

Special Feature Articles on Autonomous Ships

(Foreword: Invited Paper)

Recent Trends and Issues for Practical Application of MASS

..... *Tokyo University of Marine Science and Technology Etsuro SHIMIZU*..... 1

Active research and development, including demonstration experiments, aiming at practical application of the ships called maritime autonomous surface ships (MASS) in English and automated ships, unmanned ships and autonomous ships in Japanese are underway in countries around the world. This paper introduces trends in research and development of technologies for autonomous ships in Japan and other countries, and describes the technical challenges and the necessary topics for research and development identified by the author.

Research and Development of Collision Risk Decision Method for Safe Navigation and its Verification

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Over a 5-year period beginning in 2016, the NYK Line, MTI, Japan Marine Science, Furuno Electric, Japan Radio, and Tokyo Keiki carried out a “Study on collision risk judgment and autonomous operation of vessels” as a project selected under the initiative “Subsidized research and development projects for advanced safe ship technologies” of Japan’s Ministry of Land, Infrastructure, Transport and Tourism (MLIT). Among the results of that research, this paper introduces the development of collision risk indexes and a collision risk area display system by three navigational instruments manufacturers for the purposes of preventing ship collision accidents and supporting safe navigation by ship captains and navigation officers, and presents an outline of a demonstration of the effects of the developed technologies based on a demonstration experiment using a navigation simulator.

Development of AI-based Automatic Collision Avoidance System and Evaluation by Actual Ship Experiment

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High expectations have been placed on the development of automated and autonomous ships as a solution to the problems of ship collision accidents caused by human factors and future shortages of seamen. To realize automatic navigation technologies, it is thought that moves to develop automatic maneuvering systems that are not limited to “cognition” assistance in maneuvering, but extend to “judgment” and “action” will accelerate in the future. This paper presents an overview of an AI-based automatic maneuvering system that was developed with the support of the Transportation Technology Development Promotion System of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) (FY2018 to 2020), and introduces an evaluation of the AI using a navigation simulator, together with the results of an actual ship experiment conducted in Osaka Bay.

Challenge of Technology Development through MEGURI 2040

.....*Mitsui O.S.K. Lines, Ltd. Takeru SUZUKI*..... 51

To what extent can technology contribute to improving navigational safety and reducing the workload on seamen, which are important goals for shipping companies? A consortium represented by Mitsui O.S.K Lines is taking up the challenge of conducting demonstration experiment in quay-to-quay autonomous navigation with actual ships in commercial service that had not been attempted by anyone in the past. In writing this paper in the second year from the start of this project, the author reviewed these efforts and summarized the progress to date and the points that we have realized as a shipping company. I have endeavored to describe this work in a way that conveys the actual state of the project, and I hope that this paper will be read by everyone who has an interest in autonomous navigation, beginning with those involved in technology development for automatic navigation and the creation of the necessary framework for autonomous ships.

Development of Automated Ship Operation Technologies

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In the field of ship operation, the technological development for ship operation support and automation and the creation of the necessary legal and regulatory framework in the IMO are underway. Mitsubishi Shipbuilding Co., Ltd. is participating in the Joint Technological Development Program for Demonstration Experiments of Unmanned Ships with the Nippon Foundation. In this demonstration experiment, advanced technologies including AI, image processing and use of cloud technology will be installed on a large ferry, and automated operation technologies will be developed and verified aiming at unmanned ship operation. This paper presents an overview of the technologies installed on the ferry.

Development of Maneuvering System for Realizing Autonomous Ships

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Akishima Laboratories (Mitsui Zosen) Inc. Takayuki IOKI*..... 67

In recent years, active technological development has been carried out aiming at autonomous ship operation, and further into the future, unmanned ship operation. This paper presents the definitions of the requirements for development of the maneuvering system and conceptual design for autonomous operation of ships, followed by the composition and technical explanation of the maneuvering control system that controls the movement of the ship, and in particular, approach maneuvering control. Finally, a preliminary report on a demonstration experiment involving ship approach and berthing maneuvering control is presented for an actual large-scale ferry at an actual quay, in which an in-port maneuvering control system incorporating the explained approach maneuvering control and berthing control functions was used.

Safety Evaluation for Technologies related to Autonomous Ships *Research Institute*..... 81

Some concrete development projects for autonomous ships have been launched all over the world. This paper mainly describes how to evaluate the safety of technologies related to autonomous ships from the standpoint of a classification society together with initiatives of research institute of ClassNK.

Technical Topics

Development of Simplified Formula for Froude-Krylov Force of 6-DOFs Acting on Monohull Ship

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Hull Rules Development Department, Kawasaki Heavy Industries, Ltd. Shinsaku ASHIDA*..... 93

In this research, simplified formulae for the Froude-Krylov force of 6 degrees of freedom (DOFs) were developed with the aim of developing simplified formulae for wave loads using the main hull-form parameters ($L, B, d, C_w, C_b, C_m, KG, LCF$), which can be used with any arbitrary ship type and size. The developed formulae for the Froude-Krylov force are expressed by explicitly using hull-form parameters, together with the wave direction and wave length. Numerical analyses using the actual hull-forms of 154 merchant ships of various types and sizes were compared, the results confirmed that the formulae possess satisfactory accuracy under all conditions.

Development of Closed Formula of Wave Load Based Upon Long-Term Prediction

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Ship designers need to be able to reasonably estimate hull motion in waves from various aspects such as passenger safety, ride comfort and wave loads for ship designs. Nowadays, hull motion in waves is accurately estimated by seakeeping analysis tools such as the 3-D panel method and the estimation is practically used for all hull design and standard development. At the same time, however, there also is high demand for methods which allow for more simple estimations of hull motion to be made that do not rely on numerical analysis. This paper introduces the development of a general-purpose and high precision closed formula for maximum loads with an exceedance probability of 10^{-8} by formulating the long-term prediction for ships of any size or type.

Climate Change Initiatives for Reduction of Greenhouse Gases

..... *Renewables and Environment Department*..... 127

Moves toward decarbonization are accelerating at the governmental level. However, climate change initiatives, that is, efforts to promote voluntary decarbonization at the private-sector level originating from the financial sector, represented by institutional investors and banks, have now become a global trend, and cannot be ignored, when Japanese companies are to continue their activities in international supply chains. This paper presents an overview of these international climate change initiatives, and describes ClassNK's support business for Japanese companies responding to those initiatives.

Efforts Related to "Innovation Endorsement" *Digital Transformation Center*..... 139

With the maritime industry now engaged in efforts to realize digital transformation (DX), ClassNK announced the "ClassNK Digital Grand Design 2030," which summarizes the expected roles of ship classification societies in digital society by around the year 2030, and launched "Innovation Endorsement" as a framework for certifying innovative technologies and efforts. This paper provides an outline of the Digital Grand Design, and introduces Innovation Endorsement and its related services as part of efforts toward its realization.

This article introduces recent topics discussed at IMO (International Maritime Organization). At this issue, a summary of the decisions taken at 103rd Maritime Safety Committee (MSC 103) is provided.

