



## Paper Chart Information in A Digital Era – Some Considerations

By Robert Ward, Australian Hydrographic Service, Australia

Many of the world's Hydrographic Offices are creating official electronic charts for use in Electronic Chart Display and Information Systems (ECDIS) principally by converting the data already found on their paper charts. This may well be expedient but it also means that the full potential of ECDIS cannot be realised. In addition, the direct conversion or extraction of material from paper charts for use in other digital systems may lead to unforeseen problems. This paper highlights a number of the limitations and shortcomings of paper charts, particularly when they are used as the basis for electronic navigation. A number of future developments and possibilities for ECDIS that will ultimately depend on more data than is found in a paper chart are also discussed.

ECDIS promises to provide a powerful decision-making tool on the bridge of a ship by combining continuous electronic position fixing, ship's sensors such as radar, AIS (Automatic Identification System), depth sounder, log, gyro, and a sophisticated electronic database containing charting and other navigation information. The potential to do much more than can be achieved with a paper chart or publication is obviously inherent in the technology, but the time and expense in getting beyond paper documents as a source is a limiting factor. Thus paper charts have heavily influenced the first generation of ECDIS technology. This has resulted in the Information Systems part of ECDIS being under-exploited in most cases. However, things are changing – albeit slower than many would desire. Data-rich electronic charts, digital nautical publications, high-precision berthing applications, supplementary navigation information, dynamic tides and underkeel clearance, weather forecast integration and collision avoidance mechanisms are some of the things that are now under consideration or development. These are welcome developments but they must all be tempered by an understanding of the limitations of any underlying chart data upon which they depend.

### Use of Paper Charts for ENCs

While there are limitations in using paper charts as the source for Electronic Navigational Charts (ENCs), there are a number of attractions for so doing. In particular, the paper chart often represents the only validated, de-conflicted source of data that is relatively easy to digitise into a vector format. By contrast, creating vector data from source survey information is very time consuming and requires even greater levels of painstaking research and judgement than are required to compile paper charts. For most HOs, faced with strong demands for vector charts for ECDIS and limited or dwindling resources, there has been little alternative but

to simply copy paper charts in the first instance. While this is expedient, it has its limitations. Hopefully, in time, the ENC's thus created will be enhanced and improved with the addition of supplementary information and greater detail.

### **Data-Rich ECDIS**

The Australian Hydrographic Service (AHS) has for some years held the view that ENC's for use in ECDIS must be much more than simply a vector-format facsimile of an existing paper chart. The full potential of ECDIS will only be realised when ENC's contain much more comprehensive and accurate data sets than are presented on a paper chart. In particular, comprehensive bathymetric models are required to enable the safety depth and 'freedom of manoeuvre' features of ECDIS to be fully exploited. Additional related nautical information should also be available if the mariner is to benefit from a comprehensive, integrated navigation and bridge management decision-aid.

In following this philosophy, the AHS is creating ENC's for the most important and environmentally sensitive shipping routes through Torres Strait and The Great Barrier Reef that include much more detailed bathymetric data than can be shown on conventional paper charts. While this will enable mariners to enjoy the maximum benefits of ECDIS from the outset, it has proven to be a complex task for the AHS (Hudson, 2000).

### **Limitations of Paper Charts for Electronic Navigation**

There are a number of limitations associated with ENC's that have been created directly from paper charts.

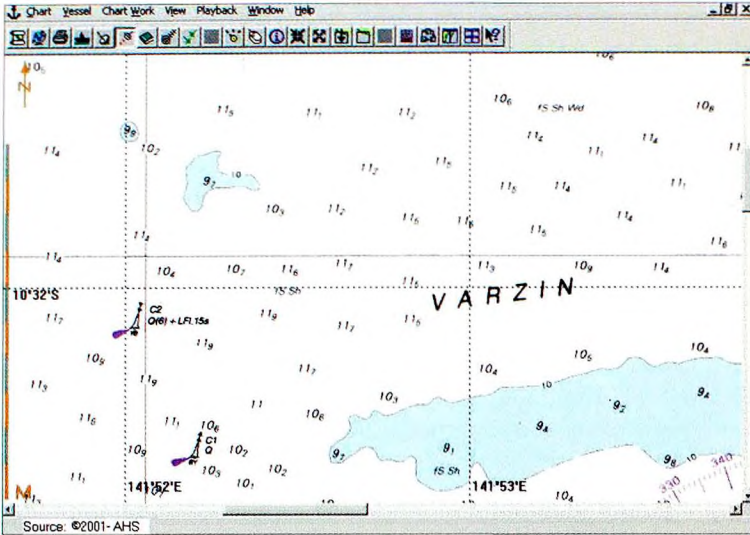
#### **Chart Scale**

Paper charts are constrained by the scale at which the information is portrayed. For a particular scale, there is a minimum plotable distance; in other words, the smallest feature or distance that can be distinguished on the paper chart. For example, at a scale of 1:75,000 (a popular scale for port approaches or constricted waterways) a line or point on a paper chart (say 0.25mm wide) represents nearly 20 metres in the real world. This means that features smaller than 20m must be exaggerated both in size and position for them to be shown on the chart. It also follows that it is not possible to plot a position on the chart or to extract a position from the chart with a precision greater than the minimum plotable distance. The minimum plotable distance is effectively the limit of position resolution. If a paper chart is used as the source of information for an ENC then all of the limitations of the scale of the paper chart will be transferred to the ENC. This has obvious ramifications in the current situation where an ECDIS user can determine and display position with significant accuracy, say a few metres for DGPS and sub-metre accuracies for real-time kinematicGPS.

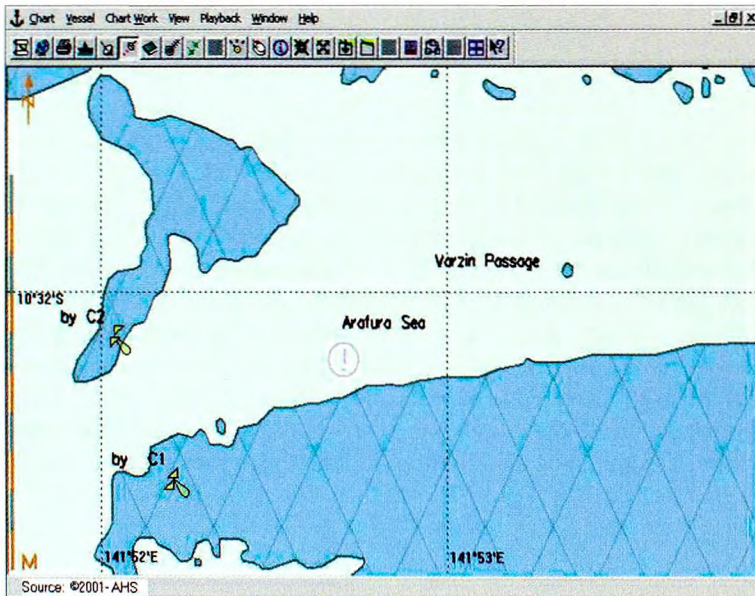
#### **Positional Accuracy of Source Data**

Another critical factor has emerged in recent years. Many (if not most) of the world's charts are compiled from historical information – some of it decades or centuries old. The positional accuracy of much of this data is in general poor by modern standards. However, the impact of such inaccuracies was minimised until now because cartographers usually adopted a chart scale that ensured that the minimum plotable distance was greater than the positional accuracy of the source data. Furthermore, the chart user's ability to obtain accurate positions was also limited by the technology of the day. The advent of DGPS and other high accuracy positioning techniques now places extreme pressure on the use of this older data. It is now most often the case that a ship's position can be determined by electronic means with greater accuracy than the information shown on the published chart. While DGPS can achieve positional accuracy of a few metres, the positional accuracy of most hydrographic surveys conducted more than about ten years ago is probably no better than 20-30 metres. For older surveys, the accuracy is typically worse. The

... In particular, comprehensive bathymetric models are required to enable the safety depth and "freedom of manoeuvre" features of ECDIS to be fully exploited ...



Paper chart - AUS 289 depiction of the entrance to Varzin Passage (GBR) - where is the safe water for a vessel limited to depths of 11m?



ENC AU411141.000 depiction of the entrance to Varzin Passage (GBR) highlighting the 11m safety contour - dark blue areas are less than 11m

paper charts that certain features must be exaggerated or must displace others for the sake of clarity and ease of use. It is often important to the mariner that radar conspicuous objects are clearly shown on the chart. This may have the effect of displacing or obscuring other details. In the case where a navigation light or similar structure is located on the edge of a berth, it will not always be possible to show the edge of the supporting structure accurately, if at all. It is therefore important to realise that information extracted from a chart may not be suitable for use in combination with modern, accurate positioning systems.

reality is that the positional accuracy of the information available from almost all of the world's charts is now inferior to the accuracy with which a mariner can position a ship. While most of the world's survey data can be described in terms of latitude and longitude, surveys conducted more than a decade or so ago relied on many different models of the earth – each chosen to best suit local circumstances. The use of a universal model of the earth (the so-called satellite datum) has only happened since the regular use of GPS. There are many published charts and plans that have no geodetic reference at all; there are others for which there can only be an approximate relationship between the local datum and satellite datum. Obviously, such charts are unsuitable for absolute positioning applications such as precise navigation, manoeuvring or berthing; yet there are instances where this is occurring through the ignorance both of mariners and of equipment and systems manufacturers.

**Generalisation**

Paper charts are naturally limited by the amount of information that can be shown clearly on them. It is essential that important details are readily discernible. Simplifying and generalising certain features in preference to others achieves this. It is also the case with

## Great Barrier Reef ENC

Commercial vessels operating inside Australia's Great Barrier Reef (GBR) present a significant threat both to themselves and to the environment in the event that a mishap occurs. In the last decade there have been a disturbing number of grounding incidents (ATSB, 1990-2000) (GBRSRSC, 2001), most of which have occurred without apparent warning to those on the bridge. Regardless of whether the cause of these incidents was inattention, poor navigation practice, or some other reasons, the use of ECDIS and its inherent ability to automatically monitor a vessel's navigational situation and provide advance warning of impending danger should have averted some if not all of these incidents. Commercial pressures increasingly impact on safety margins.

The inner route through the GBR has long been recognised as a navigationally demanding one, to the extent that pilotage is compulsory for vessels over 70m in length and for tankers and LNG carriers of any size (GBR Act 1975). Transit entails a passage of over 1,300 miles, equivalent to a voyage from Rotterdam to Gibraltar and includes extensive tracts of narrow and hazardous waters that pass through one of the world's most vulnerable environmental areas. Presently, there are over 65 coastal navigation charts of 1:150,000 scale or larger covering the passage.

One of the features of the GBR is that safe navigation for larger commercial vessels is limited to a narrow strip of water, which on the conventional paper chart, typically occupies less than 20 per cent of the area of the paper. The route also contains many areas where large vessels are constrained by their draft. It is the case that many of these vessels cannot or do not enter much of the area shown on the paper charts. So, with this in mind, the AHS decided to produce 'data-rich' ENCs of this constrained area and thus provide the greatest immediate safety and operational benefits. Accordingly, in 1998 the AHS began its production programme for 'data-rich' ENCs of the principal shipping routes through the GBR (Willis, 1998).

The GBR ENC coverage will in the first instance support commercial shipping primarily (the most likely vessels to be equipped with ECDIS) and incorporates the following features:

- ENCs compiled from original surveys
- ENCs containing contour intervals of one-metre or less between the depths of 5m and 20m in all navigationally significant areas

Raster Nautical Charts (RNC) will serve as the official electronic coverage outside the shipping route until ENC coverage is extended

## ENC Compilation from Source Data – Some Issues

Creation of the GBR ENC coverage is now well underway. But, it has not been without its difficulties. Few other HO's seem to be creating ENCs from source survey data; consequently there are few precedents and no stores of experience to draw upon.

### Data Deconfliction

There have been instances where bathymetry for a single area of Torres Strait, at the northern end of the GBR, has relied on up to eight overlapping surveys. The deconfliction of this data to obtain a validated bathymetric model has been exceptionally difficult in those areas where a one-metre contour interval was required, particularly when decisions had to be made about which surveys should have priority with respect to scale and accuracy. The use of source data is therefore not a trivial exercise. The deconfliction of data derived from various surveys at different scales, using different technology and of differing age is a complex, time-consuming and demanding activity that draws upon particular cartographic and surveying expertise and experience. This expertise and experience is not easily available outside hydrographic offices and is presently a major obstacle to using contractor assistance to compile ENCs from

source data where data deconfliction is required. It is generally necessary for HO's to provide contractors with a validated, non-conflicting data set from which they may compile a finished product. This involves a significant amount of preparatory work prior to the compilation of the ENC data base itself, which by comparison, is a relatively simple compilation exercise.

### **Level of Topographic Detail**

As ECDIS, by definition, requires a *continuous positioning system with accuracy consistent with the requirements of safe navigation*, (ECDIS PS, 1995) this implies the use of GPS or a terrestrial electronic positioning system. There is therefore a question over how much topographic detail is required for navigation. Theoretically, if GPS is being used as the primary means of position fixing in ECDIS, backed up by radar as a confidence check, then there is little or no need for visual references. Nevertheless, the prudent and conservative mariner may wish to see a limited number of traditional navigation marks shown on the ECDIS display. The dilemma does not arise if all the material from a corresponding paper chart is duplicated, however, this increases the compilation workload, and for what benefit? After some consideration, it was decided to limit the level of topographic and navaid detail in the GBR ENC to that found on the medium scale 1:150,000 paper chart of the area, even though the level of bathymetric detail involved corresponds to paper charts of a very much larger scale.

### **Data Reliability Information**

An indication of the reliability of the bathymetric model contained in an ENC is achieved by categorising areas according to various *Zones of Confidence (ZOC)* (ANM 2001) levels, ranging from ZOC A1 – the highest level, to ZOC D – much poorer. A catch-all ZOC value of ZOC U - *unassessed* is also available for those areas, which for various reasons have yet to be formally assessed by the publishing HO.

It is notable that most if not all HO's that are compiling ENCs from paper charts are using the 'unassessed' ZOC value 'U' by default, since this avoids the sometimes involved process of making an assessment. This is less than helpful to the mariner and actually leaves the ENC user with less information than would be available on the paper chart, where a reliability or source diagram serves a similar purpose to ZOCs. Some might argue that this contravenes the IMO Performance Standards for ECDIS that require: '*ECDIS should have at least the same reliability and availability of presentation as the paper chart published by government-authorized hydrographic offices*' (ECDIS PS, 1995).

The proper use of ZOC usually requires that the original source data be consulted or considered in order to confirm both its positional and depth accuracy together with the thoroughness of the seafloor search. This assessment is generally straightforward, however in certain cases, particularly where older surveys are concerned, a good deal of thought is required before one can decide on the correct confidence level. To date the AHS has developed and published the only existing guidance for accomplishing this requirement (AHS, 1999).

### **Clutter and SCAMIN Value**

In an ENC a minimum display scale (SCAMIN) value is introduced to control the presentation scale level at which certain features will be inhibited in the ECDIS display. The SCAMIN of an object determines the display scale below which the object will no longer be displayed. Its purpose is to reduce clutter, to prioritise the display of objects and to improve display speed.

The SCAMIN value is related to *compilation scale*, and is encoded in the ENC header file, or additionally within the SCAMIN meta object, or by the attribute SCAMIN at the object level. *Compilation scale* is defined as *an area within which the data was originally compiled at a uniform scale*. For ENCs created directly from paper charts *compilation scale* is normally taken as being the scale of the original paper chart. However, when data is sourced from survey data rather than from a paper chart there may be a variety of different scales involved. For example, the features in a harbour may be derived from adjacent surveys at different scales. If the SCAMIN value for these features is based on the scale of the survey data, then similar features in the harbour of equal importance might be 'thinned out' before others, depending upon the scale of the survey that they came from. This has led the AHS to adopt a concept of *database compilation scale* rather than *chart compilation scale* as the basis for calculating SCAMIN values.

Another issue surrounding *compilation scale* arises when the survey data used in ENC's is purely digital rather than being taken directly from survey charts or drawings. In this case, what is the *compilation scale*? It is meaningless to use the scale of a survey drawing when the underlying digital data might be at a much higher resolution. This is actually the case with large tracts of the GBR ENC's that contain data from multi-beam and laser depth sounder surveys. This data is not extracted from the survey charts or drawings but directly from the digital data record. The data was extracted at an optimum sounding density according to the *navigational purpose* of each ENC.

In some cases, the direct extraction of digital data has led to certain areas being covered by ENC cells of different *navigational purpose* code but with the same notional *compilation scale*. This in turn leads to difficulties because some ECDIS manufacturers rely only on *compilation scale* rather than considering the *navigational purpose* code to determine ENC cell display priorities. When two overlapping cells of different *navigational purpose* are loaded in certain ECDIS equipment, both cells are displayed at the same time. This normally does not occur when ENC's are compiled from paper charts because it is unlikely that two overlapping cells of different *navigational purpose* will ever be created from the same data taken from a single paper chart.

### Quality Assurance and Verification of ENC Data

When an ENC has been compiled from survey data rather than a paper chart, it presents unique QA and verification challenges. The ENC generally contains more information and supports greater functionality than can be provided with a paper chart. On a paper chart all the necessary features are presented visually and can simply be checked off against the source data. With ENC data however, all the information is in a digital format, some of it may never be presented visually, though it will be used in ECDIS navigation; and in many instances there is more information than can be shown on traditional paper plots anyway.

The QC of ENC data derived from source material is proving to be a very time consuming and exhaustive process. Although a visual check and comparison with both the source data and a corresponding paper chart remains an important check to ensure consistency, there is a requirement to examine all the data in the ENC thoroughly to ensure it is logical, fit for purpose and conforms strictly to the relevant ENC specifications.

A number of different commercial software tools are being used by the AHS to assist with inspecting ENC data. All of these tools interrogate the data to locate typical errors that occur during data capture and population; they also check that the data structure is in accordance with the relevant specifications. It has been found that these tools are not totally comprehensive; different software solutions will identify different errors. Furthermore, incorrect attribution can still occur even if all the relevant relationships are met. It is therefore necessary to use a range of checking tools and to conduct an extensive object by object check/verification even before the data is processed through any of the QC software tools. The data is also checked for consistency with adjoining and/or overlapping ENC cells.

Finally, a 'road test' is conducted on each ENC. This is undertaken using the ENC for simulated ECDIS navigation on a range of commercial ECDIS applications provided in the Australian Hydrographic Office for the purpose. This allows the ENC to be used, viewed and operated as it will be used at sea. This final check includes input from appropriately qualified mariners.

### Variation in Content between Paper Charts and ENC

The AHS considers that its primary duty is always to publish information that is appropriate and safe in relation to the relevant technology that is available. It is the case that increased levels of information can be included in an ENC that cannot be replicated in a paper chart. ECDIS similarly has capabilities that cannot be achieved by paper chart navigation. It is the AHS' view that the ENC (and consequently ECDIS) should not be effectively degraded or inhibited in order to maintain consistency with a less capable form of data encapsulation (the paper chart).

In deciding to proceed with 'data-rich' ENC's, the AHS seeks to marry a common-sense 'hydrographic' view with specific legal advice regarding any potential exposure to liability through variations in chart content (AGS 2000). As a result, 'data-rich' ENC's are being created and published wherever practicable, guided by the priority of user benefits and the resources available.

Almost by definition 'data-rich' ENC's, such as those being created of the GBR, will differ from the paper charts of the same area. Greater levels of generalisation may be unavoidable in a paper chart; certain

details may necessarily need to be omitted entirely. Such differences may initially cause a degree of concern, both for mariners and for HO's, particularly in circumstances when mariners might simultaneously reference the paper (or raster) chart and the ENC of the same area.

Some HO's may consider that they expose themselves to an increased potential liability by publishing apparently different data sets of the same area. However, it could be argued that any HO that can reasonably publish useful material that in effect it chooses to withhold actually exposes itself to risk through charges that it is not exercising an appropriate 'duty of care'. It also needs to be remembered that HO's already publish charts with different levels of information for the same area through the publication of their paper charts at various scales. Each chart scale inherently limits the level of information that can be shown. This has not been problematic in the past, either for HO's or for mariners.

It has always been important that seafarers use charts prudently. This means that mariners must understand the differences between the various chart products, their capabilities and their limitations. Well-established programmes of education and training have ensured this up until now. As a result, qualified and proficient mariners generally select the most appropriate paper charts and publications that satisfy their circumstances and intentions. Obviously, this training and education must now be extended to include ENC and ECDIS. Once it is explained to them, there is no reason why professional mariners will not quickly appreciate that a paper chart transferred to an electronic medium remains inherently limited for use by its original form (paper!). That knowledge in turn will enable such charts to be used with the appropriate level of prudence.

### **What Next for ECDIS?**

While HO's continue to grapple with the task of providing data for the *chart display* part of ECDIS, manufacturers and others are developing the *information system* aspects at a great pace. There are many ECDIS enhancements and proposals under consideration. There are also an increasing number of supplementary tools and display methods being developed by ECDIS manufacturers to take advantage of the chart data and use it in combination with additional information – some of it in discrete data bases, such as historical ocean current information; others coming from sensors such as radar and AIS equipment with yet others coming from on-line broadcasts, providing such information as weather forecasts and observed or 'real-time' tidal heights.

### **Bathymetric Detail**

Creating data-rich ENCs such as Australia's Inner GBR coverage raises a number of new possibilities. In the areas of one-metre depth contours, the AHS has not included individual soundings other than certain limiting depth values – the logic being that with such a comprehensive bathymetric model, individual soundings that do not indicate a critical depth are superfluous. Some mariners have initially been sceptical of this approach and expressed a preference for individual soundings to be shown similar to a paper chart (AHS, 2001).

Meanwhile, other mariners wish to view more depth contours than just their own ship's safety depth (AHS, 2001). But doing this makes it difficult or confusing for the mariner to visualise the shape of the seafloor unless the depth contours are labelled with values, or additional shading or colouring is employed.

For large vessels in narrow channels it is just as important to know how shoal is the adjacent water as it is to know how deep is the channel. This is because of suction and other shallow water effects on the hull. There is already a demand for contour intervals of less than one-metre, particularly for berthing and other precise navigation and depth critical activities. There is obvious scope to provide different views such as 3-D perspectives and these are now being offered as a supplementary view in a number of ECDIS.

### **Data Visualisation**

So far, the IHO has focussed on a paper chart-like display of ENC data. The inherent flexibility of the ENC data base means that there are many other possibilities to present the data both alone and in combination with other data and information. 3-D visualisations and so-called *fly-through* capabilities are continuously being improved and offered as additional functions in ECDIS.

The IHO standards governing the display of chart information only provide comprehensive guidance on the presentation of the paper chart-like display (IHO S-52, 1996). It is the author's view that HO's should resist the temptation to set similar specifications for these novel displays, because it will effectively restrict their development and the benefit of choice to the users.

### Tidal Adjustments

Presently, the depths indicated on all official charts, paper or electronic, are referred to a chart datum. It is then up to chart users to account for the height of tide in order to determine the likely amount of water available at any particular time. Increasingly, there are locations in the world where the tidal height is

monitored and broadcast continuously to enable mariners to make more accurate determinations of the depth of water available to them. This is particularly so in ports and for depth critical areas such as the English Channel or Torres Strait. Inevitably, mariners and manufacturers will want to take advantage of these broadcasts by including a real-time tide compensating capability in ECDIS in the future. How quickly this can be reliably implemented will depend in part on HO's' ability to develop comprehensive co-tidal models for the areas to be charted.

### Berthing Chart Production

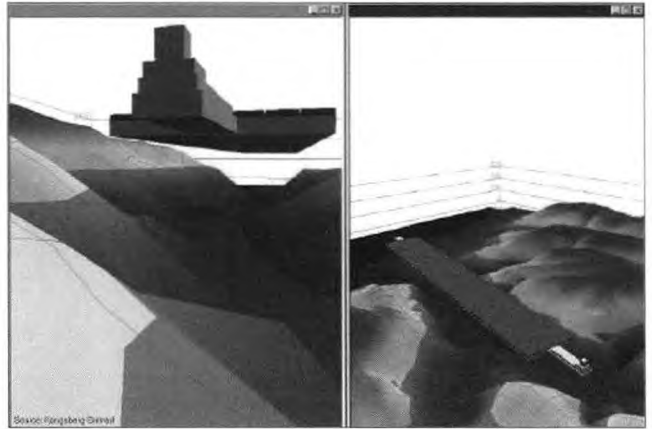
ENC *navigational purpose codes* range from:

- |   |          |  |
|---|----------|--|
| 1 | Overview | route planning and oceanic crossings   |
| 2 | General  | navigating oceans, approaching coasts and route planning                                     |
| 3 | Coastal  | navigation along the coastline, either inshore or offshore                                   |
| 4 | Approach | navigating the approaches to ports or major channels or through intricate or congested areas |
| 5 | Harbour  | navigation within ports, harbours, bays, rivers and canals and for anchorages, etc           |
| 6 | Berthing | detailed data to aid a vessel to berth   |

*Berthing* ENCs will be highly detailed and contain very accurate positional and depth information. At present few if any HO's provide large scale *berthing charts* as part of their paper chart series'. Paper charts in general only support the uses envisaged in purpose codes 1 to 5. The creation of very accurate, detailed *berthing* charts or plans has always been left to port authorities, pilots and other interested parties to supply them according to their own needs. Such aids have never attracted 'official chart' status, nor do they need to. This is because these 'charts' or plans are only used as reference aids for manoeuvring vessels close to berths rather than for navigation as such.

In compiling its ENCs, the AHS has decided not to use navigation purpose code 6 at all. This leaves the way open for other relevant authorities to generate highly detailed ENCs in a similar way that port authorities already create and issue large-scale plans for reference by their pilots. It is also Australia's view that such *berthing* ENCs will not require any official status, since they will not be used for navigation, but will in fact be aids to berthing and manoeuvring. The particular benefit of reserving navigation purpose Code 6 in this way will be that detailed port information will be fully compatible with ECDIS and serve as a complementary dataset to the official ENCs that support the navigation of the vessel to the approach to the berth. In such a scenario, it seems quite possible that these *berthing* ENCs could even be supplied to vessels by the pilot when he or she boards.

... 3-D visualisations and so-called fly-through capabilities are continuously being improved and offered as additional functions in ECDIS ...



3-D display of barge configuration in transit showing true vessel dimensions and real-time position in relation to charted bathymetry



**Digital Nautical Publications**

The IHO Standardisation of Nautical Publications Working Group (SNPWG) has recently provided guidance (SNPWG, 2001) on how the information found traditionally in documents that supplement the paper chart can be delivered in electronic form. This includes traditional paper documents such as:

Distance Tables  
List of Buoys and Beacons  
List of Lights  
List of Radio Signals  
List of Symbols, Abbreviations and Terms used on Charts  
Mariners' Handbooks  
Notices to Mariners  
Routing Guides  
Sailing Directions  
Tidal Stream Atlases  
Tide Tables

It is noteworthy that the SNPWG did not consider digital solutions specifically tailored for ECDIS. To do so, particularly if the S-57 ENC format is to be used directly, will require very precise and prescriptive specifications, not unlike the requirements for ENC. Not only will this be an onerous task for the relevant IHO technical working groups (Transfer Standard Maintenance and Application Development (TSMAD) Working Group, Colours and Symbols Maintenance Working Group (C&SMWG), etc), but the result would inevitably increase the compilation load on HO's, which are already overstretched by their commitment to ENC production.

The SNPWG therefore described a solution that emphasises the use of Web-based publishing standards rather than the development of a specific ECDIS specification or an extension of S-57. Web-based options provide HO's and systems manufacturers with the greatest flexibility in formats and methodology, yet ensure that data publishers and the user community are not obliged to invest in a multitude of proprietary systems and software. It also acknowledges the fact that almost all nautical publications information is currently in manuscript form rather than digital database form and this is likely to remain so for many years to come. Common file formats such as pdf, html, hgm1 and XML all lend themselves to the transformation of text information and documents into a flexible electronic form at low cost. This also follows the trend in multimedia publishing which, like digital nautical publications, must rely heavily on existing paper publications as its source. By design, the S-57 ENC Product Specifications can easily accommodate such an approach through the use of the PICREP and TXTDSC attributes.

**MIOs**

As well as chart data, which some might consider relatively static (even though it is not), ECDIS has the potential to incorporate non-cartographic objects that vary with time; such as tides (which has already been mentioned), weather conditions, AIS/VTMS (vessel traffic management systems) information, magnetic variation, and so on. These are the so-called *Marine Information Objects* (MIO). The definition and development of MIOs are a further acknowledgement of ECDIS as the logical focus of information on the bridge of a ship. MIOs do not include:

- Time varying cartographic objects
- Navigation objects such as own ship
- Radar imagery or ARPA

Implementation of MIOs will require considerable development of standards and specifications. It will involve liaison and co-operation between even more agencies and organisations than for ENCs. It will also require modifications to extant regulations and standards, particularly those associated with the IMO Performance Standard for ECDIS.

The IHO sponsored Harmonisation Group on Marine Information Objects (HG-MIO) is addressing MIO and will make appropriate recommendations.

### Smart Decision Aids

ECDIS is destined to grow into a very sophisticated navigation system. It will eventually integrate at least radar, AIS, VTMS and chart information together with a vessel's own manoeuvring capabilities and weather, tide, current and a variety of other useful parameters. ECDIS will be able to identify a vessel's freedom of manoeuvre and the sea room available to it at any time. Knowledge of other vessels' situations and intentions will be available through AIS and ARPA. It is therefore not inconceivable to suggest that if this is integrated with a database that incorporates the International Regulations for the Avoidance of Collisions at Sea (the COLREGS), then manoeuvring options can be provided to the Officer of the Watch in advance of any impending close quarters situation. While this may seem fanciful to some at present, it is an inevitable development that will occur in the future.

### Integrated Navigation Systems (INS)

Even before ECDIS has been implemented fully, let alone reached maturity, the IMO has invited study on the relationship between ECDIS, other navigation equipment and Integrated Bridge Systems (IBS). The logical development of the ECDIS concept is now to produce harmonised operational and design standards for integrated navigation systems (INS), which incorporate, amongst other things; ECDIS, Radar, AIS and VTMS. This work is intended to ensure the proper integration, display and use within an IBS environment of the ever increasing amounts of information available and required by the mariner on the bridge. The aim is to develop performance standards and operational guidance for INS in an IBS environment, together with comprehensive guidance on training in the use of this new navigation technology.

As part of this development, the IMO has invited the International Electrotechnical Committee (IEC) to develop a standard for the presentation of navigational information which harmonises the following:

- Display and interaction objects
- Multifunction displays
- Co-location, merging, processing, fusion of graphical information
- Indication of quantity, status, integrity and accuracy of information. (IMO, 2001)

In doing so, the work will take account of the relevant resolutions, decisions and existing specifications of both the IMO and the IHO. However, it is to be noted that the IHO and its Member States are in this case contributors to any resulting specifications rather than exclusive authors as has traditionally been the case when dealing with the presentation of chart related information.

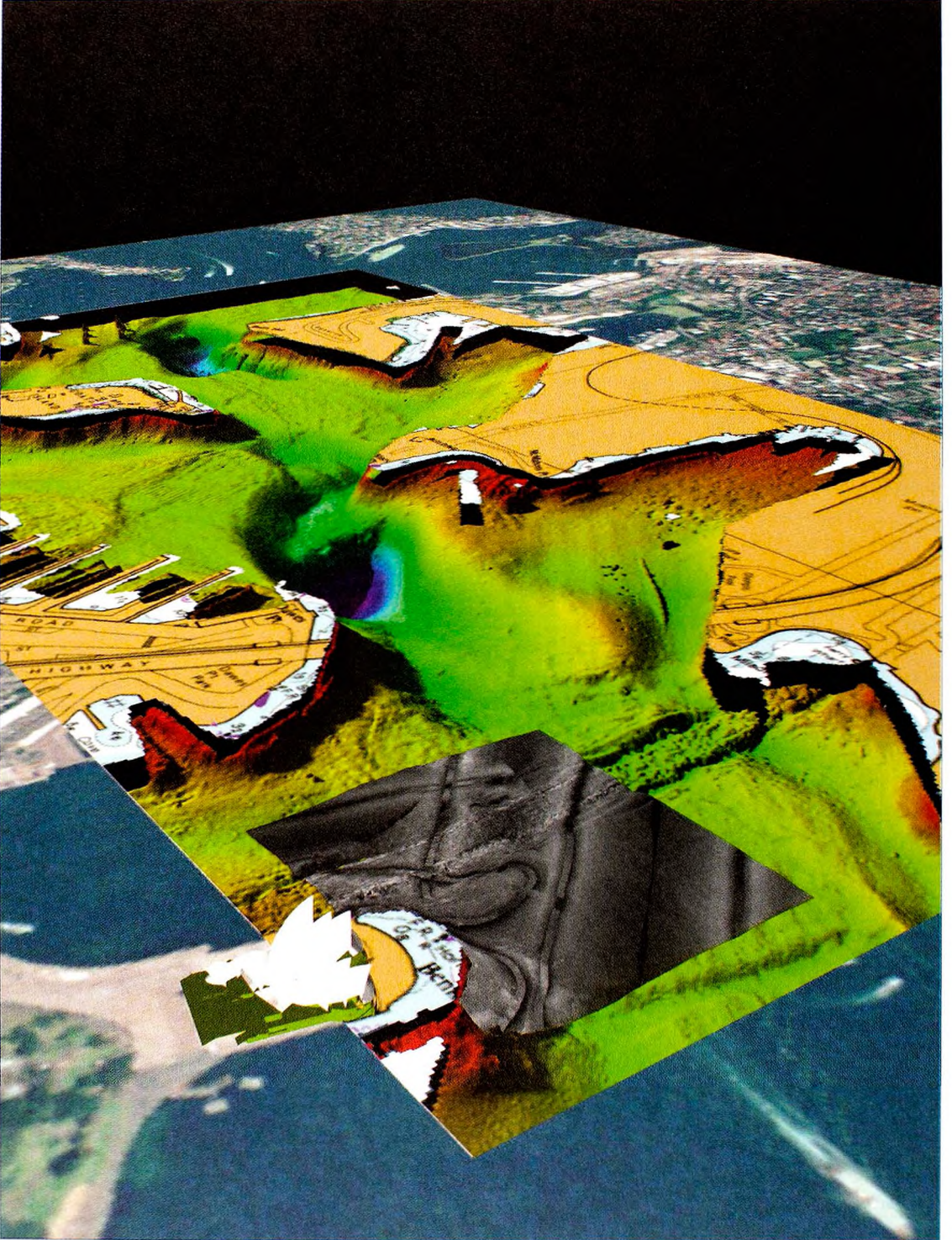
Work is also proceeding to establish appropriate symbology and procedures for the display of AIS information in an ECDIS. Once again, the IHO is involved as expert advisers rather than as sole authors of any resulting standards or specifications.

Yet another multi-disciplinary approach to INS is being taken through the Norwegian Geodata Demonstrator project (Klepsvik and Mikalsen, 2001). This phased programme of evaluation and demonstration is seeking to provide a practical solution to the navigation information requirements of mariners in the 21st century. In particular, Phase 3 of the project, to be known as 'SEANAV@2010', aims to concentrate on the development of prototype demonstrations of other ways of presenting relevant navigation information. It promises to be at least as significant to the future of bridge information management as the *North Sea Project* (ECC, 2001) was to the development of ECDIS and the first revolution in chart information and display.

### Conclusion

ECDIS provides the mariner with a new tool of immense potential but one that will only be fully realised when dependence on information from the paper chart is overcome. There are also novel ways of presenting information, that will inevitably supplement the traditional two-dimensional plan view of a chart. It must be possible for the mariner to view relevant information in an appropriate way that suits the context of the employment of a vessel and its situation. This may mean presenting the same information simultaneously and in various combinations with other information.

... there are also novel ways of presenting information, that will inevitably supplement the traditional two-dimensional plan view of a chart ...



Map composite of Sydney Harbour incorporating aerial photography (including ships underway), 3-D charted bathymetry, sidescan imagery and charted topography

The use of paper charts as a basis for ENC production should be regarded only as having been an expedient first-step and interim solution to meet the demand for data. The full benefits of ECDIS will not be realised until ENCs contain relevant data at appropriate levels of density and accuracy. Mariners must have access to the wealth of information held in HOs, which the paper chart is unable to deliver. They should also be able to take advantage of a number of complementary possibilities and enhancement that are potentially available in ECDIS once the appropriate level of chart data is available.

In the meantime, it is the author's view that for the sake of mariners' safety and the prudent use of charted information, HOs, maritime authorities and system manufacturers should all acknowledge more clearly the limitations of using paper charts as a basis for ENCs and ensure that these are known by the users. Just because paper chart data is shown in colour, in metres and is presented in ECDIS, its fitness for all purposes should not be assumed.

## References

- Hudson M. (2000) 'Electronic Navigational Charts from Survey Source Information - The Australian Experience', *International Hydrographic Review*, Volume 1, Number 2
- ATSB (1990-2000) 'Reports of Marine Investigation Unit 1990-2000', Australian Transport Safety Bureau, Available at: [www.atsb.gov.au/marine/index.cfm](http://www.atsb.gov.au/marine/index.cfm)
- GBRSRSC (July 2001) Great Barrier Reef Shipping Review Steering Committee 'Review of Ship Safety and Pollution Prevention Measures in the Great Barrier Reef', Available at: [www.amsa.gov.au/SD/gbrreview/report.htm](http://www.amsa.gov.au/SD/gbrreview/report.htm)
- GBR Act (1975) Great Barrier Reef Marine Park Act 1975
- Willis R.J. (1998) 'Towards AUS ENC One'. *Proceedings, Institution of Surveyors. 39th Australian Surveyors Congress, Launceston*
- ECDIS PS (1995), IMO Resolution A.817 (19) 'Performance Standards for Electronic Navigation Systems'
- ANM (2001), Australian Annual Notices to Mariners, numbers 25 and 25A
- Australian Hydrographic Service (1999) 'Guidelines for ZOC Assessment of Historical Sounding Data', Available on request
- AGS (2000), Australian Government Solicitor, 'Advice 2000025993 - Publication Dates and Formats', Available on request
- AHS (2001) Feedback from ENC Evaluation Voyages – SS *River Boyne*, unpublished
- IHO S-52 (1996) International Hydrographic Organization 'IHO S-52 – Specifications for Chart Content and Display Aspects of ECDIS and IHO S-52 App 2 – Colour and Symbol Specifications for ECDIS'
- SNPWG (2001) 'Proposed amendments to IHO Technical Resolutions', IHO CHRIS13/14/4A Annex A.. Available at: [www.iho.shom.fr/general/ecdis/COMMITTEE/CHRIS/chrisintro.htm](http://www.iho.shom.fr/general/ecdis/COMMITTEE/CHRIS/chrisintro.htm)
- IMO (2001) Report of the 47th Meeting of the IMO Sub Committee on the Safety of Navigation, para 4.8
- Klepvik F. & Mikalsen J. (2001) 'Norwegian Maritime Geodata Demonstrator'. *Proceedings, International Conference on Port and Maritime R & D and Technology, Singapore*
- ECC (2001) 'The North Sea Project', Available at: [www.ecc.as/About/North\\_Sea.pdf](http://www.ecc.as/About/North_Sea.pdf)

## **Biography**

Robert Ward was born in England. After serving as a surveying officer in the UK Royal Navy he transferred to the Royal Australian Navy in 1983. He has qualified as a Chartered Surveyor and is also a Member of the Australian Institution of Surveyors. In his 32 year naval career, over 20 of which have been spent in ships, he has been involved in hydrographic and oceanographic surveys across the world. His last sea posting was in command of the Royal Australian Navy surveying ship 'HMAS Moresby'. Ashore, he has served at the RN Hydrographic School as an instructor and at the Australian Navy Hydrographic School as Officer in Charge. Robert Ward is currently Head of External Relations at the Australian Hydrographic Office. Amongst other things, he is responsible for Australia's national and international hydrographic policy and relations, with particular emphasis on standards for electronic chart navigation and digital hydrographic data.

E-mail: [hpd@hydro.gov.au](mailto:hpd@hydro.gov.au)