A ship monitoring system using a communication satellite for maritime safety

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Abstract

Any subsequent action to ensure safety can be made only when the current safety level is shown quantitatively, and safety cannot be attained if there is any discrepancy in safety recognition between the controlling party and the controlled party. That is, the significance of Assessment Technology, which is an important technology for safety management, cannot be overlooked. Furthermore, it is nonetheless important to ensure shared common safety recognition between operators of the base station on shore and the navigators on board.

The primary target of this study is to establish a ship-shore communication network using satellite communication technology between the Fukae Maru and the base station in the Fukae campus. The secondary target is to develop assessment technology that is capable of quantitatively assessing safety in various ship operating modes required for assisting safe ship operation from the shore side. And, the ultimate goal of this study is to promote research and development on safety management technology to assist the safe operation of ships from shore, by incorporating assessment technology into the prototype experiment system for the ship-shore communication network.
Keywords: safety management system, information technology, assessment technology, safe ship operation.

1 Introduction

The approach to safety management of ship operations has recently been shifting from the ship-based safety management to shore-based safety management, which relies upon two-way ship-shore communication techniques.

In this study, the concept of shore-based safety management is defined as a system to achieve the safe operation of ships by having base station on shore constantly monitor the operating conditions of ships in all navigating modes, and analytically assessing data transmitted from each ship, processing such data into the safety information, and feeding back timely safety instructions together with safety guidelines for the navigator.

The important tasks to realize shore-based safety management using two-way ship-shore communication techniques are: (1) how to realize two-way ship-shore communication, (2) what ship operating information needs to be monitored, how such information is to be processed, and how the processed information should be transmitted from shore to ships as safety-assisting information, and (3) how to eliminate safety recognition gaps between ships and shore.

As is shown in Figure 1, in this study, a ship-shore communication network using the satellite communication is established between the Fukae Maru (450 GT training ship owned by Kobe University, Faculty of Maritime Sciences) and the base station within the Fuka campus, whereby studies are conducted for the purposes of developing safety management techniques to assist safe ship operations from shore.

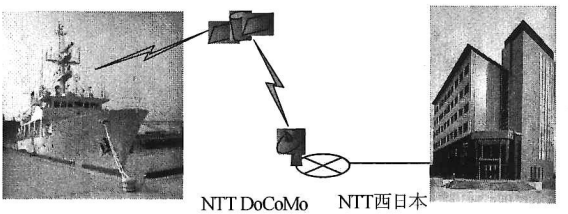

Figure 1: Concept of two-way ship-shore communication using the satellite communication.

In this study, in addition, on the basis of the concept that safe ship operation cannot be achieved if there is any disparity in the recognition of safety between the controlling side and the controlled side, which has been lacking in conventional studies, the practical usefulness of the newly developed safety management system will be verified through experiments with actual ships.

The safety management system developed in accordance with such a concept is based on the safety management that matches the recognition of the navigator. As a result, it is expected that the system would be widely accepted by mariners on board, who do not welcome control from others.

Furthermore, this system is not only useful for managing the safety of individual ships but it is also possible to develop a Vessel Traffic System; i.e., safety management of traffic flows in a specific sea area.

A benefit is that it might be feasible to enhance the Vessel Traffic System, from the conventional information system to a new system for a shore-based control system.

1.1 Forming a ship-shore communication network

Before conducting this study, Japan Marine Science Inc. introduced the Web Pilot, a ship-shore communication system using satellite communication, onboard the Kibou, a techno-superliner owned by Shizuoka Prefecture, whereby the usefulness of the system was verified on an international voyage to Shanghai.

Later, the company and this research laboratory conducted a joint research project to form an improved system between the Fukae Maru and the base station within the Fukae campus, taking over from the basic concept of the Web Pilot system.

The processes thereafter include: agreement to participate in the NTT DoCoMo Packet Network concluded in 2001; test operation commenced of ship-shore communication using the satellite communication by combining the data collection system through the shipboard LAN of the Fukae Maru and the communication management system within the base station of the Fukae campus; and in 2002, a high-performance computer capable of handling data transmission/reception control on the side of the Fukae Maru, and a high-speed, large-capacity computer for high-speed data processing and graphic data transmission at the base station within the Fukae campus were introduced.

Furthermore, additional efforts for enhancing utility have been made to improve the software for communication management, thus the foundation for the hardware and the software necessary for this study has been completed.

In 2003, research and development on safety management technology was started to support the safe operation of ships using the prototype system of the ship-shore communication connecting the Fukae Maru and the base station within the Fukae campus through the satellite communication. Figure 2 shows a view of the base station within the Fukae campus.

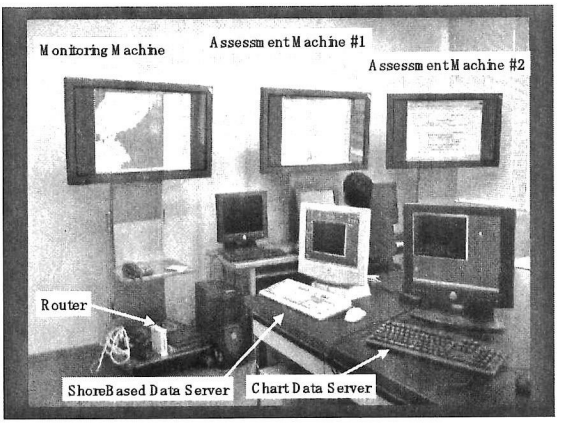

Figure 2: Base station within the premises of the university (Academic Exchange Building, 4th Floor).

2 Development of quantitative assessment technology of ship-handling risk, which is hidden behind various ship-handling modes

2.1 Monitoring ship operating information

In parallel with work to complete the ship-shore two-way communication network, safety studies were conducted on various modes of ship-handling related to information that is required to be monitored, how such information is processed, and how such safety-assisting information should be transmitted from shore to ships.

Concerning monitoring, ship operating information on position, course, speed, and ship motions of the Fukae Maru, natural environmental information on wind direction, wind speed, wave heights, wave direction, and period, and, in addition, traffic environmental information by Radar PPI image, engine operating information represented by all information displayed on the engine console comprise the basic monitoring information, and these items of information are made available in real-time at the base station on shore.

Besides the above, all data and information collected and imported into the shipboard LAN through ship-borne equipment and various sensors are made available for monitoring by requesting from shore as necessary.

2.2 Assessment technology for safety evaluation

On the assessment technology that quantitatively assesses safety in various ship-handling modes, which are required for assisting the safe operation of ships from shore, our Research Laboratory has successfully developed models for quantitatively assessing risk levels in terms of objective numerical indexes for a variety of risks such as dragging anchor, breaking failure of mooring rope, destruction of a pier, overrun, collision with shore installations, ship-to-ship collision, grounding, and capsizing, which are associated with anchoring, berthing/unberthing operations, in-harbour ship-handling, navigation in narrow channel, ocean navigation under heavy weather, and accumulated technical expertise.

For example, risk assessment models were proposed for assessing anchoring operations, using the probability of dragging anchor, and risk index of dragging anchor [1, 2], and for assessing mooring alongside a quay using rope breaking probability [3].

For ship-handling when berthing to a quay, a model capable of assessing latent risk of overrun and latent risk of destruction of a quay was proposed by introducing the concept of safety allowance [4, 5].

Furthermore, for ship-handling difficulties in harbour and in a narrow channel, where water area is restricted, and in waters where traffic is congested, Environmental Stress model (ES model) were proposed, while for grounding risk and collision risk, Unsafe Ship-handling model (US model) were proposed that reflected the risk-assessment technique from the viewpoint of probabilities of accident occurrence [6-13].

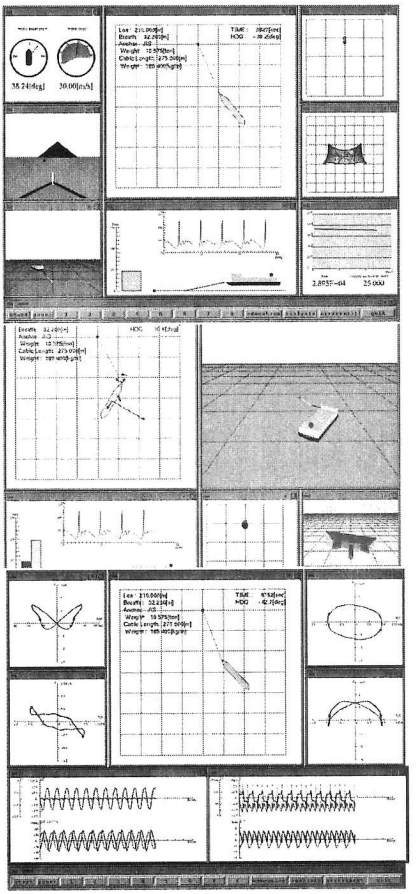

Figure 3: Assessment information images of anchoring and dragging anchor at the shore base station.

In waters with heavy traffic congestion, in particular, judging collision risks and selecting measures for collision avoidance constitute a major point of consideration. Concepts of Collision Danger Line (CDL) and Cone-shaped Collision Danger Line (CDL triangle) have been developed and proposed as practical methods for navigators to readily assess risk under a specific safety standard [14, 15].

The significance of quantitatively assessing latent risks in all ship-handling situations is to obtain basic information that enables the navigator to take the next step with confidence on the basis of the current verified safety level. When viewed from the standpoint of managing safe ship operation, these constitute indispensable factors for developing an alert system and a safety advice system for a variety of ship-handling nodes. Figures 4 and 5 show examples of assessment information images at the shore base station.

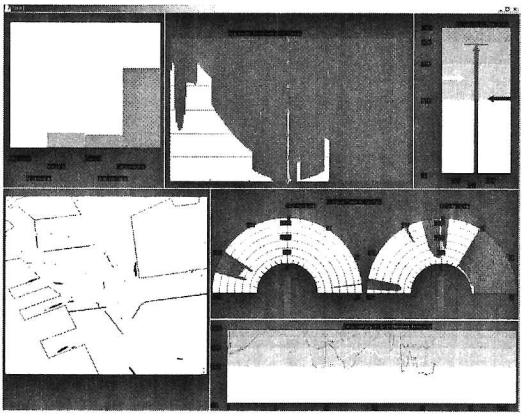

Figure 4: Assessment information images of ship-handling difficulties at the shore base station.

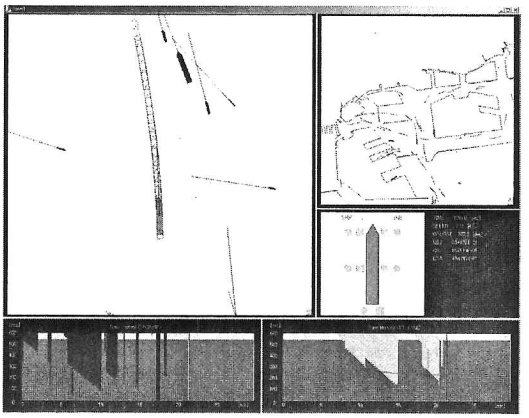

Figure 5: Assessment information images of collision and grounding risks at the shore base station.

3 Problems of human conflicts between the controlling party and the controlled party

For the preferred embodiment of an alert system and a safety advice system in the safety management of ship operation, it is necessary to compare the risk levels that can be outputted by these assessment models and the permissible risk levels.

The shore-based safety management of ship operation is prone to descend into mere inorganic information exchanges. In reality, however, there are human beings at both ends of the communication system, and the occurrence of human

errors arising from conflicts between man and information, man and machine, and between men must be carefully assessed.

Prototype experiments operating an actual ship were carried out from the end of 2003 to 2004. In an experiment carried out as a part of this project, the results of the ship-handling option on shore created on the basis of data transmitted from the Fukae Maru, while passing through Tomogashima Strait and Osaka Bay, received and analysed by the shore base station, were transmitted back to the ship as instructive information.

The results of this experiment show frequent disparities between local judgments onboard the ship based on practical visual information and the base station's data-dependent judgment, thus suggesting the need for confirming mutual intent.

To help reduce such human conflicts between the controlling party and the controlled party, system-wise efforts were made through graphic processing techniques to provide the base station with the same three-dimensional visual information that is actually seen by navigators onboard the ship.

The effectiveness of this system improvement has been validated by the prototype experiment connecting the Fukae Maru with the base station through satellite communication; i.e., it is confirmed that the system is useful for transmitting appropriate real-time alerts/safety advice for the navigator [16].

Figure 6 is a photo of an experiment carried out to reproduce in real-time scenes of the Fukae Maru going astern in the pond of the university, making a turn and departing there from.

Figure 7 shows an example of the assessment information image for assisting collision avoiding manoeuvres using the results mentioned above.

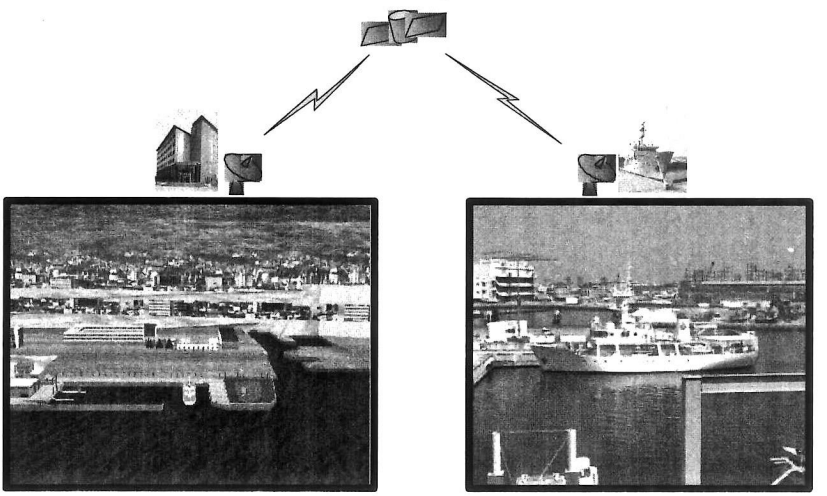

Figure 6: Reproduced three-dimensional vision information at the base station (Left: Reproduced base station image, Right: Site view).

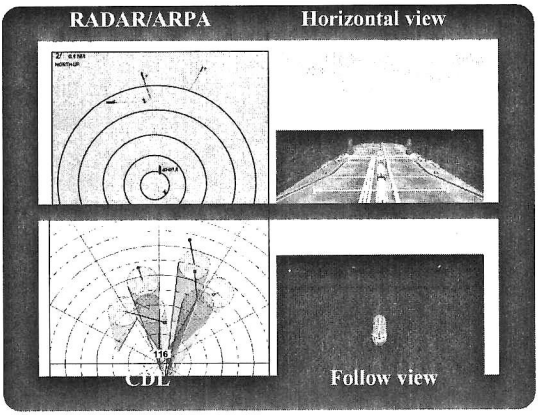

Figure 7: Collision-avoiding judgment assisting assessment information image at the shore base station.

4 Concluding remarks

Research and development on the safety management technology for shore-based assistance of safe ship operations has been steadily promoted by operating the prototype system of the ship-shore communication network between the Fukae Maru (450 GT) owned by Kobe University, Faculty of Maritime Sciences and the base station within the premises of the Fukae campus, using satellite communication.

This paper introduces the current state of the development of safety management technology for shore-based assistance of safe ship operation being undertaken by the Ship-Handling and Marine Traffic System Research Laboratory of the Maritime Sciences Faculty, Kobe University.

The project has just been started, and much is still to be completed in the future through our renewed efforts.

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