Conventional Vessels and Marine Autonomous Surface Ships – A Love Marriage?

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Agenda

- Definitions & Terms of Reference
- Background
- WMU’s Contribution to the MASS sector
- Sample of Ongoing MASS-SCC Study
- Experimental Design
- Selected Preliminary Results
- Discussion
Definitions & Terms of Reference

- **Autonomous**
  - Systems can steer the ship and make decisions about any change in control settings without human intervention
  - The use of Artificial intelligence (AI) can deliver the necessary decision supporting tools
  - May be manned or unmanned

- **Unmanned**
  - No crew physically on-board
  - May be autonomous or non-autonomous

- **MASS – Maritime Autonomous Surface Ships**
  - IMO’s terminology, used further in current study
Background: Technology Enablers & Opportunities for MASS

Marine technology for AUVs: Improved fuel, propulsion & engine systems, navigation & control systems, communication systems, sensor systems, cargo-handling systems

Ship design & construction of AUVs: Optimized hull design, improved EEDI with reduced crew space requirements, optimized design for more extreme sea-states, stability redesigns, novel hull forms (e.g. SWATHs)

Ship-side ship operations: Wider weather windows & more extreme weather conditions, more complex operations in harsher environments

Shore-side shipping operations: Improved shore-side control & monitoring, communication, reality & realism, training & education technology for controllers, automation in hinterland connections
Background: Legal Instruments

- Questions over the adequacy of international instruments in the era of MASSs
  - Expected changes to SOLAS, MARPOL, COLREGS, STCW, MLC, etc.
    - Additions or revisions?
    - Timing?
    - The role of Risk-Based Design & Goal-Based standards

- National jurisdictions pressing ahead with design, development & testing of MASSs
  - Feedback & results can provide valuable insight for international rule-making process

Rolls-Royce concept for an autonomous cargo ship. Credit: Rolls-Royce
WMU’s Contribution to the MASS Sector

- ITF Project
  - Exploring the impacts of autonomy on labour markets by 2040
    - Job profiling, predictions of unemployment
  - Mapping & comparison of autonomous technology across different transport modes

- Multi-disciplinary book publication
  - Covers topics including:
    - Ship Design & Construction
    - Navigational Safety, Shore-side Control & Data Exchange
    - Environmental Protection & Energy Efficiency
    - The Human Element & Labour Market
    - Security & Cybersecurity
    - Legal & Regulatory Challenges
  - 50+ chapters with contributors from academia & industry
WMU’s Contribution to the MASS Sector

Professor Jens-Uwe Schröder-Hinrichs
Germany
PhD Safety Science

Adrienne Mannov
USA/Denmark
PhD Social Anthropology

Xiaoning Shi
China/Germany
PhD Maritime Economics

Khanissa Lagdami
France/Marocco
PhD Law of the Sea

Tiago Fonseca
Portugal
PhD Engineering and Management

US Navy ‘Sea Hunter’ Concept.
Credit: Globalnews.ca
Scope of Study

- Maritime systems can be sub-divided into 5 sub-systems:
  - Transport means (e.g., vessels of various types, sizes)
  - Workers and drivers (e.g., ship crew including captain, officers, engineers, etc.)
  - Transport paths (e.g., open sea, coastal waters, routeing measures, etc.)
  - Traffic management (e.g., ship reporting systems, vessel traffic service (VTS) systems, shore-based monitoring and control for MASSs, etc.)
  - Organization and administrative components (e.g., IMO, IHO, IALA, national authorities and administrations)

- Current work focuses on interaction between ‘traffic management’ & ‘workers and drivers’
  - Evolutionary needs of control centres & shore-control operators
## Scope of Study: Level of Autonomy Under Investigation

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<th>Manning/Control Levels</th>
<th>Autonomy Levels</th>
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<td></td>
<td>No automation</td>
<td>Decision support</td>
<td>AI can conduct routine operations, but problem solving or deviations are handled by operators. AI initiates, adjusts and terminates functions to maintain status-quo.</td>
<td>AI can solve problems during routine operations. AI initiates, adjusts and terminates functions to maintain, or return system to status quo.</td>
<td>AI can solve emerging problems outside defined status quo by initiating, controlling or terminating various functions. AI can also initiate, control or terminate operations</td>
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Conventional Vessels and MASS – A Wedding out of Love?

**Experimental Design – A “Mixed Traffic” Scenario**

**Data collection in order to:**
- describe the fairway's and traffic situation

**Open Sea**

**Data transmission**
- Vessel Traffic Services: Information, warning, advice & instruction

**Coastal Traffic Zone (TSS, VTS)**

**River- and Harbour areas (Fairways, Pilot Port-VTS)**

**Data collection**
- RADAR
- Optical Sight
- Hyd.-met. sensors
- VHF – Radio communication

**Data analysis:**
- Analysis of the current and predicted future traffic by VTSO

**Traffic engineering rules and regulations**

**Radar-, Ships'- and Bearing data processing system and Processing of Long-range-reporting and VHF-Communication**
Experimental Design – Conventional Ships and MASS

- Traffic scenario created using AIS/radar data from VTS
  - German Bight taken as base area
    - MASS simulated as 4000-TEU containership
    - 15+ targets
    - Good visibility in daylight
    - Moderate wind (<2 BFT), calm sea-state (2), no current

- Participants asked to take-over the controls of a L2-P.R. MASS for 10 minutes

- Participants asked to repeat scenario – once with traditional bridge controls, once with limited controls

- Participants asked to reach designated point, as safely and efficiently as possible

- Full VTS/ship-ship communication during simulation
Experimental Design

- Research questions
  - What equipment set-up is more suitable for SCCs if the operators:
    - Have a seafaring background?
    - Have a non-seafaring maritime background?
  - How can the navigational performance of seafarers and experienced non-seafaring maritime professionals be compared?

- 2 versions of same scenario – using ‘traditional’ bridge controls & using limited controls

- 2 categories of participants – experienced seafarers (12) & experienced non-seafaring maritime professionals (12)
Preliminary Observations

- Quantitative results comparing safety & efficiency indexes are pending

- Qualitative results provided initial insights –
  - 11 groups managed to avoid accident; 1 seafarer group was involved in a collision
  - No group reached designated point
  - Seafarers formulated long term-strategy before taking action; non-seafarers took over-controls and manoeuvred immediately
  - Seafarers took actions more in line with COLREGs (both groups were familiar with all aspects of COLREGs); non-seafarers more creative in problem solving (‘un-hindered’ by COLREGS)
Discussion

- No significant difference between seafarer vs. non-seafarers
- No significant difference between full-bridge equipment & limited equipment scenarios
- Subtle differences highlight need for quantitative analysis
  - Preliminary analysis indicates that non-seafarers were less efficient, less safe, but more creative
  - Differences in problem-solving highlight need to train shore-control operators in COLREGs
- No concrete conclusion about impact of equipment & control-centre layout
**Discussion: Future Work**

- **Next steps:**
  - Analyse results quantitatively using safety, efficiency metrics
  - In-depth analysis of post-trial debriefing

- **Further studies to explore**
  - Impact of weather & environmental conditions
  - Impact of fatigue
  - Impact of other MASSs in area
  - Impact of decision-support systems
The work presented in this paper was conducted as part of on-going research which contributes among others to project on further development and implementation of the e-Navigation concept by new and enhanced shore-based applications (TSDG study) funded by Korea Research Institute Ships & Ocean Engineering (KRISO). It also contributed to the European project for research and technological development “OpenRisk”, co-financed by the EU – Civil Protection Financial Instrument as project 2016/PREV/26. The authors would also like to thank the ITF Seafarers’ Trust for providing project funding to WMU.

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Thank You!