DIGIMAR

KA220-HED-0002/2023

WP 4.5.

Recommendations for a Revision of the Standard Protocol of Communication

Activity Report

Leading organization:	Faculty of Maritime Studies Kotor, University of Montenegro
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WP 4.5. Summary

The specific objective of WP 4.5 was to provide research-based recommendations for systemic changes in the standard protocol of communication to the international bodies competent for maritime communication. This will be achieved through:

-Identification of the elements of the standard protocol of communication that have been assigned high-risk assessment values;

-Preparation of an inventory of recommendations for a revision of the standard protocol of communication;

- Communication of the recommendations for a revision of the standard protocol of communication to the international authorities.

WP 4.5. Result

The result 7 under WP 4, related to WP 4.5 specifically, i.e, research-based recommendations for a revision of the standard protocol of communication (to prepare recommendations that will be communicated to the main international bodies competent for maritime communication (IMO, ITU, IALA, EMSA) in order to support recommended systemic changes.

WP 4.5. Qualitative and quantitative indicators

Quantitative indicators: All international organizations competent for maritime communication identified and contacted.

Qualitative: 100% approval of the result by the partner maritime safety authorities.

1.1. WP 4.5. Partner responsibilities

The partners responsible for WP 4.5 were researchers at higher education institutions and maritime safety authorities, as follows:

Responsibilities of HEI: Identification of the elements of the standard that have been assigned high-risk assessment values. Preparation and communication of recommendations for a revision of the standard protocol of communication (IMO, ITU, IALA, EMSA).

Responsibilities of MSAs: Reviewing the recommendations for a revision of the standard.

E10027767 University of Montenegro, Maritime faculty Kotor Montenegro (Lead) – 40 mandays

E10209243 UNIVERZA V LJUBLJANI Slovenia – 15 mandays

E10195716 SVEUCILISTE U RIJECI Croatia – 15 mandays

E10166177 AB YRKESHOGSKOLAN VID ABO AKADEMI Finland – 15 mandays

E10209418 CHALMERS TEKNISKA HOEGSKOLA AB Sweden – 15 mandays

E10330679 Fintraffic Vessel Traffic Services ltd Finland – 3 mandays

1.2. WP 4.5. Content

The content of WP 4.5 included:

-Identification of the elements of the standard protocol of communication that have been assigned high-risk assessment values.;

-Preparation of an inventory of recommendations for a revision of the standard protocol of communication.;

-Communication of the recommendations for a revision of the standard protocol of communication to the international authorities

1.3. WP 4.5. Purpose

The purpose of WP 4.5. was to provide research-based support to recommended systemic changes in the standard protocol of communication, the international bodies competent for maritime communication need to be informed about the results.

1.4. WP 4.5. Expected Results

The expected results under WP 4.5. were research-based recommendations for a revision of the standard protocol of communication.

1.5. WP 4.5. Number and Profile of Participants

WP4 activities took place in the countries and at the premises of the project partners, and involved the researchers, shore service operators, higher education students, external users, and other stakeholders involved in each project activity. The expected numbers of participants, where relevant, were stated in each quantitative indicator designed to measure the quality of each project result and the achievement of specific and general project objectives.

In particular, researchers at higher education institutions and maritime safety authorities were responsible for delivering the final result under WP 4.5.

2. Methodology

As the final output of the DigiMar project, a document featuring research-based recommendations for the revision of the standard communication protocol was developed, drawing on all preceding project activities and results, i.e. all WP Activity Reports.

Taking all deliverables and activity reports into consideration, specifically the results of 4.3 and 4.4 WP and adhering to the deadlines specified below, the Faculty of Maritime Studies Kotor (University of Montenegro) drafted the WP 4.5. Activity Report and Recommendations document which is an annex to the Activity Report WP 4.5. The draft(s) were submitted to project partners for review and harmonization.

Upon mutual agreement on the Recommendations for a Revision of the Standard Protocol of Communication, the document was forwarded to MSAs for further review until 100% approval of the report is achieved and confirmed by signed consent forms.

When the final harmonized document is ready, it will be submitted via email and accompanied by a cover letter, to all relevant authorities (IMO, ITU, IALA, EMSA).

The idea was to complete these activities before the final deadline of August 31, 2026, as per the proposed deadlines given below. This schedule would leave some time for gathering prospective feedback prior to the final conference, scheduled for August 25–27, 2026.

3. Results

3.1. DigiMar Project Overview

The Digital Education for Maritime Communication (DigiMar) project is an Erasmus+ KA220-HED Cooperation Partnership in Higher Education implemented over a period of 36 months, from 1 October 2023 to 30 September 2026. The project was coordinated by the University of Ljubljana, Faculty of Maritime Studies and Transport, Slovenia, and brought together higher education institutions and maritime authorities from several European countries.

The higher education institutions participating in the project were the University of Ljubljana, University of Rijeka, Novia University of Applied Sciences, University of Montenegro – Maritime Faculty Kotor, and Chalmers University of Technology. Maritime authorities and operational partners include the Administration for Maritime Safety and Port Management, Swedish Maritime Administration, Norwegian Coastal Administration, Slovenian Maritime Administration, Fintraffic Vessel Traffic Services Ltd, and Montenegrin Maritime Administration.

The project was organised into five interconnected work packages covering project management, maritime communication standards and data collection, development and evaluation of digital educational tools, benchmarking of maritime communication practices, and exploitation and dissemination of project results. It covered the following work packages: WP1 – Project Management; WP2 – Maritime Communication Standard- and Data-based Content Development; WP3 – Digital Educational Tool Development, Deployment and Evaluation; WP4 – Maritime Communication Standard- and Data-based Benchmarking; and WP5 – Exploitation and Dissemination.

3.2. Project Motivation and Objectives

The project was motivated by the findings of Jurkovič (2022), whose corpus-based analysis of authentic routine ship–shore communication revealed significant deviations from the internationally prescribed standard communication protocol and highlighted the need for harmonization of existing communication guidelines. These findings, together with previous research conducted in different geographical contexts (Dževerdanović-Pejović, 2013; Boström, 2020), confirmed that ineffective and ambiguous maritime communication remains a significant contributor to navigational accidents and operational risks (IALA, 2017). The project aimed to enhance maritime communication skills and navigational safety through the development of open-access, research-based digital educational tools, including instructional videos and speech-recognition chatbots based on authentic communication data. Particular attention was given to shore service operators, whose communication plays a crucial role in ensuring safe navigation. It also addressed the need for the harmonization and evidence-based revision of maritime communication

standards, particularly the G1132 VTS Voice Communications and Phraseology (IALA, 2022) and the Standard Marine Communication Phrases (IMO, 2001; Jurkovič, 2022).

DigiMar was developed in response to the growing need for improved maritime communication, which remains one of the key factors affecting navigational safety. Misunderstandings in ship–shore communication may contribute to human error, accidents, environmental damage, and economic losses. The project sought to enhance maritime communication skills among both maritime students and shore-based maritime service operators through innovative digital learning solutions, including instructional videos, chatbots, and data-driven learning materials. The overall aim of DigiMar was to improve navigational safety by strengthening routine maritime communication skills and measuring learning outcomes through a digital educational pilot study. The improvement in maritime communication skills and consequently safety of navigation were achieved through an open access research-based digital educational tool consisting of instructional videos and chatbots for routine maritime communication, and an open-access inventory of data-based simulation tasks in maritime communication for maritime students. The videos and case studies, as well as chatbots are available on the official site of the Digmar project: http://digimar.si/

An important outcome concerned recommendations for a systemic revision of the international maritime communication standard. The implementation of the project objectives was supported by a series of transnational meetings that facilitated continuous coordination, monitoring of project progress, exchange of findings, and collaboration among the project partners. The project commenced with the Kick-off Meeting held on 9–10 October 2023 in Portorož, Slovenia, followed by the first transnational meeting, organized online by the University of Montenegro – Maritime Faculty Kotor on 2 July 2024. The second transnational meeting was hosted by the University of Rijeka on 26–27 May 2025, while the third transnational meeting was organized by Novia University of Applied Sciences on 12 March 2026. The final project meeting, hosted by Chalmers University of Technology on 25–26 August 2026, focused on the evaluation of overall project achievements, sustainability, and future exploitation of the project results.

The webinar, hosted by the Chalmers University of Technology University on 27 August 2026, in both an in-person and hybrid format, brought together prominent experts and key stakeholders in maritime communication, VTS operations, and the maritime industry. The participants included representatives of relevant maritime authorities and institutions, leading VTS experts and members of the VTS Committee, as well as representatives of the maritime industry, who provided valuable professional and operational feedback on the presented findings and recommendations.

3.3. Main Findings

This section presents a review of the main findings of the DigiMar project, structured according to the individual work packages and their respective activities. The findings of each relevant work package are presented separately in order to provide a comprehensive overview of the research, educational and benchmarking results generated throughout the project. These findings

subsequently provide the basis for the identification of high-risk communication elements and the formulation of the Recommendations for a Revision of the Standard Protocol of Communication.

3.3.1. WP1 – Project Management

Work Package 1 (WP1): Project Management ensured the effective coordination, administration, quality assurance, and risk management of the DigiMar project throughout its implementation period.
The package encompassed:
Project coordination and administration, so as to monitor project progress, timelines, deliverables, and partner responsibilities; Quality Assurance System (QAS) – establishing procedures to ensure that all project activities and outputs meet the required quality standards. WP1 included Risk Management System, which was aimed at identifying potential risks, assessing their impact, and implementing mitigation measures through the Risk Register and corrective action plans. In order to monitor and have a neat report of the activities and financial issues the project includes Internal reporting and monitoring meant to collect partner reports, activity reports, peer reviews, and timesheets to track project performance. Partner communication and engagement was mandatory and was based on conducting partner surveys and regular meetings to support collaboration and continuous improvement.
In order to address identified issues through action plans and monitor the effectiveness of implemented solutions, corrective measures and continuous improvement were established.
Overall, WP1 provided the managerial framework that supports the successful implementation of all other DigiMar work packages, ensuring compliance with Erasmus+ requirements, efficient use of resources, timely reporting and delivery of results, and achievement of project objectives.

3.3.2. WP2 – Maritime Communication Standard- and Data-based Content Development

The specific objectives of WP2 focused on the definition of regulatory framework and content for the open-access digital educational tools and pilot study with the aim of generating pre-educational pilot study databases of authentic routine maritime communication and of student simulations.

These contributed to the general objective of the project by setting the foundations for the data collection and analysis, and provided the content for the open-access digital educational tools (instructional videos and chatbots), and for student simulation tasks.

The specific objectives of WP2 were realized through the results of four WP2 activities:

- WP2.1. Overview of Internationally Adopted Rules, Procedures and Standards
- WP2.2. Overview of Cases in Marine Accident Databases
- WP2.3. Pre-Educational Pilot Study Authentic Routine Maritime Communication Databases (shore service operators' strand)
- WP2.4. Pre-Educational Pilot Study Learner Routine Maritime Communication

3.3.2.1. Overview of Internationally Adopted Rules, Procedures and Standards

WP2.1 represented one of the most important foundational activities of the DigiMar project, as it laid down the regulatory, educational, and operational framework upon which all subsequent project activities were built. Through a comprehensive review of internationally adopted conventions, standards, guidelines, model courses, and research literature, the work package provided a detailed overview of the rules governing routine maritime communication and the requirements related to the education and training of maritime professionals and VTS operators. The analysis covered key documents issued by the International Maritime Organization (IMO), International Telecommunication Union (ITU), International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA), SOLAS, STCW, and associated educational and training frameworks. Providing an extensive analysis of normative documents and research papers making a crux of standard maritime protocol in maritime routine communications, Jurkovič (2022) put emphasis on primary sources documentation: ITU Manual (2020a, b) as a superordinate document and the IMO SMCP (2001) as a supplementary document (p.48). With VTS manuals aimed for VTS operators only, this provides for four documents forming around which routine communications revolve (Jurkovič, 2022, 49):

1. Manual for Use by the Maritime Mobile and Maritime Mobile-Satellite Services (ITU 2020a,

2020b)

2. IALA VTS Manual (IALA VTS Manual 2008 and an amended 2022 version)

3. IALA Guideline G1132: VTS VHF Voice Communication (IALA Guideline 2017, and updated

versions from 2017 and 2022 included here)

4. Standard Marine Communication Phrases (IMO SMCP 2001)

The literature review demonstrated that routine maritime communication is founded upon a highly structured communicative system designed to ensure navigational safety, operational efficiency, and the prevention of misunderstandings in multilingual and multicultural maritime environments. Core

communication principles identified throughout the analysed documents include the use of *standard phraseology, message markers, closed-loop communication, phonetic spelling, standardized message structure, concise language, and clear turn-taking procedures*. At the same time, the literature review revealed that these principles are distributed across numerous documents developed by different international organisations, creating a complex regulatory environment that may lead to varying interpretations and implementation practices.

A particularly important finding concerned the relationship between *IMO, ITU, and IALA documents.* While the analysed documents generally pursue the same objective of promoting safe and effective communication, differences were identified in terminology, communication procedures, phraseological recommendations, and the treatment of communication-loop techniques. The review highlighted inconsistencies regarding the use of message markers, procedural words, communication repair strategies, and confirmation procedures. *These findings suggest that although a substantial regulatory framework exists, greater harmonisation between the various guidance documents would contribute to more consistent implementation in operational practice.*

The analysis presented in Activity Report 2.1. also demonstrated that contemporary VTS operations occupy an increasingly important role within the maritime communication system. However, existing communication standards remain largely ship-oriented, while VTS-specific communication requirements continue to be addressed primarily through IALA recommendations and model courses. The review therefore revealed a gap between the growing operational significance of VTS services and the extent to which VTS communication competencies are formally incorporated into international regulatory instruments such as the STCW Convention and Code.

With regard to *education and training*, WP2.1 highlighted the central importance of Maritime English competence, standard phraseology, and specialised VTS training. The analysis revealed significant differences among participating countries regarding entry requirements, language competence standards, qualification pathways, and assessment procedures for VTS operators. While IALA guidelines (IALA, 2022) provide a common reference framework, their implementation remains dependent on national administration, resulting in varying approaches to competence development and assessment. The review further demonstrated the absence of internationally harmonised criteria for assessing Maritime English proficiency among VTS personnel.

Another important conclusion concerned the role of empirical evidence in the development of communication standards. The literature reviewed within WP2.1 repeatedly emphasized the limited availability of authentic VHF communication corpora and the difficulties associated with obtaining operational communication data. As a result, many existing recommendations were based on expert judgement and operational experience rather than large-scale empirical analysis. This finding directly justified the subsequent DigiMar activities focused on corpus compilation, discourse analysis, communication assessment, and the development of digital educational tools. In this sense, WP2.1 not only reviewed the existing regulatory framework but also identified critical knowledge gaps that required further investigation throughout the project.

Based on the findings of WP2.1, several recommendations were proposed. First, international organisations responsible for maritime communication should pursue greater harmonisation of communication requirements across IMO, IALA, and ITU documents in order to reduce inconsistencies in terminology, phraseology, and communication procedures. Second, future revisions of communication standards should clearly distinguish between mandatory communication requirements and recommended operational practices. Third, VTS communication competencies should be more explicitly incorporated into international training and certification frameworks, including the STCW Convention and Code. Fourth, internationally harmonised criteria for assessing Maritime English competence among VTS operators should be developed in order to ensure greater consistency across national administrations. Fifth, future revisions of SMCP (IMO, 2001) and VTS phraseology (IALA, 2022) should reflect contemporary operational realities, technological developments, and emerging communication needs.

3.3.2.2. Overview of Cases in Marine Accident Databases

The analysis of 57 marine accident and incident reports from nine international marine accident databases covering the period 2011–2023 demonstrated that communication deficiencies continue to represent a significant threat to navigational safety. Communication was identified as the primary cause of accidents in 26.3% of the analysed cases and as a contributing factor increasing accident severity in a further 64.9% of cases. Moreover, 84.2% of communication-related accidents were associated with human error, confirming that communication competence remains one of the key human-factor elements affecting maritime safety.

The findings revealed that the most frequent communication deficiency was a lack of communication, identified in approximately 60% of analysed cases. This result involved not only language proficiency, but also inadequate communication practices, assumptions, lack of feedback, poor situational awareness, and insufficient compliance with established communication procedures.

According to Activity Report 2.2, it was found that the bridge teams were involved in communication-related accidents in approximately 74% of cases, while pilots were involved in nearly 46% of cases. This finding highlights the critical importance of effective Master–Pilot exchange, Bridge Resource Management (BRM), and continuous information sharing among bridge team members. Several accident reports identified situations where critical manoeuvring intentions were not clearly communicated, assumptions were made regarding the actions of other parties, or important navigational information was not shared among members of the bridge team.

Furthermore, the results indicated that insufficient command of English and non-compliance with standardised maritime communication procedures continue to contribute to navigational risk. The frequent use of local languages during safety-critical operations excluded other crew members from the communication loop and reduced overall situational awareness. These findings support the need for stronger implementation of the IMO Standard Marine Communication Phrases (SMCP), STCW

requirements concerning Maritime English competence, and internationally recognised communication protocols in both operational practice and maritime education.

Based on these findings, it was recommended that Maritime Education and Training (MET) institutions strengthen practical training in routine maritime communication, with particular emphasis on bridge team communication, Master–Pilot information exchange, ship-to-ship communication, and ship-to-shore communication. Training programmes should focus not only on language proficiency but also on communication behaviours such as confirmation of intentions, information sharing, challenge-and-response techniques, feedback mechanisms, and closed-loop communication practices.

It was concluded that national maritime administrations should further promote compliance with internationally adopted communication standards and ensure that English remains the primary language for safety-related communications in accordance with international conventions and guidelines. Consideration should also be given to the introduction of periodic communication competence assessments and refresher training programmes for seafarers, pilots, and VTS personnel.

In addition, it was concluded that the reported lack of communication (60%), including internal communication (among bridge crew members and with the pilot on board) and external communication (ship-to-ship and ship-to-shore/shore-to-ship), contributed to the occurrence of maritime accidents. This percentage may have been even be higher if we had included individual figures relating to engine crew and other parties showing lack of communication (59.64%), insufficient communication or bad command of English, along with the native tongue interference . Therefore, the results obtained underline the strong need for further and more comprehensive training in routine and standardized maritime communications that would benefit overall maritime safety and lead to significant reduction in human-error accidents caused by lack of communication. These are promoted through targeted training and periodic competency assessments, as communication deficiencies were identified as a major contributing factor in marine accidents and incidents.

3.3.2.3. Pre-Educational Pilot Study Authentic Routine Maritime Communication Databases (shore service operators' strand)

The transcribed corpus of authentic exchanges contained a total of 46966 words and 1654 exchanges. The transcription was done according to the transcription template to ensure subsequent comparability of results.

RESULT 4: A spoken pre-educational pilot study of specialized database of authentic routine maritime communication;

RESULT 5: Samples of authentic routine maritime communication exchanges for each geographical area aligned with the standard

WP 2.3 focused on the creation and analysis of a multilingual corpus of authentic routine ship–shore communications collected from several European maritime regions. The primary objective was to establish a reliable evidence base for the development of educational materials, simulation exercises and digital learning tools in subsequent project activities. Through cooperation between higher education institutions and maritime safety authorities, authentic VHF recordings were collected, transcribed, anonymised and analysed according to a common methodological framework. The resulting corpus was one of the most comprehensive collections of authentic routine maritime communication developed within the project. Analysis of the recordings revealed that the majority of exchanges were related to routine operational scenarios such as maritime reports, pilot information, waypoint reporting and traffic information. These findings confirmed that communication in VTS environments is highly procedural and largely follows predictable operational patterns. Such scenarios therefore represent the most suitable basis for the development of training materials, simulator exercises and AI-supported learning tools.

A particularly important finding tackled the relationship between prescribed communication standards and actual operational practice. The analysis demonstrated that VTS operators frequently omitted several communication elements recommended by international guidelines. Address-and-identify structures, the phrase “this is”, turn-taking signals such as “over”, and closing signals such as “out” were considerably less frequent than expected. Nevertheless, communication remained efficient and operationally successful. This suggests that experienced operators rely heavily on shared situational awareness, predictable communication routines and contextual knowledge rather than on the complete application of all standardised phraseology elements.

A similar discrepancy was observed in the use of message markers. Although international guidelines emphasise the importance of markers such as *Question*, *Information*, *Advice*, *Warning* and *Instruction*, authentic communications showed that these markers are used far less frequently than anticipated. In particular, markers carrying stronger legal or operational implications, such as *Instruction* and *Warning*, were rarely employed. The findings indicate that operators may perceive certain markers as overly formal or legally sensitive, leading them to prefer more implicit communication strategies. This observation raises important questions regarding the clarity, practicality and consistency of existing guidance on message marker usage.

At the same time, the corpus revealed a high level of adherence to principles that directly support communication clarity. Operators consistently favoured short, concise utterances containing a single piece of information. Messages were generally delivered in a clear and measured manner, while speech rate and articulation remained highly consistent across the analysed exchanges. These findings suggest that operational effectiveness is achieved primarily through simplicity, clarity and predictability rather than through strict compliance with all formal elements of standard phraseology.

The analysis also highlighted several recurrent linguistic features characteristic of authentic maritime communication. Questions were frequently elliptical rather than fully formed, relying on context and

established communication patterns. Likewise, operators often used non-standard procedural expressions such as *copy*, *copy that*, *roger* and *understood*, despite these not being explicitly recommended in relevant guidelines. Their widespread use across geographical areas suggests that they have become operationally accepted and generally understood by maritime professionals.

The alignment shown in Figure 1, conducted on selected authentic exchanges, further reinforced the stated conclusions.

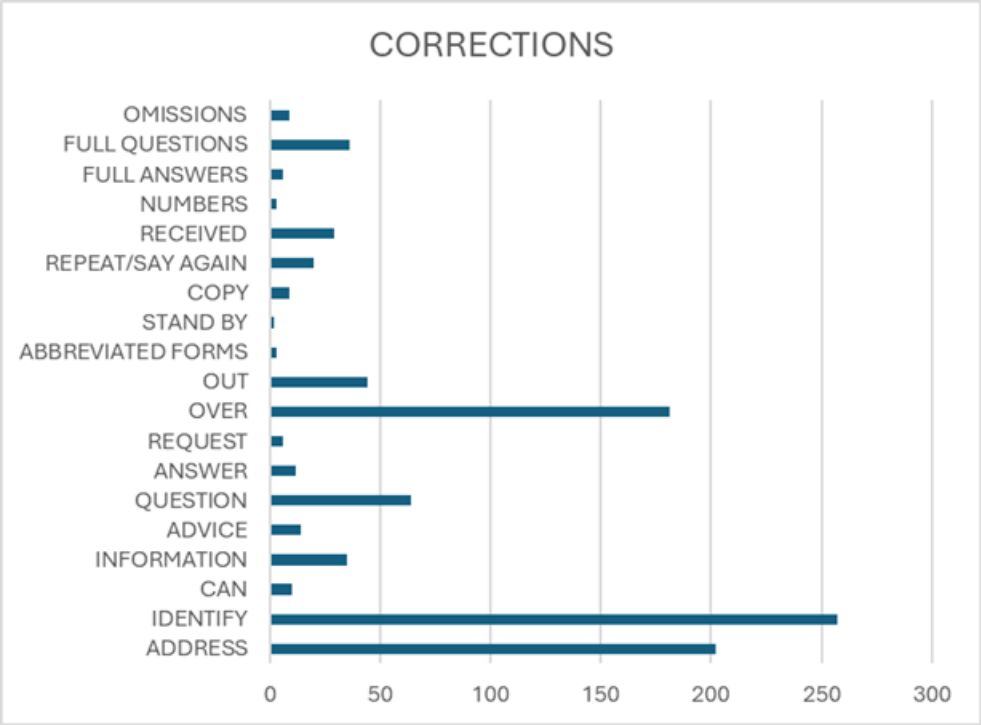


Figure 1. Number and type of corrections made in the samples of authentic exchanges

The most frequent corrections involved the insertion of address-and-identify structures, message markers, fully worded questions and turn-taking signals. While these modifications improved conformity with prescribed standards, the original exchanges had generally functioned effectively without them. Consequently, the findings showed a persistent gap between regulatory recommendations and actual communication practices in operational VTS environments.

Overall, WP 2.3 provided strong empirical evidence that authentic maritime communication is characterised by a balance between standardisation and operational efficiency. While standard phraseology remains essential for safety and interoperability, operators routinely adapt communication procedures to meet practical operational demands. The corpus, elaborated on in Table 1, offered valuable insights for the development of future training programmes and contributed to ongoing discussions regarding the revision and clarification of communication standards.

Table 1. Total hours transcribed and number of exchanges per higher education institution

TRANSCRIPTS		
HEI	**TOTAL HOURS**	**NO OF EXCHANGES**
Sveučilište u Rijeci	10h and 8 min	417
CHALMERS TEKNISKA HOEGSKOLA AB (E10209418- SE)	SMA – 8 h and 34 min NCA – 6 h and 34 min	305 163
University of Montenegro, Maritime Faculty Kotor (E10027767 - ME)	6 h and 15 min	146
UNIVERZA V LJUBLJANI (E10209243 - SI)	7h and 5 min	152
AB YRKESHOGSKOLAN VID ABO AKADEMI (E10166177 – FI)	7h and 23 min	471
TOTAL	45h and 59 min	1654

HEIs evaluated the expected and observed values for all variables included in the template. The results show interesting trends and corroborate some intuitive findings and opinions by both HEIs and MSAs. The results showing differences between expected and observed values for the message markers Answer, Advice , Information and Request are shown in Figure 2:

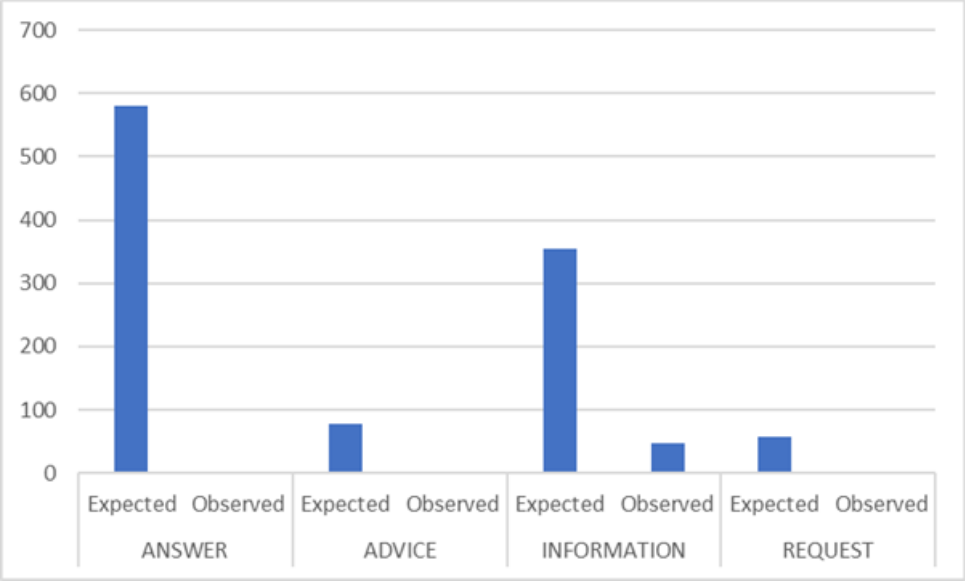


Figure 2. Results of the expected and observed values for message markers

The occurrence of syntactic ellipsis was further examined by comparing the expected and observed values for fully worded questions and answers, S+V+O structures, and simple sentences, as presented in Figure 3.

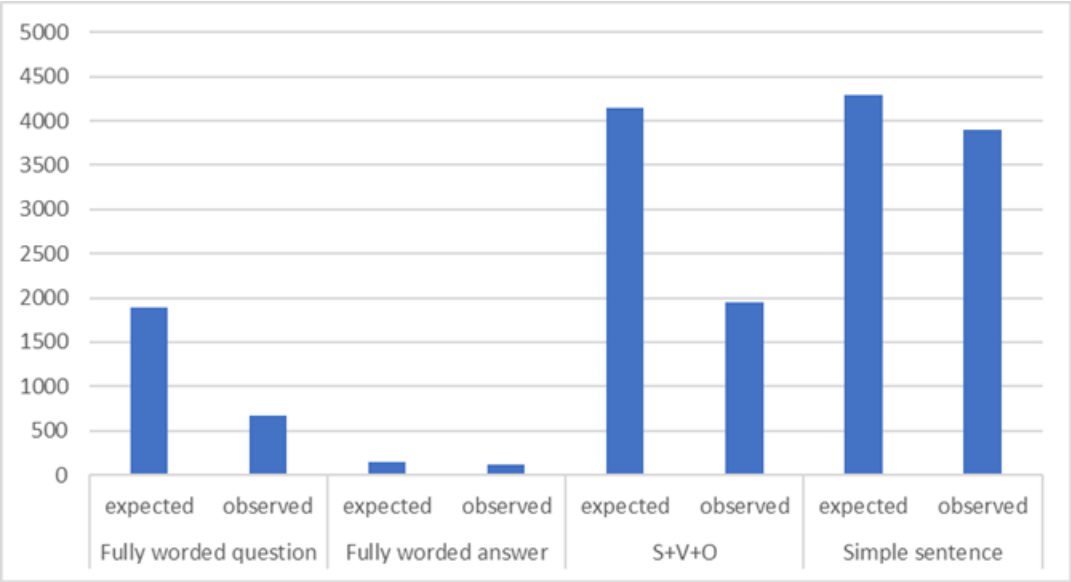


Figure 3. Results of the expected and observed values for syntactic ellipsis

The use of prowords was aslo analysed by comparing their expected and observed frequencies, revealing differences between standardized communication practices and their actual use, as presented in Figure 4.

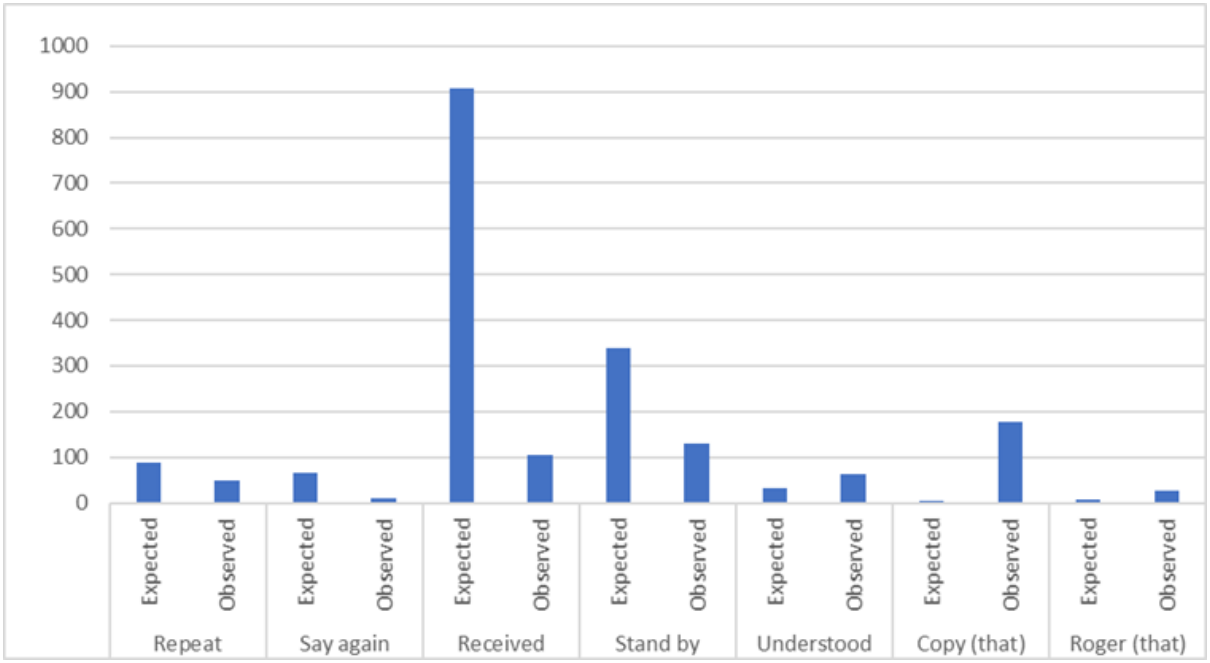


Figure 4. Results of the expected and observed values for prowords

Figure 5 illustrates the expected and observed values for three key features of spoken communication: appropriate formal tone, pace of speaking, and clarity of speech.

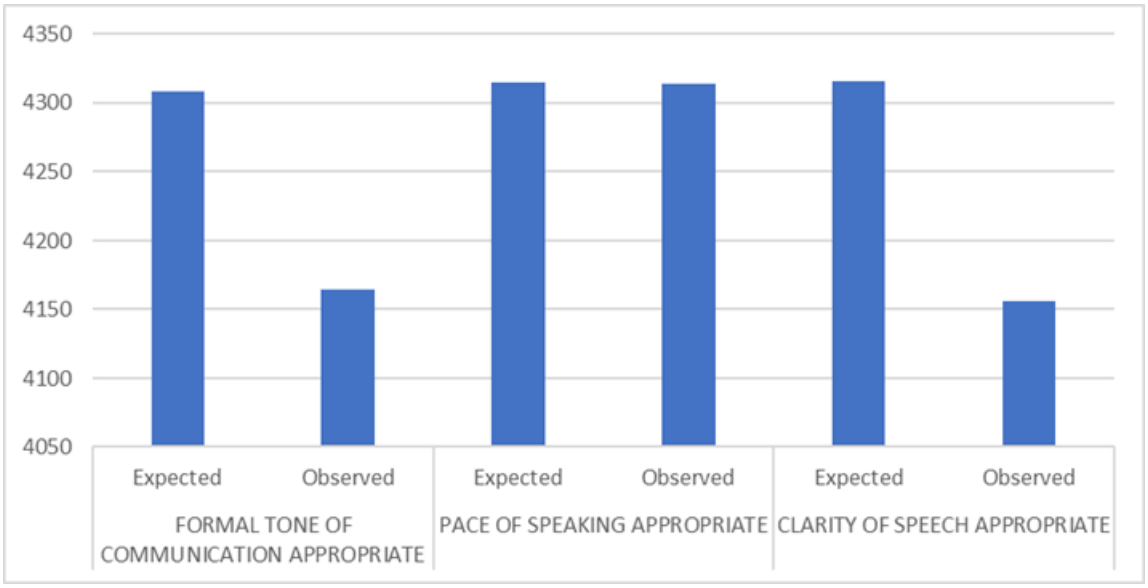


Figure 5. Results of the expected and observed values for tone, pace and clarity

Main recommendations elicited from the findings of WP 2.3 are as follows:

The findings point to several areas that could be considered in the further development of maritime communication standards, training practices and digital educational tools. Greater attention should be given to clarifying the operational role and interpretation of message markers, particularly Information, Advice, Warning, and Instruction, in order to support their more consistent use across VTS centres. At the same time, communication elements that are systematically omitted in authentic practice, such as this is, over, and out, could be reassessed to determine whether current requirements adequately reflect contemporary operational realities.

Training materials, simulator exercises and digital learning tools should place particular emphasis on high-frequency communication scenarios, including Maritime Reports, Waypoint Reporting and Traffic Information. Communication clarity should remain a central principle, particularly the use of one information unit per message, which emerged as one of the strongest indicators of effective communication throughout the corpus. Training programmes could also incorporate authentic communication patterns, including elliptical structures, shortened exchanges and commonly used non-standard expressions found in real operational communication. Their inclusion would enable trainees not only to become familiar with standardized communication practices but also to recognise and appropriately respond to forms of communication they are likely to encounter in authentic maritime environments.

Authentic corpus data could further support the development of AI-supported and chatbot-based training solutions, allowing trainees to practise realistic communication scenarios and receive automated feedback on their performance. More broadly, future revisions of maritime communication guidelines could be informed by empirical evidence from authentic operational environments, helping to ensure that international standards remain both practically applicable and effective in supporting navigational safety.

3.3.2.4. Pre-Educational Pilot Study Authentic Routine Maritime Communication Databases (students' strand)

WP2.4 focused on the development of authentic routine maritime communication simulation tasks for higher education students and the construction of a pre-educational spoken database of student simulations. Building on the authentic communication corpus developed in WP2.3, the work package translated real operational VTS communication into standardized educational scenarios that served as the foundation for the subsequent development of instructional videos, AI-supported chatbots, and the digital educational pilot study.

A total of 26 simulation scenarios were developed by the participating higher education institutions using authentic communication exchanges collected from their respective geographical areas (https://digimar.si/category/scenarios/). The scenarios covered a broad range of routine operational

situations, including pilotage, anchoring, bunkering, traffic information, entering VTS areas, vessel movements, tug operations, speed restrictions, ship drills, and ice navigation. Each scenario underwent review by the partner maritime safety authorities, whose comments and operational recommendations were incorporated before the scenarios received final approval and were published as open-access educational resources on the project website. This collaborative process ensured that all simulation tasks reflected authentic operational practice and complied with internationally recognised communication standards.

The second major outcome of WP2.4 was the construction of a pre-educational database of student simulations. Students from participating higher education institutions performed the communication scenarios in simulated VTS environments, with interactions recorded, transcribed, anonymised, and analysed according to a common methodological framework. Although database construction was still ongoing for some partners at the reporting stage, the completed recordings already provided a valuable baseline for assessing students' communication competence prior to the implementation of the DigiMar educational intervention.

The analysis demonstrated that students generally showed good command of English sentence structure, clear pronunciation, and an appropriate professional tone. They also displayed a satisfactory level of compliance with the use of the phonetic alphabet and numerical transmission. However, significant deficiencies were identified in the use of standard maritime communication procedures.

Students rarely applied address-and-identification structures, message markers, or turn-taking signals such as Over and Out, and frequently used non-standard procedural words, including Copy (that) instead of the recommended Received. Surprisingly, the turn-taking signal “Over” was used in 41 % of expected turns, while the turn-taking signal “Out” was used in 16 % of turns.

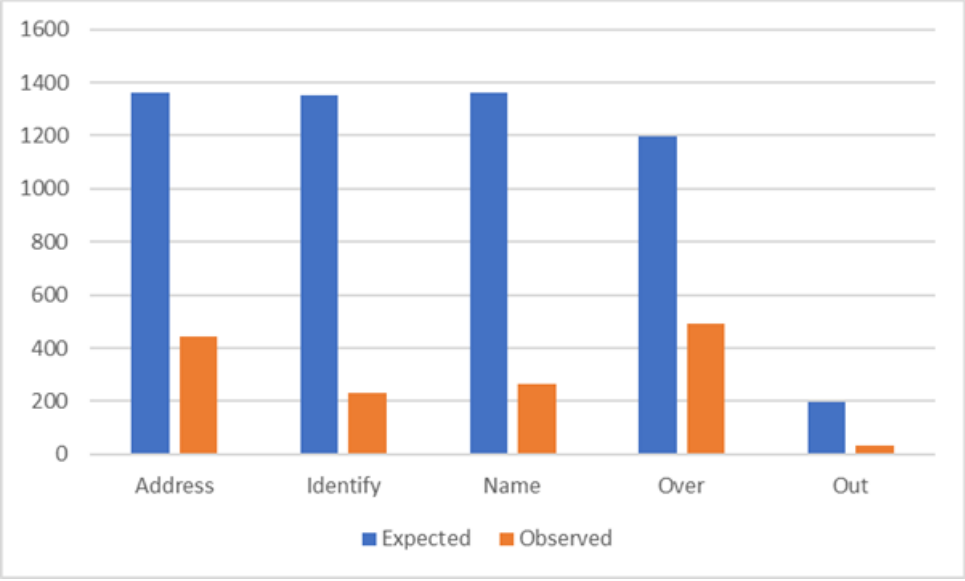


Figure 6. Results of expected and observed values for variables related to turn standards

Likewise, modal verbs and abbreviated forms appeared frequently, indicating limited awareness of the ambiguity they may introduce in safety-critical communication.

The findings confirmed that the pre-educational database successfully identified the principal communication elements requiring targeted educational intervention. These results directly informed the development of the DigiMar instructional videos and AI-supported chatbots in WP3, while also providing the benchmark against which post-training improvements were evaluated in the subsequent benchmarking activities of WP4. Consequently, WP2.4 established the essential educational baseline for measuring the effectiveness of the project's digital learning tools and their contribution to improving routine maritime communication and, ultimately, navigational safety.

3.3.3. WP3 – Digital Educational Tool Development, Deployment and Evaluation

This work package involved the development of digital learning resources, including instructional videos, chatbots, and educational tools. Testing and evaluation of these tools was then carried out with target users (maritime stakeholders, VTS operators, seafarers, students).

The specific objectives of WP3 were realized through the results of three WP3 activities:

WP3.1. Development, Deployment and Evaluation of Instructional Videos

WP3.2. Development, Deployment and Evaluation of Chatbots

WP3.3. Digital Educational Pilot Study and Evaluation

3.3.3.1. Development, Deployment and Evaluation of Instructional Videos

WP 3.1 focused on the development of open-access instructional videos designed to improve routine maritime communication skills among maritime students and shore-based professionals. Building upon the findings generated in previous work packages, particularly the analysis of authentic maritime communication exchanges and communication standards, this work package transformed research outcomes into practical digital educational resources. The overall objective was to strengthen communication competence, reduce the likelihood of misunderstandings and contribute to safer navigation and more effective vessel traffic management.

One of the most significant achievements of WP 3.1 was the compilation of a comprehensive suite of instructional materials consisting of *20 Basic Training videos* (https://digimar.si/routine-maritime-communication-basic-level/) and *10 Advanced Case-Based Training videos* (https://digimar.si/routine-maritime-communication-advanced-level/). While the *Basic Training* series targeted maritime students and focused on routine communication scenarios, the *Advanced Training videos* addressed more complex operational situations and communication challenges identified through the analysis of authentic incidents and accident reports. This distinction between foundational and advanced learning pathways represents a valuable pedagogical approach that should be further expanded in future maritime training programmes, particularly through greater use of accident-based and scenario-based learning.

The development process followed a carefully structured instructional design framework. All videos were organised around a common format consisting of an introduction, demonstration and conclusion, ensuring consistency and ease of use across learning modules. Particular attention was devoted to reducing cognitive overload through concise content, clear explanations and authentic examples. The resulting materials demonstrated the value of focusing on practical communication skills rather than extensive theoretical explanations. This suggested that future maritime communication training should continue prioritising short, focused learning units centred on specific operational tasks and communication challenges.

From a technological perspective, the project adopted a pragmatic and sustainable production model. Following the evaluation of different software solutions, *ElevenLabs* was selected for voice generation because of its ability to produce natural-sounding narration and accurately reproduce maritime terminology. Combined with standardised PowerPoint templates and accompanying transcripts, this approach ensured consistency, accessibility and scalability. The inclusion of transcripts further highlighed the importance of accessible learning resources and points towards the potential value of developing multilingual subtitles and transcripts in future iterations to support wider international uptake and inclusiveness.

A particular strength of WP 3.1 was the close collaboration between higher education institutions and maritime safety authorities throughout the development process. All instructional scripts underwent expert validation to ensure compliance with established communication standards while maintaining operational relevance. This collaborative approach ensured that educational content reflected both pedagogical principles and real-world maritime practice. The experience gained through this process suggests that future digital learning resources should continue to be developed through strong partnerships between educational institutions and maritime industry stakeholders, ensuring that training remains aligned with operational needs and regulatory developments.

The open-access and downloadable nature of the instructional videos significantly increases their long-term value and sustainability. By making all materials freely available through the project website, the consortium created a resource that can continue supporting maritime education and professional development well beyond the lifetime of the project. To maximise this impact, the videos should be systematically integrated into Maritime English courses, VTS operator training programmes and

continuing professional development activities across maritime institutions. Such integration would ensure that the educational resources developed within DigiMar become a permanent component of maritime communication training. Video scripts are available for each video and they can be downloadable and adapted to each local context or teaching mode, if required.

The evaluation framework designed within WP 3.1 further demonstrates the project's commitment to quality assurance and user-centred design. The planned assessment focuses on technical quality, instructional effectiveness, user engagement, applicability to real-world operations and compliance with communication standards. The target satisfaction rate of 80% among students and shore service operators establishes a clear benchmark for success. Beyond measuring satisfaction, however, future evaluations could explore more interactive forms of digital learning, including embedded quizzes, decision-making exercises, branching scenarios and AI-supported feedback systems. Such developments would transform instructional videos from passive learning resources into more engaging and adaptive educational environments.

To sum up, WP 3.1 represented a successful transition from research findings to practical educational outputs. By combining authentic maritime communication data, modern instructional design principles and digital technologies, the results demonstrate how evidence-based educational resources can support both maritime education and navigational safety. Importantly, the project also highlighted the value of using authentic communication corpora as the foundation for future digital learning tools, ensuring that training materials remain realistic, credible and closely aligned with operational practice. Continuous updating of these resources in response to evolving communication practices, technological developments and regulatory changes would further strengthen their long-term relevance and effectiveness.

The final versions of the videos are available published as open-access resources, in the project website:
- Basic level videos: https://digimar.si/category/digital-tools/instructional-videos/routine-maritime-communication-basic-training/ , and case study videos: Case study-based advanced level videos: https://digimar.si/routine-maritime-communication-advanced-level/

3.3.3.2. Development, Deployment and Evaluation of Chatbots

WP3.2 translated the findings from WP2.1 and WP2.2 into practical, scenario-based training through speech-recognition chatbots, enabling VTS operators, bridge teams and maritime students to actively practice standardized maritime communication in accordance with IALA VTS Voice Communications and Phraseology Guidelines (G1132). The chatbot scenarios reinforced message structure, communication loop closure, avoidance of ambiguity, and the correct use of standard maritime phraseology, thereby supporting the development of communication competencies required for safe and effective vessel traffic management. The two versions of chatbots were developed:

- keyword-based chatbots and, based on the needs expressed by the MSAs, AI-integrated chatbots. Both versions are based on 44 authentic scenarios derived from the contexts of the project partners.

Based on the WP3.2 Activity Report results, it became evident that routine maritime communication training should incorporate AI-supported speech-recognition simulation tools that enable VTS operators and bridge personnel to practise standardised phraseology, read-back procedures, communication loop closure, and external ship–shore communication in realistic operational scenarios aligned with IALA VTS Voice Communications and Phraseology Guidelines (G1132).

3.3.3.3. Digital Educational Pilot Study and Evaluation

WP3.3 focused on the implementation of the digital educational pilot study through the testing, evaluation, and revision of the instructional videos (WP3.1) and maritime communication chatbots (WP3.2). The pilot study involved higher education students, shore service operators, and members of the wider maritime community across multiple European countries. A common evaluation framework was developed and applied through 11 multiplier events, enabling participants to assess the effectiveness, usability, and relevance of the digital educational tools.

The results demonstrated strong engagement, with more than 500 users participating in the evaluation process and quantitative participation targets being exceeded. User feedback confirmed a high level of satisfaction with both the instructional videos and chatbots, exceeding the project's target of 80% satisfaction. Participants particularly valued the accessibility, realism, and practical applicability of the learning materials. At the same time, the evaluation identified several areas for improvement, including greater interactivity, enhanced AI-supported feedback, clearer categorisation of learning materials according to user expertise, and improved speech-recognition functionality.

The findings were systematically analysed and used to revise the digital educational tools. As a result, instructional videos and chatbot scenarios were amended to better align with user needs, pedagogical objectives, and operational maritime communication requirements.

WP3.3 directly informed the project's recommendations by providing evidence-based insights from a large and diverse group of end-users. Digital maritime training could be further supported by strengthening interactive and AI-supported learning functionalities and enhancing feedback mechanisms that support the continuous improvement of communication skills. Educational resources could also be categorised according to beginner, advanced, and professional user groups, allowing digital training tools to better respond to different levels of knowledge, experience, and operational needs. At the same time, external communication and dissemination should be improved to increase awareness and encourage wider adoption of digital maritime training tools.Further involvement of bridge crews, VTS operators, and other maritime stakeholders in the design, testing, and validation of future digital training solutions would help ensure their practical applicability and relevance to authentic operational environments. In this respect, continuous collaboration between higher education institutions, maritime administrations, and industry representatives should be promoted to ensure that educational tools remain operationally relevant and aligned with evolving maritime communication standards. These findings provided a solid foundation for future development of digital maritime communication training systems and supported the broader objective of improving navigational safety through enhanced communication competence among maritime professionals and students.

3.3.4. WP4 – Maritime Communication Standard- and Data-based Benchmarking

The specific objective of WP4 was focused on the improvements in navigational safety resulting from the digital pilot study analyzed and benchmarked against the international standard, and communicated.

This package contributed to the general objective of the project by:

- analysing the change in maritime communication skills after the digital educational pilot study had been implemented, developing new routine maritime communication simulation tasks,

- providing a comparison between the routine maritime communication compliance with the standard protocol of communication before and after the digital educational pilot study (gap analysis),

- providing an assessment of improvements in navigational safety as a result of the digital educational pilot study, and - providing research-based recommendations for systemic changes in the standard protocol of communication to the international bodies competent for maritime communication.

The specific objectives of WP4 were realized through the results of the following activities:

WP4.1. Post-Educational Pilot Study Authentic Routine Maritime Communication Databases

WP4.2. Post-Educational Pilot Study Routine Maritime Communication Simulations Databases WP4.3. Benchmarking against the Standard Protocol of Communication

WP4.4. Assessment of Improvements in Navigational Safety

WP4.5. Recommendations for a Revision of the Standard Protocol of Communication

The main results of these activities are presented below.

What will be the main results of this work package?

RESULT 1 (WP4.1.): A post-educational pilot study spoken database of authentic routine maritime communication for each geographical area was carried out (a post-educational digital pilot study of authentic routine maritime communication database of shore service operators' communication with ships (shore service operators' strand).

RESULT 2 (WP4.1.): Samples of authentic routine maritime communication exchanges for each geographical area were aligned with the standard protocol of communication (samples of authentic routine maritime communication exchanges for each geographical area were selected aligned with the standard).

RESULT 3 (WP4.2.): An open-access inventory of new routine maritime communication simulation tasks (to create and publish an open-access inventory of routine maritime communication simulation tasks).

RESULT 4 (WP4.2.): A spoken post-educational pilot study database of routine maritime communication simulations constructed (students' strand)).

RESULT 5 (WP4.3.): A comparative report on shore service operators' and students' compliance with the standard protocol of routine maritime communication was compiled, benchmarking the pre-educational and post-educational pilot studies against the standard protocol of communication.

RESULT 6 (WP4.4.): An assessment of improvements in navigational safety resulting from the digital educational pilot study was conducted, based on statistically significant differences in risk factor values.

RESULT 7 (WP4.5.): Research-based recommendations for the revision of the standard protocol of communication were developed and communicated to the main international bodies competent for maritime communication (IMO, ITU, IALA, and EMSA), with the aim of supporting recommended systemic changes.

3.3.4.1.Post-Educational Pilot Study Authentic Routine Maritime Communication Databases (shore service operators' strand)

This WP was focused on assessing the impact of the digital educational pilot study on the maritime communication skills of shore service operators through the creation and analysis of post-training authentic maritime communication databases. Following the implementation of the instructional videos and communication chatbots developed in WP3, participating Maritime Safety Authorities collected authentic routine ship–shore communication exchanges, which were transcribed, anonymised, analysed, and compiled into specialised spoken databases for each geographical area. HEIs have collected and transcribed the authentic VHF exchanges from their respective areas. This has resulted in creating a spoken post-educational pilot study specialized database of authentic routine maritime communication. The database contained a total of 1832 exchanges. HEIs have also selected a sample of 12 authentic routine maritime communication exchanges and aligned them with the standard.

Through corpus analysis and comparison with the communication standards established in WP2.1, the project identified changes in communication practices and assessed the extent to which the educational intervention contributed to improved standardisation and communication quality.

The resulting databases provided a unique evidence base for evaluating maritime communication performance, developing new simulation tasks, and supporting future research, training, and AI-assisted maritime communication systems.

The implementation of WP 4.1 resulted in creating a spoken post-educational pilot study specialized database of authentic routine maritime communication. The database contained a total of 1832

exchanges. HEIs also selected a sample of 12 authentic routine maritime communication exchanges and aligned them with the standard.

Through corpus analysis and comparison with the communication standards established in WP2.1, the project was able to identify changes in communication practices and assess the extent to which the educational intervention contributed to improved standardisation and communication quality.

The resulting databases provided a unique evidence base for evaluating maritime communication performance, developing new simulation tasks, and supporting future research, training, and AI-assisted maritime communication systems.

The implementation of WP 4.1 successfully resulted in the creation of a post-educational pilot study database of authentic routine maritime communication exchanges from several European geographical areas. The compiled corpus represented a valuable multilingual and operationally authentic resource that could support future research, training, and simulation-based maritime education activities. Despite delays related to training schedules and data collection in some partner institutions, all participating HEIs and MSAs contributed to the successful completion of the database and alignment tasks.

The analysis of communication variables demonstrated that the educational materials developed within the DIGIMAR project had a positive impact on the use of standardized maritime communication procedures. The results stated improvements in the use of message markers, communication structure, prowords, and clarity of communication, while also revealing certain regional differences in operational practice.

Furthermore, the aligned communication samples developed within this work package provided a practical foundation for future simulation scenarios and standardization activities. The outcomes of WP 4.1 contributed directly to the broader project objective of enhancing navigational safety through improved communication practices and harmonized training standards across European maritime environments.

The analysis of authentic VTS communication exchanges revealed that the most dominant operational topics were approaching port (369 occurrences), traffic information (301), pilotage (292), departure (264), and berthing (211). Other frequently represented themes included anchoring, entering the VTS area, manoeuvring, towage, speed limits, bunkering, ship drills, and clearance procedures, reflecting the wide range of routine communication situations encountered in maritime operations.

The comparative analysis of communication variables demonstrated a generally high level of compliance with the Standard Marine Communication Phrases (SMCP). Variables related to turn standards showed that addressee identification was consistently applied across most corpora, while procedural signals such as “Over” and “Out” appeared less frequently, suggesting a reliance on contextual understanding rather than strict procedural compliance. Message markers were dominated by “Information” and “Question”, which was expected given the operational nature of VTS communication, whereas markers such as

"Advice", "Request", "Warning", and "Intention" appeared less frequently and varied between national corpora. Differences between geographical areas may have been linked to local operational procedures and varying traffic complexity. The results nevertheless demonstrated that VTS operators increasingly recognized the importance of structured communication after the implemented training activities as shown in Figure 7.

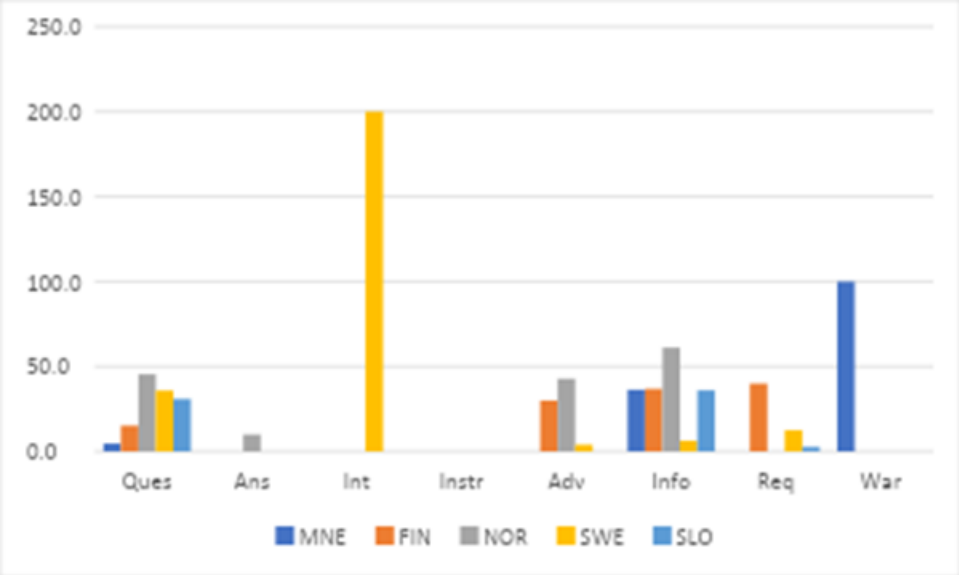


Figure 7. Results of expected and observed values for message markers

The analysis of syntactic variables indicated a strong tendency towards the use of complete questions, complete answers, simple sentence structures, and standard S+V+O constructions, contributing to communication clarity and reducing the risk of misunderstanding. Similarly, variables related to letters, digits, modal verbs, and abbreviated forms showed a satisfactory level of standardization, although some variations reflected local communication practices.

The use of prowords demonstrated greater variability across the corpora. While expressions such as "Received", "Stand by", were present, their frequency differed considerably among participating regions, indicating opportunities for further harmonization. Finally, the analysis of extralinguistic variables confirmed high levels of clarity and professionalism in communication, while differences in politeness strategies appeared to reflect cultural and organizational practices rather than deficiencies in training. Overall, the results showed that the educational activities contributed positively to communication standardization and increased awareness of the importance of structured, clear, and safety-oriented maritime communication.

3.3.4.2. Post-Educational Pilot Study Routine Maritime Communication Simulations Databases (students' strand)

RESULT 3: An open-access inventory of new routine maritime communication simulation tasks (to create and publish an open-access inventory of routine maritime communication simulation tasks).

RESULT 4: A spoken post-educational pilot study database of routine maritime communication simulations for each higher education institution (to construct a post-educational digital pilot study routine maritime communication database of student simulations (students' strand).

The analysis of variables related to letters, digits, modal verbs, abbreviated forms, prowords, and extralinguistic aspects highlighted the overall effectiveness of maritime radiotelephony communication across the participating regions. Operators generally demonstrated a high level of compliance with standardized procedures when spelling letters, reading numbers, and using abbreviated forms, reflecting a strong awareness of the importance of precision and clarity in operational communication. Although minor inconsistencies were observed, these appeared to be linked to local communication habits and established operational routines rather than a lack of competence.

Considerable variation was identified in the use of prowords such as *Received*, *Stand by*, and *Say again*. While some operators consistently employed standardized acknowledgement and confirmation procedures, others preferred shorter and less formal responses. Despite these differences, communication remained functionally effective. Nevertheless, greater adherence to standardized proword usage could further enhance consistency, reduce ambiguity, and support more predictable communication practices. The findings also suggested that the educational materials and training activities developed within the project contributed to a greater awareness of communication loop closure procedures and the role of standardized phraseology.

The analysis of extralinguistic aspects further confirmed the generally high quality of communication observed across the corpora. High clarity scores indicated that operators were able to produce messages that were understandable, operationally appropriate, and aligned with professional communication standards. Variations in politeness strategies were likely to reflect cultural and organizational communication practices rather than deficiencies in training. Overall, the results demonstrated that the communication practices observed were largely consistent with established standards and that the project activities positively contributed to both linguistic accuracy and professional communication behaviour, ultimately supporting safer and more effective maritime operations.

Within this work package, the project partners developed a total of 32 routine maritime communication simulation tasks based on authentic routine maritime communication exchanges collected and analysed in WP 4.1. The scenarios were designed according to the jointly agreed template and reflected typical operational situations encountered in the participating geographical areas.

The simulation tasks covered a broad range of routine maritime communication activities, including vessel reporting procedures, pilot boarding arrangements, anchoring operations, traffic information, restricted visibility situations, engine malfunctions, dangerous cargo reporting, environmental incident reporting, ice navigation, and harbour manoeuvring activities.

Each higher education institution prepared simulation tasks based on authentic local communication practices and operational requirements. Following the initial development phase, the scenarios were reviewed by the respective maritime safety authorities. Suggestions and recommendations provided during the review process were incorporated into the final versions of the scenarios. Upon completion of the revision process, all simulation tasks received approval from the maritime safety authorities and were subsequently published as open-access educational resources on the project website.

The simulation tasks constituted a practical educational resource that could be used for role-play activities, simulation exercises, classroom teaching and independent learning. The publication of these tasks fulfilled the quantitative and qualitative indicators associated with Result 3 of WP 4.2.

The second result of WP 4.2 involved the construction of a spoken post-educational pilot study database of routine maritime communication simulations performed by higher education students.

A total of 85 students participated in the recording activities. Thirty-five students were recruited by the University of Ljubljana and fifty students by the University of Rijeka. Prior to participation, all students received training based on DigiMar educational resources, including instructional videos and chatbot-supported learning activities. Participation was voluntary and all students signed consent forms in accordance with the General Data Protection Regulation (GDPR).

The student simulations were recorded using the newly developed communication scenarios. The recordings were subsequently transcribed with the support of speech-to-text software and manually checked for accuracy. The resulting transcripts were anonymised and uploaded to the shared project repository.

The post-educational pilot study database represented a valuable source of authentic student-produced maritime communication and was used together with the pre-educational pilot study database developed in WP 2.4 for benchmarking and comparative analysis within WP 4.3.

The analysis of student simulations focused on the linguistic and extralinguistic variables defined in the project methodology and aligned with the standard protocol of routine maritime communication developed in WP 2.1.

The results indicated a generally high level of compliance with the expected communication standards. Students demonstrated strong performance in the use of addressing and identification procedures, turn-taking signals, message construction, sentence structure, and communication clarity.

Particularly positive results were observed in the use of vessel identification procedures, the communication signals “Over” and “Out”, the application of simple sentence structures, and adherence to the Subject–Verb–Object pattern recommended by IALA, 2022. Students also showed a high level of accuracy in the pronunciation of numbers and in the use of the phonetic alphabet (as prescribed by IALA, 2022; ITU, 2020a; IMO SMCP, 2001).

The analysis further demonstrated that participants maintained an appropriate professional tone throughout the simulations. Communication exchanges were generally complete, clear and conducted in English, with no significant use of local language elements recorded.

Although some variation was observed in the use of message markers and specific prowords, the overall findings suggested that students successfully applied the communication principles introduced through the DigiMar educational materials and training activities.

The results of WP 4.2 demonstrated that the developed simulation tasks and educational resources contributed positively to the acquisition of routine maritime communication skills among higher education students.

The successful development and publication of authentic simulation tasks fulfilled Result 3 of the work package, while the construction of the post-educational pilot study database fulfilled Result 4. Together, these results provided an important foundation for the final benchmarking and gap analysis activities within WP 4.3. The findings confirmed the value of combining instructional videos, chatbot-supported learning and simulation-based practice as an effective approach to developing maritime communication competence and, consequently, contributing to navigational safety.

Based on the results of WP 4.2, several recommendations were formulated to support the further development and optimisation of maritime communication training within the project.

Firstly, it was recommended to continue and expand the development of routine maritime communication simulation tasks. The existing scenarios demonstrated strong applicability in training contexts; however, additional scenarios covering a broader range of operational situations would further enhance the authenticity and pedagogical value of the training materials. Secondly, the completion and expansion of the post-educational pilot study database was prioritised. In particular, the delayed datasets from partner institutions were finalised in accordance with the agreed methodological framework to ensure full comparability and completeness of the overall dataset. Furthermore, increasing the number of student participants in future data collection cycles was recommended to improve the representativeness and robustness of the findings.

Thirdly, continued enhancement of pre-simulation training resources was advised. The DigiMar instructional materials, including video-based learning tools and chatbot-supported activities, showed positive educational outcomes and should be further refined and standardised to ensure consistent learning experiences across participating institutions. Fourthly, targeted pedagogical attention was given

to areas of observed variability, particularly the use of message markers and standardised prowords in accordance with the Standard Marine Communication Phrases (SMCP). Additional focused practice in these components was recommended to further improve uniformity and operational accuracy in student performance. Fifthly, it was recommended to maintain and further strengthen adherence to SMCP principles, particularly with regard to sentence structure, message clarity, and professional communication tone. While overall performance was strong, continued reinforcement was considered necessary to consolidate competence at a high operational standard. Finally, it was recommended that the completed post-educational pilot study database be systematically utilized in WP 4.3 for benchmarking and comparative analysis against pre-educational datasets. This enabled a more comprehensive evaluation of learning outcomes and provided evidence-based insights into the effectiveness of the applied training approach.

3.3.4.3. Benchmarking against the Standard Protocol of Communication

Based on the findings presented throughout the report, the digital educational pilot study within WP4.3 demonstrated a generally positive impact on the compliance of routine maritime communication with the standard communication protocol among both higher education students and VTS operators. Overall, the HEI group exhibited substantial improvements across almost all analysed variables, while the MSA group showed a more selective and uneven pattern of development. The statistically significant interaction effects observed for most variables indicate that the intervention influenced the two contexts differently.

The most pronounced differences were observed in the structural elements of maritime communication. Following the intervention, HEI participants showed substantial improvements in stating the addressee (41.9%–84.9%), using *this is* (25.6%–69.6%), identifying the calling station (24.6%–67.4%), and applying the procedural markers *over* (40.6%–96.6%) and *out* (17.6%–87.5%). In contrast, the MSA group showed more modest gains, while some features remained infrequent or even declined. Particularly noteworthy is the use of *this is*, which decreased from 12.0% to 3.9% in the overall MSA dataset. These findings suggest that HEI participants adopted a communication style more closely aligned with recommended maritime phraseology, whereas operational communication remained influenced by local routines and contextual practices.

A similar pattern emerged regarding the use of message markers. The HEI group recorded strong increases in the use of *question* (5.0%–61.9%), *information* (7.1%–67.2%), *instruction* (6.5%–35.7%), and *request* (7.4%–36.5%). Although some improvements were also observed within the MSA group, the gains were generally smaller and remained at lower levels. The results therefore suggest that students became considerably more explicit in signalling communicative intent, which contributes to greater transparency and predictability in communication.

One of the most important findings concerned the management of communication breakdowns and the implementation of closed-loop communication. The HEI group demonstrated major increases in the use of *repeat* (37.5%–76.8%), *say again* (0%–58.7%), and *read back* (0%–85.8%), whereas the MSA group

displayed more limited improvements. Since these expressions play a crucial role in confirming understanding and preventing misunderstandings, the results showed that the intervention was particularly successful in strengthening communication safety among HEI participants.

The findings should also be interpreted in relation to the nature of the analysed corpora. The HEI dataset consisted of student simulations specifically designed to practise standard maritime communication, whereas the MSA corpus is based primarily on authentic operational exchanges collected in real VTS environments. Furthermore, the Montenegrin dataset was analysed in terms of overall compliance because not all operators participated in the intervention, preventing direct pre- and post-comparisons. The authentic nature of operational discourse may therefore partly explain the lower compliance rates observed for certain phraseology elements. Nevertheless, the results clearly indicated that several key components of standard maritime communication were not systematically employed in everyday operational practice.

The Montenegrin results were particularly revealing in this respect. While operators demonstrated very high levels of compliance in the use of digits (98.4%), formal tone (100%), pace of speaking (99.8%), and generally clear communication, compliance remained considerably lower for several phraseology-related variables, including *this is* (3.7%), identification of the calling station (12.4%), *question* (4.7%), *repeat* (11.1%), and use of the phonetic alphabet (2.1%). These findings suggested that VTS operators possess strong operational communication skills but do not consistently employ the standard phraseology recommended by IMO and IALA communication guidelines.

Based on these findings, future training programmes should place greater emphasis on the consistent use of standard phraseology, particularly the structural elements of communication, message markers, and communication-loop procedures. Special attention should be given to the use of this is, over, out, repeat, say again, and read back, as these were among the variables showing the greatest discrepancies between educational and operational settings although their use may significantly contribute to the reduction of communication ambiguity. The findings also suggest the need for closer alignment between educational practice and operational reality. Future revisions of maritime communication guidelines should clearly distinguish between mandatory and recommended communication practices, as the present results indicate that some elements promoted during training are not consistently applied in authentic operational discourse. Harmonising these expectations across training materials, VTS guidance documents, and operational procedures would contribute to greater consistency and potentially enhance communication safety.

Finally, future research should explore the reasons why certain elements of standard phraseology remain underused in operational environments despite their prominence in training programmes and international guidance documents. Such research would provide valuable insights into the relationship between prescribed communication standards and authentic maritime discourse and could support the development of more realistic and operationally relevant communication training models.

3.3.4.4. Assessments of Improvements in Navigational Safety

The primary aim of WP4.4 was to assess improvements in navigational safety resulting from the implementation of the DigiMar digital educational pilot study by transforming communication incompliances identified in WP4.3 into measurable and statistically testable safety risk scores. More specifically, the work package sought to develop a transparent and scientifically grounded methodology for assigning risk factor values to communication non-compliances and for determining whether the digital educational intervention contributed to a statistically significant reduction in communication-related navigational risks. The expected result of WP4.4 was therefore the establishment of an evidence-based assessment framework capable of quantifying improvements in navigational safety and identifying communication elements requiring priority intervention in future revisions of the Standard Protocol of Communication.

The results of WP4.4 confirmed that communication deficiencies in maritime VHF communication can be systematically transformed into measurable navigational safety risks through the application of a composite risk model based on Impact and Likelihood scores. The study analysed 12,551 communication turns extracted from 16 spoken corpora collected in six countries (Slovenia, Croatia, Montenegro, Finland, Sweden, and Norway), making this one of the most comprehensive comparative studies of routine maritime communication conducted within the European maritime educational context.

The findings demonstrated that the digital educational pilot study contributed to a substantial reduction in communication-related risk, particularly among higher education students. The HEI group recorded statistically significant improvements across almost all analysed communication variables ($p < .001$), including communication structure, message markers, prowords, numerical accuracy, and communication repair mechanisms. Particularly notable improvements included the use of *Over* (from 40.55% to 96.58%), *Question* markers (from 4.97% to 61.94%), *Information* markers (from 7.14% to 67.20%), and numerical transmission accuracy (from 58.11% to 96.65%). These results strongly suggested that the DigiMar digital tools are effective in reducing communication incompliances that pose significant navigational safety risks.

The Maritime Safety Authority (MSA) strand revealed a more complex and context-dependent picture. Although significant improvements were observed in some variables, such as stating the addressee (from 51.54% to 78.35%) and identification of the calling station (from 35.39% to 72.87%), improvements among professional VTS operators were generally less pronounced and more uneven than those observed among students. In certain cases, the use of procedural markers such as *This is* and *Out* even declined in post-study recordings, suggesting that experienced operators may rely more heavily on established local communication practices and operational routines than on standardized phraseology.

Important regional differences were also observed. Finnish VTS experts generally assigned lower impact ratings to communication deficiencies than experts from Montenegro, reflecting differences in operational environments, traffic density, safety culture, and organizational practices. In contrast, Montenegrin experts consistently assigned the highest impact scores (5/5) to the most critical communication risks, particularly those associated with message markers, read-back procedures, and

collision avoidance communications. Norwegian respondents frequently emphasized the importance of complete read-back procedures and accurate numerical transmission, while Swedish experts highlighted communication clarity, speech intelligibility, and accurate vessel identification as critical safety concerns.

The qualitative findings further demonstrated that communication risks cannot be evaluated independently of operational context. Experts repeatedly emphasized that communication deficiencies become particularly critical during pilotage operations, port approaches, restricted visibility, emergency situations, high-density traffic conditions, and complex multi-vessel interactions. Under such circumstances, even a single communication failure may directly contribute to collisions, groundings, or serious navigational incidents. Consequently, communication risk should not be regarded as static but rather as dynamic and highly sensitive to operational complexity.

The risk assessment framework identified Message Markers and Prowords and Preventing Ambiguity as the two highest-risk communication categories, together accounting for more than three quarters of the total aggregated communication risk. Among the 36 analysed Risk Aspects, *Read back advice* generated the highest overall risk score (3.38), followed by *Warning* (2.76), *Instruction* (2.75), *Modal verbs* (2.40), and *Advice* (2.36). These findings clearly indicate that the omission of explicit communicative intent and inadequate confirmation procedures constitute the most significant communication-related threats to navigational safety. According to research and documents review in WP 2.1 Read back communication pattern is recommended, particularly by VTS so as to confirm that the message has been correctly understood in which case message 'Read back' is used by VTS (IALA 2017, p.7).and give also other ships the possibility to hear the message a second time.

The expert interviews additionally revealed the importance of organizational and human factors in shaping communication performance. Fatigue, high workload, insufficient rest, watchkeeping arrangements, stress, and varying levels of language proficiency were repeatedly identified as factors capable of amplifying communication-related risks. Although opinions differed regarding the precise contribution of language proficiency to accidents and incidents, all participating regions acknowledged that multilingual communication environments require robust standardization, continuous training, and effective communication repair strategies.

According to the Fintraffic results, obtained from a follow-up survey conducted among 20 Finnish VTS operators, the DigiMar digital learning tools were positively evaluated as an effective complement to traditional VTS training. The findings showed that 95% of respondents considered the tools beneficial for learning, 85% regarded them as at least moderately useful, 80% reported that the digital format saved training time, and 80% supported wider deployment of the tools provided that further improvements are made. Moreover, 65% believed that the tools contributed to improved traffic safety, while 60% considered that continuous and active use could lead to genuine improvements in operational communication. The instructional videos were consistently rated more positively than the chatbot, with 80% evaluating the videos as good or very good, whereas the chatbot received more mixed evaluations due to technical limitations and rigid response recognition.

Overall, the results indicated that the greatest value of the DigiMar tools lies in strengthening learning, improving accessibility to training and reinforcing standard maritime communication practices rather than producing immediate operational changes after a single course. The findings further suggested that continuous practice, shorter refresher modules, more realistic scenarios and further development of AI-supported chatbot functionalities would significantly increase the transfer of learning into operational practice. Consequently, the Fintraffic results provided strong support for the wider integration of digital learning tools into VTS and maritime communication training and reinforce the recommendations proposed in WP4.5 for improving communication standards, training practices and, ultimately, navigational safety.

Based on the Fintraffic findings specifically , maritime institutions should integrate digital learning tools into continuous communication training, supported by regular refresher courses and realistic scenario-based exercises. Further development of AI-supported training systems, combined with simulator-based learning, should enhance communication competence and operational readiness. Short, modular and easily accessible digital learning resources should support continuous professional development, while regular evaluation and user feedback should guide the ongoing improvement of digital maritime communication training.

Overall, WP4.4 successfully achieved its expected objectives by demonstrating that communication incompliances can be quantitatively linked to navigational safety risks and that targeted digital educational interventions can significantly reduce these risks. The results provided a strong empirical foundation for WP4.5 and clearly indicate that future revisions of the Standard Protocol of Communication should prioritize closed-loop communication procedures, message markers, procedural words, communication repair mechanisms, and standardized message structures. Furthermore, the study confirmed the considerable potential of digital educational tools, authentic communication scenarios, and AI-supported conversational agents as innovative instruments for enhancing maritime communication competence and, consequently, navigational safety.

3.3.4.5. Recommendations for a Revision of the Standard Protocol of Communication

As the final output of the DigiMar project, the WP 4.5 document presented research-based recommendations for the revision of the standard protocol of maritime communication. The recommendations stemmed from the findings of all project activities and deliverables, with particular emphasis on the results obtained within WP 4.3 and WP 4.4. The process involved the analysis of authentic and simulated maritime communication corpora, the evaluation of communication practices across higher education institutions and maritime safety authorities, and the identification of communication elements associated with lower compliance levels and increased communication risk. Based on these findings, a set of evidence-based recommendations has been developed with the aim of supporting potential systemic improvements to existing communication standards.

Following review and harmonisation among project partners and maritime safety authorities, the recommendations are to be communicated to the relevant international bodies responsible for maritime

communication, including the International Maritime Organization (IMO), the International Telecommunication Union (ITU), the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA), and the European Maritime Safety Agency (EMSA). The overall objective is to contribute to safer, clearer, and more consistent maritime communication through the continuous improvement of international communication standards.

3.3.5. WP5 – Exploitation and Dissemination

Work Package 5 (WP 5.1, WP 5.2 and WP 5.3) focused on ensuring the effective dissemination, exploitation, long-term visibility, and sustainability of the DigiMar project and its outcomes. It was organised into three complementary activities that together established the dissemination strategy, implemented communication and dissemination activities, and promoted the project among external stakeholders and the wider international maritime community.

WP5.1 Exploitation and Dissemination Strategy established the overall strategic framework for dissemination and exploitation. It identified the project's target audiences, defined dissemination channels and communication materials, developed key messaging, and established qualitative and quantitative indicators for monitoring dissemination effectiveness. The strategy also provided the basis for coordinated dissemination activities throughout the project and promoted the long-term exploitation of the project results by maritime education institutions, maritime authorities, industry representatives, policymakers, and the wider maritime community.

WP5.2 Exploitation and Dissemination Management focused on implementing the dissemination strategy through the continuous management of communication activities. The work package coordinated the maintenance of the DigiMar online portal, management of the project's social media channels, publication of newsletters with infographics, dissemination through scientific conferences, and organization of multiplier events. It also monitored dissemination performance through predefined qualitative and quantitative indicators, ensuring continuous visibility and accessibility of project outputs throughout the project duration.

WP5.3 Project Marketing and Promotion concentrated on actively engaging external stakeholders and promoting the project beyond the consortium. The work package coordinated the identification of relevant stakeholder groups, marketing communication, organization of five national multiplier events, recruitment of external users for the digital educational pilot study, and the organization of the final international online conference. Through these activities, DigiMar successfully disseminated its educational tools and research outcomes to maritime professionals, educators, policymakers, international organizations, and decision-makers, while encouraging wider adoption and future exploitation of the project's results.

Together, the three work packages established an integrated exploitation and dissemination framework that combined strategic planning, operational dissemination management, and targeted marketing and stakeholder engagement. This approach ensured broad international visibility of the DigiMar project, facilitated the dissemination of its research findings and digital educational tools, strengthened

collaboration with key maritime stakeholders, and supported the long-term sustainability and impact of the project beyond its formal completion.

3.4. High-Risk Communication Elements

Based on the review of the project findings and the identified high-risk communication elements, a set of research-based recommendations was developed. The recommendations consolidate the evidence generated across the relevant DigiMar work packages and translate the identified gaps between standardised communication requirements and operational practice into proposed areas for improvement. Particular attention is given to communication procedures, phraseology, message structure, ambiguity reduction, communication competencies and training, as well as greater harmonisation of the relevant international maritime communication standards.

The recommendations are intended to support the continuous improvement of maritime communication practices and navigational safety and are addressed primarily to the international bodies competent for maritime communication, including IMO, ITU, IALA and EMSA. The complete set of recommendations is provided in the accompanying *Recommendations for a Revision of the Standard Protocol of Communication*.

3.4.1. Closed-Loop Communication

Closed-loop communication, including *read back*, *repeat back*, *received*, and message acknowledgement procedures, represents one of the most critical safety mechanisms in maritime communication. Previous studies reviewed in WP2.1 indicate that communication loops are often only partially completed or omitted altogether, increasing the risk of misunderstanding and incorrect execution of navigational instructions. An important distinction should be made between practices that should be mandatory, more specifically, the use of closed-loop communication and those that should be recommended (e.g., the use of "This is").

3.4.2. Message Markers

The use of message markers (*Information, Question, Answer, Request, Instruction, Advice, Warning,* and *Intention*) is intended to clarify the communicative purpose of each transmission. However, research cited in WP2.1 demonstrates that these markers are frequently omitted or inconsistently applied, potentially creating ambiguity regarding the sender's intention and the urgency of the message.

3.4.1. Identification and Message Structure

The standard communication structure prescribed by ITU and IALA requires the identification of both the called station and the calling station through the use of *THIS IS* and associated call procedures. Failure to follow these procedures may result in confusion regarding message ownership, particularly in congested traffic areas involving multiple vessels and shore stations.

3.4.1. Turn Taking Procedure (OVER and OUT)

Research reviewed identified inconsistent use of the procedural words *OVER* and *OUT*. Incorrect application or omission of these markers may create uncertainty regarding whether a reply is expected or whether the communication exchange has been completed, potentially disrupting the communication flow.

3.4.5. Communication Repair Strategies

Procedural words such as *repeat*, *say again*, *correction*, and *received* are designed to repair communication failures and prevent misunderstandings. Their limited use in operational communication represents a significant risk factor, particularly in situations involving poor reception, heavy traffic, or linguistic difficulties.

3.4.6. Numerical Information and Reporting

The transmission of numbers, bearings, courses, speeds, distances, latitude, and longitude requires strict adherence to ITU and IMO procedures. Any misunderstanding involving numerical information may directly affect navigational decision-making and vessel safety, making this one of the highest-risk communication categories. Future revisions should consider whether the prescribed Figure Code pronunciations (e.g., *fower*, *ait*, and *niner*) are consistently applied in operational practice and whether any discrepancies exist between the standards and actual shipboard usage (ITU, 2020a, p.94; IMO SMCP, 2001, p. 13).

The phonetic alphabet is essential for the accurate transmission of call signs, vessel names, waypoints, and other critical information. Failure to use standard phonetic spelling increases the likelihood of communication errors, particularly in multilingual environments and under poor radio conditions.

3.4.5. Ambiguity Caused by Modal Verbs

The use of modal verbs such as *should*, *could*, and *might* may blur the distinction between advice, recommendations, and instructions. Since maritime communication prioritises clarity and unambiguity, excessive reliance on modal constructions may create uncertainty regarding the expected action.

The use of modal verbs should be simplified to minimize ambiguity. Modal verbs such as *need* and *may*, as well as polite forms (e.g., *I would* and *I could*), may result in inconsistent interpretation in operational communication. Greater emphasis should be placed on the standardized use of *can*, *must*, and *must not* to convey ability, obligation, and prohibition in a clear and consistent manner.

International standards should therefore strengthen the requirement for closed-loop communication and mandatory confirmation of safety-critical messages, particularly during pilotage, collision avoidance, port approaches, and VTS interactions. The findings also suggest the need to expand the Standard Marine Communication Phrases (SMCP) to better support the communication of intentions and manoeuvres in complex traffic situations.

Furthermore, training programmes should place greater emphasis on communication competence, including teamwork, situational awareness, bridge resource management, and effective interaction between masters, pilots, bridge teams, and VTS operators. Particular attention should be given to reducing the use of local languages during safety-critical operations, as several accident reports demonstrated that language switching excluded crew members from the communication loop and negatively affected shared situational awareness.

Finally, clearer guidance should be developed regarding proactive VTS intervention and communication-related risk management. Communication failures should be recognized as a distinct human-factor category within accident investigations, enabling more systematic monitoring of communication-related safety risks and supporting future improvements to international maritime communication standards.

The use of general English, slang, and non-standard phraseology remains a recurring concern in maritime communication research. Such forms may be interpreted differently by speakers from different linguistic and cultural backgrounds, thereby increasing the risk of misunderstanding. The results of WP4.3 provide strong evidence that the DIGIMAR educational framework has successfully translated the standards and recommendations identified in WP2.1 into measurable improvements in routine maritime communication performance. While WP2.1 established a comprehensive overview of internationally adopted communication standards and educational requirements. WP4.3 demonstrated that these standards can be effectively operationalized through digital learning tools, simulation-based training, and structured educational interventions. The statistically significant improvements observed across participating higher education institutions and maritime safety authorities confirm that targeted communication training can substantially increase compliance with internationally accepted communication procedures and phraseology.

The findings support the conclusion that routine maritime communication should be regarded as a critical safety competence rather than solely a language-related skill. Modern maritime operations depend increasingly on effective interaction between vessels, Vessel Traffic Services, pilots, port authorities, and other shore-based stakeholders operating in multilingual and multicultural environments. In such circumstances, deviations from internationally agreed communication protocols may contribute to misunderstandings, reduced situational awareness, and increased navigational risk. Consequently, greater emphasis should be placed on communication competence within maritime safety management frameworks and training programmes.

The project results indicate that the most significant improvements were achieved in areas directly linked to communication safety, including the use of standard message structures, message markers, communication repair strategies, closed-loop communication patterns, and procedural phraseology. These elements are specifically designed to reduce ambiguity and facilitate accurate information exchange, particularly in situations involving high workload, language barriers, or operational complexity. Their improvement following the DIGIMAR intervention demonstrates the practical value of continuous communication training and reinforces the rationale behind existing IMO and IALA recommendations.

Based on the project findings, it is recommended that maritime education and training institutions further integrate routine maritime communication training throughout the entire educational process rather than limiting it to individual courses or isolated simulation exercises. Communication competence should be progressively developed from introductory Maritime English courses to advanced bridge resource management and vessel traffic service training. Particular attention should be given to the practical application of communication standards in realistic operational scenarios.

It is further recommended that maritime administrations and Vessel Traffic Service organizations establish periodic refresher training and assessment programmes focused specifically on communication competence. The results of the project demonstrate that even experienced operators benefit from structured training interventions. Communication standards evolve over time, operational environments become increasingly complex, and personnel may gradually develop local communication practices that diverge from internationally accepted standards. Regular benchmarking exercises similar to those conducted within the DIGIMAR project could therefore serve as an effective quality assurance mechanism.

The project also highlights the significant potential of digital educational technologies in maritime training. The positive outcomes associated with the use of instructional videos, chatbot-supported learning environments, digital simulations, and self-directed learning tools suggest that these methods should become a permanent component of maritime communication training programmes. Such tools offer cost-effective opportunities for continuous learning, facilitate access to training regardless of geographical location, and enable standardized delivery of educational content across different institutions and countries.

From a policy perspective, the results support closer cooperation between higher education institutions, maritime safety authorities, and international organizations responsible for maritime communication standards. Future revisions of communication guidelines and training recommendations may benefit from incorporating evidence generated through projects such as DIGIMAR. The project demonstrates the value of evidence-based approaches that combine regulatory analysis, authentic communication data, educational intervention, and statistical evaluation within a single framework.

The findings further suggest that future research should focus on the collection and analysis of larger multinational corpora of authentic maritime communication. Despite the increasing importance of communication in maritime safety, there remains a limited availability of authentic datasets for research and training purposes. The establishment of shared international repositories of anonymized communication data would support the development of more accurate training materials, facilitate comparative studies, and contribute to a deeper understanding of communication-related safety risks.

*Furthermore, consideration should be given to expanding future research beyond routine communications to include communications during emergency situations, pilotage operations, traffic congestion, adverse weather conditions, and interactions involving emerging technologies such as remote vessel operations and autonomous shipping systems. As maritime transport continues to undergo digital transformation, communication standards and training me*thodologies must evolve accordingly.

3.5. Key Findings from Comparative Communication Analysis

The final comparative and benchmarking analyses conducted within the DigiMar project brought together the results generated through the preceding research and educational activities. Particular attention was given to changes in compliance with the Standard Protocol of Communication before and after the implementation of the DigiMar educational intervention, as well as to the implications of these changes for navigational safety. The combined findings provide the immediate empirical basis for drawing the final conclusions, identifying areas requiring particular attention, and formulating recommendations for the revision and further harmonisation of the Standard Protocol of Communication.

The recommendations are grounded in the comprehensive analysis of authentic and simulated maritime VHF communications conducted throughout the DigiMar project. The analysis encompassed 16 spoken corpora collected from Higher Education Institutions (HEIs) and Maritime Safety Authorities (MSAs) in Slovenia, Croatia, Finland, Sweden, Norway, and Montenegro, comprising a total of 12,551 communication turns. Of these, 4,449 turns originated from student simulations and 8,102 from authentic VTS communications. The corpora were collected both before and after the implementation of DigiMar digital educational interventions, enabling a direct comparison of communication practices and compliance with the Standard Protocol of Communication.

The comparative analysis revealed statistically significant improvements in the majority of communication variables following the implementation of DigiMar educational tools. Improvements were particularly evident in the use of communication structuring elements, message markers, procedural words, and communication repair strategies. In several cases, compliance increased by more than 50 percentage points after training. For example, the use of the procedural marker *Over* increased from approximately 12% to over 80% among VTS operators in Slovenia, while the correct use of the message marker *Question* increased from 15% to 67%. Similarly, among HEI participants, the use of the marker *Information* improved from less than 2% to more than 76%, while the use of *Question* increased by over 60 percentage points.

The statistical analysis identified several communication elements that repeatedly exhibited low compliance rates in both authentic VTS communications and student simulations. These elements are considered high-risk because their omission or incorrect use may lead to misunderstanding, delayed responses, incorrect execution of instructions, and ultimately compromise navigational safety. Among the identified high-risk areas, the most critical are closed-loop communication procedures, message markers, identification procedures and message structure, procedural words and turn-taking markers, communication repair strategies, and message completeness.

Closed-loop communication procedures, including *Read back, Repeat, Say again, Received,* and message acknowledgement practices, emerged as one of the most critical safety-related communication areas. Prior to the educational intervention, these procedures were frequently omitted despite being required

by the communication context. For example, the use of *Read back* among HEI participants increased from 0% to over 57% following training, while *Say again* increased from 0% to approximately 57%. Similar improvements were recorded among VTS operators. These findings demonstrate that communication loops are often not naturally completed in routine operations and therefore require explicit standardisation and continuous training. Failure to perform communication confirmation and acknowledgement procedures increases the probability of misunderstandings remaining undetected, particularly during high-workload situations, complex manoeuvres, or emergency operations.

The use of message markers (*Information, Question, Answer, Request, Instruction, Advice, Warning,* and *Intention*) was identified as another high-risk area. Across the analysed corpora, message markers were frequently omitted or inconsistently applied. In several pre-study corpora, the use of markers such as *Question* and *Information* was below 20%, while some markers were almost completely absent. After targeted training, significant improvements exceeding 50 percentage points were recorded, confirming that operators and students can readily adopt these structures once adequately trained. The omission of message markers may create ambiguity regarding communicative intention, urgency, and the expected response, particularly in multilingual and high-density traffic environments.

Identification procedures and message structure also emerged as significant areas of concern. Communication structuring elements, including stating the addressee, the use of the phrase *This is*, and identification of the calling station, were among the variables demonstrating the largest improvements following training. For example, among Slovenian HEI participants, the correct use of *This is* increased from approximately 18% to 60%, while correct station identification increased from 19% to more than 60%. Similar trends were observed among VTS operators and other partner institutions. Incorrect or incomplete identification procedures may result in uncertainty regarding message origin or destination and may lead to messages being ignored, misunderstood, or acted upon by unintended recipients.

Substantial inconsistencies were also identified in the operational use of procedural words, particularly *Over, Out, Stand by,* and *Received*. Prior to training, authentic VTS communications demonstrated particularly low compliance regarding the use of *Over*, which in some corpora appeared in only approximately 12% of expected instances. Following training, compliance exceeded 80%. Similar improvements were observed for *Received* and *Stand by*. Given their role in turn management, channel discipline, and communication clarity, procedural words represent an important safety-related communication area.

The findings further underline the importance of communication repair strategies and message completeness. Standardised mechanisms for repetition, clarification, acknowledgement, and correction are essential for detecting and resolving misunderstandings before they affect operational decisions. Likewise, incomplete transmissions may require additional clarification exchanges, increase communication workload, and delay decision-making in time-sensitive situations. The improvements observed following training suggest that these elements can be strengthened through targeted educational interventions.

In contrast, elements such as formal tone, pace of speaking, clarity of speech, standard sentence structure, and the use of the phonetic alphabet generally demonstrated high levels of compliance even before the intervention. This suggests that the main communication risks identified by the project are not primarily related to general language proficiency, but to the consistent operational application of standardised communication procedures.

Overall, the findings indicate that deficiencies observed in routine maritime communication cannot be attributed solely to individual operator performance but point to broader challenges in the implementation, interpretation, and operationalisation of the existing communication standard. At the same time, the substantial improvements recorded following the educational intervention demonstrate that digital educational resources, authentic scenarios, and AI-supported conversational tools can enhance compliance with standardised communication procedures. The identified high-risk communication elements therefore provide the empirical basis for defining priority areas for future training and for the further revision, clarification, and harmonisation of international maritime communication standards.

4. Evaluation

Responsibilities of HEI: Identification of the elements of the standard that have been assigned high-risk assessment values. Preparation and communication of recommendations for a revision of the standard protocol of communication (IMO, ITU, IALA, EMSA).

Responsibilities of MSAs: Reviewing the recommendations for a revision of the standard and 100% approval of the final document.

5. Conclusion

This document represents an Annex to the Recommendations developed within the DigiMar project, which are intended to be communicated to the relevant competent international maritime organisations and institutions. The Annex provides additional clarification, research evidence, and supporting information for the recommendations and their further consideration by relevant maritime stakeholders.

In this context, the Recommendations are intended to support greater alignment among international maritime organisations and policy makers responsible for the development of maritime communication standards. Greater integration and harmonisation of communication principles across the relevant IMO, ITU, and IALA documents should be encouraged, while taking into account technological developments and the continuously evolving and dynamic nature of maritime communication. Such coordination would contribute to a more coherent international communication framework and facilitate the consistent development and implementation of maritime communication standards. The recommendations distinguish between areas where new or revised international guidance is genuinely needed and areas that are already adequately covered by existing standards, guidelines, or training frameworks, but require more consistent implementation, training, supervision, or follow-up by VTS providers and maritime education and training institutions.

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DIGIMAR

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Recommendations for a Revision of the Standard Protocol of Communication

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1. List of abbreviations

Abbreviation	Full term
AI	Artificial Intelligence
AIS	Automatic Identification System
COLREG	Convention on the International Regulations for Preventing Collisions at Sea
CPD	Continuous Professional Development
DigiMar	Digital Education for Maritime Communication
EMSA	European Maritime Safety Agency
ESP	English for Specific Purposes
GMDSS	Global Maritime Distress and Safety System
HEI	Higher Education Institution
IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities
IMO	International Maritime Organization
ITU	International Telecommunication Union
MET	Maritime Education and Training
MSA	Maritime Safety Administration
OOW	Officer of the Watch
SMCP	Standard Marine Communication Phrases

SOLAS	International Convention for the Safety of Life at Sea
STCW	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers
VHF	Very High Frequency
VTS	Vessel Traffic Service

2. Executive summary

This document presents the key recommendations developed within the Erasmus+ KA220-HED Digital Education for Maritime Communication (DigiMar) project. Based on comprehensive research and collaboration between HEIs and MSAs, the document proposes evidence-based recommendations for the future revision and harmonization of international maritime communication standards. The recommendations are intended to support safer, clearer, and more consistent maritime communication and to contribute to the continuous improvement of international maritime communication practices.

2.1. Purpose of this document

The purpose of this document is to present evidence-based recommendations for the future revision and harmonization of international maritime communication standards. The recommendations are intended to support international organizations and standard-setting bodies in strengthening communication procedures, improving navigational safety, and promoting greater consistency in maritime communication practices.

2.2. Why the study was undertaken

The study was undertaken in response to the increasing importance of effective and standardised maritime communication in ensuring navigational safety. Although comprehensive international communication standards and guidance documents are available, previous research and operational practice have revealed differences in terminology and communication procedures and highlighted the need of aligning the IALA, ITU and IMO guidelines on VTS communications. The DigiMar project therefore sought to identify communication practices that may benefit from further clarification, harmonisation, and standardisation through evidence-based research.

The project brought together HEIs, following communication standards “by the book”, and MSAs, providing valuable feedback from operational experience. These combined perspectives highlighted the interaction between theory and practice and provided valuable recommendations for their better harmonisation and alignment.

The post-intervention courses, where the project results were delivered to a wider audience and subsequently tested, significantly improved participants’ (HEIs and MSAs) use of procedural words and the overall structure of communication, while supporting knowledge refreshment among MSA operators, particularly regarding address and identification procedures, and message markers.

MSAs provided valuable feedback, emphasising the need to reserve the right to adapt or shorten communication when their operational experience and the specific communicative situation, particularly in safety-critical contexts, dictate so.

2.3. Research evidence collected

The recommendations presented in this document are based on evidence collected throughout the DigiMar project using multiple complementary research approaches. These include the review of international maritime regulations and guidance documents, corpus-based analyses of authentic VTS communications and student simulations, accident investigation reports, benchmarking activities, surveys and interviews with maritime professionals, the development and evaluation of digital educational tools, and educational pilot studies. The continuous involvement of MSAs ensured that the findings reflect both regulatory requirements and contemporary operational practice.

2.4. Major findings

The research identified several communication elements that continue to present operational challenges due to inconsistent application, ambiguity, or differences among existing international standards. The findings particularly highlight the need for greater standardisation of communication procedures, message markers, procedural words, communication repair strategies, station identification, communication structure, and VTS communication competencies. The study also demonstrated the importance of closer harmonisation between the principal international maritime communication documents.

2.5. Benefits for the maritime community

The recommendations presented in this document are intended to support international organisations, MSAs, VTS providers, training institutions, and maritime professionals in strengthening communication practices and improving navigational safety. These recommendations are intended primarily for policymakers and international regulatory and standard-setting bodies, particularly IMO, ITU, and IALA, which are in a position to support greater alignment and harmonisation of the key international documents governing maritime communication. Particular attention should be given to the IMO SMCP as a central reference framework connecting the principal actors involved in maritime VHF communication, including both seafarers and VTS operators.

3. About the Digimar project

Digital Education for Maritime Communication (DigiMar) is an Erasmus+ KA220-HED – Cooperation Partnerships in Higher Education project, coordinated by the University of Ljubljana, Faculty of Maritime Studies and Transport, Slovenia. The project runs from 1 October 2023 to 30 September 2026 (36 months).

The DigiMar project is implemented by a consortium of HEIs and MSAs from five European countries. Together, the project partners contribute complementary academic, operational, and technical expertise, ensuring the successful implementation of the project activities and the achievement of its objectives. The participating organisations are listed below.

1. HEIs:
    1. Applicant - UNIVERZA V LJUBLJANI (Slovenia)
    2. AB YRKESHOGSKOLAN VID ABO AKADEMI (Finland)
    3. CHALMERS TEKNISKA HOEGSKOLA AB (Sweden)
    4. Sveučilište u Rijeci (Croatia)
    5. University of Montenegro, Maritime faculty Kotor (Montenegro)
2. MSAs:
    6. Fintraffic Vessel Traffic Services ltd (Finland)
    7. Ministrstvo za infrastrukturo, Uprava Republike Slovenije za pomorstvo (Slovenia)
    8. Norwegian Coastal Administration (Norway)
    9. Swedish Maritime Administration (Sweden)
    10. UPRAVA POMORSKE SIGURNOSTI I UPRAVLJANJA LUKAMA (Montenegro)

The project consisted of five work packages: WP1 Project Management; WP2 Maritime Communication Standard- and Data-based Content Development; WP3 Digital Educational Tool Development, Deployment and Evaluation; WP4 Maritime Communication Standard- and Data-based Benchmarking; and WP5 Exploitation and Dissemination.

3.1. Project overview

Digital Education for Maritime Communication (DigiMar) is an Erasmus+ KA220-HED Cooperation Partnership in Higher Education implemented from 1 October 2023 to 30 September 2026 and coordinated by the University of Ljubljana, Faculty of Maritime Studies and Transport. The project brings together HEIs and MSAs from several European countries, combining academic expertise with operational maritime experience.

DigiMar was developed in response to the need to improve routine maritime communication and reduce communication-related risks to navigational safety. The project focuses on strengthening the

maritime communication skills of maritime students and shore-based maritime service operators through research-based and innovative digital learning solutions.

A central feature of the project is the use of authentic maritime communication data as the basis for research, education, and training. The project combines the analysis of international maritime communication standards and accident reports with authentic ship–shore communication data and student simulations. These complementary sources provide the research basis for the development and evaluation of digital educational tools, the benchmarking of maritime communication performance, and the formulation of research-based recommendations for the revision of the standard protocol of maritime communication.

Through its five interconnected work packages, DigiMar moves from the analysis of communication standards and authentic communication practices, through the production of open-access instructional videos and the development of educational chatbots, both available at digimar.si and designed to support the practice of VHF communication across a range of operational communicative situations, to the evaluation of these digital educational tools, the benchmarking of communication performance, and the development of these research-based recommendations for the revision of the standard protocol of maritime communication.

3.2. Main objectives

The DigiMar project aims to improve the quality, consistency, and effectiveness of maritime communication through research, digital education, and international cooperation. Its main objectives are to analyse authentic maritime communication practices, identify communication elements affecting navigational safety, develop innovative digital learning resources, strengthen communication competencies among maritime professionals, and formulate evidence-based recommendations for the future revision and harmonisation of international maritime communication standards.

3.3. Data and research evidence collected

The recommendations presented in this document are based on comprehensive evidence collected throughout the DigiMar project. The research combined multiple complementary methods, including the review of international regulations, standards, and guidance documents, analyses of authentic VTS communication corpora, accident investigation reports, benchmarking activities, surveys and interviews with maritime professionals, as well as the development, implementation, and evaluation of digital educational tools through pilot studies.

The evidence was collected and analysed through several interconnected work packages, integrating qualitative and quantitative research approaches. The continuous involvement of HEIs and MSAs ensured that the findings reflect both scientific evidence and contemporary operational practice, providing a robust basis for the recommendations presented in this document.

The analysis and project activities generated the following research evidence:

- **57 marine accident and incident report**s retrieved from nine international marine accident databases, covering the period **2011–2023**;
- **16 spoken corpora** collected from HEIs and MSAs in **Slovenia, Croatia, Finland, Sweden, Norway, and Montenegro**, comprising:
    - **12,551 communication turns** in total, including **4,449 turns** from student simulations and **8,102 turns** from authentic VTS communications;
    - **3,486 communication exchanges** in total, including **1,654 pre-educational exchanges** and **1,832 post-educational exchanges**;
    - **46,966 words** of transcribed authentic VTS communications;
    - **45 hours and 59 minutes** of transcribed authentic VTS communications;
    - authentic VTS communication data collected from **five European geographical areas**;
- **58 maritime communication simulation scenarios**, comprising **26 pre-educational scenarios** and **32 post-educational scenarios**;
- **85 students** who participated in the **post-educational pilot study**;
- evaluation of the developed **digital educational tools through 11 multiplier events**, involving **more than 500 participants**.

Open-access digital educational resources involved 30 instructional videos (20 Basic Training and 10 Advanced Case-Based Training) published on the DigiMar project website (www.digimar.si).

4. Recommendations for the Revision of the Maritime Communication Standard

This document presents the policy recommendations arising from the DigiMar project. More detailed information about the DigiMar project, including its methodology, analyses, work package activities, and supporting empirical evidence, is provided in the accompanying Activity Report derived from WP 4.5 (Annex 1).

The quantitative and qualitative statistical analyses conducted within the project identified several communication elements that consistently exhibited low compliance rates in both authentic VTS communications and student simulations. These elements represent high-risk areas because their omission, inconsistent application, or incorrect interpretation may lead to misunderstandings, delayed responses, improper execution of navigational instructions, and ultimately compromise navigational safety.

The following recommendations are therefore aimed at strengthening these critical communication elements, improving the consistency and standardisation of maritime communication practices, and supporting future revisions of international maritime communication standards. Particular consideration is given to areas where new or revised international guidance may be needed, as well as to those already adequately addressed by existing standards, guidelines, or training frameworks, but where more consistent implementation, training, supervision, and follow-up by VTS providers and MET institutions could further strengthen communication practices.

1. Greater Emphasis on Closed-Loop Communication
2. Use of Message Markers
3. Alignment and Clarification of Procedural Words
4. Standardisation of Syntax and Vocabulary
5. Strengthening Standardised Communication Structure
6. Modality and Ambiguity
7. VTS operators' Competencies, Training and Assessment
8. Maritime English Framework and VTS Communication

4.1. Greater emphasis on closed-loop communication

According to IALA VTS Communication and Phraseology "Closed-loop communication is a technique used to avoid misunderstandings. The sender gives a message, the receiver repeats a received message, or an appropriate part thereof, back to the sender to obtain confirmation of correct reception" (IALA, 2022, 19).

Closed-loop communication procedures should be strongly emphasised for all communications involving navigational instructions, traffic organisation, pilotage, berthing, emergency response, and other safety-critical operations.

- It is recommended to promote the appropriate use of closed-loop communication according to the nature, complexity, and safety significance of the message.
- Clear guidance and practical examples should be provided to assist VTS operators and other users in identifying situations where acknowledgement, read-back, and confirmation are particularly important for safe and effective communication.
- The use of closed-loop communication should be adapted to specific operational situations, particularly in heavy vessel traffic and confined waters, where its extensive use could compromise language economy and communication efficiency.
- Greater awareness should be raised among both seafarers and VTS operators of the importance of responsiveness in maritime communication, particularly in safety-critical situations.

4.2. Use of message markers in VTS communications

Eight message markers are defined in the IMO SMCP, seven of which are frequently used by VTS, and IALA (2022) guidance recommends that the appropriate message marker be spoken before the message

- Message markers should precede all operationally relevant transmissions to clearly indicate communicative intent, facilitate prioritisation of information, and reduce ambiguity in multilingual communication environments.
- The use and meaning of message markers are already addressed in existing IALA guidance (2022). Due to observed instances of inconsistent use of certain message markers, the relevant IALA guideline and IMO SMCP could be further reviewed and expanded with additional explanations and authentic operational examples. This would support both VTS operators and maritime education and training institutions in applying and teaching them more consistently.
- When it comes to the potentially interchangeable use of message markers, clear guidance on their use should be provided, as message markers such as *Instruction, Warning,* and *Request* may be used differently depending on the operational context.
- IALA (2022, 9) provides a more detailed explanation of the message marker *Instruction*, specifying that it indicates the sender's intention to direct the action of others. In the VTS

context, IALA further emphasises that ships should comply with instructions issued by a VTS, unless there are contradictory safety or marine environmental protection reasons, and highlights the need for the VTS issuing an instruction to have the appropriate regulatory status and authority. The IMO SMCP (2002, 47) provides a more general framework for its communicative use. In light of this, the distinction between the communicative function of the message marker and the operational or regulatory authority associated with its use could be made more explicit and harmonised across the relevant guidance documents.

- Also, the distinction between Advice/Information may be clarified as Advice may be interpreted either as a recommendation or as an expected course of action, leading to inconsistent interpretation and response by seafarers.
- Future revisions of the standard may consider whether the message marker Advice should be used consistently in place of the verbal form Advise (e.g. Advice. Recover your fishing gear. instead of Advise you to recover your fishing gear.). As the two forms differ only slightly in pronunciation (/s/ vs. /z/), their use in voice communication may lead to confusion. The consistent use of a single standardised form could therefore improve clarity and reinforce the standardised use of message markers.

4.3. Alignment and clarification of procedural words

The use of procedural words should be adapted to communicative function and the context of the exchange.

- The revised protocol should provide precise definitions, operational explanations, and authentic examples illustrating the contextual use of procedural words under different operational conditions, including routine traffic management, restricted visibility, emergency situations, and distress communications.
- Existing IMO, ITU and IALA documents should provide aligned definitions and guidance so that the procedural words (*Over, Out, Received, Stand by, Say again, Read back, Repeat,* etc.) are understood and used consistently throughout maritime discourse.
- For self-initiated repair, the word *Mistake* needs to be followed by the word *Correction*, after which the corrected part of the message should be repeated (IMO SMCP, 2001, p. 15). The IALA Guideline (*VTS Communications and Phraseology*, 2022) prescribes using only *Correction* followed by the corrected part of the message. Consideration should therefore be given to harmonising these procedures in future revisions of the communication standard.
- Repair prowords such as *Repeat* and *Correction* occur relatively infrequently in authentic communication and could therefore receive greater emphasis in future maritime communication training. This would support both VTS operators and maritime education and training institutions in applying and teaching them more consistently.
- The operational distinction between *Repeat* and *Say again* should be explicitly clarified to prevent their interchangeable use and ensure uniform communication practices across VTS providers. According to the ITU Manual (2020a, p. 32), “I say again” is used by the sender

when repeating a transmission ("I am repeating the transmission"). However, a discrepancy exists between the ITU Manual and the complementary IMO SMCP (2001). According to the IMO SMCP and IALA 2022 phraseology, the sender should use *Repeat* when repeating a transmission ("Do not overtake – repeat – do not overtake"), whereas *Say again* is used by the receiver to request repetition of a message that has not been understood ("Say again your position for identification").

- *Read-back* – "Repeat all, or the specified part, of this message back to me exactly as received and understood." (IALA, 2022, 21) should be consistently applied, particularly in safety-critical VTS communications, to confirm that a message has been correctly understood and to allow other vessels monitoring the frequency to hear the safety-critical information a second time (IALA, 2017, p. 7). In this way, a communication loop is reinforced.
- A graded classification of standard phrases according to the level of communicative certainty they convey (e.g. message received → message understood → message read back and verified → intended action confirmed) would help distinguish more clearly between what has merely been received, what has actually been understood, and what has been confirmed for subsequent action, thereby reducing ambiguity and promoting consistent interpretation across maritime communication contexts.

4.4. Standardisation of syntax and vocabulary

4.4.1. Syntax

- The syntax should adhere to the *subject + verb+ object* pattern as in "I require assistance". Truncated sentences in communication exchange must not be used as they make the message unclear as in "Towards Anchorage", rather say "MV Horizon, proceed towards anchorage".
- Intonation alone should not be used to indicate interrogative meaning, as it may lead to misunderstanding in radiotelephony communication. Instead, greater emphasis should be placed on encouraging interrogative structures and question words wherever possible (e.g., *what, where, when,* and *which*), and their consistent use in future standardised communication protocols.
- Each communication exchange should communicate only one topic, avoiding unnecessary information within the same transmission (IALA 2022, 10).
- Therefore, greater emphasis should therefore be placed on training and practical application to promote the use of complete and clearly structured utterances in operational communication.

4.4.2. Vocabulary

- A glossary could be included at the beginning of the document, identifying words and expressions that contribute positively to clear and effective maritime communication, while also highlighting those whose use should be avoided. It could be considered to semantically distinguish between affirmative (preferred) and non-standard or potentially ambiguous lexical items used in maritime VHF radio communications. Such a classification, included as a phrase inventory, could provide users with a clear overview of expressions recommended for operational communication.
- Affirmative or preferred expressions could include words and phrases encouraging and clarifying communication such as *this is, must, yes, correction, received, read back, say again, over,* and *out*. Conversely, non-preferred, negative or potentially ambiguous expressions to be strongly discouraged include modal verbs and lexical items such as *may, might, need, could, should, have to, maybe*; obsolete or scarcely used lexemes such as *jettison;* words used to address stations such as *Madam, Sir, Captain, Mate, Lady*; non-standard acknowledgement terms including *okay, copy, copied, copy that, roger, ok,* and similar expressions whose meaning is not consistently established across maritime communication standards.
- The vocabulary (IMO SMCP, 2001; IALA, 2022) should prioritise simple, high-frequency operational (active) verbs (e.g. *stand, check, take, go, make, proceed, change, follow, transfer, give, turn, sail, put, send, open, pick, wait, assist, get, meet, pass, rig, steer*); relationship verbs: *be, have, do*; reporting verbs: *report, inform*; verbs: *occur, change, increase, decrease, improve*; aspectual verbs: *keep, stop, start*.
- Future revisions of the IMO SMCP (2001) may also consider reducing the use of certain multi-word expressions that may be difficult for seafarers to memorise and use and that are rarely encountered in actual communication practice (e.g., *run into danger, make fast, make water, get underway, give a wide berth, etc*).

4.5. Communication structure and station identification

A standardised communication structure and unambiguous station identification procedures are fundamental elements of effective maritime communication, reducing ambiguity and supporting safe and efficient information exchange between communicating stations.

4.5.1. Station identification

The standard should reinforce the requirement for complete and unambiguous identification procedures at the beginning of every communication exchange. The compulsory use of the addressee, the phrase *This is,* and identification of the calling station should be explicitly prescribed for all routine and safety-related communications, as prescribed by the ITU Manual for Use by the Maritime Mobile and Maritime Mobile-Satellite Services (2024).

4.5.2. Turn-taking procedures

The procedural words “over” and “out” should remain part of maritime communication training, and both seafarers and VTS operators should be encouraged to use them appropriately in operational communication.

Consistent use of the turn-taking signal “over” throughout the entire radio exchange would support orderly and clear turn-taking, maintain the continuity of communication, and reduce the risk of simultaneous transmissions or misunderstandings in simplex radiotelephony.

“Over” should signal the completion of each transmission when expecting a reply, while “out” should be used only to indicate that the communication has been completed. The combined expression “Over and out” should not be used.

4.6. Modality and ambiguity

Inconsistencies were identified across IMO, ITU and IALA guidance regarding the use of modal verbs.

Modal verbs such as *may, might, need, should,* and *could*, as well as polite forms (e.g. *Would you...?*), may lead to different interpretations in operational communication. IMO SMCP (2001) includes the use of both *may* (e.g. “You / MV ... may stop search and proceed with voyage”) and *can* (e.g. “I / MV ... can proceed without assistance”) and need (“No, you need not take tug(s)”).

IALA guidance identifies modal verbs such as *may, might, should,* and *could* as potentially ambiguous. Their use should therefore be aligned across the two documents and their communicative functions clearly defined, with particular emphasis on *can* for ability, *must* for obligation, and *must not* for prohibition in a clear and consistent manner.

The relevant IMO, ITU and IALA guidance should therefore be reviewed and further harmonised to ensure that the use and interpretation of modal verbs, terminology, and related communication procedures are presented consistently across the different documents, particularly where differences may affect clarity.

4.7. VTS Operators’ competencies, training and assessment

Internationally harmonised criteria for assessing Maritime English proficiency among VTS personnel should be developed and incorporated into relevant international training and certification frameworks.

Although the IALA V-103 model course framework (IALA, 2022) provides a common basis for VTS education and training, greater international harmonisation is still needed regarding entry requirements, prerequisite qualifications and competency standards. Differences among countries in accepted maritime qualifications (e.g. nautical education, certificates of competency and equivalent professional experience) may lead to inconsistencies in the knowledge and skills of VTS personnel. Therefore, internationally agreed minimum competencies should be more clearly defined, together with harmonised entry requirements and qualification criteria, to ensure a consistent standard of VTS personnel regardless of the country in which they are trained or certified.

Establishing common assessment criteria would promote greater consistency in VTS training, facilitate mutual recognition of competencies, and contribute to safer and more effective maritime communication.

4.7.1. Recurrent training and continuous professional development

Communication competencies should not be assessed solely during initial certification. Instead, recurrent training and periodic reassessment should be introduced.

- Continuous professional development programmes for VTS operators and maritime personnel should include dedicated modules addressing message markers, procedural words, communication repair mechanisms, and closed-loop communication procedures.
- The findings also suggest the need to expand and revise the IMO SMCP (2001) to better support and adapt the communication of intentions and manoeuvres in complex traffic situations. In this context, further standardisation of maritime communication should also take into account the ongoing transition towards digital communication and data exchange systems, ensuring that standardised communication procedures remain applicable and consistent across both voice and digital operational environments.
- Maritime education and training institutions should integrate digital learning tools, including instructional videos, AI-supported chatbots and Moodle-based learning platforms, into regular communication training programmes rather than using them solely as one-off educational activities.
- Continuous refresher training and realistic scenario-based exercises reflecting authentic VTS operational environments should be incorporated to reinforce routine communication skills and facilitate the effective transfer of learning into operational practice.

4.7.2. Authentic and region-specific training scenarios

Training materials, simulations, and digital learning tools can be developed using authentic communication scenarios that reflect the geographical and operational characteristics of the respective VTS region, thereby complementing international standards with local operational practice.

For example, authentic training scenarios should reflect local geographical features such as narrow channels, traffic separation schemes, pilot boarding areas, archipelagos, inland waterways, seasonal tourist traffic, ice navigation, or offshore operations.

4.8. Maritime English framework and harmonisation

Future revisions should explicitly identify the status of communication requirements, procedures, and phraseology across the core international maritime communication documents, clearly indicating whether individual provisions are aligned and harmonised: recommended, optional, or discouraged in safety-critical communications. Such harmonisation should be considered across the following reference documents:

(1) Manual for Use by the Maritime Mobile and Maritime Mobile-Satellite Services (ITU, 2024a, 2024b);

(2) IALA Guideline G1132: VTS Voice Communications and Phraseology (2017; revised 2022); and

(3) Standard Marine Communication Phrases (IMO SMCP, 2001).

Phraseology should instead be presented through clear explanations, appropriate operational contexts and examples of good practice.

A defined Maritime English proficiency level should also be established for VTS operators. The required level should reflect the communication demands and safety responsibilities associated with VTS operations.

4.8.1. Recognition of VTS communication

The analysis also demonstrated that contemporary VTS operations occupy an increasingly important role within the maritime communication system. However, existing communication standards remain largely ship-oriented, while VTS-specific communication requirements continue to be addressed primarily through IALA recommendations.

The growing operational significance of VTS providers should be reflected in future revisions of international regulatory instruments, including the STCW Convention and Code, through the explicit incorporation of VTS communication competencies and greater interconnection between IALA, IMO, and ITU documents governing external maritime communications.

4.8.2. Standardised performance indicators

The relevant maritime policymakers in the maritime industry should consider developing a harmonised framework of measurable communication performance indicators or variables that would enable the systematic monitoring and evaluation of compliance with standardised communication procedures.

A defined Maritime English proficiency level should also be established for VTS operators. The required level should reflect the communication demands and safety responsibilities associated with VTS operations. Maritime English language and its specific phraseology should be presented through clear explanations, appropriate operational contexts, and examples of good practice.

The development of a Maritime English Model Course for VTS operators and a corresponding assessment tool would be strongly supported. These could provide a common international

framework that MSAs, VTS providers, and training institutions could use when training and assessing personnel, while leaving decisions on implementation to national legislation, competent authorities, or other applicable governance arrangements.

5. Conclusion

The DigiMar project has demonstrated that effective and standardised maritime communication remains a fundamental component of navigational safety. Based on the analysis of international regulations, accident reports, authentic VTS communication, student simulations, benchmarking activities, surveys, interviews, and digital educational tools, the project identified several areas in which the existing communication framework could benefit from further clarification and harmonisation.

The findings particularly highlight areas that could benefit from further alignment or development of international guidance, especially in relation to closed-loop communication, message markers, procedural words, communication repair, message structure, station identification, and VTS communication competencies. In this context, the findings highlight the need to consider the revision and updating of the IMO SMCP (2001), together with further harmonisation of IMO, IALA, and ITU guidance relating to VTS communications.

The recommendations presented in this document are advisory in nature and should not be interpreted as questioning the effectiveness of the existing regulatory framework. Rather, they are intended to support its continuous harmonisation and modernisation while preserving its fundamental principles and operational effectiveness. Developed through research and close collaboration with MSAs, seafarers, researchers, and students, they provide a complementary contribution to the existing body of knowledge and may serve as a basis for further discussion and consideration by relevant international organisations and maritime stakeholders.

Therefore, the recommendations aim to encourage, strengthen, clarify, and harmonise good communication practices. At the same time, they recognise that the practical implementation and assessment of these practices may remain the responsibility of the relevant competent authorities, in accordance with national legislation and organisational procedures.

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7. Annexes

Annex 1 – WP 4.5. Recommendations for a Revision of the Standard Protocol of Communication (Activity Report)

Available upon request from the Project Coordinator at violeta.jurkovic@fpp.uni-lj.si