WORLD MARITIME UNIVERSITY

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

Autonomous Shipping in inland navigation 2018

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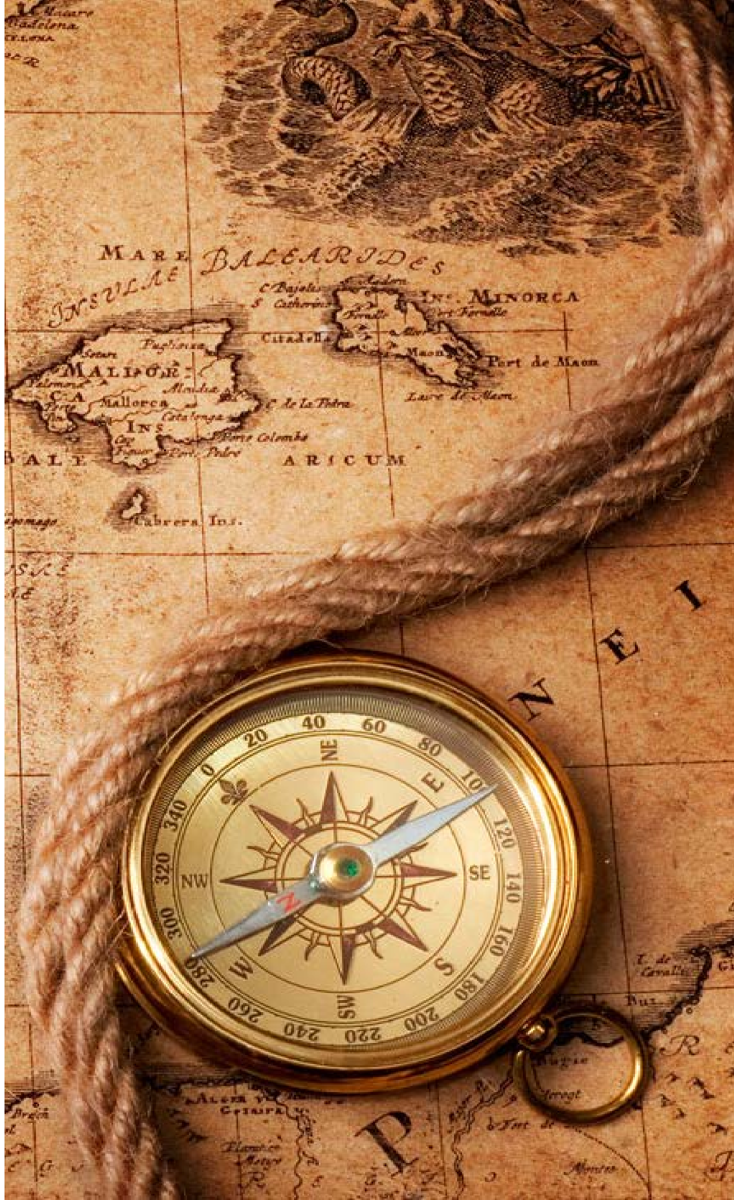


Agenda

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

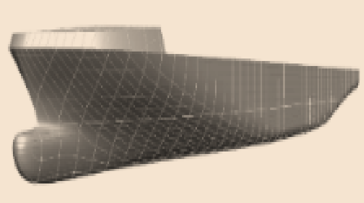
Definitions & Terms of Reference

- 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 re-designs, novel hull forms (e.g. SWATHs)

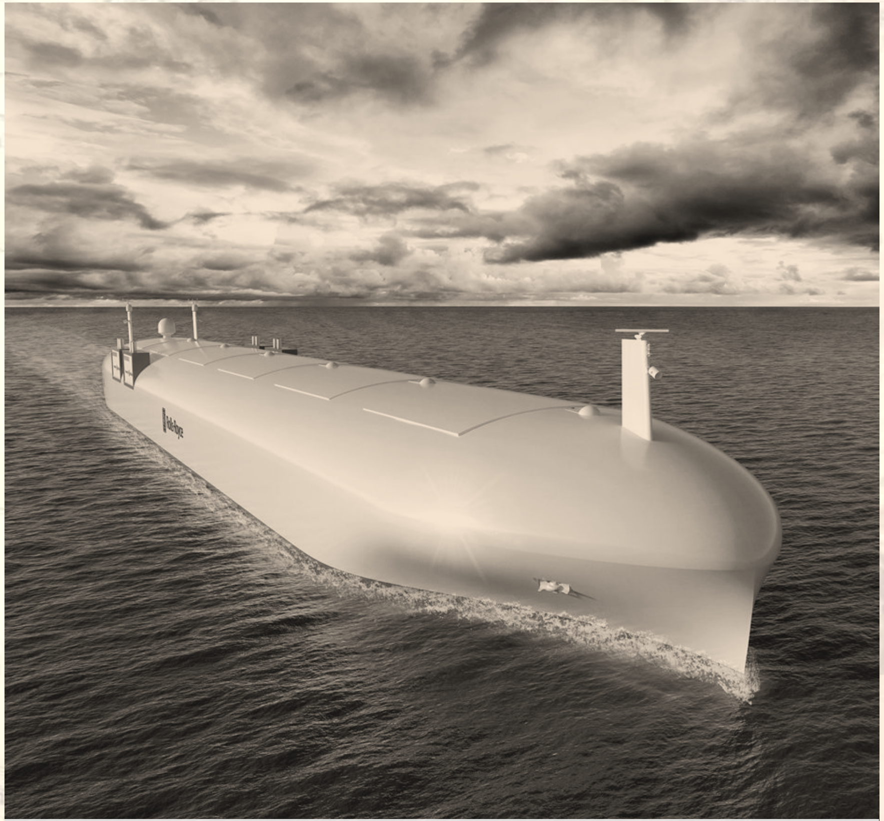


Ship-side ship operations:
Wider weather windows & more extreme weather conditions, more complex operations in harsher environments

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

US Navy 'Sea Hunter' Concept.
Credit: Globalnews.ca

WMU’s Contribution to the MASS Sector

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

Scope of Study

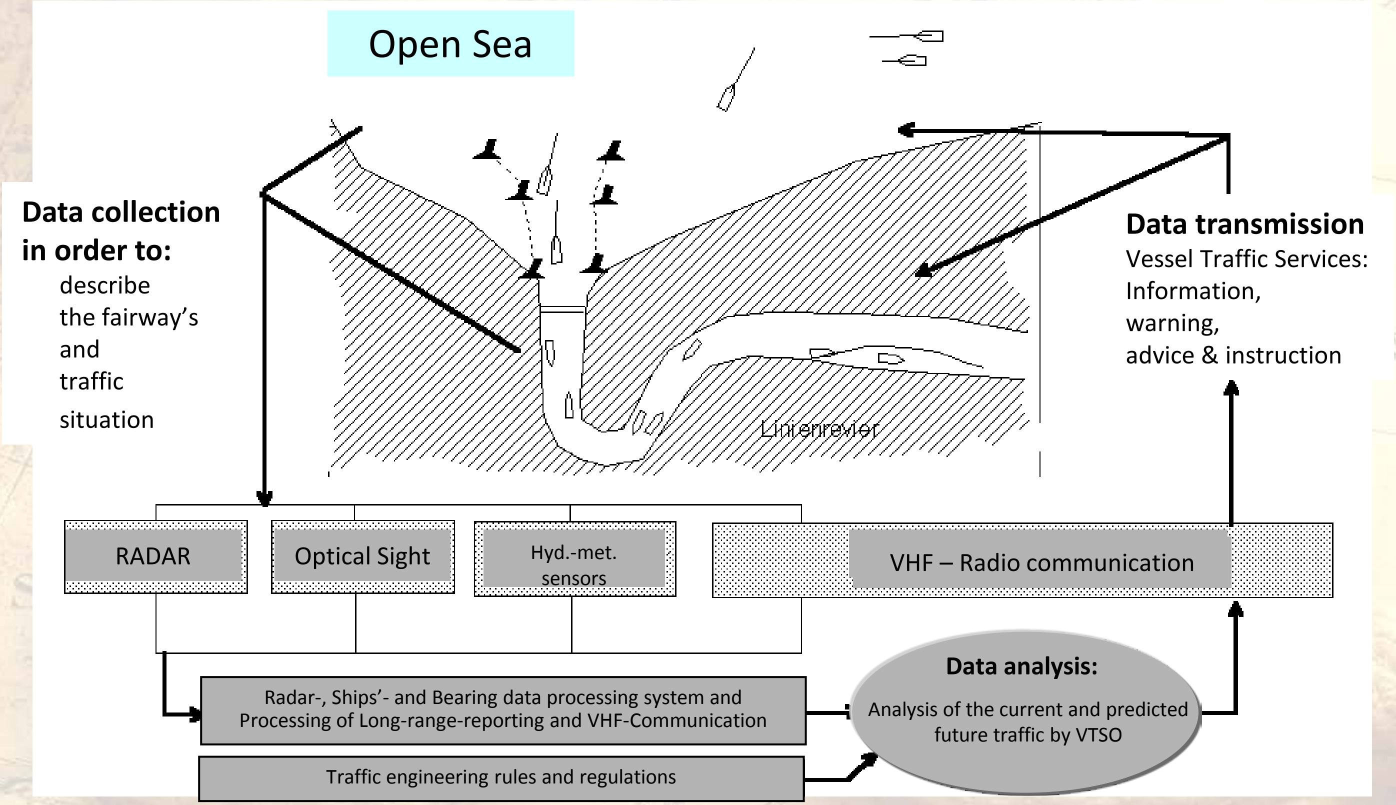
- Maritime systems can be sub-divided into 5 sub-systems:
  - Transport means (e.g., vessels of various types, sizes)
  - Workers and drivers (e.g., ship crew including captain, officers, engineers, etc.)
  - Transport paths (e.g., open sea, coastal waters, routeing measures, etc.)
  - Traffic management (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

Manning/Control Levels		Autonomy Levels				
		L0	**L1**	**L2**	**L3**	**L4**
		No automation	Decision support	AI can conduct routine operations, but problem solving or deviations are handled by operators. AI initiates, adjuts and terminates functions to maintain status-quo.	AI can solve problems during routine operations. AI initiates, adjusts and terminates functions to maintain, or return system to staus quo.	AI can solve emerging problems outside defined status quo by initating, controlling or terminating various functions. AI can also initate, control or terminate operations
Continous	Central					
	Remote					
Periodic	Central					
	Remote					
	Hybrid					
Emergency	Central					
	Remote					
	Hybrid					

Experimental Design – A "Mixed Traffic" Scenario

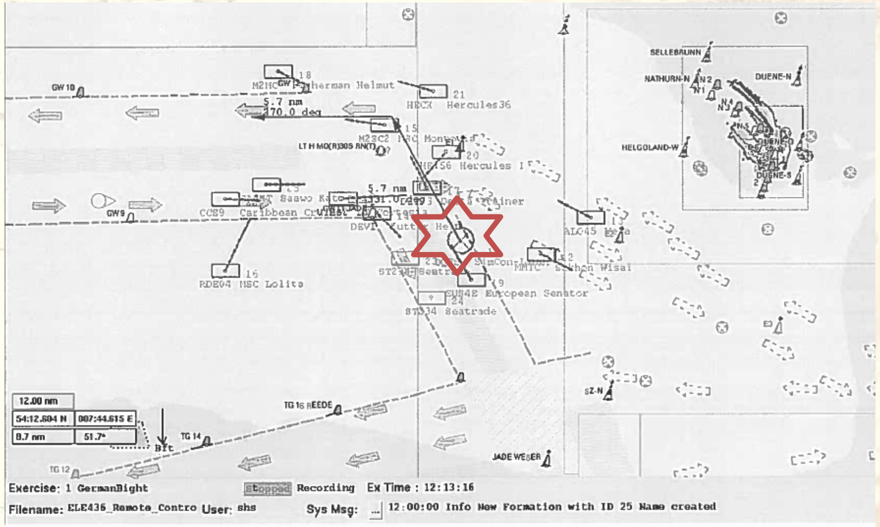


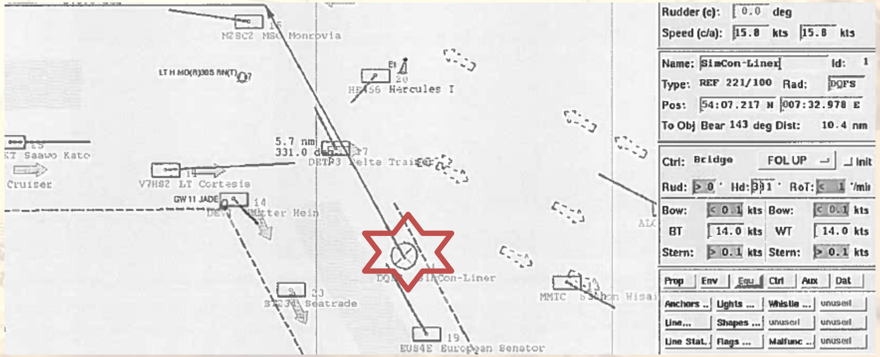
Coastal Traffic Zone (TSS, VTS)

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

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





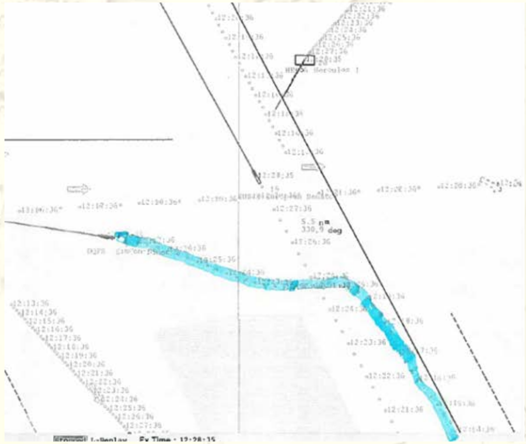
Experimental Design

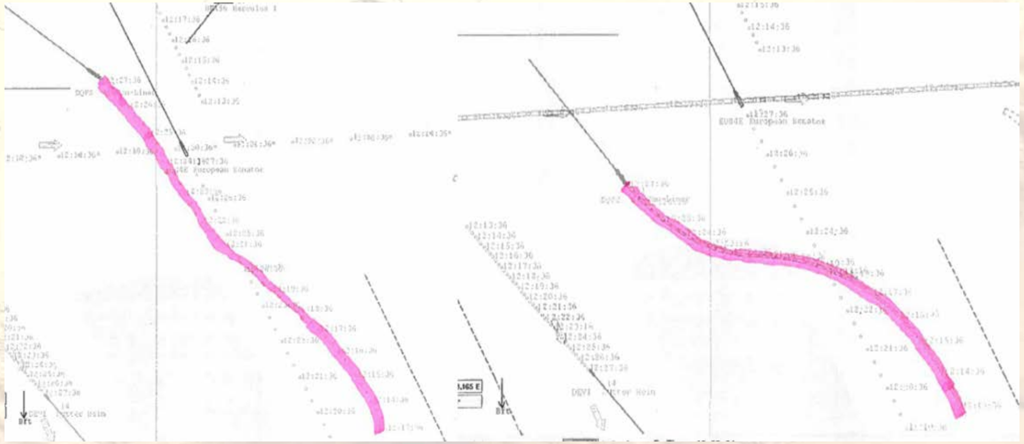
- Research questions
  - What equipment set-up is more suitable for SCCs if the operators:
    - Have a seafaring background?
    - Have a non-seafaring maritime background?
  - How can the navigational performance of seafarers and experienced non-seafaring maritime professionals be compared?
- 2 versions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

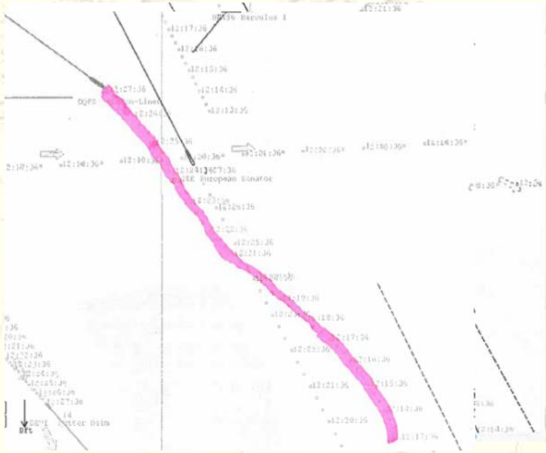
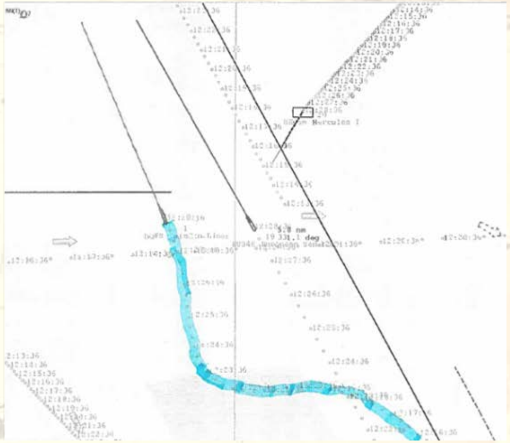
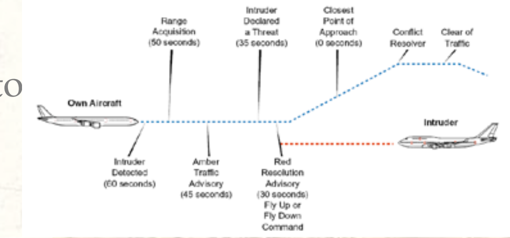
- Qualitative results provided initial insights –
  - 11 groups managed to avoid accident; 1 seafarer group was involved in a collision
  - No group reached designated point
  - Seafarers formulated long term-strategy before taking action; non-seafarers took over-controls and manoeuvred immediately
  - 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)

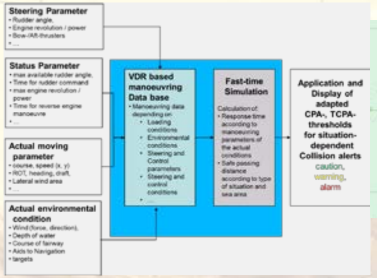


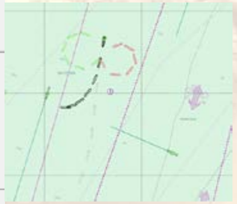


Discussion

- 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

Rolls-Royce concept for a land-based control centre.
Credit: Rolls-Royce

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!