Advanced Autonomous Waterborne Applications (AAWA) Initiative

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AGENDA

1. Introduction to AAWA
2. Vision of remote controlled operation
3. Key findings from the research
   • Technology
   • Safety & security
   • Societal & legal acceptance
   • Economy and business models
4. Conclusions and next steps
Introduction to AAWA
AAWA INITIATIVE - OBJECTIVES

Create competence for remote controlled vessel in commercial use

Create hotspot for waterborne remote control technology

Develop commercially Viable short to medium term solutions
RESEARCH AREAS

TECHNOLOGY

SAFETY & SECURITY

SOCIETAL & LEGAL ACCEPTANCE

ECONOMY & BUSINESS MODELS
PROJECT TIMELINE

PHASE 1
2015
- Concept definition

PHASE 2
2016-2017
- Solution development and focused research

PHASE 3
2018
- Proof of concept(s)
Vision of Remote Control Operation
REMOTE CONTROL AND AUTONOMY

Remote Controlled

Autonomous
In normal conditions ship is autonomous
Control center is informed about actions
Operator confirmation or decision making can be needed.
HOW DOES IT WORK?

Abnormal situations may require operator intervention
Abnormal situations may require operator intervention
DIFFERENCES BETWEEN SHIP TYPES
TECHNOLOGY DEVELOPMENT AREAS IN AAWA

Technologies for realizing remote and autonomous ships exist. The task is to find the optimum way to combine them reliably and cost effectively.
SENSOR FUSION FOR SITUATIONAL AWARENESS

- Perceiving the surroundings of the ship to create real-time Situational Awareness (SA)
- Various sensors have different strengths and weaknesses
- The key technology for reliable SA is **multiple sensor fusion** (applied in cars, aviation, etc.)
- AAWA: **optimal sensor fusion for marine SA**
  - Reliable object detection and collision avoidance
  - Use of existing methods (e.g. automotive)
  - Optimal sensors for marine environment (testing)
SA-SENSOR EXAMPLES: PASSIVE TECHNOLOGY

• **Visual range color cameras**
  • High resolution (object identification)
  • Cheap
  • Not good in darkness or in bad weather

• **Thermal LWIR cameras**
  • Imaging in darkness, better weather tolerance
  • Lower resolution (smaller field of view)
  • Expensive
SA-SENSOR EXAMPLES: ACTIVE TECHNOLOGY

• Radar
  • Operation in any weather
  • Gives target distance
  • Not good for identification

• LIDAR
  • Detailed 3D map of surroundings
  • Works in darkness, potentially weather tolerant
  • Expensive
CAMERAS + SHORT RANGE RADARS

Initial testing done

LIDAR (+ CAMERAS, RADARS)

Will also be investigated

SENSOR DATA PROCESSING

ELECTRONIC NAVIGATIONAL CHARTS

VEHICLE LOCALIZATION AND POSE ESTIMATION

NAVIGATION AND REACTIVE COLLISION AVOIDANCE

+ long range ship radar

+ weather
Mapping, navigation and reactive collision avoidance
GLOBAL AND LOCAL MAPPING FOR AUTONOMOUS SHIPS

• Creating a model of the world which can be used for safe navigation
  • Global: electronic navigational charts + GNSS
  • Local: obstacles detected by the SA system
• Occupancy grid map: local + global features
• Critical task: robust mapping of the dynamic environment
• Input to reactive collision avoidance (CA)
REACTIVE COLLISION AVOIDANCE

• Optimal and drivable path while avoiding obstacles
  • Dynamic and kinematic constraints: turn radius, stopping distance, external conditions

• Autonomous navigation system (ANS) architecture in AAWA: integration of CA with Dynamic Positioning (DP) system
  • DP provides ship model + sensor data (e.g. GPS, inertial)

• Ship control implemented through DP

• Modular ANS implementation for DP enabled vessels
  • No ad hoc control setups required
TECHNOLOGY DEVELOPMENT AREAS IN AAWA

Ship state definition and communication
SHIP STATE DEFINITION

- “Virtual Captain” (VC) monitors the state of onboard systems and decides on the state of the vessel
  - SA sensor status?
  - Communication link status?
  - Other critical ship systems?
- Can VC handle the navigation?
- Allowed ship operation mode from VC: autonomous, remote control, failsafe → different level of operator involvement
- Remote control override by the operator via parallel DP
**OFF-SHIP COMMUNICATION**

- **Datalink capacity may vary** (location, weather, traffic)
  - Need for (only) sufficient bandwidth
  - Bandwidth upscaling on demand
  - Inmarsat dual Ka/L-band satellites + cellular backup
- **Humans can interpret imperfect SA sensor data**
  - Use of SA sensor processing to reduce data transfer to a remote operator
- **Varying level of detail depending on current need and datalink capacity**
Safety & Security
SAFETY OF AUTONOMOUS SHIPS

- Effects of autonomous/remote control of merchant ships on safety and security have not been widely studied

- Major concerns, hazards and risks need to be identified, assessed, addressed, known better and understood to ensure safe solutions for the new technologies

- Operations with the new kind of ships must be "at least as safe as with traditional ships", but they may be even better

- The areas where new risk control options (RCOs) are needed will be addressed
TOP-DOWN APPROACH – JOHARI WINDOW

Technical, operational, economical, environmental, social …
- Validation of relevant IT structure and software,
  problems related to its functioning, e.g.
  • How to include risk-based design in COLREGS implementation
  • Operation and fall-back strategies in case of abnormal situations
- Cognitive overload for the operator, “automation awareness”
- Etc. …

Technical, operational, economical, environmental, social …
– they are matters we know to some extent, but not well enough
– Interaction between manned and unmanned ships
– Operations in harsh weather conditions
– Maintenance management
– Robustness of IT-structure, also in long term
– Etc. …
- Progress only by small and cautious steps, apply systematic approach in risk assessment, increase knowledge and understanding in areas of ‘unknown’, improve dissemination, and listen to relevant stakeholders, avoid unacceptable risk, and confirm safety

- Co-operative actions are needed to develop international standards and guidelines for the industry

Remote and autonomous ships shall be made at least as safe as existing vessels.

There is potential to reduce human based errors but at the same time new types of hazards and risk may arise and will need to be addressed.
Societal & Legal Acceptance
GENERAL ABOUT RULES AND REGULATIONS

• Not much research to date – in particular on larger commercial ships

• Challenges: what rules need to change?

• Preliminary observations
  • Trading area
  • Degree of automation
### ON THE NATURE OF THE CHALLENGE

<table>
<thead>
<tr>
<th>INTERNATIONAL</th>
<th>REMOTE CONTROLLED</th>
<th>NATIONAL</th>
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</thead>
<tbody>
<tr>
<td></td>
<td><img src="image" alt="Remote Controlled International" /></td>
<td><img src="image" alt="National" /></td>
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<td><img src="image" alt="Remote Controlled Fully Automated" /></td>
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**REMOTE CONTROLLED**

**FULLY AUTOMATED**
# Maritime Law - Layers and Types of Rules

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<tr>
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<th>Jurisdictional rules (main target: states)</th>
<th>Technical req. and standards (main target: flag states)</th>
<th>Private law issues (main target: shipowner and commercial partners)</th>
<th>Other rules (Criminal, social, commercial, public law etc.)</th>
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</thead>
<tbody>
<tr>
<td>Global (UN)</td>
<td>UNCLOS</td>
<td>SOLAS, MARPOL, STCW, COLREGS, MLC</td>
<td>Private law conventions on e.g. liability, limitation, arrest, carriage of goods, salvage, etc.</td>
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<td>Global (IMO &amp; ILO)</td>
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<tr>
<td>Global (IMO, UNCITRAL, CMI etc.)</td>
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<td>European Union</td>
<td>Ship safety directives &amp; regulations</td>
<td>Product liability rules, insurance requirements</td>
<td>Rules on competent jurisdiction and applicable law</td>
<td>Several issues covered by EU Treaty &amp; legislation</td>
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<td>Limitations on exemptions</td>
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<tr>
<td>Nordic states</td>
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<tr>
<td>National (Finland)</td>
<td>National implementing legislation, discretion of flag state administration (Trafi)</td>
<td>Finnish Maritime Code 674/1994, other specified acts on liability, insurance etc.</td>
<td>The entire legislation applies <em>a priori</em> for ships flying its flag</td>
<td></td>
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</tbody>
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INTERNATIONAL RULES

• Mostly technical rules
• Operational rules: functions (safe speed, lookout, manoeuvring)
• Exemptions, equivalences
• Safe manning – flag state
• STCW, MLC? (watchkeeping)
• Practical challenges (documentation, PSC, pilotage?)
PRIVATE MARITIME LAW (NORDIC MARITIME CODES)

• Who is liable?
  • Starting point: Shipowner (‘reder’) is liable
  • Broad range of helpers covered
• For what acts/omissions is liability triggered?
• Environment/collision liability rules
• New players involved, causal links, may give rise to other types of liability (e.g. product liability)
• Insurance
• International private law (whose rules apply?)
SUMMING UP

• Trading area and degree of automation are important for scope of legal challenge

• Generally, the key lies in the IMO layer: if that is OK, the other layers will follow (discussions have already started)

• The maritime code seems to require less immediate amendment (but note national variations, new forms of liability etc.)

• Laws can always be changed if there is political willingness for it
Economy & Business Models
REDEFINING SHIPPING – A TRANSITION
MARITIME ECOSYSTEM IS NOT ISOLATED

- Megatrends: digitalization, robotization, IoT

- Self-driving cars
  - A need for sensors, competing architectures
  - Fully autonomous vehicles by 2025
  - Dominant design?

- A new ecosystem around autonomous capabilities

- Ecosystems interact and exchange knowledge which **reshapes business models and networks**
IMPACTS EXTEND TO ALL PARTS OF THE MARITIME SECTOR

CURRENT SHIPPING BUSINESS

System providers → Shipyards → Ship operators → Ports → Cargo owners → Shipowners → Society

AUTONOMOUS SHIPPING BUSINESS

System providers → Shipyards → Ship operators → Ports → Cargo owners → Shipowners → Society → New service provider → Remote operator → Integrator
Conclusions and next steps
PHASE 1 CONCLUSIONS

Operation: Will be hybrid of remote control and autonomy and will depend on the type and function of the vessel.

Technologies: Technologies to make remote and autonomous ships a reality exist. The task is to find the optimum way to combine them reliably and cost effectively.

Safety: Ships will be as least as safe as existing vessels. There is a potential to reduce human based errors but at the same time new types of risk will arise and will need to be addressed.

Legislation: can be changed if there is a political will. Change will start at a national level and extend to the global level. The question of liability remains open.

Business: It’s not about ships or equipment but the shipping business as whole – remote controlled and autonomous ships has the potential to redefine the maritime industry and the roles of the players in it.
Available 21.6.2016 at RR ship intelligence web page:


or:  http://bit.ly/1tA8z8a
NEXT STEPS

TECHNOLOGY…

• SA-sensor testing in real-life conditions in 2016
• Sensor fusion and data analysis algorithms
• Autonomous ship control system simulations including satellite link testing

SAFETY, LAW, BUSINESS…

• Detailed and focused research – continuation of work started in Phase 1
• Supporting analyses for the proof of concept demonstrator