Enhanced Methodology for Impact Assessment of e-Navigation applications – the SMART case

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Maritime Post-graduate University
Established by IMO in 1983
Focus on Maritime Education, Capacity-Building & Research

Principal Financial Supporters
Government of Sweden
Nippon Foundation, Japan
City of Malmö
e-Navigation - bringing people together

International teams of interdisciplinary, enthusiastic Researchers
Outline

• Introduction
• Present Situation and State of the Art
• Assessment of Potential Impact of e-Navigation
• Training Needs and Requirements
• Preliminary Results and Discussion
• Outlook
From History to Modern ...

Disasters seems to be going on

TITANIC, 1912

Andrea Doria, 1956

Heine - Mataram, 1988

R. Schulte, 2009

Pictures: www.titanicuniverse.com; www.shipfriends.gr
Present situation ...

Maritime Accidents

Serious Losses 1996 - 2010
By Cause, All Vessel Type
(vessels > 500 GT)
Present situation ...

Vessel traffic in the North Sea per 2012 and Prognosis 2025
Present situation ...

• Safe and environmentally-friendly shipping

• Technological Development: substantial changes in ICT (Data exchange – volume, types, almost real-time)

• VTS – FOC – Unmanned ships and autonomous Navigation

Source: www.interschalt.com

Source: www.iunmanned-ship.org
Approaching to assess impact of e-Navigation

- IMO method to assess impact of e-Nav applications
- SMART – Navigation: Korean approach to implement IMO e-Navigation: more comprehensive impact assessment
  * non-SOLAS, including fishing & coastal ships
- Development of a method for quantification
- Case study “Korea” – application and results
e-Navigation aims and ambitions

Why accidents occur?

Main Causes

✓ Human Error: 75 ~ 96%
  among others:
  • Rothblum (2012)

✓ Multiple reasons combined
  Among others:
  • Höllnagel, Schröder-Hinrichs & Baldauf (2012)
  • Wagenaar & Groeneweg (1987)
e-Navigation aims: main tool kit applications

✓ 5 Prioritized Solutions
✓ 7 Risk Control Options (RCOs)
✓ 16 Maritime Service Portfolios (MSPs)

* Source: Annex 1 of NAV 59/6, p 20
IMO e-Navigation (MSC95, 2014)
- Expected Reduction of accidents for SOLAS ships: 22.8%

Nav. Acc.(43.2%) × total Direct Causes (52.7%) = 22.8%

HE(65%) × detailed DCs (94%) × c (65%) = 39.7%
TF (18%) × detailed DCs (82%) × c (65%) = 9.6%
EF (17%) × detailed DCs (30%) × c (65%) = 3.3%
SMART-NAVIGATION – Application and Coverage

**Scalability**

- **Non-SOLAS: SMART-phone like services**
  1. Provide NAS service to fishing boats and non-SOLAS ships for collision prevention
  2. Tug-Barges dumping dredged-sediments
  3. Sightseeing, Coastal Passenger boats
  4. Coastal Ship; Dangerous Cargo Carriers

**LTE Service**

- **5 Solutions**
- **6 RCOs**
- **16 MSPs**

65% for SOLAS Ships, 55% for non-SOLAS Ships
SMART-Navigation: SMART-phone like services
Non-SOLAS ships: S-mode. LTE-M + VDEs

<table>
<thead>
<tr>
<th>Items</th>
<th>Analog</th>
<th>Digital</th>
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<tbody>
<tr>
<td></td>
<td>VHF</td>
<td>3G</td>
</tr>
<tr>
<td>Data Sp’d</td>
<td>9.6 kbps</td>
<td>2.4-14.4 M</td>
</tr>
<tr>
<td>Compare</td>
<td>1</td>
<td>250-1500</td>
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</table>
**SMART-Navigation**

**Identification of RCOs relevant for non-SOLAS**

| RCO 1 : | Integration of navigation information & equipment including improved software quality assurance |
| RCO 2 : | Bridge alert management |
| RCO 3 : | Standardized mode(s) for navigation equipment |
| RCO 4 : | Automated and standardized ship-shore reporting |
| RCO 5 : | Improved reliability and resilience of onboard PNT |
| RCO 6 : | Improved shore-based services |
| RCO 7 : | Bridge and workstation layout standardization |
Impact Assessment: enhanced and comprehensive quantification

\[ AVSA = \sum (RSAD \times ARDC_{HF/TF/EF}) = \sum (RSAD \times c \times \sum RDCC_{HF/TF/EF}) = c \times \sum (RSAD \times \sum RDCC_{HF/TF/EF}) \]

where is:
- c = Coefficient (65% for SOLAS ships, 55% for non-SOLAS ships)
- AVSA = Actual Volume of selected accident to be reduced by e-navigation
- RSAD = Rate of selected accident distribution
- ARDC = Actual Rate of risk reduction of each direct cause to be reduced by e-navigation
- RDCC_{HE} = Rate of risk reduction of detailed direct cause of Human Error to be reduced by e-navigation
- RDCC_{TF} = Rate of risk reduction of each detailed direct cause of Technical Failure to be reduced by e-navigation
- RDCC_{EF} = Rate of risk reduction of each detailed direct cause of External Factor to be reduced by e-navigation
Case study: Quantify potential effect of SMART-Navigation

KMST Statistics (2009-2013)

- Total: 4,871
- Navigational Accidents
  - 43.5% among total
  - 64.1% among non-Fishing
  - 37.1% among SOLAS Ships
- Human Error: 90.7%
  cf. NMA: 43.2% (SOLAS), Human Error: 65%
### Case study: Quantify potential effect of SMART-Navigation

<table>
<thead>
<tr>
<th>Items</th>
<th>IMO e-Navigation</th>
<th>SMART-Navigation</th>
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</thead>
<tbody>
<tr>
<td>Reduction</td>
<td>22.8% + non-NA</td>
<td>56.6%</td>
</tr>
<tr>
<td>Navigational Accidents</td>
<td>22.8% (52.7%)</td>
<td>33.9% (65%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Fishing: 19.1%, non-F: 14.8%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• SOLAS: 9.2%, non-S: 24.7%</td>
</tr>
<tr>
<td>Other Accidents</td>
<td>Not provided</td>
<td>22.7%</td>
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<tr>
<td></td>
<td></td>
<td>• Fishing: 16.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• non-Fishing: 6.2%</td>
</tr>
<tr>
<td>SOLAS non-SOLAS</td>
<td>SOLAS only (22.8%)</td>
<td>• SOLAS ship: 13%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• non-SOLAS Ships: 43.6%</td>
</tr>
</tbody>
</table>
Challenges for improvement

Complexity:
e-Navigation will provide a mixture of applications, require interaction between a great variety of users

- Maritime Cloud
- Multi-Source Positioning & R-Mode MF DGNSS ; AIS Services
- Maritime Safety Information/Notices to Mariners Service
- Tactical Route Suggestion Service (shore/ship)
- Tactical Exchange of Intended Route (ship-ship and ship-shore)
- Dynamic Predictions
- SMART-Applications, ...

Questions:
What is the exact contribution to more safety?
How to ensure smooth introduction to achieve all potential benefits?
How can we avoid “e-Nav-assisted” accidents?
...

Simulation-based case studies to identify risk reduction factors and dependencies

Tactical route
- Shore-ship route suggestion
- Electronically transfer a route segment
- Display of intended route

Strategic route
- Long term planning
Simulation-based case studies (2)

Use of dynamic predictions

- Planning of safe, sustainable; time-and energy-efficient manoeuvre sequences
- Monitoring and correcting/adapting the manoeuvring process
Simulation-based case studies – synergy effects

Selected Outcome and Results for MET

Training should include:

- Type specific training (urgent user demand/need)
- Training on operational use, limits & possibilities
- Limitations of sensors and information given in the system
- Overall simple and easy to use
Summary, Conclusions and Outlook

• Assessment of potential impact of e-Navigation applications shall include not only SOLAS nut also Non-SOLAS vessels

• IMO Member states shall investigate maritime safety situation in their countries in detail to identify best solutions and priorities

• Application of SMART-Navigation tool kits can have significant impact on Safety of Navigation

• Learning from the past: Adequate training measures needs to be identified and implemented to ensure smooth introduction and avoid e-Navigation-assisted accidents

• Identification and quantification of risk reduction factors
Thank you for your attention!
Awaiting your questions!

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