Best standardized nautical information for safe navigation in ports - the Port ENC!
Results of the integrated EU research project EFFORTS - work package 1.3 - Port ECDIS.

June 21th - 23th 2010, Quebec – Canada
Why a Port ECDIS – Port ENC?!
The chart requirements for manoeuvring big ships with Minimum Under-Keel Clearance in narrow fairways (harbour access channels), within the port area and for the port maintenance go far beyond the current ECDIS and Inland ECDIS standard in

- up-to-date-ness
- quality and
- accuracy (topography and bathymetry)
- large scale charts
- special chart features/objects and attributes
- and reliability

of hydrographic data (Bathymetry) and geographic data (Topography).
For Port operations, there are special requirements for vertical and horizontal accuracy. This is achieved by using modern sensor technology. The same accuracy must be inherent in the underlying electronic charts.
Why a Port ECDIS – Port ENC?!

Masters and Pilots, the Harbour Master, Ship's Officers, Transport Execution, Port Maintenance and other needs the best available up-to-date digital charts (Port ENC's) to obtain the required nautical information they need!

The Port ENC takes into account this high level of special requirements!! (known request and the result of the Port ECDIS questionnaire).
Why a Port ECDIS – Port ENC?!

- Increasing of vessel sizes versus less harbour and manoeuvre space (vessel size in relation to fairways and basins),
- Minimum Under Keel Clearance and
- special requirements for minimum dredging
- call for the highest level of digital chart information for navigation in fairways and ports currently not being met by equipment according to SOLAS V Carriage requirements!
Why a Port ECDIS – Port ENC?! 

The situation in the Port of Hamburg

Very Large Container Carrier (VLCCs)

Very Large Cruise Liner
Why a Port ECDIS – Port ENC?!  

The situation in the Port of Hamburg
Why a Port ECDIS – Port ENC?! 

- The situation in the Port of Hamburg

  precise berthing

  less manoeuvre space
Why a Port ECDIS – Port ENC?!

The situation in the Port of Hamburg

- less manoeuvre space
- bulk vessel
- turning and docking

Hasenpusch / Hafen Hamburg
Why a Port ECDIS – Port ENC?!

- The IHO ECDIS standard for maritime ENC’s and the Inland ECDIS standard for Inland ENC’s (IENCs) using the same accuracy and quality definitions (→ ZOC Assessment)

- but both without meeting the requirements ports have!

- At present, there is no standard or extension considering the special requirements of port operations!

- That call for a specific “Port ECDIS” → Port ENC.
Why a Port ECDIS – Port ENC?! 

- The Port ENC standard should be an independent but complementary standard to maritime ENC and Inland ENC.
- The development of a Port ENC standard focuses on high precision operations in ports.
- A Port ENC intended to align with the ongoing developments for maritime and Inland ENCs → S100
- Port ENC data should serve as the missing link between maritime and Inland ENCs.
IHO Standards (S-57 & S-44)
IHO Standards (S-57 & S-44)

- IHO Standards do not provide significant **topographic source data** for integration in ENCs and

- no dedicated accuracy requirements are defined that apply for different navigational purposes / categories (e.g., port operations)

- Within ENC's and Inland ENC’s, the IHO S-57 **Zone of Confidence (ZOC)** assessment is used to describe only the quality of **bathymetric** data,

- the **Zone of Confidence (ZOC)** is not used for **topographic** data!
IHO Standards (S-57 & S-44)

1. Co.34 Replace the existing ZOC table and the associated comments with the following:

**S57 ECDIS definitions (Zone of Confidence - bathymetry)**

<table>
<thead>
<tr>
<th>ZOC</th>
<th>Position Accuracy</th>
<th>Depth Accuracy</th>
<th>Seafloor Coverage</th>
<th>Typical Survey Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>± 5 m</td>
<td>=0.50 + 1%d</td>
<td>Full area search undertaken. All significant seafloor features detected and depths measured.</td>
<td>Controlled, systematic survey high position and depth accuracy achieved using DGPS or a minimum three high quality lines of position (LOP) and a multibeam, channel or mechanical sweep system.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>± 0.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>30</td>
<td>± 0.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>100</td>
<td>± 1.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1000</td>
<td>± 10.5</td>
<td></td>
</tr>
<tr>
<td>A2</td>
<td>± 20 m</td>
<td>= 1.00 + 2%d</td>
<td>Full area search undertaken. All significant seafloor features detected and depths measured.</td>
<td>Controlled, systematic survey achieving position and depth accuracy less than ZOC A1 and using a modern survey echosounder and a</td>
</tr>
</tbody>
</table>
### Minimum Standards for Hydrographic Surveys

*To be read in conjunction with the full text set out in this document.*

<table>
<thead>
<tr>
<th>Reference</th>
<th>Order</th>
<th>Special</th>
<th>1a</th>
<th>1b</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chapter 1</td>
<td>Description of areas.</td>
<td>Areas where under keel clearance is critical</td>
<td>Areas shallower than 100 metres where under keel clearance is less critical</td>
<td>Areas generally deeper than 100 metres where a general view of the sea floor is considered adequate</td>
<td></td>
</tr>
<tr>
<td>Chapter 2</td>
<td>Maximum allowable THU 95% Confidence level</td>
<td>2 metres</td>
<td>5 metres + 5% of depth</td>
<td>20 metres + 10% of depth</td>
<td></td>
</tr>
<tr>
<td>Para 3.2 and note 1</td>
<td>Maximum allowable TVU 95% Confidence level</td>
<td>a = 0.25 metre, b = 0.0075</td>
<td>a = 0.5 metre, b = 0.013</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glossary and note 2</td>
<td>Full Sea Floor Search</td>
<td>Required</td>
<td>Required</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Para 2.1 Para 3.4 Para 3.5 and note 3</td>
<td>Feature Detection</td>
<td>Cubic features &gt; 1 metre</td>
<td>Cubic features &gt; 2 metres, in depths up to 40 metres; 10% of depth beyond 40 metres</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Para 3.6 and note 4</td>
<td>Recommended maximum Line Spacing</td>
<td>Not defined as full sea floor search is required</td>
<td>Not defined as full sea floor search is required</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chapter 2 and note 5</td>
<td>Positioning of fixed aids to navigation and topography significant to navigation (95% Confidence level)</td>
<td>2 metres</td>
<td>5 metres</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chapter 2 and note 5</td>
<td>Positioning of the Coastline and topography less significant to navigation (95% Confidence level)</td>
<td>10 metres</td>
<td>20 metres</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chapter 3 and note 5</td>
<td>Mean position of floating aids to navigation (95% Confidence level)</td>
<td>10 metres</td>
<td>10 metres</td>
<td>20 metres</td>
<td></td>
</tr>
</tbody>
</table>

**Mismatch between IHO S57 ECDIS Requirements and S44 Special Order!**

S57 ECDIS ZOC +/- 5m versus IHO S44 Special Order +/- 2m

**Quay walls, bridges, locks etc. ?!**

Dieter Seefeldt
Bath, UK, Sept. 2008

S44 Ed. 5 new - Minimum Standards for Hydrographic Surveys - February 2008
IHO Standards (S-57 & S-44)

One example is the official ENC of Hamburg.

Produced and issued by BSH (Federal Maritime and Hydrographic Agency / Germany),

it meets all the relevant ENC related standards and fulfills the requirements for maritime navigation (SOLAS V carriage requirements),

but the ENC is too small in scale,

does not have any bathymetric detail,

not showing up-to-date information

and poorly defined horizontal accuracy for topographic features such as quay walls, piers, pontoons, etc.
Comparison
HPA Basis Port ENC - BSH ENC

BSH ENC-cell Port of Hamburg
Federal Maritime and Hydrographic Agency
name: DE521500.000
date: 27.05.2005
scale: 1:15 000  ➔ small scale!!
accuracy:
S-57 Object Class: M_QUAL
attribut: CATZOC = B (3) ±50m
Comparison the official maritime ENC and the Port ENC

the official BSH - ENC has a different purpose to meet (usage band 5 - harbour)!
The integrated EU research project EFFORTS

Project acronym: **EFFORTS**
Project title: **Effective Operation in Ports**

**Sub-Project 1**
*Navigation in Ports*

- WP 1.1 TUG ASSISTANCE
- WP 1.2 PRECISE NAVIGATION AND MANOEUVRING in PORTS
- WP 1.3 PORT ECDIS

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**Effective Operations in Ports**

- The Subproject 1 “Navigation in Ports” aims at the **improvement of safety and efficiency of navigation in ports** considering **decreasing manoeuvring space** (vessel size in relation to fairways and basins) versus **increasing traffic** and **vessel sizes**.
The EFFORTS Work Package 1.3 - Port ECDIS results
The EFFORTS Work Package 1.3 - Port ECDIS results

Gradation of the S-57 ENC products

- Standard exist
- Maritime ENC (ENC) - Product ID 1
- Inland ENC (IENC) - Product ID 10 +
- Port ENC (PENC) - new objects/features

- Port ENC (PENC) - Product ID 20 ++
As part of the EFFORTS project, there are a number of new port specific objects, as well as requirements for the accuracy of these objects. These new requirements will ensure that the Port ENC makes the most accurate data available to the port users.

The use of gridded bathymetry, channel outlines and channel depth model data will allow the users of the Port ENC to have an accurate and up to date 3D information of the depth situation within the port. This will improve both, safety of navigation as well as port maintenance.
The EFFORTS Work Package 1.3 - Port ECDIS results

- Document about "Potential users and requirements" (structured questionnaire, study)
- Definition of present Data Quality in Standards used for ENC data (S57 versus S44 standard) – the current situation
- Port ENC specification documents
  - Port ENC Feature Catalogue → description of the Port ENC features
  - Port ENC Encoding guide → representation and symbolisation
  - Port ENC Product specification
- Port ENC prototype (software and dataset) → Port of Hamburg
  - including a Port ENC viewer
- Tests with Port ENC prototype (based on basic dataset) and evaluation of tests (report)
- Port ENC follow-up requirements document
The EFFORTS Work Package 1.3 - Port ECDIS results

Results - overview:

- For Port operations a new port related dataset, a **precise Port ENC**, is needed and required (→ result of the Port ECDIS questionnaire).
- **High accuracy charts** (for using RTK-DGPS, local RTK - DGPS services deliver cm accuracy, position must fulfil or be better than IHO - S44 Special Order)
- **Large scale information** (1:500 up to 1:5000) with up to date information including special objects / features such as e.g. fenders, fender line etc. for special port navigation and operation
- **3D possibilities** (Grid / Raster / TIN)
- A designed / constructed **3D - Channel Reference Model (CRM) → the theoretical harbour bottom that must be maintained e.g. for dredged areas**
The EFFORTS Work Package 1.3 - Port ECDIS results

Port ENC bathymetric data quality – suggestion ➔ CATZOC ➔ accuracy

Object Class: **Accuracy of ENC data**

Acronym: \texttt{m\_aenc}

Set Attribute A: \texttt{battacc}; \texttt{topacc};
Set Attribute B: \texttt{INFORM}; \texttt{NINFOM}; \texttt{ntxtds}; \texttt{txtdsc};
Set Attribute C: \texttt{RECDAT}; \texttt{RECIND}; \texttt{SORDAT}; \texttt{SORIND};

The attribute battacc is from the type “enumerated”. There is one attribute value, this value is based on the IHO Standards for Hydrographic Surveys (Special Publication N° 44 Ed.5) and be called Special.

<table>
<thead>
<tr>
<th>ID</th>
<th>Meaning</th>
<th>Max. allowable THU</th>
<th>Max. allowable TVU</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Special</td>
<td>±2 m</td>
<td>$a = 0.25 \text{ m}$ $b = 0.0075$</td>
</tr>
</tbody>
</table>

\textit{Tab.1: allowable uncertainty for bathymetric data}
### The EFFORTS Work Package 1.3 - Port ECDIS results

iddledieter seefeldt

#### Port ENC geo-/topographic data quality – suggestion ✔ CATZOC ✔ accuracy

<table>
<thead>
<tr>
<th>ID</th>
<th>Meaning</th>
<th>Object class</th>
<th>Positional accuracy</th>
<th>Vertical accuracy</th>
<th>Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Zone A</td>
<td>(BCNCAR), (bcncar), (BCNSD), (bcnsid),</td>
<td>± 0,1 m</td>
<td>± 0,1 m</td>
<td>Fixed object relevant for berthing, dockling and lock passage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BCNLAT, bcnlat, (BCNSAW), (bcnsaw),</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>(BCNSPP), (bcnsp), bridge, cblohd,</td>
<td></td>
<td></td>
<td></td>
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<td>clsseg, DRYDOC, FLDOC, flocdoc,</td>
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<td></td>
<td>lokbsn, MORFAC, PILPNT, pipohd,</td>
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<td></td>
<td></td>
<td>PONTON, ponton, PYLONS, SLCONS, sicoons,</td>
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<td>slicoons</td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>berthis, BIJSGL, HREFAC, hrbrac,</td>
<td>± 0,5 m</td>
<td>± 0,5 m</td>
<td>Fixed object relevant for navigation (maneuvering, turning, towage)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LNDMRK, NAVLINE, (RADLNE), RADSTA,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>RESARE, resare, (RSCSTA), RTPECN,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>SLTNN, sitat, sistaw, sitawa</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The EFFORTS Work Package 1.3 - Port ECDIS results

Port ENC geo-/topographic data quality – suggestion ➔ CATZOC ➔ accuracy

<table>
<thead>
<tr>
<th>ID</th>
<th>Meaning</th>
<th>Object class</th>
<th>Positional accuracy</th>
<th>Vertical accuracy</th>
<th>Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Zone B</td>
<td>(BCNCAR), (bncarc), (BCNISD), (bncisd),</td>
<td>0,5 m</td>
<td>± 0,5 m</td>
<td>Fixed object relevant for berthing, docking and lock passage</td>
</tr>
</tbody>
</table>
|    |         | BCNLAT, bclat, (BCNSAW), (bcnsaw), (BCNSPP), (bcnsp), bridge, chl, cll, cllg, clrow, 
|    |         | GATCON, gatcon, HULKES, hulke,                 |                     |       |                                                 |
|    |         | lhken, MORFAC, PILPNT, pipod, PONTON, ponton,  |                     |       |                                                 |
|    |         | PYLCNS, SLCON, scon,                            |                     |       |                                                 |
|    |         | berths, BUISGL, HRFAC, hrfac,                   | 2,5 m               | ± 2,5 m           | Fixed object relevant for navigation (maneuvering, turning, towage) |
|    |         | LNDMRK, NAVLNE, (RADLNE), RADSTA, RESARE,       |                     |       |                                                 |
|    |         | resare, (RSCSTA), RTPECN, SITNLK, sitat, sitaw  |                     |       |                                                 |

Tab. 2: The characteristic of the attribute “Accuracy of topographic data”
The EFFORTS Work Package 1.3 - Port ECDIS results

- Port ENC encoding guide → CATZOC → accuracy
  - representation and
  - symbolisation

Port ENC highest quality level

Port ENC second highest quality level

<table>
<thead>
<tr>
<th>ID</th>
<th>Bathymetric</th>
<th>Topographic</th>
<th>S-52 representation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>Zone A</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td></td>
<td>Zone B</td>
</tr>
</tbody>
</table>

Tab.3: S-52 representation for the meta object “Accuracy of ENC data”
The EFFORTS Work Package 1.3 - Port ECDIS results

A lot of accuracy and functional tests using the new Port ENC dataset were carried out in the Port of Hamburg (report):

That means: accuracy and functional tests onboard of a survey vessel, tests during docking manoeuvres of cruise liners, test onboard of a Trailer Suction Hopper Dredger, tests onboard of a Large Container Carrier using a PPU (Marimatech), functional test using the Port ENC as base information in the Port of Hamburg VTMIS (ATLAS MS)

Remark:

All the tests running very successful
Delivering very promising results
Demonstrating the outstanding quality and accuracy of the developed Port ENC!!
The EFFORTS Work Package 1.3 - Port ECDIS results

Example: PPU (Marimatech) test onboard of a Container vessel (VLCC)

Container Vessel → Yang Ming Uberty  (Lenght 333.5m - Breadth 42.8m - Draught: 11.0m).
The EFFORTS Work Package 1.3 - Port ECDIS results

Example: PPU (Marimatech) test onboard of a Container vessel (VLCC)
The EFFORTS Work Package 1.3 - Port ECDIS results

Example: PPU (Marimatech) test onboard of a Container vessel (VLCC)
The EFFORTS Work Package 1.3 - Port ECDIS results

Example: PPU (Marimatech) test onboard of a Container vessel (VLCC)
The EFFORTS Work Package 1.3 - Port ECDIS results

We think that the Port ENC – could/must be a core component for e-Navigation

DRAFT STRATEGY FOR THE DEVELOPMENT AND IMPLEMENTATION OF E-NAVIGATION

1 DEFINITION AND SCOPE

1.1 E-navigation is the harmonized collection, integration, exchange, presentation and analysis of marine information on board and ashore by electronic means to enhance berth to berth navigation and related services for safety and security at sea and protection of the marine environment.

1.2 E-navigation is intended to meet present and future user needs through harmonization of marine navigation systems and supporting shore services.
The EFFORTS Work Package 1.3 - Port ECDIS results

the Port ENC & the Port ECDIS viewer - examples

This software must not be used as an aid to navigation.

The EFFORTS Port ECDIS Viewer was designed and developed exclusively as a demonstrator. The idea is to give an impression how Port ECDIS data can be visualized and how Port ECDIS data can help to make Operations in Ports more effective.

In no event shall the manufacturer be liable for any other damages whatsoever (including, without limitation, damages for loss of business profits, business interruption, loss of business information, or other pecuniary loss) arising out of inability to use, or the use, of the Software, even if the manufacturer has been advised of the possibility of such damages. In any case, the manufacturer's entire liability shall be limited to the amount actually paid by you for the software.

The manufacturer disclaims all warranties, either expressed or implied, including but not limited to implied warranties of fitness for a particular purpose, with respect to the Software, the accompanying manual(s) and written materials.

Moreover General Terms and Conditions of SevenCs GmbH (as of July 2009) must be accepted when using this software.
Port ENC
Base Chart
The EFFORTS Work Package 1.3 - Port ECDIS results
the Port ENC & the Port ECDIS viewer - examples

Port ENC
Base Chart

Bathymetric ENC (bENC)
The EFFORTS Work Package 1.3 - Port ECDIS results

- Port ENC
- Base Chart
- Gridded Data [BAG]
- Absolute depth
Dieter Seefeldt
The EFFORTS Work Package 1.3 - Port ECDIS results
the Port ENC & the Port ECDIS viewer - examples

Port ENC
Base Chart

Gridded Data
[BAG]
safety depth
Port ENC
Base Chart

Channel
Reference
Model
Port ENC
Base Chart

Gridded Data
[BAG]
CRM vs. depth
3 D – view
Bathymetry
3D view Channel Reference Model
3 D – view
Bathymetry versus CRM
Developing a Port ECDIS - a challenge mastered!!

Final statement

It must be reliable and clear, that the harbour master, the pilot, the captain and all other user can trust the topographic and bathymetric information within the Port ENC!

So the Port ENC can be used as reference system for navigation!

"If the vessel sails on land the positioning of the vessel is inaccurate, not the Port ENC!"
Developing a Port ECDIS - a challenge mastered!!

Thank you for your attention!!
Kontaktdaten

on behalf of the

HPA Hamburg Port Authority AöR

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