ANY OTHER BUSINESS

FSA Study on ECDIS/ENCs

Submitted by Denmark and Norway

SUMMARY

Executive summary: This document contains a summary of an FSA study on ECDIS/ENCs. This study is referred to in document MSC 81/23/13 containing proposals for new work programme items for NAV and STW.

Action to be taken: Paragraph 3

Related documents: MSC 81/23/13, MSC 81/INF.9

Introduction

1 Document MSC 81/23/13 by Denmark and Norway is titled “Proposal for a new work programme item for NAV on carriage requirements for ECDIS, and for STW on ECDIS Training and familiarization”. In that document a number of references are made to an ongoing FSA study on ECDIS/ENCs. This study is now finalized, and the results and recommendations of this FSA study are reported at annex.

2 A more detailed report on the Risk Assessments (Annex I) as well as the Cost Benefit Assessments (Annex II) performed in this FSA study, is included in document MSC 81/INF.9. The INF-document is in black-and-white only, and can be obtained with some figures in colours at: http://research.dnv.com/skj/FSA-ECDIS/ECDIS.htm

Action requested of the Committee

3 The Committee is requested as follows:

.1 to take this document into account in relation to its consideration of the proposals contained in document MSC 81/23/13; and

.2 to refer this document to NAV 52 for further consideration.

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1 CONCLUSIVE SUMMARY

A joint project was established involving the Norwegian Maritime Directorate (NMD), Norwegian Hydrographic Service (NHS), Swedish Maritime Administration (SMA), Danish Maritime Authority (DMA) and the United Kingdom’s Maritime and Coastguard Agency (MCA) to carry out a study on the cost effectiveness of Electronic Chart Display and Information System (ECDIS). The four countries participating each paid one quarter of the total cost. The background is the FSA study for Large Passenger Ships Navigation (NAV 51/10) that proved that ECDIS is a cost effective risk control options for large passenger vessels.

In the present study, a cost benefit assessment has been undertaken to evaluate the cost effectiveness of this measure for other vessel types as well. The focus has been kept on ECDIS as a risk control option to reduce the grounding risk.

To evaluate the cost effectiveness of ECDIS for the world fleet, limited time and resources makes it impossible to study the whole fleet with all vessel types and sizes. The present study has therefore selected three cases that are expected to have different cost effectiveness due to the differences in the nature of the trade, cargo, etc. The intention has been to use these cases to generalize for other segments of the fleet. After detailed consideration, the following cases were chosen:

- Tanker for Oil, 80,000 DWT (approx. 40,000 GT) trading between the Middle East (Kuwait) and the Mediterranean (Marseille, France)
- Product Tanker, 4,000 DWT (approx. 2,000 GT), trading between Mongstad (Norway) and Stockholm (Sweden)
- Bulk Carrier, 75,000 DWT (approx. 38,000 GT), carrying Coal between Newcastle (Australia) and Tokyo (Japan).

These choices are based on world fleet statistics, world main trade routes, and vessel size distribution on these routes.

Based on a cost-effectiveness assessment of ECDIS for these cases, the following has been concluded:

- ECDIS, as defined in IMO’s performance standard, is cost effective for the three selected cases.
- The proven cost effectiveness of ECDIS for these cases can also be considered valid for all other vessel types in international trade. It is valid for all vessel sizes, with the exception of the smaller vessels.
Due to a very small reduction in number of saved lives, the GrossCAF values are high, which indicates that as a measure to save lives, ECDIS is not a cost effective measure. However, the NetCAF value is negative, which indicates that the RCO is beneficial in itself, i.e. the net economic benefit exceeds the cost of implementation.

The ratio between costs and benefits is in the range of 2-5 for the three selected cases. With the high GrossCAF, the ratio between costs and benefits is almost equivalent to the robustness of the conclusion result (i.e. the results are robust with a factor of 2 to 5). The robustness of the generalization to all vessel types is considered equal.

If the suggested “willingness-to-pay” to avoid a ton of oil spilt of $60,000 developed in ref. /2/ had been used instead of only direct cost of an oil spill, the environmental cost would have increased significantly, especially for large tankers. For the largest tanker case (80,000 dwt), the total economical benefits would have increased by a factor of 3.5. For smaller tankers the effect is less, in the order of 20% for the smallest tanker case (4,000 dwt). The robustness of the Cost Benefit Assessment will increase accordingly. However, the present cost-benefit assessment is based on direct costs of an oil spill only, and not the “willingness-to-pay” value.

An important condition for this robustness is the assumption of 100% Electronic Navigational Charts (ENCs) coverage for the evaluated cases. For routes where only parts of the track are actually covered, the effect is less. It is assumed that if ECDIS is installed, it is also in use and operated by qualified and trained personnel.

The presented results are thus considered robust for the two large vessel cases, but less robust for the smaller tanker case. There could also be other potential economic benefits, e.g. fewer business interruptions and long term effects like improved company reputation, which are not considered. Neither is the additional risk reducing effect that ECDIS may have on the collision risk analysed. Taking this into consideration would make ECDIS even more cost-effective.

2 Introduction

According to FSA Large Passenger Ships Navigation (NAV 51/10), ECDIS is one of the risk control options that proved to be cost effective for large passenger vessels. The Gross Cost of Averting a Fatality (GrossCAF) was just $2,000 for ECDIS. The Net Cost of Averting a Fatality (NetCAF), which takes into account potential economic benefits, was negative, indicating that the net economic benefits exceeded the costs. ECDIS could therefore be introduced both for economic reasons as well as a cost effective measure to save lives.

In the present study, a cost benefit assessment has been done to evaluate the cost effectiveness of this measure for other vessel types as well. The FSA study reference above have been used, updated and extended to be useful as a basis for decision-making at IMO relating to ECDIS in general, for all vessel types.

2.1 Objective and Scope of Work

The objective is to carry out a Formal Safety Assessment, including cost benefit assessment of Electronic Chart Display and Information System (ECDIS) for relevant vessel types (excl. High Speed Crafts). The cost effectiveness will be measured as Gross/Net CAF values, i.e. the cost invested of averting a fatality.
The following tasks have been carried out:

- Define a set of representative vessel types and trades
- General study on ECDIS and the effect of ECDIS
- Update and extend the risk model for grounding to become valid for an extended set of vessel types. The detailed modelling has been carried out for two vessel types, and extended to other vessel types by more general considerations
- Quantify risk reducing effect of ECDIS, costs of implementation and potential economic benefits to calculate GrossCAF and NetCAF values for the selected cases
- General considerations of other vessel types and sizes
- Reporting

2.2 Limitations

The FSA focuses on risk for personnel, risk of environmental damage and risk for property damage.

Limited time and resources makes it impossible to study the whole fleet with all vessel types and sizes. The present study has therefore selected three cases that are expected to have different cost effectiveness due to the differences in the nature of the trade, cargo, etc. The intention is to use these cases to generalize for other segments of the fleet.

The choice of routes used for the estimation of number of dangerous courses is supposed to represent a typical trade for the vessel type and size in question. Routes are assessed to be either neutral or conservative for the cost effectiveness calculations.

The study has assumed 100% Electronic Navigational Charts (ENCs) coverage for the evaluated cases. For routes where only parts of the track are actually covered, the effect is less, and considered low (down to 0) for areas with no coverage. However, availability of an ECDIS system onboard enables use of Raster Navigational Charts (RNCs) when ENCs are not available. This could have a certain positive effect on the navigators understanding of the fairway, in addition to use of paper charts. However, this effect has not been quantified.

For areas with full coverage, it is assumed that paper charts for these areas are not required to be carried on board.

Statistics have been used to coarsely calibrate the results from the modelling, however, statistics are not considered to be the correct answer. Fatalities as a result of groundings are very rare, and fatality rates based on the available statistics are highly sensitive to single events. The result from the modelling is therefore considered a better estimate on what is the actual risk level for grounding relevant vessel types.
2.3 Abbreviations

DMA  Danish Maritime Authority  
DNV  Det Norske Veritas  
ECDIS  Electronic Chart Display and Information System  
ENC  Electronic Navigational Chart  
FSA  Formal Safety Assessment  
GrossCAF  Gross Cost of Averting a Fatality  
HSC  High Speed Crafts  
IMO  International Maritime Organization  
MCA  Maritime and Coastguard Agency  
NetCAF  Net Cost of Averting a Fatality  
NHS  Norwegian Hydrographic Service  
NMD  Norwegian Maritime Directorate  
RCO  Risk Control Option  
SMA  Swedish Maritime Administration

3 METHOD OF WORK

The FSA methodology used in the study is described in Figure 3-1.

![Flowchart](Image)

**Figure 3-1 The five steps of Formal Safety Assessment**

The work has been based on the previous study for Large Passenger Ships, ref./1/, however adjusted to evaluate other vessel types.
The main work in the project has been carried out by risk analysts, listed in Annex I – Appendix D. The work with the risk assessment and the cost effectiveness assessment was done consecutively. This approach has the advantage that the risk models were reviewed in detail when the cost effectiveness assessment was carried out.

The risk model is based on Bayesian theory and network models were made for a grounding accident scenario. The models are based on ref. /1/, developed further to be valid for new vessel types by a team of risk analysts, and the process was supported and reviewed by navigational experts.

The costs and economic benefits combined with risk reducing effect from the model for selected cases has been used to evaluate the cost effectiveness of ECDIS for all vessel types.

The study was initiated in September, and most of the work was carried out in November/December 2005.

4 DESCRIPTION OF THE RESULTS ACHIEVED

4.1 Step 1: Hazard Identification

There has not been a need for a separate Hazard Identification for this project. The study has been carried out based on ref. /1/, with additional input from navigators on specific issues related to the new vessel types.

4.2 Step 2: Risk Assessment

The objective of FSA Step 2 is to establish a risk model of all important influencing factors involved in avoiding grounding, and to quantify the risk level. The model is based on the need to analyse and evaluate the risk reducing effect of the ECDIS system.

The goal is to evaluate ECDIS as a risk control option for all vessel types, except high speed crafts. As stated earlier, the whole world fleet with all vessel types and sizes has not been studied in detail due to the complexity and size of such a task. The present study has therefore selected three cases that are expected to have different cost effectiveness due to the differences in value of vessel, cargo, nature of the trade, etc. The intention is to use these cases to generalize for other segments of the fleet.

Based on detailed considerations, the following vessels, sizes and trades were chosen:

- Tanker for Oil, 80,000 DWT (approx. 40,000 GT) trading between the Middle East (Kuwait) and the Mediterranean (Marseille, France)
- Product Tanker, 4,000 DWT (approx. 2,000 GT), trading between Mongstad (Norway) and Stockholm (Sweden)
- Bulk Carrier, 75,000 DWT (approx. 38,000GT), carrying Coal between Newcastle (Australia) and Tokyo (Japan).

These choices are based on world fleet statistics, world main trade routes, and vessel size distribution on these routes. Tankers and bulk carriers represent about 65% of the world fleet measured in gross tonnage, thus this is a natural choice. In addition, in order to establish a basis
for drawing general conclusions on cargo ships, it was decided to include a ship type providing the combination of relatively low value of the ship itself; low value of its cargo as well as low pollution potential. The bulk carrier carrying coal was chosen for this purpose.

The modelled results as well as statistical risk levels are presented in Table 4-1.

**Table 4-1 Comparison of risk level, modelled and statistical**

<table>
<thead>
<tr>
<th>Ship Type</th>
<th>Modelled Grounding Frequency</th>
<th>Modelled Fatality Frequency</th>
<th>Statistical Grounding Frequency</th>
<th>Statistical Fatality Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tank 80' DWT (Kuwait-Marseille)</td>
<td>$7.0 \times 10^{-2}$</td>
<td>$3.4 \times 10^{-4}$</td>
<td>$6.4 \times 10^{-3}$</td>
<td>$4.5 \times 10^{-5}$</td>
</tr>
<tr>
<td>Tank 4' DWT (Mongstad-Stockholm)</td>
<td>$1.2 \times 10^{-1}$</td>
<td>$3.2 \times 10^{-4}$</td>
<td>$6.4 \times 10^{-3}$</td>
<td>$4.5 \times 10^{-5}$</td>
</tr>
<tr>
<td>Bulk 75' DWT (Newcastle-Tokyo)</td>
<td>$3.2 \times 10^{-2}$</td>
<td>$5.0 \times 10^{-4}$</td>
<td>$1.6 \times 10^{-2}$</td>
<td>$7.6 \times 10^{-5}$</td>
</tr>
</tbody>
</table>

1) The statistics are based on the Lloyd’s Fairplay casualty database.

It needs to be emphasized that the modelled frequencies are route specific, and can not be directly compared to the statistical frequencies.

The figures in the table above shows that a tanker of size 80,000 dwt trading between Kuwait and Marseille is expected to experience a grounding every 14 ship year, while the smaller tanker trading between Mongstad and Stockholm has a grounding return period of 8 year. The differences in these two return periods are mainly due to the nature of the trade (waters, geography, etc.), not the internal factors onboard the vessels.

For the bulk carrier case, sailing from Newcastle to Tokyo, the return period is 31 years. This does not mean that the bulk carrier in general is a safer vessel, but the choice of trade means that this ship is less exposed than, for example, the product tanker navigating along the challenging Norwegian coast and into the Baltic Sea.

Compared to statistics, the modelled frequency results are higher. For the tanker cases, the frequency for the selected trades is 10-20 times higher than world wide average statistics. For bulk carriers, the accident frequency is two times higher. There are mainly two reasons for this discrepancy. One reason is that the statistics do not include all grounding incidents. Numerous minor incidents are not reported, and this is accounted for in the modelled frequency. The other reason is that the model evaluates the risk of a specific route, whereas the statistics are generic data for the world fleet. This is more detailed explained in detail in Annex I.

In general, the accident statistics show that grounding scenarios give a very low contribution to the overall risk of fatalities compared to accident scenarios like foundering (especially for bulk carriers) and collisions (for both vessel types).
4.3 Step 3: Risk Control Option (RCO)

ECDIS is a navigation aid that can be used instead of nautical paper charts and publications to plan and display the ship’s route, plot and monitor positions throughout the intended voyage.

ECDIS is a real-time geographic information system. Its purpose is to continuously determining a vessel’s position in relation to land, charted objects, navigational aids and possible unseen hazards. In daily navigational operations, it should reduce the workload of the navigating officers compared to using paper charts. Route planning, monitoring and positioning will be performed in a more convenient and continuously real time way, enabling the navigator to have a continuous overview of the situation.

It is possible to integrate ECDIS with both the radar system and Automatic Identification System (AIS). However, this study considers a basic ECDIS system as described in the Performance Standard for ECDIS of IMO.

The main benefits of using ECDIS considered in this study include:

- Liberate time for the navigators to focus on navigational tasks
- Improved visual representation of fairway
- More efficient updating of charts

The effect of the RCO has been tested by comparing with a vessel with ECDIS installed and in use, with a vessel without ECDIS.

4.4 Step 4: Cost Benefit Assessment

The objective of the cost benefit assessment is to evaluate the cost effectiveness of introducing ECDIS as a mandatory requirement for all vessel types.

The Cost Benefit Assessment has consisted of studying the risk reducing effect expected from using ECDIS as a risk control option for selected segments of the fleet, i.e. for a 4,000 dwt product tanker, for an 80,000 dwt tanker for oil and for a 75,000 dwt bulk carrier, and the costs related to implementing the RCO.

The risk model described in Annex I shows that ECDIS has a risk reducing effect on grounding risk of around 36% for all three cases, which is also in line with previous research in the industry. This is a reduction in grounding frequency when the vessel is already on a dangerous course. The reason for the reduction is complex and is linked to elements (or nodes in the model) like: more available time on the bridge, better overview, updating routines etc. It is assumed that ECDIS is installed and used by qualified and trained personnel.

The costs and economic benefits of implementing the RCO are given in Table 4-2.
Table 4-2 Costs and benefits of implementing ECDIS

<table>
<thead>
<tr>
<th>Vessel Type/Size</th>
<th>Cost of implementation (NPV in $)*</th>
<th>Benefit of implementation (NPV in $)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tank 80’ DWT (Kuwait-Marseille)</td>
<td>75,000</td>
<td>396,000</td>
</tr>
<tr>
<td>Tank 4’ DWT (Mongstad-Stockholm)</td>
<td>75,000</td>
<td>175,000</td>
</tr>
<tr>
<td>Bulk 75’ DWT (Newcastle-Tokyo)</td>
<td>75,000</td>
<td>295,000</td>
</tr>
</tbody>
</table>

* Figures are given in Net Present Value.

The costs of implementation are assumed equal for all vessel types. This is due to the fact that the number of people that needs training is assumed the same for all vessel types and sizes analysed and that the type of equipment is the same. The benefits are in this study considered as reduced accident costs due to fewer accidents, using values for spill cost and property cost and subsequently finding the reduction in accident cost due to use of ECDIS.

Based on the costs, benefits and risk reducing effect, the GrossCAF and NetCAF values are presented in Table 4-3.

Table 4-3 GrossCAF and NetCAF for all RCOs

<table>
<thead>
<tr>
<th>Vessel Type/Size</th>
<th>Gross CAF [$]</th>
<th>NetCAF [$]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tank 80’ DWT (Kuwait-Marseille)</td>
<td>23,900,000</td>
<td>&lt; 0</td>
</tr>
<tr>
<td>Tank 4’ DWT (Mongstad-Stockholm)</td>
<td>14,600,000</td>
<td>&lt; 0</td>
</tr>
<tr>
<td>Bulk 75’ DWT (Newcastle-Tokyo)</td>
<td>16,000,000</td>
<td>&lt; 0</td>
</tr>
</tbody>
</table>

Due to a very small reduction in number of saved lives, the GrossCAF values are high, which indicates that as a measure for averting fatalities only, ECDIS is not a cost effective measure. However, the NetCAF value is negative, which indicates that the RCO is beneficial in itself, i.e. the net economic benefit exceeds the cost of implementation. The economical benefit is in this assessment only measured in terms of reduced accident costs. Other economical benefits, e.g. fewer business interruptions, are not considered. Neither is the effect ECDIS may have on the collision risk. Taking this into consideration might make the RCOs even more cost-effective.

The ratio between costs and benefits is in the range of 2-5 for the three selected cases. With the high GrossCAF, the ratio between costs and benefits is almost equivalent to the robustness of the conclusion result (i.e. the results are robust with a factor of 2 to 5).

The presented results are thus considered robust for the two large vessel cases, but less robust for the smaller tanker case. There could also be other potential economic benefits, e.g. fewer business interruptions and long term effects like improved company reputation, which are not considered. Neither is the additional risk reducing effect that ECDIS may have on the collision risk analysed. Taking this into consideration would make ECDIS even more cost-effective.

There are three factors that influence the cost effectiveness of a measure:

- Cost of implementation
- Economic benefits, in this case: reduced number of accidents and accident costs
- Number of saved lives
It has been concluded that the chosen cases can represent the world fleet, ref Annex I, and that a proven cost effectiveness of ECDIS for tankers and bulk carriers of the selected sizes also is valid for all other ship types in international trade.

It is valid for all vessel sizes, with exception of the smaller vessels. The results are valid for tankers down to 4,000 dwt, which corresponds to around 2,000 GT. The limit can be drawn further down, but the uncertainty is significant. Considering that the results for the 4,000 dwt tanker is not very robust, this report does not give a clear lower gross tonnage limit for which the analysis is valid.

The effect of ECDIS is based on 100% Electronic Navigational Charts (ENCs) coverage. For routes where only parts of the track are covered, the effect is less, and down to 0 for areas without coverage of neither ENCs nor Raster Navigational Charts (RNCs). The effect of using RNCs in areas with no ENC coverage has not been assessed.

4.5 Step 5: Recommendations

Based on the FSA of ECDIS the following is observed:

- ECDIS as defined in IMO’s performance standard is cost-effective for the three selected cases (4,000 dwt product tanker, 80,000 dwt tanker for oil and 75,000 dwt bulk carrier).
- The proven cost-effectiveness of ECDIS for these cases can also be considered valid for all other vessel types in international trade. It is valid for all vessel sizes, with exception of the smaller vessels. The lower limit has not been determined.
- Due to a very small reduction in number of saved lives, the GrossCAF values are high, which indicates that as a measure for averting fatalities only, ECDIS is not a cost effective measure. However, the NetCAF value is negative, which indicates that the RCO is beneficial in itself, i.e. the net economic benefit exceeds the cost of implementation.

5. REFERENCES

/1/ NAV 51/10 - Full report can be found at: http://research.dnv.com/skj/FSALPS/FSA-LPS-NAV.htm
/2/ Skjong, R, E Vanem and Ø Endresen Risk Evaluation Criteria SAFEDOR-D-4.5.2-2005-10-21-DNV