at a point to cease using paper charts as backup. The consensus was that paper charts act as such an effective failsafe that they are worth keeping on board any vessel.

More and more commercial vessels and larger ships are making use of dual ECDIS to meet Canadian carriage requirements and are therefore using minimal to no paper charts. The majority of Canadian Navy has gone to electronic systems as a primary means to navigation. The Navy utilises dual ECDIS and for additional redundancy will have a backup laptop for the use of digital raster products. For the most part, the Canadian Coast Guard still maintains paper charts due to the specialized nature of their work; however, some larger vessels have gone to dual ECDIS and no longer have paper charts on board.

An example of where paper charts are currently serving an integral role is with Canadian Coast Guard Auxiliary search and rescue missions. As a specific illustration, a respondent referred to a past experience where during a search and rescue for a mariner who had abandoned ship at night in poor weather conditions that relying on electronic systems proved to be disadvantageous. It was stated that electronic chart plotters and radar, even in night mode, can negatively impact ones night vision due to the brightness of the screens making it challenging to survey the waters. Additionally,

the extra manipulations required (e.g. moving a cursor, selecting different settings, adding/removing layers) with electronic systems can be challenging in choppy waters and take up crucial time.

The BC Coast Pilots are now all using portable pilot units that allow them to have access to raster charts wherever they are. It was indicated that raster was their chosen format as it is a familiar format to most mariners and displays a high level of detail, including topographic information, needed by the pilots.

Another common sentiment expressed throughout the consultations was the value of using paper charts for in-person meetings, briefings, and navigation training for new mariners. Many participants like having a tangible, hard copy to work with and a larger format (in comparison to the electronic systems) for displaying information to groups of people.

MEETING USERS NEEDS FOR SAFE NAVIGATION AND TRAINING

While the uses for paper charts vary substantially and are notably different from years ago, they still play an integral role for many mariners. This section expresses the need for paper charts and discusses a prominent example from the Royal Canadian Navy on the value of paper charts in training.

All consultation participants stated that the CHS paper charts were meeting their organization's needs for whatever purpose they were using them for (e.g. navigation, redundancy, training etc.).

It has been widely suggested by the respondents that paper charts provide an excellent platform from which to teach basic skills essential to navigation, including those required for electronic navigation. Many of the respondents expressed the importance of learning on a paper chart and the value of having even a basic familiarity with their use. Support for this notion is demonstrated through the Navy's experience in the Venture training school.

With the Navy's decision to go paperless a number of years ago, they stopped teaching new students to use paper charts and moved away from interacting with paper charts in any form; students were strictly exposed to electronic navigation at that point in time. A consultation response given by a Lieutenant Commander involved with the Venture training school for the Navy disclosed that this change actually hindered the students' ability to understand electronic charts and interact with them in such a way as one would expect a sensible, professional mariner to do. Following this realization approximately five years ago, they moved back to teaching core skills with the use of paper charts. The Navy experienced that without learning navigational skills on paper charts the students were lacking basic situational awareness skills; they determined that individuals are successful at using electronic charts because they have a broader context to their functioning as acquired through learning on paper charts.

Similarly, many recreational boaters such as some of those involved with the Canadian Power and Sail Squadron (CPS) are also being taught how to navigate with paper charts. A past-commander and current Chief Instructor of the navigation course with the CPS stated his firm belief in the importance of ensuring students know how to use a compass rose and understand all of the symbology on paper charts. While the instructor acknowledged that much of the CPS has moved towards the use of electronic charts, the instructor continues to demonstrate the value of paper charts.

A number of individuals, without prompting, contacted the project researchers to provide input with the main objective of sharing the level of importance they place on paper charts and to share how highly they are valued. The idea of paper chart production ceasing at the CHS was a thought that made people uncomfortable and concerned.

CHANGES AND IMPROVEMENTS

With respect to current options and consideration for future improvements, respondents provided suggestions on changes they would like to see made in the upcoming years. The specific ideas and requests from the chart users are presented below.

The primary changes or improvements suggested throughout the consultations surrounded the topics of distribution and printing options. Generally speaking, respondents were happy with the content of paper charts but would like to see improved access to or availability of charts and would like to have options for customizing products.

Repeatedly, participants stated that having custom print options would be appreciated. Mariners would like the option to be able to go online and order paper charts based on their preferences. The consultations brought to light the fact that mariners have varied uses for their charts and have different preferences for the content displayed. Many said they would like to be able to select options such as the size of the chart, the units displayed (i.e. whether it's in metric or otherwise), the orientation (e.g. towards magnetic north), the format, and the scale, etc. Given that there does exist a range of uses for charts it would be highly valuable if chart users were able to tailor their orders to meet their specific needs. Based on a selection of certain criteria on a checklist, the charts could be printed off at any given time in the specifications chosen by the individual. For example, pleasure craft boaters or those operating smaller coast guard vessels may find the size of paper charts to be cumbersome and could choose to order booklets, double sided products, or smaller formats such as A1 or A2.

The consultations indicated that mariners want to have better access to charts. Those whose organizations do the ordering for them or have their own print shop are happy with the current distribution arrangement. For individuals who are personally responsible for obtaining their own charts, many had issues with the present system. Currently chart dealers, especially in smaller centers, will often times not be stocked with the particular charts sought after by the chart user. Having the option to print from home or even from on a ship, etc. was frequently suggested; charts could be ordered online and then

delivered or emailed as a digital file. Some participants said they would like free data/products but this was not a readily brought up point; others stated that the current price point was reasonable. Therefore, the issue is predominantly around access and customization of products.

Two respondents pin pointed the American system as a model they would like to see implemented in Canada. This could, in part, offer free options including more customized products based on individual chart user preferences. A discussion on this model, including an explanation of carriage requirements, can be found in the Chart and Map Provider Practices section.

Interest has been demonstrated towards having access to survey data as well. There is an abundance of multi-beam data that exists now; understandably all that information cannot be displayed on charts but some respondents have stated that it would be beneficial if chart users could access that data should they want greater levels of detail. Having access to data or chart archives could also be useful to some mariners and could be a potential source of additional revenue for the CHS. At the least, a respondent proposed that it would be valuable to increase the ease of access to CHS data across all government departments.

Furthermore, participants indicated overall that the quality of the paper that charts are now printed on is inferior to when lithographic paper was used. The paper currently used does not stand up to repeated marking with pencils and erasing, nor does it stand up to folding. A frequently stated improvement to CHS charts would therefore be to switch to printing on a more durable paper product; this would notably only pertain to instances where charts are purchased from a distribution center and not printed by users themselves, should that become an option.

SHIFTING TO ELECTRONIC (DIGITAL) OPTIONS

In looking to the future of navigational charts, the trend is shifting towards increased use of electronic means of navigation. Participants were asked about both the idea of going entirely paperless and about the idea of maintaining a paper product that was a printed ENC; the chart users' feedback is incorporated into this section.

Going Paperless

Consultation participants recognized that the CHS is facing a market shift and needs to address changing demands and the prevalence of new technologies. Generally speaking, participants were responsive to the notion of continued improvement, efforts to increase efficiency, and initiatives to streamline production and reduce costs.

On the whole, respondents were not receptive to the idea of completely eliminating paper charts and shifting to electronic charts only. Even though electronic navigation is becoming more prevalent, the reliance on paper charts for specific uses remains sufficiently significant that without them navigational safety could be at risk. Most

recreational boaters do not have dual ECDIS on board nor would it be feasible to acquire. Additionally, most recreational boaters only have one power source so in the case of a systems failure or power outage they would be at a complete loss. To go electronic only, mariners would need to have a separate backup power supply that was able to generate power for the duration of ones voyage to ensure access to a chart at all times. Respondents also posed the question of what would happen in the case of a lost satellite signal? Until these issues are addressed, the common sentiment was that going paperless could be hazardous.

Respondents said that using paper charts allows for better watch keeping as mariners may be more prone to look out the window more frequently opposed to only focusing on electronic screens. Nevertheless, respondents indicated that they see an evolution towards eventually going paperless but that the combined use of paper and electronic charts is the most reliable. If the CHS did go paperless, a respondent suggested that if chart users had the option to print on their own from a digital file that could fill the void for anyone still wanting the tangible copy.

While going paperless may be seen as inevitable respondents expressed that the Canadian nautical community is not yet there. As previously stated, the Navy relies heavily on paper charts for training and does not believe there is an equivalent alternative at the present time. They have, however, stated that they will follow suit with whatever the evolution of charts may be and that they will tailor their training if needed to continue meeting the demands of modern navigation.

There exists a general sense that there is too large of a gap between what paper charts can offer and what electronic charts can provide; to be able to fully rely on electronic systems and move completely away from paper chart options was thus not viewed as a feasible option. Several comments were made about the size of the viewing screen for electronic charts and the lack of fidelity of the information displayed. In many instances a larger viewing surface, such as that of a paper chart, is preferred. Paper and electronic charts are being used in ways that the other cannot currently substitute. The type of information on paper charts, such as the topographical features and names of locations, rocks etc. would need to be replicated on ENCs before paper charts could be eliminated or even in order to derive a paper chart from an ENC.

For mariners with predominantly unchanging routes, such as ferry service providers, the need for paper charts seems to be less important than for mariners with frequently changing courses. Similarly for commercial vessels or larger ships equipped with dual ECDIS, going paperless may be less of an issue than for boaters who are not as easily able to acquire adequate electronic systems. Responses indicated that going paperless may be feasible from a deep-sea navigation perspective but not from a coastal perspective where navigation may be less predictable and higher levels of risk may be present. A participant pointed out that going paperless would likely make it easier for

updating charts both from the perspective of the CHS and for the chart users themselves.

If the assumption could be made that paper charts were strictly for secondary purposes, such as for redundancy or training, then charts would not need to be updated as often; this could work if electronic charts were the primary source for navigation for all mariners. If it was known across the nautical community that paper charts were not updated regularly this would still allow them to be used in an office setting or for training purposes. For updated versions, with new navigational aids etc. needed for primary navigation, mariners could refer to the electronic version. This does not address the use of paper charts as a backup though in the case that electronic systems can no longer be used.

In general, respondents felt that going fully electronic could have an adverse effect on safety, such as with new mariners who, according to some respondents, have an over-reliance on electronic systems. There would be value to incorporating an education or training component for any major changes implemented by the CHS. Going entirely paperless to strictly electronic navigation could require a change to the pertinent regulations and legislation for non-SOLAS users as well.

Printed ENCs

During the consultations, participants were asked what their thoughts were on shifting from the traditional paper chart presentation to a printed digital version that resembled the ENC presentation; the overall response was positive and the majority of chart users were tentatively open to this idea.

Many respondents indicated that creating paper charts using the ENC presentation and symbolization could establish some consistency between the two platforms which would allow certain components to be immediately recognizable regardless of which chart type is being used. A potential benefit is therefore that it may help to reduce the level of confusion for some mariners, such as those who are not accustomed to using both formats. A Harbour Master and Director of Marine Operations stated that similarly to how one would use Chart 1 for symbols and abbreviations, everything should be streamlined so that electronic and paper charts resemble one another; this would likely increase the clarity and ease of use. As an example, the respondent stated that the coloring of the depth areas on the electronic charts do not display the same as they do on paper charts, depending on the selected settings, and for some individuals this can be confusing; the respondent indicated that the discrepancy between the way the paper charts look and the way electronic charts look is the biggest issue regarding the appearance of charts. By increasing the similarities between the two products it could make it easier for mariners to switch between the two and be able to more quickly continue navigating on a paper chart if there was an electronic system failure.

For numerous respondents, the utility of the paper charts is in having the hard copy to work with; it is not the presentation of data that matters the most, therefore, changing the look of the paper charts would be acceptable for many individuals. Furthermore, it may serve as a step towards familiarizing seasoned mariners to the look of electronic charts, a good step towards transitioning to navigation by strictly electronic means.

Numerous respondents did, however, suggest that if paper charts were to be an exact printout of an ENC, the product would lose a lot of the fidelity that it currently possesses. Modifications would need to be made to incorporate various features onto the paper that are not present in the ENC such as annotations, masking, chart notes, and marginalia. Overall, the general sentiment was that people are open to using paper charts that are a representation of electronic charts.

SUMMARY

To maintain the utmost level of quality at the CHS, understanding the needs of current chart users is valuable. Though it is clear that the role of paper charts is evolving, the consultations with chart users suggest that they still play an essential role in safe navigation.

Taking on a predominantly secondary function, paper charts are vital for back up navigation due to power/satellite loss or in emergencies and for the training of new navigators. Increasing numbers of today's mariners are using electronic charting systems and only carry paper charts because of legal requirements. Chart user experience has shown that, at present, using paper charts for teaching navigation is highly effective, including for teaching the fundamentals to electronic navigation. Overall, chart users did not want to see any elements removed from paper charts and in fact would support the inclusion of greater detail. The predominantly mentioned suggestions included improving access to paper charts as well as survey data and having more custom print options for charts. Moving to strictly electronic navigation at this time was not well received by most respondents. A large number of the respondents took the opportunity to reiterate the importance of maintaining access to some form of hard copy paper charts into the future. The idea of deriving paper charts from ENCs was viewed as being a reasonable paper chart alternative and a viable way of transitioning towards eventually electronic only navigation.

From the consultations with various CHS clients across Canada, common ideas and perspectives have emerged. These common elements can now be included in future considerations on how the paper chart can or should evolve; this could also suggest the level of user acceptance that could be anticipated on certain changes.

CHART AND MAP PROVIDER PRACTICES

Both nationally and internationally there are many comparable organizations producing chart and map type products all facing similar issues with the arrival of the electronic age. These issues are best addressed in a concerted and cooperative manner to ensure unified solutions are created for a seamless transition. Information specific to the CHS has been included as a point of reference when examining the practices external to Canada.

The following sections are a review of current operations globally, anticipated changes and future ideas regarding the paper chart. For further detail or follow up to any of the principles discussed with the various chart and map providers, it is recommended that the CHS contact them as all were forthcoming and open to further engagement.

LEGISLATED CARRIAGE REQUIREMENTS

Respondents from each country consulted with provided information on the regulatory frameworks adhered to for safe navigation as well as details on the specific Acts where requirements can be found. A general summary of international parameters can be found here with greater detail listed in Appendix C.

Maritime countries have adopted varying legal requirements that mariners are expected to meet or exceed for the carriage of nautical charts. Canada, Australia, the United States, Germany, France, and the United Kingdom are all member states of the IMO and at a minimum have agreed to enshrine the SOLAS Chapter V Regulations into legislation. Countries will often meet the fundamental requirements established by the IMO and build upon certain regulations within their own domestic legislation to address specific safety concerns.

As with most legislation there are exceptions and varying degrees of applicability for different situations and vessel types. Table 1 outlines various requirements of the IMO, Canada, and the five countries referenced throughout this report. This table is a succinct version of the most pertinent sections of legislation relating to nautical charts. All of the countries consulted with legally require up-to-date charts issued under the authority of the hydrographic organization to be on board all vessels. The carriage of paper charts is still a major requirement in most countries for mariners to meet basic legal requirements, except when dual ECDIS can be used. The United States is one of the exceptions to paper chart/ECDIS requirements and permit mariners to use other electronic systems to meet requirements, such as Electronic Chart Systems (ECS).

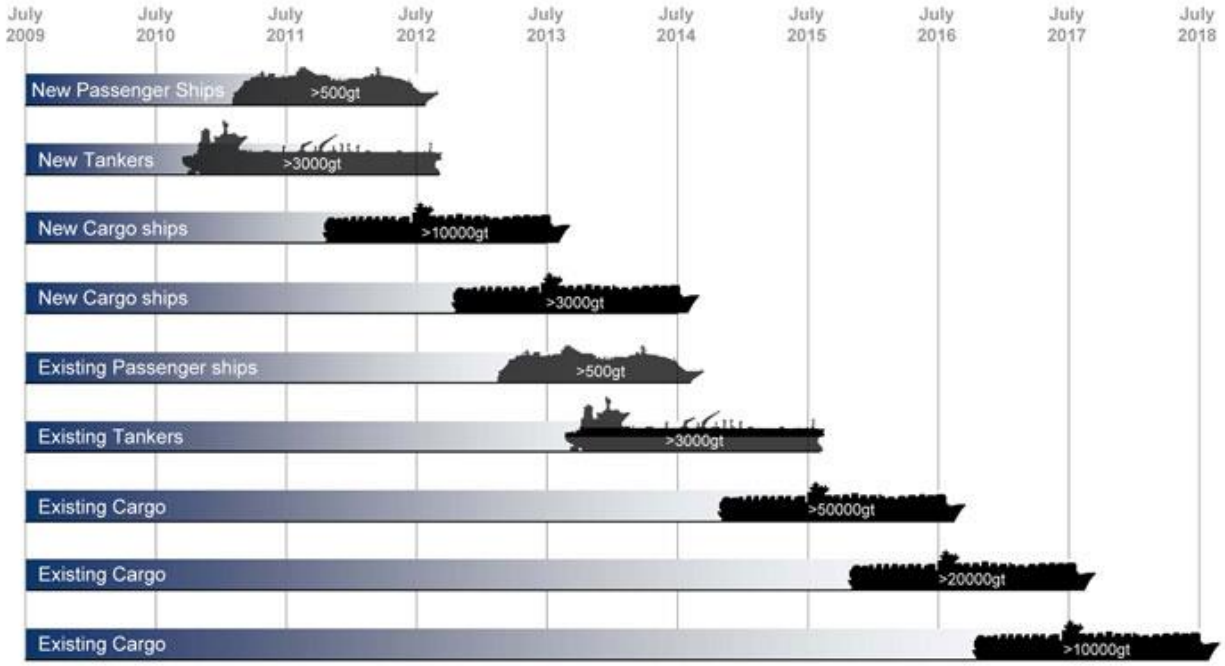
Table 1. Summary of Chart Carriage Requirements

Country and Hydrographic Organizations (HO)	Charts required?	Charts up to date?	Paper Charts Required?	Issued on Authority of HO?	Exceptions
IMO	Y[1]	Y	Y[2]	Y	[1]Government Vessels [1]Great Lakes Vessels [2]Vessels equipped with ECDIS and approved electronic backup
Canada (CHS)	Y[1]	Y	Y[2]	Y	[1]< 100gt & Sufficient knowledge (see Appendix C for details) [2]Vessels equipped with two independent ECDIS
Australia (AHS)	Y	Y	Y[1]	Y	[1] Vessels equipped with two independent ECDIS
United States (NOAA, NGA)	Y[1]	Y	Y[2]	Y	[1]Vessels < 1600gt (not incl. towing vessels 12m or longer) [2]SOLAS vessels equipped with two independent ECDIS. Non-SOLAS vessels must have RTCM Class ECS and back-up system
Germany (BSH)	Y	Y	Y[1]	Y	[1] Vessels equipped with two independent ECDIS
France (SHOM)	Y	Y	Y[1]	Y	[1] Vessels equipped with two independent ECDIS
United Kingdom (UKHO)	Y[1]	Y[2]	Y[3]	Y	[1]UK Government Vessels [1]UK Fishing vessels (see Appendix C for details) [2]UK Pleasure vessels < 150gt [3]Vessels equipped with two independent ECDIS

Note: Y = Yes, N = No

IMO countries require large commercial seagoing vessels to be adequately equipped with official nautical charts and publications that are up to date with respect to edition and/or NTM (Stavanger, 2004). Exceptions to this are typically granted to smaller vessels and those of non-commercial classification. Since 2009, the IMO has also facilitated the legal requirement for vessels with SOLAS designation to transition over to ECDIS navigation. Each year the ECDIS transition has been required by more vessels and by 2018 all SOLAS vessels will require EDCIS installation. Figure 1 denotes this gradual transition. Currently there are no requirements for vessels outside of the SOLAS designation to transition to ENC products or approved electronic navigation technology such as ECDIS or ECS.

Figure 1. ECDIS Compliance Dates for SOLAS (UKHO, 2015)



PRINTING AND DISTRIBUTION

The printing and distribution options available through each chart/map provider vary considerably. The particulars of each are presented in this section followed by a summary of all the options available to chart users in Table 2. Summary of Printing and Distribution.

CHS

At present, the CHS prints paper charts in house and distributes them to dealers for sale to the public. There are also super-dealers who are able to distribute charts to their own networks but the printing is still done by the CHS. The CHS has approximately 100 publications, such as Sailing Directions, Chart Catalogues, Chart 1, Tide and Current Tables, and a Tidal Manual which are all printed by commercial printers along with numerous products that are in publications format (e.g. Chart 3312). Currently, the CHS has 50-60 paper charts that are still printed lithographically.

Standard A0 charts as well as a limited number of A2 bound cruising atlases for popular recreational areas are offered by the CHS along with strip charts that are folded and have a cover. Charts are printed on a water-resistant media and the charts that are water-proof, of which there are a few dozen, are printed on Yupo paper. The CHS uses standard HP 6200 plotters, UV ink, and heavy weight paper for the A0 products. The cruising atlases are bound and printed by commercial printers. All of current chart options are considered to meet long-standing product specifications. As the CHS has started a pilot project allowing super dealers and dealers (e.g. MapTrak) to print charts themselves, there is the possibility of providing different options to chart users in the

near future. A Manager of Client Services at the CHS suggested that it is probable that dealers will have the option to print on synthetic waterproof paper and offer these charts as a premium product to the recreational boating market.

AHS

The Australian Hydrographic Service (AHS) caters to an Australia wide network and does not outsource any of its printing. The AHS uses print on demand (POD) technology with the production platform CARIS and do not use any alternate special technologies for printing. Distribution is done through a network of AHS approved agents which are divided into correcting and non-correcting categories. The AHS only produces standard charts and offers them as double fold, single fold, or half charts. Neither double sided charts, booklets, nor any other specialized charts are produced.

All content found within AHS charts meets IHO specifications laid out in the S-4 standard. While they do not currently offer any non-standard chart options, the AHS is exploring the possibility of producing charts that would be a 50% size reduction of the standard navigational chart for unofficial use as boating (small craft) charts, though this has not yet been started.

BSH

The German Hydrographic Service (BSH) prints all of their own charts and distributes them to authorized agents for sale to the public. They are currently transitioning away from offset, lithographic printing to POD technology. Currently the BSH does not offer any specialized chart options outside of the standard A0 charts but does offer small craft booklets (i.e. bound A2 size).

NOAA

The National Oceanic and Atmospheric Administration (NOAA) of the United States uses eighteen certified commercial POD venders to print and distribute all of their charts. Some of the POD venders offer NOAA's charts in waterproof and water resistant forms. NOAA offers charts that are printable in a portfolio and book format and booklet charts can be downloaded and printed from home using NOAA's website. The only special content charts that they offer are oil lease block charts in the Gulf of Mexico as an ENC overlay. NOAA's POD venders use their own media, hardware, and software and as such NOAA only certifies the end products and not the methods that are used by individual vendors.

Commercial entities are permitted to use NOAA's chart data to produce their own products, including cruising guides, and can use RNCs in electronic chart display applications. However, only certified POD charts and ENCs meet carriage requirements; in other words, products printed from a chart user's home do not meet carriage requirements.

UKHO

The United Kingdom Hydrographic Office (UKHO) prints the majority of their own charts using industry standard technologies with some configurations for their own requirements, such as using bespoke services. They develop their own software system interfaces when required; for example, adding Quick Response (QR) codes to refer to Notice to the Mariners page on their website. Another example is their External Print on Demand where standard industry equipment is used in conjunction with a print management system developed by the UKHO to ensure the data is protected at all stages of the process and that only the most up-to-date print files can be accessed. Traditionally, they used four color lithographic printing but are now moving towards digital printing solutions. The remainder of their charts are produced under their control but through their global distribution chain using external POD. The UKHO is planning to move towards print on demand in the future. The UKHO's paper charts and ENCs are produced from the same database; but do not always cover the same geographic area. Furthermore, their paper products meet the IHO S-4 specifications in depiction and ENCs meet S-52/S-57 for IHO digital standards.

The UKHO offers numerous non-standard options. For their SOLAS market (major commercial market) most of the charts are folded one-sided charts. For their leisure market however they offer a range of double sided charts in A2 packs. Customized options such as defense products, port booklets, or other special purpose products (e.g. for the 2012 Olympics the UK produced a series of Olympic charts and chartlets for the yacht racing) are also offered.

As a government agency, the UKHO licenses data to non-navigational markets; products that these markets produce are not necessarily approved by the UKHO. All products that are produced by the UKHO for navigational purposes meet IHO specifications. The data that they license to other leisure chart producers that do not necessarily meet UKHO requirements and therefore may not meet IHO specifications. No legislation changes were required for outside venders to offer special chart formats.

SHOM

SHOM transitioned away from offset printing at the end of 2014. At present, charts are either printed by SHOM with POD plotters or by offset printer from a subcontractor; the latter being in the case of large volume printing. Moving away from offset printing was made possible by implementing a continual maintenance system of raster charts with NTM weekly reports and a raster chart database. Production makes use of an integrated vector database in CARIS HPD from which ENCs and paper charts are derived. Charts printed by SHOM are distributed to the public by a network of authorized distributers and SHOM's digital charts are available through their online store. SHOM also has contracts with private companies who want to use SHOM's cartographic data. Given that this data is produced by an HO and thus considered to be official, electronic charts produced from this data are authorized for pleasure crafts.

SHOM does, however, impose the following constraints on the co-contracting parties: they must inform clients by means of a list of (corrected) errors that were committed in the derived products by reproducing, modifying, or using SHOM's products; the outside agencies must also include a cautionary statement on the derived products indicating that the information displayed was not verified by any official hydrographic service nor can any HO be held responsible for the fidelity of the outside agency's product or any ulterior modifications. Furthermore, the possession of these derived products does not waive the necessity of using the appropriate nautical documents as required by national and international regulations.

SHOM offers a variety of paper chart options including standard nautical charts referred to as C Charts. These are for navigators required to carry charts and nautical publications as per the SOLAS convention. These charts are produced according to IHO specifications for international charts and for S-4 paper charts. L Charts (where the number is followed by the letter L) display the same cartographic information as the C Charts with the same number. The difference is that L Charts are folded as a single sided A4 format (21 x 29.7 cm) and printed on a special water-resistant paper; they hold up better to folding and moisture and are better suited for smaller boats than the standard charts. They are updated on a regular basis (on average every two years). SHOM produces G Charts that depict bottom qualities and describe the distribution of different types of sediment; these charts provide additional information to the standard charts for mariners such as commercial fishers. Z Charts are for military exercise areas and have an additional layer depicting the limits and bathymetry of the military zones used by the Navy; these charts allow for an easy identification of the zones following a NTM. No regulatory changes were required to authorize the range of paper charts as those designed for navigation purposes are produced by the HO and kept up-to-date; furthermore, the media, such as the type of paper used, or the addition of supplementary data does not affect this either.

NGA

The National Geospatial-Intelligence Agency (NGA) of the United States does not distribute or print charts. The Defense Logistics Agency (DLA) and various commercial dealers print and sell charts to commercial mariners for a price determined at their own discretion; the DLA distributes charts to military chart users at no cost. The NGA offers one product format – the A0 standard single sided chart meeting IHO specifications.

DND - HSO

The Canadian Department of National Defense Hydrographic Services Office (DND – HSO) prints both CHS charts and HSO material. They are a printer and distributor for Canadian government departments, such as the CCG, DND, the RCMP, and CBSA. DND uses the same HP6200 plotters as the CHS using UV inks which can print on a wide range of materials and will not run. Some charts are produced on Tyvek for various

operations if they need to be waterproof, however, Tyvek media is expensive (i.e. approximately three to four times the cost of the equivalent roll of paper) but is extremely durable.

DND charts are all custom products derived from CHS charts, source data collected by the HSO, satellite data, and data provided by allies. Specialised content such as wrecks, anchorages, and bottom qualities are all important especially for products made for submariners. DND's custom products with thematic content for military operations may not all meet carriage requirements or IHO standards as they are strictly for internal purposes and therefore not mandated to meet the aforementioned requirements/standards. DND ensures that all elements critical to navigation are on the charts but also include a chart note to refer to the official chart for navigation. There is no set legislation requiring change from the Navy's perspective as they do not release their charts as official government document.

CCMEO

The Canada Center for Mapping and Earth Observations (CCMEO) within Natural Resources Canada (NRCAN) has digital products (i.e. topographical maps) available for printing by users. They also have approximately eight regional distributors from which users can order paper products through. Approximately ten years ago, the CCMEO had printing presses and were able to print their own maps with lithographic printing presses. At the time, they had a suite of National Topographic Series maps that were plotted on Tyvek paper and were indestructible.

The CCMEO does not currently offer any special formats. There are no special materials used and options such as folding, double-sided products, or booklets are not currently offered. The CCMEO permits vendors to print custom products; some of them are printing two maps on one sheet, some are double-sided and can be folded, and venders will typically place their own logo on customized CCMEO maps.

Table 2. Summary of Printing and Distribution

Agency	In-House Printing	POD	Distribution Method	Comments
CHS	Y	Y	External	
AHS	Y	Y	External	
NOAA	N	Y	External	
BSH	Y	N[1]	External	[1]POD starting in 2016
SHOM	Y[1]	Y[2]	External	[1]Partial In house/Commercial [2]Partial POD/Lithographic
UKHO	Y[1]	Y[2]	External	[1]Partial In house/Commercial [2]Inhouse printing via Lithographic
DND - HSO	Y	Y	Internal	
CCMEO - NRCAN	N[1]	Y	External	[1]Will print if required
NGA	N	Y	External	

Note: Y = Yes, N = No

FREE DATA/PRODUCTS

Whether data and products are offered to the public for free or for purchase by the various organizations consulted with is elucidated in this section. Clarification on which data and products meet carriage requirements is also discussed below.

CHS

At this time, the CHS does not offer free products or survey data to the public. All data and products that are used by third parties are licensed through the CHS and can be subject to fees and royalties depending on the intended purpose and the money generated as a result (e.g. value added resellers). However, recently in a DFO Program Evaluation of the CHS, a main recommendation that emerged was to address the lack of free data that is accessible to the public. As a result, the CHS is now working towards increasing the amount of data available to the public for free. The aim is to make this data available through an automated self-serve online environment[2]. This data would not meet carriage requirements as only products created and issued by the CHS meet the legislated requirements. The pricing of all CHS products were established in 1996 and are in accordance with the Nautical Charts and Related Publications Fees Order SOR/94-28; the pricing for digital products can be changed as required.

AHS

The AHS operates under the assumption that all common law collected data is public data so it is made available to the public for a fee and through a licensing agreement to ensure that the data is not reproduced, used to produce products, or sold. The AHS structures it's pricing around the perspective of cost recovery. They aim to set their prices for paper charts around the mid-range of what other Hydrographic Organizations sell their charts for.

BSH

The BSH only offers parts of their chart content for free, however the charts themselves are not free of charge. To purchase a raster or a PDF, a license is required which is available for a fee. An exception is for students, who may need a chart for a report, who can get a one-time license for free. Additionally, if an outside person or organization wants to produce private charts from BSH data and sell them then a special license is required for which there is a charge. The BSH also offers soundings and survey data that can be acquired for free. Privately produced charts are not legal for navigational and only official charts that are produced and printed by the BSH are considered to meet carriage requirements. The review of BSH pricing for the charts is done every two years in comparison to other countries that offer comparable products; prices are adjusted as required.

[2] For more information refer to the Intellectual Property Licensing Office at: http://www.charts.gc.ca/copyright-droitdauteur/index-eng.asp

NOAA

NOAA has both data and products offered for free as well as products that are for purchase. Everything produced by NOAA can be acquired for free unless a printed copy is wanted. If non-SOLAS vessels or vessels not yet required to use ECDIS are using a paper chart to meet carriage requirements, it must be purchased and printed by a certified POD provider. This is to ensure that a certain level of quality is met to fulfill carriage requirements; for NOAA to assume liability they need to be able to ensure that charts are being printed to a specified standard. If the chart user goes online and prints a chart themselves, there is no way of knowing if proper specifications were met, including if the chart was printed in black and white, on what kind of paper, and if the right scale was used or not. Free downloads are available to increase the use of charts and promote safety but they do not meet carriage requirements and thus NOAA holds no responsibility in the cases of free products being used. In theory, all mariners should have to buy charts from NOAA approved POD agents and can supplement, but not substitute, them with non-approved charts.

UKHO

The UKHO has its data available to the public for free but not charts that a vessel would carry on board for navigation purposes. Any survey data that is funded by the UK Government is free to the end user. Similarly, the UKHO provides free seven day tidal predictions under software called EasyTide. Copyright licenses to use their data free of charge are also made available pending it is not for commercial purposes. Given that it is only the data offered for free and not a complete product, carriage requirements are not met by this service. Prices are not statutory but rather are determined from a business perspective.

SHOM

SHOM makes certain data available to be viewed online or downloaded for free and has also put into place an online distribution center. For nautical charts, there are geo-referenced images of charts and S-57 data of SHOM's ENCs that are kept up to date with SHOM's weekly notice to mariners review. RNCs and ENCs can be accessed through the data portal as view-only with no printing or downloading options; official navigation products must still be purchased. Other cartographic products that are not kept up to date are also available online, including thematic charts, scanned products combining topographic maps and navigational charts (Scan littoral products produced with the National Geographic Institution), and RasterMARINE products which are small scale raster charts for economic development in the marine industry. The geo-referenced images of charts and the S-57 ENC data available for purchase through the online distribution center satisfy carriage requirements for pleasure crafts under 24 meters but does not meet carriage requirements for other vessels.

NGA

All NGA data and products are available for free to the public. The US Government prohibits the NGA from selling anything; however, dealers can sell products and determine the pricing (i.e. no statutory pricing exists). The public can download and plot out a downloaded NGA chart and it would meet carriage requirements.

CCMEO

The CCMEO used to sell the National Topographic Database as a digital product but over time they abandoned all cost recovery from digital data. Currently, all of their data and products are free to the public. The only products that are not free are air photos which are for purchase from the National Air Photo Library; this also operates as a revolving fund to recover the cost of printing. The free data/products do meet international specifications (i.e. ISO Standards and Open Geospatial Consortium Standards).

PROCESS AND PRODUCTION: INCREASING EFFICIENCIES AND ANTICIPATED CHANGES

Ongoing practices and methods of production across the chart and map providers vary considerably. Many of the organizations have undertaken initiatives to decrease the work intensity of certain processes and reduce costs where possible. Any anticipated changes across the various organizations are also provided in this section.

CHS

The CHS has 946 charts covering all three coastlines and the major inland waterways of Canada. In HPD, the CHS has six usages (scale bands) with most data falling into the Harbour (2001-20,000), Approach (20,001-50,000), and Coastal (50,001-150,000) usages. There are numerous paper chart scales, such as in the Pacific Region there are 179 paper charts all of which fall into 45 scales. The 1:20,000, 1:40,000, and 1:80,000 scales make up approximately 54 percent of the products. The CHS uses a traditional paper chart scheme with adjacent charts overlapping and does not currently use cell based limits. Both electronic and paper charts produced by the CHS maintain full IHO specifications.

For small but important changes to products NTMs are issued and for larger more complex changes a patch will be issued. A new edition is typically produced if an update is comprehensive and covers a large area. At this time, there is no maximum NTM to trigger a new edition. Within the next eighteen months, into 2017, the CHS is considering outsourcing all of its in-house printing and distribution to a combination of dealers, super-dealers, and commercial printers. Once this happens, all charts will be available through POD format with the ability to be updated, on average, monthly.

AHS

At present, the AHS has 436 paper charts in their portfolio and intend to withdraw approximately half a dozen of their 300,000 scale paper charts where there is appropriate 150,000 scale charts underneath; the aim is to do this in 2016 to minimize the maintenance overhead. The original coastal paper chart plan for Australia was to offer complete coverage at both 150,000 and 300,000. A few years ago though, the decision was made to only offer one scale so for any given area in Australia there will be a chart at either 150,000 or 300,000 but not both; this resulted in a notable decrease in what the intended portfolio would look like. The AHS relies mostly on NTMs to update paper products yet make a lot of new editions as well.

In CARIS HPD, the AHS has four product usages with a total of eleven scale bands for their ENC products. ENCs have one usage for navigation purpose 5, navigational purpose 4 and 3 are combined into a single usage; and navigational purpose 2 and navigational purpose 1 have their own usages. On ENCs, the AHS makes use of the S-57 meta object M_CSCL so as to define different discrete scaled areas within their ENCs. From a paper chart perspective, the AHS has approximately seventeen different scales.

The AHS has changed their production process as of 2015 and is now producing ENCs first from source data with the paper chart being a derivative. This was done with the aim of increasing efficiency but the change has not necessarily translated into a decreased level of effort. The Deputy Director of Charting Standards and Specifications along with the Deputy Director of Chart Production and Maintenance shared that it is difficult to say whether their recent changes have made chart production any less expensive or work intensive. All they are doing now with the paper charts is taking the data and running it through a translation process into CARIS to compile the chart. The requirement for source compilation is not changing so there is not necessarily less effort put into production, it has just been redirected to the ENC.

At this stage the AHS does not have any further changes planned beyond those already in place. The AHS is in the position to now observe what is being done by other HOs in terms of paper charts portfolios. The next anticipated step will be addressing the outcomes of the IHO discussion on the future of the paper chart; the AHS is hoping that an IHO position will emerge that will inform IMO discussions on the future of carriage requirement with respect to what is included in SOLAS Chapter V. The IHO Nautical Cartography Working Group, of which the Deputy Director of Charting Specifications and Standards of the AHS is a part of, was instructed to deliver a discussion paper on the subject to the Hydrographic Services and Standards Committee and aims to do so in November 2016; it is hoped that this will help form the basis of further discussions and moving forward.

BSH

Currently, the BSH produces 70 A0 charts and fourteen booklets. The BSH has a large variety of scales but are moving to standardize their charts in A0 and A1 sizes and will only have five: 12,500; 30,000; 50,000; 150,000; 375,000. Bound chart booklets in A2 will be replaced by the A1 format. For some of the smaller harbours in the Baltic Sea there may be a few larger scales as well. Additionally, older charts with 200,000 and 250,000 scales may need to be maintained.

The BSH uses NTMs to update charts between new editions. If something large needs to be corrected a new edition will be produced and occasionally they will use block corrections (which are similar to a patch) but the BSH prefers to avoid blocks given that they produce new editions annually so it is not always worth the effort to do a block. They have ceased production of charts that are adjacent to German waters and are now solely focused on German waters. The BSH is planning on transitioning to POD from offset/lithographic printing and as of last year was staffing a chart corrections office.

NOAA

Presently, NOAA produces 1024 charts. Over the past year, two charts with redundant coverage were cancelled, one of which was a small craft chart and the other was a very small scale chart over the North Pacific. Considerations are being made for future cancellations of other redundant coverage including small craft charts.

NOAA has chart panels (i.e. main chart insets and extensions) that fall into more than 100 scales. Their new central database production system has 22 compilation scales but typically they will only use three or four of the usages with the most common being Harbour, Approach, Coastal. While NOAA's charts are predominantly in alignment with IHO S-4 there are a few exceptions such as with the use of fathoms and feet for soundings and different symbology for buoys and beacons. NOAA considers their raster charts (i.e. RNCs and PODs) to be fit for navigation and fully meeting carriage requirements.

NOAA has significantly reduced the cost to the Government by no longer paying for printing. It was the FAA that was previously paying to print charts but it is now commercial printers.

Over the past three years, NOAA has had several iterations of improving the final stages of chart production to make the process shorter and more efficient. NOAA is switching to a central database and is finding that the compilation time in ENCs requires more than the compilation on a raster because of the additional time needed to encode the attribute data associated with each charted feature; currently they still have to maintain the raster as well. In their new system the aim is to reduce the overall compilation time required for both products. Once NOAA has their full ENC coverage uploaded into the new system they hope to have raster chart production largely

automated. The intent is that data for paper chart production would be pulled from the central database followed by a small amount of cleaning it up, making adjustments to the automated symbolization, and ensuring that no content is in the way of any other items.

With respect to chart updates NOAA offers new digital version (RNCs and PODs) of raster charts on a weekly basis; these contain all NTM and LM updates that have been received and occasionally include newly compiled data as well. New editions are typically made when significant amounts of new hydrographic, topographic, or other new sources have been applied to a chart. The Chief of the Marine Chart Division shared that the difference between weekly updates and new editions is becoming a matter of bookkeeping opposed to content.

NOAA is in the midst of transitioning to the use of a central database and does not foresee any additional changes at this time. NOAA anticipates using the POD model well into the future. They foresee the use of RNCs in electronic chart systems for private or small craft boaters and the use of ENCs for larger and commercial ships which they suggested may eliminate the need for paper charts eventually. Furthermore, NOAA suggests that ENCS are likely to completely replace the need for raster charts of any kind (i.e. RNCs and PODs).

UKHO

The UKHO has approximately 3500 charts globally and approximately 450 in the United Kingdom itself. The UKHO monitors world changes such as the opening or closing of ports; if a new port is established they collect the data and produce a chart and if a port is closed they may withdraw the relevant chart. When there is an intention to withdraw a chart, the UKHO will send out a NTM bulletin and will give the end users eighteen weeks to respond with any concerns. If no responses are received the assumption is made that the chart is no longer needed. There is currently no plan to have a large scale reduction in the number of charts produced.

The UKHO continually reviews their processes to see if production can be made more efficient. As a means of decreasing the level of re-work, there have been considerable amounts of work done on defect analysis in error reduction. The approach being taken by the UKHO is that of the ‘right-first-time’ principle rather than building in another check at the end of the job. This means they are trying to reduce the amount of checking by investing earlier on in the process to make sure they can get it right the first time. Over the past three to four years, the Geographic and Data Acquisitions Manager stated that a considerable investment in time, people, and finances has been made to streamline the process while not compromising accuracy or safety. The UKHO’s aim is to get data in the right format, at the right scale, at the right price, and with the right commissions; they want the process to be as error free as possible so that the level of re-work on a given job is minimized. Furthermore, the UKHO employs root cause analysis to assess

any errors that occur to determine if a process needs to be re-engineered or if human error was involved and what can be done to avoid future errors.

In the UKHO home waters database there are sixteen compilation scale bands which also includes those charts of older home waters with a previously wider scale range. Globally, the UKHO has near to 250 scales that are used on their chart products which they are currently working to refine. All UKHO paper charts and ENCs comply with IHO specifications except in the instance where a product from a partner organization or foreign HO is adopted into a UKHO series.

The UKHO will issue a NTM for simple textual changes or blocks/patches that can be stuck on but if information needed to be added extends beyond what could be covered in a NTM they will produce a new edition. Urgent new editions are also issued if a change needs to be turned around at a faster rate than a traditional new edition but the urgent new edition will be restricted to the specific change involved. All updates are in line with IHO publications S-4 section B-600. Typically a NTM will not be produced with more than ten positions in it, on occasion eleven or twelve, to ensure the end users task of updated their portfolio is not too onerous.

As an active contributor to many IHO working groups, the UKHO is keen to develop new ways of approaching chart production and to support others in the development of new methods and techniques. Along with looking for new products and services to offer, the UKHO strives to find new more effective approaches for existing products and services, such as maintaining a full paper chart portfolio but increasing process efficiencies.

SHOM

SHOM has approximately 900 paper charts and their goal for 2016 is to reassess their portfolio and replace compiled charts with raster charts. SHOM subcontracts the bulk of its printing and the rest is done on demand by SHOM. The use of CARIS allows for paper charts to be easily derived from the S-57 data; the transformation of S-57 content into a raster image is facilitated by the software. In CARIS HPD, SHOM has 11 usage bands. Production is based on paper chart limits; when ENC production first began SHOM was using a tiling system for ENC limits, but as of 2016 all French ENCs are cut to match paper chart limits. SHOM is able to maintain full IHO compliance and updates its paper charts and ENCs simultaneously. SHOM makes use of raster and vector updates to maintain their charts. Mariners are informed of important information by chart corrections and eventually with patches assembled weekly in the NTMs; NTMs are free and strictly available online. The introduction of a quick response code on each chart allows for new corrections and temporary notices to be quickly accessed. SHOM's objective is to release new editions of ENCs and paper charts within less than a month of one another.

A number of SHOM's charts cover foreign waters; they are progressively trying to get certain surrounding countries to take on SOLAS conventions including hydrography,

cartography, and nautical documents. SHOM's 2017-2020 plan includes researching the different printing options as future possibilities, including the possibility of printing through venders if interest exists.

NGA

The NGA currently has 3500 charts in their global portfolio and to date have not had any reductions in content or coverage. Instead of making DNCs from paper charts, the NGA utilises software that will take the DNC and convert it into a paper chart with some manipulations. Charts can then printed by customers on an as needed basis from the up-to-date DNCs. The NGA currently uses four scale bands: harbour, approach, coastal, and general. They are using cell based production so there is no overlap between charts and they are able to maintain full IHO specifications with all paper and digital charts. Similarly to other chart providers, the NGA relies primarily on NTMs and will only put out new editions if there are extensive new sources, if they re-scheme a harbour, traffic separation scheme implementations, or survey data that significantly changes an area. Therefore, unless there is a notable amount of change or if a chart is significantly older and needs to be updated, the NGA will issue NTMs. There are no changes currently planned for the NGA; the military is happy with the current delivery of services and products.

DND - HSO

The DND - HSO has thirty custom charts that it produces for internal users. A few steps have been taken to increase efficiency and reduce workload including the use of use existing vector data from other adjacent products or scales. Duplication is also minimized through collaboration and co-production with outside agencies that have a similar mandate, such as the NGA.

To eliminate overlap, the DND - HSO uses a cell based scheme for most of its Additional Military Layers (AML) products which are based on a NATO worldwide grid. This grid consists of two main scales, either one degree by one degree or five degree by five degree. If a larger scale if desired then an individual grid square can be further divided up until the desired scale is reached. NATO has developed a process to facilitate changing scale bands without overlapping content. As this grid is administered in a sequential format worldwide, it is relatively easy to determine which products cover certain areas and what adjacent products are.

Rather than trying to meet IHO specifications, quality assurance (QA) is the main focus of the DND - HSO. There are certain products that must meet IHO specifications, specifically those that are co-maintained with agencies like the NGA; for all other products, a strong focus is placed on internal QA and third party software testing to make sure the product will work for their end users and is received in a timely fashion. When it comes to product maintenance, new information is incorporated via new edition rather than NTM or patch.

Currently, DND is happy with where they are at now with the changes that they have made over the past couple of years. The next phase will be a concerted effort on their submarine ENC program.

CCMEO

Given that map production is inherently expensive, the CCMEO has moved away from ground surveys for compiling map content and moved towards other sources of data. Different types of remotely sensed data including air photos and satellite imagery have played a large part in reducing costs. There are also numerous provincial and municipal agencies continually collecting data such as road networks, hydrographic networks and land cover types that are useful to the CCMEO. Other agencies have also co-purchased datasets of mutual value such as high resolution satellite imagery for shared use. These data sharing agreements have become a large factor in reducing costs and workload for map production. As a result of a data sharing focus, the CCMEO has become more involved with data management and integration rather than production.

In terms of products, the CCMEO provides access to a 190,000 product inventory of which 13,000 are National Topographic Series (NTS) maps. These NTS maps are available in three file formats, PDF, TIFF and GeoTIFF in a single scale of 1:50,000. The one product that was not maintained was the older 1:250,000 NTS maps, other than that, all products are still available. The current suite of publications and map products are accessible through their web application called GeoGratis, which includes a Web Map Service (WMS) that have proven valuable to users with the advent of Geographic Information System (GIS) based software. With respect to product maintenance, the CCMEO has not removed any content from their products suite to save time or money. However, in the data sharing paradigm, temporal accuracy of map content is highly dependent on the supplying agency. Some content such as road networks are usually reviewed frequently and are more up-to-date than other content that might not be reviewed for years.

To decrease production time, in 2012 CCMEO spent one year developing a specialized piece of map production software to assist cartographers with compiling maps from multiple sources. This complex software drew upon numerous databases automatically compiling topographic, boundaries, and toponymic data into an NTS map. Production effectively quadrupled and what would typically take two days of work was now less than half a day. Over a period of three years a total of 1800 maps were compiled using this software.

In the future, the CCMEO expects there will be more reliance on individuals and the private sector to generate tailored map products. In the years to come, there will be fewer standardized maps and more web map services where people can embed them to their own applications or own environment. Similar to when the CCMEO transferred the map printing away from government operations over to regional distributors where

anyone can now buy a plotter and plot their own maps. The Senior Technical Advisor suspects this same principle will apply one day not only to printing but compilation as well. The power of compilation is now available through crowdsourcing; citizens and organizations with good image of a particular region and given some basic tools can draw elements such as the road networks and infrastructure placements. The challenge for the CHS is that a process of product validation is required, given that nautical charts act as a legal document, making the concept of crowdsourcing more difficult that with topographic maps. It was suggested that the base information on the coastline of charts (i.e. the topographic components) could potentially be automated in a big way.

SHIFTING TO ELECTRONIC (DIGITAL) OPTIONS

With new technologies and shifting market demands, the respondent chart and map providers are all at different stages of shifting towards the primary use of electronic based products. Differing approaches exist amongst HOs on how to approach the eventual phasing-out of paper charts, with some placing greater emphasis on the value of maintaining paper charts than others.

CHS

The CHS does not plan on going completely electronic in the immediate future but has started undertaking initiatives to ensure it is well positioned for the impending international shift to electronic navigation. CHS initiatives include a legislative review of carriage requirements and an assessment of the paper chart, in the *Future of the Paper Chart* report, with consideration for the growing prevalence of electronic navigation. The legislative review will look at how Canada might modernize the requirements for mariners to navigate safely in Canadian waters, including the potential approval of ECS type navigation systems for non-SOLAS vessels. The potential options outlined in this report will help to inform the CHS on more ENC oriented navigation and production methods.

AHS

The AHS is iteratively and carefully moving forward with reducing their paper chart portfolio to eventually shift to digital (ENC) only. They are trying to coordinate with other IHO Member States for an international perspective on the future of the paper chart. Having to maintain dual products is becoming increasingly difficult due to staffing resources and economics. In 2018 the AHS plans to start reducing their paper chart portfolio but a lot of questions will need to be answered before then on what chart reductions can be done. As of June 2014, the AHS has withdrawn their AusRNC service for raster charts and no longer offers updates or support, thus AusRNC no longer meets the AHS legal carriage requirements. By making this decision, mariners are must use either paper charts or ENCs (AHS). The AHS stated that there may be a future requirement to produce small scale overview charts to give mariners a broader view of their position relative to the smaller ECDIS screen view. The AHS acknowledges that one of the biggest obstacles in terms of ECDIS take-up is that a lot of the information

that can be seen on a paper chart is not necessarily visible on the ECDIS unless the user drills down into the data or adjusts the ECDIS display scale so that features relevant to the mariner's situational awareness are visible; this is a deterrent for some mariners to use the ECDIS.

With respect to maintaining paper charts but shifting to a printout of a vector chart opposed to the current paper presentation the AHS requires more time to assess. With the transition in the past four months to producing ENCs first and deriving paper charts from the ENCs, the AHS wants to see what impact that has on their ability to produce and maintain both products before moving forward. The goal is to eventually be able to produce a paper chart derived from corresponding ENCs in two weeks. Given that they are in the early stages of this transition, they need to wait to acquire more figures to properly evaluate its success and then re-evaluate in terms of future resources and budgets. Depending on outcomes, the AHS will more actively consider the possibility of reducing their paper chart portfolio. In April 2016, at the Next Nautical Cartography Working Group meeting, the AHS's Deputy Director of Charting Standards and Specifications hopes to present a paper on the AHS's experiences thus far on producing ENC's first and paper charts as a derivative.

In switching to a printout of electronic charts, the divergent elements required on each format need to be considered. The AHS stated that increased topographical information could be added to the ENCs and that as per the IHO chart specification S-4 for ENCs and paper charts there is a requirement to display information on the ENC deemed to be useful to a mariner in terrestrial navigation, such as with visual position fixing. For a brief time the AHS thought it did not need to include topographic information on ENCs because a position is fixed by the GPS in the ECDIS. But feedback from mariners led to a re-evaluation so that the AHS is now putting the topographic information back in.

BSH

For the foreseeable future, the BSH plans to maintain paper charts. Likewise, the BSH feels that the current presentation of the paper chart will remain as is. They believe that more information is needed on paper charts than what is displayed on ENCs (e.g. annotations) and therefore do not at this time think shifting to a printed digital version that resembles an ENC is a good idea.

NOAA

NOAA does not have any current plans to shift to digital only charts; however they recognize that this is likely to occur over time. NOAA does have some new ENC coverage for which no corresponding raster charts will be produced. By 2018 when carriage requirement change for all SOLAS vessels, NOAA aims to have ENCs being the preferred chart option for mariners.

When asked about their thoughts on shifting from traditional paper chart presentation to a printed digital version, resembling the ENC presentation, NOAA responded by saying they are making a concerted effort to moving towards an ENC first model. Over the next few years ENCs will become their primary product and there has been a shift in their work force to ensure that all staff is familiar with working on ENCs in addition to paper. The goal is to make the paper charts from the same central database from which ENCs are produced, but for now they are being maintained with separate software. NOAA has made a lot of progress and currently has over 500 ENCs loaded in the database so they are over half way done. For updates, they update the data in the central database and then do an export of the data to automatically symbolize the raster product, followed by some edits. NOAA has talked about doing printed ENCs but think they can do a bit better than that without too much extra effort in the long run. Their understanding of HOs that have tried making printed ENCs is that it still requires substantial recompilation to make it useable and to add the extra content needed on paper.

UKHO

The UKHO plans on meeting end users' needs for both paper and digital charts for as long as is required. It is acknowledged there is a transition for the mandatory use of ENC and ECDIS by the year 2018. However, this will not apply to every vessel and their internal research suggests that there will be a market for paper charts well beyond that time. They regularly engage with industry and businesses, such as shipping companies, and engage with other agencies to stay in tune with what the market wants. It is clear that the sale of paper charts is decreasing nearly everywhere in the world but the question they ask is whether it is still a viable business decision to continue producing; for chart users that do not need ENCs, they will continue to need paper products and so the UKHO plans to continue providing that service.

The UKHO has produced images from ENCs for internal uses; at present, doing this does not meet carriage requirements and so they do not see this as an option even though producing a paper chart from an ENC would use the same dataset, the same database, and basically just be a "screen dump" making it relatively inexpensive. If there is a move for the IMO and the IHO to accept a print of an ENC as a chart equivalent or if it were to meet SOLAS Chapter V requirements then this could be considered. Given that it can be a lengthy process for international bodies to adopt such change, the UKHO's Geographic and Data Acquisitions Mangers suggested that it is likely that amending SOLAS requirements could take several years.

NGA

The NGA has shared that the US Military is supposed to be full transitioned to electronic charts by 2018. Once this has occurred the aim is to reduce the portfolio by approximately 60%, though it is more likely that it will only be reduced by 30%. There are no plans to completely eliminate hard copy charts given that not all vessels will be entirely digital.

In terms of doing an electronic printout of charts, the NGA does offer what they refer to as EPODs (Enterprise Product-On-Demand) which are derived from DNCs. EPODs are a relatively up-to-date PDF that can be downloaded by the end user and printed through a proper government-owned, large format printer such as those available at the NGA Remote Replication Site Facilities[3]. EPODs are certified as safe for navigation only if they are printed at the appropriate scale. These charts can also be used for situational awareness and planning at smaller scales (National Geospatial-Intelligence Agency, 2016).

DND - HSO

DND is able to print a fairly good representation of a paper chart from an ENC or from the DNC (i.e. what the NGA has). If production went towards having paper charts being printed representations of ENCs there could be issues with creating and using lookup tables to convert ENC symbology to paper chart symbology. The Superintendent of the Hydrographic Services Office estimates that it could be another ten to fifteen years before Canada is able to drop the paper chart and print from ENC source files.

Regarding paper versions on ENCs, DND will use a source file for a digital product and an AML and if somebody wants a paper product, DND can take the source file and add Chart 1 features; alternatively they can pull the features from the ENC and use a lookup table which results in a good representation. The paper equivalent is generated from the vector file and the format used is a geo-PDF so there are coordinate information and true distances. Additionally, the file is only a couple of megabytes in size making it a smaller file relative to a raster or geo-TIFF.

The newest version of ECDIS software being used by the Navy reads geo-TIFF images directly so instead of spending a lot of time creating the BSB format, they create geo-TIFFs which are much faster.

The Superintendent of the Hydrographic Services Office stated that the geo-TIFF is essentially the universal GIS format and it should be an accepted format in S-100. So in terms of exchange format, it was suggested that if the CHS were to go to geo-TIFF format and drop BSB, it could save a lot of time. The DND HSO only has four staff members for production so keeping processes as time effective as possible is a priority. They do produce one BSB (i.e. 3456 with a military grid on it) and they follow CHS processes for that. That takes a couple of days to get it right, whereas with a geo-TIFF "it's simply a save-as and you've got it". As such, the question was asked whether the CHS will need to produce three formats in the future if a paper representation of an ENC can be made or alternatively a geo-PDF or a geo-TIFF which can be read by the ECDIS software in raster mode or even in a chart viewer such as Nobel Tech.

[3] For more information on downloading EPODs refer to:
NIPRNet: https://www.geointel.nga.mil/products/dnc/epods/index.htm
SIPRNet: http://www.geoint.nga.smil.mil/products/dnc1/epods/index.htm
JWICS: http://www.geoint.nga.ic.gov/products/dnc1/epods/index.htm

CCMEO

The CCMEO has essentially shifted to digital only and do not do paper products anymore; they only make reproductions on an as needed basis such as if a distributor would be at a loss for producing a certain product. If a map is needed for an office setting or for discussions at a table, the CCMEO will print one on an adhoc basis from the digital product using a plotter.

They have vectorized all of their maps and have a products called CanVec, an evolution of the National Topographic Database, which offers all of the vector data from which all topographic maps can be produced. Digital formats available include PDF, GIF, TIF, and geoTIFF for raster data and SHAPE, GML or FGBD for vector data. The CCMEO, however, wants to encourage more use of its web mapping services opposed to its digital products. They have a Canada base-map as a web service and individuals can use that within their own environment. As an example, on Passport Canada's website a map is displayed to indicate the locations of all the Passport Canada offices; the background map is a mapping service that the CCMEO created.

Overall, the shift to digital only products has worked well for the CCMEO. Some challenges have included getting older folks to see that this shift is possible. There are a large number of people that are used to the 'good old paper maps' and this is an obstacle to overcome. There is value to paper maps and there is still a market for paper products but the market has become very narrow now. Even in government, there are people who are not familiar with what can be done digitally with maps and are still looking for the paper maps; whereas the Senior Technical Advisor with the CCMEO said many case would be much better served by using a web-mapping service. Education is the challenge when shifting to digital only options; it is key to increasing awareness on what can be done with a computer if a person knows where to go to get the maps that are available.

SUMMARY

Hearing from a number of chart and map providers elucidates that the CHS is leading the way in many regards yet also in a position to learn from the innovative initiatives of other organizations. In developing a better understanding of what other chart and map producing agencies are doing, the CHS can make informed decisions on how to move forward with its own practices and procedures.

Currently, most IHO Member States that were consulted with legally require paper charts to be on board unless a vessel is equipped with type approved ECDIS. All of the chart/map providers consulted with have transitioned to using POD for paper charts, or are planning on transitioning, and have outside venders involved with the distribution and sales of charts; some venders are also the responsible party for printing charts. The print options available vary across the chart/map providers but many do offer custom formats of some sort. While many chart/map providers offer free data or free charts, most do not accept the free or downloadable charts as meeting carriage requirements.

Generally for liability, charts must be printed and obtained from an approved HO or authorized vender. With respect to production, there is a wide range of processes currently in place. Of all the organizations consulted with, some are using central databases to compile both ENCs and paper charts while others are using two distinct databases and continuing to maintain both product lines. Two of the chart providers are moving towards ENC first models with one actively working towards phasing out paper charts.

Identifying external practices globally helps the CHS to identify organizations with which further engagement could be beneficial, depending on the direction the CHS chooses to take. Understanding the practices and procedures of agencies with similar objectives as the CHS can provide a framework from which to discuss viable options for change within the CHS. Additionally, it can provide a platform from which the CHS can innovate and contribute to leading the international dialogue on the future of the paper chart.

DISCUSSION

Determining which products to offer and how to most effectively print and distribute them will contribute to safe navigation in the years ahead. This section brings together key themes from both chart user and chart provider perspectives with regards to their significance for the future of the paper chart. Predominant ideas and concepts from the consultations are discussed in the context of their application to the CHS. The aim is to provide a framework for dialogue both nationally and internationally and suggest potential options for the CHS to consider.

MARINERS AND SAFE NAVIGATION

Chart Content

Over the past 130 years the design and content of Canadian charts has evolved to a stable point that are well received by most mariners. As with any graphical representation of the physical world, there is a balance between showing too much information thus reducing the ease of interpretation and showing too little information, putting mariners in a potentially hazardous situation. More information is generally preferred by mariners as if offers better insight into what to expect or features to look for while navigating a vessel. Soundings, contours and hazards are the core of any nautical chart but the value of information above the high waterline should not be underestimated.

In the era of GPS and ENC navigation, elements such as topographical and visually conspicuous features become seemingly obsolete. However, these features offer a layer of safety enabling the mariner to visually and actively confirm a vessel's course and position in the real world rather than relying on passive positioning systems. In reduced visibility or offshore navigation, mariners often employ RADAR to confirm their vessel's position which is only valuable with an accurately charted and detailed coastline along with topographic features to overlay. With an increasing push to ENC navigation there should be an emphasis placed on maintaining the fidelity of features from the paper chart to the ENC.

Mariners have indicated the desire for complete data access for the areas they navigate including better access to historical charts, digital elevation models (DEM) and survey data. While charts would remain the only official product from which to navigate, augmenting the information available would make mariners better aware of all the hazards that exist. Options to make this a reality could include DEMs for an entire coast, survey specific or product specific DEMs made available through WMS or web portal. This would also be a step towards mariners being able to create their own custom products via manipulation through a more advanced GIS or web portal.

Primary/Backup Navigation

With the increased usage and acceptance of electronic navigation technology, paper charts are more frequently used as backup and training material opposed to a tool for

primary navigation. Very few modern mariners rely on paper charts for anything other than a small scale overview for route planning or in the case of an emergency which renders electronic equipment ineffective. Current ENC products offer large scale coverage for the majority of Canadian waters which is a great fit for the primary navigation role. As paper charts are being relegated to secondary and sometimes tertiary roles, the rational of coupling two similar products with different roles, presentations, and production timeframes needs to be questioned.

While the primary purpose of both ENC and paper charts is safe navigation, how that purpose is achieved is vastly different in the context of normal versus emergency situations. When using the ENC as the primary means of navigation, mariners may be able to take routes or explore areas that might be perilous if navigating via paper charts. During an electronic failure where systems become inoperable and navigation is reduced to the rudimentary means of a paper chart the objective of the navigator changes. This is important to acknowledge because in these situations mariners need a paper copy of something to navigate directly to safety and are unlikely to take risky routes to avoid exposure to further danger. Given the different role paper charts now play, CHS could change elements such as scale, spatial coverage, adjacent chart overlap, or presentation to still meet mariners needs but reduce the amount of time and level of work required for creation and maintenance.

Training

Paper charts provide an inexpensive platform for learning the basic techniques of safe navigation. These principles are the foundation for more advanced courses involving electronic, radio and radar navigation. ECDIS and ENC navigation has its benefits but new mariners can easily be consumed with their many features and as a result basic safe navigation principles are pushed aside.

As discovered by the Canadian Navy Venture School, learning the basics on paper charts gets new mariners to think outside of the electronic box at the bigger picture. By ingraining these skills on paper by hand the mariner can understand what they are doing when they eventually move onto electronic navigation. This indicates to the CHS that paper charts are a valuable training resource and efforts should be made to continue to produce paper charts in some capacity for this purpose.

Similar to basic paper chart navigation, ENC navigation is a skill that requires training and practice. A source of potential resistance to fully embracing ENC navigation is the lack of familiarity with certain features and functions of ENCs. Mariners that are only accustomed to paper or RNC products can be overwhelmed with elements such as the display of safety contours and depth area colouring; such features can make an ENC presentation very different from the paper chart equivalent. Nevertheless, reluctance can be overcome with training, exposure to the proper setup, and navigation using an ENC. Collaboration with the CHS and organizations that provide training to mariners,

such as the Canadian Power and Sail Squadrons, could prove to be effective in helping safely transition to ENC navigation.

CHART/MAP PROVIDERS AND PRODUCTION PARADIGMS

Shifting Production

The AHS and NOAA will be the first HOs to shift production focus to an ENC first model with the paper chart considered a derivative. While any cost savings or production efficiencies remain to be seen, the AHS is positioning itself for the long term when the classic paper chart becomes a relic. An important step prior to the AHS shifting its production efforts was a complete revision of its chart portfolio, both in terms of coverage and scale, making changes where necessary to maximize efficiency. For the CHS to make a similar transition, the necessary revision could be challenging yet represents a great opportunity.

Both chart users and chart providers acknowledge that a shift towards ENCs as the primary means of navigation is expected and in many cases already happening. While it may not be entirely feasible for the CHS to go paperless at this time, nor would it be risk free or desired by the chart user, the CHS is in a position to follow the lead of other HOs and consider moving towards deriving paper charts as a secondary product following ENC production. For this to happen, the CHS would need to focus compilation on the scale, presentation, and limits of ENC products rather than paper chart products. As ENCs can be considered scale-less, it would have to be decided at what level of detail to compile ENCs. Compilation could consist of a mid-range scale between scale minimum and scale maximum attributed features or it could be done on an area by area basis depending on navigation purpose and vessel traffic type.

A major justification for changing production priorities is the fact that ENCs are typically ready for release long before the paper chart equivalent. Unfortunately the ENC is held back until the time consuming paper chart is fully completed, as there can only be one official chart. This places both the mariner and the chart provider at distinct disadvantages; mariners are deprived of timely up-to-date products and the CHS is faced with the burden of producing and maintaining multiple product lines. This type of production change may not be simple but rather would need to be well thought out and executed. It also must be acknowledged that this type of profound change affects not only the actual process but the people involved with production, such as the cartographers; countries have been producing paper charts for hundreds of years using essentially the same techniques and in order to change processes new training or education programs would need to be implemented for current and future CHS cartographers.

Minimum Deployment Portfolios

With major CHS clients consisting of other government departments, such as DND and specifically the Royal Canadian Navy, considering the direction taken by these groups is

important. As the Navy has transitioned to utilising a minimum deployment portfolio (MDF), at the bare minimum, the CHS could consider establishing an MDF to ensure the charts in this portfolio are well-maintained and up-to-date.

MDFs could potentially fill the niche between ENC navigation and the desire for many mariners to have paper charts for route planning and backup. As paper charts are often the secondary means of navigation, with many vessels only carrying portfolios because it is required by law, paper chart schemes and scales could be adjusted to achieve safe backup using fewer, smaller scale charts. Compilation, generalization, and layout of these charts would need to keep the objective of safe emergency navigation in mind, perhaps including insets or details that would otherwise be remitted to a large scale chart. Development of a minimum paper chart portfolio would also simplify the number of charts a navigator has to purchase and maintain as well as reduce the number of charts needed to pullout and organize during an emergency. For the CHS it would reduce the burden of maintaining a complimentary product line to the ENC and perhaps facilitate the phasing out of the paper chart as it exists today.

Automation

Technological advances over the past 30 years have changed chart production dramatically. Now that production is computer based by means of a database structure, focus can be placed on the automation of time consuming manual tasks. Paper chart presentation editing is one of the more laborious parts of the production process, can potentially result in small presentation inconsistences between overlapping charts, and generally slows product release. Some tasks such as annotations are semi-automated already but could be further refined to include placement of text, making it fully automated. The CCMEO provides an example of where automation has greatly reduced compilation times. Developing a program similar to the map generator from the CCMEO could be used to eliminate the time spent on feature masking, annotations and marginalia. Such a program could also be used to pull information from other databases such as federal, provincial and municipal databases. This would simplify the cartographers' compilation duties by making numerous sources readily available as integrated layers within HPD. All CARIS products currently have WMS capabilities and if a relevant database has WMS functionality cartographers can manually connect to it. Recently CARIS introduced new functionality involving dynamic masking which is a step to increasing automation. Dynamic masking would be a simple next step for the CHS to test and consider implementing once it has been tailored to support the specific needs of the CHS.

PRODUCT EVOLUTION

Legislation

Even with the advent of ENC navigation, paper charts still play a major role in meeting carriage requirements for all vessel types. In most countries, paper charts are at minimum required as a backup unless navigating with two independent IHO approved

ECDIS systems. Current legislation in Canada is prohibitive to non-SOLAS and pleasure craft vessels from fully embracing a regulated and official means of ENC navigation. The price tag of an approved ECDIS is approximately $15,000, making one - let alone two systems - cost prohibitive for many smaller vessels compared to non-approved navigation technology (Almeida, 2012). Furthermore, current ECDIS systems are large and provide functions that most non-SOLAS users do not want or need; this creates a barrier to fully adopting ENC products and the ability to meet carriage requirements.

A resolution to this issue would be amending legislation to allow a range of ECS type navigation solutions and developing appropriate standards to which they must adhere for carriage requirements. A logical starting point would be to review the Radio Technical Commission for Maritime Services (RTCM) Standard for ECS (RTCM, 2008); this standard could provide the framework from which the CHS could build upon.

ECS might prove to be a financially viable option for smaller vessels and eventually propel non-SOLAS and pleasure craft mariners into ENC navigation. Similar to the gradual implementation of SOLAS required ECDIS; new requirements for the remaining mariners could be phased in over a period of years. Once mariners have used, tested, and moved to ENCs, HOs might then find a warmer reception to the discontinuation or portfolio reduction of traditional paper charts.

Shifting to digital

By 2018 a large segment of the paper chart market will disappear and HOs must look at transitioning the remaining non-SOLAS and pleasure vessels to ENCs in a similar fashion (Australia, 2015). If a transition is done correctly, it could facilitate the gradual phasing out of paper charts and related products such as the raster chart. Chart users that currently employ RNCs as a means of electronic navigation will be impacted by a shift to ENC navigation; the presentation and functionality is vastly different from ENCs and could be a shock to some mariners if paper chart, and ultimately raster chart, availability is reduced in either scale or coverage. One potential option would be the ability to have the ENC presentation display similarly to the paper chart; this may be possible in an ECS system via lookup table; however, the presentation of ENC data may be best left to the equipment manufactures. Nevertheless, the CHS could advocate or recommend improvements on behalf of its clients and direct innovation through legislation or technical requirements.

Eventually discontinuing RNC production, as the AHS has done, will require mariners to either shift to ENC products or navigate using paper charts. Discontinuing one product line would reduce some of the burden to the CHS resources and potentially facilitate paperless navigation in the future. Given that the 2018 date to fully transition SOLAS vessels to ECDIS and ENC navigation is approaching, the CHS should focus on ensuring 100% ENC coverage by that date. Once 100% ENC coverage has been achieved, eliminating raster charts would likely be the most logical option to pursue.

Another approach to delivering CHS products in the digital realm is the development of a Web Mapping Service (WMS). A WMS would enable the CHS to put products and surveys at the fingertips of mariners and the general public for a variety of purposes in a controlled setting. With the availability of WMS and a standard GIS package or even web portal, users could display CHS products or surveys to which they could incorporate features of importance to them. As demonstrated by the CCMEO, a WMS enables users to effectively produce their own products at a scale, spatial coverage and output size they desire. WMS providers can choose what data users can view and how they can interact with the data. Incorporating standards such as IHO S-4 into the WMS could potentially open the door for users to create custom products meeting current chart specifications. One of the few HOs using this service is NOAA which currently offers its RNC products though WMS. The Government of British Columbia and Capital Regional District are two other examples of how a WMS might be deployed for the CHS (Data BC,CRD, n.d.).

Cell Based Production

Increased efficiency at the CHS could be achieved by adopting a cell based production scheme for paper charts. Reducing overlap between adjacent products of the same scale would remove any duplication of effort, maximize the spatial coverage for each paper chart and eliminate the potential for conflicting presentation between products released at different times. This would be an unfamiliar departure from the traditional paper chart scheme for conventional paper chart users and could make position plotting difficult at the extents of the product limits. However, not many mariners are actively using paper charts as their primary means of navigation. As such, cell based schemes might be appropriate as paper charts are assuming secondary and tertiary roles in navigation.

It appears as though there are currently no HOs using or considering switching to a cell based scheme for paper charts and opportunity exists for innovation and discussion within IHO regarding this concept. Although the CCMEO and DND - HSO do not produce conventional nautical paper charts they have reported success employing cell based product limits which could be used as an example of how this might be adapted for CHS paper chart schemes.

Cost Free Products

Product availability and pricing schedules vary widely from country to country. A cost free structure for some or all of the CHS products is a topic of discussion amongst mariners and was mentioned during chart user consultations with regards to the paper chart. Cost recovery and cost free models each have their advantages and disadvantages but some pricing systems will put more products in mariner's hands then others, potentially reducing future groundings or marine accidents. While most HOs are familiar with cost recovery pricing for their products there are a few that offer products at

no cost, such as NOAA. In 2013 NOAA launched the beta version for its free PDF nautical charts and within 90 days had 2.3 million downloads (NOS, 2015). The beta release has been hailed as an overwhelming success and is now permanently available to mariners (NOAA, 2014). As a caveat to safe and official navigation products, it should be noted that while free and downloadable, they do not meet carriage requirements and only products obtained through official dealers or NOAA themselves are legal for official navigation. This type of model could be a future consideration for the CHS paper products as preventing as many maritime accidents as possible is a key mandated objective.

Printed ENCs

Moving towards printed ENCs as an alternative to the traditional paper chart brings with it both advantages and challenges. Printed ENCs would reduce the efforts required in production as multiple product lines would no longer need to be maintained. This would meet the users' needs of having a hard copy to work with and as backup in the event of a power failure. The CHS would need to consider what additional elements would need to be added to the printed ENC as a direct print out from the vector data would be lacking certain crucial components such as annotations, various symbologies, and scale generalizations. There would be considerable modifications needed to add the extra content required on paper to make them useable. Most users consulted did not foresee an issue with paper charts taking on a new presentation and in fact, streamlining the ENC and subsequent paper reproduction to look similar to one another could facilitate transitioning between the two chart types. Having a printed ENC as the type of paper chart available would help mariners become more accustomed to the ENC representation of data making it easier to eventually shift completely away from traditional paper charts and RNCs.

Producing images from an ENC would be relatively easy as it would use the same dataset and be relatively inexpensive. Currently a print out of an ENC does not meet SOLAS V requirements and similarly, the IMO and the IHO have not yet identified printed ENCs as an acceptable equivalent to a paper chart. As such, the legal standing of printed ENCs would need to be reviewed, as discussed in the aforementioned Legislation section. If printing by the chart user becomes a reality then liability would need to be considered. Carriage requirements may still require that charts be purchased through the CHS or perhaps a waiver would be an option to place liability on the users themselves. Similar to SHOM and their georeferenced images, printed ENCs could be limited to specific vessel categories or sizes, minimizing danger and liability while maintaining more flexibility for mariners to use the CHS product format most suited to their needs.

Printing and Distribution

Restructuring the current system for printing and distribution of charts would allow the CHS to better meet the wide range of chart users' needs. If the CHS was to task out

printing to a large commercial printer, costs could be reduced to the government and custom options not currently available to the CHS chart users would become a reality. Outside printers can provide specialized printing for chart users such as those available to NOAA clients. Numerous chart users indicated they would like to have the option of choosing print media as well as finished product size. One of the initial commercial printers NOAA partnered with offered tenfold the finished product options than NOAA could offer with lithographic or standard POD printers. For emergency backup these options are attractive for mariners seeking durable and portable products. In the marine environment the lifespan of a paper chart is short and even shorter when they are not stored in a chart cabinet or on a chart table, both of which are not options for smaller vessels.

Larger commercial printers and distributors typically offer the ability to order online and either ship to home or to the nearest chart dealer, an option that many respondents indicated was desirable. This is more convenient for most charts users and prevents them from having to go chart dealer to chart dealer in search of the products they wish to purchase which is currently the situation. Enabling super dealers or dealers to print official CHS charts could also create just-in-time paper chart printing, where charts are printed to order. Just-in-time printing would guarantee mariners are getting the most up-to-date chart, in excellent condition, with only having to make one order. This also minimizes the amount of stock dealers have to warehouse and maintain.

While it was widely stated by chart users that more information is always preferred to less on paper charts, there was a wide variance on what data mariners would like to see more of. This supported the idea that customizable order and print options for charts would be well-received by chart users and allow individual users to include and exclude content based on their specialized needs.

In summary, the Discussion outlines numerous ideas that were predominantly expressed throughout the consultations with both chart users as well as chart and map providers from across the globe. These ideas may serve to stimulate discussion on the options that can be considered and applied in the Canadian context. The key findings and main suggestions are summarized in the following section on Potential Options for the CHS in moving forward.

POTENTIAL OPTIONS

There are a number of options and combination of options available to the CHS for addressing the future of the paper chart. These recommendations are highly dependent on the direction the CHS decides to pursue, overarching internal objectives, and feasibility assessments. It is anticipated that ENC usage will become the standard for navigation and the recommendations presented are tailored to that end state. It must, however, be acknowledged that most mariners would prefer the availability of a paper based product as well and this should be obliged in an effort to maximize safety of

navigation. The potential options listed below are summarized points extracted from the Discussion section and have been categorized by their horizon of completion.

Short Term:

- Ensure that the SOLAS ECDIS requirements, specifically 100% ENC coverage, can be met for 2018. Related to this is ensuring that all ENCs are available to cover the provisional chart list in NOTMAR 13.
- Partner with large commercial printers for augmented printing and distribution.
- Investigate, develop, and refine fully automated tools for paper chart masking and annotations so that only minimal manual adjustments would be required.
- Actively engage/partner with innovating countries such as AHS/NOAA to learn and discuss innovative best practices for future chart production.
- Introduce topographic features into the ENC.

Mid Term:

- Modernize non-SOLAS vessel electronic carriage compliance requirements (e.g. approved ECS systems).
    - Develop industry requirements/certification for non-SOLAS ECS using RTCM standards as a guideline.
    - Develop a plan to encourage more ENC usage for non-SOLAS/pleasure vessels.
    - Phase out RNC where ENC coverage exists.
- Thoroughly review high, medium and low risk charts to determine what level of effort is required to maintain safety of navigation and if certain charts are still needed.
- Change philosophy and production focus to ENC first model, thus making ENCs the driving and flagship product.
- Investigate making products and data available through a WMS, GIS, or web portal.

Long Term:

- Investigate non-overlapping cell based schemes (similar to DND - HSO) for paper chart product limits.
- Investigate the possible schemes for a minimum chart portfolio (1:80000).
- Decouple ENC and paper chart production (e.g. ENC based production, fewer and smaller scale paper charts).

For any of these potential options to be successfully implemented the CHS must clearly define the organizational objectives surrounding the paper chart. Once the objectives are known, a framework can be created and work can begin to evaluate the most feasible way forward with the least negative implication to mariners and the CHS. Some work has already begun with the evaluation of current Canadian legislation relating to carriage requirements and a pilot project for evaluating super dealer/dealer

paper chart printing. Further work will be required to fully take advantage of advancing technologies including the implementation and development of WMS or GIS access as well as automated tools within the CARIS production environment. Additional work will also be required to review how and where the CHS can minimize duplication and overall effort invested into paper charts. Each of the potential options will have inherent implications, both advantageous and disadvantageous.

CONCLUSION

Offering three similar, although uniquely distinct products (i.e. paper charts, RNCs and ENCs), is costly and work intensive for HOs around the world. In today's modern and electronic world mariners have changed how they navigate and chart providers must adapt accordingly. If the CHS wants to start making more of a shift to electronic (ENC) navigation then there has to be a transition away from requiring mariners to carry paper charts. Gradual steps need to be taken towards better supporting electronic means of navigation in order to maintain maritime safety and chart user satisfaction.

The findings in this report offer a general introduction to chart users' perspectives and chart providers' current practices. From the predominant concepts presented by the chart user respondents, topics for further consideration by the CHS have been established. While the CHS is leading the way in some regards, in other aspects the CHS is in an ideal position to benefit from the leading developments and processes of other organizations. From the external practices discussed with the various chart and map providers, the CHS gains a perspective on a range of current practices that could potentially be applied in Canada.

Any changes that the CHS chooses to implement do not have be done all at once nor to all products in the Canadian portfolio; based on careful prioritization of the CHS objectives, major changes can be phased in. Moving forward, this report can serve as a foundation to ongoing discussions on how the CHS can maintain a leading edge in hydrography, reduce costs and time required for production, all the while ensuring a quality and relevant product is available to today's mariners.

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Australia & New Zealand. (2015, April 2). *The Future of the Paper Chart.* Retrieved 2016, from IHO - 1st NCWG Meeting: https://www.iho.int/mtg_docs/com_wg/CSPCWG/CSPCWG11-NCWG1/CSPCWG11docs.htm

This paper was a submission to the International Hydrographic Organization, Nautical Cartography Working Group during the 2015 face to face meeting in Rostock, Germany. It ties together past IHO paper submissions and external articles relating to the increasing shift to electronic charts. It provides a concise background to the issues currently facing HOs around the world and highlights many of the questions that surround the future of charting, both paper and electronic. These questions will certainly act as a catalyst for discussion at the international level but should also be discussed within HOs as they have many implications for chart production and navigation.

Australia. (2014, November). *Australian experiences in deriving paper charts from ENC.* Retrieved January 2016, from IHO - 6th HSSC Meeting: https://www.iho.int/mtg_docs/com_wg/HSSC/HSSC6/HSSC6Docs.htm

This paper was presented to the International Hydrographic Organization, Hydrographic Services and Standards Committee during the 2014 face to face meeting in Vina del Mar, Chile. Australia outlines the initial phases and considerations for shifting its chart production approach. This shift will result in the ENC driving production, with the paper chart being a derivative later on in the process. The first few sections of the paper detail why and how the AHS has moved to adjust its production approach. Australia's situation is similar to many HOs and the steps that the AHS has taken to change their production paradigm are most likely applicable to other HOs. The analysis and discussion section includes lessons learned and is good base of information as HOs start shifting to ENC based production.

Australia. (2013, November). *Future demand for Paper Nautical Charts.* Retrieved January 2016, from IHO - 5th HSSC Meeting: https://www.iho.int/mtg_docs/com_wg/HSSC/HSSC7/HSSC7Docs.htm

This paper was presented to the International Hydrographic Organization, Hydrographic Services and Standards Committee during the 2013 face to face meeting in Shanghai, China. With the upcoming mandatory implementation of ECDIS for SOLAS vessels, Australia discusses a survey of chart distributors and user groups to quantify paper chart usage beyond 2018. They discuss how charts are distributed, which users are purchasing paper charts, and how the implementation of ECDIS is likely to affect both. There are some broad assumptions that are made during the survey but the paper does raise questions that the IMO and individual HOs will inevitably face after 2018 regarding the future of the paper chart.

Bunzel, M. (n.d.). *The Future of Paper Charts*. Retrieved January 26, 2016, from Canadian Yachting: http://www.canadianyachting.ca/diy/seamanship/2136-the-future-of-paper-charts

Bunzel's article is a summary of general information on how the paper chart operation of NOAA has changed over the past few years. It briefly covers CHS operations and what is required for chart carriage in Canadian waters. The article also recommends how mariners should approach navigation for the safest route planning possible using electronic means.

Casey, M., & Brunt, D. (2014, April). *The End is Nigh; The Fall of Paper Charts.* Retrieved January 2016, from Canadian Hydrographic Association - 2014 Conference Papers: http://hydrography.ca/chc-2014-conference.html

Casey and Brunt examine a number of past, present and future topics regarding paper and electronic charts. Changing IMO ECDIS requirements, technology shifts/advances and their cumulative impact on the future of paper charts are the main topics of discussion. The article also discusses what the paper chart offers to users and what changes to chart production are inevitable for HOs to deliver modern and relevant products to today's mariners.

Halls, I. (2014, May). Next Generation Paper Chart. *International Hydrographic Review*(11), 21-30.

Author Halls writes this article from the perspective of how paper charts might be overhauled in order to keep them relevant in a digital landscape. The article reviews S-4/S-52 charting standards as well as SOLAS requirements before discussing various options, implications and legalities for making the classic paper chart a more dynamic less burdensome product for HOs and mariners alike.

IHO. (2010, January). *S-66 Facts about Electronic Charts and Carriage Requirements.* Retrieved December 2015, from IHO - Publications: https://www.iho.int/iho_pubs/IHO_Download.htm

In this article the IHO comprehensively presents most aspects relating to electronic charting. Topics include an overview of electronic charting and regulations, a list of flag state authorities, ECDIS training, and technical details of electronic charts. It combines information from the most basic such as the definitions of what an ENC or ECDIS actually is to more detailed information regarding carriage requirements and technical data.

APPENDIX A

PARTICIPANTS

Domestic Chart Users

- British Columbia Coast Pilots
- Canadian Coast Guard
- Canadian Coast Guard Auxiliary
- Seaspan Ferries Corporation
- Port of Montreal
- Western Canada Marine Response Corporation
- Council of BC Yacht Clubs
- Canadian Power and Sail Squadron
- Department of National Defence

Chart Providers

- Australian Hydrographic Service
- National Oceanic and Atmospheric Administration (United States)
- United Kingdom Hydrographic Organization
- German Hydrographic Organization
- National Geospatial-Intelligence Agency (United States)
- Service hydrographique et océanographique de la Marine
- Natural Resources Canada
- Department of National Defence - Hydrographic Services Office

APPENDIX B

CHART PROVIDER QUESTIONS

Hydrographic Organization

1. What are your legislated carriage requirements for paper charts?
    a. Please specify the title of the Act containing the pertinent regulation.
    b. Are there different categories (i.e. recreational, commercial, exempt etc.)?
    c. With the increase in use of electronic (digital) charts to what extent are mariners continuing to adhere to requirements for carrying paper charts?
2. Who prints and distributes your products (e.g. Hydrographic Organization, super dealer, commercial printers, or chart users)?
3. What options do users have for paper chart physical format (e.g. trifold, waterproof, double sided, booklets/custom prints) and/or content format (e.g. wrecks, anchorages, diving locations, bottom qualities, etc.)?
    a. What technology is required to produce these products (special media/plotters, software etc.)?
    b. Are these options approved by the Hydrographic Organization or just offered by a commercial printer?
    c. Do these non-standard formats meet carriage requirements/IHO specifications?
    d. Was a legislation change required to offer these different formats?
    e. Do these formats maintain a relationship to digital products? Please discuss.
    f. If only traditional options are available, are there plans to adopt more options in the future?
4. Do you offer free data to the general public (PDF/raster products, survey data etc.)?
    a. Do these formats meet carriage requirements?
    b. If products are for purchase by the public, what pricing is used?
5. Have you done anything to make paper chart production less expensive and work intensive?
    a. How many compilation scale bands do you have?
    b. Are you using cell based production? Are you considering moving to cell based?
    c. Are you able to maintain full IHO specifications with both your digital and paper charts?
    d. How many paper charts do you currently produce? Have there been any reductions in content, coverage, or overlap?
    e. Do you rely mostly on Notice to Mariners to update paper products rather than new editions?
6. Are there plans to reduce your paper chart selection and shift to digital only?

   a. What are your thoughts on shifting from traditional paper chart presentation to a printed digital version resembling the ENC presentation?
7. Are there any other plans to change what is currently being done or do you see your organization changing the way it delivers paper products in the future? Please explain what the changes could entail and how they might be implemented.

Canadian Coast Guard

1. With the increase in use of electronic (digital) products to what extent are users continuing to use paper products?
2. Who prints and distributes your paper products (e.g. CCG, super dealer, commercial printers, or clients)?
3. What options do clients have for paper product physical format (e.g. trifold, waterproof, double sided, booklets/custom prints) and/or content?
   a. What technology is required to produce these products (special media/plotters, software etc.)?
   b. Are these options approved by CCG or just offered by a commercial printer?
   c. Do these non-standard formats meet international specifications?
   d. Was a legislation change required to offer these different formats?
   e. Do these formats maintain a relationship to digital products? Please discuss.
   f. If only paper options are available, are there plans to adopt more options in the future?
4. Do you offer free products to the general public (PDF/raster products etc.)?
   a. Do these formats meet any international requirements?
   b. If products are for purchase by the public, what pricing is used?
5. Have you done anything to make production less expensive and work intensive?
   a. How many paper products do you currently produce? Have there been any reductions in content, coverage, or overlap?
   b. How often do you update paper products (i.e. new editions/updates)?
   c. Are there plans to reduce your paper product selection and shift to digital only?
6. Are there any other plans to change what is currently being done or do you see your organization changing the way it delivers paper products in the future? Please explain what the changes could entail and how they might be implemented.

Department of National Defence – HSO
Questions (Chart Use)

1. What are your minimum requirements for a paper chart to enable safe navigation (e.g. minimum chart scale, fewer scale ranges etc.)?
    a. What extra content on paper charts do you consider non-essential and could be removed?
2. What proportion of your membership use paper charts either for primary navigation, for backup navigation, or not at all?
3. To what extent are CHS paper charts currently meeting your organization's needs?
    a. What is currently working for your organization that you would like to see maintained (e.g. format [size, layout, look/feel], content, and distribution)?
4. What aspects of the paper chart could the CHS change/improve to better meet the needs of today's chart users (e.g. format [size, layout, look/feel] content, distribution options [commercial printers, users])?
5. What are your thoughts on shifting from paper charts to completely digital products?
    a. What are your thoughts on shifting from traditional paper chart presentation to a printed digital version resembling the ENC presentation?
6. Is there any further feedback that your organization could offer that we did not explicitly cover but that you feel could be of use to the CHS regarding the future of paper chart production, distribution, and use?

Questions (Chart Production/Distribution)

1. Does DND create custom paper products?
    a. How many paper products do you currently produce?
    b. How are they produced? (e.g. physical format, content, software)
    c. How many compilation scale bands do you have?
    d. Do these formats have a digital equivalent?
    e. Do the paper products maintain a close (or identical) presentation relationship to digital products?
2. Do users have additional options for paper product physical format (e.g. trifold, waterproof, double sided, booklets/custom prints) and/or content format (e.g. wrecks, anchorages, diving locations, bottom qualities, etc.)?
    a. What technology is required to produce these products (special media/plotters, software etc.)?
    b. Do these non-standard formats meet carriage requirements/IHO or other international specifications?
    c. Was a legislation change required to offer these different formats?
    d. If only standard paper options are available, are there plans to adopt more options in the future?

3. Have you done anything to make your paper products less expensive and work intensive to create/maintain?
    a. Are you using cell based production? Are you considering moving to cell based?
    b. Are you able to maintain full IHO or other international specifications with both your digital and paper products?
    c. Have there been any reductions in content, coverage, or overlap?
    d. Do you use Notice to Mariners to update custom paper products or produce new editions?
    e. Are there plans to reduce your custom paper product selection and shift to digital only?
4. Are there plans to change what is currently being done or do you see your organization changing the way it delivers paper products in the future? Please explain what the changes could entail and how they might be implemented.

Natural Resources Canada – CCMEO

1. Do you have legislated requirements for your paper products?
    a. If so, please specify the title of the Act containing the pertinent regulation.
    b. With the increase in use of electronic (digital) products to what extent are users continuing to use paper products?
2. Who prints and distributes your paper products (e.g., NRCAN, super dealer, commercial printers, or clients)?
3. What options do clients have for paper product physical format (e.g. trifold, waterproof, double sided, booklets/custom prints) and/or content format?
    a. What technology is required to produce these products (special media/plotters, software etc.)?
    b. Are these options approved by NRCAN or just offered by a commercial printer?
    c. Do these non-standard formats meet international specifications?
    d. Was a legislation change required to offer these different formats?
    e. Do these formats maintain a relationship to digital products? Please discuss.
    f. If only paper options are available, are there plans to adopt more options in the future?
4. Do you offer free data to the general public (PDF/raster products, survey data etc.)?
    a. Do these formats meet any international requirements?
    b. If products are for purchase by the public, what pricing is used?
5. Have you done anything to make production less expensive and work intensive?
    a. How many compilation scale bands do you have?

   b. Are you using cell based production? Are you considering moving to cell based?
   c. Are you able to maintain full international specifications with both your digital and paper products?
   d. How many paper products do you currently produce? Have there been any reductions in content, coverage, or overlap?
   e. How often do you update paper products (i.e. new editions/updates)?
   f. Are there plans to reduce your paper product selection and shift to digital only?
6. Can you discuss the map generator process that you were involved with and how it had an impact on topographic maps and cartographic specifications?
   a. Could this be applied to paper chart production?
7. Are there any other plans to change what is currently being done or do you see your organization changing the way it delivers paper products in the future? Please explain what the changes could entail and how they might be implemented.

DOMESTIC CHART USER QUESTIONS

General Chart Users

1. What type of users make up your organization (e.g. commercial, fishing, recreational)?

2. What are your minimum requirements for a paper chart to enable safe navigation (e.g. minimum chart scale, fewer scale ranges etc.)?
   a. What extra content on paper charts do you consider non-essential and could be removed?

3. What proportion of your membership use paper charts either for primary navigation, for backup navigation, or not at all?

4. To what extent are CHS paper charts currently meeting your organization's needs?
   a. What is currently working for your organization that you would like to see maintained (e.g. format [size, layout, look/feel], content, and distribution?

5. What aspects of the paper chart could the CHS change/improve to better meet the needs of today's chart users (e.g. format [size, layout, look/feel] content, distribution options [commercial printers, users])?

6. What are your thoughts on shifting from paper charts to completely digital products?
   a. What are your thoughts on shifting from traditional paper chart presentation to a printed digital version resembling the ENC presentation?

7. Is there any further feedback that your organization could offer that we did not explicitly cover but that you feel could be of use to the CHS regarding the future of paper chart production, distribution, and use?

Canadian Coast Guard/Department of National Defence

1. What are your minimum requirements for a paper chart to enable safe navigation (e.g. minimum chart scale, fewer scale ranges etc.)?
    a. What extra content on paper charts do you consider non-essential and could be removed?

2. What proportion of your organization use paper charts either for primary navigation, for backup navigation, or not at all?

3. To what extent are CHS paper charts currently meeting your organization's needs?
    a. What is currently working for your organization that you would like to see maintained (e.g. format [size, layout, look/feel], content, and distribution?

4. What aspects of the paper chart could the CHS change/improve to better meet the needs of today's chart users (e.g. format [size, layout, look/feel] content, distribution options [commercial printers, users])?

5. What are your thoughts on shifting from paper charts to completely digital products?
    a. What are your thoughts on shifting from traditional paper chart presentation to a printed digital version resembling the ENC presentation?

6. Is there any further feedback that your organization could offer that we did not explicitly cover but that you feel could be of use to the CHS regarding the future of paper chart production, distribution, and use?

APPENDIX C

CARRIAGE REQUIREMENTS AND LEGISLATION

International Maritime Organization
SOLAS Chapter V Safety of Navigation

Regulation 1 – Application
1 Unless expressly provided otherwise, this chapter shall apply to all ships on all voyages, except:

.1 warships, naval auxiliaries and other ships owned or operated by a Contracting Government and used only on government non-commercial service; and

.2 ships solely navigating the Great Lakes of North America and their connecting and tributary waters as far east as the lower exit of the St. Lambert Lock at Montreal in the Province of Quebec, Canada. However, warships, naval auxiliaries or other ships owned or operated by a Contracting Government and used only on government non-commercial service are encouraged to act in a manner consistent, so far as reasonable and practicable, with this chapter.

2 The Administration may decide to what extent this chapter shall apply to ships operating solely in waters landward of the baselines which are established in accordance with international law.

3 A rigidly connected composite unit of a pushing vessel and associated pushed vessel, when designed as a dedicated and integrated tug and barge combination, shall be regarded as a single ship for the purpose of this chapter.

4 The Administration shall determine to what extent the provisions of regulations 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27 and 28 do not apply to the following categories of ships:

.1 ships below 150 gross tonnage engaged on any voyage;
.2 ships below 500 gross tonnage not engaged on international voyages; and
.3 fishing vessels.

Regulation 9 - Hydrographic services
1 Contracting Governments undertake to arrange for the collection and compilation of hydrographic data and the publication, dissemination and keeping up to date of all nautical information necessary for safe navigation.

2 In particular, Contracting Governments undertake to co-operate in carrying out, as far as possible, the following nautical and hydrographic services, in the manner most suitable for the purpose of aiding navigation:

.1 to ensure that hydrographic surveying is carried out, as far as possible, adequate to the requirements of safe navigation;

.2 to prepare and issue nautical charts, sailing directions, lists of lights, tide tables and other nautical publications, where applicable, satisfying the needs of safe navigation;

.3 to promulgate notices to mariners in order that nautical charts and publications are kept, as far as possible, up to date; and

.4 to provide data management arrangements to support these services.

3 Contracting Governments undertake to ensure the greatest possible uniformity in charts and nautical publications and to take into account, whenever possible, relevant international resolutions and recommendations.*

4 Contracting Governments undertake to co-ordinate their activities to the greatest possible degree in order to ensure that hydrographic and nautical information is made available on a world-wide scale as timely, reliably, and unambiguously as possible.

* Refer to the appropriate resolutions and recommendations adopted by the International Hydrographic Organization

Regulation 19 - Carriage requirements for shipborne navigational systems and equipment

1 Application and requirements

Subject to the provisions of regulation 1.4:

1.1 Ships constructed on or after 1 July 2002 shall be fitted with navigational systems and equipment which will fulfil the requirements prescribed in paragraphs 2.1 to 2.9.

1.2 Ships constructed before 1 July 2002 shall:

.1 subject to the provisions of paragraphs 1.2.2 and 1.2.3, unless they comply fully with this regulation, continue to be fitted with equipment which fulfils the requirements prescribed in regulations V/11, V/12 and V/20 of the International Convention for the Safety of Life at Sea, 1974 in force prior to 1 July 2002;

.2 be fitted with the equipment or systems required in paragraph 2.1.6 not later than the first survey after 1 July 2002 at which time the radio direction-finding apparatus referred to in V/12 (p) of the International Convention for the Safety of Life at Sea, 1974 in force prior to 1 July 2002 shall no longer be required; and

.3 be fitted with the system required in paragraph 2.4 not later than the dates specified in paragraphs 2.4.2 and 2.4.3.

2 Shipborne navigational equipment and systems

2.1 All ships irrespective of size shall have:

.4 nautical charts and nautical publications to plan and display the ship's route for the intended voyage and to plot and monitor positions throughout the voyage; an electronic chart display and information system (ECDIS) may be accepted as meeting the chart carriage requirements of this subparagraph;

.5 back-up arrangements to meet the functional requirements of subparagraph .4, if this function is partly or fully fulfilled by electronic means;*

* Refer to resolution MSC.64(67), annex 1 - Performance standard for Integrated bridge systems.

Regulation 27 – Nautical charts and nautical publications
Nautical charts and nautical publications, such as sailing directions, lists of lights, notices to mariners, tide tables and all other nautical publications necessary for the intended voyage, shall be adequate and up to date.

Canada
Canada Shipping Act, 2001 S.C. 2001, c. 26

Charts and Nautical Publications Regulations, 1995 SOR/95-149

Carriage of Charts, Documents and Publications
4. (1) Subject to subsection (2), the master and owner of every ship shall have on board, in respect of each area in which the ship is to be navigated, the most recent editions of the charts, documents and publications that are required to be used under sections 5 and 6.

(2) The master and owner of a ship of less than 100 tons are not required to have on board the charts, documents and publications referred to in subsection (1) if the person in charge of navigation has sufficient knowledge of the following information, such that safe and efficient navigation in the area where the ship is to be navigated is not compromised:
(*a*) the location and character of charted
    (i) shipping routes,
    (ii) lights, buoys and marks, and
    (iii) navigational hazards; and
(*b*) the prevailing navigational conditions, taking into account such factors as tides, currents, ice and weather patterns.

(3) If a ship, other than a pleasure craft of less than 150 tons, is making a foreign voyage, a home-trade voyage, Class I, II or III, or an inland voyage, Class I, the master and the owner of the ship shall have on board and make readily available to the person in charge of the navigation of the ship an illustrated table of life-saving signals for use by ships and persons in distress when communicating with life-saving stations, maritime rescue units or aircraft engaged in search and rescue operations.

(4) If a Canadian ship is of 150 tons or more, the master and the owner of the ship shall have on board and make readily available to the person in charge of the navigation of the ship the *International Aeronautical and Maritime Search and Rescue Manual, Volume III, Mobile Facilities*, published by the IMO.

Use of Charts
5. (1) Subject to subsection (2), in order to plan and display a ship's route for an intended voyage and to plot and monitor positions throughout the voyage, the person in charge of the navigation of the ship shall use the most recent edition of a chart that
(*a*) is issued officially by or on the authority of
    (i) the Canadian Hydrographic Service, when the ship is in Canadian waters, and

(ii) the Canadian Hydrographic Service or the government or an authorized hydrographic office or other relevant government institution of a country other than Canada, when the ship is outside Canadian waters;

(*b*) applies to the immediate area in which the ship is being navigated; and

(*c*) is, for that area,

(i) the largest scale chart according to the reference catalogue, or

(ii) of a scale that is at least 75 per cent of the scale of the chart referred to in subparagraph (i) and is as complete, accurate, intelligible and up-to-date as that chart.

2) The person in charge of the navigation of a ship may use the most recent edition of a chart that is the second-largest scale chart for an area according to the reference catalogue where

(*a*) the scale of the chart is at least 1:400,000 (2.16 nautical miles to the centimetre); and

(*b*) the ship is

(i) more than five nautical miles from any charted feature or charted depth of water that represents a potential hazard to the ship, or

(ii) within an area for which the largest scale chart, according to the reference catalogue, is primarily

(A) a chart intended for the use of pleasure craft,

or

(B) a chart of an anchorage, a river or a harbour that the ship will not transit or enter.

3) The chart may be in electronic form only if

(*a*) it is displayed on an ECDIS or, in the case of failure of the ECDIS, on a back-up arrangement; and

(*b*) the ECDIS

(i) in waters for which an ENC is available, is operated using the ENC,

(ii) in waters for which an ENC is not available, is operated using an RNC,

(iii) when the ECDIS is operating in the RCDS mode, is used in conjunction with paper charts that meet the requirements of subsections (1) and (2),

and

(iv) is accompanied by a back-up arrangement.

Use of Documents and Publications

6. (1) Subject to subsection (3), the person in charge of the navigation of a ship in waters under Canadian jurisdiction shall use, in respect of each area to be navigated by the ship, the most recent edition of

(*a*) the reference catalogue;

(*b*) the annual edition of the *Notices to Mariners*, published by the Department of Fisheries and Oceans;

(*c*) the following publications, namely,

(i) sailing directions, published by the Canadian Hydrographic Service,

(ii) tide and current tables, published by the Canadian Hydrographic Service,

(iii) lists of lights, buoys and fog signals, published by the Department of Fisheries and Oceans, and

(iv) where the ship is required to be fitted with radio equipment pursuant to any Act of Parliament or of a foreign jurisdiction, the *Radio Aids to Marine Navigation*, published by the Department of Fisheries and Oceans; and

(*d*) the documents and publications listed in the schedule.

(2) Subject to subsection (3), the person in charge of the navigation of a Canadian ship in waters outside Canadian jurisdiction shall use, in respect of each area to be navigated by the ship, the most recent edition of

(*a*) the reference catalogue;

(*b*) the annual edition of the *Notices to Mariners*, published by the Department of Fisheries and Oceans;

(*c*) the following publications referred to in the reference catalogue, namely,

(i) sailing directions,

(ii) tide and current tables,

(iii) lists of lights, and

(iv) where the ship is required to be fitted with radio equipment pursuant to an Act of Parliament, the list of radio aids to navigation; and

(*d*) the documents and publications listed in the schedule

3) The publications referred to in paragraphs (1)(*c*) and (2)(*c*) may be replaced by similar publications issued officially by or on the authority of an authorized hydrographic office or other relevant government institution of a country other than Canada, if the information contained in them that is necessary for the safe navigation of a ship in the area in which the ship is to be navigated is as complete, accurate, intelligible and up-to-date as the information contained in the publications referred to in those paragraphs.

Maintenance of Charts, Documents and Publications

7. The master of a ship shall ensure that the charts, documents and publications required by these Regulations are, before being used for navigation, correct and up-to-date, based on information that is contained in the *Notices to Mariners, Notices to Shipping* or radio navigational warnings.

<u>Australia</u>

Australian Navigation Act, 2012, chapter 6, Division 6 Section 224.

Marine Order 21 (Safety of navigation and emergency procedures) 2012

29 Nautical charts and nautical publications

[SOLAS V/27]

29.1 The owner of a vessel embarking on a voyage must ensure nautical charts and nautical publications on board for the voyage are adequate and up to date.

29.2 The owner of a vessel must ensure that any electronic version of a nautical chart or publication mentioned in subsection 29.1 is:

(a) a version officially issued by an administration, authorised hydrographic office or other approved organisation; and

(b) accessible using a computer that is:

(i) located on the bridge; and

(ii) available at all times to the officer of the watch; and
(iii) connected to the vessel's main and emergency power supplies; and
(c) available:
(i) on at least 1 other back up computer that can be made available to the officer of the watch within 5 minutes; or
(ii) as up to date printouts of the nautical charts or publications.

29.3 For an electronic nautical chart, the owner must ensure that the chart is displayed on an electronic chart display and information system in accordance with Regulation 27 of Chapter V of SOLAS.

29.4 The owner of a vessel must ensure that all software and hardware used for accessing official electronic versions of nautical publications complies with the recommendations of MSC/Circ.891 Guidelines for the onboard use and application of computers.

29.5 The master of a vessel must ensure that the information mentioned in subsections 29.1 and 29.2 is on board before embarking on a voyage.

United States

3 U.S.C. 1222(5), 1223, 1231; 46 U.S.C. 2103, 3703; Department of Homeland Security Delegation No. 0170.1 (75). Sec. 164.13 also issued under 46 U.S.C. 8502. Sec. 164.61 also issued under 46 U.S.C. 6101.

U.S. Code of Federal Regulations, CFR, Title 33, Chapter 1, Subchapter P, Part 164, 164.33.

164.01 Applicability.

(a) This part (except as specifically limited by this section) applies to each self-propelled vessel of 1600 or more gross tons (except as provided in paragraphs (c) and (d) of this section, or for foreign vessels described in §164.02) when it is operating in the navigable waters of the United States except the St. Lawrence Seaway.

(b) Sections 164.70 through 164.82 of this part apply to each towing vessel of 12 meters (39.4 feet) or more in length operating in the navigable waters of the United States other than the St. Lawrence Seaway; except that a towing vessel is exempt from the requirements of §164.72 if it is—

(1) Used solely within a limited geographic area, such as a fleeting-area for barges or a commercial facility, and used solely for restricted service, such as making up or breaking up larger tows;
(2) Used solely for assistance towing as defined by 46 CFR 10.103;
(3) Used solely for pollution response; or
(4) Any other vessel exempted by the Captain of the Port (COTP). The COTP, upon written request, may, in writing, exempt a vessel from §164.72 for a specified route if he or she decides that exempting it would not allow its unsafe navigation under anticipated conditions.

(c) Provisions of §§164.11(a)(2) and (c), 164.30, 164.33, and 164.46 do not apply to warships or other vessels owned, leased, or operated by the United States Government and used only in government non-commercial service when these vessels are equipped with electronic navigation systems that have met the applicable agency regulations regarding navigation safety.

(d) Provisions of §164.46 apply to some self-propelled vessels of less than 1600 gross tonnage.

164.33 Charts and publications.

(a) Each vessel must have the following:

1) Marine charts of the area to be transited, published by the National Ocean Service, U.S. Army Corps of Engineers, or a river authority that—

(i) Are of a large enough scale and have enough detail to make safe navigation of the area possible; and

(ii) Are currently corrected.

(2) For the area to be transited, a currently corrected copy of, or applicable currently corrected extract from, each of the following publications:

(i) U.S. Coast Pilot.

(ii) Coast Guard Light List.

(3) For the area to be transited, the current edition of, or applicable current extract from:

(i) Tide tables published by private entities using data provided by the National Ocean Service.

ii) Tidal current tables published by private entities using data provided by the National Ocean Service, or river current publication issued by the U.S. Army Corps of Engineers, or a river authority.

(b) As an alternative to the requirements for paragraph (a) of this section, a marine chart or publication, or applicable extract, published by a foreign government may be substituted for a U.S. chart and publication required by this section. The chart must be of large enough scale and have enough detail to make safe navigation of the area possible, and must be currently corrected. The publication, or applicable extract, must singly or in combination contain similar information to the U.S. Government publication to make safe navigation of the area possible. The publication, or applicable extract must be currently corrected, with the exceptions of tide and tidal current tables, which must be the current editions.

(c) As used in this section, ‘‘currently corrected’’ means corrected with changes contained in all Notices to Mariners published by the National Imagery and Mapping Agency, or an equivalent foreign government publication, reasonably available to the vessel, and that is applicable to the vessel’s transit.

Germany

Currently there are no legislated carriage requirements by the German government for non-SOLAS vessels. However, SOLAS ships are required to meet requirements set forth by the IMO SOLAS Chapter V.

France

Complete information could not be retrieved at the time of drafting this report but in the future should be able to be found at the following link:

http://www.developpement-durable.gouv.fr/SOMMAIRE-GENERAL-DES-TEXTES.html

United Kingdom

UK Merchant Shipping Act, 1995.

UK Merchant Shipping Safety and Navigation Regulation, 2002.

Interpretation

2.—(1) In these Regulations—

"Chapter V" means Chapter V of the annex to the SOLAS Convention

"MCA's 2002 SOLAS V publication" means the MCA publication entitled "Safety of Navigation, Implementing SOLAS Chapter V, 2002", published May 2002, including its Annexes;

Application

4.—(1) Subject to the following paragraphs and to the provisions of individual regulations in Chapter V, these Regulations apply to all United Kingdom ships wherever they may be and to all other ships while they are within United Kingdom waters.

(2) These Regulations do not apply to—

(a) warships or naval auxiliaries;

(b) ships, other than United Kingdom ships, which are owned or operated by a Contracting Government and used only on government non-commercial service; or

(c) ships navigating solely the Great Lakes of North America and their connecting and tributary waters as far east as the lower exit of the St. Lambert Lock at Montreal in the Province of Quebec, Canada

Safety of navigation requirements

5.—(1) Subject to paragraphs (3) and (4), a ship to which these Regulations apply shall comply with such of the requirements referred to in paragraph (2) as apply in relation to a ship of its description.

(2) The requirements are those referred to in the following regulations or paragraphs of regulations in Chapter V which are set out in the MCA's 2002 SOLAS V publication—

paragraph 3 of regulation 7,

paragraph 7 of regulation 10,

paragraph 7 of regulation 11,

paragraphs 2 and 3 of regulation 17,
paragraphs 1 to 3 and 7 and 8 of regulation 18,
regulation 19,
paragraph 1 of regulation 20,
regulations 21 to 30,
paragraphs 1 and 4 of regulation 31,
paragraphs 1, 2, 4 and 5 of regulation 32,
paragraphs 1 and 2 of regulation 33, and
regulation 34.

(3) A ship to which these Regulations apply shall alternatively or additionally (as the case may be) comply with such of the requirements referred to in paragraph (4) as apply in relation to a ship of its description.

(4) The requirements referred to in paragraph (3) shall—

(a) relate to amendments from time to time of regulations in Chapter V,

(b) be specified in a Merchant Shipping Notice, amending or replacing the MCA's 2002 SOLAS V publication, which is considered by the Secretary of State to be relevant from time to time,

(c) be specified in that Merchant Shipping Notice as alternative or additional requirements which apply in relation to a ship of its description, and

(d) relate to all or any of the purposes set out in section 85(1) of the Act.

(5) Where a requirement referred to in paragraph (2) or (3) is set out in a provision to which there is a footnote, and it is clear from the wording and the context that the content of the footnote, or of a document referred to in the footnote, is intended to form part of the requirement, then such content shall be treated as part of the requirement; and for these purposes a "footnote" is a note marked with an asterisk in the text of Chapter V.

(6) Nothing in regulations 24 to 26 in Chapter V relating to the use of an automatic pilot shall override special rules made by an appropriate authority for roadsteads, harbours, rivers, lakes or inland waterways connected with the high seas and navigable by sea-going ships; and for these purposes an "appropriate authority" means any person empowered by law to make the special rules.

UK Merchant Shipping Safety and Navigation Amendment, 2011. Maritime and Coastguard Agency SOLAS Ch V - Regulations

Annex 3 - Nautical Charts and Publications

These guidance notes should be read in conjunction with Regulations 19, 21 and 27, which cover the carriage of Charts and Nautical Publications. The Regulations revoke the Merchant Shipping (Carriage of Nautical Publications) Regulations 1998 (SI 1998 No. 2647)

General

1.) Regulation SOLAS V/1.4 allows Administrations to determine to what extent Regulations 15 to 28 apply to smaller vessels and fishing vessels. In the case

of Regulation 19.2.1.4 the carriage requirements for charts and publications do not apply to the following:

a.) UK Ships of Class V.
b.) UK Ships which are neither passenger ships nor seagoing.
c.) New ships of class A,B,C or D
d.) Fishing vessels
e.) Pleasure vessels under 150 gt.

Small craft

2.) All small-craft users should note that Regulation 34 (Safe navigation and avoidance of dangerous situations) is not listed in Regulation 1.4 and therefore applies to ALL SHIPS ON ALL VOYAGES (Regulation 1.1). The definition of "ship" in this respect includes all small watercraft. Operators of small craft of the categories listed in 1(a), (b) and (c) above should therefore have sufficient charts and published information on board to be able to plan the intended voyage and execute it safely. When the type and structure of a small vessel means that it is impracticable to carry charts and publications, the crew should have sufficient knowledge of the area of intended operation and of all local dangers and regulations so that they can complete the intended voyage in safety.

Requirement to carry nautical publications

3.) a.) All ships, except those listed in para. 1 above, shall carry-

i.) Charts, as defined in Regulation 2.2 or an electronic chart display and information system (ECDIS) using Electronic Navigational Charts (ENCs) or Raster Navigational Charts (RNCs) to meet the requirements of Regulation 19.2.1.4 with the necessary back-up arrangements required by Regulation 19.2.1.5. The back-up arrangements may either be duplication of the ECDIS or a reduced portfolio of paper charts. (ANNEX 14 - Electronic charts contains MCA guidance and also includes IMO SN Circ/207 "Differences between RCDS and ECDIS".)
Advice on determining suitable backup is given in MGN 285; and
ii.) such adequate and up to date sailing directions, lists of lights, notices to mariners, tide tables and other nautical publications, as defined in Regulation 2.2 to meet the requirements of Regulation 19.2.1.4;

Nautical publications presented in electronic format are acceptable when issued by or on the authority of an authorised Hydrographic office or other relevant Government institution.

b.) All sea-going passenger ships, and all other ships of 300 gt or more and all other ships required by SOLAS to carry a radio installation, shall carry the International Code of Signals published by the International Maritime Organization.
(See Regulation 21)
Furthermore to comply with the Radio Regulations published by the International Telecommunications Union (ITU), ships to which the Merchant Shipping (Radio Installation) Regulations (SI 1998/2070) apply i.e. passenger ships and other ships of 300 gt or more on international voyages, when provided with equipment

for use in sea areas A2, A3 or A4 i.e. beyond VHF range of coast stations, shall also carry the following publications of the ITU:

- List VIIA, the Alphabetical List of Call Signs and Numerical Table of Identity of Stations.
- The Manual for Use by the Maritime Mobile and Maritime Mobile Satellite Services.

Charts

4.) The charts or ECDIS referred to in Regulation 19.2.1.4 must be of such a scale and contain sufficient detail as clearly to show-

i) all navigational marks which may be used by a ship when navigating the waters which are covered by the chart,

ii) all known dangers affecting those waters, and

iii) information concerning any ships' routeing and ship reporting measures applicable to those waters.

All charts and publications must be of the latest obtainable edition and, be kept up to date from the latest relevant obtainable notices to mariners and radio navigational warnings.

Publications

5.) The following publications are considered to satisfy the requirements of Regulation 19.2.1.4

- International Code of Signals (IMO)
- Mariners' Handbook (UKHO)
- Merchant Shipping Notices, Marine Guidance Notes and Marine Information Notes (MCA)
- Notices to Mariners (UKHO)
- Notices to Mariners – Annual Summary (UKHO)
- Lists of Radio Signals (UKHO)
- Lists of Lights (UKHO)
- Sailing Directions (UKHO)
- Nautical Almanac
- Navigational Tables
- Tide Tables
- Tidal Stream Atlases
- Operating and Maintenance Instructions for Navigational Aids Carried by the Ship

NOTES:

i.) In the case of publications listed above, only those parts of the publication which are relevant to a ship's voyage and operation need be carried. For example, “The Admiralty-Kingfisher Fisherman’s Pilot” series of consolidated publications which contain information essential for safe navigation of fishing vessels.

ii.) Where the UK Hydrographic Office (UKHO) is given as the publisher, any other chart or publication which meets the definition in Regulation 2.2 shall be acceptable