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Accident Prevention Based on Maritime Collision Cases in a Port: AI-based Measures to Prevent Ship Collision Accidents

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Abstract: This study investigates a collision incident that occurred in Nagoya Port on 12 July, 2022, highlighting the weaknesses of passing agreements that depend on VHF international radiotelephony and the role of human error in frequent port collisions. In this incident, diminished course-keeping ability at low speeds and minor course adjustments were incorrectly interpreted as the other vessel initiating a manoeuver. This misunderstanding resulted in a delay or failure to execute the agreed starboard-to-starboard passing, communicated via VHF, ultimately contributing to the collision. To address this, the authors propose a 'digital passing agreement' system integrated with an Automatic Identification System (AIS). This system converts verbal passing agreements into machine-readable data, displaying the agreed status, counterpart's intent and navigational assumptions on the Electronic Chart Display and Information System/radar/AIS. In addition, it detects early deviations from agreements based on tracks, bearings and speed, facilitating alerts, cancellations or renegotiations to visualise agreements and ensure compliance. The design also enables fast incorporation of third-party advice and alerts through integration with Vessel Traffic Services. Analysis from the 4M perspective indicates that this proposal effectively targets man/management factors, capable of reducing discrepancies in situational awareness under media conditions within the port. This proposal effectively shifts decision-making from a voice-dependent model to a data-driven approach, thereby significantly reducing the impact of human error on vessel operations within the port.

Keywords: Collision at sea, AI, AIS, Digitalisation of passage agreements.

INTRODUCTION

The global shipping industry is a crucial sector that supports international trade. Over 80% of the world's trade volume is transported by sea [1], connecting virtually every nation through maritime networks. Various vessels, including container ships, tankers and bulk carriers, efficiently transport vast amounts of cargo, from raw materials to manufactured goods, across continents.

According to the Japan Coast Guard, the number of vessel accidents in Japanese coastal waters in 2024 reached 1,835, an increase of 37 incidents from the previous year [2][3]. Of these, 331 vessels, equivalent to 18%, were collision accidents [2]. The high vessel density in harbours is exacerbated by the frequent movement of vessels entering and leaving port, as well as the presence of tugs and service vessels. Narrow waterways require slow-speed manoeuvring, making vessels susceptible to wind and tidal currents. In addition, the concentration of vessel arrivals, departures and berthing/unberthing operations in port areas has been linked to a relatively high number of accidents.

On the other hand, recent advancements in AI technology have been significant. In the shipping sector, AI applications are expanding across various areas, including autonomous navigation and automated operations [6][7], route optimisation, improvements in operational efficiency, preventive maintenance [6], cybersecurity [7] and environmental adaptation [8].

Research into AI technology for collision avoidance support is currently being actively conducted to enhance collision prevention.

This study analyses a collision incident that occurred in Nagoya Port on 12 July 2022. It proposes a system for the AI-integrated digitalisation of passing agreements as a measure for preventing collisions, and it evaluates the system's effectiveness.

COLLISION INCIDENTS IN NAGOYA PORT

The following is an outline of the vessel collision incident that occurred in Nagoya Port on 12 July 2022.

The cement carrier Pacific Breeze, with a crew of 12, including the captain, was underway north-northeast along the Nagoya Port North Channel towards Zone 1 of Nagoya Port. On the other hand, the cargo ship No. 5 Koei Maru, with the captain and three other crew members on board, had just weighed anchor in Zone 1 and was proceeding southwest towards the northern route. These two vessels collided within the northern route. The Pacific Breeze sustained dents to the bow shell plating and bulbous bow, as well as abrasions to the port stern shell plating. The No. 5 Koei Maru experienced buckling and a breach in the port bow shell plating, along with buckling and cracking in the bulbous bow and buckling of the port stern shell plating. Fortunately, no casualties occurred on either vessel. The incident occurred as the Pacific Breeze was proceeding north-northeast towards its berth in Nagoya Port's Zone 1 and as the No. 5 Koei Maru was moving southwest after weighing anchor from the same zone. It happened after both vessels had previously agreed via VHF international radiotelephone to pass starboard to starboard. The captain of the Pacific Breeze navigated the starboard side of the northern route at reduced speed and commenced a port turn just before the collision. It is believed the collision occurred because the captain of the No. 5 Koei Maru, after initially turning slightly to port, then turned to starboard immediately before impact. The Pacific Breeze's captain reduced speed as he approached the intended berth, operating under the belief that vessels should navigate on the right side of the channel. This led him to attempt a left turn near the channel exit. Meanwhile, the captain of the No. 5 Koei Maru likely initiated a starboard turn just before the collision, mistakenly believing that the Pacific Breeze had started to turn to starboard after observing its bow swing slightly in that direction. In addition, the captain of the Pacific Breeze had reduced the main engine speed from half speed ahead to slow speed ahead in preparation for berthing. This reduction in speed diminished the ship's steering responsiveness, causing the bow to gradually swing approximately 3° to port. This was followed by a slight swing of approximately 2° to starboard. This change in heading may have contributed to the No. 5 Koei Maru's captain misinterpreting the Pacific Breeze's actions as a commencement of a starboard turn [10].

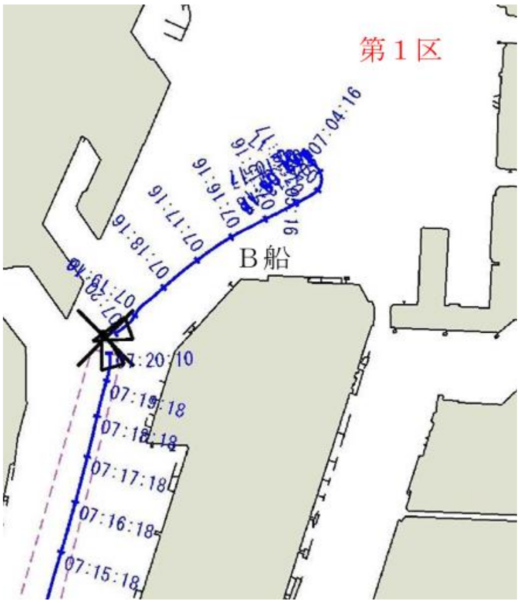

Fig.1.1: Tracks of both ships leading up

Fig.1.2: Positions of both vessels 2 min before collision [10].

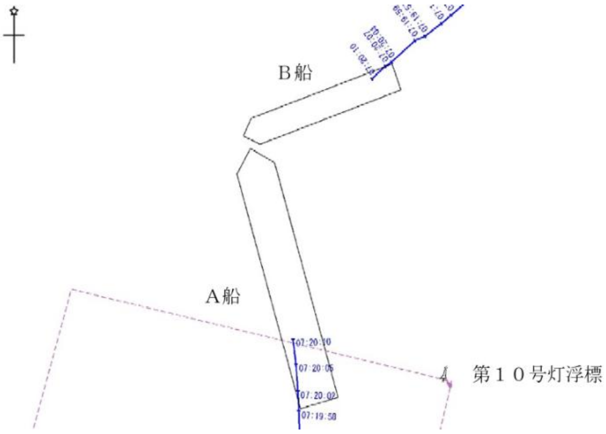

Fig.1.3: Conditions of both vessels at the time of collision [10].

PROPOSAL FOR ACCIDENT PREVENTION MEASURES

The 4M4E analysis examines accident prevention measures using the 4E framework (Education, Engineering, Enforcement or Example, Environment), while addressing accident causes identified through the 4M approach (Man, Machine, Media, Management). In addition, the SHELL analysis focuses on the components of Software, Hardware, Environment, Liveware (those directly involved) and Liveware (those not directly involved), along with their interrelationships, to assess accident prevention strategies.

Research indicates that approximately 80% of shipping accidents are linked to human error [11]. Consequently, measures targeting personnel, such as education, training and the analysis of past incidents, have been implemented for years. However, completely eliminating human error remains a challenge. Recently, advancements in the research and development of autonomous vessels, which operate without human intervention, have gained momentum [2][13][14]. This study explores accident prevention measures, particularly from management and systems perspectives.

Challenges and Collision Risks Associated with Reliance on VHF International Radiotelephony

Several reports highlight the risks associated with using VHF international radiotelephony for collision avoidance [15]. It has been noted that collisions often occur when the officer in charge of navigation is distracted by VHF communications, leading to delays in implementing necessary collision avoidance measures [16]. The following points outline the risks of proximity and collision associated with VHF international radiotelephony:

- Prolonged reliance on VHF international radiotelephony may lead to inattention, resulting in the loss of valuable time needed for collision avoidance manoeuvres.
- When evasive actions agreed upon through VHF communications differ from those outlined in the International Regulations for Preventing Collisions at Sea (COLREGS), it can create a false sense of security, increasing the risk of collision.
- Dependence on VHF international radiotelephony may result in inadequate bridge team management, leading to the false assumption that 'the other vessel will act appropriately', which can create a misplaced sense of security.
- If AIS signals are interrupted, insufficient information may be obtained in congested waters, leading to VHF communications based on incomplete information, thereby heightening the risk of collision.
- Misunderstandings or delays in comprehension may occur when non-native English speakers are in charge of navigation, further increasing the risk of accidents.

Overview of the AIS-linked 'Digitalisation of Passing Agreements' System

The AIS-linked 'Digitalisation of Passing Agreement' system (hereinafter referred to as 'this system') transforms passing agreements, previously communicated via VHF international radiotelephony, into machine-readable information through AI analysis. This digitisation includes key elements such as the agreed state, the intentions of the other vessel and navigational constraints, which are consistently presented to both the bridge and the engine room. In addition, the system features a design that enables early detection of deviations from agreed terms using various sensors. It employs AI-driven judgement to issue alerts as a fail-safe function, facilitates agreement cancellation and allows for renegotiation, all aimed at preventing collisions. This system is expected to improve the accuracy and sharing of information, thereby reducing the risk of accidents caused by miscommunication or human error.

Objective

This system utilises AI to convert voice agreements made through VHF internationalistic radiotelephony into machine-readable data. It displays the agreed status, the intentions of the other vessel and navigational assumptions in a cohesive format on the Electronic Chart Display and Information System (ECDIS), radar and AIS. A fail-safe mechanism monitors deviations from the agreed parameters early on using sensor data such as course, heading, speed and steering input. This triggers alerts, cancellations or renegotiations to address non-performance or delays caused by human error. In addition, the system shares the agreement status with the port Vessel Traffic Service (VTS), enabling third-party intervention when necessary.

Functional Elements

This system organises and shares passing agreements, previously communicated verbally via VHF radio, as ‘agreement data’ that can be processed by a computer. This approach prevents misunderstandings or differences in the interpretation of the agreement terms, ensuring reliable implementation and early detection of deviations. Specifically, it incorporates navigational information from AIS, radar and ECDIS, along with data transcribed from VHF radio communications and relevant regulations. This information is consolidated into a single set of ‘agreed data’ that includes aspects such as the passing method, speed, meeting point and validity period. In addition, navigational constraints such as speed reductions and no-turn restrictions are incorporated to ensure a consistent display across all interfaces.

The display is designed for quick comprehension, showcasing the route (green), prohibited areas (red), meeting points, time indications and passing methods. The process follows the sequence of (1) verbal agreement → (2) written documentation → (3) digitisation → (4) mutual confirmation → (5) display and sharing. This sequence also facilitates version control in case of changes.

Safety is a priority in the system’s design, addressing potential issues such as speech recognition errors and display delays through mechanisms such as re-confirmation prompts and warning messages. Consequently, the system effectively ‘visualises and shares’ the passing agreement, enhancing safety.

Anomaly Detection and Fail-Safe

This function continuously monitors the vessel’s navigation to ensure compliance with the passing agreement. It detects unintentional deviations or changes in course early on and guides the vessel to a safe position. The system continuously monitors the course, speed, positional deviation and steering operations based on the agreed-upon details (such as passing methods, speeds, prohibited areas and meeting points), and makes decisions based on the severity of any anomalies. Minor deviations are then categorised as ‘caution’; multiple or continuous deviations as ‘suspected deviation’; and changes in intent or critical situations as ‘confirmed deviation’. If a deviation is confirmed, the system prompts an immediate transition to either cancel or renegotiate the agreement to ensure safety.

The display occurs in two stages:

1. In L1 (Warning), a yellow indication and a simple warning prompt the user to make a correction.
2. In L2 (Action Required), red highlighting and a strong warning are presented, along with action buttons to ‘Cancel Agreement’ and ‘Start Renegotiation’. Users can also easily send a request for confirmation of intent to the other vessel.

During operations, the situation is initially assessed at Level 1. If no issues arise, the process continues; if problems occur, the situation escalates to Level 2 for renegotiation.

In cases of serious risk, the system also alerts VTS for additional support. Reliability is further enhanced through measures to prevent false alarms, auxiliary indicators to reduce missed detections and a user interface designed for rapid operation.

Establishment of Common Situational Awareness

This feature ensures that the same information is shared in a uniform format across all bridge stations, eliminating recognition discrepancies caused by differences in equipment or language. Information such as the contents of the passing agreement, the route and prohibited areas, meeting points and relevant regulations is overlaid on the ECDIS, radar and AIS screens according to standardised rules. The display is organised by priority, allowing users to quickly access necessary information and history. Users can view the course (green), prohibited areas (red), candidate courses (blue dotted line), meeting points, valid times, passing methods (e.g. starboard-to-starboard), relevant rules and deviation status (indicated by yellow or red warnings) all at a glance.

Once an agreement is finalised, it is immediately reflected on all screens. Updates can only be made by authorised users, and a change history is maintained. Differences in display between devices are standardised through common rules, ensuring that the display remains clear and does not overload users with information while also considering visibility at night and colour vision differences. This approach guarantees a consistent understanding in all situations.

Collaboration with VTS

This function facilitates the sharing of passing agreements and their implementation status with the Vessel Traffic Service (VTS). This allows vessels to receive necessary support in the form of advice or alerts. Notably, the final decision and command remain with the captain, with the VTS providing only advisory support. The system automatically notifies the VTS when agreements are created, updated or when deviations occur, based on the details of the passing agreement (e.g. the passing method, meeting point, validity period, approval status) and any deviations. On the VTS side, the vessel in focus is highlighted, enabling immediate identification of the course and meeting point while generating necessary advisory messages automatically. The screen displays a list of agreement statuses, risk indicators (such as Closest Point of Approach (CPA) and Time to CPA (TCPA)) and alert information, allowing users to easily select templates and initiate calls.

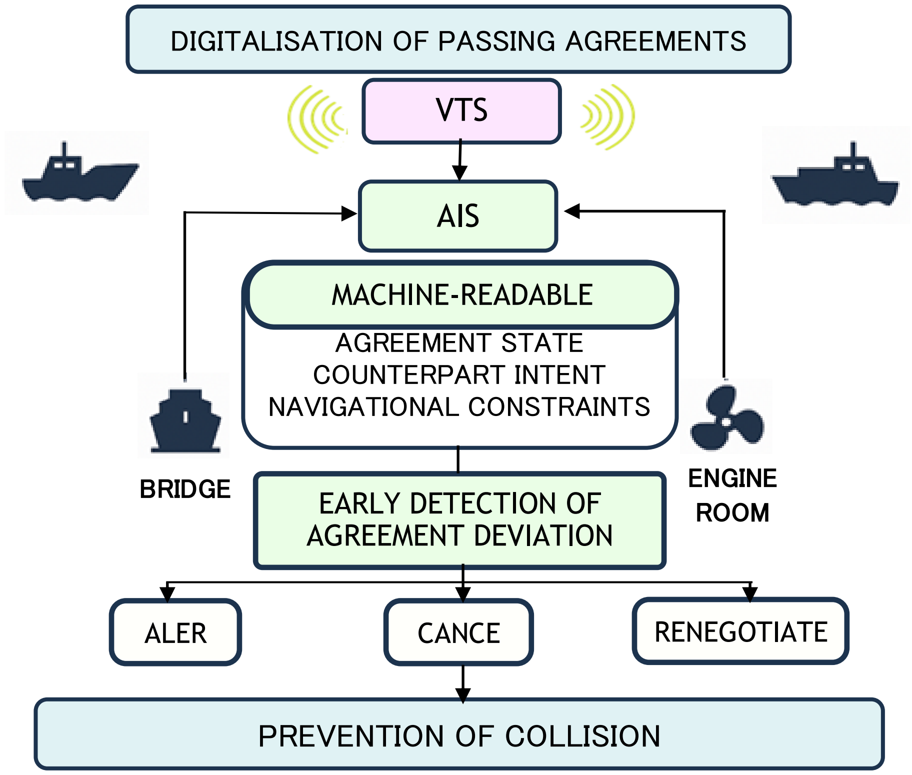

Fig. 2: Outline of the "Digitalization of Passing Agreements" System Linked to AIS

During operations, the system alerts the VTS when an event occurs and provides advice or issues warnings as needed. This information is recorded for subsequent analysis and training purposes. Operations will continue on board the vessel even if communication is lost, with data synchronised once communication is restored. Moreover, design measures are implemented to ensure reliability and usability in actual operations, preventing role confusion, communication redundancy and prioritising the display of information.

SYSTEM RESPONSE TO THE CAUSE OF THE INCIDENT

Various methods have been proposed for accident analysis, including 4M4E analysis, SHELL analysis and HFACS. In this section, we examine the causes of the accident from the 4M perspective within the 4M4E analysis and outline the countermeasures proposed by this system.

Man

Problems Arising from Captain A's Actions

Captain A, the master of the Pacific Breeze, reduced speed in preparation for docking and began a port turn while the vessel's course-keeping ability was compromised. During this manoeuvre, the bow initially veered 3° to the left before swinging back 2° to the right, leading Captain B of the Koei Maru No. 5 to mistakenly believe that a 'turn to starboard' had commenced. In addition, despite both vessels agreeing via VHF international radio to pass 'starboard-to-starboard', Captain A continued navigating while maintaining the starboard side of the fairway. Consequently, the navigable space on the starboard side of Vessel A was reduced, complicating Captain B's ability to turn safely to port. Furthermore, Captain A attempted to turn left at the exit of the traffic route based on the common understanding that 'keeping to the right is the rule on traffic routes'. Consequently, the navigable space on the starboard side of Vessel A was reduced, making it difficult for Captain B to turn safely to port. This Captain A's decision clearly contradicted the existing agreement and contributed to the accident.

This system is equipped with the following functions to detect misinterpretations of the operator's intentions or changes of mind (discrepancies from the agreement) at an early stage:

- Detection of minute course changes and initiation of the verification process. Upon detecting any changes that might lead to misunderstandings by the other vessel, such as a rightward deviation of approximately 2° due to a loss of course-keeping ability, the vessel shall inquire whether the other vessel intends to initiate a turn to starboard.
- Immediate alerts for discrepancies between response content and agreement. If the response received is 'Commencing a turn to starboard', this will be interpreted as a change of intention regarding the previously agreed action, prompting an immediate alert.
- Transition to the process of reconfirming and renegotiating the intention to manoeuvre the vessel. Following the alert, a renegotiation process commences to clarify both parties' intentions concerning vessel manoeuvring.
- Detection of discrepancies between agreed operational content and actual vessel manoeuvres.

If a vessel continues navigating on the starboard side of the route despite having agreed to a starboard-to-starboard passing, the other vessel shall be asked whether the agreement is still valid. If the response indicates a change of intention, an alarm is activated.

These measures can significantly reduce human error arising from misinterpretation, miscommunication or changes in intentions regarding vessel manoeuvring.

Problems Arising from Captain B's Actions

Although Captain B was approaching a situation in which Vessel A was near the entrance to the fairway, he continued on course without adjusting speed. This decision limited the opportunity to avoid a collision and contributed to the accident. In addition, Captain B commenced the voyage without adjusting the departure timing, despite being aware of the potential for an encounter occurring within or near the route after weighing anchor; this also contributed to the accident. Furthermore, although port-to-port passing is standard procedure, both vessels opted for starboard-to-starboard passing via VHF radio, leading to an unusual manoeuvring decision that complicated the situation and is considered a contributing factor to the accident.

This system also detects and corrects errors in Captain B's decision-making at an early stage, described as follows:

- Detection and warning of inappropriate continuation of course in a head-on situation. If Vessel B continues without adjusting its speed, the system will issue an immediate alert.
- Detection of inappropriate timing for weighing anchor. If the vessel had chosen to delay setting sail, it could have avoided a collision. However, if it proceeds to set sail, the system will issue an alert prompting the crew to reconsider their course of action, such as re-anchoring or adjusting speed.

This also facilitates the management of human factors, such as Captain B's delayed decision-making and the inappropriate choice to continue the voyage.

Machine

Vessel A's speed decreased because the main engine was throttled back, which impaired its ability to maintain course and made the bow susceptible to yawing from side to side. This behaviour may have led Captain B to misinterpret the situation, possibly believing that the vessel was about to turn to starboard, which may have contributed to the accident. Because no technical faults were found in the steering and propulsion systems, we can conclude that mechanical failure was not the direct cause; rather, the vessel's handling characteristics at low speed contributed to the accident.

This system does not directly enhance the mechanical factors themselves, such as engine and steering performance.

Media (Environment and Information)

The northern route of Nagoya Port is narrow with limited navigable area. This contributed to the accident by reducing the manoeuvring space available to both vessels. In addition, because this route is governed by the Port Regulations Law, the stipulation in Article 13, Paragraph 3 that 'vessels shall keep to the right when meeting' influenced the manoeuvring decisions of both vessels, thus serving as a contributing factor to the accident. Captain A failed to provide an adequate 'early and clear warning' as required by the COLREGS, and this discrepancy between the regulations and Captain A's actions also contributed to the accident. In close proximity, even the slightest yawing of the bow can easily lead to misinterpretation. External environmental factors, such as wind, waves and tidal currents, may have exacerbated the situation and contributed to misjudgements, further serving as a factor in the accident.

This system does not directly eliminate environmental or information-related factors. However, by encouraging individuals to reconsider and adjust their behaviour through early detection, warning and re-confirmation (renegotiation), we aim to mitigate risks associated with these factors.

Management

The two vessels had agreed via VHF international radio to pass each other starboard-to-starboard. However, Captain A continued to navigate with a focus on maintaining the starboard side of the route, even after the agreement was reached. This inconsistency with the agreed terms was a significant factor contributing to the accident. Meanwhile, Captain B misinterpreted Vessel A's initiation of a right turn and, by ordering Vessel B to turn right, increased the risk of collision, which also contributed to the accident. In addition, following the agreement, neither captain monitored the other vessel's movements or re-established contact, failing to fully confirm each other's intentions. This lapse in communication management further contributed to the accident. Furthermore, Captain A did not clarify the priorities between various manoeuvring requirements, such as preparing to dock and navigating the channel. The simultaneous need to maintain the starboard side of the channel, reduce speed and make a delayed port turn near the channel exit compounded the risks involved, which was another contributing factor in the accident.

This system addresses operational and communication management challenges by implementing the following measures:

- Early detection of discrepancies between agreed specifications and actual operations and alerts. An alert is issued immediately if any discrepancy exists between the agreed method of passing (e.g. starboard-to-starboard) and the vessel's actual course or intended manoeuvre.
- Guiding the process of reconfirming intent (renegotiation): Following the alert, both vessels reconfirm their manoeuvring intentions in accordance with standard protocol and, if necessary, agree on a new passing arrangement.
- Continuous monitoring and approval loop: Even after the agreement has been reaffirmed, the system will continue to monitor the consistency between the vessel's manoeuvres and the terms of the agreement for a specified period and distance. If discrepancies arise, a further warning and inquiry will be issued. These measures will effectively reduce risks derived from inadequate operational and communication management. Notably, because the final decision on vessel operation rests with the human operator, the system is not designed to eliminate the causes of accidents but rather to significantly reduce the probability of accidents occurring through early detection and procedural corrective measures.

CONCLUSION

This study examined collisions in the highly congested and constrained operational environment of a port. Through an analysis of an incident that occurred in the Port of Nagoya, we identified the vulnerabilities of decision-making processes dependent on VHF international radiotelephony. We elucidated the complex sequence of events involving human error (e.g. misinterpretation, change of mind and inattention) that led to the accident. In particular, we demonstrated that even slight changes in course and reduced course-keeping ability at low speeds can lead to misunderstandings when manoeuvres are initiated, resulting in delays or failure to comply with passing arrangements established through radio communication.

In response to this issue, we proposed a system for the digitalisation of passing agreements linked to the AIS. This system transforms conventional voice-based passing arrangements into machine-readable data, presenting the agreed status, the intentions of the other vessel and navigational prerequisites in a cohesive format on ECDIS, radar and AIS. By detecting deviations from the agreement early on based on factors such as track, heading, speed and steering input, the system aims to visualise the agreement and ensure its execution, facilitating a transition to alert, cancel or renegotiate processes. In addition, the system is designed to share the status of agreements with the VTS, enabling rapid intervention through advice and warnings from traffic control.

The expected benefits include: (1) a reduction in misinterpretations via the standardisation of interpretation of minor course changes; (2) a reduction in redundant and lengthy radio communications while promoting compliance with COLREGS; (3) early detection of changes in intent through the clarification of shared assumptions; and (4) the establishment of a time buffer via an immediate response process (re-confirmation and renegotiation) in the event of a deviation from the agreement. However, the system has limitations. It does not directly enhance machinery or steering characteristics, nor does it address environmental disturbances (Machine/Environment). Therefore, comprehensive safety management, including HMI design, operational procedures and training, is essential. Implementation challenges remain, including preventing false alarms, ensuring cybersecurity, managing AIS and GNSS signal loss and adhering to legal frameworks and operational rules.

This proposal effectively shifts decision-making from a voice-dependent model to a data-driven approach, thereby significantly reducing the impact of human error on vessel operations within the port.

REFERENCES

[1] UNCTAD “Review of Maritime Transport 2024”, https://unctad.org/publication/review-maritime-transport-2024, (Accessed on April 2026.)

[2] Japan Coast Guard, Maritime Accident Statistics for 2024 (Preliminary Figures), https://www.kaiho.mlit.go.jp/11kanku/03kakuka/10kotsu_taisaku/202501kouhou.pdf (Accessed on April 2026).

[3] Japan Coast Guard, 2024: Current Status and Countermeasures Regarding Maritime Accidents – Protecting Precious Lives, https://www6.kaiho.mlit.go.jp/info/keihatsu/20250414_state_measure01.pdf (Accessed on April 2026).

[4] Document for the Maritime Subcommittee of the Transport Policy Council, Ministry of Land, Infrastructure, Transport and Tourism. https://www.mlit.go.jp/common/001005758.pdf (Accessed on April 2026).

[5] Matsuda, S., M. Miyata, Basic Analysis for Factor and the Damage of Vessel Collision with Mooring Facilities. Journal of Japan Society of Civil Engineers, 2020, 76(2): p. 396–401.

[6] MARITIME MAX, AI Transformations in Maritime Shipping: Navigating 2025, https://www.shipuniverse.com/news/ai-transformations-in-maritime-shipping-navigating-2025/, January 22, 2025 (Accessed on April 2026).

[7] MARITIME INNOVATION, Opportunities and Challenges with Autonomous Ships, https://maritime-innovations.com/autonomous-ships-2025/, August 24, 2025 (Accessed on April 2026).

[8] NAUTILUS SHPPING, The Future of Maritime Trade: Applications of AI in the Marine Industry, https://nautilusshipping.com/news-and-insights/the-future-of-maritime-trade-applications-of-ai-in-marine-industry, March 13, 2025 (Accessed on April 2026).

[9] MARITIME EDUCATION, Maritime Industry Trends 2025: AI, Automation & Smart Ports Shaping the Future of Shipping, https://maritimeducation.com/maritime-industry-trends-2025-ai-automation-smart-ports-shaping-the-future-of-shipping/, 2025 (Accessed on April 2026).

[10]Japan Transport Safety Board, Ship Accident Investigation Report, https://jtsb.mlit.go.jp/ship/rep-acci/2023/MA2023-13-5_2022yh0118.pdf (Accessed on April 2026).

[11]Wróbel K., Searching for the origins of the myth: 80% human error impact on maritime safety. Reliability Engineering and System Safety, 2021, 216.

[12]Zhou Y., et al., Human errors analysis for remotely controlled ships during collision avoidance. Frontiers in Marine Science, 2024, 11: p. 1–19.

[13]Laakso A., et al., A risk assessment of an autonomous navigation system for a maritime autonomous surface ship. Journal of Marine Engineering & Technology, 2025, 24(4): p. 253–269.

[14]Sonodai S., et al., Analysis of Human Errors in Remote Ship Operation using Task Analysis and Bayesian Network. The Journal of Japan Institute of Navigation, 2025, 153: p. 76–86.

[15]Wakita R., S. Fujiwara, and S. Fujimoto, Study of the relation between VHF and Rules of the Roads. Journal of the Japan Institute of Navigation, 2014, 131: p. 25-32.

[16]Use of VHF in collision avoidance, Steamship Mutual, Published: April 27, 2018.