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OPERATIONAL REQUIREMENTS FOR ELECTRONIC CHART DISPLAY AND INFORMATION SYSTEMS (ECDIS). PROCEDURAL AND ORGANIZATIONAL CONSIDERATIONS

Summary. Navigating with ECDIS is fundamentally different from navigating with paper charts. The paper below lists a range of bridge work-processes that are affected by changing to an ECDIS system, and which may require that procedures are amended or developed. The paper includes some points for analysis and consideration. It is not implied that all items mentioned should result in corresponding written procedures, nor is it implied that the list in any way is conclusive.

WYMAGANIA OPERACYJNE DLA SYSTEMÓW ECDIS. WZGLĘDY PROCEDURALNO-ORGANIZACYJNE

Streszczenie. Prowadzenie nawigacji w oparciu o system ECDIS zdecydowanie różni się od nawigacji prowadzonej na podstawie papierowych map nawigacyjnych. W niniejszym artykule wymienione zostały te czynności wykonywane na mostku nawigacyjnym, które ulęgną zmianie w momencie przejścia na system ECDIS i które wymagać będą wprowadzenia zmian lub opracowania nowych procedur. Artykuł zawiera tezy do dalszych analiz i rozważań. Nie należy rozumieć, iż wszystkie opisane w nim kwestie wymagają opracowania nowych procedur, ani też, że podana niżej lista jest już definitywnie zamknięta.

1. INTRODUCTION

Navigating with ECDIS is fundamentally different from navigating with paper charts. Important bridge work-processes are significantly affected, in particular, voyage planning and voyage execution task - route planning and route monitoring. These require careful analysis and consideration. So, what are the operational considerations when using ECDIS?

2. ECDIS - VOYAGE PLANNING

Voyage Planning is different on an ECDIS compared to a paper chart. There are a number of available features, such as safety contours, alarms, click-and-drop facilities for waypoints and markers, etc. While it is still possible to make errors in Voyage Plans (VPs) they are likely to be different in type from the errors most frequently observed on paper charts. Consideration should be given to developing a “best practice” for ECDIS VPs.

Issues such as which chart types are available in the ECDIS for the segments of the voyage should be considered. The process analysis should also cover the situations where vessels are operating ECDIS in addition to traditional paper charts, where VPs are drawn on paper charts as well as programmed on the ECDIS.

The VP format should be considered. The existing formats in use may not have been drawn up with ECDIS in mind, and a VP format produced by the ECDIS may not fulfil the needs of the company. How should an ECDIS VP be backed up during voyage execution, in case the ECDIS must be reset or the navigation sensors fail?

2.1. Voyage Planning Considerations

In preparation for voyage planning, a wide array of information must be reviewed and considered. The following is a list of some items the officer in charge of voyage planning might consult [4]:

- Appropriately-scaled charts, navigational publications such as notices to mariners, and nautical publications,
- Waterway characteristics, navigational obstructions, bar crossings and water depths,
- Institutional knowledge of areas to be transited from previous voyages (may be taken from previous voyage plans developed by fleet vessels),
- Characteristics, condition (including engineering conditions), and operational limitations of the vessel,
- Applicable local regulations, including Vessel Traffic Services (VTS), tug escort or assist services, and pilotage requirements, etc.,
- Predicted weather, current, tidal, wind, swell, and visibility conditions along the route,
- Vessel traffic patterns and areas of expected high traffic density,
- Internal and external communication procedures and requirements,
- Vessel operations which require additional searoom, such as ballast exchange or pilot embarkation,
- Anticipated watch conditions, and
- Company's regulations such as ships' routing schemes and reporting systems.

2.2. Voyage Planning Elements

A comprehensive voyage plan will include details marked on the appropriate charts (paper or electronic) as well as voyage planning forms provided by the vessel's management company under their Safety Management Manual and consistent throughout the company's fleet. The voyage plan should include the following details as a minimum [4]:

- Planned track with true course and distance of each leg, plotted out on appropriately-scaled charts (if an electronic charting system is used, the appropriate waypoints should be entered in the system and checked by another individual),
- Safe speed for each leg of the passage, taking into account navigational hazards, maneuvering characteristics, and draft in relation to water depth including squat and heel effect when turning, as applicable,
- Estimated times of arrival at critical points in the plan,
- Wheel over positions, as applicable,
- Turn radius for each alteration, as applicable,
- Areas to be avoided where the vessel is restricted either by local regulations (i.e., marine sanctuaries) or restricted due to water depth or local dangers,
- Areas covered by local regulations such as VTS, tug escort or assist services, and pilotage requirements,
- Areas with high traffic density and/or ferry crossings,
- Areas considered to be pilotage waters where the Master, an area license holder, or a Pilot should be on the bridge,

- Areas where it is considered that the engine room should be at an increased state of readiness,
- Navigational marks to use when navigating visually near a waypoint indicating an alteration of course,
- Method and frequency of position fixing, including primary and secondary alternatives, and
- Contingency plans for emergencies including abort points for port, channel, and/or berth approaches, and actions to take to place the vessel in deep water or proceed to a port of refuge or safe anchorage.

2.3. Safety contour in use

When using ECDIS for voyage planning, the navigation officer should establish a "safety contour" around the vessel to fully use the automated function of ECDIS. The safety contour function of the ECDIS allows the mariner to choose a depth contour (isobath) from the database to be emphasized and associated with a variety of available alarms. If the ship crosses a safety contour or approaches a prohibited or specially-defined area such as a traffic separation zone, ECDIS will automatically indicate the error while the route is being planned and executed. Due to the complexity of the system, navigation officers should receive training on the vessel's specific ECDIS system with annual refresher training [2].

2.4. Approval of VPs

VP validation or approval presents another set of new considerations. Validating a VP made on an ECDIS is different from validating a paper chart based plan. The plan may also have to deal with issues such as the planned settings of the equipment and the alarms. It requires a different mindset to review a paper plan than it does to review a plan made on a computer. It is comparable to the difference between reading a complex paper on a PC compared to reading papers in hard copy.

Planning and validation of the route has therefore to consider issues such as which chart types are available for the various segments of the voyage. The format of the voyage plan is likely to differ from the traditional alphanumeric lists of waypoints used with paper charts and should include information on the usability of connected electronic navigational devices such as GPS/GNSS and AIS and their actual alarm settings.

It is essential to make use of the in-built automatic check functions provided by ECDIS when validating and approving the voyage plan. Thought also needs to be given to ensuring that a backup to the voyage plan on the ECDIS is available in case of equipment failure of the ECDIS itself or the connected sensors.

2.5. Communication to other Officers

Voyage Plan presentation or communication to other Officers must also be considered. Once a VP has been prepared and approved it should be communicated to the other Officers. The communication of the VP will in many ways be similar to the approval. However, it is an issue, which requires separate attention to ensure that all bridge Officers are properly prepared for the intended voyage. This should include information on equipment status and backup procedures. Communication of the VP could cover the presentation to the bridge Officers at the beginning of the voyage as well as the Officer's review of the part of the voyage likely to be sailed during a watch.

2.6. Sharing of VPs

VPs may be stored and shared between several users or ships. It is possible for an Officer with a few keystrokes to print and present a complete and comprehensive VP – possibly made for a vessel with different characteristics.

VPs can be sent ashore for approval or for the creation of a VP bank. Although the sharing of VPs may be economically attractive, there may be legal and other considerations

3. OTHER PROCEDURAL AND ORGANISATIONAL CONSIDERATIONS

3.1. Voyage execution

The voyage execution impacts on various bridge procedures, and the consequence of the new procedures introduced with the ECDIS should be analysed and appreciated. It concerns e.g. issues such as the changing of the watch and the settings of the equipment and additional systems and sensors.

At the beginning of the voyage, as well as at any change of watch, the officers should review the voyage plan and agree the selected pre-settings of functions, alarms and indicators to be used on the ECDIS [3].

3.2. Both paper charts and ECDIS in use

Where vessels carry an ECDIS or ECS in addition to paper charts (standard navigational charts), in those situations the role of the ECDIS and the charts should be considered. If the ECDIS is used for real time navigation, the statutory requirements regarding monitoring of the progress of the voyage and marking of positions should be considered [3]:

- are positions marked in paper charts solely for record keeping purposes?
- what steps are taken to ensure that intended tracks marked on the paper charts correspond with the ECDIS information?
- have the bridge procedures set in place by the shipping company been adapted for the use of ECDIS and are all persons concerned with the navigation familiar with these adaptations?
- are all persons concerned with the navigation of the vessel using the same equipment according to the bridge procedures?

Until all the world is covered by ENCs, it is most likely that most vessels to some degree will have to operate a dual – or triple – system with paper (SNC, Standard Navigational Charts), raster (RNC, Raster Navigational Charts) and vector (ENC, Electronic Navigational Charts) charts.

3.3. Change of watch

It should be possible for the Officer taking over the watch to look through the intended track on an ECDIS in preparation to take over the watch at the same time as the equipment is in use for manoeuvring in confined water or in dense traffic conditions.

Considerations should include:

- the degree of details regarding the settings of the equipment to be covered in handing over the watch,
- the amount of time to be allocated to the change of watch,
- the considerable number of possible settings on an ECDIS which often requires that a range of sub-menues are called up,
- whether the verification of settings above impacts on the availability of the system for navigation purposes.

3.4. Standard ECDIS Settings

Consideration should be given to which ECDIS settings shall be dictated by the bridge procedures, and which settings should be left to the Officer to decide upon. For most settings the degree of freedom and the level of authority should be considered, for instance in relation to the following items:

- statutory requirements,
- corporate procedures and guidelines,
- Master's standing orders,
- VP recommendations,

- Officer of the Watch preferences,
- day or night.

3.5. Human elements

The human element must also be appreciated. While young navigators will often be quick to explore the ECDIS and learn the details, the older and more experienced senior officers may be more reluctant users.

The danger is that electronic navigation becomes an exercise that is controlled by those with a flair for computers rather than those with experience in navigation. On the other hand, young officers may rely too much on the electronic systems, and forget to cross check the information given. Procedures and training programmes may be designed to accommodate these concerns.

The degree of familiarisation training required for the various staff positions onboard should be considered. The approval of a VP requires equivalent knowledge of the system to that expected of the person doing the planning. What level of familiarisation is required of a newly assigned watch officer before that person is allowed to stand individual watches?

3.6. Auditing

Vessels are audited by internal and external parties. How is it ensured that the company's internal auditors can verify that the system is set up and operated in accordance with the corporate plans? What training is needed for the auditors and superintendents? Are ECDIS auditing and inspection procedures required?

4. WHAT SHOULD YOU CONSIDER BEFORE PROCURING AN ELECTRONIC CHART SYSTEM?

There are a lot of essential questions:

- Which system should you have? Do you have a need for ECDIS, which gives greatest effectiveness and can replace the paper chart, or is ECS adequate?
- Will you have a system which reads vector or raster data? If you require vector data, can the system receive S57 data directly, or must the data be converted by a system supplier?
- How many "refinements" do you require?
- Is the size of the hardware acceptable? Have you enough data power?
- How usable is the system? Is it user-friendly? Does it take a long time to learn the system?
- How comprehensive, legible and understandable is the user manual?

Do not rush out to buy before thinking these things through. Do not discuss them only with the supplier, but contact other users for their experiences and opinions, ask independent experts.

5. FIRM QUALITY CONTROL GUARANTEES THE SAFETY OF NAVIGATION

For testing the contents of the data, a reference model will be implemented with which the data can be compared. It defines the relations between objects of two classes. The spatial relation check will check all spatial relations contained in the data and raises alarm if any problems exist e.g.:

- landmarks in water,
- submarine cables on land,
- depth contours crossing (including safety contour),
- depth areas not closing,

For testing the conformance to S-57, edition 3.11 structure and ENC product specifications, an external ENC validation tool will be used.

The ENC production line will be controlled by a workflow management system. Procedure descriptions are stored as flow diagrams and stored in a workflow library. ENC operator actions are

guided by these procedure descriptions and job status reports are always available to system administrators and authorized users.

6. SYSTEM INTEGRITY MONITORING AND MAINTENANCE OF EQUIPMENT

6.1. The Digital Chart

For over few hundred years all local geographical information has been supplied to the end user in the form of printed paper charts. Digital techniques have made it possible to increase the amount of information considerably, and open up new fields of opportunity.

It is important to understand the digital chart system in order to use the new techniques correctly and safely.

6.2. System Integrity Monitoring and Maintenance of Equipment

ECDIS integrity related functions, integrity monitoring and maintenance of equipment:

- on-line tests,
- manual tests of major functions of system,
- hardware and sensor data,
- visual tests of chart data,
- verification of proper functioning,
- final checking of safety in navigation process,
- system safety manual,
- maintenance of equipment.

7. IEC 61174 - ENC TEST DATA SET - GENERAL REQUIREMENTS

This data set is necessary to accomplish all ECDIS testing requirements which are specified in this standard. The data shall be encoded according to the IHO ENC product specification included in IHO S-57. The data shall be provided, in an unencrypted form on CD-ROM.

The test data set shall include:

- data sub-set A for testing the ENC,
- data sub-set B for testing automatic updating,
- data sub-set C for testing manual updating.

In addition to these data sets the following shall be provided:

- an instruction manual,
- a set of graphical representations,
- a read-me file which shall include this specification together with an index to the data contents.

7.1. Data Sub-Set A - ENC

7.1.1. Complex area

This data set shall cover a complex area representing a complicated navigational scenario. The contents shall include:

- at least four, large scale cells (> 1:80,000) providing continuous coverage,
- an area containing no data,
- examples of features named in both English and another language,
- examples of features from each of the priority layers defined in IHO S-52 and appendix 2 of IHO S-52,
- examples of features making use of SCAMIN,
- examples of features making use of INFORM,
- an example of an object, attribute and attribute value not valid for ENC purposes,
- at least two scale-area meta objects,

- an example of corrupted data,
- an example of a feature which is depicted as an area with an associated area-centred symbol,
- an example of objects,
- an example of "unofficial" data, (i.e. data whose source identification indicates that the data is non-HO). This data should be in a datum other than WGS-84. Part of the "unofficial" data shall be superimposed on HO produced ENC data.

7.1.2. Small scale data

The data set shall include equivalent data for the next smaller scale navigational purpose for the area specified above. The data shall be at a scale of < 1:80.000 and shall include an area sufficient to cover a route of 25 nautical miles. It shall also include an area situated at least 10 nautical miles from the centre of the specified area.

7.1.3. Data content

The content of the data set shall support the use of display base, standard display and all other information as specified in annex B.

A separate text document shall be provided containing a selection of positions, distances, bearings, etc., relating to the data set and which support examples of all the navigational calculations listed in IHO S-52.

7.1.4. Graphical representations

Graphical representations of the data set shall be provided to the requisite accuracy and resolution for:

- Base display,
- Standard display,
- All other information,
- Small scale representation of data for area to demonstrate the use of the SCAMIN attribute, and
- Small scale data for area.

7.2. Data Sub-Set B - Automatic Updating

7.2.1. Update data: Contents

The data set shall include:

- Multiple individual updates, certain of which shall affect topology,
- An update with an invalid producing agency identifier,
- An update referring to a superseded edition of a cel,
- An update which comes into effect at a future date,
- Data which falls outside the area of data sub-set A,
- An example of corrupted data,
- A separate text document containing the required contents of the summary report and an application report described in appendix 1 of IHO S-52.

7.2.2. Update data: Sequence

The data set shall include a sequence of update, e.g. 1, 2, 3, 4 and 5, where 3 and 4 are logically linked but two versions of 3 are provided, one which makes 4 invalid, the other being compatible with 4.

8. CHECKLIST OF REQUIRED FEATURES

Checklist of required features	Complies?
– Updated electronic charts on board for entire voyage	……..
– Vector data (NTX or IHO s-57 format) charts	……..

- Updating system for electronic charts ……..
- Variable display modes (i.e. Ships Head up, North up, etc…) ……..
- Route planning ability (waypoints use, etc…) ……..
- Route monitoring ……..
- Plot ships position ……..
- DGPS Receiver present and integration with ECDIS ……..
- Equipment malfunction alarm ……..
- Safety depth and/or contour setting ……..
- Hazard proximity positioning alarm ……..
- Off-scale or over-scale chart alarm ……..
- Off track indication ……..
- Loss of primary positioning information alarm ……..
- Gyrocompass integration with ECDIS ……..
- Echo sounder integration with ECDIS ……..
- Radar image integration with ECDIS and/or ARPA targets ……..
- Speed log integration or similar system ……..
- Back up arrangements in case of ECDIS failure (please specify) ……..
- Training bridge personnel in the use of ECDIS, including capabilities and limitations …….
- Power supply (both emergency and changing supplies: as per Ch. II-1, SOLAS) ……..

9. CONCLUSIONS

ECDIS provides a number of additional planning functions and features such as safety contours, alarms, click-and-drop facilities for waypoints and markers, etc. Whilst in many ways ECDIS makes voyage planning easier it is still possible to make errors, however these are likely to be of a different type to those encountered when using paper charts. It is important that there is good communication of the voyage plan to all bridge officers so that they are prepared for the intended voyage.

There is a tendency to put too much trust in computer based systems and believe whatever is on the display. It is essential that officers remember to cross check the information displayed by all other means available; especially by looking out the window and watching the radar! Bridge-procedures must be adapted appropriately and ENC training must be carried out to alleviate these concerns.

Properly trained navigation officers should determine what is appropriate in terms of alarms and navigation parameters according to the characteristics of the vessel and other prevailing conditions.

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