TECHNOLOGY READINESS LEVEL OF MARITIME RISK RESEARCH IN THE BALTIC: CURRENT STATUS AND FUTURE PRIORITIES

The objective of this policy brief is to sum up the academic outcome from the research project BONUS BALTIMARI, "Review, Evaluation and Future of Baltic Maritime Risk Management" concerning the Technology Readiness Level (TRL) in the Baltic Sea Region (BSR). The policy brief draws on two studies, one relating to waterways risk management and another relating to decision support systems for shipping accident prevention to describe the current TRL and suggest future research priorities to benefit the Baltic Sea maritime authorities and industry.

WHAT IS TECHNOLOGY READINESS LEVEL (TRL) AND WHY IS IT RELEVANT FOR MARITIME RISK RESEARCH IN THE BALTIC SEA REGION?

Academic research presents new ideas, principles, concepts, tools and solutions in the form of models, simulations, technologies, decision support systems, etc. Typically, testing and validation of these concepts leads to materialization into real operation. The progress of technology from its formulation in the conceptual stage of academic research to its uptake by industry through actual system test, launch and operations is measured by Technology Readiness Level (TRL). Thus, TRL measures uptake of technological research by the industry.

The 9-point TRL scale adopted by the European Union (figure 1) begins at TRL 1 when the basic principles of a technology are observed, and attains the highest level TRL9, when the actual system is proven in an operational environment.

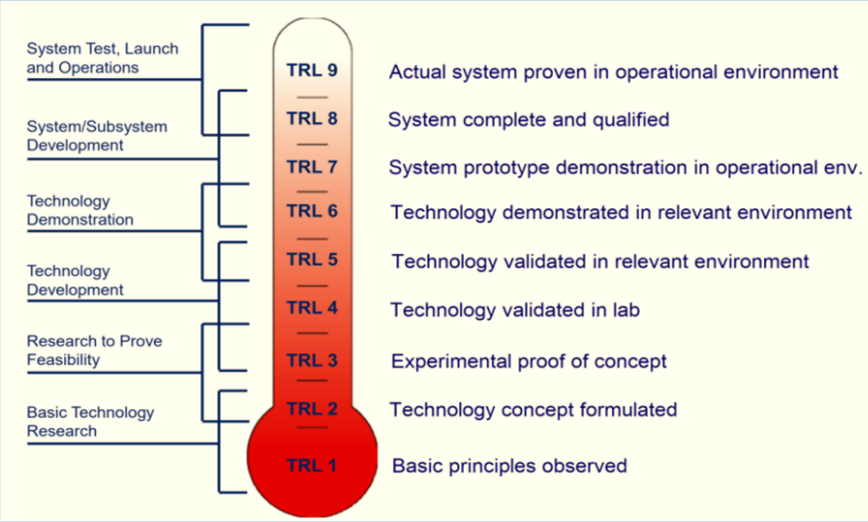


Figure 1. TRL scale

Waterways are the lifeblood of global economy, including the Baltic Sea Region. Prevention of accidents on waterways is of critical importance as past experience indicates that maritime accidents can result in grave consequences to economy, marine wildlife and environment of countries besides impacting human health of coastal communities. Consequently, intergovernmental agencies such as the Helsinki Commission and European Union have been investing heavily in maritime risk research with the hope of reaping rich dividends in the form of increased maritime safety, particularly in the environmentally sensitive Baltic Sea Region.

WHAT IS THE BALTIC CONTRIBUTION TO MARITIME RISK RESEARCH?

Research on maritime safety is undoubtedly high on the global academic agenda. Two parallel track research initiatives[1] as part of BONUS Baltimari program revealed that 463 research articles were published between 1971 and 2019 relating to waterways risk management whereas 98 articles published from 2009-2019 focused on Decision Support Systems for prevention of maritime shipping accidents.

Maritime risk research in the Baltic Sea Region is especially noteworthy, given the fact that authorship of 206 of the 463 research articles published over the last fifty years is owed to Baltic research institutions. Even more noteworthy is the fact that, since 2010, the Baltic Sea Region has maintained a leadership position in maritime risk research.

BALTIC CONTRIBUTION
TO GLOBAL MARITIME RISK RESEARCH

45%
OVER PAST 50 YEARS

No.1
OVER PAST DECADE

WHAT IS THE *TRL* OF MARITIME RISK RESEARCH IN THE BALTIC?

Whereas overall, the TRL of maritime risk research is relatively low, the review indicates that the TRL of the Baltic rather contrasts its global leadership position in maritime risk research.

Research published on waterways risk management by researchers and research institutions in the Baltic Sea Region largely aggregated at TRL2, corresponding to "formulation of technology concept, with the remainder distributed at TRL 1 and TRL 3. **No research on waterways risk management achieved TRL 9.**

Research published on Decision Support Systems for maritime accident prevention yielded similar results. 60% of the research attained TRL 3, which is merely the proof of the concept and 87% is clustered between the first three levels, with much work performed to create concepts which were never implemented into real operational tools. Most present only theoretical concepts and the vast majority do not contain the results of the tool's demonstration even in laboratory conditions. However, two of the most advanced papers pertaining to collision-avoidance tool achieved the highest TRL of 8 and 9 and notably, both feature authors from a Baltic State research institution.

2 Baltic maritime risk research papers achieved highest Technology Readiness Level

[1] *See* Preventing shipping accidents: Past, present, and future of waterway risk management with Baltic Sea focus (Kulkarni et al., 2020) *and*, A systematic review and analysis of shipboard DSS for accident prevention (Gil et al., 2019)

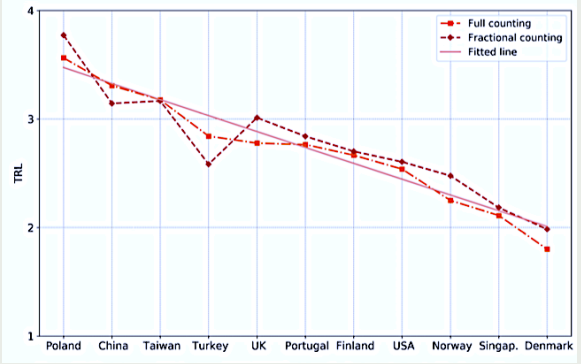
WHAT ARE THE PROBABLE ISSUES AND CONCERNS RELATING TO *TRL* OF MARITIME RISK RESEARCH IN THE *BSR*?

INTRINSIC PLAUSIBLE FACTORS

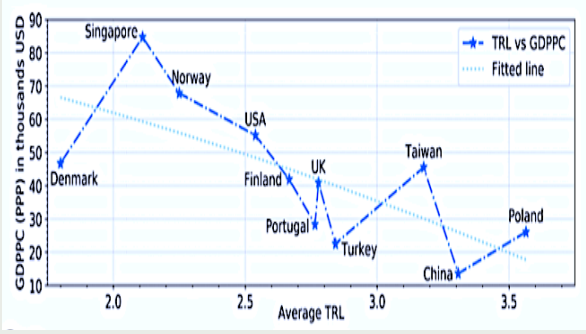
- Possible lack of larger outlays for the validation and demonstration phase of work as compared with the conceptual stage
- Possible challenges in forming a relevant team during the implementation of the solution due to an increased workload
- Possible lack of common communication language between research institutions and industry and authorities, which create a barrier to technology diffusion
- Lack of applicability of solutions and concepts introduced in research to meet the requirements of dynamically changing maritime transportation

EXTRINSIC ISSUES AND CONCERNS

- In stark contrast to expectations, the more developed and wealthier the country, the more it focuses on basic science
- In countries with lower index of economic development, more of the mainstream funding is probably directed at applied research, and all tool development stages are usually conducted at universities instead of in companies which then yields more scientific papers with higher TRL owing to researcher affiliations



Average TRL from 2009-2019 in select countries



Gross Domestic Purchasing Power Parity versus Average TRL from 2009-2019 for select countries

HOW CAN WE IMPROVE *TRL* OF MARITIME RISK RESEARCH IN THE *BSR*?

Partnership and collaboration	• Transferring commercial tool implementation phase to start-ups • Innovation clusters to exchange and develop research concepts
Research context	• Mapping TRL of research by the research institutions • Road-mapping TRL into research
Funding	• For further experiments and technology build-ups to exceed TRL 3

WHAT ARE THE SUGGESTED FUTURE RESEARCH PRIORITIES?

The research priorities are dynamically changing on one hand, and on the other hand, some gaps that emerged in the past and current research remain to be addressed. It is suggested that the future research priorities may focus on complex matters and emerging challenges faced by the maritime transportation industry and maritime authorities as summarized in the table below.

RESEARCH AREA	RESEARCH DESCRIPTION
Ice-waters	• Navigation in ice water and arctic areas, winter navigation in BSR • Arctic shipping safety challenges • Oil spill occurrence, costs of clean-up operations, response effectiveness and impacts in iced waters
Automation	• Maritime Autonomous Surface Ships safety, risks, and Decision Support Systems
ISO 31000	• New risk management processes involving the ISO 31000:2018 risk management standard
Human Factors	• Consideration of human and organizational factors in risk analysis
TRL	• Bridge academia and end-user professional maritime communities
Alternative fuels	• Safety assessment of Liquified Natural Gas operations and different types of hazards including the risk of human life loss • Synthetic fuels response equipment
Oil spill	• Socio-cultural and health impacts of oil spills • Visual risk diagrams modelling of oil spill prevention and response approaches
Policy nexus	• Examination of how research have been utilized by practitioners and policymakers and how the effectiveness of knowledge can be improved • Inclusion of stakeholders throughout the modeling processes to improve social learning and enhance decision-making and support implementation
Organizational Risk Management	• Linkage of risk management processes to organizational processes, and to inter-organizational governance bodies e.g., in regional sea basins, or at the European level

This policy brief by Anish Hebbar, Jens-Uwe Schröder-Hinrichs and Anas Alamoush @ World Maritime University summarizes the key highlights of TRL from the journal articles, “Preventing shipping accidents: Past, present, and future of waterway risk management with Baltic Sea focus” by Kulkarni et al. (2020) *and*, “A systematic review and analysis of shipboard DSS for accident prevention” by Gil et al. (2019). For sources, citations and more detailed analysis, please email us at ah@wmu.se

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