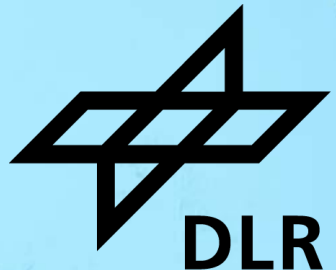


OPTIMIZING SATELLITE COMMUNICATION FOR MARITIME AUTONOMOUS SURFACE SHIPS (MASS) MONITORING: OVERVIEW OF THE ROLE OF AGE OF INCORRECT INFORMATION IN PREVENTING DATA CHANNEL CONGESTION

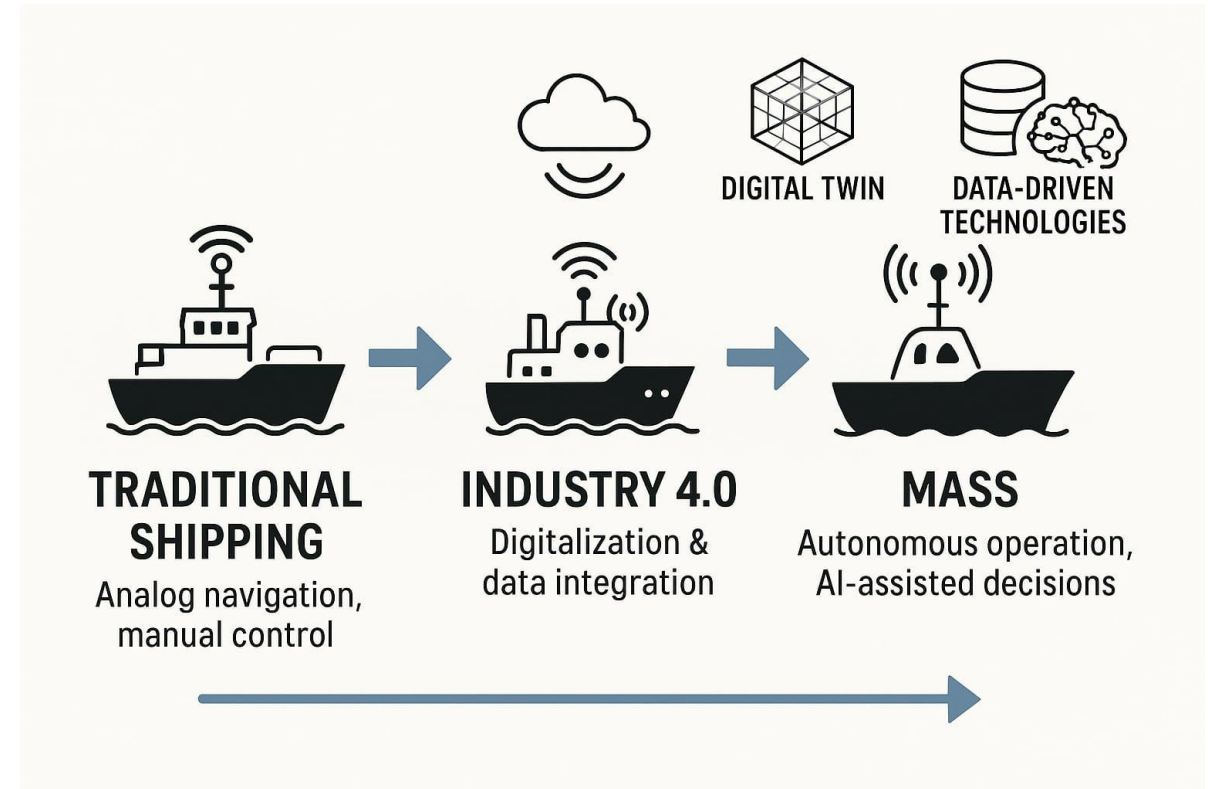
Benjamin Reitz, Andrea Munari, Dennis Höhn

09.10.2025, Hamburg



Motivation

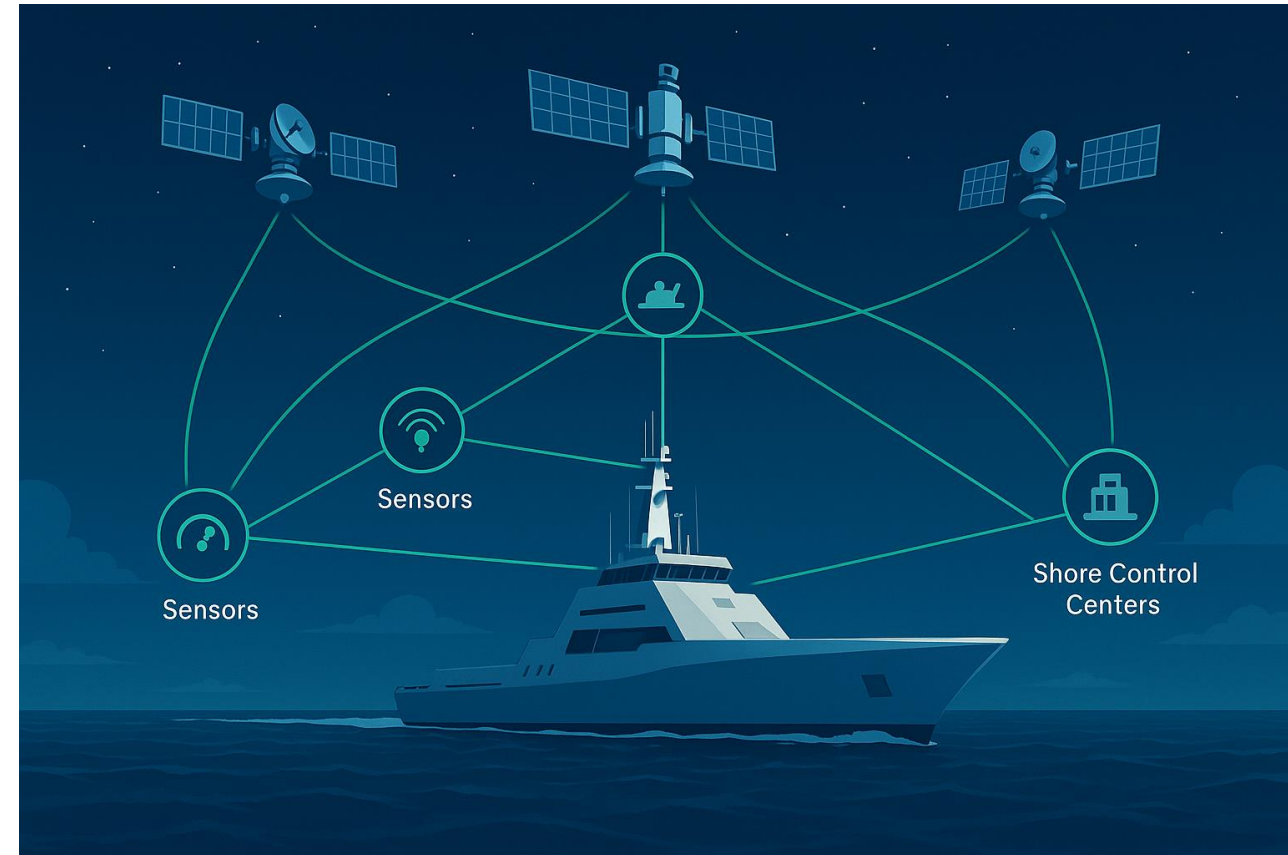
- MASS are one of the next significant advancements
- Dependence on reliable communication is critical
- Industry 4.0 moving onboard, like digital twin, data-driven operations
- At sea, satellites are the only option for communication



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Importance of communications for MASS

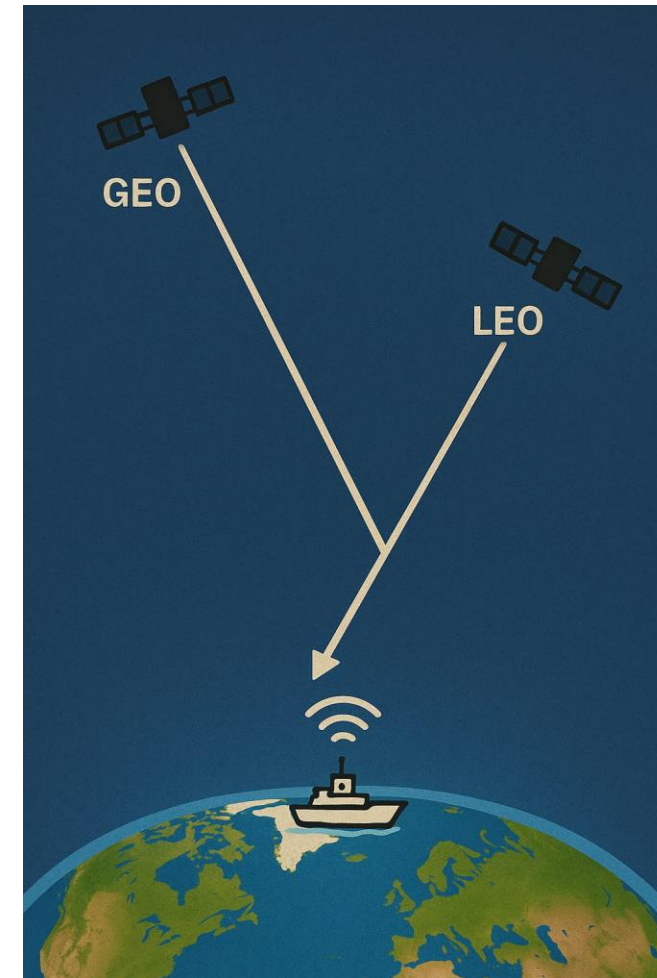
- Communication is the backbone for MASS operations
 - Fundamental enabler for exchange of in real-time
- Situational awareness depends on continuous, timely data
- MASS Degree 1-3 amount of information exchange will rise
- Requirement for safe reliable operations



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Satellite connectivity at sea

- Inshore there are different technologies for data exchange, like 4/5G or Wifi
- At sea no alternative to satellite connectivity at sea, especially on a global scale
- Satellite constellations like Starlink or Kuiper can enable significant more data exchange



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Satellite connectivity - Challenges



- In dense shipping areas with high traffic potential congestion and saturation of satellite connectivity
- Similar problem already occurs with AIS
- AIS satellite congestion leads to loss or incomplete data retrieval

Challenges for MASS communications

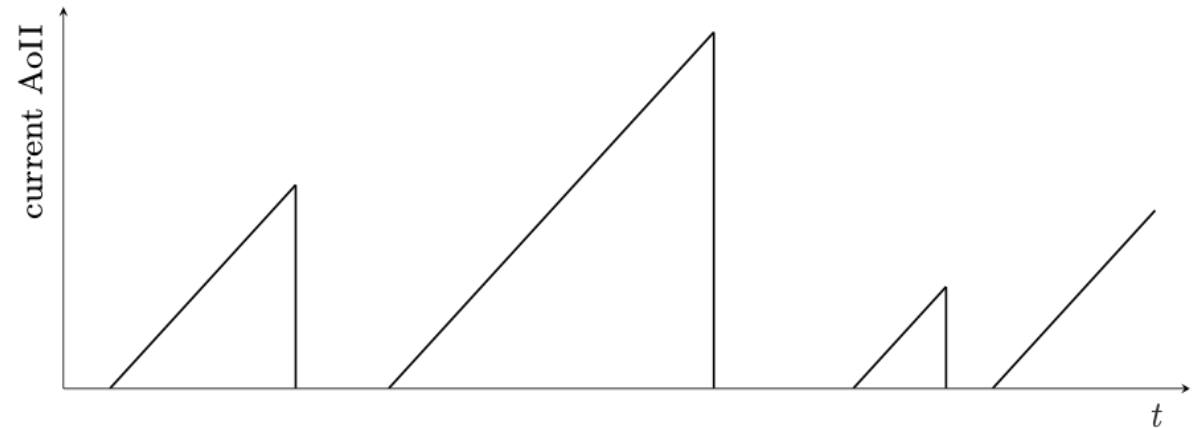
- Increasing number of MASS units → more satellite traffic
- High data volume: navigation, monitoring , diagnostics, control
- Congestion might lead to loss of information or no timely -> risk for situational awareness & safety
- Need for smart prioritization methods



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Introducing Age of incorrect information (AoII)

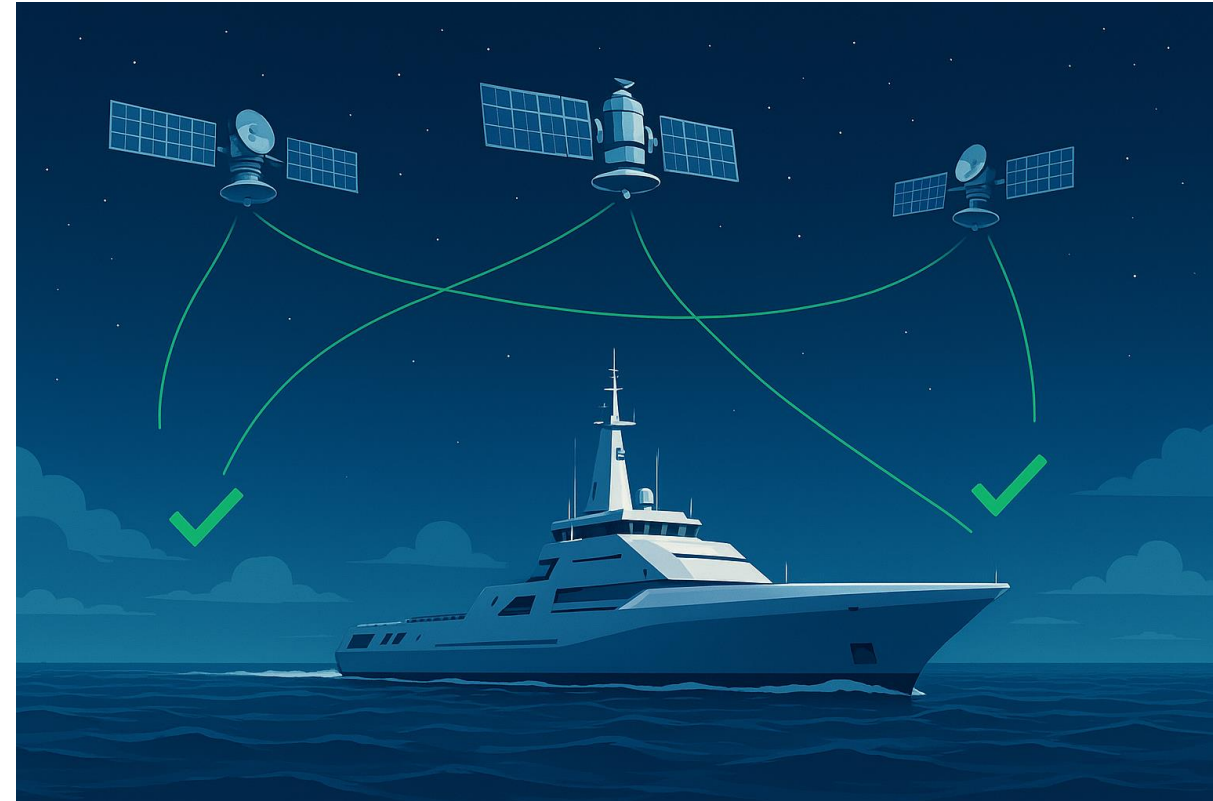
- Traditional Age of Information (AoI) = time since the last update
- AoII adds context: importance and correctness of data
- Not all data equally relevant, so prioritization is required
- For example:
 - Engine monitoring data (not highly relevant if stable)
 - Engine monitoring data highly relevant when temperature rises in critical levels



- Not applicable for high-capacity services (e.g. video streaming)
- Aoll enables data relevance and so prioritization -> context aware prioritization
- Operational resilience due to still-valid data even when older, as long as no significant changes occur
- Satellite bandwidth can be used more intelligent, when adapting transmission

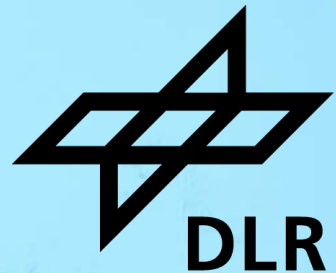
Outlook and Conclusion

- Outlook:
 - Conceptual validation
 - Simulation, modelling
 - Experimental validation
 - Standardization
- Communication as one backbone of MASS
- Satellites remain critical but limited resource
- Aoll can be a promising tool to ensure timely, relevant and reliable data exchange



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QUESTIONS?



Topic: Optimizing Satellite Communication for Maritime Autonomous Surface Ships (MASS) Monitoring: Overview of the Role of Age of Incorrect Information in Preventing Data Channel Congestion

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Institute: Institute of Systems Engineering for Future Mobility

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