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Using the Closed Loop Communication System to Prevent Accidents Caused by Human Errors

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ABSTRACT

This paper focuses on the implementation of the Closed Loop Communication System to minimize misunderstandings on board ship, which could be main causes of incidents/accidents at sea.
The Closed Loop Communication System is a communication system used specifically to avoid misunderstandings, in which the interaction between the sender and the receiver does not end until the message has been issued, received and, finally, verified and closed by the sender.
The only problem with this system is that its effectiveness is not generally known to seafarers and proper attention is not given to the communication problem as one of the main causes of accidents caused by Human Error.
This work is divided into 3 parts, the first, which talks about the main causes of communication failures, such as sociological, technological or linguistic factors. A second part in which the Closed Loop system is explained and examples of use to prevent communication failures and incidents related to human error. Finally, a third, more practical part, which has some empirical studies based on the results obtained in a survey of seafarers on the use of the system, implementation and its effectiveness. The results of the study can show that the mandatory implementation of this communication system on ships would improve onboard communication and will provoke the reduction or elimination of misunderstandings during critical operations, positively affecting the safety of the ship in general.
The Closed Loop communication system is the future of onboard communications, this may be the determining factor in minimizing something that has haunted seafarers over time: human error.

1. Introduction.

Statistics indicate that 75% of all maritime accidents are caused by human error (Allianz Global Corporate, 2023). Communication is the third most common human error, affected by differences in nationalities, mother tongues, body languages and language skills (Bocanegra Valle, A., 2011). Implementing an effective communication system can prevent many accidents attributable to 'human error'. In practice, even the captain can make mistakes in courses or orders. To prevent accidents, it is crucial to focus on improving systems rather than looking for culprits. With a proper system, for example, the third pilot can and should question the captain to avoid misunderstandings.

It is common that during radio communication (fixed or portable station) messages are not heard or understood correctly, and many seafarers do not ask for them to be repeated for fear of the reactions of the captain or officers. This lack of clarity can result in errors that lead to accidents. In critical operations such as anchoring or manoeuvring in rivers and canals, it is vital to execute all orders correctly, which is facilitated by a good on-board communication system. This system also promotes constant and effective communication between teams, which is crucial for safety on board.

There is a universal system known in the maritime industry as 'double check', which involves repeating the information re-

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ceived. However, this system is not always effective enough to prevent serious errors or misunderstandings. The 'closed loop' technique in communication during critical operations could significantly improve this situation, although its effectiveness is not widely recognised among seafarers, contributing to the problem of human error accidents. This work seeks to address and mitigate this lack of information.

In the maritime working environment it is of vital importance to ensure good communication, as in the course of day-to-day tasks it is easy for misunderstandings to occur, leading to possible accidents. This is what inspires this work: the recurring lack of success in communications on board ships even though there are international standardised tools to avoid misunderstandings (IMO, 2002), as evidenced by Porathe, Eklund and Goransson in their research studies published in 2014 and which form the theoretical basis of this work.

It is important that those who work on merchant vessels or are linked to them have all the information and manage the variables, which in this case would be the existing communication systems, and thus can make an intelligent decision that results in fewer accidents.

2. Literature Review.

2.1. Background to Closed Loop communication.

The origin of the closed loop communication system is not entirely clear, although it is suggested that its use began with early radio communications in the military. In this context, the need to confirm receipt of messages was crucial, especially as radio allowed messages to be sent beyond visual range. This led to the use of specific terms to close the communication loop: 'Roger', 'Over' and 'Out', meaning respectively 'message received', 'I'm done talking, your turn' and 'end of communication'. This system was designed to ensure that each message was not only sent, but also received and understood correctly in often confusing situations and under pressure.

Closed-loop communication involves a clear and concise exchange of information, confirmation of its receipt and verification of its correct understanding and, where possible, its proper execution. This method reflects a verification strategy that confirms that messages sent are received and interpreted as intended, promoting explicit and effective communication within teams. This communication pattern ensures that all team members share the same objectives, plans and understanding of the situation.

Given its high effectiveness, the closed-loop communication system has been implemented in multiple high-responsibility sectors such as healthcare, where it is used by operating surgeons; in the nuclear power generation industry; in aviation; and in the maritime domain, including merchant ships, icebreakers and cruise ships. In the latter, its use is vital due to the high economic and human value of the operations involved.

2.2. Closed Loop communication system.

Closed Loop communication is a technique of communication used to avoid misunderstandings. When the sender gives a message, the receiver repeats it. The sender then confirms the message using the word 'YES'. When the receiver repeats the message incorrectly, the sender will say 'NO' (or something similar) and then repeat the correct message. If the sender, i.e. the person sending the message, does not receive a response, he/she must repeat the message until the receiver begins to close the loop. To address the receiver, the sender can use his or her name or functional position. This system forces the sender to follow up on his request and close the request.

Closed-loop communications are essential in times of stress and tension, where it is important that the message is transmitted effectively. In the case of merchant vessels, almost all operations and manoeuvres include critical moments where safety is compromised, including the integrity of the ship and cargo, the environment and human life.

Below is the report (The Australian Transport Safety Bureau 2013) of the accident of the ship 'Bosphorus' caused by human error (Failure of communication system during critical operation).

On 29 October 2013, the general cargo ship 'Bosphorus' with the pilot on board ran aground at Lytton Rocks in Australia due to Human Error. There was a simple failure of the communication system on the bridge. No injuries, damage or pollution were reported as a result of the accident.

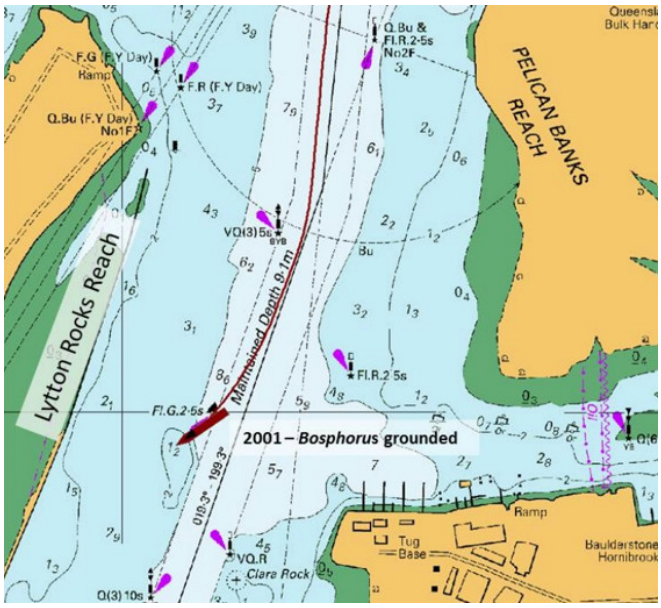
At approximately 20.00 hours, upon entering the very narrow part of the Brisbane River in Australia the pilot observed that the ship was not stable, but continued to swing to starboard towards shallow water. He ordered 'MIDSHIPS' followed immediately by 'PORT 10'. The helmsman responded verbally with 'PORT 10', but instead applied 10º of rudder to starboard. The pilot then ordered 'PORT 20' and then 'HARD A PORT'. Each time the helmsman repeated the command, but applied rudder to starboard. Within 9 seconds, the pilot noticed that the rudder was still to starboard and then shouted 'you go to starboard'. The third officer then intervened and turned the rudder hard to port. The pilot then ordered 'ALL BACK', and then a tug to 'come to help'.

At the critical stage of navigation, effective monitoring of the implementation of the rudder orders by the bridge team could have allowed early intervention to prevent the ship from running aground. However, the helm orders and their application by the helmsman were not being effectively monitored by the bridge team. However, by the time the helm was all the way to starboard and the pilot shouted 'you're going the wrong way', it was too late to prevent the ship from running aground.

This accident is an obvious example of Human Error caused by not having an effective communication system in place.

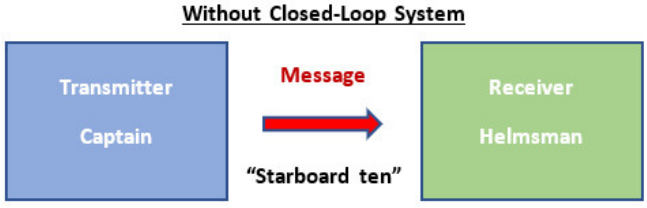
The fact that someone is asked to do something does not mean and is not a guarantee that they actually heard it properly and understood it correctly. And this demonstrates the importance of a communication system that allows the sender and receiver to be sure that the message has been sent and received successfully and its correct execution.

Figure 1: Nautical chart of the accident.



Source: Australian Hydrographic Office.

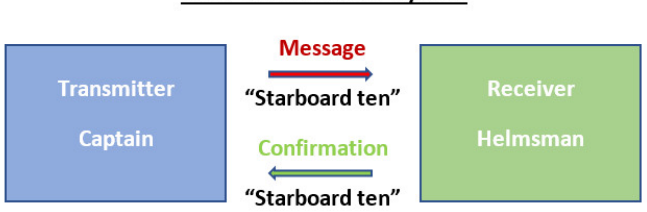
Figure 2: Closed Loop Communication System Process. Order / Execution (Simple message).



Source: Authors.

In this case, the order is executed without receiving any type of confirmation from the receiver, so in the case of erroneous or deficient communications, we have no way of confirming that the order received was the correct one and it is 'up to the receiver's interpretation'.

Figure 3: Closed Loop Communication System Process. Order / Execution (Double Check system).

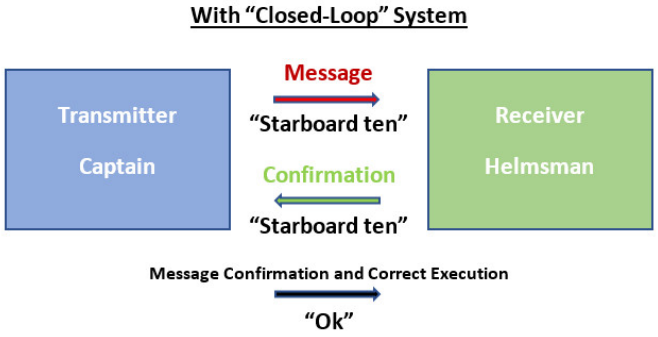


Source: Authors.

The "Double Check" system refers to a method often used in various fields to ensure accuracy and safety by having two individuals independently verify the correctness of a task or process.

This system is designed to prevent errors and enhance safety by ensuring that at least two people have independently confirmed that all parameters are correct before proceeding with a critical task. It's a simple yet effective way to reduce the likelihood of mistakes due to oversight or miscommunication.

Figure 4: Closed Loop Communication System Process. Order / Execution (Closed-Loop system).



Source: Authors.

The "Closed-Loop" system operates by continuously monitoring the output of a process and adjusting the input accordingly to maintain the desired output.

The defining characteristic of a closed loop system is the use of feedback. The system compares the desired output or indicated command (set point) with the actual output measured by the sensors or, where appropriate, the decision made by the receiver or operator. Any discrepancy between these two signals or what is the command and the application of the command (the error signal) is used to make corrections on a continuous basis, exercising the appropriate corrections.

Depending on the type of vessel such activities and processes vary according to the purpose of each vessel, but in general, a list of common activities on board merchant vessels that merit the use of the Closed Loop system would be as follows:

- Any order or directive given by a superior.
- Changes of watch.
- Helm orders.
- Orders/requests to the engine room.
- Orders during docking, undocking and anchoring operations.
- Changes to bridge equipment parameter settings (Critical and non-critical).
- Orders during ballasting and loading operations.
- Changes in the bridge command line.

2.3. Use of the Closed Loop System on board: example on an ice-breaking vessel.

Icebreaker operations are highly hazardous due to the harsh environmental conditions, the high risk of collision and the complexity of the procedures. In the following, a summary of the study conducted by Boström (2020) will be presented, which aimed to investigate the extent to which the Closed Loop communication system is used during icebreaker operations, to describe verbal maritime communication in the context of icebreaker operations and whether this practice deviates from the stipulated communication protocols. The data for this study consisted of verbal radio communications between an icebreaker and icebreaker-assisted ships over 40 days. The data were then compared with the stipulated communication protocol described in the Standard Marine Communication Phrases (SMCP) (IMO, 2002).

The results showed that closed-loop communication is not used to its full extent. Some types of messages are completely repeated, mainly instructions and questions, while other types of messages, such as information and intent, often receive a yes or no response. Closed-loop communications, i.e. a given message, completely repeated and followed by an acknowledgement, was only observed in 16.4% of the messages initiated by an icebreaker vessel and in 14.0% of the other vessels. Therefore, this study clearly shows that there is a gap between the actual use of language and the stipulated communication protocol.

The SMCP require that when an instruction or recommendation is given, the response must be a complete answer with the same meaning as the message. The same applies to yes or no questions. Given that research suggests that Closed Loop communication has positive benefits both in the maritime context and in other professional contexts (e.g. medical), Boström (2020) suggests that it would be prudent to use such a system even when it is not regulated.

Boström's (2020) study provides a comprehensive description of the communications of an icebreaking vessel with the ships it attended, but the findings are not limited to those operations alone. Instead, they extend to other domains within the maritime business, as well as beyond the maritime area. The scope of interest could extend to any situation where interpersonal interaction is required and there is limited scope for operations that can be seriously affected by misunderstandings in verbal communications. Such as, for example, other areas within the transport sector, control rooms, manufacturing processes, military personnel and medical personnel.

2.4. Importance of oral communication for effective navigation.

Bringing a ship into port and berthing it safely is a difficult task that requires the combined efforts of the entire bridge team and other seafarers involved in this major task. Just one small mistake by any individual could result in a large-scale accident. There are endless scenarios that can occur on board where the ship can be operating with minimal safety margins and where there is definitely no room for communication errors. The entire team both on the bridge and the parties involved (VTS, Pilots, tugs, among others) have to work together to safely navigate the vessel. Add to this the fact that there may be a combination of nationalities and languages, and the situation becomes more complicated. The pilot, tugs and dock handlers may come from different countries, as may the port control personnel and the VTS operator. Each of these individuals may have different accents, even if they speak a common language. To deal with this successfully, the aim is for all these professionals to have good verbal communication skills to ensure the safety of the ship.

2.5. Effective communication on the bridge.

The main purpose of communication is to convey thoughts or ideas to another person and to get them to carry out the actions that need to be taken. Always encouraging the receiver to express what he/she thinks in order to be sure that the message has been clearly understood. If the communication fails to get the receiver to perform the desired action correctly, it could lead to an accident. Given the multinational and multilingual nature of the on-board environment, it is essential that when you speak, you speak clearly, slowly, precisely and explicitly, using simple words and short sentences. In addition, make sure it is loud enough to be heard above the general sound level of the surroundings, as English may not be the first, second or even third language of the recipient. On this basis, many authors argue that the use of the IMO Standard Phrases for Maritime Communications (SMCP) is a good resource, as seafarers in all countries are familiar with them and applying them is good practice, even if English is the first language.

On board it is operated in such a way that the sender, after having issued a communication, waits to see if the receiver understood it; it is shipboard policy, as a general rule, that the receiver repeats the given communication and, in the case of the use of the Closed Loop system, the sender must acknowledge that what the receiver repeated and executed is correct, thus closing the loop. Another key to successful communication is to know what information is needed, how best to ask for it and for whom the information is requested.

3. Methodology.

For this work we have used a questionnaire as the data collection technique for this research, which was constructed in Jotform (https://form.jotform.com/233073351964053) for easy distribution. The seafarers selected as a sample population were sent a link to a blank questionnaire ready to be filled in. In total, 44 seafarers were sent the link and 42 of them answered the questionnaire.

This questionnaire is broken down into nine questions, based on the research questions and objectives, as well as the information from the Closed Loop used in this study. The first two questions of the survey refer to specific information about the person who is carrying out the survey, i.e. the respondent, revealing the type of vessel he/she sails on and the rank he/she holds there.

Following these, questions 3 and 4 are related to the Closed Loop System, in order to find out if they are aware of it and how they learned about it, respectively. The next question refers to the company, whether it requires its use or not. Questions 6 and 7 refer to the effectiveness of the Closed Loop System and the respondent's opinion on the mandatory implementation of the Closed Loop System on board. Finally, question 8 reflects whether the respondent has experienced any communication problems using the Closed Loop system and finally, question 9 determines whether the respondent believes that there is any other method of communication more effective than the Closed Loop system. The Jotform tool was efficient in the completion of the questionnaire and in reviewing the responses, as it provides graphs showing the results of the questionnaires.

The 21% of the respondents who answered that they were not familiar with the Closed Loop Communication System were explained what it was and given a short example of a simple order to answer the entire survey.

They were additionally provided with a definition of the Closed Loop system and a short example so that those who were not familiar with it would have a reference and be able to answer the survey questions in full.

Figure 5: Example of the use of Closed Loop during anchoring operation.

NORMAL MESSAGE

A: Forward station, prepare **STARBOARD** anchor for emergency.

B: Ok Bridge, will prepare **STARBOARD** anchor for emergency.

A: **YES**, Forward station, **PLEASE GO AHEAD**.

MISUNDERSTOOD MESSAGE

A: Forward station, prepare **STARBOARD** anchor for emergency.

B: Ok Bridge, will prepare **PORT** anchor for emergency.

A: **NO**, prepare **STARBOARD** anchor for emergency.

B: Ok Bridge, will prepare **STARBOARD** anchor for emergency.

A: **YES**, Forward station, **PLEASE GO AHEAD**.

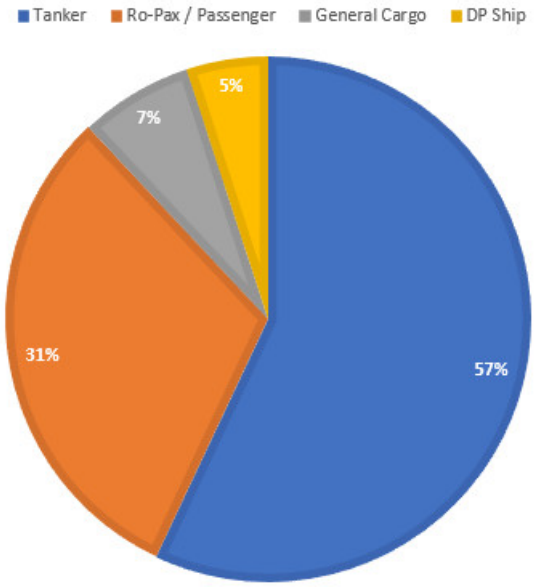
Source: Authors.

4. Results.

We wanted to find out how the Closed-Loop system is or is not currently in use in the sector.

Active merchant seafarers from different companies and in different roles were selected for the survey instrument. The survey consisted of nine questions, the results of which are presented below.

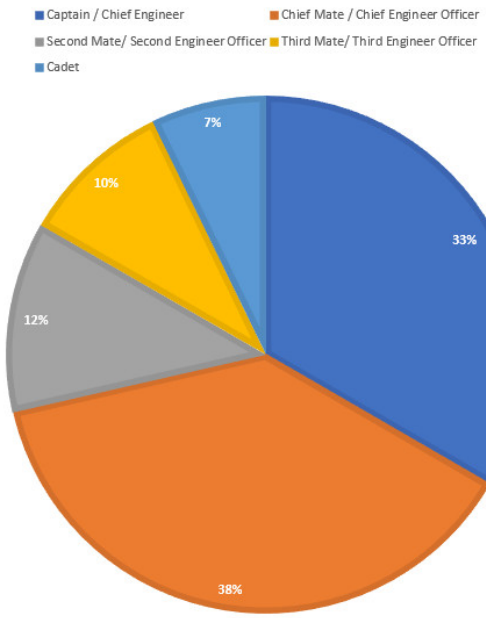
Figure 6: Ship Type.



Source: Authors.

As can be seen, most of the officers interviewed belonged to tankers and ro-ro/passenger ships, although we have also counted officers on other types of ships, which tend to be in the minority.

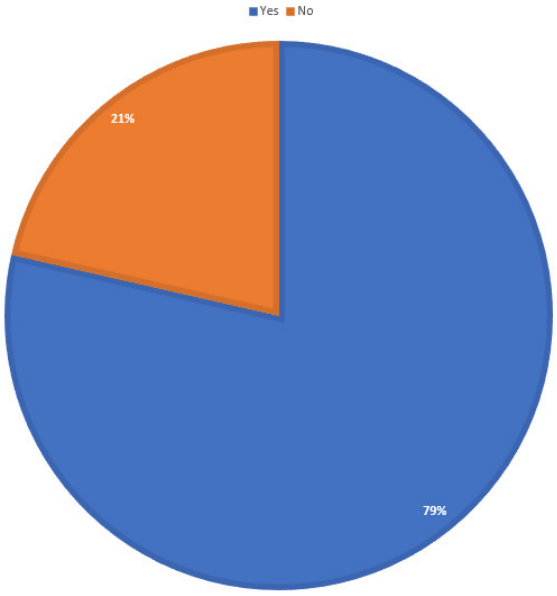
Figure 7: Position on board.



Source: Authors.

More than 70% of the answers correspond to Captains/Chief Engineers and Chief Navigation and Engineer Officers, precisely those who could benefit the most from the application of a communication system such as the one described to lessen the errors that could occur and therefore the consequences that could derive from such actions.

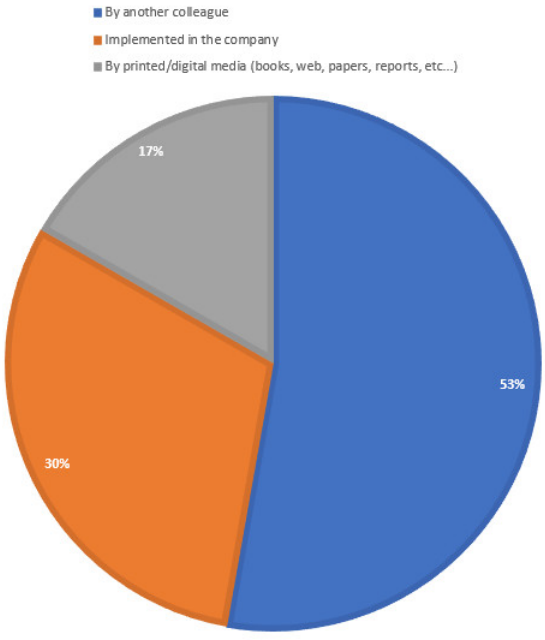
Figure 8: Do you know the Closed-Loop system?.



Source: Authors.

In the answers obtained, it stands out that 79% of the officers know it and, taking into account question number two, we could say that the Masters/Chief Engineers and Chief Officers are the ones who know the system the most, being the persons with the highest authority on board and the chief officer the head of the operations of loading, unloading, ship stability, maintenance, etc. and the one who manages the largest number of personnel on board, the officer who must ensure that the instructions and orders are carried out or executed correctly.

Figure 9: How did you hear about the Closed-Loop system?.



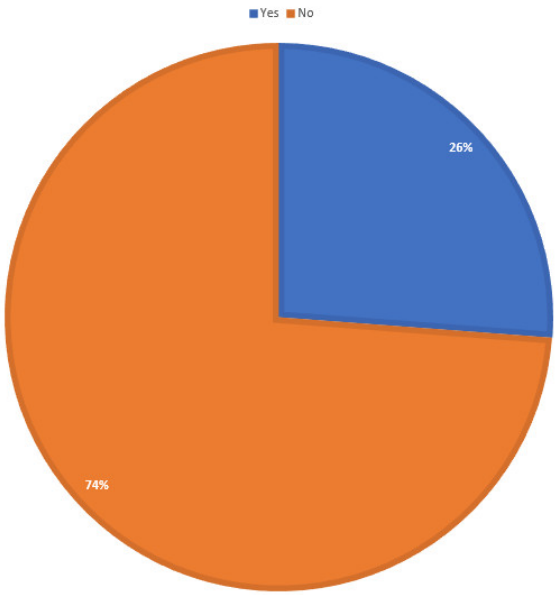
Source: Authors.

Most of the officers know about the system through a professional colleague, i.e. someone has told them or commented on this communication system; however, 53% of the officers are only aware of its existence but do not use it on a regular basis.

The opposite is the case for 31% of the officers surveyed, who are required to have this type of communication and its implementation on board from the company's own management system, which is good news but clearly insufficient.

And only 6% stated that they have learned about the system through print or digital media.

Figure 10: Is it required by the company as a tool for your job?.

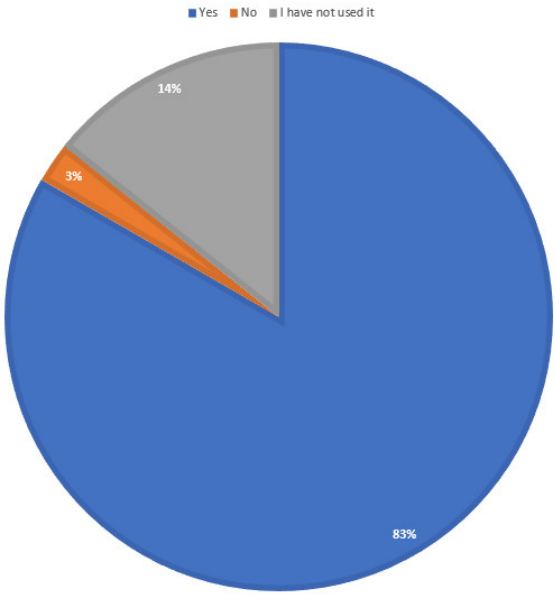


Source: Authors.

It is clear that the system under study is not used by the majority of merchant seafarers, unless the company makes it a requirement. It also coincides with the fact that 26% of the officers who answered yes to the question are precisely those who work on board cruise ships and passenger vessels, precisely because of the importance in these cases of avoiding errors due to misunderstood orders.

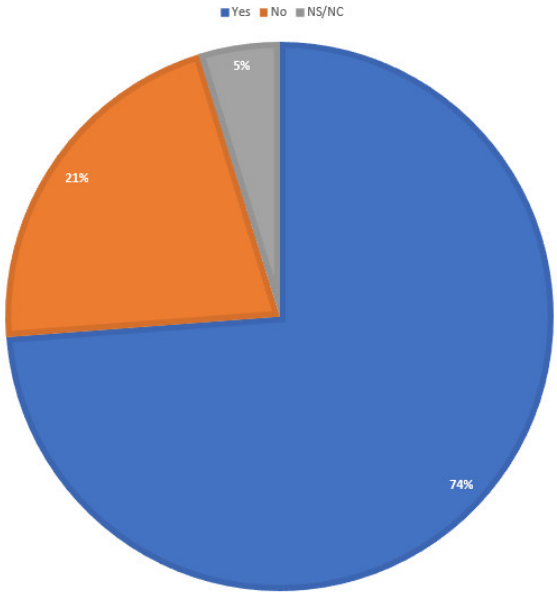
In the next graph (Figure 11), the majority of respondents agreeing that the Closed Loop Communication System is an effective system for avoiding misunderstandings, and assessing the numbers of officers and cadets who are aware of the system, those who have used it and those who have not, it can be concluded that by simply knowing how the system works and projecting it in day-to-day life on board merchant ships, maritime professionals can give an informed opinion on its effectiveness.

Figure 11: Do you find this system effective in avoiding misunderstandings?.



Source: Authors.

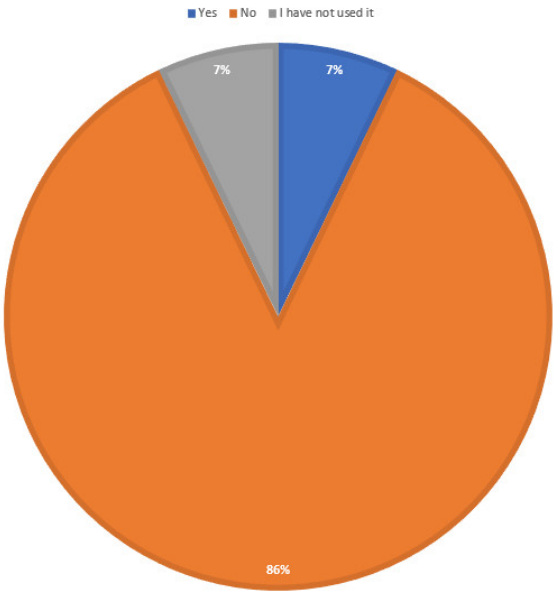
Figure 12: Do you think the Closed Loop system should be mandatory in the maritime domain?.



Source: Authors.

Although the majority of the respondents answered that they do consider that the Closed Loop Communication System should be made mandatory in the maritime world, there is a fifth of the respondents who either do not consider it necessary or are hesitant. This is not a negligible number, and highlights the difficulty of implementing new procedures and measures, as well as the fact that such changes often take a long time to implement and adapt. In addition, specific training and education campaigns are needed to raise awareness of the system and its benefits.

Figure 13: Have you experienced any inconvenience/misunderstanding using this system on board?.



Source: Authors.

This question, like the others, is key to highlighting the importance of good communication on board merchant ships to avoid or reduce misunderstandings. Of all subjects who use or have used the Closed Loop system, more than 85% have not experienced any inconvenience or misunderstanding on board. The low possibility of making mistakes or causing accidents due to misunderstandings in communications using this system is fully evident.

But accidents on ships due to communication errors are unfortunately common and can have devastating consequences. Communication errors can arise due to a variety of factors including unclear instructions, linguistic misunderstandings, technical problems with communication equipment, and the lack of standardized protocols. For example, we can cite the following cases:

- Costa Concordia (2012): Although the sinking of the Costa Concordia was primarily due to a poor decision by the captain, subsequent investigations also revealed significant communication failures between the crew and rescue teams, complicating evacuation operations and increasing the severity of the accident.
- Exxon Valdez (1989): This environmental disaster, one of the largest oil spills in history, was partially attributed to communication errors. Failures in communication between onboard personnel and shore-based radar operators contributed to the tanker veering off course and grounding.
- Queen Elizabeth 2 (1992): The ocean liner struck a submerged object while navigating off the coast of Massachu-

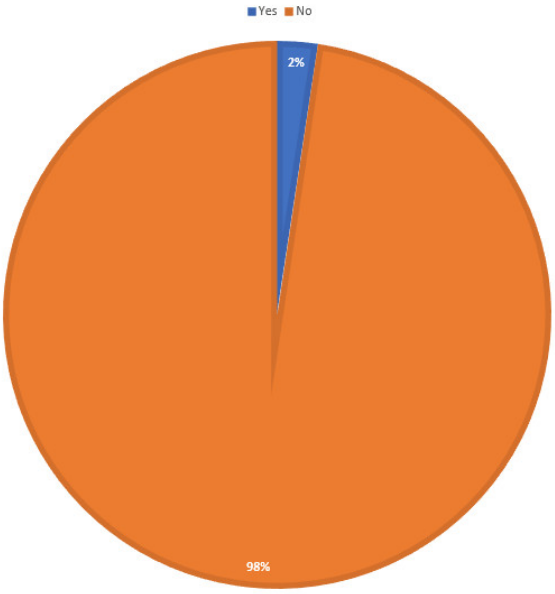
setts. Subsequent investigations suggested that poor communication between the control bridges and the engine room during navigation in shallow waters was a contributing factor.

- The Herald of Free Enterprise (1987): Shortly after leaving the port of Zeebrugge, Belgium, this ferry capsized, resulting in the deaths of 193 people. The main cause was that the ship's sea doors were left open by mistake. A failure in communications among the crew who were responsible for ensuring these doors were closed was one of the key factors in the accident.

- MSC Napoli (2007): This cargo ship suffered structural failure and was abandoned in the English Channel. Investigations indicated that there were communication confusions during storm conditions, which led to erroneous decisions exacerbating the critical situation of the ship.

To conclude the survey and to affirm the importance of the Closed Loop Communication System as the most suitable communication system to be implemented on board merchant ships, respondents were asked if they knew of any other systems that could be more effective or at least similar to the Closed Loop, and virtually all of the respondents answered negatively, as can be seen in the following chart (Figure 14). This clearly demonstrates that the Closed Loop Communication System is undoubtedly the best communication option on board.

Figure 14: Are you already aware of a more effective system than the Closed Loop?.



Source: Authors.

Conclusions.

On the basis of the results obtained in this study, we will make a series of considerations:

1. Onboard communication already has an established universal language, it already has the necessary guidelines to be carried out, the only thing missing is to establish an effective communication system that complements the previously mentioned factors, here enters the Closed Loop, which makes sure to reduce the probability of a misunderstanding onboard. The Closed Loop Communication System allows that once an order or request has been given to a designated person to perform a procedure, the giver of the order explicitly acknowledges the request. Additionally, the sender knows with certainty that his requests have been heard and understood.
2. The results reflect the need to optimise communication systems in the maritime world with the intention of minimising the possibility of error in orders flowing through the chain of command.
3. There is evidence of acceptance of the Closed Loop system and recognition that it is effective in its purpose.
4. Communication based on this system has been shown to reduce the rate of error by removing ambiguity from instructions, allowing questions to be asked if the instruction/request is not made clearly and allowing others present to be aware of what is happening and what is going to happen.
5. Any working team, in our case, the bridge team on board merchant ships, needs to be efficient if all team members are aware of their role, communicate correctly and are able to operate in an atmosphere of trust and respect.
6. Good communication is essential for operating ships, especially in times of stress. It is important to maintain a common vocabulary, to create a kind of shared mental model of the situation they are in, to avoid assumptions and misunderstandings leading to accidents.

In terms of future perspectives and as a result of this research, the importance of the contribution of maritime professionals to assist in research to improve on-board communications is evident, due to the technical complexity of the language used on board and the difficulty of accessing the data, examples and scenarios necessary for researchers in the area of communication (Bocanegra-Valle, A., 2011). The Closed Loop communication system is the future of shipboard communications, which may be the determining factor in minimising something that has haunted seafarers throughout time: human error.

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