# Worldwide and route-specific coverage of Electronic Navigational Charts

E. Vanem, M.S. Eide & R. Skjong
*DNV Research & Innovation, Det Norske Veritas, Høvik, Norway*

G. Gravir
*DNV Energy Region Nordic and Eurasia, Det Norske Veritas, Høvik, Norway*

A. Lepsøe
*DNV Maritime Technology and Production Centre, Det Norske Veritas, Høvik, Norway*

ABSTRACT: This paper presents the results from a recent study on the coverage of Electronic Navigational Charts (ENC). Global traffic data has been evaluated in relation to the coverage of ENC and eleven specific ship routes, representative for global merchant shipping, have been analyzed in further detail. Overall, the ENC coverage was found to be extensive, with 82 – 94% coverage for SOLAS ships, and 28 – 100% coverage along selected routes. Furthermore, it has been demonstrated how the coverage of ENCs could be taken into account when assessing the effect of ECDIS for safer ship navigation and associated cost effectiveness.

## 1 INTRODUCTION

### 1.1 *Background and motivation*

Electronic Chart Display and Information Systems (ECDIS) represent a means for increasing the navigational safety of ships. Formal Safety Assessments (IMO, 2002) have been carried out on various shiptypes, e.g. large passenger ships (Norway 2005), oil tankers, bulk carriers, product tankers (Denmark & Norway 2006) and LNG vessels (Vanem et al. 2007a), and ECDIS emerged as a cost-effective risk control option for all these shiptypes.

The possibility of formulating mandatory carriage requirements for ECDIS has been on the agenda of the Maritime Safety Committee (MSC) and the subcommittee on safety of navigation (NAV) at the International Maritime Organization (IMO). However, many delegates expressed the view that sufficient coverage of ENC would be a prerequisite for such mandatory carriage requirement.

In order to investigate the actual coverage of ENC in more detail, this paper compares global ship traffic densities with actual ENC coverage. In this way, the extent of holes in the global ENC coverage and its effect on the cost-effectiveness of ECDIS may be assessed. This will allow for a more accurate evaluation of ECIDS as a risk control option. This has been done for various shiptypes and representative shipping routes for the present situation as well as for the anticipated ENC coverage in 2010.

### 1.2 *ENC and ECDIS*

ENCs are vector charts compiled from a database of individual geo-referenced objects. IMO offer the following definition for ENC (IMO 1995): *ENC means the database, standardized as to content, structure and format, issued for use with ECDIS on the authority of government-authorized hydrographic offices. The ENC contains all the chart information necessary for safe navigation, and may contain supplementary information in addition to that contained in the paper chart (e.g. sailing directions) which may be considered necessary for safe navigation.* Being a database, ENC content may be continuously retrieved by special operational functions in ECDIS to give warnings of impending danger related to the vessel's position and its movements.

The IMO ECDIS Performance Standards (IMO 1995) defines ECDIS equipment as follows: *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/20 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.*

### 1.3 *Description of data sources*

Two types of data are essentially needed for this study, i.e. estimates of the distribution of the global ship traffic and information about the global coverage of ENCs.

For ship traffic distributions, AMVER and COADS data has been used (Endresen et al. 2003).

Global traffic distributions were hence based on a joint dataset containing both COADS and AMVER data corresponding to a complete year. The ship traffic density from this dataset is illustrated in Figure 1.

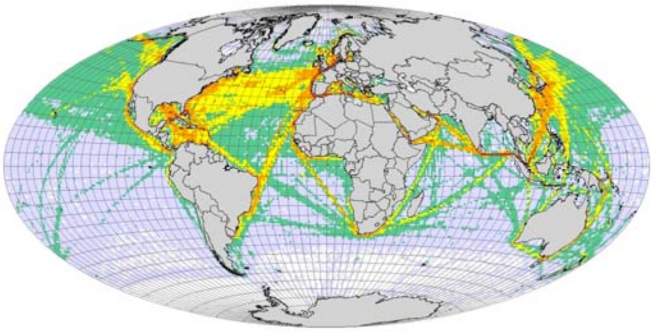

Fig. 1. Combined AMVER and COADS data for one year 2000/2001

An overview of the worldwide coverage of ENC is provided by the online catalogue of the International Hydrographic Organization's (IHO) website (http://www.iho.shom.fr). The catalogue distinguishes between ENCs that are commercially available and ENC that will be available in the near future. The coverage may be investigated for different usage bands, i.e. *overview*, *general*, *coastal*, *approach*, *harbour* and *berthing*. There are known to be some gaps in the IHO ENC catalogue, thus the results based on this source will tend to be somewhat conservative. The coverage of commercially available ENCs with resolution *coastal* or better according to this catalogue is illustrated in Figure 2.

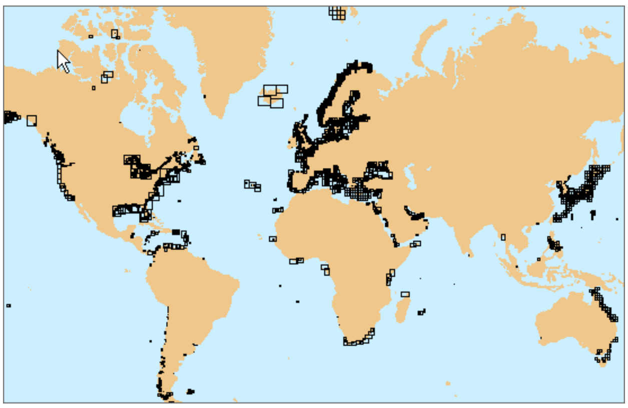

Fig. 2. Global coverage of commercially available ENCs of coastal or better resolution according to the IHO catalogue

## 2 GLOBAL ENC COVERAGE

### 2.1 *Suitable ENC coverage*

In order to estimate the global coverage of ENC, it is necessary to regard ENCs as suitable or not. For the purpose of this study an ENC is assumed suitable if it contains sufficient level of detail for safe navigation for the specific area it covers. It is further assumed that ENCs labelled *coastal* or better will be suitable for navigation in waters within 20 nautical miles from the shore. I.e., suitable ENC coverage will be assumed for all parts of a voyage closer to shore than 20 nautical miles where officially approved ENCs of scale *coastal* or larger are available. In open waters further away from shore, *general* or *overview* ENCs are deemed sufficient.

### 2.2 *ENC coverage for SOLAS ships*

Worldwide coverage of ENC has been mapped to global ship traffic distributions in order to investigate the percentage of the global traffic that operates in areas with sufficient ENC coverage, i.e. available ENC coverage of resolution *coastal* or better for all stretches of the trade closer than 20 nautical miles to shore. World traffic patterns have been collected for one complete year 2000/2001, and these traffic distributions have been utilized. The world traffic pattern is assumed unchanged in 2007 and 2010 compared to this dataset.

The ship traffic is reported on a global grid with a 1x1 degree grid cell resolution. The size of the observation grid cells introduces considerable uncertainties into this part of the study, and two different approaches have been employed in order to estimate which part of the traffic takes part in areas close to shore. The first approach is to count the traffic in all the grid cells intersecting with the 20 nm band. The second approach is to count only the traffic in the grid cells whose centre point intersects with the 20 nm band. These counting approaches will be referred to as intersecting and centre-intersecting, respectively. It is noted that the intersecting counting approach will regard notable more traffic to be within the coastal bands.

Two similar approaches have been employed in order to estimate whether there is ENC coverage within a cell or not, i.e. where there are ENC coverage intersecting with any part of a cell and where there are ENC coverage intersecting with the centre of the grid cell respectively. Thus, there will be four estimates of the ENC coverage based on the possible combinations of the two counting approaches. The most conservative approach is to use the intersecting traffic grid cell counting approach for traffic estimation coupled with the ENC centre-intersecting grid cell counting approach for ENC coverage estimation.

Accordingly, a conservative estimate of the percentage of world shipping traffic within 20 nm to shore having sufficient ENC coverage is 82% for 2007. The most optimistic estimate is 94%. Thus, the percentage of the current world shipping trade having suitable ENC coverage along their voyages are between 82% and 94%. For 2010, this is anticipated to increase to 85% and 96% respectively.

Comparing the results for the anticipated ENC coverage in 2010 to the current estimates, a slight increase is expected. This is attributable to ongoing or planned activities at various national hydrographic offices. However, the increase is insignificant, and this is explained by the fact that ENC coverage is already quite extensive along coastal areas that carry a great portion of the world ship traffic.

Estimates of the ENC coverage were also broken down on four major shiptypes according to the differences in trading patterns among these. The most conservative estimates are presented in Table 1, for the current situation as well as the anticipation for 2010. It can be seen that the variation between the different shiptypes are not significant, and all the four shiptypes that were investigated are associated with ENC coverage around the global average and well above 80%. Container ships were found to have the highest coverage of more than 90%.

Table 1. Percentages of world ship traffic within 20 nm to shore with sufficient ENC coverage – major shiptypes.

| Ship type | 2007 | 2010 |
|---|---|---|
| Bulk carrier | 82.4 | 84.4 |
| Tanker | 84.9 | 86.8 |
| Container ship | 90.4 | 91.4 |
| General cargo ship | 86.4 | 87.9 |

## 3 SPECIFIC REPRESENTATIVE ROUTES

In order to evaluate the effect of holes in the ENC coverage, particular routes and shiptypes have been selected for more detailed investigation. These are representative of the global traffic of merchant shipping, in terms of reflecting both the most common shiptypes and the busiest waters. For the purpose of this study, eleven routes were selected as representatives for the world seaborne trade, i.e. three typical oil tanker routes, three bulk carrier routes, two container vessel routes, one general cargo route, one LNG carrier route and one chemical tanker route. The selected routes, which are indicated on a world map in Figure 3, are:

- Oil tankers:
  1. Dammam, Saudi Arabia – Yokohama, Japan
  2. Yanbu, Saudi Arabia – Galveston, TX, USA
  3. Yanbu, Saudi Arabia – Barcelona, Spain
- Container vessels:
  4. Singapore, Singapore – Rotterdam, Holland
  5. Hong Kong, China – Long Beach, CA, USA
- Bulk carriers:
  6. Newcastle, Australia – Qinhuangdao, China
  7. Vitoria, Brazil – Hamburg, Germany
  8. Vancouver, Canada – Salvador, Brazil
- General cargo vessels:
  9. Helsinki, Finland – Cadiz, Spain
- Chemical tankers:
  10. Rotterdam, Holland – Savannah, GA, USA
- LNG carriers:
  11. Point Fortin, Trinidad & Tobago – Everett, MA, USA

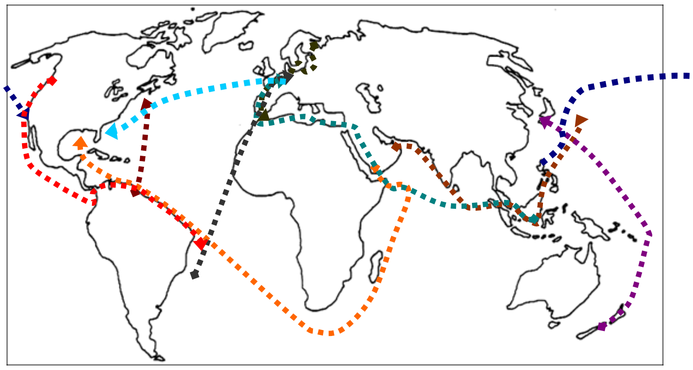

Fig. 3. Specific routes selected to represent global shipping

## 4 THE EFFECT OF LACK OF ENC COVERAGE

Previous studies have developed comprehensive risk models based on Bayesian Networks and spreadsheet models for accidents related to navigational failure (Norway 2005). The risk models developed in these previous studies were utilized also in the current study in order to assess the effect of holes in the ENC coverage along ship trades. In these risk analyses, the frequency of grounding due to navigational error (powered grounding) was estimated based on the definition of three types of waters, i.e. open waters, coastal waters and narrow waters. The effect of ECDIS and hence of the extent of ENC coverage will be different for these types of waters. For the purpose of this study, the types of water are defined in the following way:

- Open waters: > 5 nm from shore
- Coastal waters: 2 - 5 nm from shore
- Narrow waters: < 2 nm from shore

In order to investigate the ENC coverage along the selected routes, the IHO global ENC catalogue has been used to assess the availability of suitable ENCs together with detailed route descriptions and estimates of the time of voyage for each of the selected routes. An additional three day in port has been assumed for each trade.

The effect of holes in the ENC coverage along a route will be less risk reduction attributable to ECDIS. In areas where suitable ENCs are not available, no benefits from ECDIS are assumed. I.e. no risk reduction is ascribed to ECDIS in raster mode. For the purpose of this study, it is assumed that the effect of such holes is proportional to the ratio of the route in coastal and narrow waters where ENC coverage is insufficient, i.e. the ratio of the route closer to shore than 5 nautical miles where suitable ENC is not available. Thus, the net risk reducing effects of ECDIS, $\Delta R_{NET}$ will be reduced accordingly.

$$\Delta R_{NET} = \Delta R_{ECDIS} \times \frac{ENC_{CN}}{(ENC + No\ ENC)_{CN}} \quad (1)$$

In equation (1), $\Delta R_{NET}$ denotes the net risk reducing effect of ECDIS for the selected route, $\Delta R_{ECDIS}$ denotes the risk reducing effect of ECDIS for areas where suitable ENCs are available (about 38% according to previous studies (Denmark & Norway 2006), assuming dual ECDIS). $ENC_{CN}$ denotes the distance along the route in coastal or narrow waters with suitable ENC coverage and $(ENC + No\ ENC)_{CN}$ is the total distance along the route in coastal or narrow waters. These distances have been investigated for the 11 selected routes.

It is noted that this study only accounts for the effect of grounding risk reduction. It is acknowledged that also other navigational risks may be reduced, e.g. related to collision, and the estimates of risk reduction used in this study should therefore be regarded as conservative.

It is considered out of scope of this paper to present the investigation of each of the eleven routes in detail. The investigation of one of the routes will be explained in more detail as a proxy, and it is noted that the remainder of the routes are investigated in a similar manner. Hence, in the following, the investigation of the route between Yanbu, Saudi Arabia and Barcelona, Spain will be outlined.

### 4.1 *Examining the Yanbu – Barcelona trade*

The route between Yanbu in Saudi Arabia and Barcelona, Spain, covers about 2100 nautical miles, from the Red Sea, through the Suez Canal and past the south tips of Sicily and Sardinia to the west coast of Spain. 575 nautical miles of this route is closer to shore than 20 nautical miles (27%), 187 nautical miles is closer to 5 nautical miles (9%) and 96 nautical miles is closer than 2 nautical miles (4%). The route is illustrated in Figure 4, and the ENC coverage for this route is illustrated in Figure 5. The characteristics of the route together with the ENC coverage are presented in Table 2. The voyage excluding time in port is estimated to take about 6 days.

The characteristics of this route have been used to obtain the probability of critical course per year. The corresponding annual grounding frequencies for ships sailing this trade are presented in Table 3, including estimates with and without ECDIS. It is noted that for this particular route, the ENC coverage is already quite extensive, and there are no anticipated increase in ENC coverage within 2010.


Fig. 4. Route from Yanbu to Barcelona

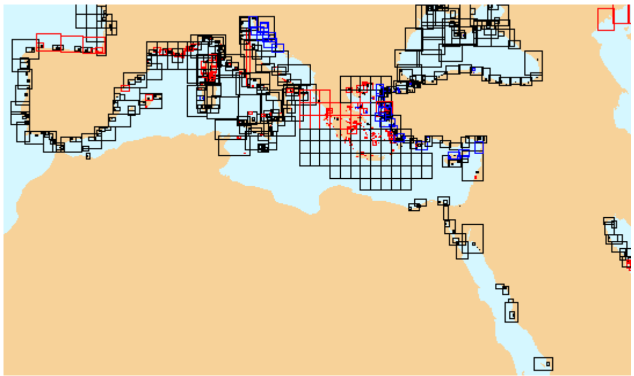

Fig. 5. ENC coverage along the route Yanbu – Barcelona

Table 2. Route characteristics and ENC coverage for the route Yanbu – Barcelona.

| | Total | < 20 nm | < 5 nm | < 2 nm |
|---|---|---|---|---|
| Distance | | | | |
| nm | 2154 | 575 | 187 | 96 |
| % | 100 | 27 | 9 | 4 |
| ENC coverage | | | | |
| 2007 | | 95% | 94% | 98% |
| 2010 | | 95% | 94% | 98% |

Table 3. Annual grounding frequencies (per shipyear) and frequency reduction for the route Yanbu – Barcelona.

| | Without ECDIS | 100% ENC coverage | Actual ENC coverage |
|---|---|---|---|
| Frequency | $7.2x10^{-2}$ | $4.6x10^{-2}$ | $4.8x10^{-2}$ |
| Frequency reduction | | 38% | 36% |
| Groundings averted | | $2.8x10^{-2}$ | $2.6x10^{-2}$ |

### 4.2 *Estimated grounding risk reduction in light of actual ENC coverage*

Similar exercises have been performed for the 10 other routes as well, and the ENC coverage, grounding frequency reduction and the expected number of averted groundings per shipyear are summarized for all of the selected routes in Table 4 (only for the current situation).

Table 4. Estimated grounding frequency reduction and groundings averted due to ECDIS with current ENC coverage.

| | ENC Coverage (< 5 nm) | Grounding frequency reduction | Groundings averted (per shipyear) |
|---|---|---|---|
| Dammam - Yokohama | 41% | 15% | $7.2x10^{-3}$ |
| Yanbu - Galveston | 57% | 22% | $1.8x10^{-3}$ |
| Yanbu - Barcelona | 94% | 36% | $2.6x10^{-2}$ |
| Singapore - Rotterdam | 63% | 24% | $1.5x10^{-2}$ |
| Hong Kong - Long Beach | 100% | 38% | $3.1x10^{-3}$ |
| Newcastle - Qinhuangdao | 28% | 11% | $1.3x10^{-3}$ |
| Vitoria – Hamburg | 65% | 25% | $8.7x10^{-3}$ |
| Vancouver - Salvador | 49% | 19% | $7.9x10^{-3}$ |
| Helsinki - Cadiz | 100% | 38% | $1.2x10^{-2}$ |
| Rotterdam - Savannah | 100% | 38% | $8.9x10^{-3}$ |
| Point Fortin - Everett | 100% | 38% | $8.1x10^{-3}$ |

The following general observations can be made based on the examination of the selected routes:
- 4 of the 11 selected routes already have 100% ENC coverage in coastal areas
- 6 of the 11 selected routes sees no anticipated changes in the ENC coverage from 2007 to 2010
- The estimated grounding frequency reductions due to ECDIS, in light of actual ENC coverage, are between 11 and 38% for the selected routes
- The different routes have ENC coverage between 28% and 100% for stretches closer to shore than 5 nm. The global ENC coverage for ship traffic closer to shore than 10 nm was estimated to be between 84 – 96%.

### 4.3 *Cost effectiveness of ECDIS in light of actual ENC coverage for selected routes*

The cost effectiveness corresponding to implementing ECDIS on a newbuilding expected to sail its entire life-time on each of the selected routes have been estimated and the corresponding GCAF (Gross Cost of Averting a Fatality) and NCAF (Net Cost of Averting a Fatality) (see definitions in Norway (2000)) values are presented in Vanem et al. (2007c). In estimating the cost effectiveness, the effect of reduced probabilities for oil spills are taken into account based on the recently proposed CATS approach, as described in Vanem et al. (2007b).

Based on these results, the following general observations can be made, all of which are equally true for 2007 as for 2010:
- GCAF > USD 3 million for all routes. This is due to the generally low fatality rates in grounding accidents for cargo ships, and hence a somewhat limited effect of ECDIS in terms of saving lives.
- NCAF < 0 for all routes except one, indicating that ECDIS is a cost effective risk control option.
- For cargo ships, the most important effect of ECDIS is the environmental and property protection in case of grounding.
- NCAF > USD 3 million for the route with poorest ENC coverage only. Hence, ECDIS will only cease to be cost effective on particular routes with poor ENC coverage.

## 5 GENERIC COST EFFECTIVENESS OF ECDIS IN LIGHT OF ENC COVERAGE

The cost effectiveness of ECDIS, taking the actual ENC coverage into account, has been estimated for particular routes. However, in order to formulate recommendations for the world fleet, some globally applicable estimates are required. Thus, the arithmetic average reduction in grounding risk for all routes will be assumed to represent the global risk reduction from ECDIS implementation, i.e. for the current situation: $9.1 \times 10^{-3}$ groundings averted per shipyear (this would increase to $1.0 \times 10^{-2}$ groundings averted per shipyear for the anticipated ENC coverage in 2010).

Different shiptypes are associated with very different accident costs, and some global average will be needed. It was found that the accident costs are considerably higher for oil tankers than for other cargo ships, mainly due to the high costs associated with major oil spills, and that the accident cost generally increase with ship size. Hence, a simple average accident cost per GT will be assumed for oil tankers and other cargo ships respectively. The following average accident costs were derived based on the cost model established by Spouge (2002), but adopting the CATS approach to account for prevention of oil spills:
- Oil tankers: 720 USD/GT
- Other cargo ships: 120 USD/GT

The expected number of fatalities in a grounding accident is generally a function of crew size and shiptype. The crew size is generally a function of the size of the ship, but an average crew size of 25 has been assumed for all ships for the purpose of obtaining average estimates. According to the risk models utilized in this study, the corresponding average fatality rate per grounding accident, applicable to all shiptypes, is 0.01 fatalities per grounding event.

An average expected lifetime of 25 years is assumed for all vessels. All estimates are assumed to be valid for all SOLAS ships larger than 500 GT. Ships smaller than this is considered out of scope of this study. Based on these assumptions as well as estimates related to the cost of ECDIS acquisition, installation and maintenance, generic cost effectiveness estimates for new and existing cargo ships may be obtained.

### 5.1 *Cost effectiveness for newbuildings*

GCAF values associated with implementing ECDIS on newbuildings are USD 30 million. This would be reduced to USD 27 million for the anticipated coverage in 2010. The NCAF value will generally be a function of shiptype and size due to large variations in accident costs.

For oil tankers, ships of 500 GT are associated with an NCAF of USD 8.2 million. It can be shown that NCAF will be less than USD 3 million for all ships greater than 630 GT and negative for ships larger than 700 GT. Hence, ECDIS have been assessed to be cost effective for all new oil tankers larger than 630 GT.

For other cargo ships, ships of 500 GT are associated with an NCAF of USD 26 million. It can be shown that NCAF will be less than USD 3 million for all ships greater than 3800 GT and negative for ships larger than 4200 GT. Hence, ECDIS have been assessed to be cost effective for all new cargo ships, other than oil tankers, larger than 3800 GT.

### 5.2 *Cost effectiveness for retrofit on existing ships*

For existing ships, the cost effectiveness achievable from implementing ECDIS will be a function of the ship age. However, it can be shown that GCAF will never be less than USD 3 million, which has been used as cost effectiveness criteria in FSA applications at IMO.

The NCAF value corresponding to implementing ECDIS on existing cargo ships will generally be a function of the shiptype, the ship size and the ship age. The size of ships that correspond to NCAF < USD 3 million and NCAF < 0 have been calculated for various ship ages and are summarized in Tables 5 (for oil tankers) and 6 (for other cargo ships) respectively.

Table 5. Oil tanker sizes corresponding to NCAF < USD 3 million and NCAF < 0.

| Ship age | Ship size (GT) | |
|---|---|---|
| | NCAF < USD 3M | NCAF < 0 |
| Newbuilding | 630 | 700 |
| 5 years | 720 | 780 |
| 10 years | 870 | 920 |
| 15 years | 1200 | 1200 |
| 20 years | 2000 | 2100 |
| 24 years | 9300 | 9300 |

Table 6. Other cargo ship sizes corresponding to NCAF < USD 3 million and NCAF < 0.

| Ship age | Ship size (GT) | |
|---|---|---|
| | NCAF < USD 3M | NCAF < 0 |
| Newbuilding | 3800 | 4200 |
| 5 years | 4300 | 4700 |
| 10 years | 5200 | 5500 |
| 15 years | 7000 | 7300 |
| 20 years | 12,000 | 13,000 |
| 24 years | 56,000 | 56,000 |

## 6 CONCLUSIONS

The coverage of ENC in coastal waters have been investigated and compared to global ship traffic data. It was found that the actual worldwide coverage of suitable ENC lie between 82% and 94% for SOLAS ships. A selection of specific trades was made, and the ENC coverage along these routes varied from 28% to full coverage. In light of this, the cost effectiveness of ECDIS as a risk control option for new and existing cargo ships has been evaluated.

The Gross Cost of Averting a Fatality will exceed USD 3 million for all cargo ships. However, considering the Net Cost of Averting a Fatality, ECDIS emerged as cost effective for many combinations of ship types, sizes and ages. In general, there are major differences between oil tankers and other types of cargo ships. This is mainly due to the high costs ascribed to major oil spills. Indeed, for cargo ships, averting oil spills was found to be the most important aspect of averting grounding accidents in terms of significant contributions to accident cost savings.

The cost effectiveness in terms of NCAF as a function of ship size and age has been evaluated, and recommendations regarding carriage requirements for ECIDS may be based on these results. Thus, based on the analysis presented herein and IMO criteria, it may be recommended that ECDIS be made mandatory for:

– All new oil tankers of 500 gross tonnage and upwards.
– All new cargo ships, other than oil tankers, of 3000 gross tonnage and upwards.
– All existing oil tankers of 3000 gross tonnage and upwards.
– All existing cargo ships, other than oil tankers, 10,000 gross tonnage and upwards.

## 7 ACKNOWLEDGEMENTS

This study has been carried out with the support from the Finnish Maritime Administration, Norwegian Mapping Authority – Hydrographic Service, Swedish Maritime Administration and National Survey and Cadastre (Denmark). Results from the study have been reported to IMO (NAV 53).

## REFERENCES

Denmark and Norway (2006). "FSA Study on ECDIS/ENCs", Submitted by Denmark and Norway, MSC 81/24/5, IMO.

Endresen, Ø, Sørgård, E, Sundet, JK, Dalsøren, SB, Isaksen, ISA, Berglen, TF and Gravir, G (2003). "Emission from international sea transportation and environmental impact", Journal of Geophysical Re-search, Vol 108, 4560.

IMO (1995). "Performance standards for electronic chart display and information systems (ECDIS)", IMO resolution A.817(19).

IMO (2002). "Guidelines for Formal Safety Assessment (FSA) for use in the IMO rule-making process". MSC/Circ.1023 - MEPC/Circ.392, IMO.

Norway (2000). "Formal Safety Assessment – Decision parameters including risk acceptance criteria", Submitted by Norway, MSC 72/16, IMO.

Norway (2005). "FSA – Large Passenger Ships - Navigational Safety", Submitted by Norway, NAV 51/10, IMO.

Spouge, JR (2002). "A Simple Model of the Costs of Ship Accidents Rev 1", DNV Job No C383184/5.

Vanem, E, Antão, P, Castillo, F and Skjong, R (2007a). "Formal Safety Assessment of LNG Tankers", Proc 10th International Symposium on Practical Design of Ships and Other Floating Structures, PRADS 2007.

Vanem, E, Endresen, Ø and Skjong, R (2007b). "CATS – Cost-Effectiveness in Designing for Oil Spill Prevention", Proc 10th International Symposium on Practical Design of Ships and Other Floating Structures, PRADS 2007.

Vanem, E, Gravir, G and Eide, MS (2007c). "Effect of ENC Coverage on ECDIS Risk Reduction", DNV Report no. 2007-0304, Det Norske Veritas. http://research.dnv.com /skj/FSA-ENC/ENC.pdf