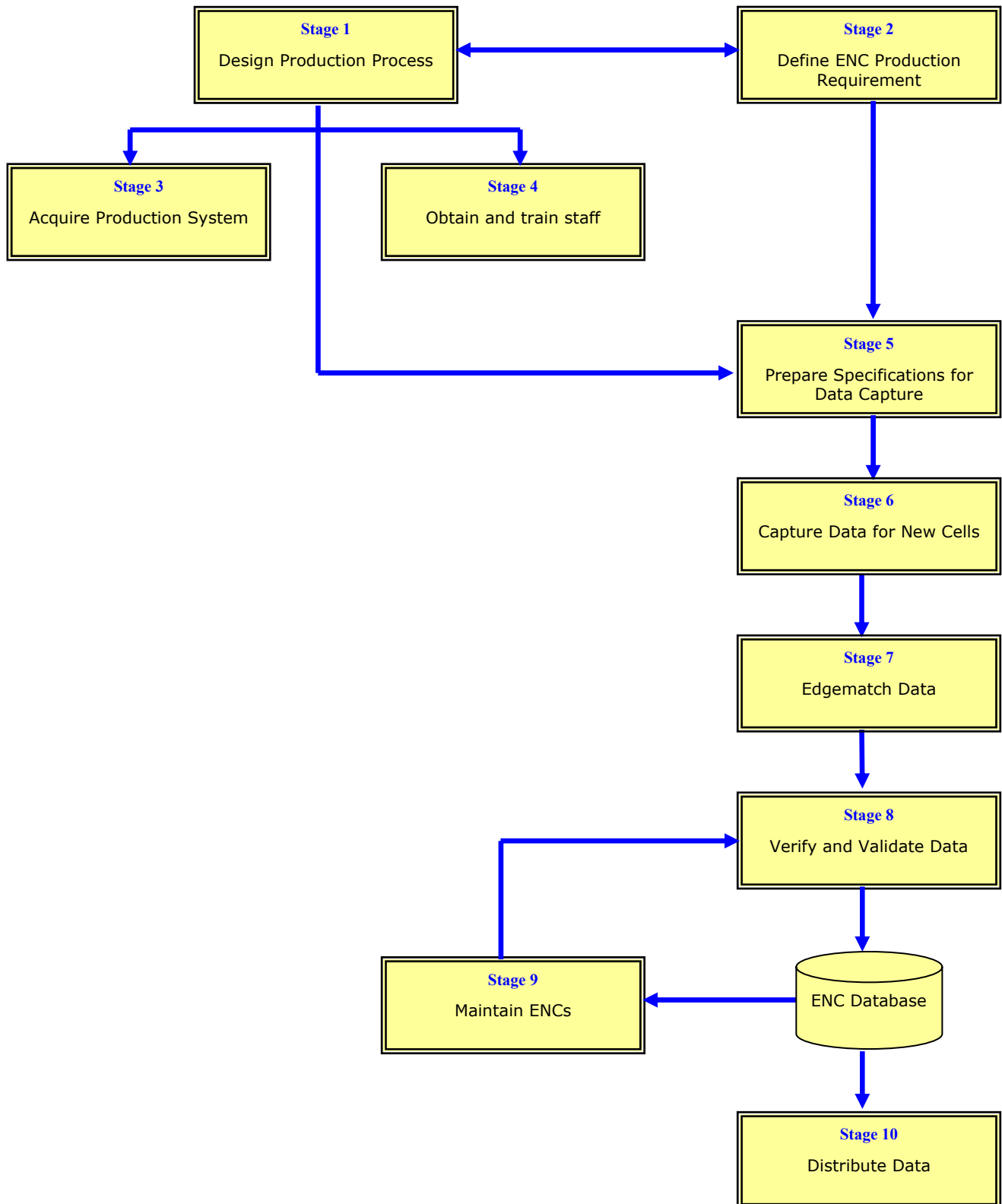




Key Stages in the Production of ENC





ENC PRODUCTION AND DISTRIBUTION GUIDANCE

STAGE 1 – Design Production Process

STEP 1 – Production Method

- Before the production process can be designed, it has to be decided which source material will be used for the ENCs.

ENCs can be encoded directly from original survey material, databased information, from existing paper charts or a combination of each.

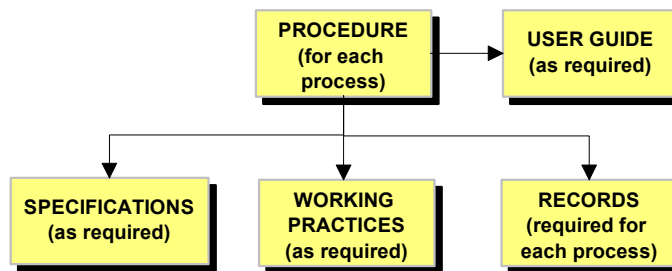
The decision as to which source material will be used will depend on several factors:

- The quality and format (i.e. digital or analogue) of existing survey data. For example it may be more efficient and prudent to produce ENCs only from surveys completed to modern surveying standards.
 - The availability of accurate transformations for existing information to WGS-84 where required.
 - The existence of, or facilities to produce, rectified raster images of existing charts.
- Once it has been decided which source material will be used, a production process needs to be designed and a Quality Management System (QMS) for ENC developed to interface with existing production processes.
 - Any production process will be dependent on whether the Data Capture is to be carried out 'in house' or under contract – see Stages 5 & 6. This decision must be based on the in house production capacity, number of cells to be captured, required timescales, available staff and IT resources, and funding. Each has its own advantages and disadvantages. These include:
 - In house capture should provide a more flexible solution but may require a longer lead time for staff training and may have resourcing issues where a large team is needed for initial capture and a much smaller team to maintain the service thereafter.
 - Contracting out the work should reduce the costs of basic capture, however the time necessary to put the contract in place should not be underestimated nor the effort required to support it; also final validation needs to be carried out by the HO taking responsibility for the product.
 - Options such as using external resources to provide an initial 'bulk load' - see Stage 2 - with all further capture and maintenance carried out in-house should be considered.
 - Consideration should be given to ensure that the publication of ENCs and updates is co-incident with the publication of the equivalent paper chart information.



STEP 2 – A Quality System

- Procedures should be put in place to ensure that each stage of the production process is carried out correctly and consistently. These should be approved by a relevant body as conforming to a suitable recognised standard; typically this will be ISO 9001:2000.



ENC PROCESS DOCUMENTATION

- The production of ENCs demands a high level of quality control and quality assurance. It is important to bear in mind the difference between these two concepts:
 - Quality Control – those checks made on a product after production;
 - Quality Assurance – the overall set of processes, of which Quality Control forms a part, designed to ensure that a product is produced correctly and without errors.

The IHO WEND principles state the following with reference to Standards and Quality Management:

- ❖ A Quality Management System should be considered to assure high quality of ENC services. When implemented, this should be certified by a relevant body as conforming to a suitable recognised standard; typically this will be ISO 9001:2000.
- ❖ There must be conformance with all relevant IHO and IMO standards.

Useful References: **UKHO Quality Procedures**



STAGE 2 – Define ENC Production Requirement

STEP 1 – Identify Requirements

- While each nation has the responsibility for ENCs in its own waters, many aspects of the overall service to the mariner will be improved through their working within the relevant Regional Hydrographic Commission (RHC). This will expedite the completion of small scale coverage and the agreement of cell boundaries between nations. The WEND Task Group recommended that RHCs should:

- Identify key shipping routes and ports within their regions
- Identify charts covering these routes and ports to be captured as ENCs
- Identify producer nations for the ENCs
- Arrange for their production

Wherever possible ENCs should be based on INT charts and the producer nations for the ENCs should be the same as the producer nations for the corresponding INT charts.

If ENCs are to display correctly in an ECDIS it is especially important that there is no overlap of data within the same navigational purpose band. The ENC Product Specification² makes it clear that such overlap must not occur. See also section 11 of Annex A.

In addition to the agreement of boundaries, it is important that neighbouring nations agree, where possible, factors such as use of SCAMIN, contour intervals etc to provide a seamless depiction when possible.

STEP 2 – Produce Production Plan

- A national production plan then needs to be compiled to define:
 - which geographic areas are to be captured – note that this relates to actual areas of data coverage rather than the rectangular cell limits.
 - which navigational purposes are to be populated for each area
 - how the areas are to be divided into cells for each navigational purpose
 - the order of capture; e.g. larger scale cells first
- The production plan will be dependent on some of the following factors:
 - The reason for the requirement – Defence / SOLAS
 - Priority given to major ports and traffic routes, based on volumes of goods and number of passengers
 - Liaison with bordering countries to maximise production, improve efficiency and coverage, and to ensure cross-border consistency
 - Design considerations outlined below.

² Reference B, Appendix B.1



The IHO WEND principles also state the following with reference to responsibility and ownership.

- ❖ SOLAS Chapter V, Regulation 9, requires Contracting Governments to ensure that hydrographic data are available in a suitable manner in order to satisfy the needs of safe navigation. Once the carriage of ECDIS becomes mandatory, there will be a consequential requirement to ensure that such data, as agreed by IMO, are available in a form suitable for use in ECDIS.
 - ❖ It is expected that Member States, for waters of national jurisdiction, will have mature supply systems for ENC's and their subsequent updating in place by the earliest date for mandatory carriage of ECDIS.
 - ❖ By the dates established by IMO, Member States will strive to either:
 - a Provide the necessary ENC coverage, or
 - b Agree with other States to produce the necessary ENC coverage on their behalf.
- IHO will address overall coverage on a regional basis through Regional Hydrographic Commissions.
- ❖ The INT chart system is a useful basis for initial area selection for producing ENC's.
 - ❖ Responsibilities for providing digital data outside areas of national jurisdictions must be established.
 - ❖ In producing ENC's, Member States are to take due account of the rights of the owners of source data and if paper chart coverage has been published by another Member State, the rights of that State.
 - ❖ Responsibility for the production of ENC's can be delegated in whole or in part by a country to another country, which then becomes the producing country in the considered area.
 - ❖ When the limits of waters of national jurisdiction between two neighbouring countries are not established, or it is more convenient to establish boundaries other than established national boundaries, producing countries are to define the boundaries for ENC production within a technical arrangement. These limits would be for cartographic convenience only and shall not be construed as having any significance or status regarding political or other jurisdictional boundaries.
 - ❖ In international waters, the INT chart producer nation shall be assumed to be the producer of the corresponding ENC. Where the offshore limits of waters under national jurisdiction have not yet been established, the clause above should apply.
 - ❖ In areas where the paper INT charts overlap, neighbouring producer nations should agree a common limit of ENC production in the overlapping areas. Cartographic boundaries should be as simple as possible, for example: a succession of straight segments and turning points corresponding to such things as meridians, parallels, or chart limits. Where different producer nations are responsible for INT coverage of the same area at different scales, those nations should agree on a suitable set of boundaries so as to provide the user with the most coherent service possible.



Cell Schema Design Considerations

Limits of ENC Cells

- The HO has to decide how the limits of the planned ENC cells should be defined. The limits can be based on the existing limits of paper charts, or be defined by a rectangular grid.
- The ENC Production Specification, Appendix B S-57, states that *"the geographic extent of the cell must be chosen by the ENC producer to ensure that the resulting dataset file contains no more than 5 megabytes of data. Subject to this consideration, the cell size must not be too small in order to avoid the creation of an excessive number of cells."*

It also states that "cells must be rectangular". Within this, the actual data coverage can be any shape.

Compilation Scales

- It is recommended that the compilation scales for ENCs are based upon standard radar ranges.

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

- Normally, the nearest larger standard scale should be used, e.g. an ENC produced from a 1:25,000 paper chart should have a compilation scale of 1:22,000
- Exceptionally, if source material permits, the next larger scale may be used.
- Where the source scale is larger than 1:4,000 or smaller than 1:3,000,000 then the actual scale should be used.



Navigational Purposes

- Dependent on its intended navigational purpose an ENC is assigned to one of the 6 navigational purposes defined in S-57:
 - Overview
 - General
 - Coastal
 - Approach
 - Harbour
 - Berthing
- S-57 Edition 3.1 does not define minimum and maximum scales for each navigational purpose.



STAGE 3 – Acquire Production System

STEP 1 – Identify Requirement

- The capacity and capability of the production system required will depend on the production plan (see Stage 2) and on the extent to which data capture will be contracted out.
- In the broadest terms there are two types of production software:
 - Those which populate and maintain a database of ENC objects, attributes and attribute values in a format which is compatible with IHO Transfer Standard for Digital Hydrographic Data, S-57 (ENC Product Specification);
 - Those which create individual flat files each forming a single ENC cell.
- A Statement of Requirement (SOR) should be written to set out clearly the requirements of any contract. The SOR should include Key User Requirements, capability of the system, the number of workstations required, any support requirements, and any interfaces with other existing production systems. The contract could include hardware as well as software or just the latter for installation on existing infrastructure. See also Stage 4 regarding the potential for including training provision as part of this contract

STEP 2 – Invitation to Tender

- Once the required production capacity is known (see Stage 2) then an invitation to tender should be sent out to those companies identified as being capable of supplying a suitable system.
- The tenders rendered can then be evaluated against the criteria defined in the initial invitation.
- The contract can then be awarded to the selected company following the evaluation.

STEP 3 – System Installation and Testing

- Before acceptance, the system needs to be installed and tested to ensure that all contractual requirements have been met.

STEP 4 – Live Running

- When the supplier has demonstrated that the system performs in accordance with the specifications it can be contractually accepted and transferred to live running.



STAGE 4 – Obtain and Train Staff

STEP 1 – Staffing Levels

- Staffing levels need to be defined for the production of new ENC cells and the maintenance of existing cells. The staff requirement will be based on whether the decision is to contract out the data capture or capture data in-house, on the number of cells planned, and the proposed targets to achieve those plans.
- To assist with this planning the following provide some guidelines on the approximate timescales (based on UKHO ENC production) for the production and maintenance of cells, from initial preparation to final publication. These are based on production of ENC from paper charts with updates matching the paper chart Notice to Mariners service:
 - Production of New Cells = approximately 5 weeks of an operator's time for a full paper chart equivalent.
 - Production of New Editions = approximately 5 weeks.
 - Production of Updates = approximately 1 hour per update.

Information from other HOs indicates that these figures may vary considerably depending on the complexity of the area, the verification and validation processes adopted and the experience of the staff involved.

Australia's experience is that if highly detailed ENCs are compiled from source material such as hydrographic data, rather than from existing paper charts, substantial additional time will need to be allowed. This will depend on the extents of the cells, area of data coverage, depth contour interval adopted and how complex the source data is. As an example, one degree square ENC cells in the Great Barrier Reef where the seabed is quite complex, compiled from source surveys showing **one** metre depth contours and depth areas, with a navigational purpose of 4, took about 26 weeks to produce, including checking and validation. Such cells often approach the maximum size of 5 MB after optimisation and grouping of soundings has been carried out.

STEP 2 – Determine Skill Levels

- The training needs depend on whether existing staff are to be re-trained or new staff recruited for ENC production.
- A Skills Analysis and Training Needs Analysis should be employed to determine the skills required for the job and the skill levels of the staff. Commercial companies can assist with this task. Where appropriate, reference should be made to Publication M-8; FIG/IHO/ICA 'Standards of Competence for Nautical Cartographers'.

The following training may be required:

- Chart Awareness Training, especially regarding navigational marks
- ENC/S-57 Awareness training
- Quality Assurance training, including quality control aspects



- Production System Training
- ECDIS training – for displaying ENC's to assess portrayal

STEP 3 – Identify Training Provider

- Once the requirement for training has been identified, the training provider needs to be determined. For Production System training, the system provider in most cases will provide the initial training and this needs to be specified within that contract. For Chart Awareness, QA and ENC/S-57 training, this could be provided internally by existing staff, or externally. Courses that are available internationally are listed in IHO Publication S-47, "Training Courses in Hydrography and Nautical Cartography".

The IHO WEND principles state that:

- ❖ Member States' HOs are strongly recommended to provide, upon request, training and advice to HOs that require it to develop their own national ENC provision.

Useful References: FIG/IHO/ICA 'Standards of Competence for Nautical Cartographers'
UKHO ENC Training Documentation;
UKHO Job Descriptions;
S-47 IHO Training Courses.



STAGE 5 – Prepare Specifications for Data Capture

STEP 1 – Published Specifications

- The IHO Transfer Standard for Digital Hydrographic Data, S-57, defines the content, structure and format of the data for ENC. Appendix B1 of the standard contains the Product Specification for ENC.
- Reference should be made to Appendix A (Object Catalogue) and Annex A to Appendix B1 (Use of the Object Catalogue for ENC), of S-57, which define how charted objects should be encoded for ENCs together with the “Recommendations for Consistent ENC Data Encoding” (Annex A).
- It should also be noted that S-57 is maintained by Maintenance Documents and any clarifications within these documents apply to ENCs complying with S-57 Edition 3.1. TSMAD, the IHO group responsible for maintaining and developing S-57, also produces ENC Encoding Bulletins and Frequently Asked Questions (FAQ) about ENC encoding issues. These are all available on the IHO website. TSMAD welcomes additional queries from member states or HOs about ENC encoding issues.

All of these sources need to be searched when collating specifications relating to ENC data capture.

STEP 2 – Data Capture and Product Specifications

- The S-57 standard, although comprehensive, leaves it to HOs to decide what should be the content of the ENCs, what the limits of the cells should be, and which navigational purposes the cells should belong to.
- Supplementary Data Capture and Product Specifications should be produced to clarify the content and construction of ENC cells and the capture of ENC data, in addition to the recommended and mandatory requirements of S-57. As well as clarifications regarding content, these should include elements such as accuracy requirements and file naming conventions for cells and associated text and picture files.
- Ensure consistency with neighbours wherever possible.

The IHO WEND Principles state that:

- ❖ There must be conformance with all relevant IHO and IMO standards.

Useful References: UKHO Data Capture Specification;
UKHO ENC Product Specification;
(Plus those documents listed above).



STAGE 6 – Capture Data for New Cells

STEP 1 – Optionally, place external capture contract

- If it has been decided that new cells are to be captured externally, a suitable contract needs to be agreed. This requires:
 - Definition of a suitable Statement of Requirements.
 - Identification of companies able to carry out the work; this can include a requirement that they be ISO9001:2000 certified.
 - Issuing of Invitations to Tender, including possible production of sample cell.
 - Evaluation of Tenders.
 - Selection of the contractor.
- Alternatively, other Hydrographic Offices may be able to offer production capacity, either on a commercial basis or as part of a wider bilateral agreement.

STEP 2 – Capture data

- In order to facilitate capture, a 'package' should be created for each cell containing all the necessary source information (For example, where capture is from paper charts: Raster Files; List of Lights; Overlays for clarification etc) for populating the cell.
- Depending on form of data capture used:
 - The package will be sent (via a secure route) to external contractor or HO; for facilitating this aspect, consideration should be given to sending such data in batches.
 - A suitably trained in-house operator will be tasked.
- The data must be captured in compliance with the recommended and mandatory requirements of S-57 and in accordance with any HO clarification or Data Capture Specifications.

Useful References: UKHO Data Capture Specifications;
 UKHO Quality Procedures



STAGE 7 – Edge Match Data

STEP 1 –National data

- Once a New Cell has been captured, or a New Edition of an ENC produced, it is important that the data on the cell border is aligned and matched with the corresponding data in any adjoining cells particularly of the same navigational purpose.
- When editing data on the border of cells to match adjoining data, it is important that the data is edited so that depth contours, depth areas etc. are adjusted on the side of safety.
- Editing should also only be done within a specific tolerance so that the accuracy of the data is not impaired to too great a degree.

STEP 2 – Between Nations

- In areas which include neighbouring producer nations, HO's should co-operate to agree on cell boundaries. It is recommended that where advantageous, nations agree data boundaries within a technical arrangement based on cartographic convenience and benefit to the mariner.
- Suitable communications with neighbouring nations should be put in place to ensure data consistency across cell boundaries. These will include exchange mechanisms to allow access each other's ENCs.

The IHO WEND principles state:

- ❖ Member States are encouraged to work together on data capture and data management.
- ❖ ENC duplication should be avoided. A single ENC producing country should exist in any given area.
- ❖ Responsibility for the production of ENC can be delegated in whole or in part by a country to another country, which then becomes the producing country in the considered area.
- ❖ When the limits of waters of national jurisdiction between two neighbouring countries are not established, or it is more convenient to establish boundaries other than established national boundaries, producing countries are to define the boundaries for ENC production within a technical arrangement. These limits would be for cartographic convenience only and shall not be construed as having any significance or status regarding political or other jurisdictional boundaries.
- ❖ In areas where the paper INT charts overlap, neighbouring producer nations should agree a common limit of ENC production in the overlapping areas. Cartographic boundaries should be as simple as possible, for example: a succession of straight segments and turning points corresponding to such things as meridians, parallels, or chart limits. Where different producer nations are responsible for INT coverage of the same area at different scales, those nations should agree on a suitable set of boundaries so as to provide the user with the most coherent service possible.



STAGE 8 – Verify and Validate Data

STEP 1 – Production Systems and Procedures

- Thorough verification and validation procedures need to be in place to verify and validate ENC cells for content and accuracy, ensuring consistency with the IHO Data Transfer Standard S-57 Edition 3.1.

STEP 2 – Verification

- Cells need to be checked for content and capture accuracy. Typically this will take the form of a 100% check of the vector data against the source information so as to ensure that no charted objects or attributes have been omitted from the cell or captured in an incorrect position.

STEP 3 – Validation

- Validation software should be used to perform checks on the completed ENC cell. This is to ensure that an ENC is compliant with the S-57 ENC Product Specification. The minimum checks are defined within S-58.
- The validation process used should include software provided by a different supplier to that used for production. Some HOs use more than one validation software package as each tends to pick up different warnings and errors.

The IHO WEND principles state:

- ❖ The Member State responsible for originating the data is also responsible for its validation in terms of content, conformance to standards and consistency across cell boundaries.
- ❖ Member States should recognize their potential exposure to legal liability for ENCs.

A list of companies supplying ENC Validation Tools is maintained on the IHO website (www.iho.int > Links > Industry List > Search on 'ENC validation').



STAGE 9 – Maintain ENC

STEP 1 – Establish mechanism for ENC updating

- Once an ENC cell has been produced and made available to the end user, then that data has to be maintained.
- The overall Quality Management System must include mechanisms for ENC updating for both Notices to Mariners and New Editions designed to meet the needs of the mariner regarding safety of navigation. This should be synchronised with paper chart equivalents; however, if paper chart production cycles are lengthy, the option of issuing ENC updates and New Editions earlier should be considered together with any wider implications.

The IHO WEND principles state:

- ❖ It is expected that Member States, for waters of national jurisdiction, will have mature supply systems for ENCs and their subsequent updating in place by the earliest date for mandatory carriage of ECDIS.

STEP 2 – Notice to Mariners (Updates)

- ENC Cells require updating to include details published in paper chart Notices to Mariners. These are in two forms: Chart Correcting Notice to Mariners (NM), and Temporary and Preliminary Notice to Mariners (T&P NM). Updating has to be completed within a rigid timescale for cells that have been issued to customers.
- The updates must be produced so as to replicate the corrections on the equivalent paper chart, and be produced at the same time, whether that is weekly, fortnightly or monthly.

STEP 3 – New Editions

- New Editions of the equivalent paper charts will require an ENC new edition or update.

STEP 4 – Distribution of Updates

- The distribution of the updates can be on CD-ROM, through the Internet, over INMARSAT, or by landline communication. However, see Stage 10 regarding wider distribution principles.

The IHO WEND principles also state the following with reference to Updating of ENCs:

- ❖ Technically and economically effective solutions for updating are to be established conforming to the relevant IHO standards. The updating of ENCs should be at least as frequent as that provided by the nation for correction of paper charting.
- ❖ National HOs providing source data are responsible for advising the issuing HO of update information in a timely manner.



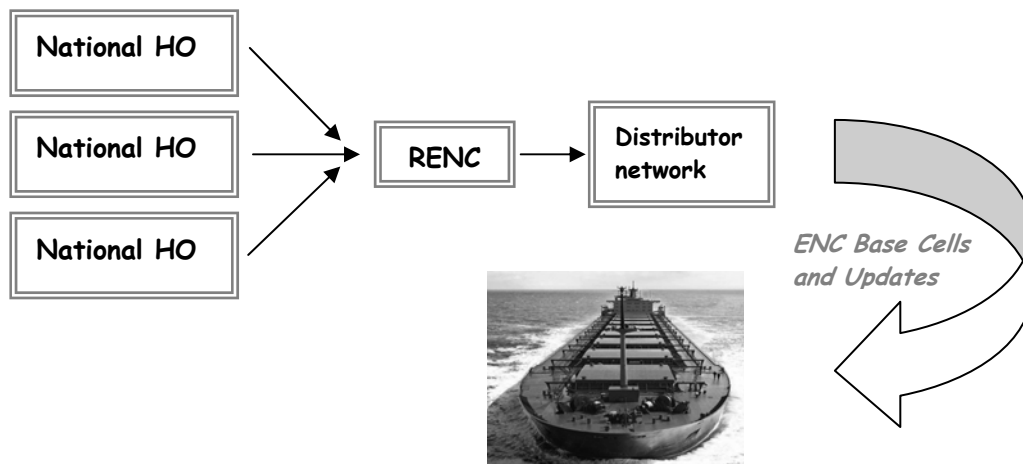
STAGE 10 – Distribute Data

STEP 1 – Identify Distribution Method

- It is recommended that all data (New cells, New Editions, Updates) is distributed through a Regional ENC Co-ordinating Centre (RENC).

The IHO WEND principles state:

- ❖ Member States are encouraged to distribute their ENCs through a RENC in order to share in common experience and reduce expenditure, and to ensure the greatest possible standardization, consistency, reliability and availability of ENCs.
- ❖ Member States should strive for harmonization between RENCs in respect of data standards and service practices in order to ensure the provision of integrated ENC services to users.



- The supply of data through RENCs reduces the overall cost of ENCs by centralising the distribution of the data, thus avoiding the need for each individual HO to invest in developing their own service and distribution network, thus simplifying the purchasing of ENC data. RENCs also act as 'one stop shops'.
- RENCs can also ensure that data is of uniform quality (in terms of its validation against S-58) and that there are no gaps, or overlaps or inconsistencies between adjacent cells.
- RENCs help promote the production of ENCs around the world, and thus help to ensure that developments in electronic charting are coordinated and meet the requirements of the market.

STEP 2 – Sign Agreement

- Whatever distribution mechanism is adopted, where an outside organisation such as a RENC is involved, the rights and responsibilities of each partner should be detailed in a signed agreement.



STEP 3 – Distribution Format

- If data is not distributed through a RENC, although not mandatory, a security system should be applied to protect the integrity of the data, prove authenticity, and prevent unauthorised copying. Reference should be made to S-63 (IHO Data Protection Scheme).
- In addition to standard S-57 (either encrypted or unencrypted) ENC data can also be distributed directly in the SENC format proprietary to an ECDIS manufacturer.

*The **IHO WEND principles** also state that:*

- ❖ Member States will strive to ensure that, mariners, anywhere in the world, can obtain fully updated ENC data for all shipping routes and ports across the world.
- ❖ Member States will strive to ensure that their ENC data are available to users through integrated services, each accessible to any ECDIS user (i.e., providing data in S-57 form), in addition to any national distribution or system-specific SENC delivery.
- ❖ A Member State responsible for any subsequent integration of a country's data into a wider service is responsible for validating the results of that integration.
- ❖ Methods to be adopted should ensure that data bear a stamp or seal of approval of the issuing HO.
- ❖ Member States should work together so that the IHO Data Protection Scheme (S-63) is used for ENC distribution to end users, to ensure data integrity, to safeguard national copyright in ENC data, to protect the mariner from falsified products, and to ensure traceability.
- ❖ When an encryption mechanism is employed to protect data, a failure of contractual obligations by the user should not result in a complete termination of the service. This is to assure that the safety of the vessel is not compromised.
- ❖ In order to promote the use of ENC data in ECDIS, Member States are to strive for the greatest possible user-friendliness of their services, and facilitate integrated services to the mariner.

In addition, the **WEND Committee**, at its meeting in March 2004, has also endorsed the following definition of integrated services:

- ❖ “A variety of end-user services where each service is selling all its ENC data, regardless of source, to the end user within a single service proposition embracing format, data protection scheme and updating mechanism, packaged in a single exchange set.”