Electronic Navigational Charts from Survey Source Information - The Australian Experience

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Australia has held for some years that Official ENCs should be much more than a simple vectorised facsimile of the paper chart series. National hydrographic offices should draw on the full range of source material available to them to provide the mariner with a 'value added' product. Furthermore, a single validated non-conflicting database of source material should be used to generate electronic and paper charts and their associated publications. The resource efficiencies in doing this are obvious.

This paper provides an insight to the challenges of producing ENCs from survey source information and is dedicated to the cartographic, development and information management staff of the Australian Hydrographic Service (AHS) who have never stopped trying.

Introduction

The collection, storage, compilation and presentation of nautical information to aid navigation is not a new activity. Manuscript or paper charts and associated publications have evolved steadily over many centuries. In contrast, electronic or digital presentations of navigational information have been under development for less than a decade or so. It has been almost inevitable therefore, that the current, first generation, Electronic Charts rely heavily on the paper chart as the compilation source.

The potential to do much more than this is obvious in the technology, but in general, the time and expense in going beyond the paper chart as source, have often mitigated against this option being taken up.

Matters are complicated by the fact that modern digital technology has also provided low cost methods for organisations other than Hydrographic Offices (HOs) to copy and sell digital facsimiles of official paper charts. It is notable in fact, that over the last 250 years, chart production has shifted from private entrepreneurs to Governments but with the evolution of technology is now swinging back to the non-government sector. This circumstance has the potential to place great stress on public institutions as Governments are seduced with promises of low cost 'charting' performed by commercial companies. This must not be confused with chart copying. The answer, as always, will lie somewhere between the two extremes. In Australia's quest to provide official ENCs, the approach has been to use Industry to develop technology and compile charts to agreed specifications. Meanwhile, AHS staff have concentrated on those issues that are core

Government functions in publishing and endorsing an 'official' chart. These functions include the selection and management of data, the assessment of data quality, Quality Assurance (QA) of products and ultimately an acknowledgement of the consequences and the potential liability that this attracts.

Background

Australia has held for some years that official Electronic Navigational Charts (ENCs) should be much more than a simple vectorised facsimile of the paper chart series. This approach ensures that the full potential of the emerging technologies is harnessed to the benefit of the mariner. National HOs should therefore attempt to draw on the full range of source material available to them to provide the mariner with a 'value added' electronic chart product. Furthermore, a single validated non-conflicting database of source material should be used to generate electronic and paper charts and their associated publications. The resource efficiencies in doing this are obvious.

During the last decade of the 20th century, the AHS with their Industry partner Hydrographic Sciences of Australia (HSA), developed and trialed software applications to meet these principles. In 1998 the AHS began a program to produce ENCs of the complex waters of the Great Barrier Reef in north east Australia. This covers a distance that is equivalent to a voyage from Rotterdam to Gibraltar. (In the Australian chart series there are over 65 coastal navigation charts of 1:150,000 or larger, covering this route). The compilation is based primarily on original non-chart source information, is being undertaken in a unique software environment and by staff who have largely had to learn as they go.

This paper will describe some of the key challenges and lessons learned so far.

Developing a Production System

At the beginning of the 1990's, the AHS had virtually no experience of electronic charting and limited knowledge of the relevant standards and specifications. As a first step, a test data set was developed with the assistance of HSA. This was intended to:

- Expose AHS staff to the issues associated with ENC compilation and data management
- Provide a demonstration data set to educate relevant defence and civil agencies in the new technology
- Provide a baseline for further development

As a result of this initial work several follow-up activities were undertaken.

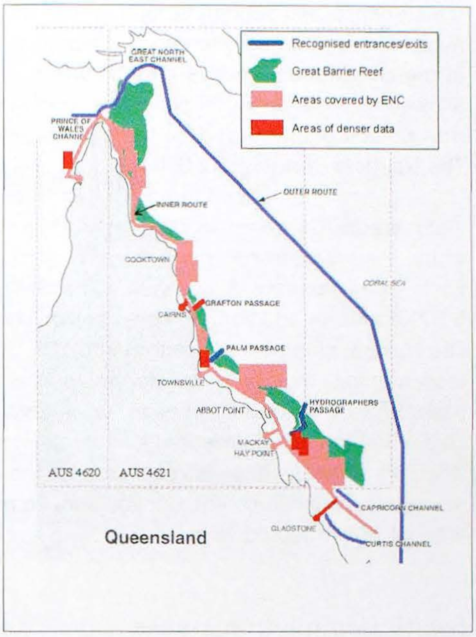
- The concept of managing ENC data in discrete data bases for key objects was tested by the development of a dedicated navigation marks data base in S-57 format (this is described in greater detail elsewhere in the paper)
- A prototype ENC production tool known as ChartStation was developed by HSA
- An early decision was taken to convert all the paper chart series to raster format for maintenance purposes
- As a design principle, all future products were to be generated from the same validated source data set

In parallel to this development work the AHS was attempting to obtain funding for a digitally based data management and chart production system. This has since crystallised into an acquisition project known as SEA 1430 – Digital Hydrographic Database, which is currently in the course of delivery. However, it was realised that the mariner could not wait for SEA 1430 to progress, nor could AHS staff wait for much needed exposure to ENC compilation and management issues. The prototype ChartStation was therefore adopted as an interim production system and based on navigation priorities, a start was made on compiling ENCs in the Great Barrier Reef of Queensland.

The Swath Project

The shipping route through the Great Barrier Reef in Queensland has long been recognised as a navigationally demanding area, to the extent that pilotage is compulsory through much of it for vessels over 70m in length and for tankers and LNG carriers of any size. In 1998, the AHS embarked on a project to provide an ENC over the length of this route, a distance of some 1,300 miles.

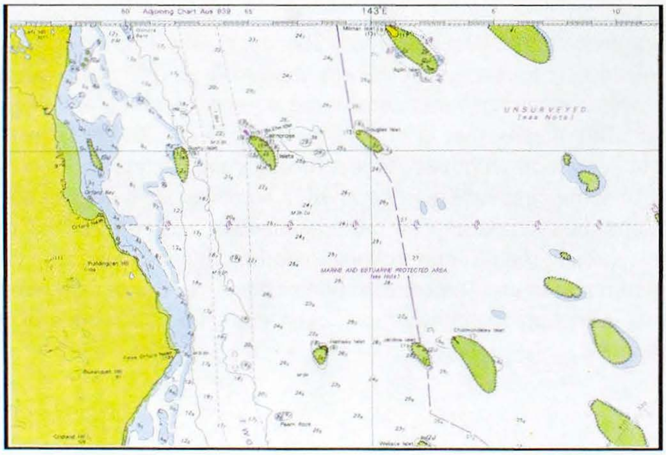
One of the unique features of this area is that safe navigation is limited to a narrow strip of water, which on the conventional paper chart, typically occupies less than 20% of the area of the paper. The route also contains many areas where larger vessels are constrained by their draft.



Coverage of swath ENC

The unique nature of this area therefore lends itself to unique charting solutions. As vessels could not enter much of the area shown on the paper charts might it not be better to tailor an ENC to this constrained area? After many debates it was decided that the ENC of this area would have the following features:

- Vector S-57 information compiled from original surveys covering the shipping route
- Only selected S-57 objects, such as key Navaids that were outside of but supported the shipping route would be captured
- One metre contours between the depths of 5m and 20m occurring in the shipping route would be included
- A Usage Code 2[1] ENC that provided a backdrop over the entire area would be created
- Raster Nautical Charts (RNC) would serve as the official electronic coverage outside the shipping route



Typical section of Inner Route - Great Barrier Reef

The first step in this program was to retrain all AHS cartographic staff in a GIS environment and to be able to compile in S-57.

Training the Staff

The transition to ENC production involved the phasing out of the existing CAD mapping system, known as 'Autochart', in use in the AHS since 1979 and the phasing in of 'ChartStation'. The new ChartStation was developed to give the AHS the capability to produce S-57 data, for ENC products, together with deriving a traditional paper chart from the same data set. As the necessary training required for ChartStation use would impact on normal production demands, especially when the experienced compilers underwent their S-57 training, it was decided that all the existing paper chart series would be captured in raster digital format to significantly reduce the

[1] Each ENC cell is given a usage code (from 1 –6) which relates to its intended navigation purpose and determines its priority for display in an ECDIS. Usage Code 1 equates approximately to small scale planning charts while Usage Code 6 equates to very large scale berthing plans

maintenance and reprinting load. This released staff to enable normal production to continue on the Autochart system, as a temporary measure. It also had the added advantage of training these extra staff in the compilation process so that they in turn could be trained in S-57 procedures when the schedule allowed. (Over a period of two years, this raster approach has also enabled the AHS to nearly double its New Edition output to reduce the need for Blocks and complex Notices To Mariners).

The Nautical Charting Section required some 29 staff at Technical Officer (TO) level to be trained. Each training group comprised three TOs, as this was to be the basis of a ChartStation compilation team. The junior grade TOs were trained later by their respective supervisor, when they were allocated to a position within a production cell.

Each group received 8 weeks of ChartStation training, which included converting an existing chart to S-57 format. In addition, selected senior staff were provided with training in Systems Management.

The training plan commenced in April 1997 and was completed by April 1998. As each group completed their training, they then transferred to ChartStation for all new compilation tasks, either producing the paper chart and its S-57 version, or an ENC based on Swath data.

This initial training delivered significant benefits beyond that needed directly for the swath project. It provided a knowledge base in readiness for the introduction of a purpose designed ENC production and data management environment. In addition, It provided knowledgeable staff to oversee an ever-increasing amount of contracted work.

Swath Compilation Issues

The compilation of ENC data sets from source data produced a number of challenges for compilers, supervisors and management alike. The issues outlined below provide an insight to the major hurdles faced in developing ENCs from survey source information.

Usage Codes

ENC cell usage codes (Navigation Purpose) range from 1 (Overview) to 6 (Berthing). The AHS has decided, that for the immediate future, there would be no usage code 6 cells produced as using very large scale survey information to compile ENCs over a small area was considered a separate issue and likely to have only limited application in Australia. This means that in effect the AHS has only 5 'levels' with which to cover the complete range of typical navigation purposes. This is further complicated by the concurrent conversion of paper charts to ENC. In some cases there is swath data compiled from original surveys overlapping with direct chart conversions. In such cases, the preference would be for an ECDIS to display the more detailed swath data before the paper chart conversion. To do this, the swath data must have a higher usage code than the converted paper chart. The combination of these factors has resulted in the swath cells having a usage code of 4 (port approach navigation), even though a usage code of 3 (coastal navigation) is probably more appropriate.

Cell Matrix

The data set compilation scales for the swath project were set at 1:150,000 in a matrix of 1 degree cells defined by the latitude and longitude of the southwest corner of the cell. On completion of the first cells, it was realised that the 1 degree cell, when converted to S-57 exchange format, exceeded the 5MB limit imposed by the S-57 standard. This was the result of the compilation platform having curve point interval settings at too short an interval, producing an excess of points along any curved line. In addition, the one metre contour interval resulted in a much denser data set than from a paper chart conversion. The solution required the curve point interval of the compilation platform to be adjusted to minimise the points along curved lines without compromising line quality, and to further sub-divide the 1 degree cells

into 10 minute cells where required.
The AHS is still debating the best long-term approach for ENC cells. A systematic rectangular matrix arrangement, with appropriate identifiers similar to the NIMA DNC may be the ideal solution for a full digital environment. However, some form of hybrid scheme will probably need to persist as long as both paper and ENC product co-exist. This issue also requires careful assessment when determining how and where boundaries between different nations' ENCs are determined.

Compilation Limits

With compilation of data at a one metre contour interval, the volume of work required to populate 100% of each cell was prohibitive. It was decided therefore that compilation from source would be restricted to the currently charted shipping routes and the entrance to the Great North East Channel. To achieve this, the 1:150,000 paper charts covering the intended project area were consulted and the limits to which compilation would be restricted defined on a master set of charts. This was further defined once compilation had commenced to include the outer limits of surveys falling within the initial swath limit. The main issue resulting from these decisions was the deconfliction[2] of surveys overlapping with surveys not falling within the initial swath area, and therefore not being considered in the compilation process. This matter has been resolved on a case by case basis, with some surveys being included in the compilation process, and in other cases the boundary of the swath limited to the originally defined limit. At a later date further compilation from source using standard paper chart contour intervals may be initiated to complete 100% coverage of the cells, or 'one to one' conversion of the 1:150,000 paper charts to complete the coverage (which has already begun for some cells) may be initiated.

Generalisation

When producing ENCs from paper chart source, generalisation is not an issue as data thinning appropriate to the chart scale and the intended usage of the paper chart has already taken place. However, for compiling from original survey source data, generalisation issues become significant. Initially, an attempt was made to generalise the entire data set in line with procedures to generalise a standard 1:150,000 paper chart. This was followed by a trial compilation with topology generalisation kept to a bare minimum with some generalisation for population of cultural and infrastructure objects. Eventually, the second alternative was adopted as the preferred method, with generalisation of bathymetric contours being restricted to the controlling depth contours. Coastline, reef edges and infrastructure were taken from the current editions of the 1:150,000 paper charts covering the project area. This method has resulted in a variance in the complexity of topology representation in the swath area, as survey scales range from 1:2,000 to 1:150,000. In addition, surveys from digital source have had contours generated and imported 'on-line', with minimal intervention from the cartographer. The issue of the level of generalisation in relation to the usage code of ENC cells needs to be further addressed within the AHS and firm guidelines adopted for the future.

Deconfliction

In parts of the Swath, there are up to eight overlapping surveys and the deconfliction of this data became a major driver in keeping the project on time. Two issues became apparent as compilation progressed.

- Firstly, with one metre contour intervals, the deconfliction task was exceptionally complex, particularly in deciding which surveys have priority with respect to scale (generalisation issues) and accuracy (Zone of Confidence-ZOC)

[2] Deconfliction is a process of editing a number of conflicting data sets to produce a single unambiguous data set

- Secondly, the handling of digital data and methods of deconfliction of this data compared with manually compiled data created new challenges, especially where the digital data is the latest data set

Importing a layer of digital information over the manually compiled data resulted in a mass of linework, which is almost impossible to deconflict as a single layer on the screen. As the ChartStation prototype has no method of displaying information on more than one layer or ability to switch between layers, digital data must be compiled first, then all manuscript data deconflicted against this set.

Topography

The issue of the amount of topographic detail to be shown on an ENC was also the subject of many debates. Opinion ranged from full depiction of all topographic information that could be derived from source topographic maps, to depiction of the coastline and only major infrastructure of a lesser level than the paper chart. As there is theoretically no need for visual reference when navigating with an ENC coupled with GPS and or Radar, there was also a school of thought that no topography at all was required. In the end, the decision was taken to use the 1:150,000 paper chart series as the benchmark for topographic detail and seek user input as experience with ENCs becomes more widely spread. In the longer term, the addition of a broad range of topography, infrastructure etc and its supplementary information has the potential to render Sailing Directions obsolete.

Use of CATZOC[3]

The AHS commenced replacing Reliability Diagrams (RD) with Zones of Confidence (ZOC) Diagrams on all new charts and new chart editions in 1998. This single description was considered to be simpler than the multiple factors shown in a RD and provided a lead in to its application to ENCs.

The most significant feature of the introduction of ZOC diagrams is that the AHS must assess and summarise the confidence, which can be placed in each portion of the chart or ENC cell. With RD diagrams the mariner could consider the factors involved and make his/her own assessment considering the type of vessel, the circumstances etc. This assessment is generally straight forward, however in certain cases, particularly where older surveys are concerned, a good deal of thought is required to decide on the correct confidence level.

The most significant issue of applying ZOCs to an ENC occurs when surveys of differing quality overlap. For example, where a survey which would warrant a ZOC B classification overlaps one which would warrant ZOC C, the common area will take the higher ZOC value, in this case ZOC B. In the paper chart the ZOC diagram polygon will have the value B and that is all the mariner will see, with the exception that individual lower accuracy soundings can be displayed in hairline. With an ENC the mariner has the potential to see which soundings originate from the ZOC B survey and which originate from ZOC C. However this is really a false picture as the combined survey is of ZOC B standard. Consequently the decision was made to upgrade all the soundings to the higher ZOC so that the mariner can be presented with a homogeneous picture.

However, some lower accuracy soundings should be still regarded as such. For example, the general depths in an area might be 15 metres, but a sounding from an old survey indicates a depth of 13_5. A decision must be made as to whether there is sufficient modern work to discard the old sounding. Unless further survey work is conducted, the decision will often be that the old sounding should be retained. However, the situation could even be more critical. Whilst the 13_5 sounding could be an inaccurately measured 15 metres, it could also be a genuine shoal. This might represent a significant danger to the mariner and an appropriate warning must be given.

Within the confines of the current ENC standards, such a warning can be provided by classifying the

[3] S-57 Attribute – Category of Zone Of Confidence. Indicates that particular data meets minimum criteria for position and depth accuracy and seafloor coverage

sounding as Sounding Doubtfull i.e. 'a depth shown on a chart over a shoal, a rock etc, that may be less than that indicated'. On the ENC display, this sounding will be enclosed in a grey circle, so the mariner is aware that the sounding is of lower quality, without perhaps knowing why. It is hoped that future upgrades of the standard will enable the reason to be coded and accessed by the mariner.
Having now spent some two years applying ZOCs to a very wide range of surveys, it has become apparent that there is a need for an additional ZOC. There are many leadline surveys that do not technically meet ZOC B standard, but are really not poor enough to be classified as ZOC C. Alternatively, the descriptions of the existing ZOCs need to be modified.

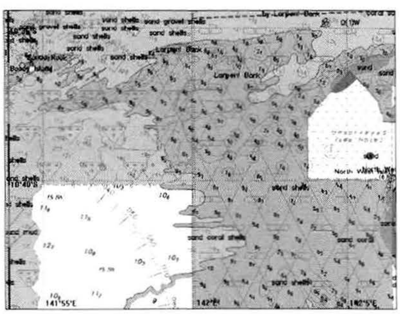
S-57 Issues

Producing ENCs from source documents allows encoders to populate far more S-57 attributes than if only the paper chart is used as source. The AHS has prepared guidance documents for encoders, that include not only the mandatory attributes, but those attributes considered to be of importance to mariners navigating in Australian waters. There were some minor shortfalls in S-57 Edition 3 and through the TSMAD[4] working group, additional attribute values have been adopted for inclusion within Edition 3.1 and as extensions for future editions S-57. Examples include CATLND 20: cay and CATMFA 5: pearl culture farm. There have also been many additions and some clarification to encoding rules within the 'Use of the Object Catalogue' document. A number of these additions and clarifications have come about through issues faced by encoders compiling ENCs from source documents.

SCAMIN[5]

Within a short time of starting the Swath project, it became apparent that much of the AHS's ENC data in its as compiled form was cluttered when displayed on Electronic Chart Display and Information Systems (ECDIS). The careful application of SCAMIN is the key to ensuring mariners have an uncluttered and easy to read display.
S-57 prohibits the use of SCAMIN on Group 1, so called 'skin of the earth' objects - Depth Areas (DEPARE), 'Dredged Areas' (DRGARE), 'Floating Dock' (FLODOC), 'Hulk' (HULKES), 'Land Area' (LNDARE), 'Pontoon' (PONTON) and 'Unsurveyed Areas' (UNSARE). Most Group 2 objects however, (i.e. All the other objects contained in S-57) can be allocated a 'SCAMIN Factor'.
SCAMIN values for Australian ENCs are calculated using the formula below:

Database Compilation Scale of lowest
Navigational Purpose Category database   *   SCAMIN factor
the feature will appear in



Section of Swath ENC including integrated RNC'

For example, a bridge has a SCAMIN factor of 2.5 and a cable area has a SCAMIN factor of 4.0. If the Database Compilation Scale of lowest Navigational Purpose code database that the feature will appear in was 1:10,000 the bridge would drop out at 1:25,000 and the cable area would drop out at 1:40,000.
'Database Compilation Scale', rather than 'Compilation Scale' (CSCALE) or survey source data scale, is used in the above for-

[4] Transfer Standard Maintenance and Application Development Working Group of the IHO Committee of Hydrographic Requirements for Information Systems (CHRIS)
[5] Acronym for Scale Minimisation – methodology in S-57 to ensure the display of information in ECDIS is clear

mula to ensure consistency throughout all datasets. When compiling from a variety of survey source information, more than one survey scale can exist. Therefore, adjoining features such as wharves may have a different CSCALE or survey source data scale values. If SCAMIN is calculated for these features based on CSCALE or survey source data scale, features of the same type from different surveys may be 'thinned out' before the other.
SCAMIN values will initially be populated manually during compilation, with the intention that the process will become semi-automated during the implementation of project SEA1430.

Mandatory Attributes Table

Early on in the swath project, it was recognised that ENC attributes were not being populated consistently by all cartographers. The level of attributisation for each object class is of high priority to ensure that within each ENC cell the attributes being captured were consistent across all ENC cells.
The solution for this issue was to create the 'AHS ENC Mandatory Attributes Table'. (Note: The 'AHS Mandatory Attributes Table' is compliant with S-57 APPENDIX B.1 'ENC Product Specification' Edition 1.0).
This table has provided the following benefits:

- Faster production times, as personnel know exactly which attributes to encode
- A streamlined quality control process as personnel responsible know what attributes are to be checked
- Clear guidance to various data managers within the HO as to which information sets have priority for resources

A consistent level of attributes for each object class also provides the mariner with the same level of information, regardless of the area they are passing through.

Navigation Marks Data Base (NMD)

The primary purpose of this seamless database is to facilitate the storage, management and retrieval of all digital navigation mark data and selected aids to navigation within Australia's region of charting responsibility. A Navigation Marks census in 1994, estimated that there were 12,500 marks and 875 leading lines. At present, NMD contains roughly 3,000 navigation marks/lines, with the majority concentrated on the eastern seaboard and major ports.
NMD is a proprietary Geographic Information System (GIS) application, designed by HSA, that caters for Navigation Marks/Aids in the production of both traditional Paper Chart products and ENCs. NMD is operated via a Motif Graphical User Interface, linking VISION GIS software with an ORACLE Relational Database Management System (RDBMS) and is kept compatible with the current edition of S-57.
NMD is generally populated manually from source data, however it does have an automated population facility for data in its proprietary GINA (.gia) format, Port Authority File (.paf) or ASCII Text File. To this end, the various port and marine agencies in Australia are being encouraged to provide data to the AHS in digital format.
Paper chart data extraction from NMD is achieved at the Graphic User Interface (GUI) level via the Export to ChartStation (CS) facility. This facility enables the user to select part of or the entire database into a GINA file (.gia), which can then be loaded into the ChartStation environment.
NMD data that will be used in the production of ENC's undergoes a preliminary QC process before it is released for merging with its corresponding ChartStation database.
DXaminer is the proprietary quality assurance tool developed by HSA for the AHS and other producers of S-57 ED 3.0 data. This application can be spawned from the NMD GUI, automatically loading the most recent SENC database. The application applies numerous automated S-57 compliance tests on the data and provides the user with a system error log file. The user, who is undertaking the QC, complimenting the existing AHS NMD QC procedures reviews this log file.

S-52 Issues

The Australian area of charting responsibility includes about one eighth of the Earth's water area and most of this area is still unsurveyed. There are also huge tracts of water classified as inadequately surveyed. Such areas have provided their own symbology issues, not necessarily faced by other HOs. As an example, in the two-way route passing through the inner Great Barrier Reef there is a sharp turn around an island with a large unsurveyed area behind it. Unsurveyed areas do not have a 'safety contour' within ECDIS; however, this feature is needed when using the ECDIS. Representations have been made to the IHO Colours & Symbols Maintenance Working Group (C&SMWG) to investigate methods to incorporate the 'safety contour' into the unsurveyed area symbology.

With the inclusion of one metre depth contours within critical areas, particularly choke points within the Great Barrier Reef swath cells, it is very difficult using ECDIS to form a three-dimensional picture of the bottom as depth contour values do not appear on the display. The only method currently available to the mariner to determine the values is to pick a contour and examine its attributes for the value. This situation is not workable and again, representation was made to the C&SMWG to add the value to the display of the 'safety contour'. Although this does not fully resolve the problem, it is a start.

In the areas of one metre depth contours, the AHS has not shown soundings. Some mariners have been skeptical of this approach and expressed a preference for additional soundings. The jury will probably be out on this issue for some time as mariners come to grips with a new way of navigating - there may well be a place to have both options available in future ENCs with users able to tailor bathymetry and contours for their own purposes.

When using CATZOC in the way it was designed (i.e. using CATZOC categories A1, A2, B, C and D which define the positional and depth accuracy in combination with the seafloor coverage), rather than simply using category U (data not assessed), the display on an ECDIS becomes cluttered by the CATZOC symbology. This matter has been referred to the C&SMWG, but is still being considered. As more ENCs are produced in areas which are 'out of the ordinary', new issues regarding the S-52 symbology for ECDIS will doubtless come to light.

ECDIS Issues

Scaleless Data

Many of the survey data sets being used by the AHS are in digital format from multi-beam and LADS systems. As such, they do not have a scale and an optimum sounding density for a particular 'navigational purpose' as defined in S-57 needs to be determined.

In some cases the AHS has produced ENC cells of the 'same scale' but for different 'Navigational Purposes'. Some ECDIS manufacturers have been caught out by this approach and when the overlapping cells of different 'Navigational Purpose' are loaded to the ECDIS, both cells were displayed at the same time. This is an issue not normally faced when compiling ENCs from paper charts as it is unlikely that two different 'navigational purposes' would exist at the same scale on a paper chart.

Quality Assurance and Verification of ENC Data

The Quality Assurance of ENC data has been the greatest challenge in compiling from survey source. It is also a foreign domain to many cartographers, even for those who have been performing traditional paper chart editing for many years. With a paper chart all the necessary features are presented visually in the form of a verification plot and this is simply checked off against the source data. With ENC data however, all information is supplied in a digital format, which can only be viewed using various software packages. All features are held within this file in the form of S-57 Objects with their appropriate Attributes and must meet the appropriate standards.

The QC of AHS data derived from source material has proved to be a very time consuming and exhaus-

tive process. Initially, a plot of the captured data is needed to verify that all the required features from the source data actually exist.
The verification of existing mandatory and additional attributes for these features (objects) can be accomplished by performing some basic checks available within the ChartStation data capture environment, but the values need to be verified to the source material. Variables can be set which allow the checking of such things as duplicate linework.
A number of QC software tools are utilised within the AHS. These include DXaminer, (which is a component of ChartStation), SevenCs Analyzer and Inspector and Dkart Inspector. All of these interrogate the digital data in S-57 format for typical errors that occur during capture and population; they also ensure that the data structure is in accordance with the specifications. Through the resultant error logs, and with the aid of a visual display, the data can be examined to make the necessary corrections. It has been found though that incorrect attribution can still occur even if all the relevant relationships are met.
To ensure that everything is in fact correct, there must also be an extensive object by object check/verification before the data is processed through the QC software tools. The data is finally checked for consistency with adjoining data sets.
At this point the ENC database is run through an ENC Simulator, in order to view and operate it, as the user will. This final check includes input from a qualified mariner.

Documentation

Other than the relevant IHO standards, there is little or no documentation on how to manage the compilation of ENCs from survey source. Throughout the production process, a small project team has compiled a Management Plan to document the AHS approach. This plan will eventually form an in-house supplement to the Standards and be a key reference for staff training and compilation procedures.

Conclusion

Australia's experience with producing ENCs from survey source continues to be a challenging one. Indeed, there have been many occasions when it was debated whether the potential benefits of the ENC from source would outweigh the pain of the steep learning curve. What was obvious however, is that this approach has enabled the AHS staff to explore the full range of ENC production issues.
The advent of ENCs has provided the mariner with a new tool of immense potential that will only be realised if the paper chart paradigm is discarded. Australia's aim is to give the mariner access to the wealth of information held in HOs, which the paper chart has not been able to unlock. This process is not an easy one, there is no magic formula and no one to provide a 'how to do it' course. To realise the full benefits of the ENC, there also needs to be a corresponding development in HO production systems. The information needs to be managed in a fully digital, geo-referenced database environment with the ability to register, store, retrieve, manipulate, edit and audit on-line.
While the AHS has a long way to go in compiling ENCs, it at least now has a good idea of where the challenges lie. What is also apparent, is that the care, dedication and innovation of the cartographers will remain the strength of a HO regardless of the technology.

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Biography

Commander Hudson joined the Royal Australian Navy (RAN) in 1970 and saw early service in HMA Ships Bayonet, Torrens and MELBOURNE. He joined the Hydrographic Service in 1978 and has served in HM Ships FLINDERS, MORESBY and COOK. He has completed the Royal Navy Long Hydrograhic Course and attended the RAN Staff College. During his career he has commanded the Fijian survey ship HMFS RUVE, HMA Ships BETANO and MORESBY and was on the project staff of the LADS system.
Commander Hudson has served in the Australian Hydrographic Office since 1994 and is currently the Director of Hydrographic Operations responsible for ship operations, chart production and hydrographic data management and assesssment.