



# STANDARD SAFETY

SETTING THE STANDARD FOR SERVICE AND SECURITY

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## ECDIS – UNDERSTANDING THE FUTURE OF NAVIGATION SPECIAL EDITION



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### IN THIS EDITION

<b>2</b>	New ECDIS carriage requirements
<b>3</b>	ECDIS and ECS
<b>4</b>	ENC and RNC
<b>6</b>	Integrating ECDIS with other electronic systems
<b>7</b>	ECDIS back-up system requirements
<b>8</b>	Training requirements for ECDIS
<b>10</b>	Updating and maintaining ECDIS
<b>12</b>	The benefits of ECDIS
<b>12</b>	Passage planning with ECDIS
<b>13</b>	Certification
<b>13</b>	Port state control inspection
<b>13</b>	Club condition survey evidence
<b>13</b>	Checklist for the master
<b>14</b>	Checklist for the ship operators/managers
<b>14</b>	Lessons learnt
<b>15</b>	Conclusion
<b>15</b>	Acronyms associated with ECDIS



^ ECDIS – Image courtesy of ECDIS limited

This special edition of *Standard Safety* aims to explain the new legislation relating to Electronic Chart Display and Information System (ECDIS), its implementation and discuss the need for effective ECDIS training for navigating officers. Members need to understand that ECDIS is radically changing how ships are navigated. They should identify ECDIS training requirements, ensure the training resources are available and that all bridge watch-keepers are properly trained through the use of generic and type-specific ECDIS training courses. This quantum change in how ships are navigated with ECDIS needs to be understood primarily by those on the ship's bridge but also by those mariners in marine and safety departments ashore. We enclose two training CDs with this *Standard Safety* to explain ECDIS and to simulate how ECDIS operates (courtesy of ECDIS Ltd and TRANSAS).

International regulation has had difficulty in keeping pace with the growing development and use of ECDIS, while realising the need for mandatory training.

In response to the increasing development and use of ECDIS, the International Maritime Organisation (IMO) has made amendments to the International Convention for the Safety of Life at Sea Convention (SOLAS) and the Standards of Training, Certification and Watchkeeping (STCW) code to incorporate new requirements for the mandatory carriage of ECDIS under SOLAS (for ships engaged on international voyages only) and, as a complement, mandatory ECDIS training as required under the Manila amendments to the STCW code.

The new amendments to SOLAS Chapter V (Safety of Navigation) Regulation 19 'Carriage Requirements for Shipborne Navigational Systems and Equipment' require mandatory carriage of ECDIS for certain new ships built on or after 1 July 2012 and a subsequent timeline plan for retrofitting ECDIS to existing applicable ships.

The Manila amendments to the STCW code have also been updated to complement the new ECDIS carriage requirements and include mandatory training for ships operating with ECDIS. The Manila amendments are due to enter into force on 1 January 2012.

However, certain flag states such as the UK, Bermuda, Australia and the Marshall Islands already require deck officers using ECDIS as a primary means of navigation to undergo generic ECDIS training (conforming to IMO Model Course 1.27) as well as an ECDIS type/model specific course. The issue of ECDIS type specific courses has become a topic of discussion and debate within the maritime industry as concern has been raised over the cost and time needed to train officers who are already ECDIS generic trained but lack the type/model specific knowledge. Companies that have different models of ECDIS onboard their ships are being encouraged to review their ECDIS training procedures through a gap analysis with a focus on evaluating what training requirements may be needed by their ship's flag state. The requirements therefore can be complex and costly.

The club is already aware that some companies have decided to replace existing ECDIS units to one particular model so that there is uniformity across their fleet. This can simplify the ECDIS training programme.

The International Safety Management (ISM) Code is at the forefront of compliance with new ECDIS requirements. The ISM Code requires companies to ensure each ship has properly maintained equipment with qualified and certificated seafarers in accordance with national and international legislative requirements. This includes SOLAS and STCW.

The legislative requirements for ECDIS training are daunting. The sheer numbers and scale of the training required is going to test many companies' ability to complete the training in time and interpret the varying flag state's requirements. Companies need to plan for this immediately if not already started. Many companies already have ECDIS fitted onboard their ships and yet do not insist that the watch-keepers be trained in its use, the argument being that ECDIS is not being used as a primary means of navigation and is not a mandatory requirement. This is a short-sighted approach and, in any event, ECDIS training will become a requirement under the revised STCW code when the Manila amendments enter into force on 1 January 2012. However flag states will interpret the exact training requirements for ECDIS and are likely to incorporate some kind of phasing-in timeline or programme for training for existing officers as may be allowed under Regulation I/15 'Transitional provisions' of the Manila amendments.

The transitional provisions of the Manila Amendments have caused confusion within the maritime industry, in particular the requirements and timeline for existing navigational officers to be ECDIS trained and certified when operating onboard a ship fitted with ECDIS. The transitional provisions of the Manila amendments allow flag states to continue to renew, revalidate and endorse certificates of competency up to 1 January 2017 without ECDIS training in accordance with the provisions of the Convention which applied immediately prior to 1 January 2012, that is, STCW 1995 requirements. This means that depending on what the ship's relevant flag state stipulates, shipowners and operators with existing certificated navigational officers will have a suitable time period to implement an ECDIS training programme prior to 1 January 2017 but must be in line with the specific flag states requirements.

If watch-keepers using ECDIS, even as an aid to navigation, are not properly trained in its use or fully understand the functionalities of each specific type of ECDIS unit, the risk of incidents resulting from ECDIS assisted collisions and groundings is likely to increase.

## NEW ECDIS CARRIAGE REQUIREMENTS

The new amendments to SOLAS Chapter V (Safety of Navigation) Regulation 19 (paragraphs 2.10 and 2.11 added) came into effect on 1 January 2011 and made the carriage of ECDIS mandatory for certain new ships engaged on international voyages and a timeline for retrofitting certain existing ships with ECDIS.

### ECDIS IMPLEMENTATION TIMELINE FOR NEW SHIPS

	1 July 2011	1 July 2012	1 July 2013	1 July 2014
New passenger ships of >500gt				
New tankers of >3000gt				
New cargo ships of >10,000gt				
New cargo ships of >3,000gt				

### ECDIS IMPLEMENTATION TIMELINE FOR EXISTING SHIPS

	1 July 2011	1 July 2012	1 July 2013	1 July 2014	1 July 2015	1 July 2016	1 July 2017	1 July 2018
Existing passenger ships of >500gt								
Existing tankers of >3,000gt								
Existing cargo ships of >50,000gt								
Existing cargo ships of 20,000gt <50,000gt								
Existing cargo ships of 10,000gt <20,000gt								

# ECDIS AND ECS



^ ECDIS

Companies should be aware of IMO/SOLAS performance standards for ECDIS, particularly when installing new electronic navigation systems onboard their ships. The definition of an ECDIS and its use is specified in IMO ECDIS Performance Standards (IMO Resolution A.817 (19) and Resolution MSC.232 (82)):

*'Electronic Chart Display and Information System (ECDIS) means a navigation information system which, with adequate back-up arrangements, can be accepted as complying with the up-to-date chart required by regulation V/19 & V/27 of the 1974 SOLAS Convention, by displaying selected information from a system electronic navigational chart (SENC) with positional information from navigation sensors to assist the mariner in route planning and route monitoring, and by displaying additional navigation-related information if required.'*

There are two different types of electronic navigation systems in use:

- **ECDIS (Electronic Chart Display and Information System)** – This system can be used to meet IMO/SOLAS chart carriage requirements provided it meets the specified IMO performance standards. The ECDIS must be 'type approved' to ensure it meets these performance standards. An ECDIS that does not comply or follow the relevant performance standards is classed as an electronic chart system (ECS).
- **ECS (Electronic Chart System)** – This system is not certified as a 'type approved' ECDIS and does not meet or comply with IMO/SOLAS performance standards. The ECS may allow the use of electronic navigational charts (ENC) and raster navigational charts (RNC) with comparable functionality to a 'type approved' ECDIS, but should not be solely relied upon for navigation as the system is not tested nor certified.

ECDIS must be type approved and meet IMO/SOLAS approved performance standards if it is to be used to meet the chart carriage requirements as outlined in SOLAS regulation V/19.2.1.4; this means for a ship to comply with mandatory ECDIS carriage requirements or to completely depend on ECDIS as a primary means of navigation (no paper charts), the ECDIS must conform to the following IMO performance standards:

- if installed **before** 1 January 2009, should conform to Resolution A.817(19)
- if installed **on or after** 1 January 2009, should conform to MSC.232(82)

For an ECDIS to meet IMO performance standards, the system must undergo a certification process for 'type approval' by a recognised and approved organisation, usually classification societies.

## KEY POINTS

- ECDIS should meet IMO performance standards
- ECDIS must be type approved
- ECDIS type approval certificate should be kept onboard by the master
- ECS is not certified or type approved and does not meet IMO performance standards



# ELECTRONIC NAVIGATIONAL CHARTS (ENC) AND RASTER NAVIGATIONAL CHARTS (RNC)



^ Electronic navigational chart (ENC) – (image courtesy of Warsash Maritime Academy)

There are two different types of electronic charts in use with ECDIS and all navigation officers and marine managers should be aware of their differences and limitations.

**Electronic Navigational Charts (ENC)**, commonly referred to as 'vector charts', are layered with digital information enabling the mariner to electronically interrogate features on the chart such as buoys, navigational marks, traffic separation schemes (TSS) and safety contours with detailed information displayed for the user.

ENC's enable the ECDIS to set different types of navigational alarms to act as a warning to the mariner. These warnings are usually visual as well as audible to give a clear indication of any dangers that lay ahead. The navigational alarms can include such hazards as shallow depths, shoals and isolated dangers as well as minimum under-keel clearance (for example, anti-grounding alarm) provided the ships echo sounder has been integrated with the ECDIS, draught details and alarm parameters specified. Early warning alarms of approaching waypoints and alteration of course points, position fixing reminders and changing electronic chart alarms can also be specified within the alarm parameters. ENCs provide the mariner with a clear display of the navigational situation without distorting the chart display when reducing the chart scale.

ENC must conform to IHO (International Hydrographic Office) S-57 standards. The ENCs must be supplied by or on the authority of a Government or supplied/authorised by a National Hydrographic Office. The Australian Maritime Safety Authority (AMSA) has issued a circular entitled the 'Carriage and use of Electronic Chart Display and Information System (ECDIS)' information sheet, which states:

*'...the so-called derived electronic charts produced by commercial producers or suppliers are not recognised under SOLAS Chapter V as meeting the relevant chart carriage requirements.'*

If the unofficial chart data is produced by commercial producers/suppliers, **it does not meet IMO/SOLAS standards for chart carriage and can therefore not be relied upon as a primary means of navigation.** Only ENCs officially authorised and produced by a National Hydrographic Office conforming to IHO S-57 standard can be considered as fulfilling the chart carriage requirements of SOLAS Chapter V. If an IMO-compliant ECDIS is using unofficial chart data for navigation, the ECDIS is classified as an electronic chart system or ECS.

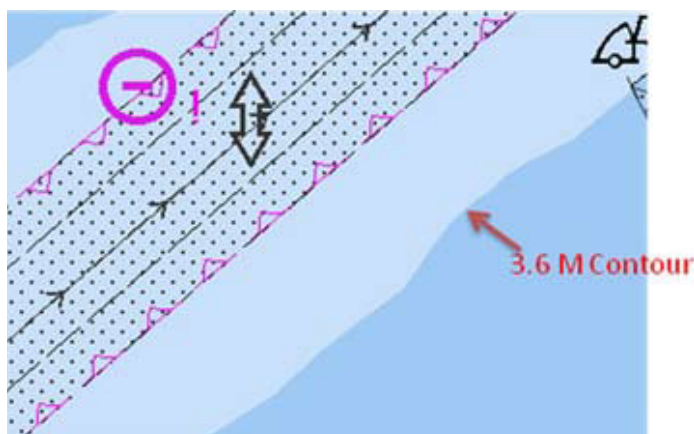
ENCs are named and identified by an eight-character code (for example GB 600100). The first two characters identify the producer (for example GB = Great Britain, FR = France). To identify a particular code and its producer, a complete list of producer codes can be found in the IHO standard S-62.

Some ECDIS systems offer additional databases for tidal information, including predictions and automatic calculation of high water, low water, tidal heights and streams. However, care should be taken when using such information as not all data provided by ECDIS manufacturers is officially authorised or approved by flag states.

Masters and officers should be aware of the limitations of ENC data, including the dangers of overreliance on ECDIS. ENC data can cause operator error particularly as electronic navigational charts contain digitally layered information. **Overreliance on ECDIS when using ENC data may prove dangerous if inadequate training and familiarisation has been given. Unfamiliarity with ENC data and ECDIS functionality may cause operator error.** The International Hydrographic Office has issued a circular warning that ECDIS may not display some isolated shoal depths when operating in 'base' or 'standard display' mode. As a result, route planning and monitoring alarms may not always be activated when approaching such dangers and may result in groundings.



^ Full display mode (www.nauticalcharts.noaa.gov)



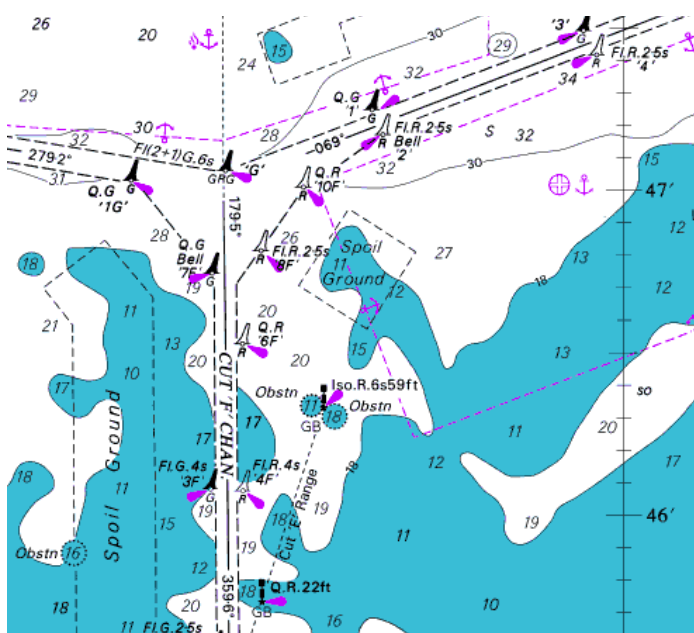
^ Standard display mode (www.nauticalcharts.noaa.gov)

Mariners must ensure their ECDIS display has been set-up properly to the circumstances and conditions so that it includes all information necessary for safe navigation. ECDIS display modes that are set-up in 'base' display mode may remove vital information. The ECDIS display should be set-up appropriate to the environment the ship is operating in. This may differ between navigational environments such as pilotage, coastal, deep sea and anchoring situations as layers of data may need to be added or removed depending on the situation.

**Raster Navigational Charts (RNC)** are scanned geo-referenced images of official paper charts.

RNC's must conform to IHO product specifications S-61 and be officially authorised and produced by or under the authority of a National Hydrographic Office. RNCs do not offer any of the added functionalities or features of ENC's as they are only digitally scanned copies of paper charts.

The chart datum used for GPS (WGS 84) may differ to the chart datum used in certain raster navigational charts when operating in Raster Chart Display System (RCDS) mode and can offset Global Positioning System (GPS) positions if a correction has not been applied (datum offset correction) to the GPS unit.



^ Raster Navigational Chart (RNC)

Paper charts will often note a GPS correction under the heading 'Satellite Derived Positions' on the chart itself if it has not been WGS 84 surveyed. This correction must be applied to the position fixing system (for example GPS) to avoid inaccurate positions. Attention is drawn to the IMO Safety of Navigation circulars, particularly SN/Circ. 213 'Guidance on chart datums and the accuracy of positions on

charts'. Some RNCs that are not WGS84 surveyed may apply the datum correction automatically by the ECDIS. However, **not all RNCs contain the data file** to enable a shift of WGS-84 as this is not always possible. Therefore it may be necessary to manually change the datum at the GPS receiver (this would be in line for ensuring that plotting such received positions onto the paper chart while in RCDS mode will therefore be the same and avoid confusion). Care should also be taken by the navigator when using RNC's that are still using fathoms for depth measurement particularly if the ECDIS is configured to metres.

**Care should be taken by navigation officers to check the chart datum of the chart with that of the position fixing system to ensure they are compatible and the positions being plotted are as accurate as possible.**

RNCs do not offer the operator the same options as an ENC to add or remove irrelevant chart features that are not relevant or suit a particular navigational circumstance as there is no digital chart layering system. The ability to scan ahead when determining upcoming alterations of course, navigational hazards and landmarks may prove tiresome as RNCs may need to be changed.

In most circumstances, the user is also unable to interrogate any of the chart features or reveal further information. Raster chart data will not trigger automatic alarms (for example, anti-grounding). Some user-defined alarms can be generated by operating in RCDS mode provided the mariner inserts the necessary information. Under IMO performance standards, the following alarms and indications are required for an ECDIS operating in RCDS mode:

- ECDIS operating in raster mode
- deviation from route
- position system failure
- approach to critical point
- different geodetic datum
- malfunction of RCDS mode
- large-scale RNC available for ship's position

Changing the display orientation from 'North-Up' may affect the readability of the chart. Chart symbols in RCDS mode are designed to be viewed in a North-Up orientation, like a paper chart. RNC chart projections can differ between each chart which can affect the detail and amount of navigational information (for example depths, contours) displayed on the ECDIS. Increasing and decreasing the chart size may distort the readability of the chart. RNC data should always be viewed at the true scale of the paper chart to avoid distortion.

RNC data highlighting existing features may differ in colour in certain circumstances to show similar chart information and may also include changes in colours used in hours of daylight and darkness. IMO safety of navigation circular SN207 (1999) 'Differences between RCDS and ECDIS' should be consulted for further information.

#### KEY POINTS

- it is important to know the difference between ENC and RNC data
- ENC's provide a greater depth of information through digitally layered data and allow the mariner to interrogate features on the chart
- ENC's must be provided by or under the authority of a government or a National Hydrographic Office and conform to IHO S-57 standard
- RNC's are scanned images of paper charts and are unable to be interrogated for further information
- RNC's must be provided by or under the authority of a government or a National Hydrographic Office and conform to IHO S-61 standard



# INTEGRATING ECDIS WITH OTHER ELECTRONIC SYSTEMS



^ Modern ECDIS usually incorporates additional electronic navigational systems  
(image courtesy of Warsash Maritime Academy)

As per IMO performance standards, an ECDIS should be connected to a ship's position-fixing system, to a gyro compass and to a speed and distance measuring device. For any ships without a gyro compass, ECDIS should be connected to a marine transmitting heading device.

However, most modern ECDIS already integrate the majority of navigational systems on modern bridges but are subject to the condition that their integration does not degrade the performance of any equipment providing sensor inputs or the performance of ECDIS itself.

The benefits of integrating additional navigational systems will include providing the mariner with a greater perspective of the navigational picture whilst increasing situational awareness. The navigation officer's work load decreases as information relating to the safe navigation of the ship (for example, depth, speed and course) can be readily viewed on the ECDIS display as well as other important information.

Additional navigation systems incorporated into ECDIS can include but are not limited to:

- AIS (automatic identification system)
- RADAR (radar image overlay RIO)
- VDR (voyage data recorder)
- Echo sounder
- NAVTEX
- Meteorological instruments such as anemometers (measuring wind speed)

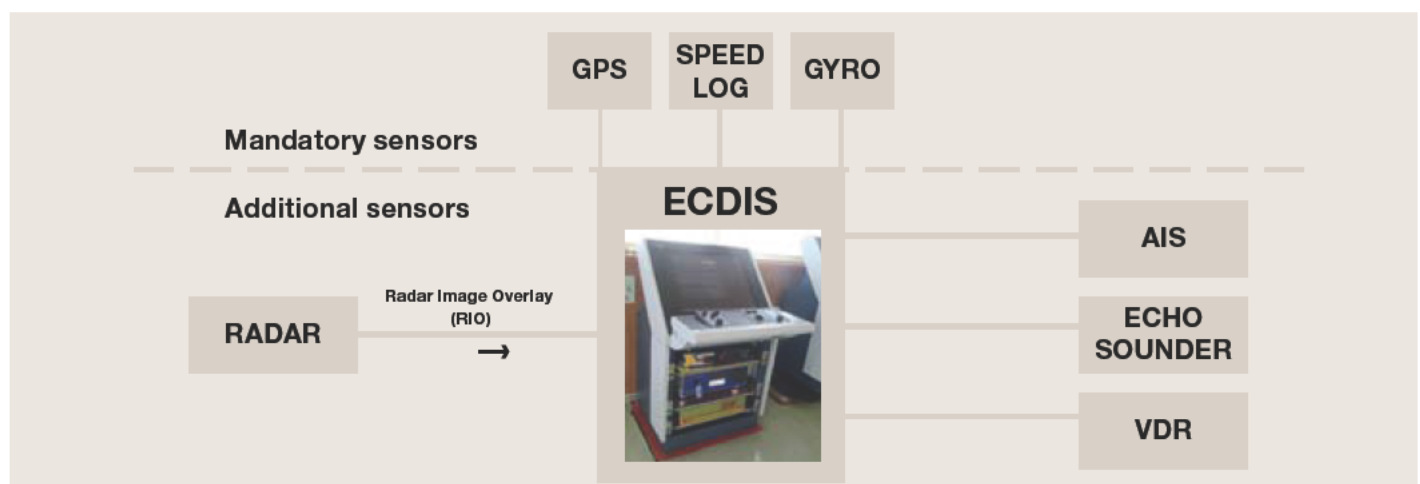
Navigation officers should be aware of which electronic systems are providing sensory inputs into their onboard ECDIS and the consequences of the inputs failing or malfunctioning due to local electronic system failure. If GPS sensors fail to provide position fixing input to the onboard ECDIS, navigation officers must be fully ready and practiced in carrying out position plotting directly onto the ECDIS using traditional position fixing methods, for example visual bearings, radar ranges, radar bearings and transits. **There is the risk with ECDIS that navigators may become dependent on monitoring and that when a sensor fails, the navigator must return to first principles to deal with the situation. This in turn may lead the navigator to incur additional errors in dealing with the situation known as 'knowledge based errors'.** Only through training, in-depth knowledge of ECDIS and its integrated electronic systems and a defined procedure for sensory failure, can the navigator expect to effectively deal with input failures to ECDIS.

There should be a procedure within the safety management system (SMS) in the event of sensory input failure to ECDIS. A checklist should be established on the bridge with clear instructions on how to deal with sensory input failures and how it may affect the safe navigation of the ship. The following points should be addressed in such a checklist:

- has the failed sensory input been identified?
- has the master been informed and does an additional navigation officer need to take over the watch?
- has the failed sensory input affected the navigation of the ship?
- implement back-up protocols as per the SMS procedure to ensure safe navigation, for example traditional position fixing methods
- has the failed sensory input affected any other electronic systems?
- has a rectification action been identified to repair the sensory input?
- does the ship's passage plan need to be amended?

## KEY POINTS

- know what additional electronic systems are integrated with your ECDIS
- ECDIS must be connected to a position-fixing system, gyro compass and speed/distance measuring device
- additional electronic systems (sensors) should not interfere with ECDIS performance or functionality
- establish clearly defined procedures in the event sensory inputs to ECDIS fail



^ Mandatory and additional sensors integrated with ECDIS

# ECDIS BACK-UP SYSTEM REQUIREMENTS

Electronic navigation systems cannot be guaranteed to be 100% failsafe; with this in mind, there must be some form of back-up or redundancy to cover ECDIS failure. IMO performance standards require the 'overall system' to include both a primary ECDIS and an adequate, independent back-up arrangement to ensure the safe takeover of ECDIS functions without resulting in a critical situation. The independent back-up arrangement must allow the safe navigation of the ship for the remaining part of the voyage in case of ECDIS failure.

The flag state must approve the ECDIS back-up arrangement to ensure it is in accordance with IMO performance standards; however, some flag states may delegate the ECDIS approval process to a recognised organisation.

The following back-up options are generally accepted as meeting SOLAS carriage requirements:

1. For ships using ECDIS as their primary means of navigation (no paper charts), an additional and independent ECDIS shall be provided as a back-up. The back-up ECDIS should be connected to an independent power supply and connected to systems providing continuous position-fixing capability.

When the ECDIS is being operated in Raster Chart Display System (RCDS) mode using RNC data due to lack of suitable coverage of electronic navigational charts (ENC), then an appropriate folio of up-to-date paper charts must be maintained for areas where only raster chart coverage is available.

2. For ships using ECDIS as an aid to navigation, the ship must carry and maintain an appropriate folio of up-to-date paper charts.

The ECDIS should be able to operate in a normal capacity even when it is connected and supplied by an emergency source of electrical power. Change over from one source of power supply to another, including any interruptions in electrical supply should not require the equipment to be manually reinitialised for a period of 45 seconds.

## PAPER CHARTS

For ships using ECDIS as their primary means of navigation, paper charts may still need to be carried in order to comply with the new carriage requirements for ECDIS, particularly if the ECDIS is being used in RCDS mode for certain parts of the voyage. The IMO performance standards require that for ships navigating in areas where only raster chart coverage is available, **the ship must have an appropriate folio of up-to-date paper charts.**

Member states of IMO have either issued or are in the process of issuing their own interpretation of the requirements for ECDIS carriage, performance standards, chart coverage and training through merchant shipping notices or equivalent.

An example is drawn from Bermuda Shipping Notice 2011-010 'Introduction to BNWAS and ECDIS', which states:

*'For Bermuda ships this back up set of paper charts when required for operation in areas without vector chart data may be a reduced set sufficient to navigate in the event of an electronic chart failure. Operators should determine, for each ship that requires these, an appropriate set of paper charts based on the risks involved.'*

The sufficient set of paper charts should be based on a suitable risk assessment of the trading area where there is insufficient ENC data and only RNC data available. The UK's Maritime and Coastguard Agency (MCA) has stated in its Marine Guidance Notice (MGN) 285(M+F) 'Electronic Charts – Use of risk assessment methodology when operating ECDIS in RCDS Mode' that prior to MCA approval for ECDIS in RCDS mode as a primary means of navigation, a risk assessment is to be undertaken by 'suitably experienced personnel in the field of risk assessment' and 'it is not intended that the entire task of undertaking the risk assessment should lie exclusively with shipboard personnel'. The MCA makes it clear that overall responsibility for the risk assessment remains with the shipping company managers 'who need to ensure that adequate resources have been allocated for the task'.

Similarly, the Republic of the Marshall Islands states in its Marine Notice No. 7-041-6 'Nautical Chart and Publication Carriage Requirements' that the owner or master is to decide the number of charts needed to satisfy the requirements of a back-up system. The Marshall Islands specify that the administration has no minimum or maximum requirement for paper charts but these should be of a sufficient number to ensure safe navigation to a port of safe refuge in the event that electronic chart navigation is unavailable.

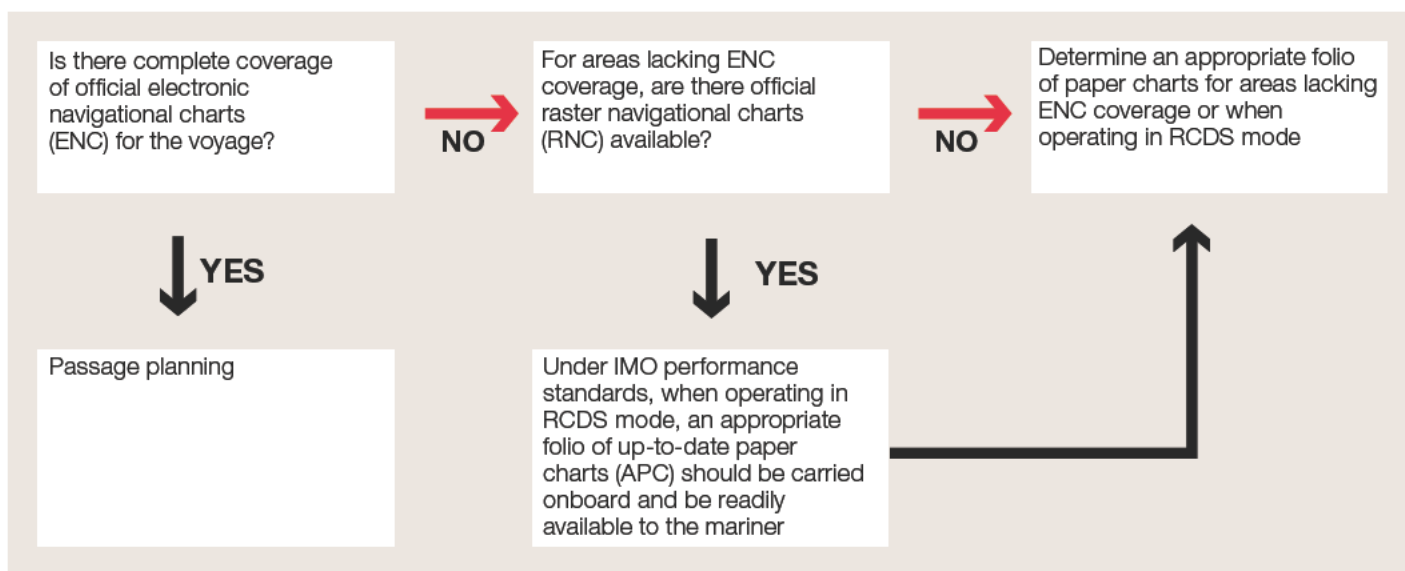
As can be clearly seen, flag states may adopt different interpretations to the risk assessment process of operating in RCDS mode and retaining an appropriate number of paper charts onboard. To avoid confusion and misinterpretation, the ship's relevant flag states should be consulted to determine the procedure on defining and approving the appropriate number or folio of paper charts needed to comply with IMO performance standards requirements.

## IHO CHART CATALOGUE – DETERMINING ENC, RNC AND PAPER CHART COVERAGE

To determine ENC/RNC chart coverage and whether paper charts are required in a particular trading area, an online chart catalogue produced by the International Hydrographic Office (IHO) provides details on the exact areas of ENC/RNC coverage. The information is gathered by the IHO from member states' hydrographic offices and updated as required when new charts are created.

## RISK ASSESSMENTS TO DETERMINE CHART COVERAGE AREAS WHEN USING ECDIS AS A PRIMARY MEANS OF NAVIGATION

Masters and navigation officers preparing passage plans will have to conduct a risk assessment for areas where the ship will be trading to determine if there is suitable electronic chart coverage and whether an appropriate folio of paper charts (APC) is needed. Not all sea areas are covered by ENC charts.



^ Risk assessment for determining electronic chart coverage when using ECDIS as a primary means of navigation

#### KEY POINTS

- ensure there is an approved/certified back-up system in place in case of ECDIS failure
- perform a suitable risk assessment for paper chart folio in RNC coverage area
- be familiar with and maintain your ECDIS back-up system

## TRAINING REQUIREMENTS FOR ECDIS



^ A deck cadet undergoing generic ECDIS training  
(image courtesy of Warsash Maritime Academy)

The Manila amendments to the STCW Code have recognised the need for navigational officers to undergo ECDIS training even if electronic chart navigation is just being used as an aid and not as a primary means to navigation. The Manila amendments, due to enter into force on 1 January 2012, will require navigation officers to undergo ECDIS training if the ship has ECDIS equipment installed onboard.

For ships trading without ECDIS, navigation officers will not be required to hold ECDIS training certification, but certificates of competency will be endorsed to reflect this.

#### INTERPRETATION OF THE STCW MANILA AMENDMENTS FOR ECDIS TRAINING AND REVALIDATION OF CERTIFICATES OF COMPETENCY

##### 'Regulation I/15 Transitional provisions

1. *Until 1 January 2017, a Party may continue to issue, recognise and endorse certificates in accordance with the provisions of the Convention which applied immediately prior to 1 January 2012 in respect of those seafarers who commenced approved seagoing service, an approved education and training programme or an approved training course before 1 July 2013.*
2. *Until 1 January 2017, a Party may continue to renew and revalidate certificates and endorsements in accordance with the provisions of the Convention which applied immediately prior to 1 January 2012.'*

##### Manila amendments to the STCW Code 2010

The understanding of the STCW Manila Amendments has caused confusion within the industry, particularly with respect to the transitional provisions for deck officers who already possess (or are due to revalidate their) watch-keeping certification and who have not undergone ECDIS training. It is of course left to flag states to interpret the code and clearly define what training and certification requirements they will specifically impose.



However, a general interpretation of the transitional provisions of the Manila Amendments is as follows (**subject to flag state interpretation**):

- after 1 January 2012, ECDIS training will be a requirement under the revised STCW Code
- parties (flag states) may continue to issue, recognise and endorse certificates in accordance with the 1995 version of the STCW Convention until 2017. But this is only permitted in respect of seafarers who, as of 1 July 2013, have already begun their seagoing service or are already involved in training activities as required by the STCW Convention (it is understood that this is to give the colleges and training providers 18 months to comply with the new regulations)
- paragraph 2 refers to revalidation. Certificates of competency could be revalidated up to 1 January 2017 under 'transitional provisions' without ECDIS training, subject to flag state requirements. However, certain flag states have issued requirements that if a ship is using ECDIS as a primary means of navigation, then officers must have generic and type specific training/certification now. Therefore, certificates of competencies that have been revalidated up to 1 January 2017 without ECDIS training may not be valid for navigation onboard ships using ECDIS as a primary means of navigation. This will depend on the relevant flag state's interpretation

### GENERIC ECDIS TRAINING

Generic ECDIS training should follow the provisions of the IMO-approved standardised *Model Course 1.27*, which lays down the minimum training and knowledge requirements for a navigation officer to operate ECDIS equipment. It is the objective of IMO that the model course will provide flag states and training companies with a standardised competency level to train navigation officers to.

This course should cover all relevant safety aspects regarding ECDIS, including operational functionality, maintenance and limitations of electronic chart navigation. The generic training should include a thorough understanding of the basic principles of electronic chart navigation and include but not be limited to:

- legal background and requirements of ECDIS
- theoretical background information, including knowing limitations of ECDIS
- types of electronic charts (ENC and RNC)
- functions and settings, including familiarity of different alarms and sensors
- types of display and orientation
- operating basic navigational functions
- understanding route planning functions with particular emphasis on route checking and monitoring
- updates and maintenance of ECDIS software and electronic charts
- knowing what back-up systems are required and necessary updates/maintenance
- knowing the risks – overreliance on ECDIS

The IMO Model Course suggests 40 hours of training to be carried out over a five-day period. However, flag states including the UK has permitted a three-day training course as fulfilling the IMO model requirements. The IMO model course is seen by many as fulfilling the absolute basic requirements for generic ECDIS training. It is recommended that an effective generic ECDIS course is undertaken rather than simply fulfilling the basic statutory requirements. A full understanding of ECDIS is very important.

Flag states such as Norway have stipulated that they may allow generic ECDIS training to be conducted in the form of computer-based training (CBT). Certain private navigation specialists are in the process of creating and introducing a product-specific computer-based ECDIS training programme, which will have two separate CBT programmes for generic and type specific ECDIS training. However, most flag states have rejected this programme as concern over the effectiveness of generic CBT fulfilling IMO Model Course 1.27 requirements may prove inadequate and substandard compared to a college-based training course.

At present, flag states including the UK and Australia have already stipulated generic ECDIS training as a requirement when ECDIS is used as a primary means of navigation. However, under the forthcoming Manila Amendments to the STCW code, due to enter into force 1 January 2012, ECDIS training will be a requirement under the revised STCW code.

### TYPE/MODEL SPECIFIC ECDIS TRAINING



^ Full simulator suite with ECDIS (image courtesy of ECDIS Ltd)

Type/model specific ECDIS training is a requirement of the International Safety Management (ISM) Code under section 6:

*'The Company should establish procedures to ensure that new personnel and personnel transferred to new assignments related to safety and protection of the environment are given proper familiarisation with their duties. Instructions which are essential to be provided prior to sailing should be identified, documented and given.'*

Under the terms of the ISM Code, all officers must be familiar with the equipment they are expected to use; this includes ECDIS equipment.

Type specific training should be based on the actual equipment installed onboard and be provided before the officer is expected to use the equipment, for example, prior to sailing. The general consensus from the IMO is that officers who have undergone ECDIS generic training may not be familiar or be able to fully operate confidently an ECDIS model that they have never used or trained on before. However, debate remains within the industry on acceptable forms of providing type/model specific training. STCW does not make type/model specific training a mandatory requirement and is very much left open to the interpretation of flag states to determine training requirements.

The UK's MCA has issued Marine Information Notice 405(M+F) 'Training for ECDIS as Primary Means of Navigation', stating that masters and navigational officers using ECDIS as their primary means of navigation are required to have completed both generic and type specific ECDIS training. The MCA requires training to relate to the make and model of the equipment fitted on the ship and to be delivered by 'the manufacturer; the manufacturer's approved agent or a trainer who has attended such a programme, trickle down training (that is, one officer training another) is not acceptable'. This implies that the MCA requires type specific training to be carried out in a training establishment ashore before a navigational officer joins a ship as opposed to an onboard training course. What MIN 405(M+F) does not make clear is what training requirements will be needed and approved for ships operating ECDIS as 'an aid to navigation' with a full set of paper charts. It is believed that the MCA will provide further clarification on its ECDIS training requirements in the coming year.

However, certain flag states have now stipulated in their merchant shipping notices that depending on flag state approval, a computer-based training course may be acceptable in fulfilling requirements of type specific training.



^ ECDIS operator undergoing type specific training (image courtesy of ECDIS Ltd)

Bermuda Shipping Notice 2011-010 has agreed 'a manufacturer's computer based training package can be accepted for this purpose' as it is widely seen as the most practical and easily facilitated type specific training course available. Isle of Man's Merchant Shipping Notice 026 'Replacing Paper Charts with ECDIS' also agrees that 'this may be in the form of computer based training'.



^ Traditional chartwork skills are under threat from electronic chart navigation

It is clear that differing views of flag states on type specific training makes it difficult to explain what kind of training would be acceptable and, more importantly, how it can be delivered. Not all flag states may accept computer-based training (CBT) and the ones that do will require their approval.

Companies should be aware that learning to be competent in the use of electronic chart navigation takes time; generic and type specific training only provides the minimum amount of knowledge necessary to operate ECDIS equipment and does not take into account the experience factor.

It is important that traditional navigation skills are not forgotten or lost. Navigators should become confident, but not overconfident, in the use of ECDIS. There is a danger that some navigation officers will increasingly trust what is displayed on the screen without question, which could lull them into a false sense of security. As with all electronic equipment, ECDIS is an aid to navigation, albeit a very significant one, **but it is not a substitute for maintaining a proper lookout at all times.**

With the increasing reliability of GPS as a primary means of position fixing using ECDIS, traditional navigational skills using terrestrial based position fixing should not be overlooked as an important cross check of the ship's position. Additionally, in the event of GPS failure, a suitable back-up procedure should be in place to utilise traditional position fixing directly onto the ECDIS. GPS failure drills have been identified within military navies as an effective training tool ensuring navigators are fully familiar with traditional position plotting techniques. The introduction of GPS failure drills onboard ships using ECDIS as a

primary means of navigation will ensure that in the event of position input failure from GPS, navigators are experienced in using traditional position plotting techniques for the safe takeover of navigation.

The "Human Element" aspects to ECDIS introduction and operation should not be ignored:

- roll-out risk assessment
- effective training
- effective communication/feedback on ECDIS operation
- effective navigational auditing
- effective ECDIS near miss collection and analysis
- effective ECDIS assisted accident investigation – learning from mistakes

The introduction of a complex system such as ECDIS requires a high standard of training and understanding.

#### KEY POINTS

- masters and navigation officers will be required to undergo generic ECDIS training after 1 January 2012 even if ECDIS is being used as 'an aid to navigation' only and under the terms of the ISM Code, type/model specific training also. However, this is subject to flag state interpretation of the Manila amendments to the STCW code and its subsequent training requirements
- generic ECDIS training and type/model specific ECDIS training is already a mandatory requirement under certain flag states where ECDIS is being used as a primary means of navigation
- generic ECDIS training could be conducted on the same equipment used onboard the ship, which would satisfy type/model specific training requirements
- consider ECDIS training for masters and navigation officers now to avoid a last minute rush at training institutes
- masters and navigation officers should attend approved generic ECDIS training courses
- consult your ship's flag state legislation for ECDIS training requirements

## UPDATING AND MAINTAINING ECDIS



^ Software and chart updates must be carried out on a regular basis to comply with SOLAS chart carriage requirements

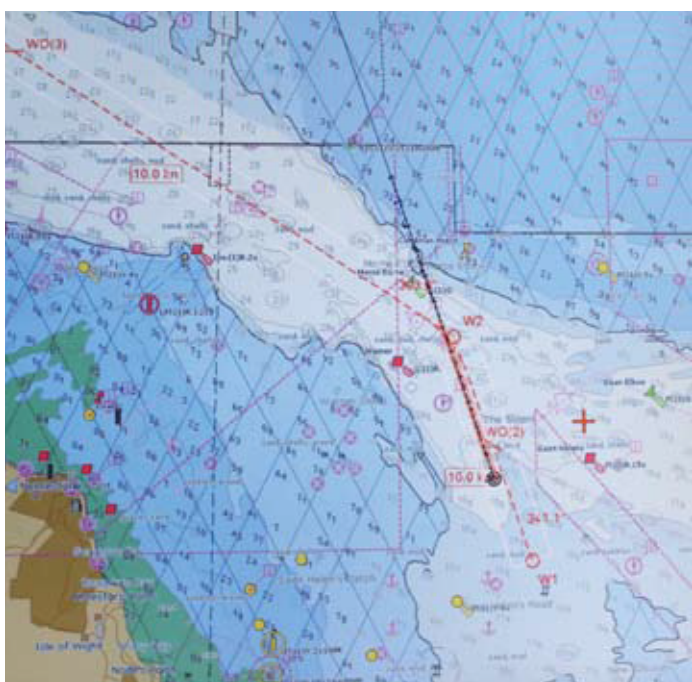
It is important to remember that ECDIS comprises three elements: hardware, software and data. ECDIS operators must ensure that their software always conforms to the latest IHO standards ([www.iho.int](http://www.iho.int))



and that an officially recognised distributor/service provider delivers regular service updates on software and official ENC/RNC data.

All masters and navigation officers should be fully aware of how to update and maintain the onboard ECDIS. **It should not be left for the designated navigation officer to have sole knowledge on the updating procedure and process.** Updating procedures should be covered under ECDIS generic training but, more importantly, also under the type specific training as different ECDIS models vary in their updating process.

Keeping the ECDIS fully up to date should be a high priority for the bridge team and should be treated as equally important as normal paper chart corrections. ECDIS updates normally coincide with weekly paper chart corrections. Updates can be sent via email and transferred onto CD or USB flash drive for updating the ECDIS. Any device used to transfer ECDIS updates should be a dedicated unit for that sole purpose only and be free of any viruses that may corrupt ECDIS software. Software and large ENC/RNC updates are generally received on a data CD and delivered to the ship, particularly where files are too large or expensive to send via email. ECDIS should store and display on demand a record of updates, including the time of application to the ECDIS database, known as the system electronic navigational chart (SENC). This record should include updates for each ENC until it is superseded by a new edition.



^ An up to date electronic navigational chart (ENC)  
(image courtesy of Warsash Maritime Academy)

In order for the ECDIS to fully comply with IMO performance standards and display all relevant digital information contained within an ENC, it should be updated to the latest version of the ENC product specification. Additionally, any ECDIS that is not updated to S-63 Data Protection Standard may fail to decrypt or properly authenticate the ENC. Failure to update your ECDIS properly may result in the latest charted features not being displayed or failure of alarms/indications even if new charted features have been included in the ENC.

**An ECDIS that is not updated correctly and on a regular basis may not meet the chart carriage requirements as set out in SOLAS regulation V/19.2.1.4.**

Please refer to IMO Safety of Navigation Circular 266 '*Maintenance of ECDIS software*'.

## TEMPORARY AND PRELIMINARY (T&P) NOTICES

Temporary and preliminary notices have not yet been fully integrated into ENC or RNC data by all National Hydrographic Offices. Caution must be exercised when navigating solely with ECDIS as some ENC or RNC data may not take account of temporary or preliminary notices.

The International Hydrographic Office has identified this problem and developed a working group to address this. The only guaranteed source for T&P information at present are Notices to Mariners (NM) issued by National Hydrographic Offices.

The United Kingdom Hydrographic Office (UKHO) has recognised the need to include T&P notices within its ENC's by including this information in its 'Admiralty Information Overlay'. This tool allows the notices to be displayed as an overlay to the ENC in the Admiralty Vector Chart Service (AVCS), thus assisting the navigator in readily identifying the location and content of a notice during passage planning and the voyage itself.

Members should issue guidance within their onboard bridge procedures and SMS on how to handle and update ECDIS with T&P notices.

## NAVAREA, NAVTEX AND LOCALLY BROADCASTED WARNINGS

Navigational warnings transmitted by satellite communications (for example, SAT C telex), NAVTEX receiver and radio-broadcasted warnings are by nature more short term and urgent than temporary or preliminary notices. Navigators using paper charts as a primary means of navigation will normally plot urgent warnings by pencil on the paper chart itself to ensure that there is clear record and other navigators can clearly see any new plotted dangers in relation to the position of the ship.

Navigators using ECDIS should be aware of the ability to plot new dangers on electronic charts through the use of the Marine Information Objects (MIO) capability. The purpose of the MIO is to highlight navigational warning information on the electronic chart.

## KEY POINTS

- know how to update your ECDIS (all navigational officers)
- know how updates are received and their frequency
- coordinate with your electronic chart supplier for arranging delivery of new ENC/RNC data in good time, particularly if the ship changes trade at short notice
- recheck your existing passage plans after updating ECDIS as new dangers may exist
- make use of the MIO capability to add received navigational warnings
- navigational audits should include checking ECDIS updates



# THE BENEFITS OF ECDIS

Although there have been some recent incidents involving ECDIS and its improper use, ECDIS when used by a competent operator who has been specifically trained in its use can provide the mariner with a greater perspective of the navigational picture and greatly increase his/her situational awareness. The benefits can include:

- navigational awareness increases – integration of separate spare navigation systems into ECDIS
- efficiency of passage planning – time taken to plan and appraise route is greatly diminished
- efficiency of chart updating – reducing work load on navigation officers to maintain charts
- fatigue may ultimately be reduced as a result of the reduction or elimination of manual chart corrections or lengthy passage planning

## PASSAGE PLANNING WITH ECDIS



^ Navigator undergoing ECDIS training in a simulator (image courtesy of Warsash Maritime Academy)

Passage planning utilising ECDIS as the main tool should not be overlooked as an important aspect of training and as an operational risk factor. The sophistication of ECDIS technology incorporates many additional planning features that are simply not available using paper charts. These include safety contours, click-and-drop facilities for waypoints, markers and alarms. However, inevitably with sophisticated technology mistakes through human error as a result of lack of familiarisation or training have led to disastrous consequences. Officers using ECDIS for passage planning should be fully confident in their ability to effectively use ECDIS, with specific emphasis on risk assessing the route for possible dangers, commonly referred to as 'validating' the route.

### ECDIS PASSAGE PLANNING TIPS

#### Appraisal and planning

- consider which electronic charts will be used for the passage, ENC or RNC data
- check areas where RCDs mode will be operated, identify whether appropriate sets of paper charts are carried
- check local requirements of coastal states that may require carriage of additional publications or local charts (consult IHO website: [www.iho-ohi.net/english/home](http://www.iho-ohi.net/english/home))
- check that electronic charts have been updated to the most recent version and chart permit licences have been bought
- route check previous passage plans after chart updating to ensure that any new dangers added don't present a risk to the ship
- modifications to the passage plan may be necessary to accommodate new chart features such as reporting schemes, traffic separation schemes (TSS), isolated dangers, etc.
- when planning new waypoints and courses, always use the largest scale possible so all features of the chart can be readily identified and risk assessed
- ensure that the plan takes into account sufficient cross track error (XTE) to accommodate any deviations for collision avoidance or currents
- ensure adequate values are inputted for safety contour and depth alarms
- once the route has been planned, **check the entire passage plan berth to berth on a 1:1 scale by manually scrolling along the track**
- if the route has been planned in conjunction with paper charts, cross-check the distances between the paper chart and electronic passage plans to ensure consistency
- check that tidal information is up to date and correct
- check that the ETA has been updated
- check that accurate draft details have been entered
- squat details should be considered
- make a back-up copy of the plan and save on a separate disk (usually USB stick)

#### Execution and monitoring

- check that the display has been set-up properly prior to sailing, otherwise important information may not be displayed
- always operate ENC on the best scale possible to avoid crucial information being auto-filtered and subsequently not being displayed
- avoid using 'base display' mode as this only displays the minimum amount of features and information
- use 'full display' mode, but layers of information may need to be de-selected to avoid cluttering the display with too much information
- auto-filter or 'SCAMIN' may affect the display as it tends to remove information from the display if the best scale chart is not being used. Operators should know how to select the best scale chart to avoid the auto-filter feature removing information when using ENCs
- ensure the GPS unit providing constant position fixing information to ECDIS has been updated with any relevant chart datum offset if the chart datum used in the raster chart is different from WGS(84). Failure to do so may result in positions being inaccurate
- **do not solely rely upon GPS position fixing when there are alternative position fixing facilities available. GPS is subject to a variety of different errors**
- traditional forms of position fixing should never be overlooked or replaced when using ECDIS; these can include but are not limited to:
  - visual bearings
  - radar ranges and bearings using variable range markers (VRMs) and electronic bearing lines (EBL)
  - transit bearings and clearing ranges
  - running fixes
  - fixing by a line of soundings
  - horizontal sextant angles (HSAs)
  - positions by celestial means (sextant)
- make use of the Marine Information Objects (MIO) capability to plot electronically navigational warnings (e.g. NAVAREA warnings)

# CERTIFICATION

The introduction of ECDIS, its carriage and training requirements has brought with it requirements to provide evidence of compliance, particularly for port state control inspections. It is likely that the following documentation will be required to be retained onboard for inspection:

- type approval certificate for IMO-compliant ECDIS
- ECDIS back-up system approved
- updates received for official ENC and RNC data
- generic ECDIS training for navigation officers
- type/model specific ECDIS training for navigation officers

# PORT STATE CONTROL INSPECTION



^ Port state control inspector

When the Manila amendments take effect from 1 January 2012, ships navigating with ECDIS (by primary means or as an aid to navigation) can expect port state control inspectors to incorporate ECDIS training requirements (if not already) within their inspection programme.

Flag states have formed numerous regional groups in the past to ensure port state control inspectors are consistent with each other's inspection processes, called memorandums of understanding (MOU), which include Paris, Tokyo and Marina. The Paris MOU has already issued 'Guidelines for Port State Control on Electronic Charts', and state inspectors are authorised to determine if:

*'Masters and deck watchkeeping officers are able to produce appropriate documentation that generic and type specific ECDIS familiarisation has been undertaken.'*

ECDIS generic and type specific training therefore is likely to become a focal point for port state control (PSC) inspectors.

**Members must ensure that ships are fully compliant with international legislation and that the requirements for ECDIS training have been fulfilled in line with flag state requirements.**

# CLUB CONDITION SURVEY EVIDENCE

During club condition surveys over the past few years, there has been evidence that:

- ship's officers are not trained in ECDIS even when it is being used
- ship's officers do not know how to update the ECDIS (one ship was found to have its electronic navigational charts three years out of date because the ship's officers were not correctly applying the chart updates)
- ECDIS guidance is not adequately given in the bridge procedures guide, SMS or included in company training programmes
- there is a poor understanding and knowledge of ECDIS by shore side staff

# CHECKLIST FOR THE MASTER

To avoid port state control deficiencies and possible detention, the following checks should be made by the master:

- type-approved documentation onboard stating ECDIS complies with IMO performance standards
- generic ECDIS training certification, as per flag state requirements
- type/model specific training given under the terms of the ISM Code and the ship's relevant flag state (method of training/ approval to be determined by relevant flag state)
- there is an approved ECDIS back-up system; this will depend on whether the ECDIS is being used as a primary means of navigation or as an aid only
- ENC and RNC data used for the intended voyage are from the latest official editions
- ECDIS is being updated properly and a system for updating electronic charts is in place from an official electronic chart supplier
- onboard safety management system has been updated to incorporate ECDIS training and familiarisation requirements, including ECDIS maintenance procedures

# CHECKLIST FOR SHIP OPERATORS/ MANAGERS

The introduction of ECDIS for most companies should be considered as a 'management of change' issue. This requires careful planning and consideration with high-level management. Adequate resources should be allocated to its implementation.

- have you carried out a risk assessment for ECDIS implementation and compliance?
- do you have qualified persons ashore that understand ECDIS compliance?
- do you have an ECDIS implementation plan in place considering the management of change issue?
- how is the effectiveness of the plan and the introduction of ECDIS going to be measured?
- what training is being supplied to those who are not familiar with ECDIS?
- have you amended your company SMS and/or bridge procedures guide to include guidance on:
  - ECDIS training
  - ECDIS use
  - ECDIS passage planning
  - ECDIS updating
  - what to do in the event of ECDIS failure
  - ECDIS checks for pre-departure, arrival, pilotage and confined waters
  - do you carry out navigational audits using suitably qualified ECDIS trained personnel?

## CASE STUDY – ECDIS ASSISTED GROUNDING

After leaving port, a ship which had ECDIS fitted as an aid to navigation proceeded to her next port of call some 600 miles away. The intended route was clearly displayed on the paper chart and on the ECDIS. It was later determined that the navigation officers were heavily relying on the ECDIS to the extent that it was being used as a primary means of navigation with little care or attention to traditional position plotting on the paper chart. The master and navigation officers held generic ECDIS certification but no type specific training had been completed in relation to the system onboard.

The master handed over the watch early in the morning after leaving port to the second officer who also had a lookout present on the bridge. The procedure for handing over the watch was clearly defined within the handover checklist under the SMS and master's standing orders. The second officer proceeded to check the instruments on the bridge during the handover period including scanning ahead on the ECDIS to check the intended route of the ship. It was later determined that, while scanning ahead to check the route, the officer had zoomed out on the electronic chart to get an overall assessment of the voyage and had not returned the display to the best chart scale possible. This meant that certain information including soundings were not shown, only depth contours.

A few hours later in the watch, the second officer realised a ship he was monitoring by radar on his port side was not taking proper action in accordance with the collision regulations. After briefly checking the electronic chart on the ECDIS, the second officer altered course 30 degrees to starboard and continued to monitor the situation.

Ten minutes later the ship grounded on a sand bank that was clearly identified as a 'no go' area on the paper chart but not properly highlighted on the ECDIS. The effect of zooming out previously during the hand over period had activated the 'SCAMIN' or auto-filter which in turn had automatically de-selected soundings and topographical features. The safety contour surrounding the bank was shaded completely in dark blue with no symbols or identification of the sand bank. The echo sounder was not active at the time of grounding.

On the previous voyage, a NAVTEX warning had been received regarding the sand bank in question informing mariners that the isolated danger mark was damaged and not flashing its light signal. The NAVTEX warning had been clearly written and identified on the paper chart but not updated on the ECDIS.

## LESSONS LEARNT

- type/model specific training is crucial to the safe navigation of the ship. Officers who have completed a generic ECDIS course may understand the principles and underpinning knowledge of ECDIS but may lack the familiarity and operational knowledge to fully operate a specific ECDIS type or model
- if ECDIS is being used as an aid to navigation, make sure regular position plotting on paper charts is maintained to crosscheck the position of the ship with ECDIS
- do not solely rely on one instrument on the bridge when making navigational decisions. **The navigator should use all available means** when determining a manoeuvre, which includes checking the paper chart for navigable sea room
- make sure all navigational warnings received which are pertinent to the ship are updated on both paper charts and on the ECDIS through the use of MIO capability



# CONCLUSION

Shipowners must realise the urgency of establishing an implementation plan to determine the need for installing IMO-compliant ECDIS (if not already installed) onboard their ships in accordance with new SOLAS carriage requirements.

The need for effective ECDIS training in accordance with the upcoming Manila amendments should be considered now and a plan implemented for training navigation officers.

The consequences of masters and navigation officers not knowing the full functionality and operation of their onboard ECDIS may lead to a serious operational risk and incur great cost to the shipowner as a result of an ECDIS related grounding or collision. Fines or a detention by port state authorities due to lack of proper certification or training is also a possibility.

Fitting ECDIS to ships and training navigators in its use takes time; shipowners that have not already given thought to ECDIS implementation should do so as soon as possible.

A proactive attitude towards ECDIS and its requirements should be adopted to ensure shipowners' costs and liabilities in the long term remain low.

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Standard P&I acknowledge with thanks the use of photographs courtesy of Warsash Maritime Academy.

# ACRONYMS ASSOCIATED WITH ECDIS

<b>APC</b>	Appropriate paper chart folio
<b>CBT</b>	Computer-based training
<b>ECDIS</b>	Electronic Chart Display and Information System
<b>ECS</b>	Electronic Chart System
<b>ENC</b>	Electronic Navigational Chart
<b>GPS</b>	Global Positioning System
<b>IHO</b>	International Hydrographic Office
<b>IMO</b>	International Maritime Organisation
<b>MIO</b>	Marine Information Objects
<b>RCDS</b>	Raster Chart Display System
<b>RNC</b>	Raster Navigational Chart
<b>RO</b>	Recognised Organisation
<b>SENC</b>	System Electronic Navigational Chart
<b>SMS</b>	Safety Management System
<b>SOLAS</b>	Safety of Life at Sea
<b>STCW</b>	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers
<b>TSS</b>	Traffic Separation Scheme
<b>WGS 84</b>	World Geodetic Datum
<b>XTE</b>	Cross track error

# STANDARD SAFETY/STANDARD CARGO PUBLICATIONS



## Standard Safety Portable Ladders May 2011

- Common hazards
- Safety precautions
- Training
- Key points



## Standard Safety The Maritime Labour Convention 2006 March 2011

- Convention requirements
- Compliance planning
- Ship design
- Club cover
- Checklists



## Standard Cargo Bulk Cargoes – hold preparation and cleaning March 2011

- SMS
- Maintenance
- Hold cleaning, washing down  
and drying equipment
- Requirements for cargoes
- Case studies



## Standard Cargo Bulk Cargo: Liquefaction (Iron Ore Fines and Nickel Ore) February 2011

- Shipper's responsibilities
- Appointment of an  
independent surveyor
- Transportable moisture limit  
and flow moisture point
- Flow table and the can test
- Trimming
- Case Studies
- Responsibilities



## The Human Element:

This book makes it clear that the human element is neither peripheral nor optional in the pursuit of a profitable and safe shipping industry. On the contrary, the capabilities and vulnerabilities of human beings are – and always will be – at the centre of the enterprise.

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