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ic-enc.org
International Centre for ENCs

Improving ENC Consistency

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1. INTRODUCTION

For some time, IC-ENC has been concerned about the many different ways in which certain elements of ENCs are being encoded by the HOs. ENC coverage has increased considerably in recent years and the differences have become more obvious, as more and more data has been displayed in ECDIS systems. Feedback from ECDIS users indicates that these differences in HOs' data and encoding practices are causing confusion and dissatisfaction, thereby threatening the viability and take-up of official ENCs.

In order to maximise the coverage available in the shortest period of time, most HOs have created their ENCs direct from existing paper charts. Anomalies in the source paper charts become glaring inconsistencies when transferred to ENCs and those ENC cells are displayed together in an ECDIS. Other inconsistencies result from differing interpretations of S-57 and its ENC Product Specification (PS), and because the standard allows some discretion, for instance, in the use of some S-57 objects and attributes.

IC-ENC personnel have validated data from approximately 30 countries and now use three different ECDIS systems in the ENC validation processes. Consequently, we are able to load and examine multiple datasets, thereby gaining a good overview of these problems. Some of the problems are relatively easy to rectify, some not so. A start needs to be made in addressing these issues and formulating some recommendations for encoders, which, when adopted, will result in greater consistency and quality, greater user satisfaction and greater use of ENCs/ECDIS by the maritime community. We have now investigated some of the issues and our findings are summarised below.

Our initial recommendations were presented to the 2nd IC-ENC Technical Experts Working Group (TEWG) meeting in the Netherlands in April 2003, and to a joint meeting of representatives of the IC-ENC and Primar-Stavanger HOs in Copenhagen in May 2003. In total, seventeen HOs have been involved in detailed discussions and the views expressed by those HOs have been incorporated into this document.

This is not an issue of S-57 compliance – all data released by IC-ENC fully conforms to S-57. It is an issue of interpretation, quality, consistency and user confidence.

N.B. The examples that have been used in this document are not intended as a criticism of any particular HOs. The examples have been selected as typical examples of the problems being described. Obviously, IC-ENC has easy access to IC-ENC countries' ENC cells, so these countries' data have been used to illustrate the various points. Similar examples could also be found in other HOs' data.

2. IN WHAT WAYS ARE ENCs INCONSISTENT?

Compilation Scale

What is compilation scale?

Compilation scale is defined in several parts of S-57:

S-57 Appendix A
IHO Object Catalogue

Definition:

> An area within which the data was originally compiled at a uniform scale. For example, it may define the scale of the paper chart from which the data was digitised.

S-57 Appendix A
Chapter 2 - Attributes

Definition:

> The scale at which the data was originally compiled.

Remarks:

For example, the scale of the paper chart that was used for the ENC compilation. This attribute is only used in conjunction with the meta-object ?Compilation Scale of data? (M_CSCL) which is used to define polygons of equal compilation scale. CSCALE should therefore not be confused with the attributes SCAMIN and SCAMAX

S-57 Appendix B.1
Annex A - Use of the Object Catalogue for ENC

2.2.6 Compilation scale

The default value for the entire data set is given in the "Compilation Scale of Data" [CSCL] subfield of the "Data Set Parameter" [DSPM] field. The default value should be the compilation scale appropriate to the greater part of the data in the cell.

If the compilation scale is different to the value given in the CSCL subfield for some part of the data set, it must be encoded using the meta object **M_CSCL**. The areas covered by these **M_CSCL** meta objects are mutually exclusive.

Meta object: Compilation scale of data (**M_CSCL**)
Attributes: CSCALE INFORM NINFOM

Remarks:

- The compilation scale provides the reference value for the overscale indication.

These definitions are confusing and misleading. There is no clear guidance within S-57 as to what value should be used for compilation scale. Some HOs are setting the compilation scale of their ENCs equal to the scale of the source chart. Others, taking into account the much reduced resolution of an ECDIS screen compared to a paper chart, set the compilation scale based on a multiple of the scale of the source chart - twice chart scale seems to be the most popular, e.g. if source chart scale = 1:100000, the compilation scale of the ENC is set to 1:50000.

Setting compilation scale equal to source chart scale often results in a cluttered display when the ENC is viewed at compilation scale. The display only becomes clearer when the data is viewed at a much larger scale (by which time the ECDIS's overscale warning may have been activated), or by selectively switching off the display of some object classes.

Setting compilation scale to double that of the source paper chart overcomes the problem of cluttered display, but could result in mariners using the data at much larger scales than it was originally compiled for. For instance, some ECDIS systems allow a mariner to zoom in 2 x compilation scale before any overscale warning is displayed. This means that an ENC cell produced from a 1:100000 scale paper chart, with compilation scale set to 1:50000, could be displayed at a scale of 1:25,000 without the mariner being aware that he is viewing the data at an inappropriate scale. Is this what we want?

In addition, if the intended usage of a paper chart at 1:100000 is for coasting and the resulting ENC has a compilation scale of 1:50000, should it still be classified as "coastal" or should it become "approaches"?

Some HOs are setting different compilation scale values over different parts of their cells, using the meta object M_CSCL. This can result in a large number of different compilation scale values in a single cell. This can be confusing when viewing the data, in particular where the density of data varies across the cell, and overscale warnings may be switching on and off as the user traverses the cell. Overuse of M_CSCL objects can also cause problems for ECDIS software and overscale patterns may appear in many different parts of the display at particular zooms. In addition, some ECDIS systems only use the compilation scale given in the header of the dataset for detecting overscale, thereby ignoring any M_CSCL compilation scale values, resulting in the overscale warning being displayed, even though the M_CSCL value indicates otherwise.

Ideally, when producing new cells from original source material, the value of compilation scale should be as large a scale as possible, taking into account the scale of the source material and the readability of the data when viewed on an ECDIS at compilation scale. Unfortunately, at present, most ENCs are not being compiled from original source data, but are being captured directly from already compiled paper charts. A uniform approach to the setting of compilation scale must, therefore, be agreed and defined. At the 14^{th} CHRIS meeting in Shanghai (August 2002), the USA submitted a proposal to adopt standard, fixed compilation scales. Canada was asked to take the proposal to the US-Canada Hydrographic Commission for investigation and to provide a recommendation to CHRIS at a future date.

After considerable discussion on the best way of defining compilation scale, the majority of the RENC countries have agreed that, where an ENC has been captured from a paper chart, the ENC's compilation scale (CSCL and M_CSCL/CSCALE) should be derived from the nearest standard radar range scale to the original paper chart scale. For example, for an ENC produced from a 1:25000 paper chart, the nearest selectable radar range to that scale is 1.5NM (see Fig. 1) with a rounded standard scale of 1:22000. So, the ENC should be given a compilation scale of 1:22000. If all HOs were to follow this rule, then compilation scale would be applied consistently by all producers, clutter could be reduced and the ECDIS display of adjacent countries' data would be much improved. There is also a greater likelihood that ENCs based on same scale paper charts would be allocated to the same usage band. However, there are problems for some countries (e.g. the Nordic HOs) in following this advice, as their data are very dense and setting compilation scale to be less than twice source scale results in too much screen clutter.

Those producers that compile from multi-scale source data, rather than from paper charts, could use similar criteria for determining which of these standard scales should be chosen for each ENC. The standard scale chosen should be based upon the intended usage scale of the cell.

Selectable Range	Standard scale (rounded)
200 NM	1:3,000,000
96 NM	1:1,500,000
48 NM	1:700,000
24NM	1:350,000
12 NM	1:180,000
6 NM	1:90,000
3 NM	1:45,000
1.5 NM	1:22,000
0.75 NM	1:12,000
0.5 NM	1:8,000
0.25 NM	1:4,000

Fig. 1 – Radar range / standard scale table for 21" monitors

Usage Band Assignment

HOs are assigning ENCs to usage bands differently. This can lead to considerable confusion when selecting and ordering cells, since the user has traditionally linked specific scales/scale ranges to a particular usage. This is also a problem when the data is viewed on an ECDIS that displays data based on the data's usage band, although most ECDIS systems ignore the assigned usage band and display the data whose compilation scale is closest to the current screen display scale.

This may be one area where S-57 needs to revert to the old more prescriptive rules of Versions 1 and 2, where minimum and maximum scales for each usage band (then referred to as scale bands) were defined. Currently, there appears to be little useful purpose served by the concept of usage bands.

The following tables give some indication of the different values used by various HOs, and suggest some proposed scale ranges for the six usage bands:

		IC-ENC COUNTRIES USAGE BAND SCALES					
	Compilation Scale	**1. Overview**	**2. General**	**3. Coastal**	**4. Approaches**	**5. Harbours**	**6. Berthing**
Belgium	1 D			100000	10000	5000	
Germany	2 D		150001 – 400000	50001 – 150000	20001 – 50000	2000 – 20000	= 5000
Netherlands			375000 – 750000	75000 - 150000	30000 – 60000	10000 – 25000	
Portugal	2 D	= 500001	150001- 500000	50001 - 150000	20001- 50000	2001 – 20000	= 2000
South Africa		= 1000000	300000 - 1000000	150000	15000 – 50000	= 15000	
Spain	2 D	1000000 ± 30%	350000 ± 30%	150000 ± 30%	50000 ± 30%	10000 ± 30%	
United Kingdom	1 D	= 300000	150000 - 200000	50000 - 100000	20000 – 40000 (1 @ 75000)	5000 – 25000	

"D" is the scale of the source paper chart.

Fig. 2 – Usage Band / Compilation Scale table – IC-ENC countries

		NON-IC-ENC COUNTRIES USAGE BAND SCALES					
	Compilation Scale	**1. Overview**	**2. General**	**3. Coastal**	**4. Approaches**	**5. Harbours**	**6. Berthing**
Sweden	2 D		75000 – 250000	40000 - 75000	20000 - 40000	7500 – 20000	>7500
Poland	2 D						
Denmark	D (some at 2 D)	500000 - 1000000	200000 – 499999	50000 – 199999	15000 – 49999	3000 - 14999	
Finland	Mixed		200000 (D)	50000 (D)	25000 (2D)		
Korea		= 500000	100000 – 300000	50000 – 75000	25000 – 40000	5000 – 20000	
Norway	1.66 D				30000	3000 – 15000	
France	D			150000 – 250000	50000 – 75000	15000 – 25000	7500 – 10000
Estonia	D		250000	100000	50000	7501 - 25000	>7501
Latvia	D			100000 - 250000		7500 - 25000	2000 - 5000
Chile			200000 - 500000	100000	25000 – 50000	10000 – 20000	
Japan		= 1500000	300001 – 1500000	80001 – 300000	25001 – 80000	7501 – 25000	> 7501

Overall Range		< 300000	75000 – 1000000	30001 – 300000	10000 – 75000	2000 – 25000	2000 – 10000
S57 V 2.0		= 2250001	300001 – 2250000	80001 – 300000	40001 – 80000	10001 – 40000	= 10000
Proposed		< 350000	150001 – 350000	60001 – 150000	15000 – 60000	2000 – 25000	= 5000

Fig. 3 – Usage Band / Compilation Scale table – non-IC-ENC countries

All of the RENC HOs agree that, ideally, common scale ranges for each usage band should be introduced. However, it would now be very difficult for some countries to re-scheme, rename and re-issue cells that have already been produced and issued. Ideally, there should be no overlaps between the ranges of each band, but, it is difficult to get consensus on the precise usage band / scale allocations without overlaps. Ranges (with some overlaps in the larger scale bands) suggested were:

Band 6	>= 5000
Band 5	2000 – 25000
Band 4	15000 – 60000
Band 3	60001 – 150000
Band 2	150001 – 350000
Band 1	<350,000

The following alternative ranges (with overlaps) have been suggested for the smaller scale usage bands (bands 1 to 3), but these ranges would pose considerable problems for some countries, particularly those that are using the full range of the rather limited six usage bands:

Band 3	60000 – 175000
Band 2	150000 – 1000000
Band 1	<1000000

Further discussion/work is required to define these ranges, taking into consideration the proposed changes to the setting of compilation scale described earlier.

The inter-relationship and interaction between usage bands, SCAMIN and compilation scale are particularly problematic and it is difficult (impossible?) to formulate voluntary guidelines that resolve all of the problems and that are acceptable to all HOs with differing views of these issues.

Use of SCAMIN

One of the most noticeable inconsistencies and one of the most complex. SCAMIN is directly related to compilation scale and there are a number of rules that must be obeyed when encoding its value. There have been a considerable number of papers, workshops, discussions etc. over the past 5 years on the best way of encoding and using SCAMIN.

SCAMIN is a very powerful S-57 attribute that can be encoded on particular objects with the aim of reducing ECDIS screen clutter. When this attribute is used, ECDIS software can simplify and generalise detail as the ECDIS user zooms out and can bring in more and more detail as the user zooms in. However, S-57 provides little useful guidance on exactly how SCAMIN values should be calculated, and as a result, different HOs have developed different automatic, semi-automatic and manual mechanisms for calculating and encoding the values. Some HOs are not using it at all. Manual encoding is very tedious and problematic, so software has been developed by some HOs for automatically encoding particular object classes with SCAMIN values. The algorithms used in this software use compilation scale as one of the parameters for calculating the SCAMIN value; therefore, even if neighbouring HOs were to use the same algorithm, the adjacent datasets would need to have the same compilation scale in order to achieve a consistent display. In addition, since a number of ECDIS systems use fixed viewing scale increments (as opposed to user-definable viewing scales), some of the SCAMIN-attributed objects will only ever be visible at overscale.

There is an obvious need for a consistent approach to the use of SCAMIN. At the moment, some HOs use SCAMIN but use different criteria for its calculation, and others don't use it, preferring to wait until clearer guidance is available or more experience has been gained in the best way of encoding and using it. As a result, in some cases, the display of different countries' data on ECDIS screens is inconsistent, confused and messy, with, for example, some object classes appearing and disappearing as the ECDIS user moves from one country's data to another's.

The following ECDIS screen dump shows two adjacent datasets where SCAMIN has been used for the eastern cell but not for the western cell.

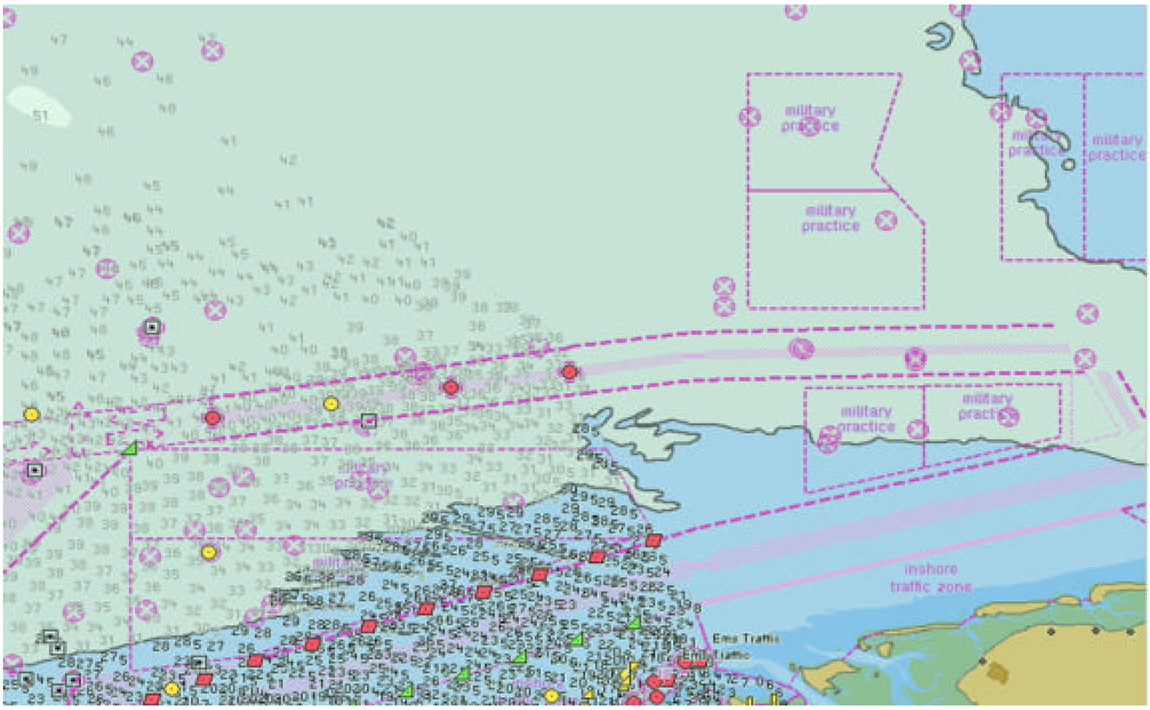


Fig. 4 – SCAMIN effects (1)

In the next screen dump, SCAMIN has been used in both cells but not in a consistent manner.

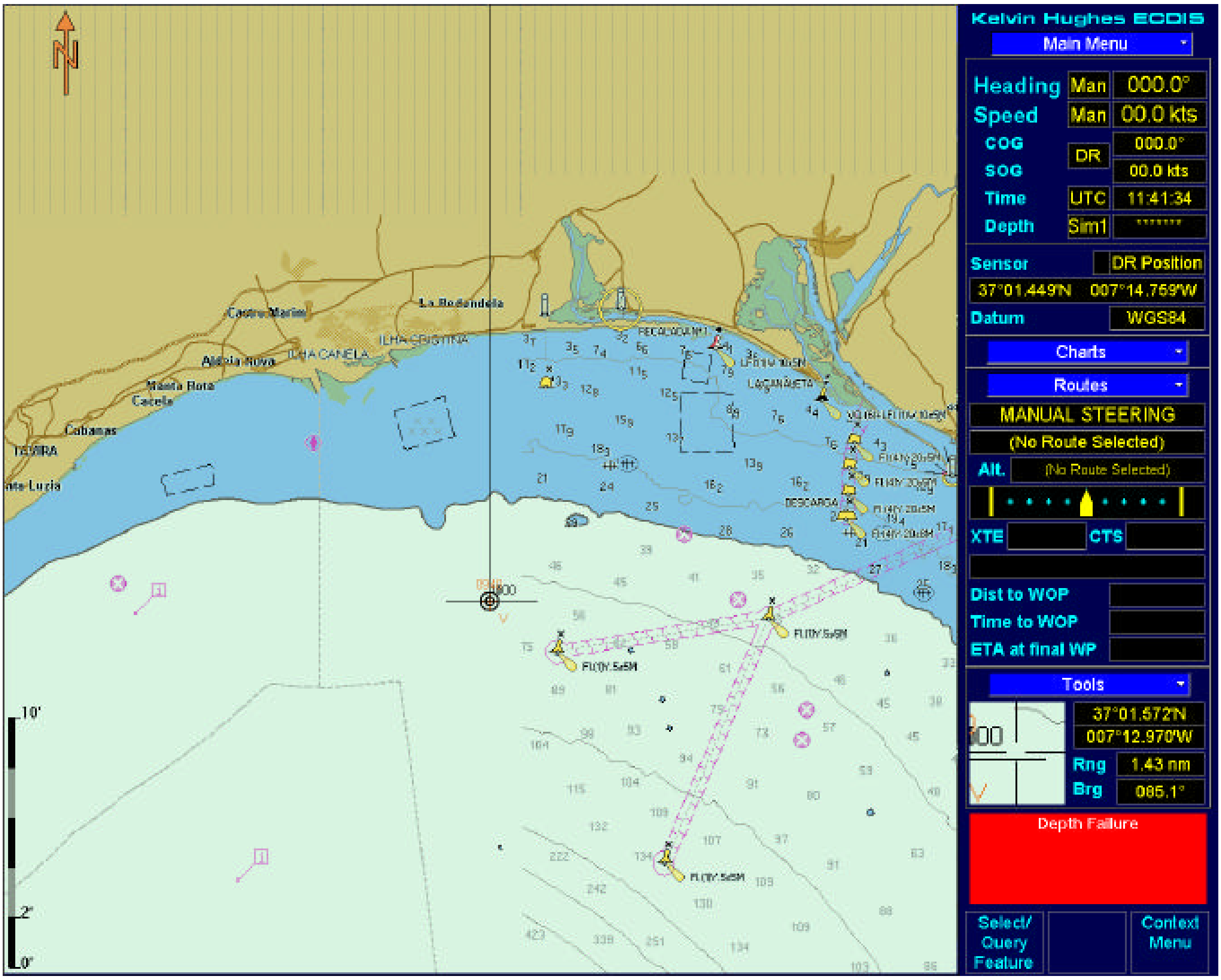


Fig. 5 – SCAMIN effects (2)

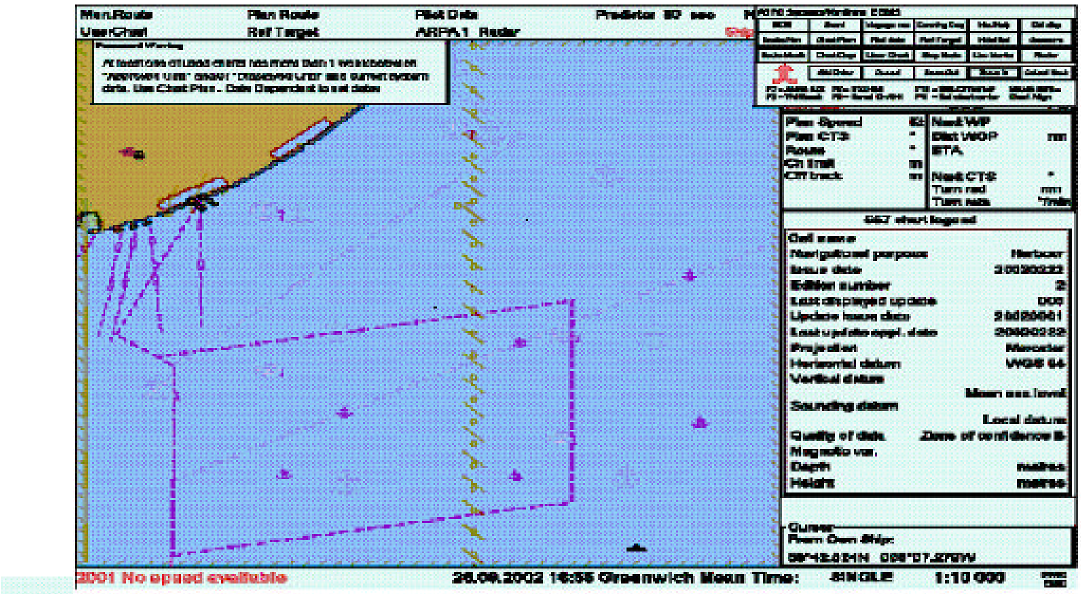
It would be sensible to use accepted cartographic rules when devising methods for applying SCAMIN, i.e. when compiling a small scale product from a large scale source, a method of simplification and generalization could be used, not just removing all objects of a certain type. For example, if applying SCAMIN to the object class SOUNDG, the more critical soundings should remain visible longer, rather than all soundings disappearing at the same moment. However, that can be a time-consuming and difficult manual process. Any strategy for assigning values to the attribute SCAMIN needs to consider the navigational significance of individual objects together with the clarity of the data when viewed at the ECDIS display scales available.

It was evident from the discussions at the RENC meetings that there are still a number of differing views on the use and setting of SCAMIN. It is becoming increasingly apparent that the current “free–for-all” situation will never result in the consistent setting of SCAMIN by different HOs. In our view, there must be either mandatory rules in the standard or there must be a common approach agreeable to all members of the RENCs, which all constituent HOs would follow and that the RENCs would monitor and enforce. It has been agreed that IC-ENC will research this issue further, gathering further information for the HOs, and will report back to the next IC-ENC TEWG meeting (September 2003). In the meantime, IC-ENC HOs will continue using their current practices.

Data Inconsistencies Across Usage Bands

Often, there are inconsistencies in the depiction of the same area on different scale paper charts. When different usage band cells are captured from these inconsistent paper chart sources, it can cause considerable confusion to the mariner, since the display changes as he zooms in or out, picking up the different usage band cells at the different zooms. For example, on medium/small scale paper charts, rivers/ports may not be drawn in detail, but covered with flat land tint (FLT) in order to force the mariner to use the larger scale chart. When this practice is repeated in ENCs, if a mariner zooms out to get an overview or better look ahead, the display will change from depicting navigable water to misleadingly depicting a land area. This can be very disconcerting and highly confusing.

The following ECDIS screen dumps show two views of the same area from two different usage band cells. Obviously at the smaller scale, that cell should not be used for navigation in this area, but it would be better if a more consistent, simplified depiction was encoded for that cell, showing at least the outline of the river/estuary area.



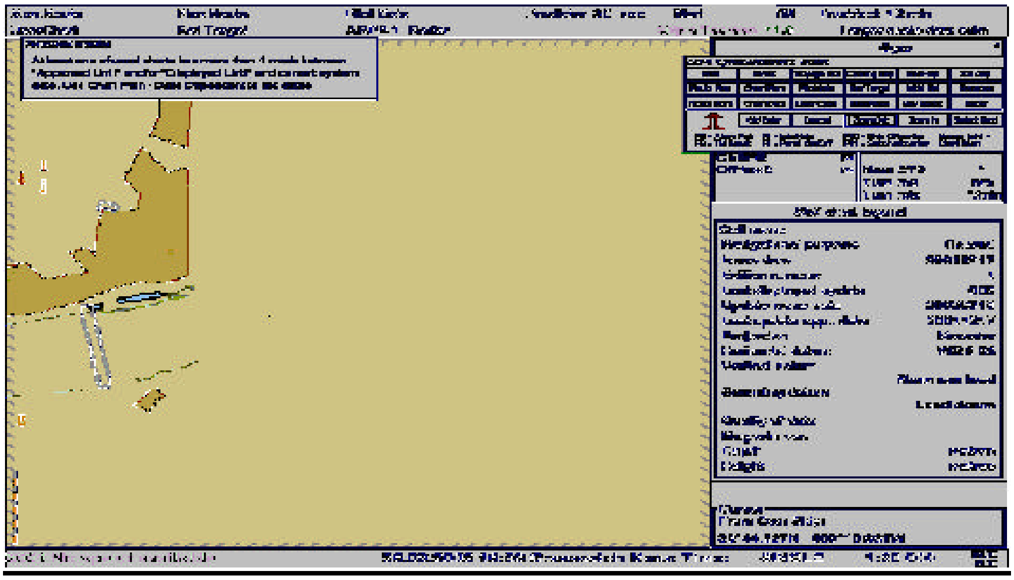


Fig. 6 – Inconsistencies across usage bands

The S-52 display of area river (RIVERS) objects is also unsatisfactory, since such objects are not part of the standard or base displays. This can result in very misleading ECDIS displays of river areas. The Colours & Symbols Maintenance Working Group (C&SMWG) has, therefore, been asked to add area RIVERS objects to the standard and base displays, so that they are displayed more consistently. A similar problem also exists with dock area (DOCARE) objects, which are displayed in an ECDIS covered by FLT. This is misleading, so the C&SMWG has been asked to add area DOCARE objects to the standard and base displays.

Other examples of inconsistencies caused by the different paper chart depiction of the same area are sources at different levels of up-to-datedness, simplification/generalisation of data, and different source surveys/maps used for compiling different scale charts. The point here is that such inconsistencies are so much more immediately apparent on an ECDIS screen with its powerful zooming and multiple ENC display capabilities than they are in the paper chart world.

Contour Intervals

There is a need to introduce a set of standard contours and depth areas across ENCs, in order to ensure that a safety contour set by a mariner is as continuous as possible. When different contour intervals are used in adjoining cells, an odd stepping effect can result when the ECDIS-generated safety contour crosses from one cell to the next.

In the following ECDIS screen dump showing adjacent cells, the safety contour has been set to 15m. The data in the north eastern corner is from a cell containing contours at 10m and 20m. The data in the rest of the area is from cells containing contours at 10m, 15m and 20m. Because there is no 15m contour in the north eastern cell, the ECDIS has defaulted to the next available deeper contour (20m) and used this for the safety contour, thereby creating a rather confusing and disjointed image.

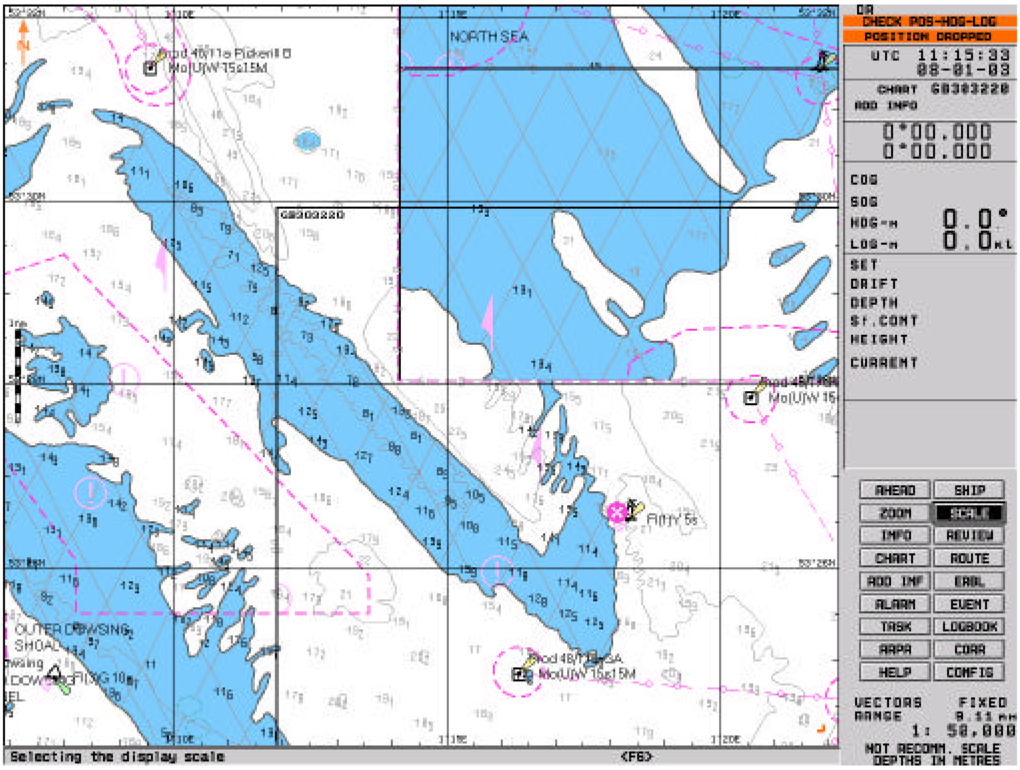


Fig. 7 – Effect of the use of different contour intervals on the display of the safety contour (1)

Another similar example where the safety contour has been set to 10m, but the eastern cell has no contours between the coastline and 30m. The ECDIS has, therefore, used the 30m contour for the safety contour in the eastern cell. Similar confused display to the previous example.

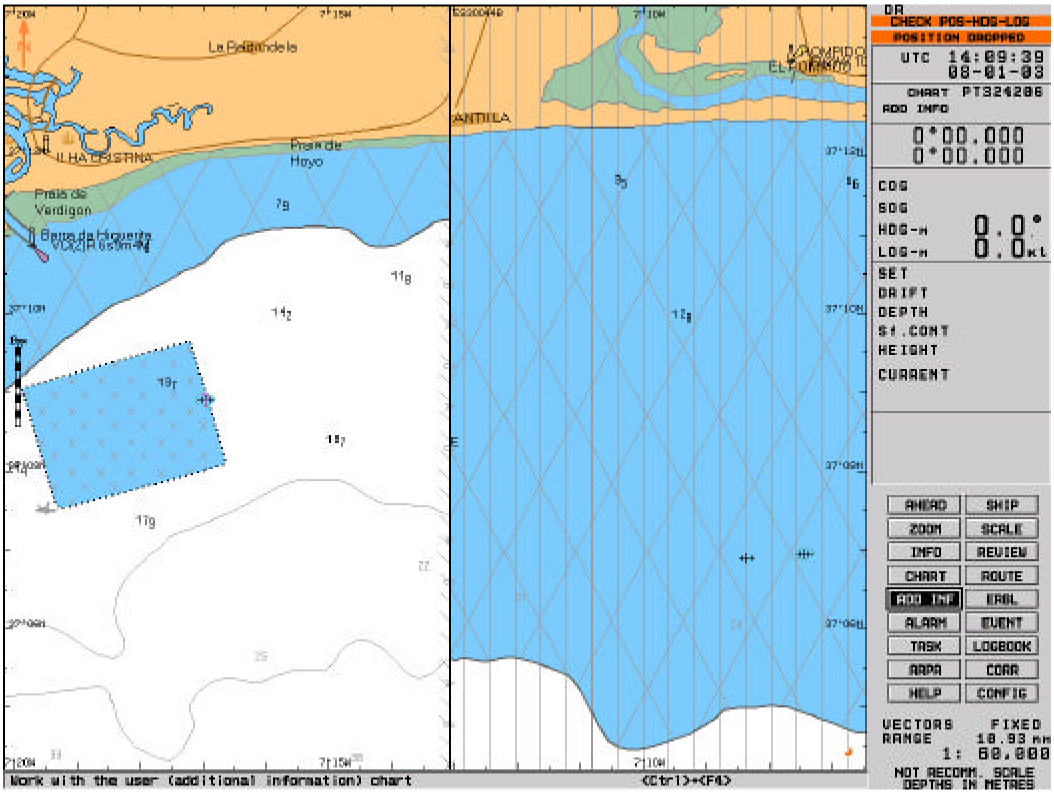


Fig. 8 – Effect of the use of different contour intervals on the display of the safety contour (2)

A further example, where the safety contour has been set to 15m. The western cell (usage band 3) has 15m depth contours, but the eastern cell (usage band 2) has no 15m contours, so the ECDIS has defaulted to the next available deeper contour (20m) and used this for the safety contour.

Note also the different density of soundings in the two cells – a consequence of the different scales of the paper charts from which the cells were digitised.

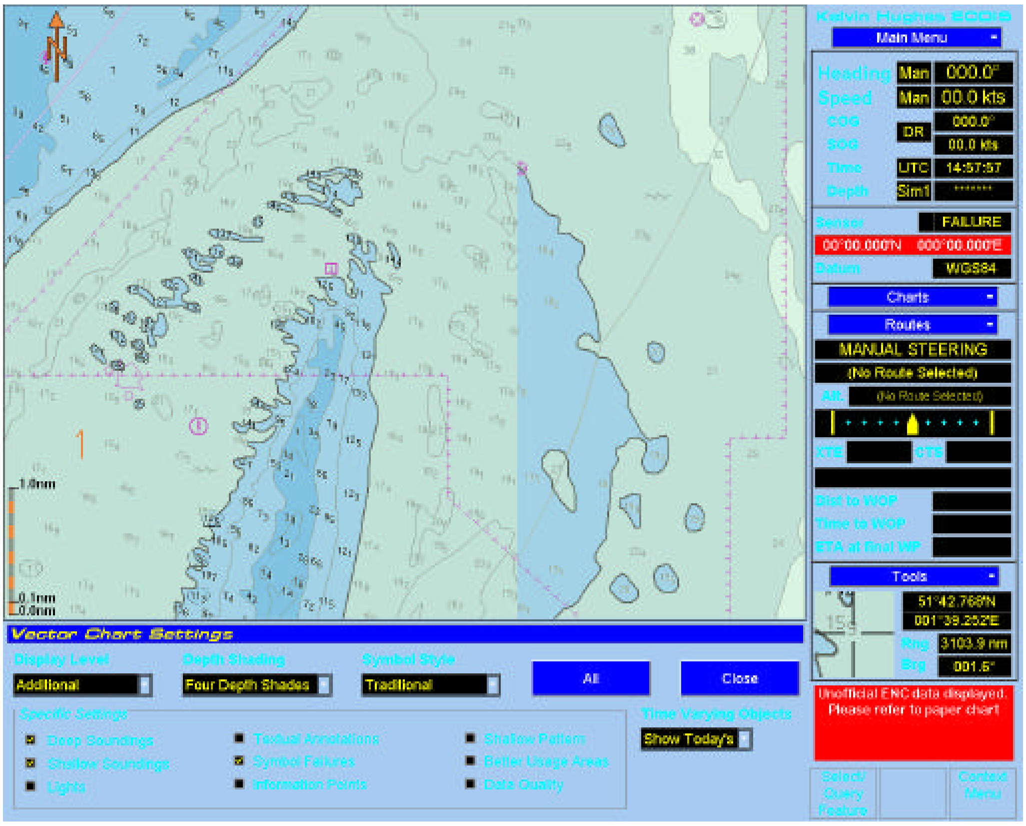


Fig. 9 – Effect of the use of different contour intervals on the display of the safety contour (3)

In order to avoid such problems, HOs should use standardised contours, wherever possible. It was agreed at the IC-ENC TEWG meeting that the contour intervals to be used should include at least those laid down in IHO publication M-4, section 411, i.e. 0, 2, 5, 10, 15, 20, 30, 50, 100, 200, 300, 400, 500, 1000 etc. metres. The 2m and 5m contours may be omitted, where they serve no useful purpose. The 4m and 6m or the 3m and 6m contours, where surveyed and charted, may be used in lieu of the 5m contour. Additional contours may be added, where of significance to the mariner in particular geographical areas.

Inconsistent Depiction and Misalignment of Data at Cell Boundaries

Particularly noticeable on linework, e.g. where contours cross from one cell to another and do not match.

Similar examples are where lines (cables, prohibited areas, contours etc.) stop at the cell boundary, and do not continue into the adjoining cell.

In the following ECDIS screen dump, a number of cables stop at the boundaries of the two cells. Presumably, that is not the case in the real world.

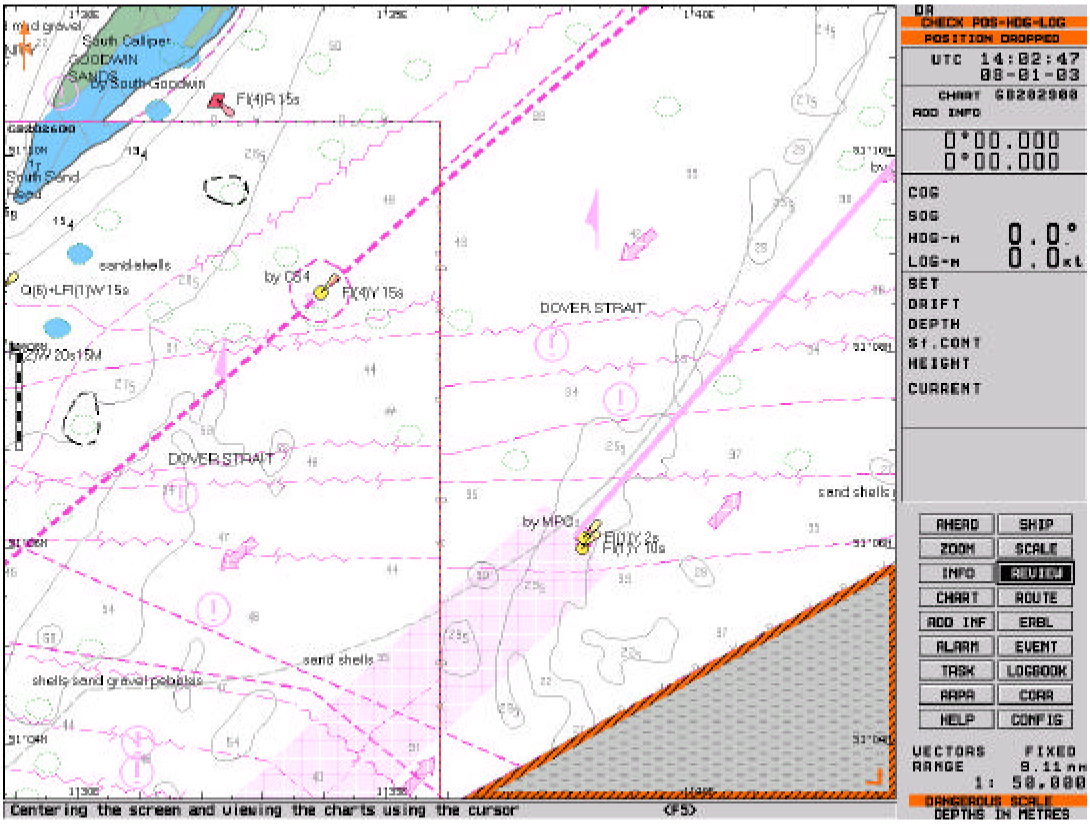


Fig. 10 – Data inconsistencies at cell boundaries (1)

In the following example, the generalised contour in the northern cell bears little relation to the adjacent more detailed contours in the southern cell.

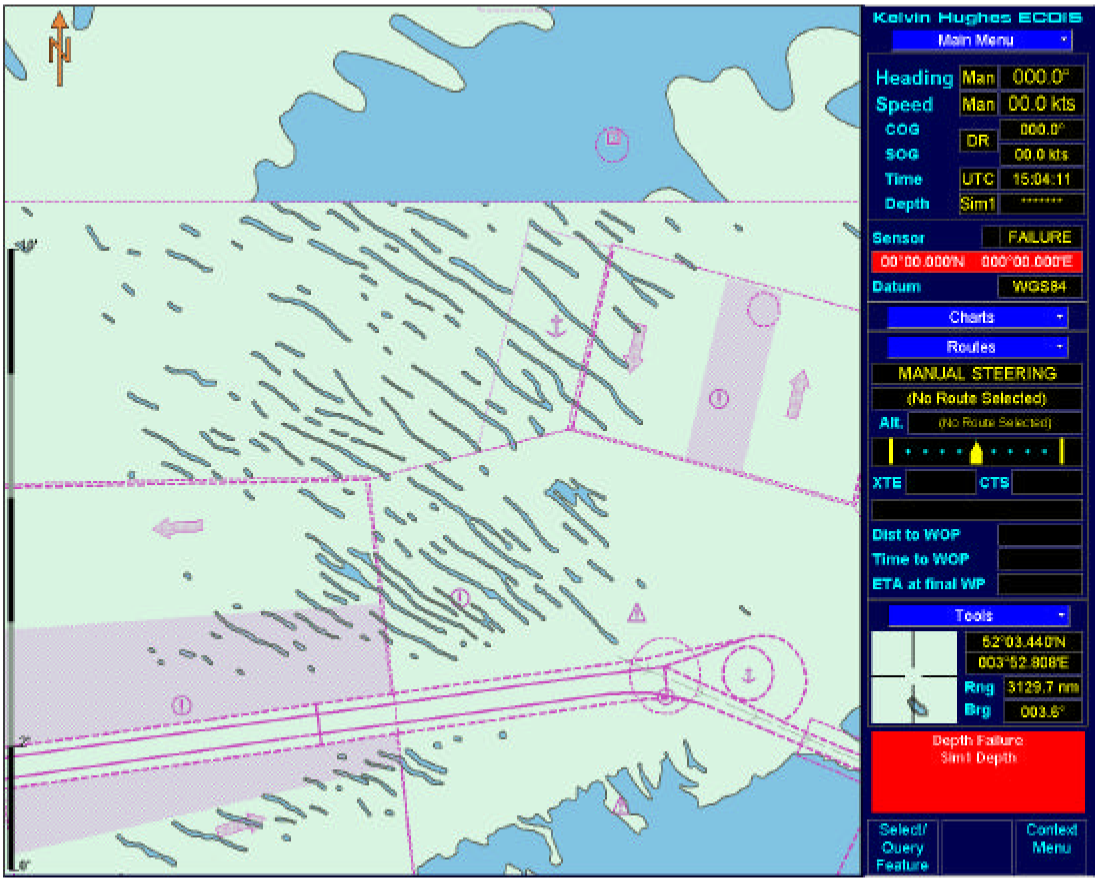


Fig. 11 – Data inconsistencies at cell boundaries (2)

Inconsistent Depiction of Data within a Cell

Often, HOs will use more than one source chart/plan to create an ENC cell. These sources may be at different scales, be of different quality, be of different vintage and have been compiled from different source material. As a result, when the source data is merged together, compilation scales may vary, the density of information may vary, and there may be mismatches at the limits of the sources. Mismatches of data within a cell are just as worrying as mismatches between cells or between countries, and the user is obviously not aware of the reasons for such discrepancies. HOs should endeavour to avoid such inconsistencies.

Holes in Data Coverage

Holes should not be left in smaller scale ENCs just because there is larger scale ENC coverage available in that area. It cannot be assumed that the ECDIS user has purchased a full complement of ENCs in all usage bands for a particular area.

In the example below, a large hole has been left in the band 3 cell because coverage is available in larger scale band 4 cells of the same area.

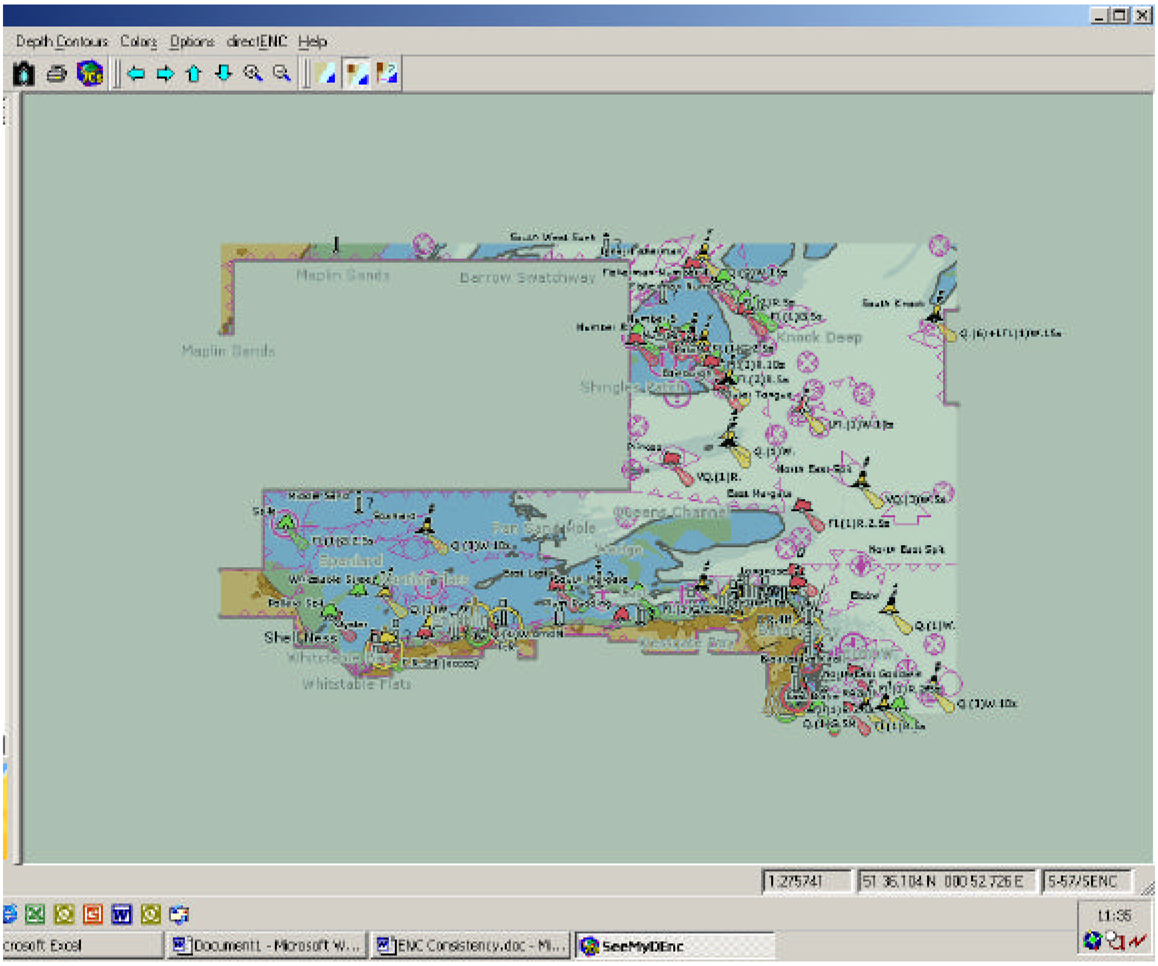


Fig. 12 – Hole in data coverage

We have also seen small "no coverage" holes in cells, often reflecting such empty areas on the paper chart, for example, where the metre conversion tables, linear scales or chart titles are positioned. These gaps are encoded as M_COVR "no coverage" areas, but could easily be filled in from smaller scale paper chart coverage

<u>Use of Attribute CATZOC on Meta Object M_QUAL</u>

The attribute CATZOC is being encoded with the value "unassessed" by some HOs. User feedback suggests that this is unsatisfactory and gives the impression of low quality, unsurveyed, untrustworthy data, no better than unofficial digital data.

Some aspects of the definitions for the various allowed values of CATZOC in the S-57 Attributes Catalogue are far too complex, making it difficult for HOs to assess and assign the correct value for CATZOC. However, for those HOs that may be concerned about these over-precise definitions, a note or paragraph in the readme.txt file could be used to explain any particular HO's use of this attribute.

This problem is not helped by the S-52 depiction of such objects - for a CATZOC value of "unassessed", the screen is densely covered with "U" symbols:

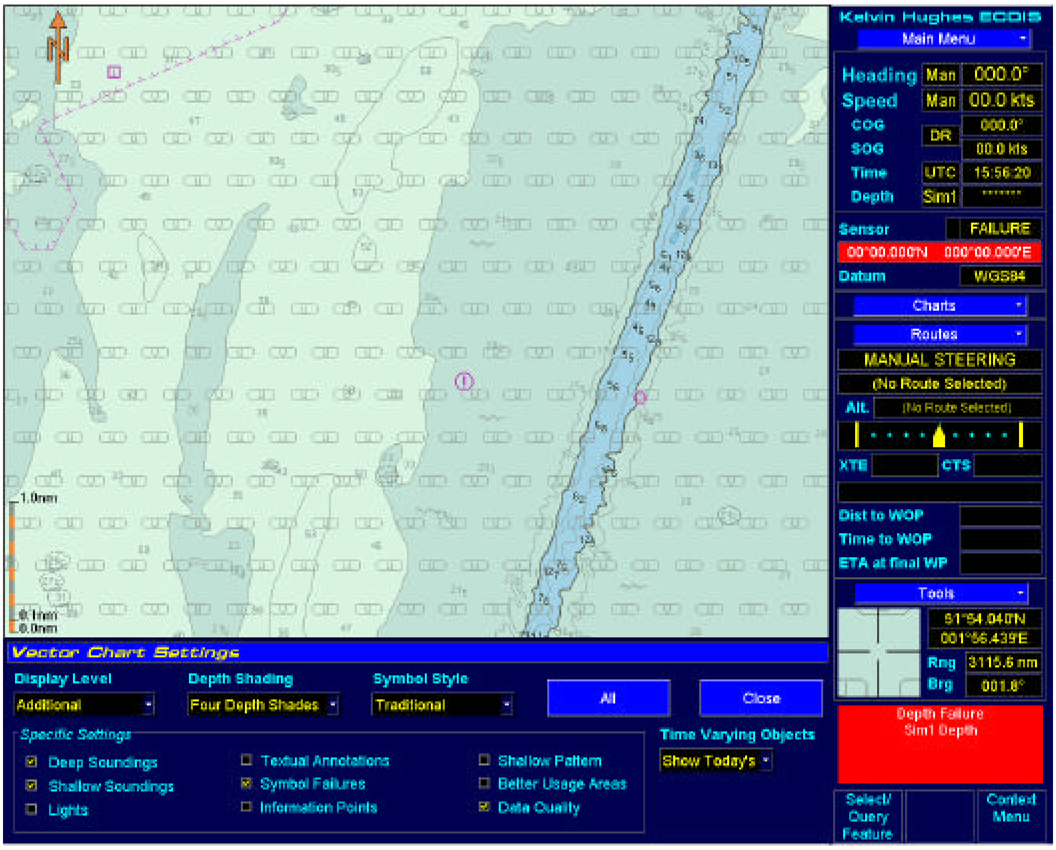


Fig. 13 – CATZOC display

Some HOs are using M_SREL to give an indication of survey reliability – this is also unsatisfactory, since there is currently no S52 / ECDIS display method for M_SREL meta objects – although such meta objects can be interrogated by the ECDIS software. C&SMWG has been asked to add such a display method to S-52.

Data Gaps and Overlaps

The problem of data gaps and overlaps has been the subject of a number of papers, proposals and discussions over many years. The accepted opinion is that it is relatively straightforward to avoid gaps and overlaps between different datasets within a particular country's own area, but that it is very difficult for countries to achieve a perfect join along the boundaries with their neighbours, without leaving gaps or creating overlaps in the data.

S-57 Appendix B.1 (ENC Product Specification), Section 2.2, paragraph 4 categorically states that data in cells with the same navigational purpose (i.e. in the same usage band) must not overlap:

> *Cells with the same navigational purpose may overlap. However, data within the cells must not overlap. Therefore, in the area of overlap* ***only one cell may contain data****, all other cells must have a meta object M_COVR with CATCOV=2 (no coverage) covering the overlap area.........*

There are no rules defined in S-57 for the handling of gaps in data between neighbouring cells. However, unnecessary gaps in data trigger alarms in an ECDIS and result in smaller scale, less appropriate data/cells being displayed as the ship transits the gap. It is, therefore, essential to try to avoid the occurrence of such gaps.

The following series of screen-dumps illustrate the effect of a small gap in coverage (the thin orange line in the south west corner of the screen) on the display presented to the mariner. As the vessel enters the gap in coverage, in addition to setting off the "non-official data" alarm, the display automatically moves from the official ENC cell out to the next available data, which, in this case, is the world backdrop chart provided by the OEM. Once the ship has crossed the gap, the display reverts, once more, to the ENC.

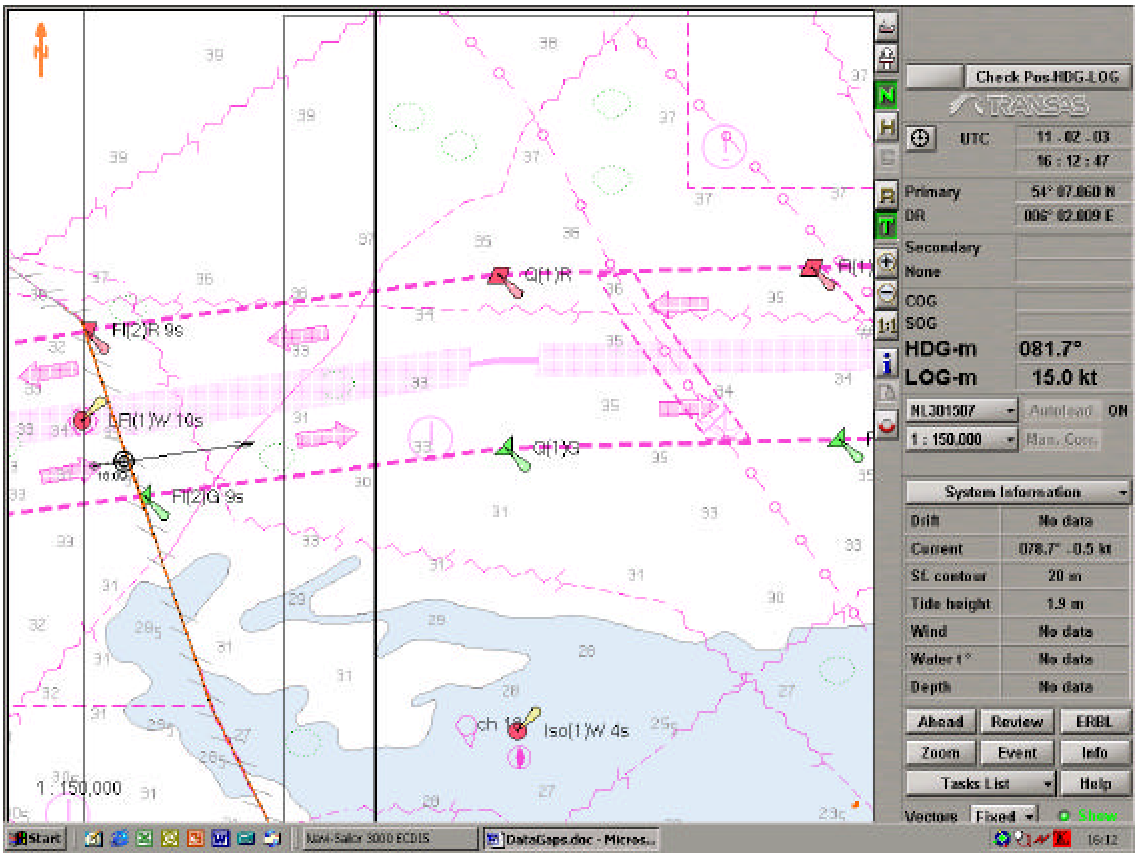


Fig. 14 – Effect of very small gap in data coverage (1)

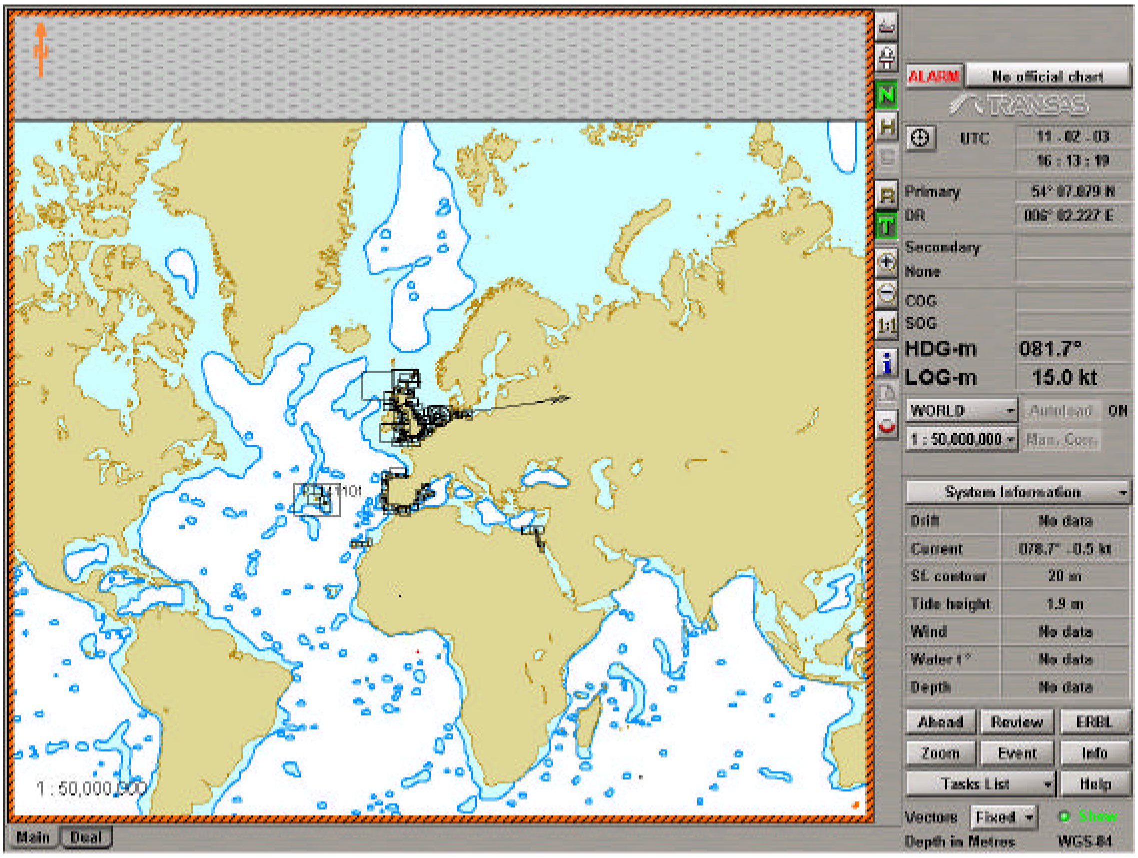


Fig. 15 – Effect of very small gap in data coverage (2)

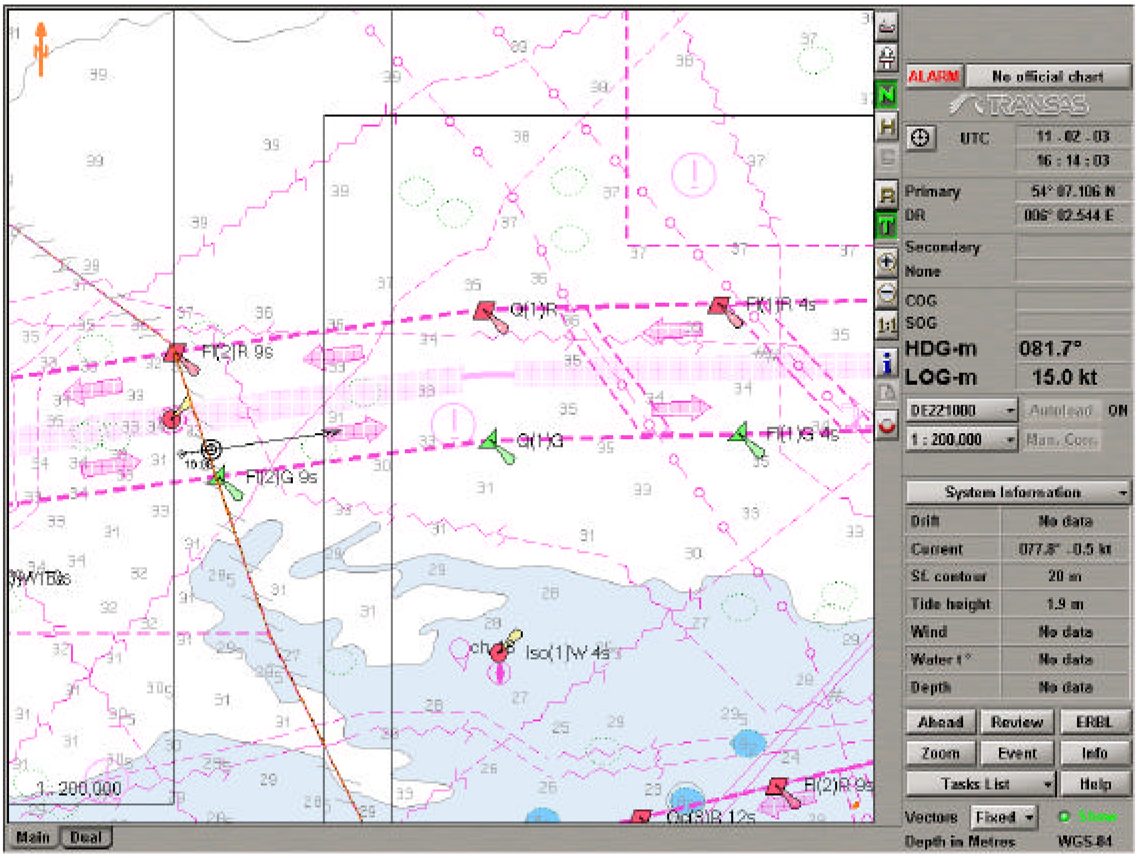


Fig. 16 – Effect of very small gap in data coverage (3)

This is unacceptable to the ECDIS user, so, in order to alleviate such problems, IC-ENC has already adopted the following policy:

> Upon receipt of a cell, IC-ENC will check for data <u>overlaps</u> between that cell and existing cells using a combination of software and manual inspection.
>
> Upon receipt of a cell, IC-ENC will check for data <u>gaps</u> between that cell and existing cells by manual inspection.
>
> Any data gaps identified during the validation of a new cell or a new edition of an existing cell will cause that cell to fail validation. Consequential gaps found in existing adjacent data sets will be reported back to the relevant HO(s) for correction at their earliest opportunity.
>
> Data overlaps will not be accepted within a country's own cells.
>
> If neighbouring countries are unable to define perfect coverage limits along their boundaries, small overlaps ("buffer zones" of up to 5m on the ground) between different countries' data at their boundaries will be accepted. To achieve this, we encourage each HO, when creating a cell adjoining its neighbour's data, to liaise closely and to exchange data sets with that neighbour. In that way, precise limits can be defined, buffer zones agreed and data can be edge matched.

N.B. These remarks only apply to data from cells in the same usage band. Obviously, there will be data gaps and overlaps between cells in different usage bands, and this is perfectly acceptable within S-57. However, from the point of view of consistency and usability, any such gaps in data between neighbouring countries' cells should be investigated and filled in.

Coordinate Multiplication Factor (COMF)

The concept of the Coordinate Multiplication Factor (COMF) is described in S-57 Appendix B.1 (ENC Product Specification), Section 4.4, paragraph 3. The COMF is used to convert decimal latitude and longitude values to integer values for the exchange dataset. The number of decimal digits is chosen by the data producer and is valid throughout the dataset. Different HOs set COMF to different values, and as a result, mismatches of data can occur at national boundaries if one of the neighbouring countries has better resolution lat/long values (i.e. has set a larger COMF value).

For example, if HO "A" stores its ENC data in its production system at a resolution of 0.0000001 (10^{-7}) (0.011112m on the ground), the value of COMF should be set to 10000000 (10^{7}). A longitude of 12.34567891E would be held in the production system as 12.34567891E and would then be converted and stored in the ENC using the formula *longitude * COMF*, which in this case would result in the longitude being held as 12.34567891 * 10000000 = 1234567891

However, if HO "B" stores its ENC data in its production system at a resolution of 0.0001 (10^{-4}), the value of COMF should be set to 10000 (10^{4}) (11.112m on the ground). Because of this lower resolution, the longitude would be held in the production system as 12.3456. It would be converted and stored in the ENC using the formula *longitude * COMF*, which in this case would be 12.3456 * 10000 = 123456. Because of the lower initial resolution and the cruder integer conversion, the longitude value is much less precise.

If HO "A" and HO "B" were to produce adjoining cells with, for instance, a submarine cable crossing the boundary, this resultant difference in the coordinates of the end points of the cable in the two cells would result in a positional mismatch at the boundary. In the example given, after the ECDIS has converted the integer longitude to degrees, minutes and seconds, HO "B"'s cable would meet the cell boundary at 12 20' 44.160" and HO "A"'s cable would meet the cell boundary at 12 20' 44.444". This 0.284" (8.8 metres on the ground) difference is very small but it is a contributory factor in some of the edge matching problems identified in neighbouring countries' cells.

We need, therefore, to recommend a standard resolution for storing coordinates in ENC production systems and a standard value for COMF. There is, presumably, no reason why the values should be set to a low figure, and, presumably, positions should be defined as accurately as possible.

Resolution 10^{-7} = 0.011112m on the ground
Resolution 10^{-6} = 0.11112m on the ground
Resolution 10^{-5} = 1.1112m on the ground
Resolution 10^{-4} = 11.112m on the ground

0.0000001 (10^{-7}) is suggested for the production system coordinate resolution and 10000000 (10^{7}) is suggested for the value of COMF.

Possible Ways Ahead

S-57, Edition 3.1 has been frozen whilst work progresses on S-57, Edition 4.0. Publication of Edition 4.0 is some years away, and, even when it has been published, it is expected that

Edition 3.1 data will still be available for very many years afterwards. Resolution of the problems identified in this paper and others cannot await Edition 4.0.

Many of the problems described in this paper relate to inconsistencies and inexactness in the ENC-related sections (Product Specification (PS) and use of the Object Catalogue (UOC)) of S-57. None of the suggested improvements affect the OEMs – the suggestions all relate to encoding rules that are already in the PS and UOC and do not require a new version of S-57. It is unlikely, anyway, that either agreement or the resources could be obtained for the unfreezing of Edition 3.1 and the preparation of an Edition 3.2.

One possible mechanism for resolving these problems might be for TSMAD to set up a small working group to further investigate the issues raised, to look at the different possible solutions and to decide on the best compromises. A list of mandatory encoding rules related to these issues could then be produced and issued by the IHB as a supplementary document to S-57, directing the producers to follow these rules.

Alternatively, in order to facilitate possible further development of the PS and UOC outside of S-57, Edition 4.0, TSMAD could consider moving those particular sections from S-57 into a new publication. This mechanism has already been used for the extraction of the list of Recommended ENC Validation Checks, which has now been published as S-58, and that list continues to be corrected and updated. We are not suggesting a complete review of the PS and UOC – that would be too difficult and time-consuming. Only those clauses relevant to the issues raised need to be investigated and rectified.

TSMAD should, therefore, seriously consider whether the correction / revision of those sections of the PS and UOC can await the completion of S-57, edition 4.0, or whether some alternative mechanism can be devised for implementing the required improvements as soon as possible.

3. RECOMMENDATIONS

From the foregoing, we recommend that:

1. A uniform approach to the setting of compilation scale must be agreed and implemented. HOs should set compilation scale to be the nearest standard radar range scale related to the original paper chart scale; e.g. an ENC produced from a 1:25,000 paper chart should have a compilation scale of 1:22,000.

2. Ideally, all HOs should use SCAMIN, which should be determined using a method that reduces the number of individual objects displayed and ensures clarity, possibly using the standard rounded display scales listed in Fig. 1. However, in view of the differing views on this topic, IC-ENC will produce a separate SCAMIN paper and report back to the next TEWG meeting.

3. HOs should agree on common scale ranges for defining cell usage bands. IC-ENC and the TEWG members have suggested some values. Further discussion/work is required to refine these ranges.

4. HOs should avoid using too many M_CSCL objects within the same cell.

5. Inconsistent depiction of the same areas in different usage bands should be avoided. For example, outlines of rivers, ports etc in smaller scale cells should be shown in simplified outline form.

6. The Colours & Symbols Maintenance Working Group (C&SMWG) has been asked to add area river and dock area objects to the standard and base displays.

7. There should be close liaison between neighbouring HOs when creating ENCs in their border areas, in order to resolve any issues of inconsistent depiction and to avoid gaps in data coverage. IC-ENC can help with this, for example in supplying any required cells to both IC-ENC countries and to others. The following issues should be investigated/resolved:
   - common border limits
   - COMF value used
   - scales / usage bands
   - overlaps / gaps - buffer zone
   - content / data alignment
   - contour intervals
   - truncated limits (areas that cross the border)
   - SCAMIN rule used.

8. Misalignment and inconsistent depiction of data at cell, source and international boundaries should be investigated and rectified.

9. HOs should use standardised contour intervals. Additional contours may be added, where required.

10. HOs must not leave holes in smaller scale coverage, assuming that the user will have larger scale data available.

11. Wherever possible, meaningful and useful values of CATZOC should be used.

12. C&SMWG has been asked to implement a display method in S52 for M_SREL meta objects.

13. Coordinates should be held in ENC production systems at a resolution of 0.0000001 (10^{-7}) and the COMF value should be set to 10000000 (10^{7}) for all cells.

14. There must not be any gaps in data between cells of the same usage band.

15. There must be no overlapping data within a country's own cells of the same usage band.

16. At national boundaries, a 5 metre buffer zone can be used, where necessary, for creating very small data overlap areas.

17. Any ECDIS problems identified by HOs or by IC-ENC must be reported back to the ECDIS manufacturers and must be resolved as soon as possible. If IC-ENC identifies any problems, these will be referred to the BSH type approval division for onward transmission to the OEMs.

18. The S-57 ENC Product Specification and UOC should be made more prescriptive and less open to interpretation. This should be borne in mind when these documents are being rewritten for Edition 4.0 of S-57, and TSMAD should be informed of these requirements.

19. TSMAD should seriously consider whether the correction / revision of the PS and UOC can await the completion of S-57, edition 4.0. Two possible courses of action have been suggested – undoubtedly, there are others.

20. In order to reach the widest possible audience in the short term, we suggest that certain of these recommendations be submitted to the TSMAD Working Group that is overseeing the operation of the S-57 Encoding Bulletins on the IHB website. They can then decide whether our ideas would be useful for other ENC producers beyond the IC-ENC HOs.

These recommendations have been listed in order of estimated effectiveness in rectifying the content and consistency problems described in this document. For example, the setting and use of SCAMIN values would have a much greater effect on display improvements than would the standardisation of COMF values. However, **all** of these recommendations would contribute to improving the ENC product and, taken as a whole, would lead to considerable quality improvements and much greater user satisfaction.

4. CONCLUSIONS

Despite many problems and obstacles, the international hydrographic community has made tremendous progress over the last few years in producing and making available large numbers of ENCs. Coverage is still very patchy and many more ENCs will need to be produced before vector ENC data can be used as the primary means of navigation for international shipping. With increasing coverage has come the realisation that there are some serious issues of content and consistency related to those ENCs. As can be seen from the examples given, the problems are very much more visible when hydrographic data can be viewed on-screen. Our investigations have identified a number of shortcomings and problems and our recommendations for improvement are detailed above. The current situation is not viable and these issues need to be addressed immediately.

Our findings and recommendations have been presented and discussed at two meetings of the RENCs' HOs and a considerable amount of consensus and agreement has been reached. However, it is clear from those discussions that there are still a number of issues where it is not possible to obtain 100% voluntary agreement (e.g. setting of compilation scale, assignment of scales to usage bands), so complete consistency is not currently possible. Further work is required by TSMAD to produce detailed changes/clarifications to the rules and some mechanism needs to be found to enforce those changes.

The HOs that make up the IC-ENC and Primar-Stavanger RENCs can now start implementing at least some of the suggestions and greater consistency will then result. It is hoped that other HOs/RENCs will adopt the same ideas. Some issues require further research, in order to identify the optimum solutions. When that has been done and once the relevant rules have been clarified and made mandatory, we will, achieve much greater consistency worldwide. In the longer term, it is hoped that the whole S-57 standard will become more prescriptive and less open to multiple interpretation. Only then will total consistency be achieved. However, that is a very long term objective and will not be easy to attain.

Mike Bisset & Richard Fowle, IC-ENC, May 2003