PROJECT DELIVERABLE REPORT

Introducing advanced ICT
and Mass Evacuation Vessel design
to ship evacuation and rescue systems

D2.3 Final version of PALAEMON Requirement Capture Framework

A holistic passenger ship evacuation and rescue ecosystem

MG-2-2-2018

Marine Accident Response

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Contents

Abbreviations

AR	Augmented Reality
BMI	Body Mass Index
EU	European Union
EMSA	European Maritime Safety Agency
GA	General Alarm
GDPR	General Data Protection Regulation
GPS	Global Positioning System
HPS	Hemiparesis Simulator
ICT	Information and Communications Technology
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IMO	International Maritime Organization
ISO	International Organization for Standardization
LTE	Long-Term Evolution
MEV	Mass Evacuation Vessel
MOB	Man Over-Board
NTUA	National Technical University of Athens
PaMEAS	Passenger Mustering and Evacuation Process Automation System
PIMM	PALAEMON Incident Management Module
Q&A	Question and answer
Reg.	Regulation
Ro-Pax	Roll-On Roll-Off Passenger vessel
SAR	Search and Rescue
SB	Smart Bracelet
SOLAS	International Convention for the Safety of Life at Sea
SRAP	Smart Risk Assessment Platform
SRtP	Safe Return to Port
UAV	Unmanned Aerial Vehicle
VR	Virtual Reality

1 Executive Summary

This report contains the results of the requirements validation process implemented in the second iteration of the requirements development of the PALAEMON ecosystem for Task 2.2. Specifically, the 2nd iteration of Task 2.2 was the validation of the already specified stakeholder and system requirements and, if possible, the extraction of new needs and expectations regarding the PALAEMON platform. For the systematic collection of the relevant information an online workshop was organized and 9 interviews were conducted. The elicited material was documented and analysed to serve as the basis for a review of the PALAEMON requirements and a reference for the update/improvement of the functions of the PALAEMON components.

The rest of this report is structured in the following sections:

Section 2 presents briefly the theory and the tools used within the framework of requirements engineering for the information retrieval process. It also describes how this deliverable is connected with the previous deliverables of the project.

Section 3 describes the PALAEMON architecture as well as the system as a whole (based on D2.6 (ATOS, 2020), including key information about the goals of the project and a concise description of the functional dependencies and interactions of its main components.

Section 4 comprises of a detailed description of the workshop as well as the interviews that were conducted in the 2nd iteration of Task 2.2. The results and information obtained from the workshop are provided for each component separately. Subsequently, the perceptions/opinions expressed for the PALAEMON components during the interviews by the stakeholders are presented.

Section 5 presents the IMO Safe Return to Port regulations and the necessity to generate supplementary requirements for the overall PALAEMON ecosystem or specific PALAEMON components is analysed.

Section 6 consists of a review of the system requirements presented in D2.6 and lists the existing system requirements for each PALAEMON components that are validated or are affected by the obtained information.

Finally, the conclusions describe how the collected information was used for the validation of the PALAEMON requirements and for developing recommendations for their update, amendment and supplementation. Finally, the conclusions describe how the collected information was used for the validation of the PALAEMON requirements and for developing recommendations for their update, amendment and supplementation. The most important part of the whole process is the understanding of the stakeholders' views and opinions and their consideration for the successful completion of the project. The most important part of the whole process is the understanding of the stakeholders' views and opinions and their consideration for the successful completion of the project.

Appendix I summarises and presents in tabular format the changes that are proposed, based on the stakeholder's requirements, to the first version of system requirements.

Appendix II provides the 2nd WP2 workshop results in detail, graphically presented in descending ranking order.

Appendix III presents in detail the study that was performed to measure the potential time delay of people with disabilities during evacuation.

2 PALAEMON Requirement Capture Framework

This section describes the rationale and the tools utilised for the second iteration of the stakeholder requirements elicitation and validation process under the framework of requirements engineering.

2.1 Requirements engineering

Requirements engineering is the field that mediates between the acquirer and the supplier or developer to establish and maintain the requirements to be met by a system, software or service of interest (ISO/IEC/IEEE, 2018). It comprises of several activities, i.e. discovering, eliciting, developing, analyzing, verifying, validating, communicating, documenting and managing requirements.

The stakeholder needs and requirements definition is a core process of requirements engineering. Its aim is to define the stakeholder requirements for a system to deliver the capabilities and characteristics needed by stakeholders in a defined environment (ISO/IEC/IEEE, 2015).

One of the first activities of that particular process is the identification of the stakeholders, i.e. the individuals who have a legitimate interest in the system. They can be the users, operators, developers, manufacturers, suppliers, trainers, maintainers, regulatory bodies, and others who will have any form of interaction with the system throughout its life cycle. Having identified the stakeholders, the stakeholder needs elicitation strategy is drawn. The strategy includes the approaches, methods, and resources to be utilized to capture the stakeholder needs and transform them into stakeholder requirements.

Based on the elicitation strategy, the stakeholder needs and expectations are identified. The stakeholder needs can be elicited directly from the stakeholder by implementing appropriate techniques. They can also be determined indirectly by studying and understanding the relevant domain, and by identifying gaps from previous studies (ISO/IEC/IEEE, 2015).

The collected stakeholder needs are then transformed into stakeholder requirements. The stakeholder requirements, along with any relevant constraints, are the input for the system requirements definition process, which transforms the user-desired capabilities into a technical solution that meets their operational needs (ISO/IEC/IEEE, 2015). They also serve as the basis of the validation criteria for the system.

2.2 Requirements validation

ISO/IEC/IEEE (2018)indicates that it is typical to have one or more formally scheduled points in the requirements engineering process where the requirements are validated. The purpose of the validation is to feed back the stakeholder requirements to the stakeholders to validate that their needs and expectations have been adequately captured and reflected in the requirements (ISO/IEC/IEEE, 2015). According to O'Regan (2017), validation can be illustrated by the phrase "building the right thing", which means validation ensures that the correct requirements are being implemented. The validation activities should verify that the requirements are complete, consistent and fit for purpose. Namely, that they define the right system, i.e. the system that the stakeholder expects. The objective is to timely identify any failures, misconceptions, or areas of improvement regarding the elicited requirements before resources are devoted to producing a system solution for the elicited requirements.

2.3 Techniques for validating requirements

According to (ISO/IEC/IEEE, 2018), the most common activities in requirements validation are conducting requirements reviews, simulation, and prototyping. The following is a brief overview of the two techniques, interviews and a workshop, utilized for the requirements review under the scope of this deliverable.

2.3.1 Interviews

An interview is a survey technique, during which the interviewer asks project-oriented questions to one or more stakeholders and documents the respective answers. The objective is to elicit as precise and unbiased statements as possible (Pohl & Rupp, 2015). The interview can be structured, i.e. the questions can be predetermined to enable an organized and more formal approach (Laplante, 2017). On the other hand, the questions may not be prepared in advance, resulting in an unstructured interview. Evidently, this practice provides flexibility and freedom to the interviewer, but may often result in low-quality results (Fernandes & Machado, 2016).

Another interview strategy is to apply a semi-structured technique, combining the advantages of structured and unstructured interviews (Laplante, 2017). The interviewer utilizes some predefined questions to serve as the basis of the discussion, but in the course of the interview, he/she also uses spontaneous unstructured questions. The answers given by the interviewee may generate new questions that can be discussed immediately.

2.3.2 Workshop

In the framework of requirements engineering, a workshop is a joint meeting, where the organizer and the stakeholders elaborate the goals or details of a certain functionality of the system of interest (Pohl & Rupp, 2015). The meeting can be formal and have a pre-organized and structured setting. During the meeting, the stakeholders, driven and facilitated by the organizer, discuss the subject of interest, and share their knowledge, experience and expertise.

2.4 Methodology and connection with previous deliverables

Within the context of Task 2.2, an initial requirements elicitation was performed to produce a first version of the stakeholder functional requirements, which would provide the basis for the further development of the PALAEMON ecosystem. The respective results were documented in the deliverable D2.2 (NTUA, 2020). This first iteration of requirements was elicited by utilizing the PALAEMON Requirement Capture Framework, which is a project-tailored and hybrid methodology based on the VOLERE technique. Specifically, the user's and stakeholder's needs for the PALAEMON ecosystem were extracted by combining interactive methods, i.e. a workshop, a focus group, and several individual interviews, and a domain analysis, i.e. a state-of-the-art analysis conducted in Task 2.1 of the project (NTUA, 2019). The stakeholder needs, integrated with high-level use cases, the expected operational conditions, and the constraints imposed by the relevant rules and regulations, were formalized into corresponding stakeholder requirements. This set of requirements, along with the system requirements generated by Task 2.4 and presented in D2.6, served as the foundation of the work performed under the scope of this deliverable, i.e. D2.3.

The methodology applied to this deliverable has similarities with the approach applied to deliverable D2.2. The aim of D2.3 is to validate the PALAEMON stakeholder and system requirements, and the potential elicitation of new needs and expectations regarding the PALAEMON platform and the evacuation process as well. Thus, the course of action required interaction with the users and the stakeholders. This collaboration was realized through a targeted workshop and a series of interviews with selected stakeholders. The information collected from these sources was then studied thoroughly and analysed and served as the basis for the second iteration of the PALAEMON stakeholder and system requirements, which are outlined in this deliverable and D2.7 respectively. D2.7 corresponds to the second iteration of the PALAEMON architecture, and complements the stakeholder's requirements compiled in this report with those of internally harvested from the own internal technology providers, thus leading to a holistic vision that widen up the spectrum of features and functionalities to be implemented.

2.5 Passenger Requirements

PALAEMON considers passengers to be one of its primary stakeholders as they are the subjects of the evacuation procedure. Their safety is of paramount importance on passenger and cruise ships. Passengers, as a group affected directly or indirectly by any system related to evacuation, have their own needs, expectations and consequent requirements for the components of the PALAEMON ecosystem.

Moreover, passengers are linked with the economic viability of the PALAEMON innovations. If the proposed solutions are not well received or they are rejected by them, then the advanced safety features of PALAEMON might prove to be an unsuccessful investment for passenger and cruise shipping companies.

For the acceptance of any innovation by the passengers, ensuring and enhancing their feeling of safety is very important. Thus, relevant preparation and knowledge are essential. This section addresses the knowledge about passengers with special needs, as well as the preparation measures to enable a better coping with emergencies.

2.5.1 Gait speed with disabilities

In the first phase of the PALAEMON requirement analysis (D2.2), the general requirements of the passengers have been elicited and taken into consideration. During the development phase of the PALAEMON components (WP3, WP4 and WP5), it was identified that there are some gaps in the experience on dealing with people with special needs and disabilities during evacuation and in the relevant literature. Especially the additional time a person with disabilities needs was a factor that was identified in the literature but was never found quantified. But in the discussions about the different algorithms needed for PALAEMON, it became obvious that this additional time, this difference in the gait speed, is crucial for the timing of the evacuation process. According to a first evaluation provided by experts, it was estimated that the additional time needed for a person with disabilities to evacuate would be around 20-25% more than for a regular individual. As this would have already a huge effect, a quasi-experimental setting was prepared, to gather data first hand for clarifying this issue. This study is presented in detail in Appendix III.

2.5.2 Evacuation supporting approaches

The result of the study needs to be integrated into the algorithms of the Decision Support System (DSS), and the Smart Risk Assessment Platform (SRAP) to provide better timing for the decision to evacuate and to enhance the monitoring of the mustering process. It is proposed to run simulations with this data to determine what the direct impact on the timing of evacuation could be. It is also suggested to use simulation software for assessing the full impact of mobility handicapped people onboard during an evacuation.

At this stage, the approach, known from practice, to be considered is the Scoop and Run method (Taran, 2009). During the evacuation, a special team of the crew is picking up passengers with mobility issues with a stretcher or wheelchair or carrying chair and brings those people to the assigned muster station and if abandonment is decided to the rescue boats. No attention has to be paid to the status of the passenger. Mobility limited passengers are just picked up and delivered.

To reach the best outcome, the evacuation is addressed in several phases (Table 1):

- Preparation– passengers with mobility issues are sent to their cabins for safety reasons;
- Alarm– passengers prepare for being picked up by crew;
- Mustering– crew members carry the passengers to the Muster Station;
- Boarding on the MEVs – Passengers are carried in the rescue vehicle;
- Launching– Rescue vehicle is watered; and
- Rescue– Rescue vehicle is considered safe and empty.

Table 1: The phases, actions and requirements to be met by the PALAEMON system regarding passengers with mobility issues.

Phase	Passenger actions	Passenger requirements
Preparation	Getting to the cabin, collecting medications and waiting for rescue	Information about process, pre-Alarm Signal
Alarm	Need to hear and see the alarm	Identification of severe situation and signal that is heard, felt, seen (acoustic, haptic, audio)
Mustering	Passenger picked up and transferred as fast as possible towards the Muster Station	Information about current status and pick up time to ensure compliance
Boarding on the MEVs	Boarding on the rescue vehicle	Carrying into the Rescue vehicle and being seated and belted
Launching	Strapped with a belt to ensure a safe position. Mobility aids are NOT to be taken on board	Safe lowering of rescue vehicle into water. Harsh acceleration can break bones and cause bleedings. In the seat, passengers need stabilization support for spine, neck, legs
Rescue	Ensure support for mobility	At the safe zone, passengers need to be re-mobilized and re-normalized. It is advised to provide them support and psychosocial support (experience of own vulnerability)

2.5.3 Transfer of patients for passenger transfer in rescue units

At land, ambulance organisations use specialized carrying seats (Figure 1). Some of these seats are available on ships.

Figure 1(a), depicts a chair mainly used for carrying individuals and then seat them in another chair for traveling. They are highly manoeuvrable and lightweight. Furthermore, this type is very robust and easy to maintain. Especially if there are several passengers with mobility restrictions, this is a carrying chair of choice.

(a)

(b)

Figure 1: Specialised chairs utilised to transfer persons with moving issues, by land-based ambulance organisations.

In case there is a low number of passengers, it could be an advantage to provide a transferable seat that is directly used within the rescue boat. Such kind of seat (Figure 1 b) is equipped with belts, has stability for spine, neck and legs and can be locked at the bottom of a floor with the right mounting system and withstand a G-force up to 10G and is used in ambulance cars around the world. This allows easy maintenance and interoperability with land bound ambulance services.

2.5.4 Awareness of issues with disabilities

Following the results of the study presented in Appendix III, it became evident that the awareness of the effects of limited mobility in evacuation scenarios needs to be improved. Therefore, it is necessary to provide information to the crew regarding the impact of mobility limitations and how to handle passengers with these issues. Additionally, different forms of disabilities – not just physical limitations – need to be taken into account. Cognitive issues could have an impact to speed as well as on reasoned actions. Especially people with mild cognitive impairments – e.g. beginning of dementia – could react inappropriately to the emergency situation. The crew needs to be prepared for this and how to get back control over these passengers fast. For the passenger, it is very important to face a calm and focused individual to allow trust and conquer the feeling of insecurity.

2.5.5 PALAEMON academy passenger section

As there are many soft skills related to crowd control and evacuation procedures, the PALAEMON Academy (Task 3.6) will set up special topics and courses for this based on daily situations from the experience of ambulance service.

Furthermore, the PALAEMON Academy will provide a section for passengers as well, to inform them about the proper procedures during an evacuation and about first aid in general to allow a higher support capacity. In several studies of Johanniter, a higher knowledge about critical situations and what to do then is related to higher comfort in general and smoother reactions in a crisis.

3 PALAEMON System definition

The PALAEMON platform shapes an end-to-end standalone ecosystem that aims at enhancing the traditional ship evacuation management, through the introduction of novel technologies (e.g., drones, augmented reality glasses, acoustic sensors, smart cameras, etc.) and services (e.g., smart risk assessment analysis, AI-based decision support systems, real-time indoor and outdoor passenger and crew positioning, etc.). These new elements will coexist and complement shipboard legacy features/devices (e.g., fire/smoke/flooding detectors/sensors, Public Address System, Automatic Identification System), building up a fully-fledged smart evacuation platform, which leads to alleviating the potential consequences of an emergency (where the extreme case corresponds to people casualties).

One of the main (and joint) outcomes of the first round of Task 2.4 was the definition of the PALAEMON Reference Architecture, which is illustrated in Figure 2. Based on the feedback from stakeholders (Task 2.2), the preparation of use cases and scenarios (Task 2.3) and the integration of all the technical components from partners as well as the legacy systems shipboard systems (Task 2.4), all the components of the PALAEMON platform were synthesized into different levels and generated the end-to-end platform presented in Figure 2.

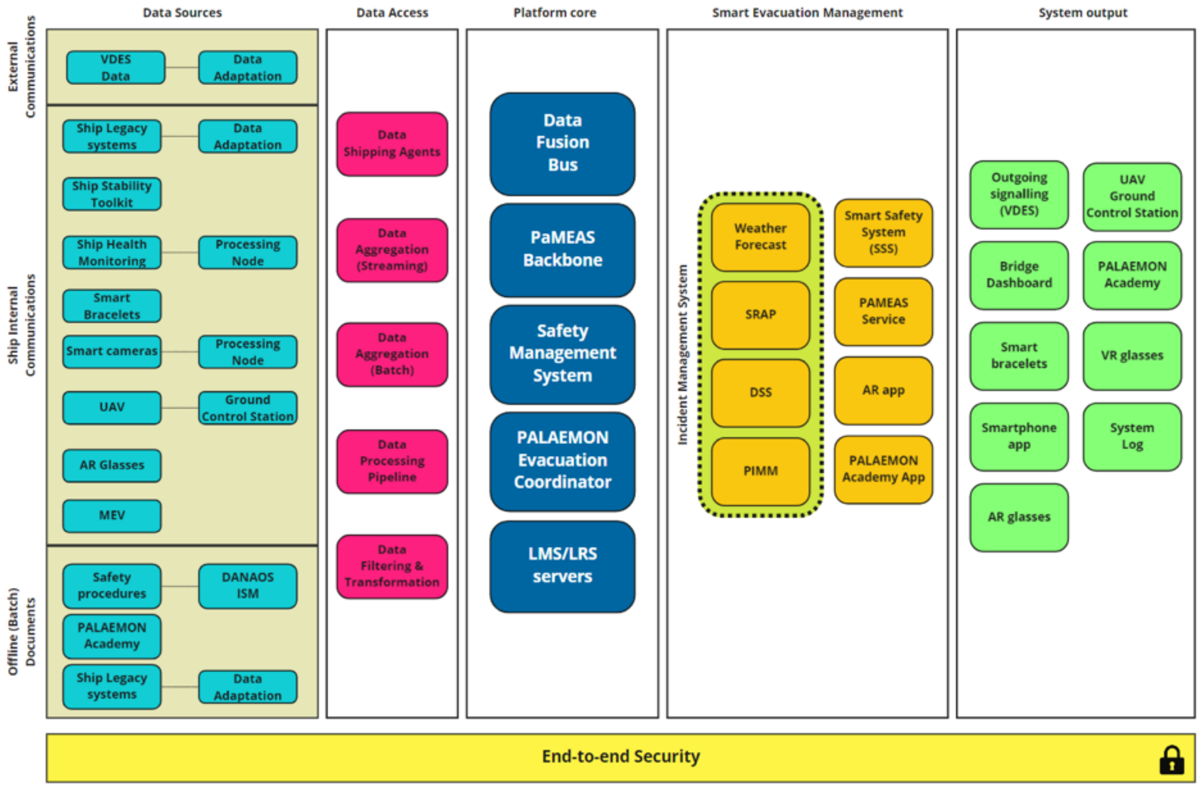


Figure 2: PALAEMON Reference Architecture.

The framework displayed from left to right in the figure above represents the information flow that spans from the moment where the data is generated (i.e., by field devices) to the point it is exploited by the different stakeholders (a monitor displaying data on the bridge or a system log, to cite a couple of illustrative examples). Amid these two sides, the layer in charge of gathering the data from the source(s) (Data Access level) is located, where the "raw" information[1] is reaped and manipulated (e.g., aggregated, synchronised, transformed, filtered, etc.) before being forwarded to the next level. At this level, which is identified as the core of the system, the data is stored in different databases (i.e., traditional non-relational for voyage data, a digitalized safety management system for evacuation procedures). Moreover, two more core components play a key role in the operation of the system. The first is the PALAEMON Evacuation Coordinator, a module in charge of monitoring the evacuation process, broadcasting any status updates to all the modules, and keeping track of components' current operation modes, whose behaviour may vary according to the ship evacuation status. The second is PaMEAS (Passengers Mustering and Evacuation Process Automation System), which includes the tools to, on the one hand, locate in real-time passengers and crew member in closed[2] and open type/weather decks[3], and on the other hand, deliver consistent real-time evacuation route indications to, both passengers and crew members. On top of the PALAEMON core, there are several high-level services that provide smart evacuation management from the information generated from sources and other core components.

To define such a complex system, as hinted at the beginning of this section, besides the internal consortium-wide interaction among the partners in PALAEMON, the participation and feedback of external stakeholders contributed to specify and fine-tune many of the aspects and features in the PALAEMON Reference Architecture, not only from a functional level but also from an operational and even regulatory standpoint.

It is worth stating at this point that the platform shown in this report (Figure 2) was taken at the time of submitting D2.6 (ATOS, 2020), where the first version of the PALAEMON Reference Architecture (v1) was defined. The revised version of the PALALEMON ecosystem will be presented in detail in D2.7.

[1] The term "raw" is used to define the information without any kind of additional processing, keeping the shape and format of the original source.

[2] Location will be calculated based on the emitted signals from users' smart bracelets and smartphones, which will be "triangulated" by a network of sensing devices (hybrid 4G/LTE-5G + WiFi radio dot deployment layout).

[3] Open type/weather decks location can be more straight forwardly achieved by using well-known Global Positioning System (GPS) solutions.

4 Validation of stakeholders needs

This section describes the information gathering process employed to validate and revise the stakeholder needs. In the first part of the section, the second WP2 PALAEMON workshop and its results are presented in detail. The second part is devoted to the description of the interviews' methodology and highlights the results.

4.1 Workshop description and results

On April 24, 2021 (M23 of the project), NTUA coordinated the second PALAEMON workshop, which was hosted online due to the COVID-19 related measures. The workshop was attended by twenty-five (25) participants (external guests and consortium members) representing the stakeholders of the PALAEMON project. Table 2 lists the stakeholder classes represented in the workshop, their respective roles and their relation to PALAEMON consortium. For the purpose of being compliant with the General Data Protection Regulation (GDPR), all attendees' identities will be handled as sensitive information and will not be explicitly exposed in the context of this document.

Table 2: Stakeholder classes and roles represented in the WP2 workshop on evacuation.

Stakeholder class	Role	Relation to PALAEMON Consortium	Organization
End-users	Master-Bridge Command Team (of Ro-Pax vessel)	Internal	ANEK, OESLM
End-users	Master (of cruise ship)	External	Celebrity Cruises
Developers-manufacturers	Naval architects, Marine Engineers, ICT Engineers	Internal	ATOS, ADS, ESI
Research Institute	ICT Engineers	External	Centre for Research & Technology Hellas
Maritime Authorities	Flag State	External	Hellenic Coast Guard
Maritime agency	European Safety Agency	External	European Maritime Safety Agency
Training Providers	Merchant Marine Academy	External	Merchant Marine Academy of Aspropyrgos

The objectives of the workshop were to:

- receive feedback on the first version of the stakeholder requirements identified to date in D2.2;
- elicit additional needs and expectations of the stakeholders regarding the PALAEMON ecosystem;
- validate the system requirements by collecting the opinions and views of the participants on the PALAEMON platform and the characteristics/functions of its components; and
- gather additional information regarding the evacuation process.

The interactive tools that were employed to extract information from the participating stakeholders were the following:

- **SLIDO:** Through the use of this Q&A and polling online platform, the attendants were asked a series of predefined questions. The questionnaire included ranking multiple-choice questions where the participants had to prioritize functions/features (already determined or under consideration) of the main PALAEMON components and a few open-ended questions, where they had to provide their viewpoint and remarks (slido, 2021).
- **Open discussions and brainstorming sessions:** These sessions aimed at determining key requirements for an evacuation system such as the one being developed in PALAEMON and determining the expected operational conditions for the PALAEMON system.

Table 3 shows the agenda of the workshop. In particular, the structure of the workshop can be separated into three main parts. The first part started with the presentation of the PALAEMON ecosystem by ATOS, which was followed by a more detailed explanation of the functionalities of the PALAEMON components combined with a series of online questions for each one prepared by NTUA. Through these questions the attendants could express their opinion and share their knowledge and experience about several PALAEMON components.

Table 3: 2nd WP2 Workshop agenda.

Wednesday, 14/04 - online		
2nd Workshop on evacuation		
Time (CET)	**Description**	**Presenter**
10:00 – 10:10	Welcome – scope of the workshop	ADS/NTUA
10:10 – 10:30	Presentation of the PALAEMON ecosystem	ATOS
10:30 – 11:10	Discussion on the PALAEMON ecosystem (Part A)	NTUA
11:10 – 11:25	**Break**	
11:25 – 11:40	Presenting MEV-I and MEV-II	ESI
11:40 – 12:00	Discussion on the PALAEMON ecosystem including MEV-I and MEV-II (Part B)	NTUA
12:00 – 12:20	ISOLA project presentation	CERTH
12:20 – 12:45	Brainstorming session PALAEMON – ISOLA	NTUA
Closing remarks – Workshop Assessment form		
End of meeting (13.00)		

The second part of the workshop comprised the presentation of MEV-I and MEV-II by ESI, followed by a corresponding online questioning session prepared by ESI and NTUA. Again, the participants were asked to share their viewpoint on specific features/functions of the MEVs.

Finally, the third part of the workshop included the presentation of the ISOLA project by CERTH, the Technical Manager of the project. ISOLA[4] is an EU funded project targeting the enhancement of the internal and external security of cruise and passenger ships. The presentation was followed by a brief brainstorming session, which was focused on the relationship of the ISOLA project with PALAEMON and the importance of the interaction and interconnection between safety and security systems.

[4] https://isola-project.eu

It should be noted that during the workshop there were opportunities for open discussion sessions between the participants, which were encouraged and coordinated by NTUA.

At the closing of the workshop, the participants were asked to fill in an assessment form that was used to evaluate the effectiveness of the workshop. Table 4 summarizes the average scores for participant satisfaction on specific aspects of the workshop, graded on a scale of Very Dissatisfied (1) to Very Satisfied (5).

Table 4: Results of the workshop assessment questionnaire.

ID	Description	Score
1.	Overall Satisfaction	4.5
2.	Workshop content	4.8
3.	Possibilities for interaction, exchanging ideas	4.5
4.	Time schedule	4.0

Based on the feedback, the most positive aspects of the workshop were the following:

- The stakeholders could provide their feedback effectively through the SLIDO application, despite the difficulties of the remote interaction.
- The sharing of opinions and experiences was made easy, due to the particular workshop environment, despite the inability to perform a face-to-face meeting.

4.1.1 Workshop results

This section describes concisely the results of the workshop, i.e. all the information extracted from the participants through the questionnaires and the discussion sessions. The questions were separated into five categories, each representing a PALAEMON component, as presented below.

The questionnaires had been arranged so that a unique ranking of the choices shall be made, without allowing the consideration of two or more choices as of equal importance.

A more detailed version of the results of the SLIDO sessions is provided in the Appendix. The maximum score for each option is the number of answers that the workshop attendants had to rank in that specific question. The answers appear according to the results obtained in a descending order of preference.

Smart Bracelets

The first set of questions posed in SLIDO concerned the Smart Bracelets (SBs). Initially, the participants were asked to rank the importance of specific features under consideration for the Bracelets apart from their function to enable localization of passengers and crew members. These features were the following, appearing with a descending ranking order:

- User-triggered alarm by pressing an emergency button;
- Notifying/Alerting automatically in case of fall detection (including Man Over Board incident); and

- Providing information regarding user health status.

Most of the participants highlighted that the SBs must provide a function (button) to enable the user to trigger an alarm in case of an emergency. They also ranked highly the feature of providing an automatic alert in case of fall detection (e.g. in the case of a Man Over Board incident where a passenger falls to the sea). The function of providing information regarding the user health status was ranked last in terms of priority by the participants.

In the next question, the participants were asked to rank the most suitable way to provide evacuation-related information via the Smart Bracelets. They had to prioritize the following three options:

- Signs;
- Audio messages; and
- Text.

The majority of the participants ranked as a priority the display of evacuation related information by the Bracelets with the form of signs. Therefore, the adoption of the signs display feature must be strongly considered. The audio messages as a form of providing evacuation information were ranked second, while the text messages were ranked last.

A key issue for the adoption of Smart Bracelets is their acceptability by the passengers and crew members. Ideally, and in order to fully exploit the capabilities of PALAEMON ecosystem, every person on board the cruise/passenger ship should always wear the bracelet. Therefore, the conditions for this must be identified, and then applied and maintained. In this context, the participants were given a list of main issues regarding the acceptability of the Bracelets and were asked to rank them. These issues were:

- Privacy issues (GDPR);
- Combination with other features (e.g. cruise id, cabin key, billing, etc.).
- Comfort; and
- Aesthetic.

In their responses, participants emphasized that the privacy of the users and the application of the General Data Protection Regulation (GDPR) must be the top priority regarding the acceptability of the Smart Bracelets. It was also pointed out as of great importance to combine the functions of the bracelets related to safety/evacuation with other functions, such as their use as cruise identification cards and cabin keys, or for billing. The comfort of wearing the bracelets was ranked third in terms of priority by the participants. It is noted that the attractiveness in appearance (aesthetic) of the bracelets was ranked fourth.

AR Glasses

The next set of questions referred to the Augmented Reality (AR) Glasses. Firstly, the participants were asked to express their preference on the way the AR Glasses will enable communication between the crew members. They were provided with four options:

- Audio;
- Video;
- Audio which is converted to text; and
  Text;

The audio communication was ranked as the most preferable of the choices, followed by the video call option. The option of audio messages which are converted to text was ranked third. The least preferable choice of the participants was the option of text messages. Apparently, it is believed that the communication by exchanging text messages would require extra effort from the crew members wearing the AR Glasses.

One of the most important issues regarding the AR Glasses is the information that they will display. Thus, the participants were given seven types of information to rank:

- Ship area status (fire, flooding, smoke, etc.).
- Passengers condition, localization and concentration;
- Information about the current evacuation plan;
- Crew members localization;
- Procedures;
- Instructions for equipment use; and
- Vessels blueprints;

Participants made their preference clear by ranking the ship area status and the passengers' condition, localization and concentration as the most important features to be displayed. These two options were followed by the information about the current evacuation plan, the localization of the crew members and the procedures to be followed by them. The least preferable options were the instructions for the use of equipment and the vessel blueprints, possibly because it is believed that the crew members must be already aware of this kind of information.

Additionally, the participants were asked to express their opinion regarding the information the AR Glasses could display without providing predefined choices for them, to make sure that their point of view is also recorded. The following answers were provided (in random order):

- Master's instructions and messages;
- Vital information for passengers on sight;
- The restricted areas for passengers' evacuation according to the master's decision;
- Blocked routes, and information for the muster station where the passengers must be guided to;
- Hot surfaces, and live photos of ship areas;
- Area temperature, and nearest firefighting equipment location;
- The information displayed to be adapted to the actual role of the crew members. For instance, the firefighting team could be provided with information regarding the fire location, the fire extinguishers' position, etc.; and
- The severity of the incident.

UAV

Concerning the Unmanned Aerial Vehicles (UAVs), the participants were asked to rank five specific functions as shown below:

- Assistance on Man Over Board situations;
- Providing images/video for damage detection/assessment;
- Searching for persons at sea following the abandonment.
- Providing the condition (through images/video) of MEVs during abandonment; and

- Providing the condition (through images/video) of MEVs during mustering.

The most important function by far, based on the ranking results, is the assistance on Man Over Board incidents. Two additional functions that the participants evaluated as crucial are the damage detection assessment and the search of persons at the sea after the abandonment. The last two functions in the ranking were the provision of the MEVs condition (through images/video) during the abandonment and the mustering.

Following the first question, the participants of the workshop were asked an open-ended question to offer their suggestions on the potential functions of the UAV. They recommended the following uses (the recommendations are presented in random order):

- Sightseeing – transmitting images/video back to the ship for entertainment purposes of the passengers e.g. to be displayed on screens in public areas;
- Monitoring all kind of incidents such as pollution accidents;
- Having night vision, taking temperature readings, being fireproof, locating people in the ship's blueprints, indicating the closest distance to muster stations;
- Monitoring the progress of the accident; and
- Use for computer-vision predictive maintenance/fault detection.

PIMM

Regarding the PALAEMON Incident Management Module (PIMM), participants were requested to rank the critical information that should be displayed. Six categories of information were provided, as shown below:

- Vessel's status;
- Status of the evacuation per route per deck;
- Status of the damage control actions;
- Status of Muster Stations;
- Crew location; and
- Status of MEVs.

The most valuable information to be displayed by PIMM according to the stakeholders is the vessel status. In addition, information of interest is the status of the evacuation per route per deck, the status of the damage control actions and the status of the muster stations. The crew location was ranked fifth, which means that this piece of information is not regarded as a priority by the participants. Finally, the status of the MEVs was ranked last by gathering the least points of preference.

In the second question, the participants were asked to rank the most critical information/data considered by the Master during the decision process of sounding the General Alarm. The choices were the following:

- Damage assessment;
- Passenger's exposure to the incident;
- Ship condition (stability, strength);
- Condition of the critical systems (propulsion, steering, fire main system, damage control systems, etc.);
- Level of containment/control of the incident; and
- Time of day that the incident occurs.

The most crucial information according to the answers given is the damage assessment. The next important pieces of information, with a slight difference in their ranking score, are the passenger's exposure to the incident, the information regarding the ship's condition, and the condition of the critical systems. The second to last preference was the level of containment/control of the incident, and the last one in terms of priority was the time that the incident occurs.

The third question on PIMM also concerned the information taken into account by the Master in his/her decision-making process during an emergency. The participants were asked to rank seven categories of critical information/data that could be considered by the Master when deciding on the ship abandonment. These were:

- Criticality of the ship condition;
- Percentage of passengers having arrived in Muster Stations;
- Weather conditions;
- MEVs' condition;
- Presence of vessels nearby;
- Distance to the nearest port; and
- Time passed since the sound of General Alarm.

The criticality of the ship condition was ranked as the top priority by the majority of the participants. The percentage of passengers that have arrived in the Muster stations, the weather, and the MEVs' condition were sorted in this order as information of similar importance. The next two options in the ranking order were the distance of the ship from nearby vessels and the nearest port. The participants ranked the time passed since the sound of the General Alarm as information of minor importance for the Master.

The next ranking question regarding PIMM was about the information/data considered by the Master to monitor the progress of the mustering process. The participants were asked to prioritize the following information:

- Percentage of passengers arriving in Muster Stations;
- Blocked evacuation routes;
- Number of trapped passengers;
- Condition of Muster Stations (open/blocked);
- Presence of crew members to guide/assist passengers; and
- Congested evacuation routes.

The percentage of passengers that have arrived in the Muster Stations and the blocked evacuation routes are considered as the top priority. The participants ranked as third and fourth most important information the number of trapped passengers and the condition of the muster stations, followed by the presence of the crew members to guide/assist the passengers. The least important information according to the ranking is the congested evacuation routes.

Besides all the above-mentioned information that the Master has to take into account during the decision-making process of sounding the General Alarm, ordering ship abandonment and monitoring the mustering process, he/she also has to receive supporting information in order to have an as high as possible situational awareness during the emergency. In this respect, the participants were asked to rank eight types of information:

- Ship survivability status;
- How the incident is evolving;
- Information about lost/trapped passengers;
- Evacuation routes to be selected;
- Mustering status;
- Health status of passengers;
- Availability of crew response teams; and
- Congested areas.

The information ranked as the most useful is the ship survivability status, followed by the way the incident evolves with a high score as well. The information regarding lost/trapped passengers was ranked third and the evacuation routes to be selected was ranked fourth. The mustering status, the health status of the passengers and the availability of the crew response teams were ranked as information of similar importance for the Master and were placed second to last. The congested areas were ranked last in the priority list.

MEVs

The first question regarding the Mass Evacuation Vessels (MEVs) concerns the priority ranking of four options for their autonomy level of navigation. The participants were provided with the following choices:

- Manual navigation;
- Remote control navigation from control station ashore;
- Remote control navigation from other MEVs; and
- Fully autonomous navigation with the crew members inspection.

They ranked the manual navigation and the fully autonomous navigation with crew members inspection as a priority for the MEV, followed by the remote-control navigation from other MEVs. The remote-control navigation from a control station shore was ranked as the least preferable option.

The workshop participants were also asked to rank six functions that could be possibly added to the MEV. The additional functions were:

- Verification of passengers onboard;
- Sensors for transmitting the MEV status/condition prior to the embarkation process;
- Sensors for transmitting the MEV status/condition during the embarkation process;
- Sensors for transmitting the MEV status/condition following the ship abandonment;
- UAV control station carrier; and
- UAV carrier.

Based on the ranking results, the verification of onboard passengers is the function of top priority. Furthermore, the option that MEVs should have different kind of sensors for transmitting their status prior to and during the embarkation process, and sensors for transmitting their status after the abandonment was considered significant. The participants seem to believe that it is not a priority for a MEV to be equipped with a UAV control station or carry a UAV, so they ranked these functions as last.

4.2 Interviews

Within the scope of Task 2.2, NTUA continued conducting interviews with selected stakeholders that aimed at eliciting needs and expectations regarding the ship evacuation process and the PALAEMON ecosystem. Each interview followed a semi-structured format, with predetermined questions used as a starting point for the discussion. The questions of each interview were adapted to the expertise of each interviewee. The information collected during the interviews was analysed in order to adapt/revise accordingly the Functional Requirements that were presented in Deliverable 2.2 and also improve the functions of the PALAEMON components.

Table 5 lists the interviews that were conducted and considered for the results provided in this report.

Table 5: Information about the WP2 stakeholder interviews.

Date	Role	Name	Place
March 3, 2021	Superintendent (ex-seafarer on RO-PAX)	Evangelos Mamios	Online
April 14, 2021	Cruise ship passenger	*	Online
April 22, 2021	ANEK Chief Officer	Ioannis Tsikalakis	Online
April 27, 2021	Cruise ship passenger	*	Online
May 8, 2021	Master at Celebrity Solstice	Alexandros Papadopoulos	Online
May 11, 2021	Naval Architect	*	Online
May 17, 2021	Associate Professor at Merchant Marine Academy of Aspropyrgos	Nikolaos Fragkiadakis	Online
May 19, 2021	Damage Control Expert	*	Online
June 04, 2021	Hellenic Coast Guard	*	Online

*The interviewee preferred not to have his/her name shown.

The selection of individuals for the interviews was made with the criterion to cover the subject as comprehensively as possible and to record the views of various experts as well as relevant stakeholders in the field. It was also made with the intention to approach evacuation from different perspectives, such as the standpoint of a passenger, to fully understand the process.

All the interviewees kindly shared their knowledge and expertise, provided essential information, and made valuable comments and proposals, which substantially helped to revise the stakeholder requirements and review the respective functions of the PALAEMON components.

4.2.1 Key points of interviews

In this section, the key points and suggestions of the interviewees regarding several PALAEMON components are provided. This information, in conjunction with the workshop results, will be used for the review of the system requirements.

Smart Bracelets

- The use of Smart Bracelets is generally regarded as a good idea that can improve significantly the evacuation process. Some of the interviewees pointed out that their adoption could be easier on cruise ships, where the passengers remain onboard for a few days. On the other hand, they noticed that their use on Ro-PAX ships engaged on short voyages while visiting multiple ports could be challenging due to the need for frequent embarkations-disembarkations of passengers.

- The use of SBs can also be proven helpful in man overboard situations, especially in combination with the UAV.
- The SBs can replace the personal cards used in cruise ships (for identification, billing, access, etc). Privacy issues are a major concern, but a generally accepted policy on the use of SBs can be established.
- An advertising campaign should be launched to familiarize the public with the bracelets and their beneficial functions.
- The aesthetic issues are of minor concern.
- The use of signs to guide the passengers and crew members requires attention because they should be as clear and simple as possible. Generally, it is not considered a good solution to use text messages on such a small device.
- Some interviewees suggested that the health monitoring function of the smart bracelets under normal circumstances is not as important, since there are so many crew members onboard that it is almost impossible to have a health issue without anyone noticing it. On the other hand, it was emphasized that the prime concern of the Master during an emergency is that all the passengers and crew members remain in good health. For example, receiving information that there is no loss of life, will reduce the induced stress during his decision making. Thus, the knowledge of their health status is a vital piece of information for the Master.
- Special consideration should be given to those technical aspects related to managing data generated from SBs and prevent the overloading of the PALAEMON ecosystem.
- Besides the evacuation related features, two very important characteristics of the SBs are their availability and reliability.

AR Glasses

- The crew members should go through special training for their use.
- The instructions given through the AR glasses should be displayed in a simple as possible manner.
- The AR Glasses should display the least information possible. By this statement, it is understood that only the relevant and most important data for the assigned task should be displayed on them to prevent the information overloading the user.
- The AR Glasses should only be worn by specific crew members. For example, they could be used by the crew members performing search and rescue tasks. However, they are not suitable for the fire-fighting teams because their members have to wear the appropriate protective equipment including breathing apparatuses. A special face mask for the breathing apparatuses with embedded/integrated AR glasses could be considered/developed in the future to enable the members of the fire-fighting squads to benefit from the AR functions.
- The cost of the AR glasses is a critical factor for their adoption.
- It was pointed out that two equally important pieces of information to the area temperature, are the oxygen level and the detection of hazardous gases in different places. These data could also be provided by the AR Glasses (if the relevant information is available).
- The batteries' specification is a factor of major importance.

- The AR Glasses should be tested and function as good as possible in poor visibility scenarios (smoke and low light conditions).
- The AR Glasses should allow the user to wear simultaneously a breathing apparatus.

SMART CAMERAS

- A modern large cruise ship is equipped with a few thousand cameras. Thus, their integration with the PALAEMON platform should be carefully developed to enable their effective and efficient exploitation and to avoid overloading the system.

UAV

- Overall, the UAV is considered by the interviewees as a very useful tool for man overboard situations.
- The UAV should fly at a relatively high speed to reduce the time needed to reach and scan the area of interest.
- The UAV should be operated by the bridge and/or by the safety center (if there is one onboard)[5].

PIMM

- Regarding the PIMM, it would be really helpful if all the important information for the Master was gathered and displayed on a big touch screen, giving him/her the ability to select different places of the ship and obtain critical information for them quickly.
- The Master needs information about the location of the incident pointed out in a general arrangement plan, its extent and its criticality. If the incident is a fire, he/she needs information about the closed fire doors and whether the fire can be isolated.
- The PIMM could display the passengers and crew members location.
- The temperature, oxygen level as well as detection of hazardous gases in the ship areas were identified as important. The bridge team should be aware of these to inform the appropriate crew members. This information could also be displayed on the AR Glasses as stated before.
- The PIMM display could be installed in the safety center if available.

MEVs

- It is preferable for the mustering station and the embarkation station to be in the same area/deck.
- A large capacity MEV would prevent the separation of families. The use of larger capacity MEVs facilitates search and rescue operations. In particular, larger MEVs means that after evacuation the responding authorities will have to search for and rescue fewer lifeboats.
- The management of persons inside a very large capacity MEV after evacuation could be a difficult and challenging task.

[5] According to SOLAS (Chapter II-2, Part G, Regulation 23) passenger ships constructed on or after 1 July 2010 shall have on board a safety center, which shall either be part of the bridge or be located in a sperate space adjacent to and having direct access to the bridge.

- The manning (number and qualifications of crew members) of a large capacity MEV should one of the parameters under consideration.
- The stability of a very large capacity MEV should be studied extensively, under various loading conditions. Special consideration should be given to the impact of various consumables on board (e.g. water rations, food rations, fuel, etc.) to the stability.
- The launching system and equipment for a large capacity MEV should be adequately strengthened to sustain the increased structural loads.
- The cost of a large MEV is considered a critical parameter.
- The use of large capacity MEVs in certain types of cruise and passenger ships, especially of smaller size, should be thoroughly studied for their cost effectiveness. The age of the ship could be a criterion to consider.

PALAEMON Training Academy

- Although Virtual Reality (VR) training is a new training and skill development tool, if VR training is introduced into the regulatory framework for maritime training, then the relevant stakeholders (e.g. authorities, training academies and institutions, shipping companies, etc.) will comply with the respective requirements and adopt the VR technology.
- An institutional framework for training systems based on Virtual Reality is missing.
- The PALAEMON Training Academy is a feasible idea. The most difficult obstacle to overcome in the establishment of the PALEMON Training Academy is the development and introduction of regulations for the use of VR technology, as well as the integration of these regulations with the existing regulatory framework regarding crew training, certification and qualification.
- Although the VR training is very efficient, the attendance of VR training sessions is not enough to prepare the crew members for emergencies. Additional training via evacuation drills and exercises is required.

5 Regulatory constraints

This section presents the IMO Safe Return to Port (SRtP) (IMO, 2006) regulation that may generate additional requirements for the PALAEMON ecosystem.

Since the beginning of 2000s, the increasing size of passenger ships and the subsequent growing number of passengers started to raise concerns about the effect on the safety risks related to this type of ships and the difficulties faced during an emergency situation with so many people on board (of completing a successful ship abandonment procedure). Consequently, IMO launched a comprehensive proactive review of passenger ship safety covering the issue "Large Passenger Ship Safety", and set the scene for the future large passenger ships, which should be designed for improved survivability, based on the long-established principle that a ship is its own lifeboat. Since then, several severe fire incidents at cruise ships have taken place, resulting in abandonment, sinking or loss of propulsion power and steering (Babicz, 2015).

"Safe Return to Port" means new set of SOLAS regulations applicable to new passenger ships having their keel laid on or after 1st July 2010, and having a length of 120m or more, or having 3 or more Main Vertical Zones (IMO, 2006). The SRtP regulation aims at the increase of vessel's robustness and ability, in order to be able to safely return to port unsupported after an incident. SOLAS Chapter II-2/Reg21 defines a casualty threshold and, provided that the fire is limited within that threshold, the vessel shall be able to return to port by its own power and also provide a safe area for all passengers offering a certain level of habitability, comfort and catering.

This casualty threshold, in the context of fire, includes:

- Loss of space of origin up to the nearest "A" class boundaries, which may be a part of the space of origin, if the space of origin is protected by a fixed fire extinguishing system; or
- Loss of the space of origin and adjacent spaces up to the nearest "A" class boundaries, which are not part of the space of origin.

The regulations are built at a functional level, generally prescribing that the different ship systems shall remain operational after a casualty. The level of performance of each system is not defined by the regulations and it is decided at a project basis.

The overall functional requirements are intended to provide the following capabilities after an incident of fire and/or flooding for the duration of the return to port voyage (DNV GL, 2016).

- Ensure propulsion, steering, manoeuvring and navigational capabilities;
- Ensure necessary service of the safety systems (fire safety and watertight integrity) in the remaining part of the ship that is not directly affected by the casualty; and
- Support safe areas for passenger and crew.

If the casualty extends beyond the defined threshold and the ship must be abandoned, the regulations (IMO MSC 216(82)) require a limited number of systems to remain available for 3 hours to facilitate an orderly abandonment.

In the context of flooding, a corresponding threshold is not prescribed, as the stability criteria for safe sailing after damage are not defined. In case of flooding, redundancy is greatly improved for passenger vessels regarding safety and habitability. For example, power supply shall be sustained even if the space of generators is flooded, in order to support life on-board for passengers and crew members (i.e. sanitation, food, water, ventilation, air-conditioning etc.).

Having listed the basic information of SRtP design principles, its interaction with PALAEMON systems will be assessed. Two are the main parts of PALAEMON involved in this interaction, the ICT part supporting the evacuation decision and process and the innovative Mass Evacuation Vessel (MEV) design.

Regarding the ICT part which supports the evacuation procedures and the decision-making process leading to it, SRtP sets requirements for the operability of systems either the casualty threshold is surpassed or not. In case evacuation has been ordered, the ICT part shall be aware of the status of these systems as they can affect the effectiveness of the evacuation procedure and the safety of passengers. SRtP acts as a measure that heightens the level of safety for the people on-board.

The MEVs will be the main means of evacuation once initiated, therefore the SRtP will not affect its design. If evacuation and abandonment are decided, then it will be carried out with the means of MEVs.

SRtP includes measures to improve the safety, habitability and comfort of the vessels in case of casualty. For the case of fire damage, these should be maintained during the whole duration of the voyage if the damage is below a certain threshold, and at least for 3 hours until safe evacuation if the damage exceeds this threshold. For flooding casualty, returning to port is not an option, as currently no stability criteria or requirements have been defined for sailing after the casualty.

6 Gap analysis

This section consists of a review/gap analysis to present how the information and views gathered from the workshop and the interviews have an impact on the first version of the system requirements of each PALAEMON component (from D2.6). The way the system requirements are affected varies. The gathered information made clear that most system requirements are well specified and meet the stakeholder needs and expectations. In some cases, the collected information revealed areas for amendment/improvement or the need for additional system requirements to be established.

The following tables (Table 6 - Table 14) present the system requirements that are affected from the information gathered through the 2nd WP2 workshop and the interviews. The system requirements are provided from D2.6 (ATOS, 2020).

Bracelets

Table 6: D2.6 system requirements of the smart bracelets affected by the gathered infromation.

Unique ID	Requirement	Description	Rationale	Priority
SB-011	Functional	SB will notify events (automated fall-detection)	Alarm	MUST

The interviewees and workshop participants ranked highly the SBs' function to provide an automated alert in case of a MOB incident and corroborated the system requirement SB-011 (Table 6).

Table 7: D2.6 system requirements of the smart bracelets affected by the gathered infromation.

Unique ID	Requirement	Description	Rationale	Priority
SB-018	Non-functional	Alarm button	User enabled alarm	SHOULD

Most workshop participants agreed that is important for the SBs to provide a function (button) to enable the user to trigger an alarm to get help in case of an emergency. Thus, the priority of requirement SB-018 should change to MUST. During an emergency, a lot of passengers would possibly be panicked. As a result, many of them would simultaneously press the help/assistance button, creating overloading to the response process and making the situation even harder to be handled by the crew members. Hence, it should be considered that this button to be disabled when the General Alarm is activated (Table 7).

AR Glasses

Table 8: D2.6 system requirements of the AR glasses affected by the gathered infromation.

Unique ID	Requirement	Description	Rationale	Priority
AR-001	Functional	The AR application will have an intuitive user interface that can be easily learned.	The rationale for this requirement is that the application will be used by any crew member with varying capabilities	SHOULD

Unique ID	Requirement	Description	Rationale	Priority
AR-002	Functional	The AR application will have a training tutorial embedded that will clearly explain each section of the interface and its functions.	The rationale for this requirement is that the application will be used by any crew member	SHOULD

Based on the information collected from the workshop and the interviews, the familiarization and training of the personnel wearing the AR Glasses on their use is a point of major importanceTable 8. Thus, requirements AR-001 and AR-002 are very important. They should become an absolute requirement and their priority should change from SHOULD to MUST (Table 8).

Table 9: D2.6 system requirements of the AR glasses affected by the gathered infromation.

Unique ID	Requirement	Description	Rationale	Priority
AR-016	Functional	Loading augmented reality temperature widget (that will appear on the user interface)	Building a rich user interface that will provide all the information needed for the user, at any given time	MUST

During the information retrieval procedure through the interviews, it was found out that the oxygen level of different spaces of the ship and the detection of hazardous gasses are considered as factors of major importance. So, an oxygen level and hazardous gases detection widget could be developed along with the temperature widget. Evidently, the particular widget will display the relevant data if the area of interest is equipped with the appropriate sensors to collect them (Table 9).

Table 10: D2.6 system requirements of the AR glasses affected by the gathered infromation.

Unique ID	Requirement	Description	Rationale	Priority
AR-017	Functional	Loading augmented reality alert messages widget (that will appear on the user interface)	Building a rich user interface that will provide all the information needed for the user, at any given time	MUST
AR-019	Functional	Loading augmented reality Ship parameters widget (that will appear on the user interface)	Building a rich user interface that will provide all the information needed for the user, at any given time	MUST

Unique ID	Requirement	Description	Rationale	Priority
AR-021	Functional	AR Technology provides a “first-person” perspective and enables users to explore the physical environment with simultaneously over imposed digital content;	AR Glasses application assists and provide crewmembers with essential digital information regarding evacuation procedures throughout a realistic environment;	MUST
AR-022	Functional	Each participant will be able to see on its user interface all the messages received from the connected system components;	This functionality will be used for ensuring good tasks execution within the evacuation plan;	MUST
AR-023	Functional	The main goal of the AR application is to provide a visual guidance and instructions to the crewmembers to follow the evacuation plan	The vital information that will help the intervention team will include evacuation tactics guidelines, environment details but also passenger’s condition	MUST
AR-028	Functional	The application will provide real-time information about the position of each crew member on the vessel's map	This functionality can be used for a better team management and staff deployment to certain areas on the vessel. For example, the Captain can choose to send, recall or relocate staff based on their real-time location.	MUST
AR-029	Functional	The application will be able to provide real-time information regarding passenger’s concentration on the vessel's map;	This functionality will help to successfully assess location, volume and direction of groups or individuals, enabling for agile evacuation procedures	MUST

The system requirements mentioned in the table above were directly or indirectly validated by the responses of the workshop participants and the interviewees (Table 10).

Table 11: D2.6 System requirements of the AR glasses affected by the gathered infromation.

Unique ID	Requirement	Description	Rationale	Priority
AR-027	Functional	Each crew member will be able to visualize system information of the current evacuation plan, crewmembers or passenger’s condition but also guidance messages from Decision Support System.	This feature will enable crewmembers to better coordinate and synchronize actions and decisions.	MUST

The AR Glasses will be worn only by specific crew teams (for example from the guest relation/hotel department) and individual crew members, that will be directly engaged with the evacuation process. The functions of the AR glasses would be extremely useful for the damage control teams (e.g. fire-fighting squads), but the glasses cannot be worn along with their personal protective equipment during an actual incident. This is a conflict to be recorded in the system requirements for the AR glasses (Table 11).

Table 12: D2.6 system requirements of the AR glasses affected by the gathered infromation.

Unique ID	Requirement	Description	Rationale	Priority
AR-018	Functional	Loading augmented reality Audio Call widget (that will appear on the user interface)	Building a rich user interface that will provide all the information needed for the user, at any given time	MUST
AR-024	Functional	The application will be able to provide real-time text communication between the crewmembers	In order to better support and organise the evacuation procedures the crewmembers will be able to communicate with each other in real-time, therefore enhancing the coordination factor.	MUST
AR-025	Functional	The application will be able to provide real-time audio communication between the crewmembers	In order to better support and organise the evacuation procedures the crewmembers will be able to communicate with each other in real-time, therefore enhancing the coordination factor.	MUST

The workshop answers made clear that the best form of communication between crew members wearing the AR Glasses and the bridge team is audio communication. Text messages should be optional. So, system requirements AR-018 and AR-025 could remain as already stated, but system requirement AR-024 should change priority from MUST to COULD. Text messages would probably be useful in an emergency as a backup method of communication (for redundancy) (Table 12).

UAV

The information gathered from the workshop and the interviews show that the expectations of the stakeholders are met by the existing system requirements of the UAV.

Nevertheless, a system requirement regarding the function of the UAV for sightseeing purposes (i.e. transmitting images and video from scenic sites back to the ship for the entertainment of the passengers) should be considered. Moreover, the function of monitoring pollution incidents was proposed.

PIMM

Table 13: D2.6 system requirements of the PIMM affected by the gathered infromation.

Unique ID	Requirement	Description	Rationale	Priority
PALAEMON-platform-006	Non-functional	Dedicated displays/monitors to show Graphical User Interfaces (GUIs) in the bridge	Apart from the legacy displays/monitors that can be seen in a real scenario (e.g. AIS, etc.), some of the PALAEMON components do require to (graphically) present their outputs in the bridge in order to support the master's decision, centralize crew's activities, etc.	MUST
PALAEMON-platform-008	Functional	System redundancy	To prevent potential system outages, PALAEMON system should be replicated / have a redundant deployment that comes to the foreground in case of sudden system halt.	MUST

The interviewees validated the requirement PALAEMON-platform-006 (Table 13). They agreed that the different outputs of the PALAEMON components must be integrated and displayed properly on dedicated displays in the bridge and/or in the safety center (if available).

The requirement PALAEMON-platform-008 was also confirmed during the workshop and the interviews (Table 13). It was pointed out that the redundancy of the PALAEMON platform is of great importance to enable the operation of the system under adverse conditions e.g. a component failure or during the loss of normal power supply.

Table 14: D2.6 system requirements of the PIMM affected by the gathered infromation.

Unique ID	Requirement	Description	Rationale	Priority
PALAEMON-platform-012	Non-functional	GDPR-compliance system	All the personal/sensitive information introduced in the PALAEMON platform must respect and be 100% with GDPR regulation	MUST
PALAEMON-platform-013	Non-functional	GDPR disclosure upon emergency status hoist	Once the evacuation alarm has been triggered, and according to GDPR's Recital 46, "Some types of processing may serve both important grounds of public interest and the vital interests of the data subject as for instance when processing is necessary for humanitarian purposes". In other words, as of this moment, GDPR restrictions are disclosed and the use of sensitive data is permitted	MUST

System requirements PALAEMON-platform-012 and 013 were positively validated during the workshop (Table 14). The participants highlighted that GDPR compliance must be a top priority.

MEVs

It is recommended to consider establishing system requirements for the following stakeholders' expectations:

- The MEVs should be appropriately manned (referring to the number and qualifications of their crew).
- The (crowd) management of persons embarked in the MEVs after evacuation should be taken into account.
- Regarding the MEV's stability, special consideration should be given to the effect of various consumables on board (e.g. water rations, food rations, fuel, etc.).
- The launching system and equipment for the MEV should be able to sustain the increased structural loads due to its size.

The integration of the MEVs into the PALAEMON architecture should also be examined. Indicatively, the MEVs could be connected with the PALAEMON platform to provide through suitable sensors real-time data regarding the number and identification of embarked passengers and crew members, as well as the condition/functional status of the MEVs before and during embarkation.

The system requirements of which the description, rationale or priority level changed due to the gathered information, are also summarised in Appendix I.

7 Conclusions

This report presents the results of the requirements validation and elicitation process that was performed for the second iteration of Task 2.2, that is part of the PALAEMON requirements development methodology in the context of WP2. The objectives of this iteration were multiple. Firstly, it was intended to receive feedback regarding the functional requirements identified in the first step of the stakeholder requirements elicitation process that was conducted for Task 2.2 and was reported with D2.2. In parallel, the aim was to elicit additional needs and expectations of the stakeholders regarding the PALAEMON components. Another key objective was to validate the system requirements specified by D2.6 for the PALAEMON ecosystem and its components.

The requirements capture/validation framework utilized was based on the application of two interactive techniques: a workshop and several interviews. The approach was able to connect the actual internal and external stakeholders of the PALAEMON ecosystem with the PALAEMON system requirements and the relevant work performed so far in the project. Moreover, a study was conducted to evaluate the potential effect of passengers with disabilities to the evacuation process.

The collected information was analysed and used as a basis for the review process of the stakeholder and system requirements. Overall, the result of this process was the full validation of most of the defined requirements and the positive verification of the main functionalities of the PALAEMON platform. Nevertheless, a few items for reconsideration were recorded and they are presented in this deliverable. These recommendations comprise the development of additional system requirements, the amendment of existing requirements as well as areas for future consideration/research.

For the purpose of this deliverable, the IMO SRtP regulations were also studied for potential impact on the PALAEMON ecosystem. The analysis showed that the SRtP framework and the relevant measures (constraints) introduced to improve the safety, habitability and comfort of the passenger ships in case of casualty, does not affect, at least noticeably, the ICT part and the MEVs, which are the two main pillars of PALAEMON.

Finally, the workshop and the interviews with the stakeholders and users of the PALAEMON platform were also a great opportunity to interact with industry professionals, collect valuable information, and enhance knowledge on the subject. Moreover, they improved the understanding of the similarities and variations between the different types of cruise and passenger ships regarding the evacuation process.

8 References

ATOS, 2020. *D2.6 PALAEMON Architecture,* Satander: ATOS.

Babicz, J., 2015. *WÄRTSILÄ ENCYCLOPEDIA OF SHIP TECHNOLOGY.* Second ed. Gda: WÄRTSILÄ.

DNV GL, 2016. *Class Guidline, Guidance for safe return to port projects,* Bærum: DNV GL.

Fernandes, J. M. & Machado, R. J., 2016. *Requirements in Engineering Projects.* 1st ed. Cham, Switzerland: Springer.

IMO, 2006. *Resolution MSC.216(82), Adoption of Amendments to the International Convention for the Safety of Life At Sea, 1974.* London: IMO.

ISO/IEC/IEEE, 2015. *nternational Standard - Systems and software engineering -- System life cycle processes.* 15288-2015 ed. Geneva: ISO/IEC/IEEE.

ISO/IEC/IEEE, 2018. *International Standard - Systems and software engineering - Life cycle processes -- Requirements engineering.* 29148:2018 ed. Geneva: ISO/IEC/IEEE.

Laplante, P. A., 2017. *Requirements Engineering for Software and Systems.* 3rd ed. Boca Raton: CRC Press Taylor & Francis Group.

Mayring, P., 2002. *Einführung in die qualitative Sozialforschung.* Weinheim: Beltz.

NTUA, 2019. *D2.1 Report on the analysis of SoA, existing and past projects/ initiatives.* Athens: NTUA.

NTUA, 2020. *D2.2 PALAEMON Requirement Capture Framework,* Athens: NTUA.

O'Regan, G., 2017. *Concise Guide to Software Engineering, From Fundamentals to Application Methods.* 1st ed. Cham, Switzerland: Springer.

Pohl, K. & Rupp, C., 2015. *Requirements Engineering Fundamentals: A Study Guide for the Certified Professional for Requirements Engineering Exam.* 2nd ed. Rocky Nook, Santa Barbara: IREB compliant.

slido, 2021. *slido.* [Online] Available at: https://www.sli.do [Accessed 2 June 2021].

Taran, S., 2009. The Scoop and Run Method of Pre-clinical Care for Trauma Victims. *McGill Journal of Medicine,* 12(2), pp. 73-75.

Appendix I

This section presents briefly in tabular format the system requirements that were changed based on the outcomes of the gathered information.

Smart Bracelets

The only system requirement of the SBs that changed level of priority is shown in Table 15.

Table 15: The SB requirement of which the priority level changed

Unique ID	Requirement	Description	Rationale	Priority
SB-018	Non-functional	Alarm button	User enabled alarm	~~SHOULD~~ MUST

AR Glasses

The AR Glasses system requirements of which the priority level changed are shown in Table 16.

Table 16: The AR Glasses system requirements of which the priority level changed

Unique ID	Requirement	Description	Rationale	Priority
AR-001	Functional	The AR application will have an intuitive user interface that can be easily learned.	The rationale for this requirement is that the application will be used by any crew member with varying capabilities	~~SHOULD~~ MUST
AR-002	Functional	The AR application will have a training tutorial embedded that will clearly explain each section of the interface and its functions.	The rationale for this requirement is that the application will be used by any crew member	~~SHOULD~~ MUST
AR-024	Functional	The application will be able to provide real-time text communication between the crewmembers	In order to better support and organise the evacuation procedures the crewmembers will be able to communicate with each other in real-time, therefore enhancing the coordination factor	~~MUST~~ COULD

As stated in Section 6, an oxygen level and hazardous gases detection widget could be developed along with the temperature widget, so the description and rationale of the system requirement AR-016 (Table 17) should be updated.

Table 17: The AR Glasses system requirement of which the description and rationale changed

Unique ID	Requirement	Description	Rationale	Priority
AR-016	Functional	Loading augmented reality temperature widget (that will appear on the user interface)	Building a rich user interface that will provide all the information needed for the user, at any given time	MUST

Appendix II

The figures below (Figure 3 to Figure 15) provide the graphic presentation of the ranking questions answered during the 2nd WP2 workshop.

Smart Bracelets

Apart from the localization of passengers and crew members, please rank the importance of the following features for the Smart Bracelets.

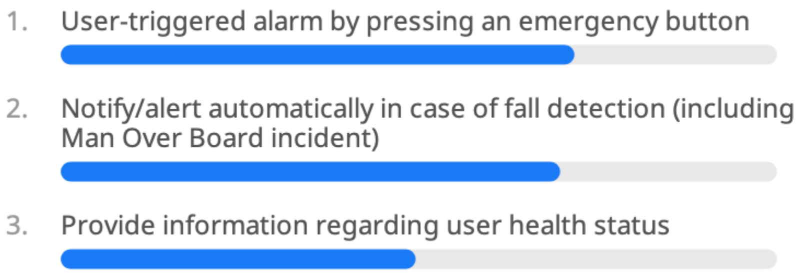


Figure 3: The results of the 1st question regarding the SBs.

Please rank the most suitable way to provide evacuation related information.

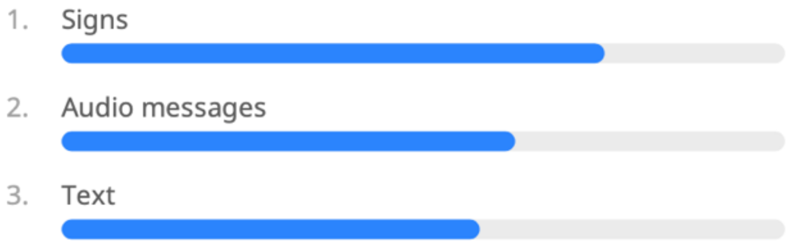


Figure 4: The results of the 2nd question regarding the SBs.

What are the main issues regarding the acceptance of the Smart Bracelets by the passengers and crew members? (please rank the following).

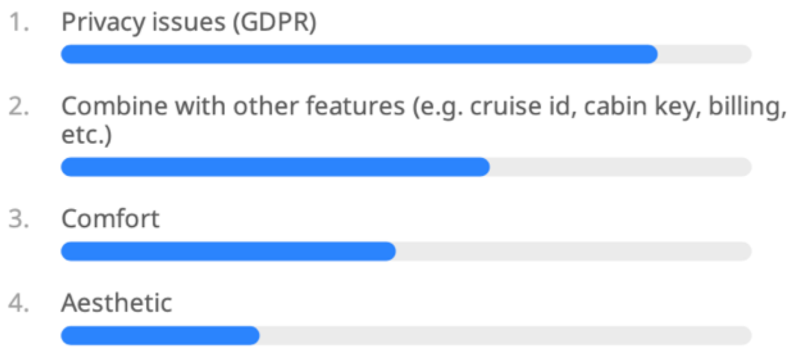


Figure 5: The results of the 4th question regarding the SBs.

AR Glasses

What is the most appropriate way for the crew members to communicate through the AR Glasses? Please rank the following.

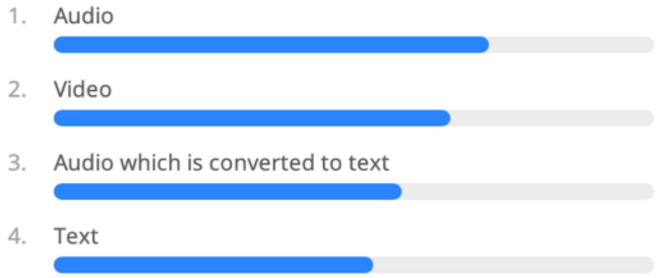


Figure 6: The results of the 1st question regarding the AR Glasses.

Please rank the type of information to be displayed in the AR Glasses in terms of importance.

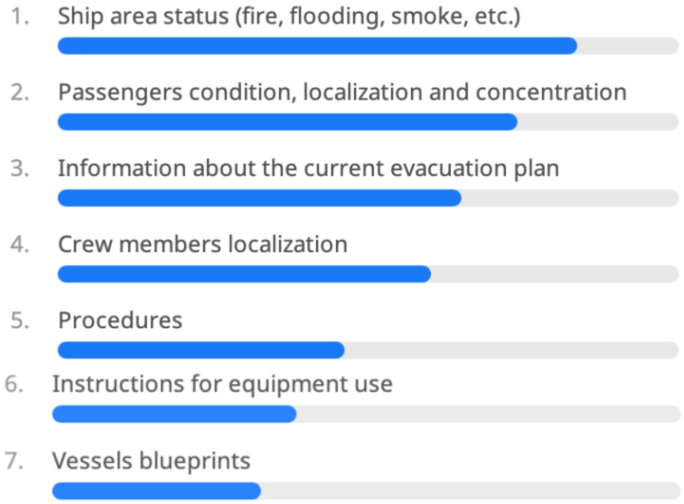


Figure 7: The results of the 2nd question regarding the AR Glasses.

UAV

Please rank the UAV functions shown below in the order of significance.

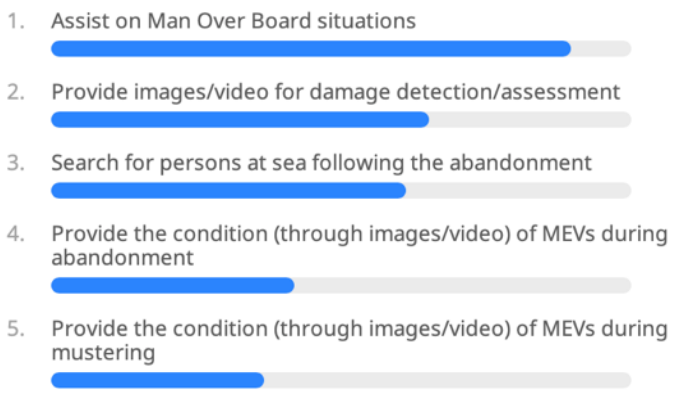


Figure 8: The results of the 1st question regarding the UAV.

PIMM

Please rank, in terms of significance, the critical information to be displayed on PIMM.

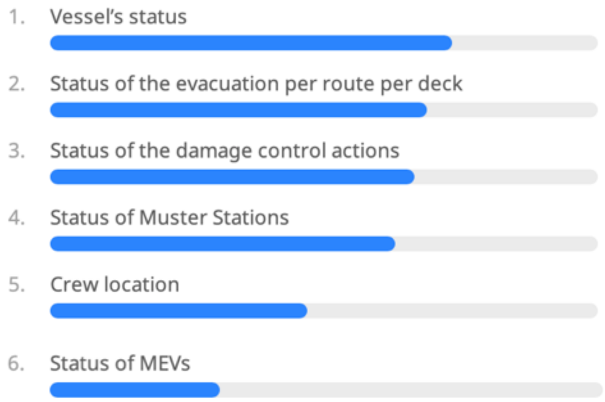


Figure 9: The results of the 1st question regarding the PIMM.

Please rank the most critical information/data considered by the Master to decide to sound the General Alarm.

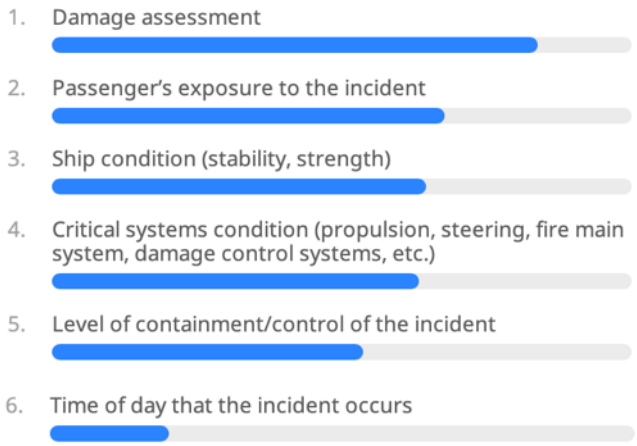


Figure 10: The results of the 2nd question regarding the PIMM.

Please rank the most critical information/data considered by the Master to decide the ship abandonment.

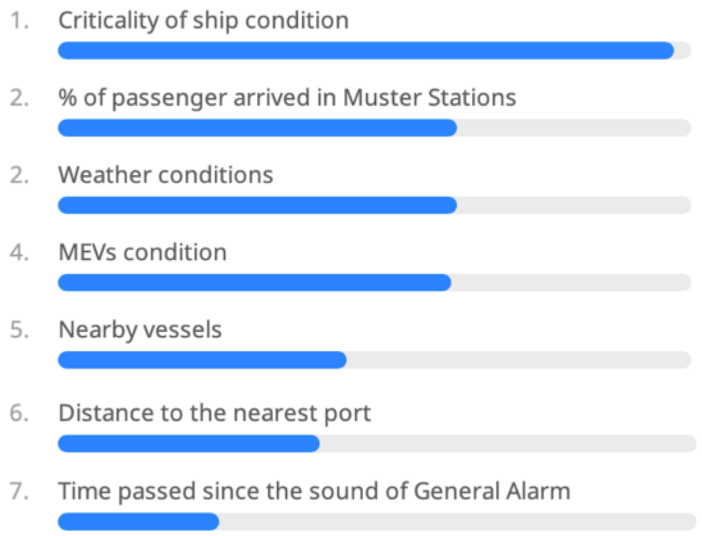


Figure 11: The results of the 3rd question regarding the PIMM.

Please rank the most critical information/data considered by the Master to monitor the progress of the mustering process.

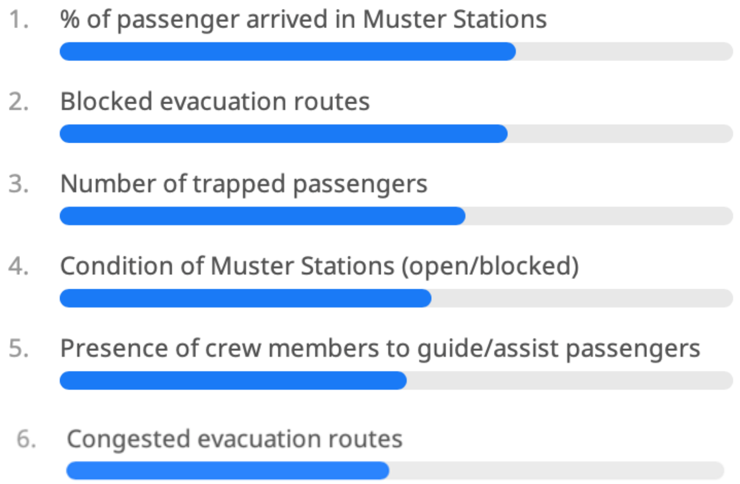


Figure 12: The results of the 4th question regarding the PIMM.

What type of support/information could be useful to enhance the situation awareness and assist the decision making of the Master? Please rank.

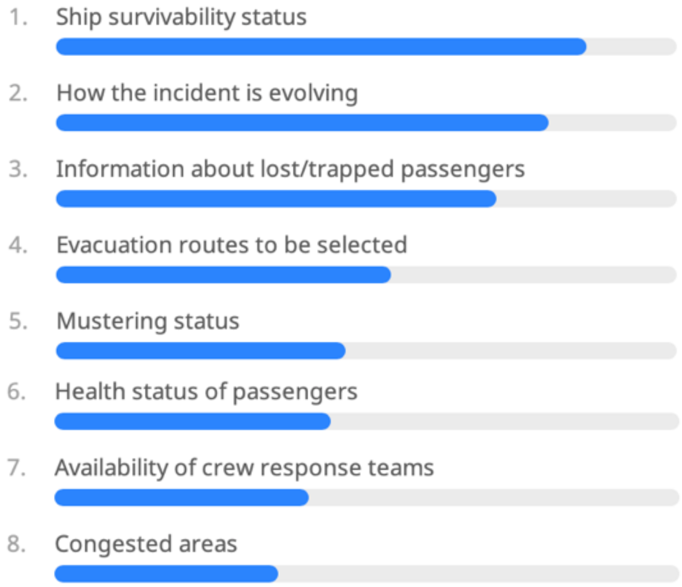


Figure 13: The results of the 5th question regarding the PIMM.

MEV

Please rank the level of autonomy that MEVs may have to navigate.

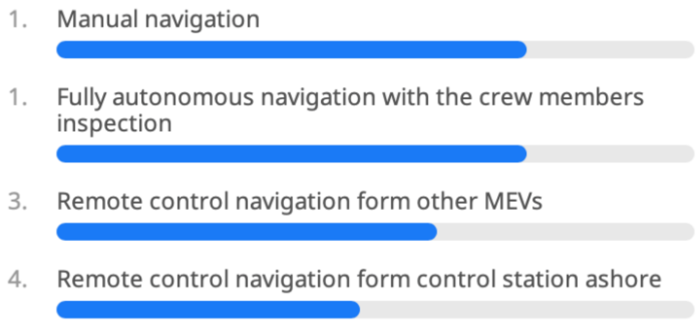


Figure 14: The results of the 1st question regarding the MEV.

Please rank the additional functions that MEVs could have.

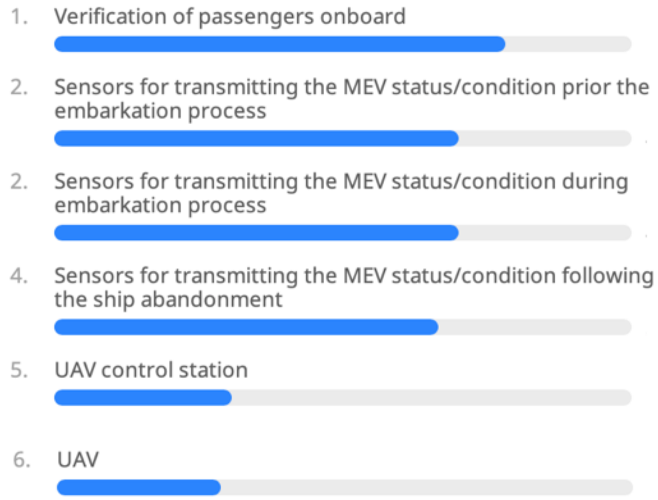


Figure 15: The results of the 2nd question regarding the MEV.

Appendix III - Effects of an unstable underground on the evacuation process

The ship movements in rough seas can make it much more difficult to evacuate passengers and crew members quickly during an emergency. Vulnerable groups, like people with disabilities and elderly people with physical limitations, are often at an even greater disadvantage in this regard. In order to show how certain limitations, make the rescue or evacuation of a person more difficult, a study was conducted to get an insight into the kind of challenges and limitations people with disabilities have to deal with and how this may affect the time needed to overcome them. This time delay is proposed to be taken into consideration by the relevant PALAEMON components.

To support the development of the evacuation prediction model for the scenario of cruise ships in the course of the PALEMON project a trial survey for measuring the time delay of people with disabilities in such situations was carried out. The relevance of this study can be emphasised by the fact that the aspect of sea rescue specific to people with disabilities has received little to no attention. Existing research about evacuation processes for people with disabilities includes locations such as high-rise buildings (Koo et al., 2013) or even densely populated sports areas (Manley & Kim, 2021). They state the importance of emergency preparedness and response especially at large scale catastrophic events when it comes to the evacuation of people with disabilities. The rise of new emergency evacuation strategies for individuals with disabilities shows the importance of awareness and planning regarding this topic as a significant portion of the world population (approximately 10–20 %) has some type of disability (Manley & Kim, 2021).

Due to this lack of research on the topic, the "Magic Dreamland" study can create important insights regarding decreased speed, as well as subjective mood and difficulty in overcoming obstacles encountered by people in distress at sea. The "Magic Dreamland[6]" is a so-called fun-house in the so-called amusement park Vienna Prater[7] with indoor and outdoor areas, in which an obstacle course is located. Due to the mostly uneven and unstable ground, this course is very similar to the usually narrow interior of a ship facing rough seas. In the first run, people walked the course in their usual street clothes and without any assistance. The second time, they wore a hemiparesis simulator that simulates a wide variety of paralysis effects and limitations. Each obstacle corresponded to a test point where the time to overcome it was measured, so that at the end a comparison of two runs of the same person with and without the hemiparesis simulator was possible.

The aims and objectives of this study were to determine the extent to which overcoming obstacles with and without a hemiparesis simulator differs by measuring running time and evaluating it by the participants.

This report contains a detailed description of the research design with the guiding questions and hypothesis, the survey setting, preparation and execution as well as the explanations of main findings and their interpretation.

[6] WIENER Prater Magic Dreamland 360º VR POR (video link): https://www.youtube.com/watch?v=aiWUPINjX4o; accessed on 09.06.2021.

[7] Vienna Prater homepage: https://www.praterwien.com/en/home/

III.1 Research Design

The “Magic Dreamland” study was conceptualized as a trial with focus on the estimation of the time delay. To use this possibility and open up a broader field of research through different indicators a mixed methods instrument was developed for data collection. The whole research process was designed as a co-creative process with rolling planning, which allows the inclusion of step-by-step adjustment.

An evacuation is most likely a stressful situation for passengers, which can also potentially influence behavior. Therefore, it is also interesting to shed light on how the mood of the individuals changes as well as how the difficulty is subjectively rated.

In this context, the following research questions guided the study:

- What are the temporal differences in overcoming obstacles with and without wearing a hemiparesis simulator?
- How do the test persons evaluate the two runs of the course with regard to their personal mood or emotional state and which changes occur?
- How do the test persons evaluate the two runs of the course in terms of difficulty?

A key element of the study is the hemiparesis simulator (Figure 16) to mimic the physical conditions of disabilities. The suit can be applied to either the left or right side of the body. In the test setting the suit was applied to the dominant side of the respective test subject. It consists of the following parts: A weight cuff for one ankle, a knee brace, a weight vest of 10 kg, a lollipop or spoon, an earplug, overshoes, coloured glasses, an arm sling and a walking stick. The simulated effects include paralysis of one leg, paralysis of one arm, vision impairment, hearing impairment, and speech and swallowing impairment.

Figure 16: The used hemiparesis simulator.

In respect of the change in physical ability of the participants in the test set up the following hypothesis were set for the survey (Bortz, 2005):

Time Delay

- H0: The measured time of the first run without and the second run with hemiparesis simulator is the same.
- H1: In the second run, where subjects wear the hemiparesis simulator, it is assumed that the turnaround time is significantly delayed because limitations in vision, hearing, and mobility make it much more difficult to negotiate obstacles such as swaying ramps, vertically spinning foam rollers, or suspension bridges.

Mood

- H0: The mood in the between the first run without and the second run with the hemiparesis simulator (HPS) is the same.
- H2: In the second run, when the subjects wear the hemiparesis simulator, it is assumed that there will be a significant deterioration in mood, as the subjects are in a physical and psychological stress situation.

Difficulty

- H0: The difficulty in the first run without and the second run with the hemiparesis simulator is the same.
- H3: In the second run, when the subjects wear the hemiparesis simulator, it is assumed that there will be a significant increase in the level of difficulty, as the subjects are in a physical and psychological stress situation.

III.1.1 Test Set Up

The parkour of the “Magic Dreamland” combines a variety of obstacles on four floors. The individual obstacles are sideways swaying ramps, narrow passages in narrow spaces with many twists and turns, vertically spinning foam rollers, horizontally spinning wooden tunnels with optical illusions and mirrors, oppositely moving ascending stairs, treadmills, tilting floor plates, narrow steep stairs, suspension bridges and slides.

For conducting the survey and be able to take a look at the impact when confronted with different hurdles, the route of the fun house was separated into 16 stations. The single test sets are described in comparison to the conditions on cruise ships. The details were validated by an experienced cruise ship attendee.[8]

[8] Sources of screenshots: https://www.youtube.com/watch?v=axPW_9gQ8J8 and https://www.youtube.com/watch?v=aiWUPINjX4o; Access on 09.06.2021

Test station 1: Swaying ramps

The swaying ramps with railings simulate the rolling of the ship in (rough) sea. There are also similar access ramps at embarkation or excursion sites.

Test station 2: Narrow passageway I

There are also narrow passageways on ships, especially on exterior levels above the main level with sun decks, etc.

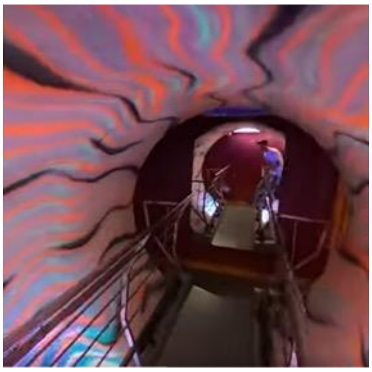
Test station 3: Rotating foam rollers I

The foam rolls are a good simulation for pushing past other people or objects. Similar situations are also common during embarkation and disembarkation, boarding of tender boats or during events (e.g. dance hall).

Test station 4: Narrow passageway II

The tilting, spinning and vibrating floor slabs can again be compared to ship movements, for example during storms or wet ground, with which the simple crossing of a passage can be made considerably more difficult and delayed.

Test station 5: Tunnel with optical illusion



The moving bridge in the tunnel sways back and forth, and spinning walls and mirrors create confusion on a visual level that can create stress similar to an emergency situation. High waves can also make people feel sick and cause them to lose their sense of balance.

Test station 6: Tilting floor plate

Jerky ship movements can also cause the floor of the ship to tilt sideways and throw people off balance. The surprise effect in particular comes into play here.

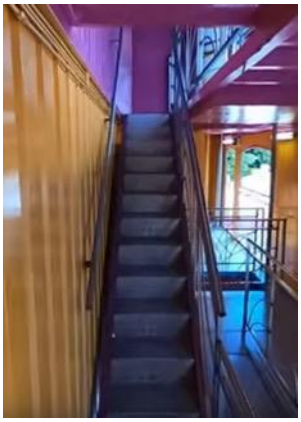
Test station 7: Treadmill

Getting on and off the treadmill required a lot of balance. Test subjects also had no control over the moving floor. This is exactly what can happen on a rolling ship, which not only sways sideways but also stops abruptly and picks up speed again. Similar situations can also occur when boarding or disembarking.

Test point 8: Tilting floor slabs

Jerky ship movements can also cause the floor of the ship to tilt sideways and throw people off balance.

Test point 9: Narrow staircase



Staircases on ships are also often very narrow and can therefore be compared well.

Test site 10: Hilly treadmill

This station simulates climbing over obstacles or debris during a stormy sea, but also reminiscent of the steps on the ship during the emergency drill.

Test point 11: Rotating foam rollers II

Similar to test station 3, the foam rollers are a good simulation for pushing past other people or objects. Similar situations are also common during embarkation and disembarkation, boarding of tender boats or during events (e.g. dance hall).

Test site 12: Treadmill II and rotating foam rollers III

The treadmill with the individual small rollers can simulate wet ground on board. Care and balance are needed to cross. The spinning foam rollers can simulate people bumping into each other.

Test point 13: Winding staircase

Staircases on ships are also often narrow and winding and can therefore be compared well.

Test point 14: Narrow passageway III

The tilting, spinning and vibrating floor slabs can again be compared to ship movements, for example during storms or wet ground, with which the simple crossing of a passage can be made considerably more difficult and delayed. At this station the height is an additional factor.

Test station 15: Suspension bridge

The suspension bridge simulates a rolling and swaying ship very well. The height of the suspension bridge can be compared to the height of a crow’s nest with a lookout/bar. The ship movements are felt much more strongly up there.

Test station 16: Narrow passageway IV with treadmill

See test point 4 and 7.

III.1.2 Methods

For this quasi-experimental pilot study to test the developed hypothesis for different conditions a dynamic survey form of Paper and Pencil Interview (PAPI) with qualitative and quantitative aspects was developed (Diekmann, 2008). The questionnaire has been kept simple to ensure a good usability in the survey situation, on the parkour for participants as well as for the research team. In addition to the time measurement, before and after each test site, the subjects were asked for a short self-assessment of their emotional state and the difficulty of overcoming. There was consideration of a five-point Likert scale for rating the mood, but in order to see how widely spread the answers are in such situations, a ten-point scale was used. When rating the mood from 1, very good, to 10, very bad, a higher number means a higher strain on the mood. In case of evaluating the difficulty from 1, very easy, to 10, very difficult, a higher number means a higher challenge. This intended to investigate whether, and to what extent, various limitations and/or disturbances make an escape route more difficult. Besides these questions, socio-demographic data like age and gender as well as health data like body weight, defective vision and the exercising frequency were covered in the questionnaire (Diekmann, 2008).

For qualitative data collection the questionnaire included space for observation comments and a closing question, to involve impressions of the participants for a better understanding of the challenges they had to face (Paier, 2010). For carrying this research concept out a two-person team is needed, one for time measurement and the other for noting the results and querying the self-assessments of the individual test subjects at the test sites.

Extensive preparations were made months before conducting the study in order to be able to take into account possible interfering factors in advance, especially those relating to safety. This included in particular pretesting with the hemiparesis simulator so that the researchers could put themselves in the perspective of the test persons on site. To assess and consider appropriate options for the survey, a small parkour was set up at the Johanniter Research and Innovation Centre. Moreover, the location had to be organized and the participants recruited. In relation of external impact local media were involved.

III.2 Execution

The study was conducted at the obstacle course "Magic Dreamland" in the Vienna Prater (Austria) on 6th May 2021 and took about 8 hours including the preparation and the follow-up. In regards of security and for preparation of the test stations for participants and the research team the test site was inspected preliminary. Because of the COVID-19 restrictions at that time it was not possible to do this beforehand. During this walk-through, the start and end points of the test stations were also determined and marked with labels to enable comparability of the runs. In regard of the conditions on site two foreseen stations were eliminated from the questionnaire, because they were assessed as too risky by the research team to let participants go through them with the simulator. For conducting the study and to stay consistent, it was decided to use the hemiparesis suit to simulate a hemiplegia of the dominant body site of the participants. To avoid unnecessary risk, e.g. when falling down, the lollipop or spoon was left out. For time measurement a commercially available digital stopwatch was used.

As participants community service workers as well as full time employees from Johanniter Unfall-Hilfe Österreich, branch Vienna were recruited. For screening variables, the focus lay on the same age cohort, a balanced gender ratio and basic physical fitness.

Furthermore, to avoid any COVID-19 associated consequences in addition to valid proof of no infection, a hygiene concept with gloves, FFP2 masks and surface disinfection of the equipment was strictly adhered to at the whole location.

Before starting the run, each participant had to sign an informed consent which not only included information about the project and the study, but also clarified the possible risk connected with the location and the appeal for personal responsibility, even in case of discomfort. Additionally, before the start of the first run, each participant received a brief introduction to the evacuation situation and was instructed to walk at a moderate pace accordingly. In total about six alternating researchers were in place, each supervising one run in teams of two, to collect the time and conduct the interview with the test subjects. In total there were two teams at a time on the parkour. Since one suit was available for the study, only one run with the suit could be conducted at a time. In order to use the time effectively, the first round was completed with other participants without a simulator. In addition, there were also two test subjects over 45 years who did not do a second round and can be used as age reference.

III.2.1 Data Analysis

For analysing the quantitative data, a combination of Excel Software and PSPP[9] Version of 2019 freeware from GNU Project was used in order to use synergies of the functions. Since this trial survey has a sample smaller than 20 participants and mood and difficulty evaluation have an ordinal scale, non-parametric tests were carried out for testing the significance of the collected data. Furthermore, the metric time data was on the one hand analysed for each station and on the other hand transferred into two indices – with and without hemiparesis simulator- to take a look at the overall time delay between the two runs. The qualitative data collected is incorporated into the discussion of the results. The verbal part was summarised in regards of similarities and differences as well as comparison with the quantitative data.

III.3 Results

The sample consists of nine participants, which completed both runs without and with hemiparesis suit. One of the participants had concerns about two stations and decided not to complete them. In order to be able to include the entire run in the analysis, the test person was excluded from the present results report. Of those nine participants, 56% were female and 44% male. The classification of the age categories is based on the Austrian health survey (Klimont, 2020). The age range for the calculations extends from 20 to 33 years. To get an impression of the fitness of the participants, they were asked how often they do sports. All of the women who took part, said that they exercise several times a week. In case of the male test subjects, the exercise frequency distributes among the categories (almost) daily, several times a week, once a week and several times a month. Furthermore, the Body Mass Index[10] (BMI), consisting of weight, height, age and gender, was calculated. 33% of the participants can be categorised as underweight, 44%- and thus the majority- as normal weight and 22%

[9] https://www.gnu.org/software/pspp/; accessed on the 09.06.2021

[10] Body Mass Index online calculator: https://www.bmi-rechner.net/; accessed on 11.06.2021

into the overweight category. The following chart (Figure 17) shows how the BMI is distributed by gender in the sample, showing that the asked women have a lower measure:

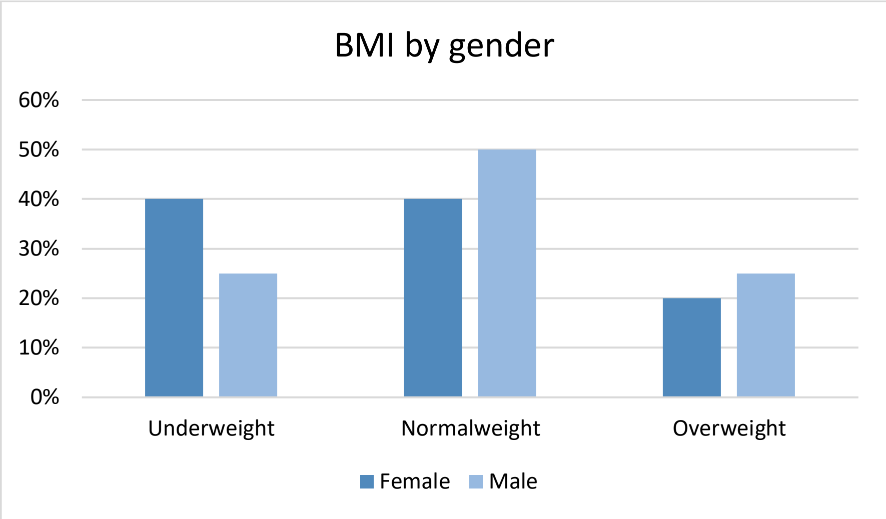


Figure 17: The BMI percentage of the sample's participants

With regard of further health data and the conditions for the testing in this context, it can be summarised that four of the nine participants were defective in vision and needed glasses or contact lenses. In addition, it should be noted here that one participant was colour blind, one had asthma and was recovered from COVID-19 and another had a mild pelvic displacement.

III.3.1 Time Delay

To get an overview of the time measured in seconds, the mean, variance, standard deviation, minimum and maximum of both runs with and without hemiparesis simulator are used below (Table 18, Table 19).

Table 18: Time measurements without hemiparesis simulator

Station	Description	Mean	Variance	SD	Minimum	Maximum
1	Swaying ramps	10.08	5.37	2.32	7.69	14.00
2	Narrow passageway I	7.68	0.92	0.96	6.19	8.97
3	Rotating foam rollers I	3.55	0.21	0.45	2.78	4.09
4	Narrow passageway II	8.93	2.88	1.70	6.35	11.38
5	Tunnel with optical illusion	2.96	0.16	0.40	2.40	3.50
6	Tilting floor slab	2.59	0.21	0.45	1.63	3.12
7	Treadmill	7.80	1.99	1.41	5.81	10.21
8	Tilting floor slabs	10.91	6.4	2.53	6.91	14.69
9	Narrow staircase	9.30	1.36	1.17	7.22	10.94
10	Hilly treadmill	3.05	0.25	0.50	2.32	3.69
11	Rotating foam rollers II	5.26	1.00	1.00	3.90	6.63
12	Treadmill II and rotating foam rollers III	5.76	0.96	0.98	4.38	7.31
13	Winding staircase	6.94	2.24	1.50	4.81	8.78
14	Narrow passageway III	8.86	2.71	1.64	6.12	11.06
15	Suspension bridge	6.48	1.76	1.32	4.56	8.10
16	Narrow passageway IV with treadmill	9.15	2.16	1.46	7.06	11.72

Table 19: Time measurements with hemiparesis simulator

Station	Description	Mean	Variance	SD	Minimum	Maximum
1	Swaying ramps	14.81	17.12	4.14	10.38	21.28
2	Narrow passageway I	11.47	6.19	2.49	7.13	15.23
3	Rotating foam rollers I	4.90	0.91	0.96	3.63	6.56
4	Narrow passageway II	16.02	10.62	3.26	10.85	21.00
5	Tunnel with optical illusion	5.11	0.82	0.91	3.72	6.38
6	Tilting floor slab	4.65	1.31	1.14	2.78	6.47
7	Treadmill	11.41	5.14	2.27	8.65	14.62
8	Tilting floor slabs	17.53	13.12	3.62	11.68	25.15
9	Narrow staircase	18.79	15.37	3.92	12.47	23.59
10	Hilly treadmill	4.71	0.84	0.92	2.84	6.06
11	Rotating foam rollers II	8.15	3.29	1.81	5.40	11.81
12	Treadmill II and rotating foam rollers III	10.19	8.62	2.94	7.25	15.94
13	Winding staircase	14.73	10.96	3.31	9.37	19.81
14	Narrow passageway III	11.69	3.83	1.96	8.12	14.19
15	Suspension bridge	11.44	7.32	2.71	6.46	14.94
16	Narrow passageway IV with treadmill	15.06	16.43	4.05	9.47	24.03

In the process of comparing the data of both runs, the percentage gives an insight of the difference in time between the first and the second run (Table 20).

Table 20: Data comparison (percentage difference) of the two runs

Station	Description	Difference (%)
1	Swaying ramps	47%
2	Narrow passageway I	49%
3	Rotating foam rollers I	38%
4	Narrow passageway II	79%
5	Tunnel with optical illusion	72%
6	Tilting floor slab	79%
7	Treadmill	46%
8	Tilting floor slabs	61%
9	Narrow staircase	102%
10	Hilly treadmill	54%
11	Rotating foam rollers II	55%
12	Treadmill II and rotating foam rollers III	77%
13	Winding staircase	112%
14	Narrow passageway III	32%
15	Suspension bridge	77%
16	Narrow passageway IV with treadmill	65%

The highest differences can be seen at station 13, with the challenge of the winding staircase, and station 9, with the obstacle of narrow staircase between the two runs. At both stations the delay is over 100% of the time required in the first run.

The Wilcoxon Signed Ranks Test for associated samples was used for testing the hypothesis significance[11] of the time delay. For this, two mean indices were computed– one for the time with and one for the time without the simulator- for an overall comparison of the time without and time with the hemiparesis simulator. Since the hypothesis about the direction of the difference was set beforehand the test is used one-sided. This approach results in a z value of -2.67 and a significance of 0.004 (Du Prel et al., 2010).

III.3.2 Evaluation of the Mood After Station

To get an impression of the subjective mood, the participants were asked "How are you?" at a scale from 1 (very good) to 10 (very bad). The following graph (Figure 18) gives an overview of how often the respective classification was chosen across the 16 wards.

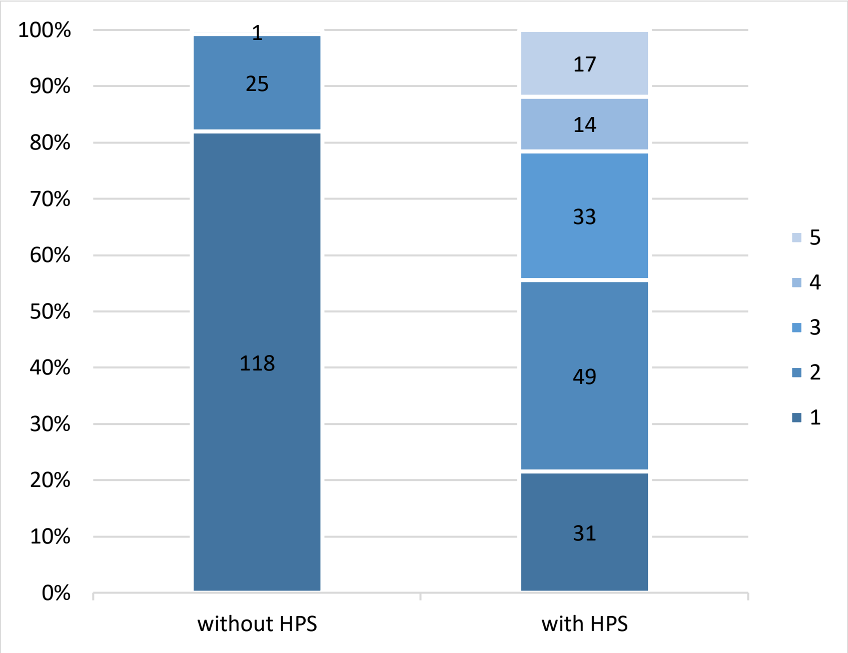


Figure 18: The ranking of the participant's answers in percentages

The left beam shows that the range of mood categorization was used from 1 (118 nominations) to 3. In regards of changes in mood between the first and the second run, the breakdown of the assessment with hemiparesis simulator is more diverse and broadly based up to the mood of 5. Most nominations (49) were made at 2.

When looking at the median comparison in the spider diagram there is no overlapping between the first and the second run. Moreover, the highest median values and also most slope are observed at the stations 1, the swaying ramps, station 4 with the narrow passage way II, station 5 with the tunnel with optical illusion and station 12, with treadmill II and rotating foam rollers (Figure 19).

[11] https://www.gnu.org/software/pspp/manual/html_node/WILCOXON.html; accessed on 09.06.2021

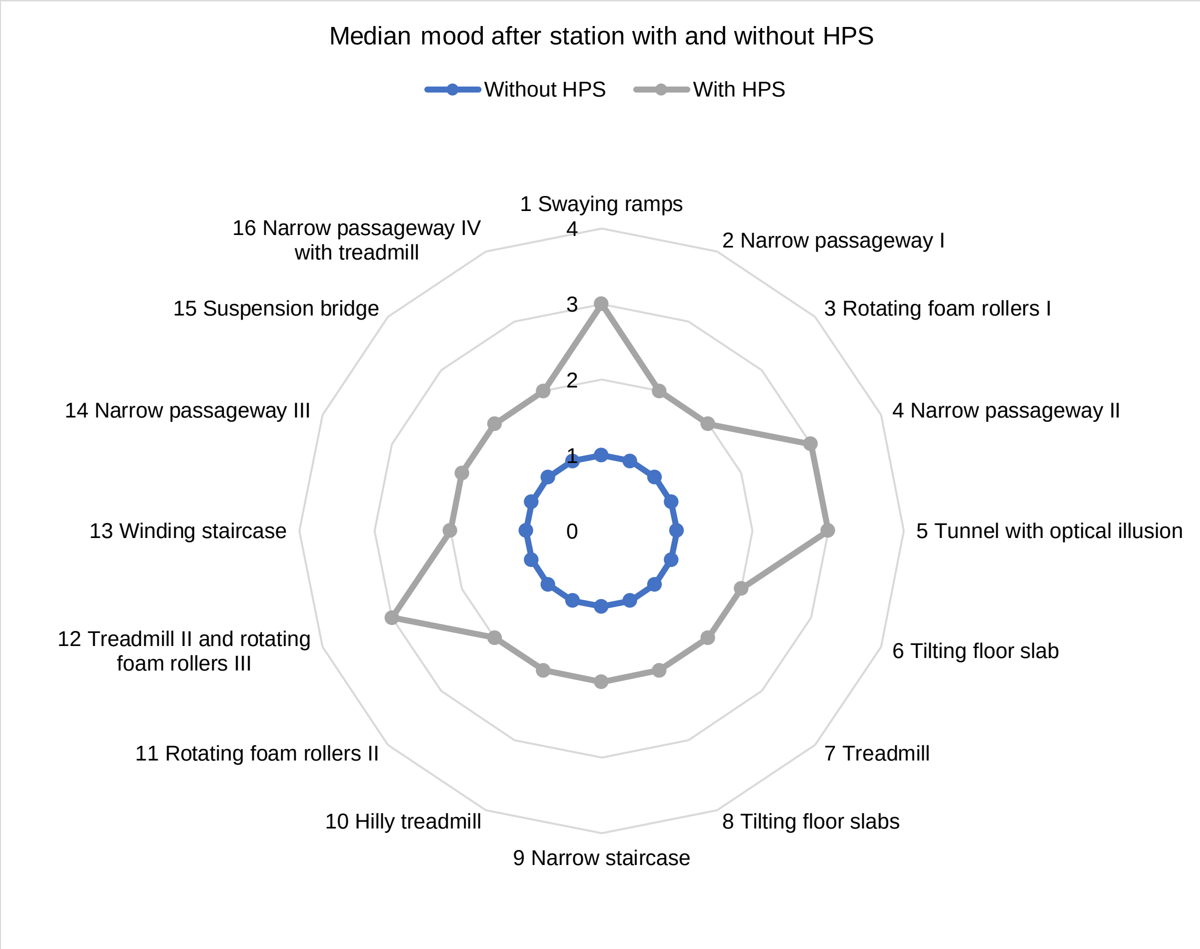


Figure 19: The spider diagram comparison between the first and the second run (mood of the participants)

To proof the significance of the differences in mood evaluation of the two runs the results of the Wilcoxon Signed Ranks Test for associated samples are listed per station. All stations show a value that is below the significance level of $p < 0.05$.

The results of Wilcoxon Signed Ranks Test for the evaluation of mood after station without and with hemiparesis suit are shown in Table 21.

Table 21: The results of Wilcoxon Signed Ranks Test for the evaluation of mood after station without and with hemiparesis suit

Station	Description	Z	Significance (one-sided)
1	Swaying ramps	-2.36	0.01
2	Narrow passageway I	-2.46	0.01
3	Rotating foam rollers I	-2.41	0.01
4	Narrow passageway II	-2.04	0.02
5	Tunnel with optical illusion	-2.39	0.01
6	Tilting floor slab	-2.26	0.02
7	Treadmill	-2.26	0.01
8	Tilting floor slabs	-2.46	0.01
9	Narrow staircase	-2.41	0.01
10	Hilly treadmill	-2.41	0.01
11	Rotating foam rollers II	-2.41	0.01
12	Treadmill II and rotating foam rollers III	-2.41	0.01
13	Winding staircase	-2.41	0.01
14	Narrow passageway III	-2.41	0.01
15	Suspension bridge	-2.23	0.01
16	Narrow passageway IV with treadmill	-2.23	0.01

III.3.3 Assessment of Difficulty

In order to be able to assess of how difficult it was for the participants to go through the individual stations with and without the hemiparesis simulator, they were asked for their rating on a scale from 1, very easy, to 10, very difficult.

The chart below (Figure 20) gives insight on how many times the stations were ranked with the same classification of difficulty.

The left beam shows that the range of difficulty was used from 1 (93 nominations) to 4. As with the mood, it can be seen that more or higher categories were used to evaluate the difficulty in the second run. Levels two (45 nominations) and three (34 nominations) were chosen the most.

In the case of the difficulty ratings, the spider diagram shows indeed overlaps in the medians of the two runs. This applies to the stations 5, tunnel of optical illusion, 10 hilly treadmill and 14 with the narrow passageway III. The station with the highest median scores is the narrow passageway of test point 4 and the treadmill with rotating foam rollers of test point 12 were assessed with a median of 4.

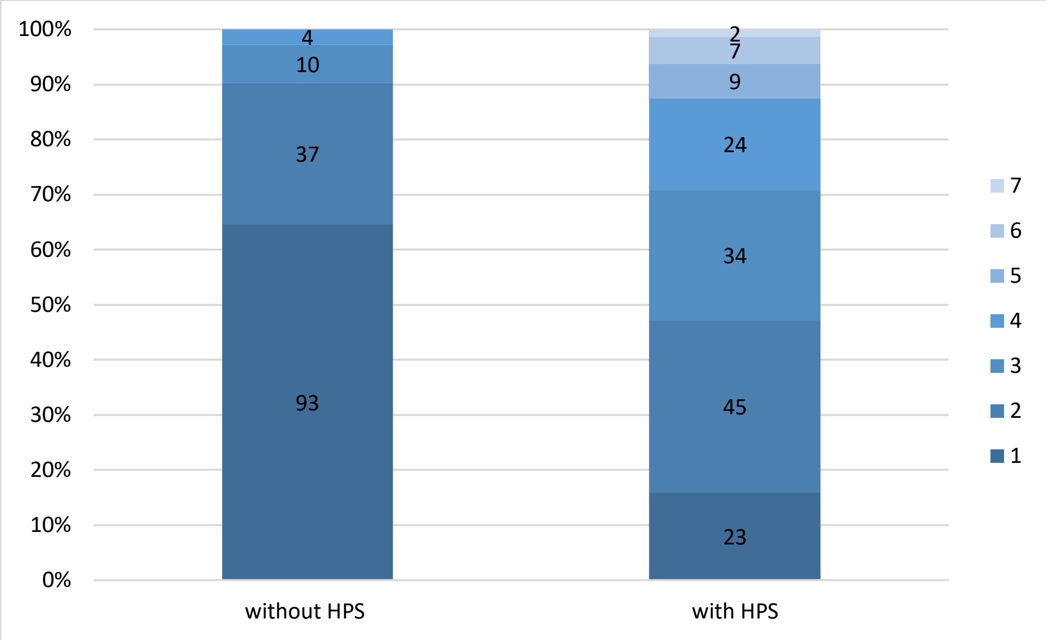


Figure 20: Graphic representation of how many times the stations were ranked with the same classification of difficulty

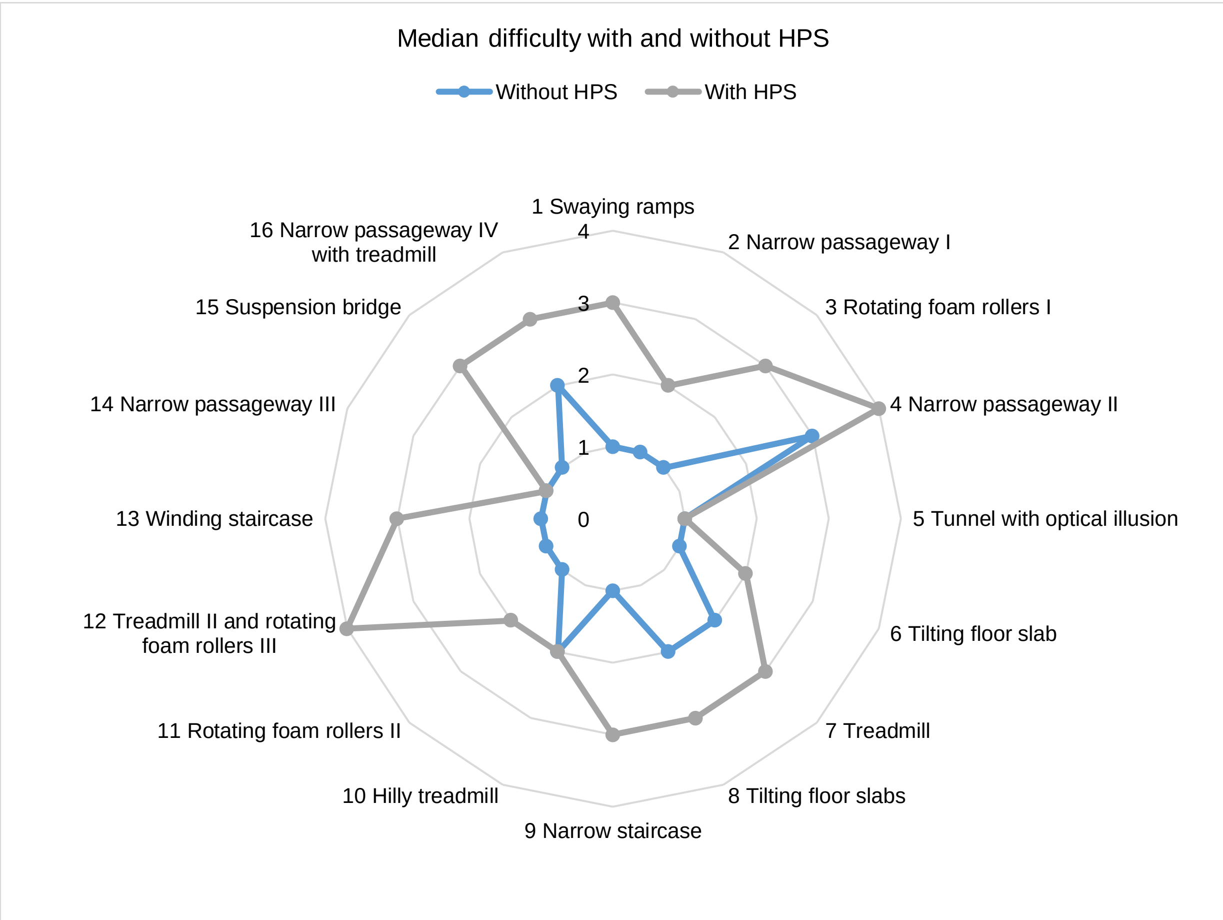


Figure 21: The spider diagram comparison diagram between the first and the second run (difficulty)

When it comes to the significance of the difference in difficulty between the two runs at the single stations the results of the Wilcoxon Signed Ranks Test at the stations 5, 14 and 10 stand out in particular for being over the significance level of $p< 0.05$.

The results of Wilcoxon Signed Ranks Test for difficulty assessment of the station without and with hemiparesis suit are shown in Table 22.

Table 22: The results of Wilcoxon Signed Ranks Test for difficulty assessment of the station without and with hemiparesis suit

Station	Description	Z	Significance (one-sided)
1	Swaying ramps	-2.41	0.01
2	Narrow passageway I	-2.76	0.00
3	Rotating foam rollers I	-2.23	0.01
4	Narrow passageway II	-2.39	0.01
5	Tunnel with optical illusion	-1.86	0.03
6	Tilting floor slab	-2.27	0.01
7	Treadmill	-2.53	0.01
8	Tilting floor slabs	-2.41	0.01
9	Narrow staircase	-2.69	0.00
10	Hilly treadmill	-0.58	0.28
11	Rotating foam rollers II	-1.98	0.02
12	Treadmill II and rotating foam rollers III	-2.75	0.00
13	Winding staircase	-2.70	0.00
14	Narrow passageway III	-1.63	0.05
15	Suspension bridge	-2.23	0.01
16	Narrow passageway IV with treadmill	-2.39	0.01

III.3.4 Mood and Difficulty

To get an impression about the connectivity of mood and difficulty cross-tabulations with the percentage scores can provide information. The colour code is used to highlight the distribution of values, where red means low and green means high.

The mood after station overall test points with difficulty at the run without hemiparesis simulator are shown in Table 23.

Table 23: The mood after station overall test points with difficulty at the run without hemiparesis simulator

	Difficulty				
Mood t1	**1**	**2**	**3**	**4**	**Total**
1	52.78%	22.92%	4.17%	2.08%	81.94%
2	11.81%	2.78%	2.08%	0.69%	17.36%
3	0.00%	0.00%	0.69%	0.00%	0.69%
Total	64.58%	25.69%	6.94%	2.78%	100.00%

Counting the votes without the hemiparesis simulator, the tab shows that the maximum of difficulty was assessed with 4 and the mood after going through the station was assessed with 3. With about 53% most of the stations were evaluated with 1 in both categories.

The mood after station overall test points with difficulty at the run with hemiparesis simulator are shown in Table 24.

Table 24: The mood after station overall test points with difficulty at the run with hemiparesis simulator

	Difficulty							
Mood t1	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
1	5.56%	6.25%	4.86%	4.17%	0,69%	0.00%	0.00%	21.53%
2	6.25%	13.89%	11.11%	2.08%	0,00%	0,69%	0.00%	34.03%
3	1.39%	6.94%	5.56%	7.64%	0,69%	0.69%	0.00%	22.92%
4	1.39%	1.39%	0.69%	2.78%	3,47%	0.00%	0.00%	9.72%
5	1.39%	2.78%	1.39%	0.00%	1,39%	3.47%	1.39%	11.81%
Total	15.97%	31.25%	23.61%	16,67%	6,25%	4.86%	1.39%	100.00%

In case of the run with the hemiparesis simulator, the highest vote of difficulty was 7 and for mood after running through the station 5.

III.4 Interpretation and Discussion

According to the collected data and the observations made during the survey, there were no problems for the participants to overcome the obstacle course without the hemiparesis suit. Especially straight distances were covered very quickly. This also matches with the time delay. With a $p = 0.004$ ($p < 0.01$) the difference between the first and the second run is statistically highly significant. This provides the basis for rejecting the null hypothesis, that the time measures in both runs are the same.

Changes in mood and difficulty can be seen as increasing exertion. Both in terms of mood and difficulty rating, the scores changed from low values to more spread out and the scales are higher in the second run. This suggests that the effort with the suit was perceived as considerably more difficult. Regarding the results of mood after the stations, the analysis per test point shows also significant results ($p<0.05$), meaning that there is a significant difference between the two runs and the H0 can be rejected.

When looking at the testing of the hypothesis regarding the difficulty rating, the results are also significant ($p<0,05$), except for two stations. Based on this, it seems that the participants found the test points hilly treadmill (10) and the narrow passageway III (14) in both runs to be similarly difficult without and with hemiparesis suit.

As far as the correlation between the mood after the station and the difficulty rating is concerned, the cross-tabulation shows that there is a tendency for a lower level of difficulty to go hand in hand with a better mood. The other way round when looking at the ratings of mood and difficulty in terms of perceived exertion, it can be seen that they increase when wearing the simulator. An increase can also be observed in the course of the second run, which suggests that the stress for the persons also becomes stronger with the duration.

Regarding the different challenges connected to the single obstacles of the ‘Magic Dreamland’ parkour, there were also many parallels when wearing the hemiparesis suit. Most participants confirmed that they found it particularly difficult to climb stairs and to cross treadmills with the simulator. The latter due to a lack of control and the stairs because they found them heavy and strenuous. Test persons stated testing stations with these obstacles as the most difficult and demanding ones. Specific reasons for these assessments varied. For one test person going up and down the treadmill with the stiffened leg, as well as the need of having quick reactions caused difficulties, while another test person was so afraid of climbing the treadmills, that they did not complete test stations with treadmills at all or only without the walking stick. Another test person named the stairs as the most difficult obstacle, but not for the reason of effort, but because a lot of thinking was necessary.

Besides all these commonalities there were also some outliers in troubles test persons had with specific testing stations. One mentioned the suspension bridge because of the gaps in the floor, which made it difficult to cross. Another test person stated at the beginning of the test that they were afraid of heights, which was then noticeable at test stations that involved heights. Another participant lost the walking stick at a narrow walk through, while another one was stuck in the foam rollers with the stick. A different test person had problems with the spinning foam rollers and some bottom plates, because of their reverse rotation. Yet another person had difficulties with the running tracks, because balance and jumping at the end was required. In addition, narrow places caused problems, as well as unexpected ground movements.

In summary, it can be said that almost all test subjects had difficulties with the same test points. This can be seen from observations of the test subjects, the perceived difficulty and mood before and after overcoming the obstacles, as well as from the final question. The stairs and treadmills were mentioned particularly often here. The former required a high level of physical exertion and the latter a great deal of balance and lack of control, as well as caution when climbing up and down. In terms of the specific obstacles, this can also be translated to the conditions on a cruise ship. In this context, stairs and also moving ground emerge as particularly important.

III.5 Conclusion and Outlook

The results of the study “Magic Dreamland” suggest revealing information about the time delay of people with disabilities that must be taken into account for evacuation processes. In the setting of cruise ship evacuation, the highly significant result of time delay poses a great risk of affected persons obstructing others. Subsequently, this can result in a considerable delay of the entire evacuation process, which can also lead to congestion. This also has a negative effect on mood, which can also affect the ability to take in instructions. Additionally, the figures provided clues as to which conditions represent the greatest barriers in regards to which areas of the ship special attention must be paid. In particular, a moving ship with narrow areas or areas with stairs and moving obstacles, e.g. other people may be stress-inducing in relation to aggravated mobility. Especially in this situation, it is important to de-escalate and avoid panic.

It should also be remembered in this context that the purpose of visiting a cruise ship is to have a good time. The perceived feeling of safety plays an essential role in this. This also means that the preventive steps for evacuation as well as the technological system developed in the PALAEMON project should have as little impact on this as possible. Especially in the circumstances of a physical disability, further requirements can be disruptive.

It must be clearly emphasized that this is a pilot study with a small sample (n<20) and therefore limitations in regards to representation. But this can be used as a first basis, on which to build further research and concretization steps for enabling better handling of elderly people and people with disabilities in evacuation situations on cruise ships. Therefore, the study design offers many points of linkage for further research that can and should be adapted for further proceedings. In any case, the analysis can still be deepened in order to elicit further possible correlations between the health-related data. In addition, a comparison with the test persons included as age references is planned.

Finally, it should also be pointed out that the "Magic Dreamland" study conducted was not only a physical experience for the participants but also allowed to increase awareness of the challenges faced by people with physical disabilities and the needs associated with them. With the words of one the test's participants: "I'm really lucky to be able to put this [hemiparesis simulator] off now. Others can't do that." A comprehensive impact was also achieved in terms of information dissemination by reaching about 380.000 people through regional online media. Also, by choosing the survey site in an urban area used for recreational purposes, the survey can be seen as building bridges in sense of connecting citizens and science.

III.6 References

Bortz, J., 2005. Statistik für Human- und Sozialwissenschaftler. 6 ed. Springer-Verlag Berlin Heidelberg: Springer-Verlag Berlin Heidelberg.

Diekmann, A., 2008. Empirische Sozialforschung: Grundlagen, Methoden, Anwendungen. 19 ed. Hamburg: Rowohlt.

Du Prel, J.-B., Röhrig, B., Hommel, G. & Blettner, M., 2010. Choosing statistical tests - Part 12 of a series on evaluation of scientific publications. Deutsches Ärzteblatt International, 107(19), pp. 343-348.

Klimont, J., 2020. Österreichische Gesundheitsbefragung 2019. Hauptergebnisse des Austrian Health Interview Survey (ATHIS) und methodische Dokumentation. STATISTIK im Auftrag des Bundesministerium für Soziales, Gesundheit Pflege und Konsumentenschutz. 2019 ed. Wien: STATISTIK AUSTRIA.

Koo, J., Kim, Y. S., Kim, B.-I. & Christensen, K., 2013. A comparative study of evacuation strategies for people with disabilities in high-rise building evacuation. Expert Systems with Applications, 40(2), pp. 408-417.

Manley, M. & Kim, Y. S., 2012. Modeling emergency evacuation of individuals with disabilities (exitus): An agent-based public decision support system. Expert Systems with Applications, 39(9), pp. 8300-8311.

Paier, D., 2010. Paier, Dietmar. Quantitative Sozialforschung: Eine Einführung. 1 ed. Facultas.wuv.