

RASTER FORMATS USED IN HYDROGRAPHIC CHARTING

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INTRODUCTION

During recent discussions in Australia and France, Mr. Adam KERR, Director of the International Hydrographic Bureau queried the status of the raster formats being developed by national Hydrographic Offices (HO's) for the production of authorised raster chart products. This discussion paper has been prepared in response to Mr. KERR's request. This paper will focus on the three main raster formats in use i.e. HCRF used by the United Kingdom and Australia; HSRP used by Canada and BSB/NOAA used by NOAA in the USA. The paper will outline the basic characteristics of each of the formats. Also discussed will be the raster formats in the DIGEST standard. The paper will present some thoughts on S-57 implementation of raster data. This paper will not discuss raster formats developed by private navigation systems companies as their formats tend to be proprietary and are usually not authorised by the HO's.

DISCLAIMER

Hydrographic Sciences Australia (HSA) Pty Ltd is an Australian private company specialising in the supply, implementation and integration of hydrographic data and information technology. HSA, in cooperation with the Hydrographic Service, Royal Australian Navy, has been actively involved in electronic charting development since 1991. In preparing this discussion paper, HSA acknowledges the requirement for each country to develop raster products to meet their national and international mandate and to provide reliable and accurate information to their internal and external users at a time of considerable change in the transition of paper charting to electronic charting. HSA does not give preference to any one particular format. This paper has been prepared in response to an informal request from Mr. Adam KERR and its preparation is not funded from any source. The paper has been

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prepared in the interest of furthering international cooperation in hydrography and electronic charting. This paper does not represent the opinions of the Hydrographer, RAN or the respective hydrographic authorities of the United Kingdom, Canada, or the USA.

RASTER FORMATS BEING USED IN HYDROGRAPHIC CHARTING

Hydrographic Chart Raster Format (HCRF)

The United Kingdom Hydrographic Office's (UKHO) aim in the electronic era, is to provide the mariner with a service which is at least comparable to that available for paper charts today. This means not only supplying reliable and accurate electronic chart data but also a comprehensive updating service which is essential to the professional mariner for safe navigation.

The UKHO recognises the long timeframe that it will take to develop world-wide vector ENC data to IHO S-57 standard for use in ECDIS and as such, to meet current market demand for "official" (i.e. from a national Hydrographic Office) electronic chart data, the UKHO has developed the Admiralty Raster Chart Service (ARCS). ARCS will provide substantial geographic coverage, supported by a weekly updating service, from the end of 1995 with worldwide coverage attained by the end of 1996. The UKHO intends ARCS and ENC data to be complementary products. (UKHO, 1995a).

The raster product format used for ARCS is the Hydrographic Chart Raster Format (HCRF).

The Hydrographic Service, Royal Australian Navy considered each of the existing raster formats and decided to adopt HCRF as the format for its digital raster chart product. The decision was based on the following reasons:

- the "product concept" of HCRF,
- the format caters for cumulative updating (similar to the paper chart);
- that charting agreements between Australia and the UK currently exist.

Australia considers the use of raster data to be an "interim" digital solution until complete data coverage in "official" IHO S-57 vector format is available. Both the UKHO and RANHO intend to maintain paper chart source reformat in digital form as a result of the raster program.

The UKHO plans to have 1500 ARCS charts available by the end of 1995. The complete ARCS series of 2500 charts will be finished by the end of 1996.

Australia intends to publish 100 HCRF raster charts early in 1996. Implementation of an updating service is planned to commence mid-1996 with all 370 charts available by the end of 1997.

Hydrographic Standardised Raster Products (HSRP)

At the April 1994 DGIWG Technical Committee and IHO COE DBWG meetings, Canada submitted a proposal for a Hydrographic Standard Raster Product Specification (HSRP). The intent of the proposal to both groups was to develop a compatible method of handling raster hydrographic charts that satisfied both the needs of the IHO as well as the requirements of the DGIWG for naval applications. Since raster standards are under study in both groups, it was felt that it was an opportune time to foster compatibility (CHS, 1994a).

HSRP was developed as a derivative of the DIGEST ARC Standardised Raster Product (ASRP) Specification in order to satisfy the nautical requirements identified by the Canadian Hydrographic Service (CHS) and the Canadian Navy. From analysing the available DIGEST raster product specifications, the CHS considered that none of the DIGEST raster product specifications addressed the unique requirements of hydrographic charts (CHS, 1994b). These unique requirements included:

- adjacent charts are often at differing scales
- charts usually do not abut each other
- hydrographic charts include insets and plans, usually at different scales to the main chart
- the nautical chart is a legal document and should therefore be presented in digital form with a minimum of spatial alteration i.e. projection to be maintained
- chart image should contain registration and diagnostic points for relative accuracy and positioning which will permit the overlaying of vector data over the HSRP raster data
- HSRP is intended for direct display.

The number of official, certified raster charts released by the CHS is 211 with another 150 charts in production. The total number of Canadian charts planned for raster publication is 1200 (STRONG, 1995).

Coast and Geodetic Survey (C&GS), NOAA

The Coast and Geodetic Survey (C&GS), National Oceanic and Atmospheric Administration (NOAA) developed a prototype raster product during 1993. To improve services to the public, C&GS has developed a program to disseminate nautical charts in raster image format to mariners for use in electronic navigation systems supplementing traditional navigation methods and to non-navigation users in geographic information systems, thematic mapping systems and desktop publishing systems (YEAGER, 1993).

The data for each chart would be obtained by scanning stable base positives made from the original colour separate films used in paper chart production. The resulting images will then be digitally combined into a single raster colour chart image. The original source scanning density is sufficient to support C&GS paper chart production.

During 1994/early 1995, NOAA and Chart Kit/Better Boating Association Inc. (BBA), together with two other American private companies entered into a Cooperative Research and Development Agreement (CRADA). The partnership of private companies runs under the name of BSB Electronic Charts.

The raster format is essentially the same as the prototype format with a few exceptions. The current format is copyrighted to BSB with the image compression patent pending from NOAA and licensed exclusively through BSB (Loy, 1995).

The total number of raster charts currently on the public market is 500 and by 1 December 1995, 775 charts will be available. This represents 75% of the available chart outfit. All charts will be available in raster format by the end of January 1996. Raster conversion of the NOAA paper chart base is 90% complete with the lag being on the part of the CD producer.

COMPARISON OF THE RASTER FORMATS

Hydrographic Chart Raster Formats

In comparing the characteristics of each of the formats, it is important to remember the initial objectives in the development of each of the formats. HSRP was developed as an exchange format and not as a working system product format (STRONG, 1995). HCRF was developed as a working system product format and not as an exchange format. Therefore, the differences between each of the formats will be subtle, however the importance of the differences should be considered in relation to the requirements for which they were initially developed to meet.

In general, a format for the exchange of hydrographic raster data should have the following characteristics:

- be well documented, describing the content of the product, the files structures, data dictionary, encapsulation, updating requirements, colour coding specifications, allowable codes (e.g. datums), security, other relevant information;
- contain sufficient Header information that describes the status and the contents of the product set, the data source, data quality, characteristics for each data set such as title, scale, datums, projections, etc;
- contain raster image data files.

The following Table provides a comparison summary of the three raster formats. The information given in the Table is not exhaustive but is given to indicate the information generally required in a raster format. Following the Table is a description of the components.

Table 1
Comparison of Format characteristics

	HCRF	HSRP	NOAA
Documentation	Published by the UK Hydrographer as NP760 2nd Ed. 1995	Proposal to DGIWG and IHO, October 1994 (in DIGEST format)	Available from BSB upon payment of a \$US 300 license fee
Header Information			
Media Volume	✓	✓	✓
Chart Catalogue	Provided with spatial coordinates to allow for plotting chart extents	A catalogue is not explicitly provided although data sets and their extents are defined within the data set description files	Provided on CD cover and as digital listing for access to data
Units of Measurement	✓	✓	✓
Geodetic Datums	✓	✓	✓
Vertical Datums	✓	✓	✓
Projection Parameters	✓	✓	✓
Registration and Diagnostic Points	Used in a polynomial expression to convert between geographic positions and pixel positions	Used in a polynomial expression to convert between geographic positions and pixel positions	Geo-referencing registration points are explicitly defined
Chart Projection	Preserved	Preserved	Preserved
Source Information	Directly related to the chart product	As an exchange format, it provides more scope for providing information about the source	Directly related to the chart product
Data quality	Accuracy is implied in relation to the chart product, the scanning accuracy and the accuracy of the horizontal datum shifts	Consistent approach for DIGEST products - data quality statements occur at several file levels within the data	Positional accuracy statement only
Insets and Plans	All included on the main chart image and are all geo-referenced	Stored in separate data files except where at the same scale where it is treated as an extension to the main chart	Handled as separate data sets but are all geo-referenced
Notes and Diagrams	All notes and diagrams are identified and classified. They are not geo-referenced	Can be stored as supplementary text files (notes) and as separate raster data files (diagrams). If diagrams are inside the neatline, chart graphic has null pixels inserted. They are not geo-referenced.	Are not identified

Marginalia	Included in main chart image files	Stored in separate data files	Included in main chart image files
Source Data/Reliability Diagram	Identified as a Note and can also be geo-referenced for plotting positions	Stored as separate raster data files. If diagrams are inside the neatline, chart graphic has null pixels inserted. They are not geo-referenced.	Are not identified.
Updating	Full updating service provided. Updates of cumulative digital permanent, temporary and preliminary NTM's are provided via an UPDATE media	Updating only available through total replacement. Patch method may be implemented in the future	Updating only available through total replacement. Patch method may be implemented in the future
Raster Image Information			
Resolution (dots per inch)	127 and 21	254 and 127	254
Tiling structure	provided	provided	no information available
Colour coding information	provided	provided	provided
Security Classification	not stated	stated in several file structures	not stated
Data Access Security (Encryption)	Described in format but requires further development for implementation	Not described	Implemented through licensing agreement with BSB
File Integrity Checking	CRC-32	no	information not available
Encapsulation	HCRF	ISO 8211	BSB-proprietary
Data Compression	Yes	Yes	Yes
Media	CD-ROM	magnetic tape and CD-ROM	CD-ROM and floppy disk
Support paper chart production	yes	not known but probable	yes
Format proposed to IHO	no	no	no

Explanation of Terms

✓	Indicates that information is provided.
Documentation	Is there documentation that describes the format?
Media Volume	Provides information concerning the contents of the media such as volume numbers, originator, product edition, product specification, creation date, etc.
Chart Catalogue	Description of the product's data content and the spatial coverage
Units of Measurement	Describes the height and depth units of the data
Geodetic Datums	Describes the spheroid and geodetic datums of the data
Vertical Datums	Describes the height and sounding datums of the data
Projection Parameters	Describes the chart/plan projection and parameters applicable

Registration and Diagnostic Points	These are points with known position that are used as control points for geo-referencing the pixels and for datum shifts. Geo-referencing is usually undertaken using polynomial equations.
Chart Projection	Indicates whether the chart projection of the paper chart is preserved in the digital image or whether the projection is transformed.
Source	This relates to specific information relevant to a chart/inset/plan such as title, editions, scale, projection, datums, etc. Within a product specification the amount of information provided is dependant on the product. Within an exchange format, the amount of information will depend on the source type and the availability of the source data.
Data Quality	Indicates the various components of data quality associated with the product i.e. scanning accuracy, data currency, positional accuracy, etc. Within a product specification the information will be specific to the product. Within an exchange format, the type of information will be broader and cover more aspects of data quality in general.
Insets and Plans	Describes how chart plans and insets are treated.
Notes and Diagrams	Describes how chart notes and diagrams such as views, index diagrams, etc. are treated.
Marginalia	Describes how chart marginalia is treated.
Source Data/Reliability	Describes how the Source Data or Reliability Diagram is treated.
Diagram Updating	Description of the product's update methodology.
Resolution	Indicates the resolution(s) of the product in dots per inch.
Tiling Structure	Indicates whether the image files structure is defined using a tiling methodology.
Colour coding scheme	Indicates what the colour codes are and how they can be converted between colour systems.
Security Classification	Indicates whether the data has a security classification.
Data Access Security (Encryption)	Indicates whether the data is encrypted to control data access privileges.
File Integrity Checking	Indicates whether the files have integrity checks applied.
Encapsulation	Indicates what format the data set is encapsulated.
Data Compression	Indicates whether the data is compressed to reduce file sizes.
Media	Indicates what physical media the data is available on.
Support paper chart production	Indicates whether the raster image files or their original digital source files (high resolution) are to be used in the paper chart production process.
Format proposed to IHO	Indicates whether the format has been proposed for consideration in S-57.

DIGEST Raster Formats

DIGEST or Digital Geographic Exchange Standard is sponsored by the Digital Geographic Information Working Group (DGIWG), and ad hoc group of North Atlantic Nations. One of the data types supported within DIGEST is raster. The DGIWG has developed exchange specifications for the different forms of raster data:

- ARC Standardised Raster Product (ASRP)
- UTM/UPS Standardised Raster Product (USRP); and
- Standardised Raster Graphics (SRG)

Each of these formats have been developed to meet specific requirements generally associated with topographic and aeronautical maps. ASRP and USRP are designed for seamless presentation where image is split at the boundaries of the map projection zones. These formats are useful when handling maps that abut and have consistent spatial coverage at scale. They however are not necessarily beneficial for representing paper hydrographic charts which do not have consistent spatial coverage terms or spatial extent or scale. It is for these reasons that the Canadians have developed HSRP (CHS, 1994a).

Whilst hydrographic charts can be converted to the DIGEST raster formats, considerable effort is required to prepare the data, particularly in relation to splitting the image at the projection boundary. This may also provide some difficulty in reconstructing the raster data where it is to be used for the production of paper charts. The requirement to support DIGEST formats will depend on the military requirements for each country. Due to several IHO member organisations also being Defence organisations, as well as harmonisation issues between S-57 and DIGEST, these formats may need to be considered for inclusion in the S-57 suite of potential raster formats.

CONSIDERATION FOR RASTER IN S-57

In considering raster formats for future inclusion in S-57, the IHO must resolve what the requirements for raster data are. S-57 describes the standard to be used for the exchange of digital hydrographic data between National Hydrographic Offices and for its distribution to manufacturers, mariners and other data users, for example for the supply of data for ECDIS (IHO, 1993).

To date, technical development of S-57 has progressed through the dedicated work of the IHO Data Base Working Group (DBWG). This work has focussed on ECDIS vector data culminating in a new Version 3.0 of S-57 to be released early 1996. This version of S-57 includes a new Product Specification for ENC data. This is a clear indication that the future development of S-57 will be similar to that of DIGEST, where S-57 will comprise a generic data dictionary, exchange format(s) as well as specific product specifications or application profiles for different types of data and products. This could also be considered as a future model for the incorporation of raster into S-57.

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In fact, S-57 Version 3.0 will include several raster formats to display ancillary non-geo-referenced pictorial data in the PICREP attribute for objects, etc. These formats proposed by a sub-group of the DBWG (IHO, 1995) investigating the handling of textual documents and pictures include:

- for photos (found in modern pilot books): JPEG
- for simple graphics (sketches, diagrams): TIFF (version 4 or higher)
- for moving pictures: MPEG
- for other file types: GIF

Given the anticipated acceptance of the IMO this month for ECDIS to have equivalence to the paper chart using S-57 Version 3.0 data in accordance to the ENC Product Specification, consideration must be given as to whether raster data, which could be fully supported by an equivalent updating service as provided for vector data and paper charting, can be considered as a potential legal equivalent to the paper chart. If this application for raster is to be considered, it is likely that S-57 will require a specific raster product specification to be developed.

Raster data can be used in several applications relevant to hydrography. These include:

- navigation (ECS and perhaps ECDIS)
- military Command and Control systems
- coastal zone management authorities
- government agencies
- education
- recreational users
- provide digital archive of chart reformat
- be used as a data backdrop for vector data and GIS applications
- assist data conversion through raster to vector processing.

The following issues need to be resolved in studying the raster implementation:

- What is the legal status of raster data as compared to vector data?
- What data types need to be handled in raster e.g. geo-referenced data such as charts, satellite imagery, etc. and the non-geo-referenced data (as already identified of S-57 Version 3.0)?
- Can ONE format handle all of the user requirements for geo-referenced data?
- What are the harmonisation issues with DIGEST?

The fact that several countries and private companies are already producing and selling raster products indicates the user need for raster data today. Whilst most HO's will generally use raster data as an interim product until S-57 vector data is available, it can be envisaged that raster data will become an acceptable data format in its own right that meets the user needs of several applications.

In addressing the raster implementation in S-57 and in relation to potential political issues, I suggest that the IHO consider the following:

- that the IHO COE establish a small working group to address raster in S-57
- the working group should comprise IHO members experienced with raster data
- the suggested terms of reference for the working group should address issues such as identifying the user requirements for raster data; legal position of raster data; development proposals for one/many raster formats; DIGEST harmonisation, etc.
- based on the acceptance by COE members of proposals put forward by this working group, the working group then consult with the DBWG to ensure that the proposed format(s) are documented in accordance to S-57 methodology and that the formats be included as extensions to S-57 Version 3.0 (refer to Canadian proposal to the October 1995 DBWG meeting) (CHS, 1995). The raster profiles for S-57 would then be fully incorporated into the next version of S-57 (say Version 4.0).

CONCLUSIONS

Raster data is today in widespread use within the hydrographic charting user community and its popularity and acceptance as authorised product from the HO's is growing. Whilst most HO's will state that raster is an interim product until the availability of S-57 vector data, it is likely that raster data will continue to be an important product in its own right well after vector data is made available. Each IHO has developed or adopted a certain raster format to meet the perceived requirements of its internal and external user market.

The IHO DBWG has focussed on vector data and whilst raster data formats have been discussed and proposed at several DBWG meetings since early 1993, the DBWG has largely ignored the raster implementation issues for S-57. By not addressing raster early in the S-57 development process, this may have been caused for the progression of several HO's to develop their own formats. This is not to say that the DBWG has been negligent, but more indicates the amount of effort and resources required just to implement a practical and workable vector solution for S-57.

S-57 Version 3.0 addresses the paper chart paradigm and the development of the next future version of S-57 will provide a challenging and exciting

time. The ongoing development of S-57 should also provide the opportunity for raster data to be considered and implemented.

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