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人間工学とルール形成戦略からの自動運航船に関する国際規則と技術革新の同時構築

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博士学位論文内容要旨
Abstract

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論文題目 Title	Development of international regulation and technological innovation on maritime autonomous surface ships from ergonomic and rulemaking strategic viewpoints		

The creation of “new technologies” by innovation has contributed to building safe and reliable societies, such as safety enhancement and environmental protection. On the other hand, “regulations” have been penetrated in societies as one of the most effective tools to maintain safety and environmental sustainability. These factors have a strong co-relationship. Regulations sometimes restrict technologies and hinder their improvement. Conversely, regulations promote technological innovation for dealing with severer restrictions related to safety, environment and labour. Thus, the appropriate collaboration between technological innovation and technical standards (regulations) is indispensable for sustainable development. In this regard, the question is raised: what is necessary to strengthen the collaboration and enhance the bridge between them? This thesis took Maritime Autonomous Surface Ship (MASS) as an example.

The recent remarkable innovation in Information and Communication Technology (ICT) has had a large effect on the maritime domain. Shipping companies have introduced a number of automated and communication systems in their commercial vessels to improve cost-effective operation as well as to reduce the crew’s workload and stress. The movement has already come to an ‘autonomous’ and ‘unmanned’ level. Various demonstration and commercialisation projects have been carried out.

When it comes to international regulations, IMO has carried out Regulatory Scoping Exercise (RSE) to assess the potential gap in existing International Maritime Organization (IMO) conventions and codes for the MASS. Maritime Safety Committee (MSC) in IMO has played a key role in this activity and agreed to include the agenda for RSE in 2017. MSC has completed the work of RSE at MSC 103 in 2021. RSE is the holistic approach and just a starting point for detailed development in the future. Besides this, industrial bodies such as DNVGL and Maritime UK have developed industrial guidelines.

One of the most important points when considering the requirements is the human-centred and ergonomic approach. The existence of ship crews cannot be ignored taking into account that the future where all operating vessels are totally unmanned has not come in decades. MASS would be operated in the sea with a lot of non-MASS and be navigated by crews or remote operators. In addition, the developed technologies for the MASS are not meaningful if they would not be smoothly practiced in the market by regulatory restriction. Moreover, the regulations regarding the new technologies lead to industrial competitiveness. In this sense, a strategic approach for the development of the regulations is sought from smooth implementation and competitive viewpoints.

Based on the above background, this thesis aims to construct the basic scheme underlying development of international safety regulations and technological innovation on MASS from ergonomic and rulemaking strategic viewpoints. In order to achieve the aim, this research focuses on two facets that have not been studied in the past research; (1) Involvement of the ergonomic viewpoint (i.e., situation awareness and mental workload) into the IMO regulation, and (2) Identification of strategic process on the development of international safety requirements. Regarding (1), this research further focuses on situation awareness regarding the competence requirements of navigators in the STCW Convention((1)-1), and identification of factors that would affect mental workload (MWL) by introduction of MASS and lead to a possible revision of current IMO

instruments ((1)-2). In addition, with regard to (2), this research focuses on the stage of submission of new work programme in the IMO and tries generalization in order to enable to utilise the results into other domains.

The first theme aims to develop the regulatory framework on the competence of RO based on the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) by exploring the concept of Situation Awareness (SA). Goal-Based Gap Analysis (GBGA) was constructed based on the human-behaviour model and the required information for SA. A case study through the mini focus group discussion with interviews by a total of three (3) veteran instructors of training ships was conducted utilising the information including the results of previous demonstration projects on the remote control. The results showed the relationship between required information and ship sense, shortage of these factors when RO is operating, additional competence and possible regulatory requirements for RO. The findings supported the usefulness of GBGA and paved the way to develop a regulatory framework for RO further.

The second theme aims to provide a scheme for identifying the relationship between MWL and MASS in the maritime that can be utilised for rulemaking and technological development. The provided scheme identified the factors that affect the MWL of operators and sub-elements of MWL through gap analysis. Five factors related to MASS operation were defined, in addition to general factors. The case study was carried out by utilising the scheme on typical cases focusing on the normal navigational situation. The NASA task load index method was used to measure MWL. Ten deck officers with various ranks, including the third officer and captain, participated in the case study. The results suggested that various causes such as conflicted situations, machine-human interfaces, mechanical-style movements of the ship, reliability of MASSs, and visibility constraints affect the MWL of operators. It also confirmed the verification of the identification scheme.

The final theme aims to develop a technology strategy coordinating with international regulations taking their recent globalization into account. Since recognizing the trend of establishment of the international regulation is indispensable as the assumption for building the strategy, this paper categorized established and amended international regulations focusing on the safety requirements in the International Maritime Organization (IMO). The research firstly reviewed the scheme and procedure for developing the new requirements. Then, based on IMO-MSC documents on new work program proposed by member States for 14 years, three categories, a motive for the development of safety requirements, required safety area, and regulatory issues, were investigated as significant factors. The result showed the identification of taxonomic classification in each category. This paper also showed the points to be considered, diversity of a motive and potential background that cannot be found in the IMO documents such as domestic political situation. Since the categorization in this paper can be generalized easily, application to other areas, such as international aviation and automobile sectors, was recommended.

This paper is believed to accelerate the development of MASS by showing new viewpoints. Moreover, this thesis is expected to be a trigger for the collaboration of multiple science fields, including engineering, ergonomics and international law.