Management Summary (Eng.)

In this study, "International Analysis of the Environment of Use Cases of Autonomous Maritime Systems (AMS)" (AMS Environment Analysis), international AMS projects were first recorded and documented, and their characteristics and framework conditions were analyzed and evaluated. Subsequently, use cases were abstracted and their probability of realization was evaluated by means of an expert survey. The results of the survey were used to develop recommendations for action with regard to AMS for the national maritime industry, administration and politics. These recommendations for action can contribute on different decision levels to promote research, development and innovation of feasible use cases of AMS as well as to enable their deployment.

The study was conducted in the following four steps:

International Project Review
In the first step of the study, AMS projects were researched in an international context. For this purpose, a total of more than 340 sources were reviewed and evaluated according to the criteria of the degree of autonomy (fully autonomous ship according to IMO definition). Ninety-four potentially relevant projects were identified and from these in turn 35 projects were selected that fully met the criteria. These projects were subjected to a qualitative ranking according to various aspects such as the technology readiness level or the planned area of operation. The 25 projects with the highest ranking were transferred to an online project catalogue and published. The project catalogue can be used by different stakeholders to get an up-to-date overview of the status of AMS development.
In order to better classify the efforts of German providers in the field of AMS, an extended country and project analysis was carried out on the basis of the project catalogue. For this purpose, the top 5 projects (2 x Norway, 1 x China, 2 x USA) from the project catalogue were described and analyzed in detail. In addition, factors favoring the development of AMS were examined more closely in a country-based PESTEL analysis.
In conclusion, it is possible to state here that Germany, measured in terms of the number of AMS projects, can keep pace with the technologically leading nations in this field. The indicator-based PESTEL analysis was unable to identify any fundamental obstacles to innovation in the development of AMS in Germany. Germany has an internationally leading specialized shipbuilding industry and a large number of potential use cases due to the existing inland and sea waterway network, so that technology leadership would also be possible in the AMS sector.

Development of Use Cases
This part of the study dealt with the theoretical design of use cases of AMS, with the definition of possible evaluation criteria and the methodical preparation of a survey in order to be able to determine the realization probability of the use cases in the next step.
The use cases were each a concrete and specific application in shipping. A total of 37 different use cases were defined; they differed according to the type of task to be performed, routes, area of operation and duration.
The criteria for evaluation were divided into five different clusters: Technology, Safety, Society, Economy and Ecology. Within the clusters, individual aspects were defined, such as: technology potential, legal framework, social acceptance, economic viability and also sustainability contribution. For this purpose, theses and questions were formulated in order to be able to evaluate the probability of realization of the use cases.
Due to the very high number of defined use cases and the complexity of the evaluation criteria, a two-stage survey became necessary.

Evaluation of the use cases
The evaluation of the use cases was carried out in a two-stage procedure. For the first survey stage, various criteria, particularly in the area of technology and safety, were identified that were deemed to be "knock-out" criteria, such as the management of accidents on the high seas. Use cases which were considered by the experts to have a low probability of realization were not considered further within the study. This reduced the number of use cases to be further evaluated to a total of 14.
The remaining 14 use cases were presented to selected experts from the fields of technology, security, society, economics and ecology for evaluation in a second, anonymized survey.
As a result, the realization probabilities of the evaluated use cases were very close to each other. However, it could be seen that use cases with planned tracks and regional areas of application, for example research, surveying or water pollution

response, were rated better in terms of probability of realization than use cases with tasks such as freight transport in the regional or inland area.
A predominantly pessimistic position of the experts towards AMS could be found in the criteria cluster economy, as the evaluation here was relatively low. In contrast, this position was more optimistic in the technology area, where the experts gave a better overall evaluation of the probability of realization of the use cases.

Identifying recommendations for action
Based on a SWOT analysis of the survey results as well as a stakeholder analysis, various recommendations for action were developed in the final step of the study, which are directed at different stakeholders:

- A national strategy (for governance) should be developed. All relevant stakeholders should be involved to ensure simultaneous market and technology development, development of regulations and procedures, and social acceptance.
- Increased investments towards early implementation of qualified systems for autonomous sailing is needed to further strengthen the innovation-friendly climate in Germany and to support Germany in the global competition for autonomous shipping.
- In the coming years, the administration and industry associations should closely accompany and help shape the design of standardization in the field of AMS internationally. This is particularly important to ensure global market access for technology from Germany.
- To further promote the technical development of AMS, agile funding programs should be introduced and coupled with intensified technology transfer programs. This may include, for example, the establishment of suitable test fields in reality and virtual space to develop and test near-market autonomous systems.
- To ensure short- and long-term profit opportunities for AMS projects, the strategic promotion and implementation of infrastructure investments should be intensified. This requires a comprehensive market potential analysis.
- Priority should be given to developing technical innovations for risk mitigation. Operational safety is a key challenge for the market introduction of AMS, which can be solved by successive adaptation of technologies.
- Incident and accident management must be manageable before a full-scale market launch. Safety and regulatory authorities and private-sector stakeholders must be involved at an early stage in testing the operational use of AMS. This must also be adequately addressed in education and training of future operators of AMS.
- The topic of autonomous shipping and the sustainable development of shipping must be placed in a common context. Potentials on how AMS could contribute to a sustainable use of the oceans need to be investigated, communicated transparently and promoted in a targeted manner. Adaptations in production, design and operation should be guided by the achievement of climate neutrality. Funding for AMS projects should be linked to sustainability criteria.

This study has shown that the further development, testing and use of AMS brings great economic potential. Increased use of AMS can not only revolutionize the national and cross-border transport sector, but also holds transformative renewal potential in other areas such as the supply industry, the maritime labor market, and sustainability of shipping.