PROJECT DELIVERABLE REPORT

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

D6.3 PALAEMON Interfaces and HMIs toolkit

A holistic passenger ship evacuation and rescue ecosystem

MG-2-2-2018

Marine Accident Response

"This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 814962"

Document Information

Grant Agreement Number	814962	Acronym	PALAEMON
Full Title	A holistic passenger ship evacuation and rescue ecosystem		
Topic	MG-2-2-2018: Marine Accident Response		
Funding scheme	RIA - Research and Innovation action		
Start Date	1st JUNE 2019	**Duration**	36 months
Project URL	www.palaemonproject.eu		
EU Project Officer	Georgios CHARALAMPOUS		
Project Coordinator	AIRBUS DEFENCE AND SPACE SAS		
Deliverable	D6.3 PALAEMON Interfaces and HMIs toolkit		
Work Package	WP6 – PALAEMON Back-End Infrastructure		
Date of Delivery	**Contractual** M32	**Actual**	M33
Nature	R - Report	**Dissemination Level**	PU-PUBLIC
Lead Beneficiary	ITML CY		
Responsible Author	Vassilis Chatzigiannakis	Email	Vchatzi@itml.com.cy
		Phone	
Reviewer(s):	Kyriakos Giannakis (KT), David Gómez (ATOS)		
Keywords	Interfaces, HMI		

List of Author(s)

Full Name	Organisation
Vassilis Chatzigiannakis	ITML
Alfredo Gardel	UAH
Ashraf Ragab	JU
David Gomez	ATOS
Julia Ruiz	ATOS
Kyriakos Giannakis	KT
Maria Belesioti	UAEG
Bogdan Gornea, Cristina Ivan	SIMAVI

Revision History

Version	Date	Responsible	Description/Remarks/Reason for changes
0.1	14/10/2021	ITML CY	DoC Draft
0.2	23/10/2021	JHS	Inclusion of partners' contributions
0.3	07/12/2021	UAH	Inclusion of partners' contributions
0.4	16/12/2021	KT	Inclusion of partners' contributions
0.5	24/12/2021	ATOS	Inclusion of partners' contributions
0.6	14/01/2022	UoAeg	Inclusion of partners' contributions
0.7	28/01/2022	ATOS, KT	Internal Review
0.9	15/02/2022	ITML	Changes from reviewers' feedback
1.0	16/02/2022	ITML	Review & Release

Contents

Abbreviations

AIS	Automatic Identification System
BLE	Bluetooth Low Energy
CCTV	Closed-Circuit Television
DFB	Data Fusion Bus
DFB	Data Fusion Bus
DPA	Designated Person Ashore
DSS	Decision Support System
GDPR	General Data Protection Regulation
GUI	Graphical User Interface
HMI	Human-Machine Interface
HW	Hardware
IDP	Identity Provider
IMEI	International Mobile Equipment Identity
IMO	International Maritime Organization
IMSI	International Mobile Subscriber Identifier
ISM	International System Management
MAC	Media Access Control
MSISDN	Mobile Station Integrated Services Digital Network
MVP	Monitoring and Verification Platform
PaMEAS	Passengers Mustering and Evacuation Process Automation System
PIMM	PALAEMON Incident Management Module
SC	Smart Camera
SC	Smart Camera
SDK	Software Development Kit
SOPEP	Shipboard Oil Pollution Emergency Plan
SSS	Smart Safety System
SWH	Significant Wave Height
VDES	VHF Data Exchange System
VDR	Voyage Data Recorder
VHF	Very High Frequency
WFT	Weather Forecast Toolkit

Figures

Tables

1 Introduction

The PALAEMON framework aims at offering a solution with a significant number of complementary services to be offered to a large variety of different stakeholders/ users, strong security properties, and an operating infrastructure that offers situational awareness and informs users on specific contexts while providing solutions for passenger ship evacuation and rescue scenarios. Such an advanced environment must be presented in an easy to use and understandable way to the end users so as to help them embrace the offered features and understand the benefits of using such an ecosystem by removing the complexity of the underlying technologies. The securely and privacy-preserving stored data, analytics results and user transactions will be utilised by advanced visualisations that can foster forensics analysis. Temporal inspection of given metrics and combinations of relevant measurements in interactive visual representations will facilitate investigation on specific alerts and can help users to better protect against future incidents and vulnerabilities. The PALAEMON visualisation module, to be developed within this task, will comprise a set of Human Machine Interfaces (HMIs) that allow users to interact with the information in a visual and intuitive way. The aggregation and combination of data will help improve the understanding, thus leading to finding better solutions in many different scenarios related to passenger ship evacuation and rescue cases.

1.1 Purpose and Scope

The main objective of this report is to develop the PALAEMON visualisation module, which will comprise a set of interfaces and HMIs that allow datasets to be viewed graphically and combined with other datasets to improve the understanding of the end - user and identify possible solutions in many different scenarios related to passenger ship evacuation and rescue cases.

1.2 Structure of the Deliverable

The deliverable report is structured in the following sections, besides the Introduction and Summary sections:

Section 2 outlines the PALAEMON Interfaces, the human interaction with the platform and DFB Access and its further deployment details. Reference is also made to the system outputs, which are presented in the form of HMI and are conceived to display useful data to people during an evacuation situation.

Section 3 outlines the technical specifications of the HMI Interfaces and their core intentions and contributions to the project, including reference to their parallel integration.

Section 4 wraps up all the contributions and components presented throughout the report, abridging the main conclusions and lessons learnt on visualization aspects.

1.3 Relation to other WPs and Tasks

WP6 is related to the development of the PALAEMON back-end to support the on-board operations at both operational and strategic levels. Within this Work Package and specifically in this Deliverable, D6.3, we describe the PALAEMON visualization module which will be developed within Task 6.3. Also, this report comprises a set of interfaces and HMIs that allow datasets to be viewed graphically and combined with other datasets to improve the understanding of the end - user and identify possible solutions in many different scenarios related to passenger ship evacuation and rescue cases. Taking into consideration D2.7

PALAEMON Reference Architecture (v2), in Section 2 we present the PALAEMON Interfaces and Data Fusion Bus Access. As we have introduced in D6.2 (PALAEMON Data Fusion Middleware), the cornerstone of Data Fusion Bus relies on the so-called ELK (Elasticsearch + Logstash Kibana) stack[1], mainly composed of a tuple of three complementary components. Furthermore, from a human machine interface, or said in other words, visualization standpoint, we describe in Section 3 a handful of dedicated components. For instance, Weather Forecast Toolkit (WFT) which provides the weather conditions charts that show the expected percentages of injuries and deaths for each incident displayed at the PALAEMON Incident Management Module (PIMM)'s dashboard, as documented on Deliverable 3.6 (PALAEMON Weather Forecast Tool). In addition, information regarding PALAEMON On-Board Decision support system is also provided, sourced by the outcome of the Deliverable 6.4. Emphasis is placed on PALAEMON Incident Management Module, which is a component that unifies the different components and makes them work together and it is related to Deliverable 6.5 (PALAEMON Incident Management Module PIMM) which describes this central multi-layer agent that will be capable of real time prediction and prevention, early detection and multi-response and risk mitigation. In addition, this report also copes with components that come from other WPs, such as WP3, where the Smart Safety System aim is to improve the safety evacuation system on board passenger ships and to provide information on the condition and all relevant information during the evacuation process (see Deliverable D3.2). Also, Passengers Mustering and Evacuation Process Automation System (PaMEAS) (D5.10) which will seamlessly integrate, through specific APIs, with other PALAEMON backend infrastructure systems and onboard tool and service is presented on Section 3. Another interface described is the Smart Cameras (D5.18) which nodes gather visual information about people in different areas, monitor people's actions and inform the crew with updated data.

As can be easily inferred, this task embraces the breakthrough achieved throughout the main core technical WPs (WP2, WP3, WP5 and WP6). As a final stage, all these components will be integrated altogether and will lead to a standalone PALAEMON Communications Platform, which will be documented in WP7's deliverables.

2 PALAEMON Interfaces

2.1 PALAEMON Core architecture

In D2.7, we defined the so-called PALAEMON Reference Architecture (v2), whose main outcome is represented in Figure 1. In this schema, we represent the logical pipeline undergone by the information, from its origin (i.e., data sources at the left), to the group of system outputs that are consumed by the final stakeholders (right part of the figure).

[1] https://www.elastic.co/what-is/elk-stack

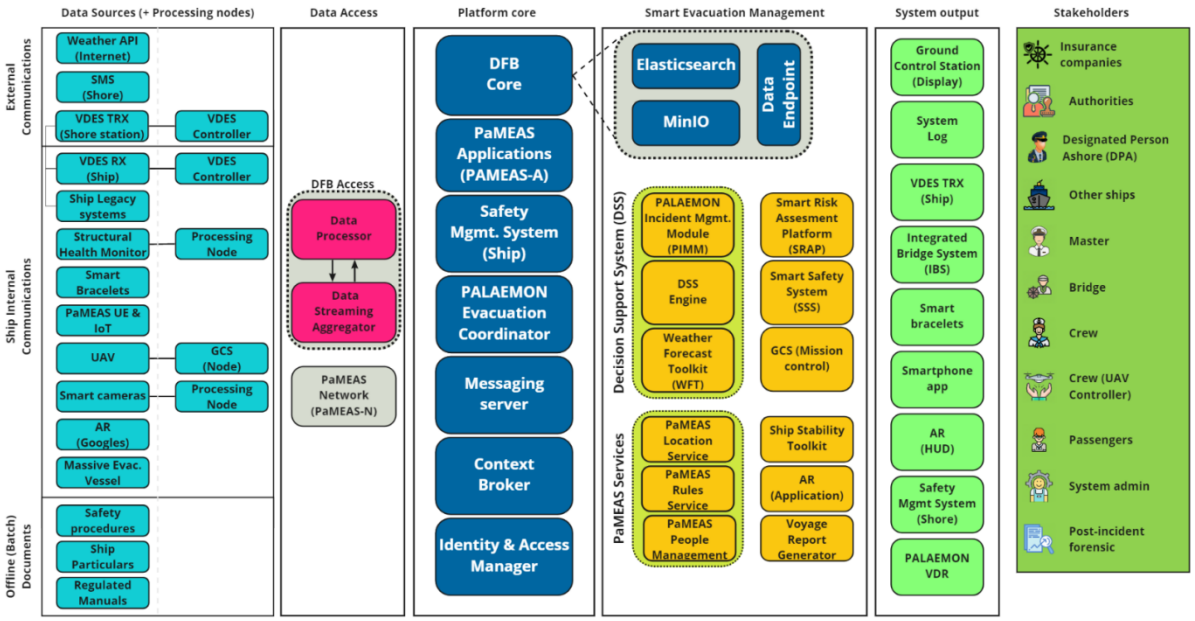

Figure 1 PALAEMON Reference Architecture v2

In the scope of this deliverable, it is worth paying attention to the right part of the figure, where the human interaction with the platform takes place. As for the system outputs, most of them are represented in the form of HMI and are conceived to display useful data to people during an evacuation situation. The only exception corresponds to the Very High Frequency (VHF) Data Exchange System (VDES) transceiver[2], a component responsible to transmit VDE-channel [3] messages from ship to shore.

Table 1 System output & Target stakeholder binding

System output	Description	Target stakeholder(s)
Ground control station (display)	Visual display to control UAVs' missions	Master, Bridge Command Team (UAV Controller)
Integrated Bridge System	An array of monitors that display on the bridge and/or safety room all the graphical user interfaces (e.g., SSS, PIMM, PaMEAS, etc.)	Master, Bridge Command Team, System admin
Smart Bracelets	A visual display that shows easy instructions to users + button to trigger alarms (e.g., fall notification)	Passengers, Crew Members
Smartphone app (PaMEAS)	Visual feedback that displays PaMEAS data (e.g., instructions, messages, etc.)	Passengers, crew members
Augmented Reality HUD	Virtual information displayed on Googles, which is merged with the user's real-world sight	Crew

[2] https://spacenorway.no/vhf-data-exchange-system-vdes-page-under-development/

[3] IALA VDES Frequently Asked Questions (FAQ) - https://www.iala-aism.org/technical/connectivity/vdes-vhf-data-exchange-system/

Safety Management System	Document management, procedures, contingency plan visualization, etc.	Designated Person Ashore (DPA)
VDES TX (no HMI)	Transceiver to exchange data between ship and shore	DPA
System log	Logging information from all SW components to assess their correct operation	System admin
PALAEMON VDR	Report that compiles all the information generated around the PALAEMON platform (e.g., sensors, routes, videos, etc.)	DPA

2.2 Machine-to-machine Interfaces

As depicted in Deliverable 2.7 PALAEMON Architecture (v2) (see Figure 1), the components are divided into the following (five) categories. In that report, these layers were described as follows (excerpted from the original text):

- **Data Sources**: Heterogeneous group that encompasses any element that may generate any kind of information that will be subsequently leveraged elsewhere in PALAEMON. We categorized between four types of sources: *streaming* (e.g., real-time information coming from sensors), *batch data* (e.g., components that process and aggregate information after a scheduled time), raw documents (e.g., PDF files that are stored before the ship leaves the shore) and, finally, *multimedia audio/video streaming* (e.g., smart cameras, AR streaming, voice calls among crew members, etc.)
- **Data Access**: Intermediate layer in charge of funneling the information from the sources, leading to the platform core. At this level, the information may be filtered, transformed, aggregated, etc.
- **Platform Core**: Cornerstone of the PALAEMON platform, responsible for storing the raw data generated by the underlying data sources, thus offering it high-level services.
- **Smart Evacuation Management (SEM) system**: Atop the core of the platform, PALAEMON will come up with several heterogeneous services that will help stakeholders (e.g., Master, Bridge, crew in general, passengers, etc.) improve their response when it comes to proceeding to evacuate the ship.
- **System outputs**: At the very end of the workflow, added-value data and services outputs are represented/displayed in a format that brings about tangible benefits to the addressed stakeholders, leading to a notable (and innovative) evolution in the frame of the maritime emergency evacuation.

Within PALAEMON, Data Fusion Bus (DFB), is designed to provide a common way of collecting and combining diverse real-time data from multiple components, in a secure way and provide access to both real-time and historical data. So, instead of creating interfaces between the components that need to communicate, all messages are shared using an event-driven architecture and a common message bus.

More information about the internal architecture and technologies used in DFB, can be found in D6.2 PALAEMON Data fusion middleware

3 Human-Machine Interfaces

3.1 PALAEMON MVP

As it has introduced in D6.2, the cornerstone of Data Fusion Bus relies on the so-called ELK stack, mainly composed of a tuple of three complementary components: Elasticsearch[4], acting as a search engine alongside a persistence system (≈ database); Kibana[5], a user interface that allows the visualization of the data stored in Elasticsearch; and Logstash[6], a processing pipeline tool that helps ingest data from their original sources.

Focusing on a Monitoring and Verification Platform (MVP) standpoint, a quick configuration in Kibana offers the system administrator a simple-yet-full overview of the whole system. This will come to help early detect possible issues and lead to quicker reactions. This component complements the PALAEMON Core Monitoring (Section 3.2), which focuses more on software status tracking.

However, Kibana can be also used to display voyage-related data to be displayed e.g., on the bridge. Thanks to the easy and intuitive configuration, Kibana offers a wide visualization engine to display data to users.

For the sake of illustration, we span below a handful of screenshots that come to reflect the possibilities brought about by Kibana, when working with DFB core.

A good starting point is shown in Figure 2, where we compile at a simple glance, an overall view of a voyage[7], with the route, the number of people aboard (passengers + crew) and the estimated departure and arrival times. This picture shows an example of the usability of the MVP to represent data in an extremely graphical way, on top of DFB (namely, grasping the information from Elasticsearch).

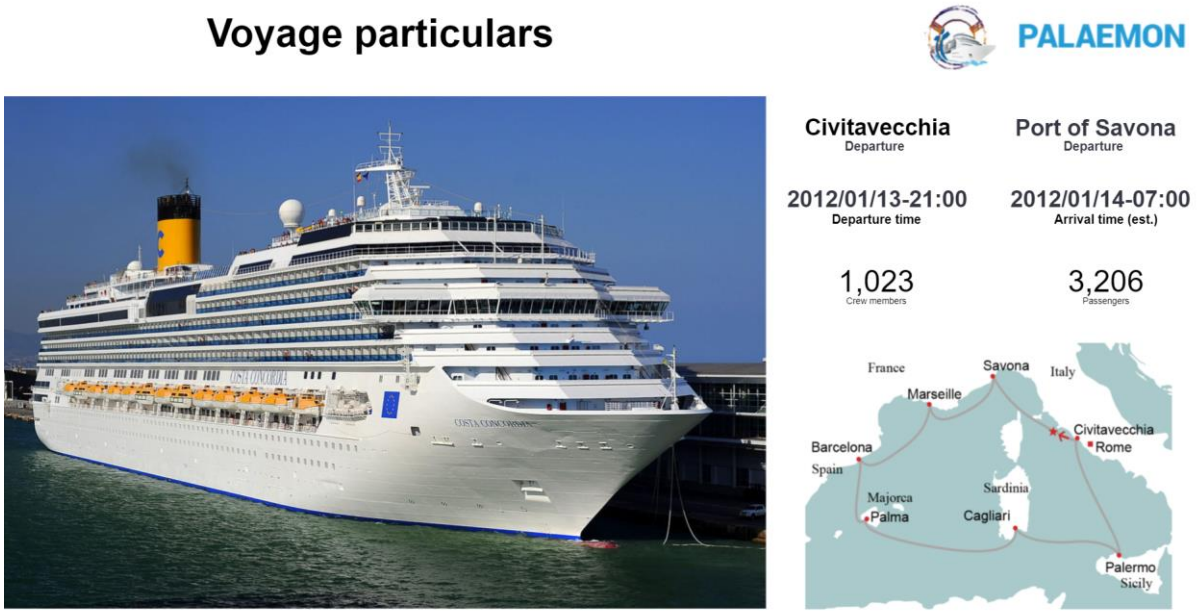

Figure 2 Kibana Canvas voyage particulars layout

[4] Elasticsearch homepage - https://www.elastic.co/what-is/elasticsearch
[5] Kibana homepage - https://www.elastic.co/kibana/
[6] Logstash - https://www.elastic.co/logstash/
[7] For the sake of demonstration, we stuck to the well-known Costa Concordia's incident to represent some easily recognizable data

Additionally, Figure 3 shows a sample of how we can display Automatic Identification System (AIS), mimicking legacy the way a monitor may show the information on a commercial Integrated Bridge Systems (IBS). In this illustrative example, we can represent the ship's current position, speed, and direction (heading), alongside some extra data gathered from PALAEMON's devices, e.g., yaw, pitch, and roll information, taken from the so-called Ship Structural Monitoring Ecosystem[8], or the PALAEMON Evacuation Status[9]. To remark a limitation witnessed in Kibana, the central part of the figure has been kept only for representation purposes (the compass-ish layout), as we could not make it dynamic (at least in a straightforward manner).

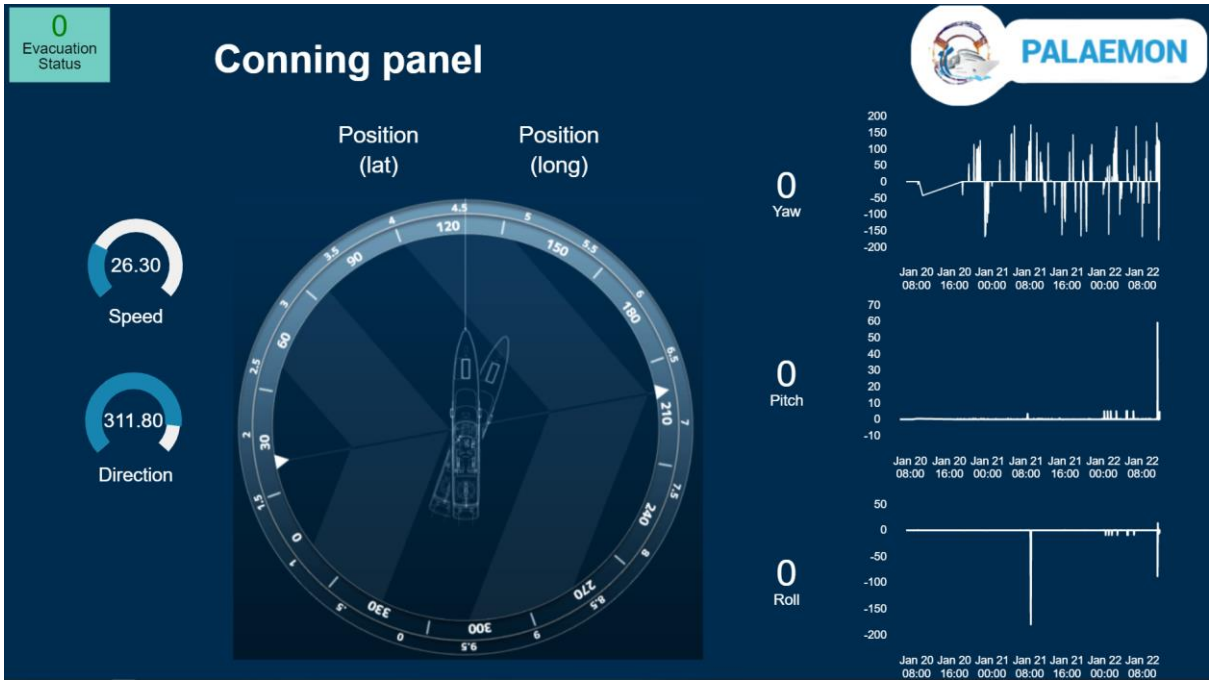

Figure 3 Kibana canvas AIS layout sample

Digging into some more technical options from Kibana, Figure 4 presents an overview of the messages captured in the platform within a time window. We can use this view to analyse the measuring rate of the components, aiming to e.g., detect potential connection outages.

[8] Ref to D6.1 – Ship Structural Monitoring Ecosystem
[9] Ref to D7.1 – PALAEMON Communications Platform

Figure 4 Kibana monitoring of individual data (sample based on Ship Structural Monitoring Ecosystem)

As the last example, Figure 5 displays a time-series plot with the information (averaged) of the data observed by the Ship Structural Monitoring Ecosystem, namely, the average yaw, pitch and roll observed by the device's accelerometers and gyroscopes. With this, we can analyse the actual nature of the data and e.g., quickly spot outliers, missing samples, etc.

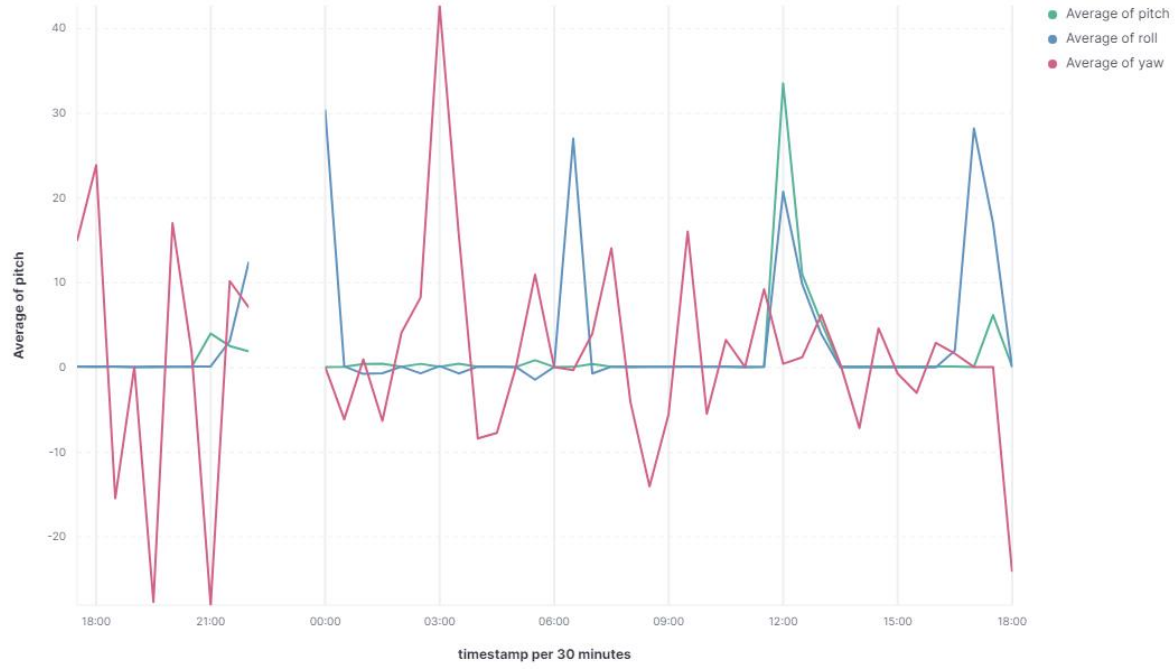

Figure 5 Kibana plot on individual data (sample based on Ship Structural Monitoring Ecosystem)

To wrap up, the main advantage is that this MVP, based on Kibana, offers a quick visualization framework, thus saving developers from coding a graphical users interface from scratch; in fact, people without any kind of technical or development skills would be able to carry out something showable in a matter of minutes. As a counterpart, it offers less flexibility (with several pre-defined visual assets) that limits a fully tailored approach (e.g., lack of actionable

elements). Due to this, we lean on other components (described in the next sections) to offer a completely bespoken PALAEMON smart evacuation solution.

3.2 PALAEMON CORE Monitoring

The Platform Core (though DFB core) is responsible for storing the raw data generated by the underlying data sources, thus offering it high-level services. Basically, any kind of information either generated or consumed by data sources or high-level services (respectively) must go across this module.

Two of the key subcomponents of PALAEMON Core are:

- Apache Kafka[10]: Kafka acts as a message broker allowing intercommunication of components in real-time. It offers higher fault tolerance in comparison to traditional message brokers supporting significantly higher throughput.
- DFB core: It acts as a monitoring stack that provides the overview of the DFB subcomponents, provides historical data and metrics, sends notifications about problems that may arise and checks for application or infrastructure errors. Using monitoring tools like cAdvisor[11] and JMX[12] the metrics are exported and stored in a Prometheus[13] database. The metrics are aggregated as needed and custom alerts can be configured to produce real-time alerting for any problems. Grafana[14] is used to provide graphs and custom set alerts.

Screenshots of Grafana monitoring the Kafka broker are depicted in Figure 6 and Figure 7.

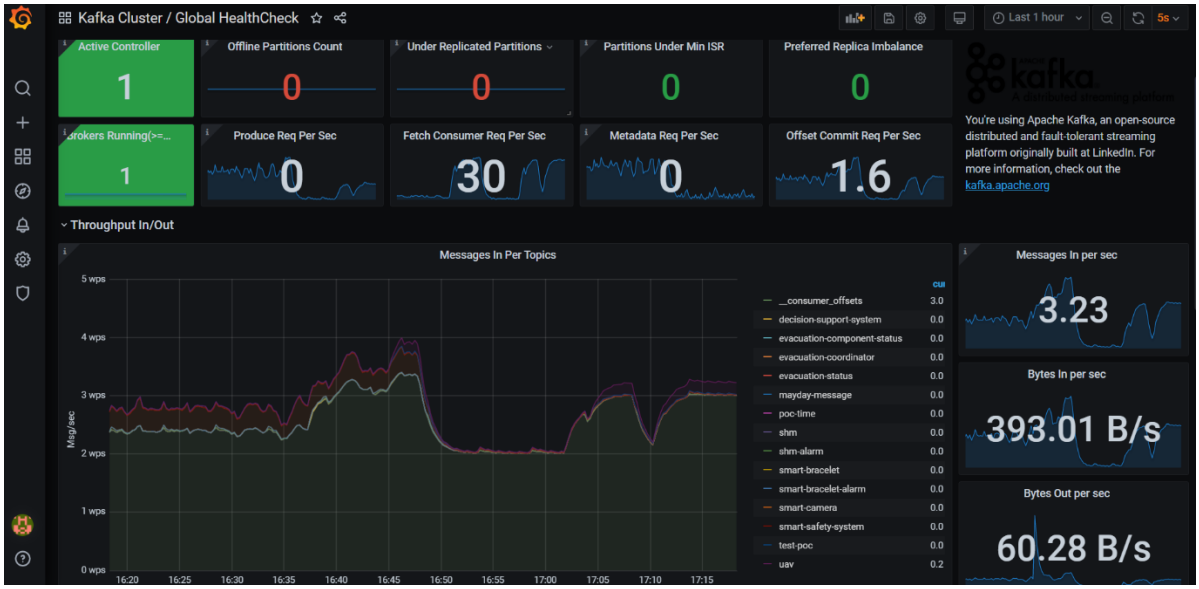

Figure 6 KAFKA Monitoring GUI – Messages per topic

[10] https://kafka.apache.org/
[11] https://github.com/google/cadvisor
[12] https://www.oracle.com/java/technologies/javase/javamanagement.html
[13] https://prometheus.io/
[14] https://grafana.com/grafana/?plcmt=footer

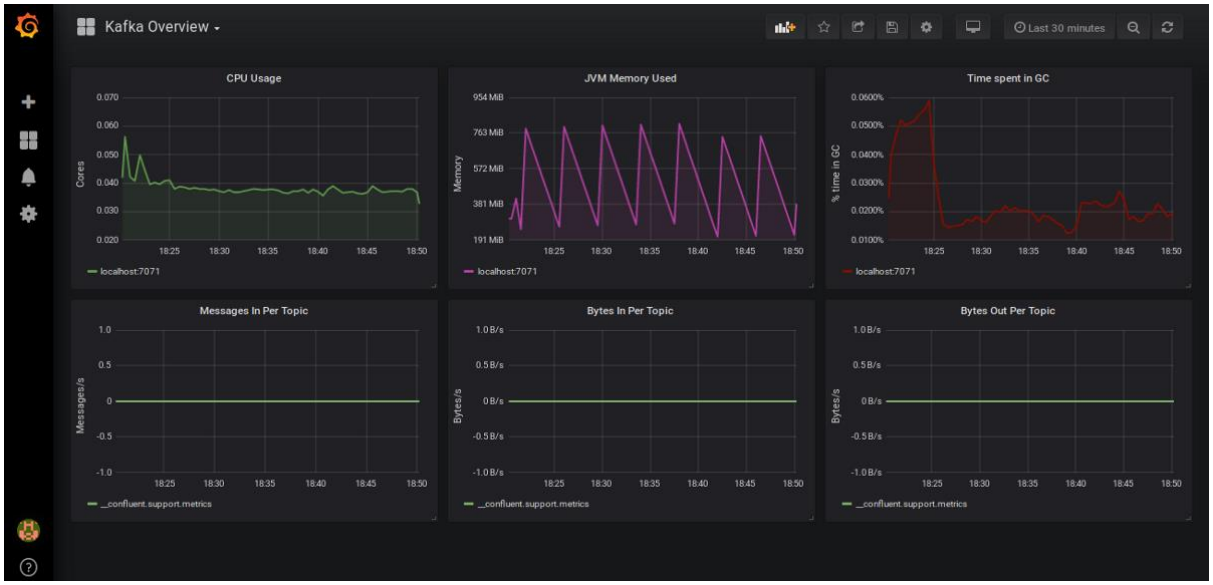

Figure 7 Kafka Monitoring – Resource utilisation

The reader might refer to D6.2 PALAEMON data fusion middleware, to find a deeper vision of this Human Machine Interface, where we display the information visually and intuitively to ease the detection of potential platform malfunctions.

3.3 PALAEMON Incident Management Module

The PALAEMON Incident Management module (PIMM) is a corner hub for managing and displaying information of different modules during an incident. PIMM is a component that unifies the different components and makes them work together. Through its friendly Graphical User Interface, access is provided to critical PALAEMON components, to be used by the Master and the Bridge Team. For example, when an incident occur, the Master can use the PIMM to view the suggested plan of action, with all the essential information from other connected components which feed the Decision Support System (DSS) and Weather Forecast Toolkit (WFT) to display useful information to the Master. Following the same example, Master's decision (i.e., in the form of e.g., evacuation orders) will be visually caught through this service and will lead to the corresponding event generation at the Ship Evacuation Coordinator.

As a matter of fact, DSS and WFT are directly integrated as part of the PIMM layout in the PALAEMON platform. Besides, PIMM also includes other components' outputs as part of the main layout:

- Smart Cameras (D5.18 – Smart Cameras v2)
- Ship Stability Toolkit (D3.4 – Development of Ship Stability Toolkit v2)
- Smart Risk Assessment Platform (D3.10 – Development of Risk Assessment Platform v2)
- PALAEMON Evacuation Coordinator (D7.1 – PALAEMON Communications Platform)
- PaMEAS (with a basic representation of people counting inside the Massive Evacuation Vessels – MEVs)

3.3.1 Weather Forecast Tool

The goal of the Weather Forecast Tool (WFT) is to identify the most appropriate set of actions that meet the needs of the corresponding incident case considering the weather conditions and utilizing past incident cases. Moreover, the WFT identifies potential risky actions for

human life using historical data to raise the awareness of the crew members. Furthermore, WFT also provides the weather conditions (e.g., wind speed, wind direction, Significant Wave Height – SWH , etc.) and charts that show the expected percentages of injuries and deaths for each incident displayed at the PIMM's.

Furthermore, we provide the flow of gathering information about real-time weather data forecasting. In Figure 8, several components intervene in the pipeline, spanning up to three different tiers: on the one hand, the ship infrastructure establishes a VHF Data Exchange (VDE) link with the shore to exchange the data. Moreover, we use a stable Internet connection at shore level to get the data from a public service interface carried out by DANAOS (which have prepared a dedicated RESTful API to offer this service). The reader might get a full description of the data flow in D3.6 – PALAEMON Weather Forecast Tool v2.

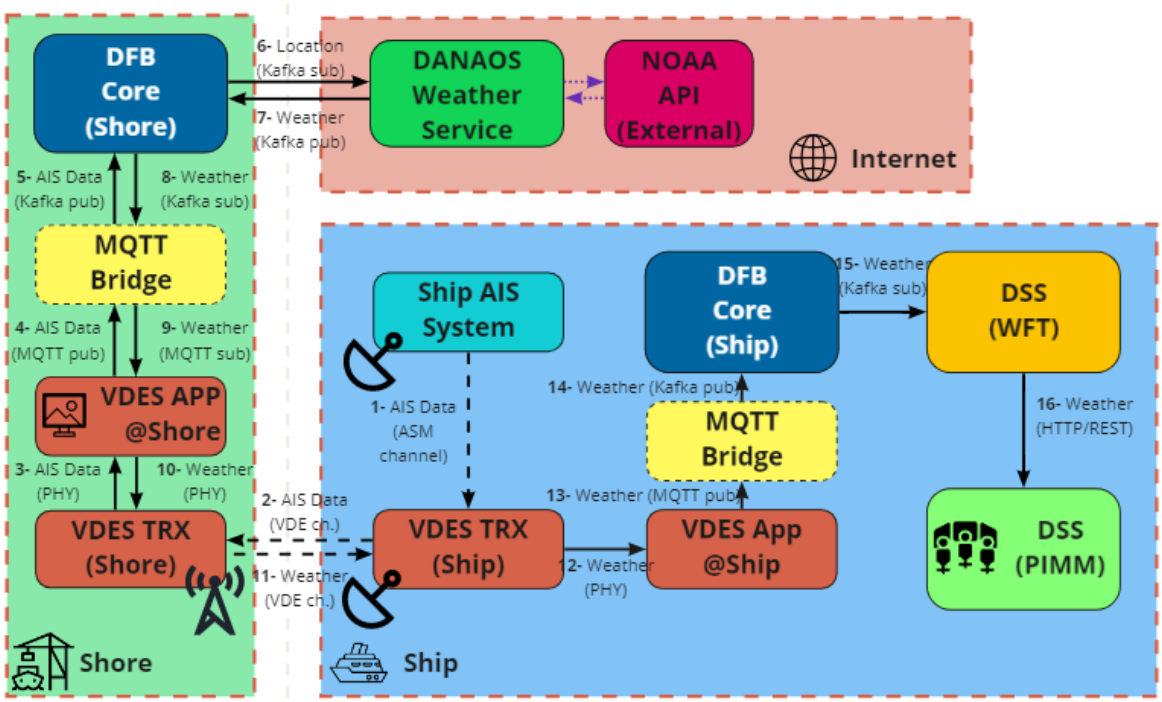

Figure 8 Weather forecast data (almost) real-time workflow (figure from D3.6).

3.3.2 Decision Support System

The PALAEMON Decision Support System (DSS) is a framework that helps the Master (and Bridge Command Team) take the proper actions/decisions after a grounding, fire, or collision incident of the ship, in order to soothe the adverse consequences of the incident and avert the problem that may drive to an evacuation of the ship. The DSS is based on the International System Management (ISM) Code. The ISM Code provides an international standard for the safe management and operation of ships and pollution prevention. Also, it takes notice of the Shipboard Oil Pollution Emergency Plan, known as SOPEP. The purpose of the SOPEP is to guide the Master and officers on board the ship concerning the steps to be taken when an oil pollution incident has occurred or is likely to occur. So, the actions that the DSS displays to the Master of the ship have been checked to comply with the protocol of the protection of the environment. The DSS will enrich the suggested actions with real-time data provided by other components. There is data from other components that are integrated into the DSS and are associated with the suggested actions. So, the DSS not only provides actions to the Master

but also combines/aggregates various data sources in a way that is useful to the Master. To illustrate the reader with some information sources that feed the DSS, we can indicatively list the following ones:

- Weather Forecast Data
- Shipboard Legacy Systems, including all the data coming from the sensors installed in the ship (i.e., native data). In this category, we can find fire and smoke detectors, watertight door sensors, flood sensors, status of fire extinguishing system, etc.
- Smart Risk Assessment Platform will calculate and return (in a numeric approach) the actual emergency level, combining at the same the information from various sources.

More information can be found at the D6.4 Development of PALAEMON On-Board Decision Support System.

3.3.3 PIMM User Interface

Technically speaking, through the use of hyperlinks, PIMM can link/embed to any other modules' dashboards (e.g., PaMEAS – see section 3.5). This way, a unified workflow can be achieved, and the Master/Bridge crew can navigate through all components/visuals in a seamless manner.

Figures 9, 10 and 11 show screenshots of PIMM. More information can be found at the D6.5 Development of PALAEMON Incident Management Module (PIMM).

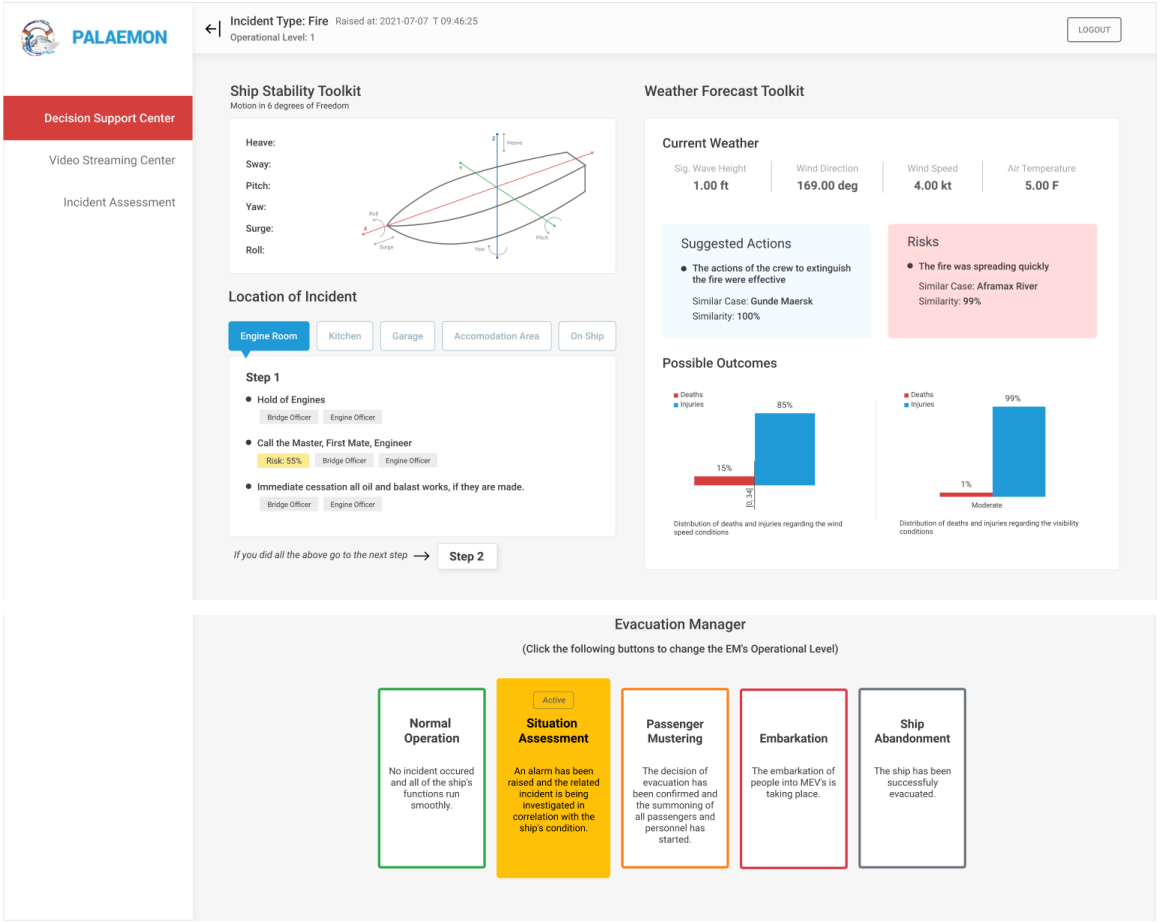

Figure 9 PALAEMON Incident Management Module – DSS – WFT – SST – Evacuation Coordinator

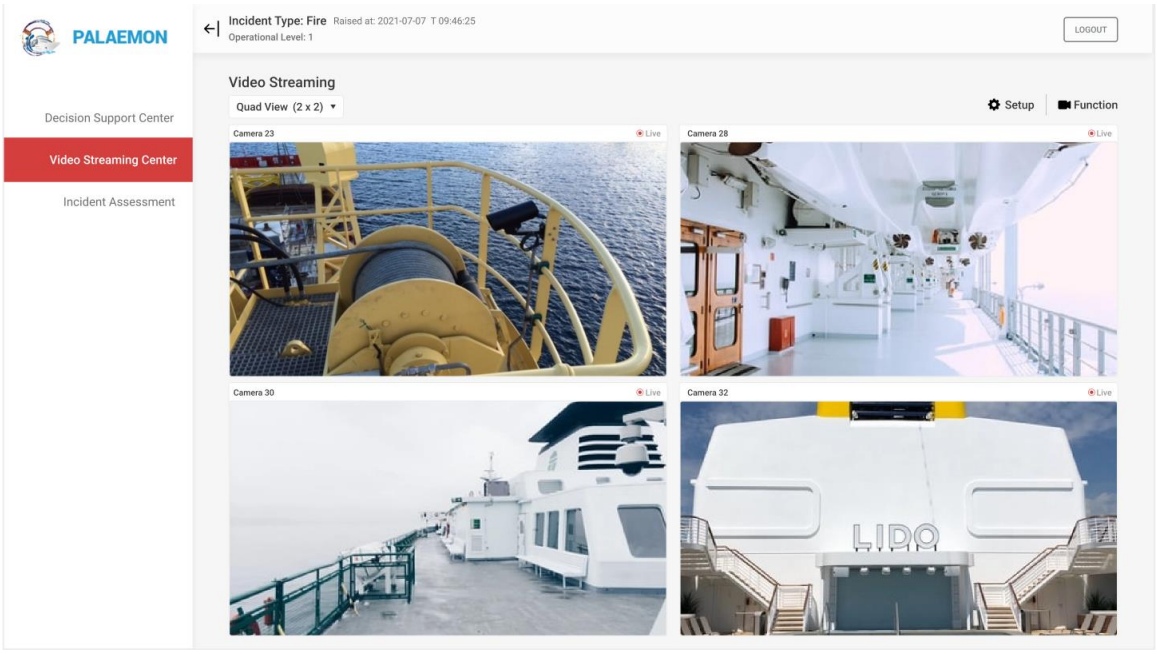

Figure 10 PALAEMON Incident Management Module – Smart Cameras System

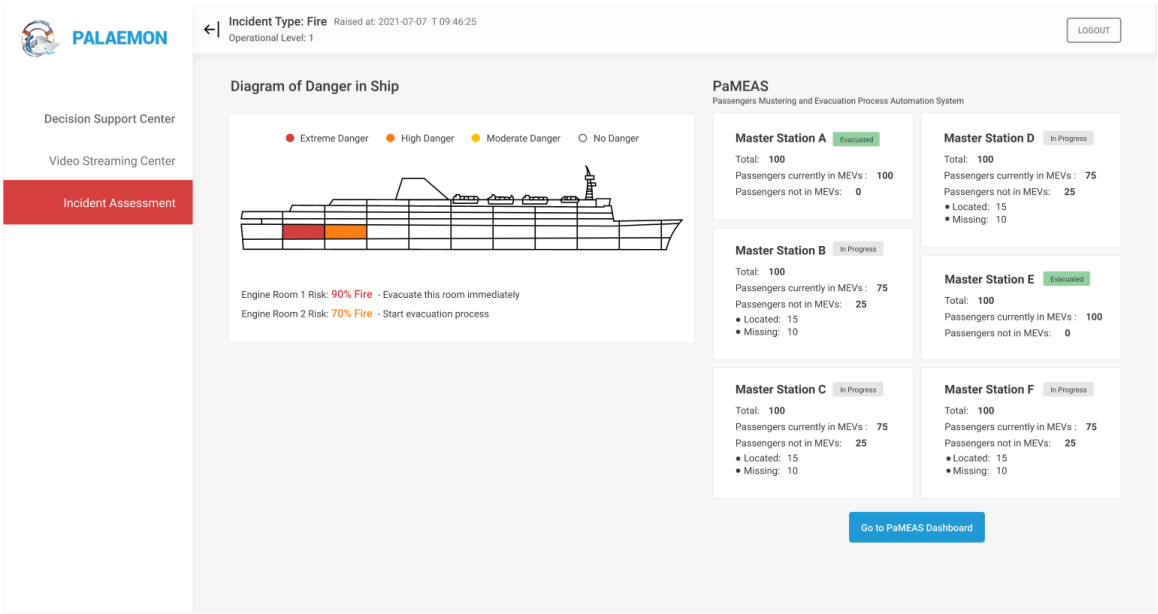

Figure 11 PALAEMON Incident Management Module – Incident Assessment Screen

3.4 Smart Safety System

The "Smart Safety System (SSS)" component of the PALAEMON project is intended to create an assisting safety system during evacuation. The system aims to improve the safety evacuation system on board passenger ships and to provide information on the condition and all relevant information during the evacuation process. All crew members on board should have access to this information. This also reduces the burden on VHF communication and provides a detailed overview of the situation on board.

The base Model of the SSS was built on similar System idea that is used for fire fighter coordination, while evacuation of buildings. The system is adaptable to assign teams and coordinate the communication in evacuation from buildings. Based on this idea, the first version of the system was developed and built to support the decision making for the officers and the evacuation team. (Ref: (Frauenhofer, 2019) , when they are proceeding with building evacuation. The needs and systematic changes are done and adapted within the system to meet the objective of T3.1 and the whole process of WP3.

The "Smart Safety System (SSS)" is designed to be an assisting safety system during evacuation. Communication on board shall get optimized by the use of the system. The interaction with other systems on board allows a more effective operation. The functions of the system are kept simple and easy to understand. It also provides an interface for the connection between the master and the evacuation team. The information is provided as a gadget in the (DSS) decision support system. Officers and crew members provide information and can rely on sensors (e.g., wristbands) and also on communication devices (e.g., tablet or Bluetooth receiver).

Through the whole process, it proved that many of the WP3 developed Systems can be more beneficial if it is integrated into one system. In the case of SSS, the system proves through its simplicity that it can be also efficient as a standalone system. Nevertheless, it was noticed by our partner that some Data, that is generated within the SSS can be helpful for other systems (e.g., DSS, Risk Assessment platform, etc.)

3.4.1 SSS Description

The "Smart Safety System (SSS)" is designed to be an assisting safety system during evacuation. Communication on board shall get optimized by the use of the system. The interaction with other systems on board allows a more effective operation. The functions of the system are kept simple and easy to understand.

The main dashboard of the SSS (see Figure 12) is divided into three main areas. The team overview is shown in the top left-hand corner, the log is directly below and the big area on the right side shows the different functions. As they can be used in different ways, the 5 windows are introduced afterwards.

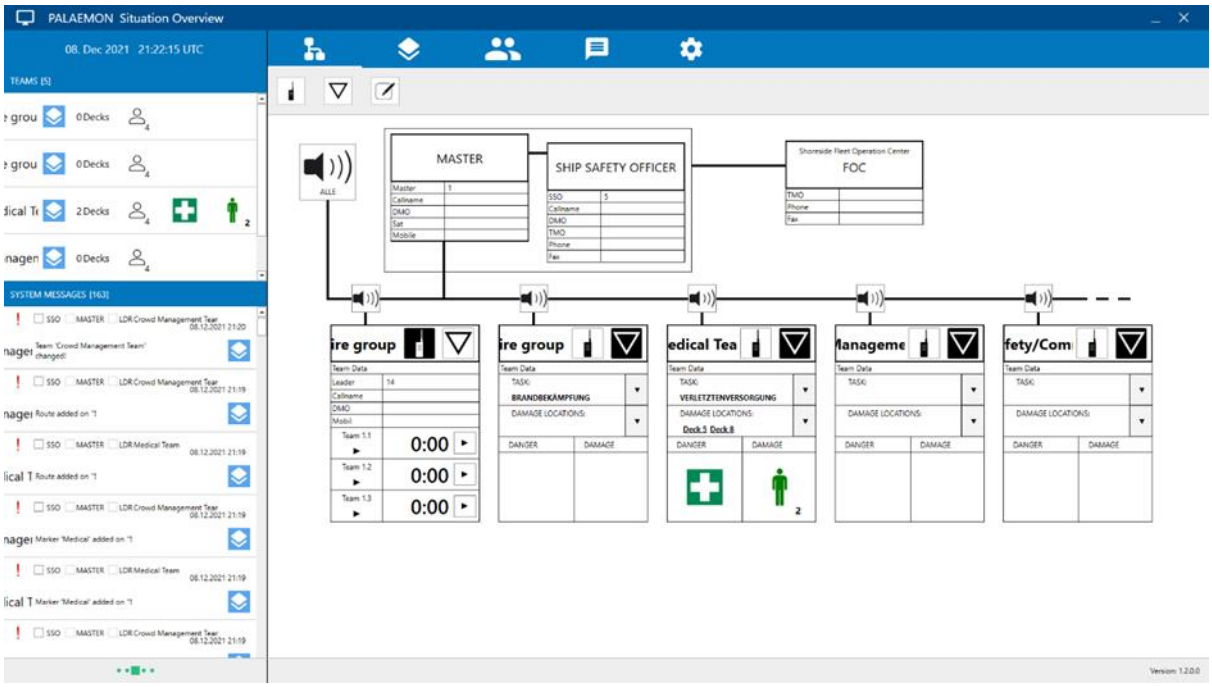

Figure 12 Smart Safety System main window layout

Figure 13 shows the team overview similar to Muster list duties on board. This diagram has to be arranged according to the specific ship requirements and circumstances in the Muster List. The review process is based on the following simple introduced arrangement:

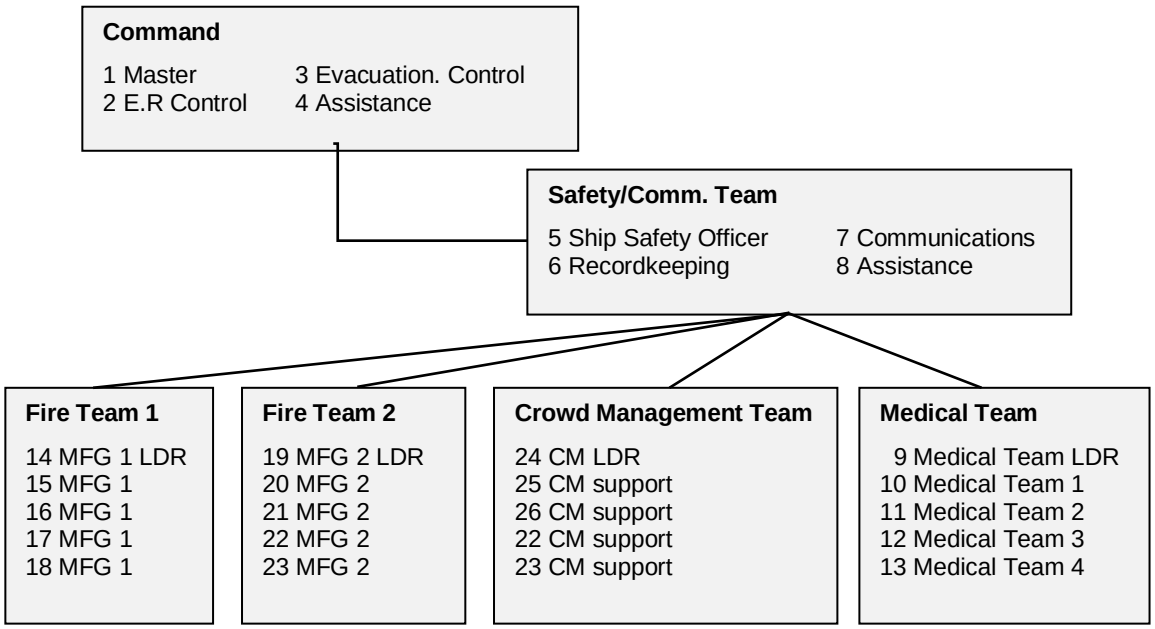

Figure 13 Muster List Scenario

The arrangement is used to check the given functions. Crew members are listed in figure 16 as a crew list. The list can be seen as a pool of all available persons for the setup in figure 12. The important feature of the SSS is the deck plan arrangement with safety tools to enable changes and information transfer. The review process is supported by a safety scenario on deck 8, described in detail later on.

The deck plan arrangement shown in figure 15, includes a side view and all decks from the selected ship:" Hellenic Spirit". The decks can be selected on the right side. Routes, symbols and markers can be added and used by the use of "drag and drop". The inserted information is now available on a local device and are send to all connected users by pressing the "safe button".

Figure 14 Available symbols

The crew list contains relevant information, such as Name, Qualification, Team and Comments. Some select options are available since others are added through the team setup as shown in figure 12. Names and comments are written by the user. The list has the same functions for editing and saving as the above presented surfaces.

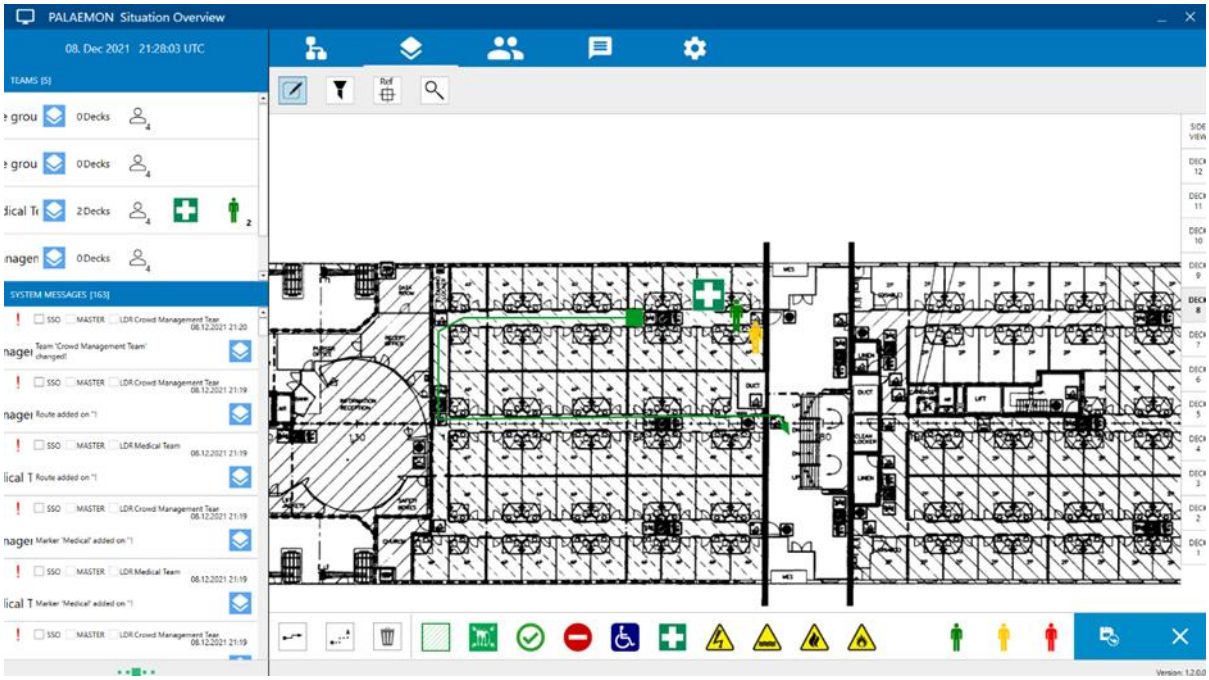

Figure 15 SSS Deck 8 toolbar

The logbook shows all actions with a time stamp and relevant contents. All movements are logged as “system messages”. Settings are located next to the logbook setup. Since the unit is designed to arrange information in and output, there are no relevant settings in the user unit. Settings are made in the control unit.

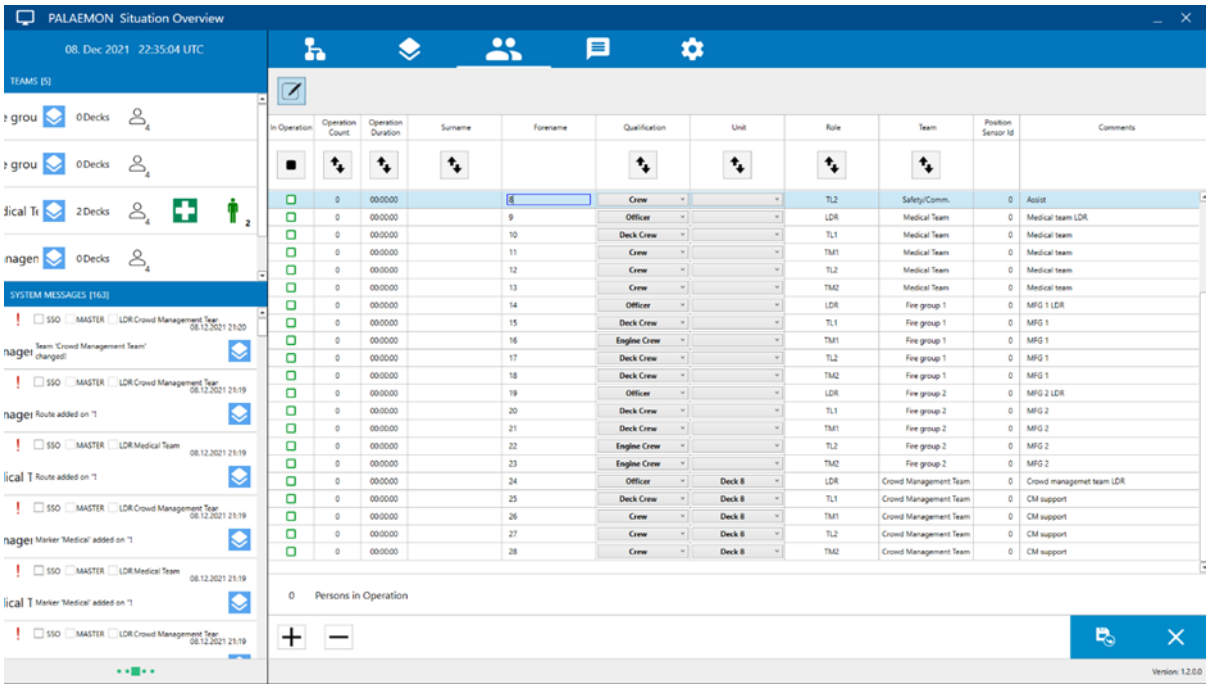

Figure 16 SSS crew list

3.5 PaMEAS

The Passengers Mustering and Evacuation Process Automation System (PaMEAS) component of the PALAEMON project, is intended to create a smart evacuation system in cases of emergencies. The software components that are required to accurately capture the

location of the passengers (and crew) in cases of emergencies and provide them with personalised evacuation instructions and assistance are the following:

- **People Management System (PMS)**: This component implements a Registration Service for the Passengers & Crew. It is implemented by a) the Pre-embarkation Registration Service and b) Embarkation Registration Service (including the PALAEMON Registration mobile app).
- **PALAEMON Wallet app**: This component implements the required cryptographic functions to enable its owner to receive from the PMS a digital identity in the format of a W3C Verifiable Credential[15]. This digital on vessel identity enables the holder to gain access to ship services via presenting it and proving ownership over it.
- **PALAEMON Passenger messaging app**: This component enables PaMEAS to send to the passengers personalised messages tailored to their specific needs (e.g. language, mobility status) and aid them in cases of emergencies.
- **PALAEMON Crew messaging app (under development)**: This component enables PaMEAS to send to the crew members personalised messages tailored to their specific responsibilities (e.g. emergency roles) and accurate location data to guide them and improve their efficiency in cases of emergencies.
- **Aruba Meridian app**: This component enables the acquisition of the real time location of the users of the system, its submission to the backend of PALAEMON and its visualisation.

Eventually, the functionality of these mobile apps might be merged to create a single PALAEMON mobile app to simplify the process and improve the user experience.

3.5.1 People Management System - PMS

The People Management System enables passengers and crew members to register with the PaMEAS to gain access to enabled on vessel services, the most prominent of which is the Emergency Evacuation Service. To ensure the accuracy of the registered information as well as maintain a solid user experience the registration process is split into two processes:

1. **Pre-embarkation Registration**: This process takes place prior to the user's embarkation. During this phase, the user creates their profile in the Palaemon backend registering the required personal identification information (via the connected eID authentication framework), medical and mobility status and or voyage and crew specific information.
2. **Embarkation Registration**: This process takes place once the user embarks the vessel and handles the accurate registration of the user's devices, ensuring that the user's location (as perceived by the system's sensors) is accessible only by authorised safety critical applications.

3.5.1.1. Pre-embarkation Registration process: flow and screenshots

1. The pre-embarkation Registration service is implemented as an online web service (publicly accessible through the internet via a simple web browser). Upon accessing it, passengers and crew are required to authenticate using their official National eID, via eID Service provider connected to the system (e.g., eIDAS Network).

[15] https://www.w3.org/TR/vc-data-model/

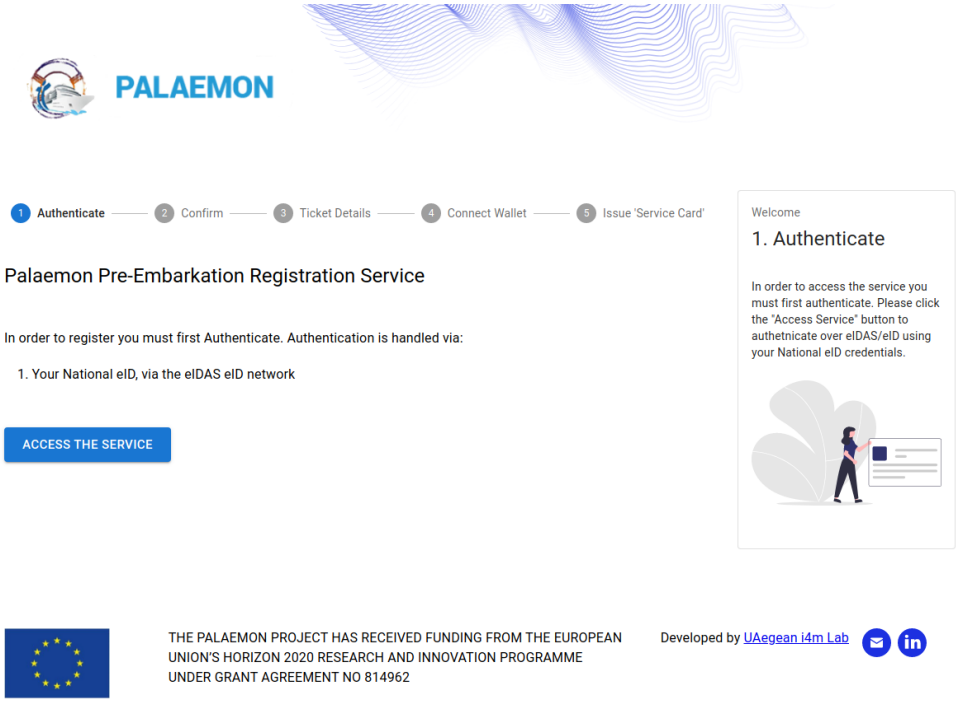

Figure 17 User authentication using their official National eID

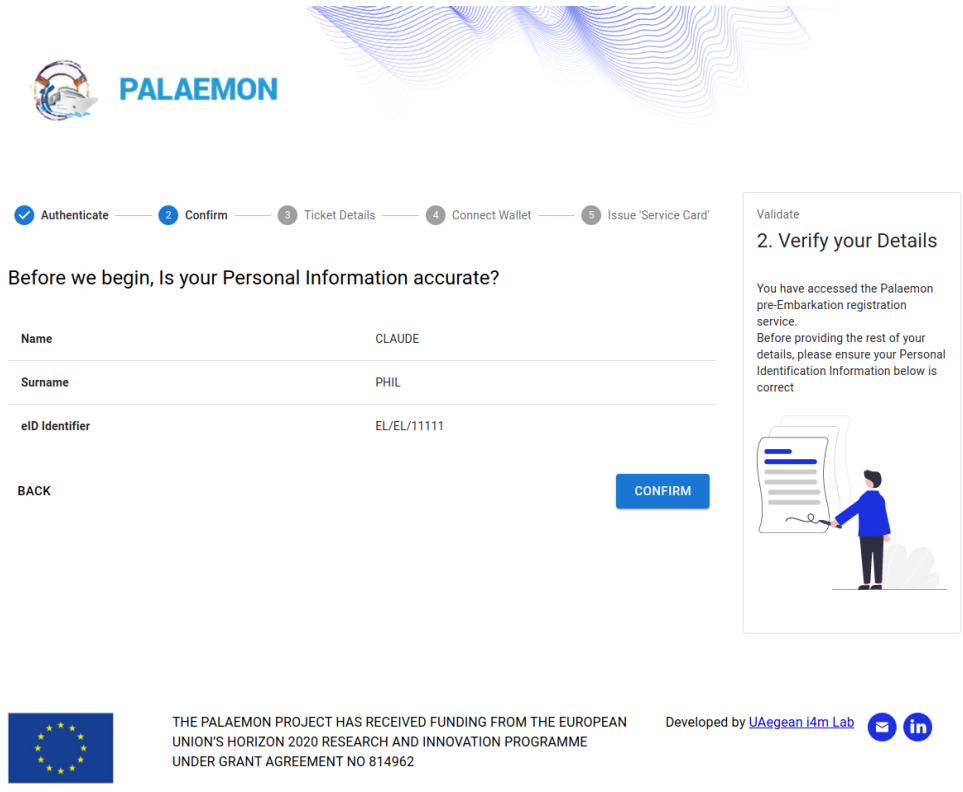

Figure 18 Confirmation of personal information

2. After authentication, their identity profile is extended with the information provided through the interconnection of PMS with the Customer Relationship Management

(CRM) System of the Ship Owner Company and additional self-attested data (e.g., Medical and Mobility status).

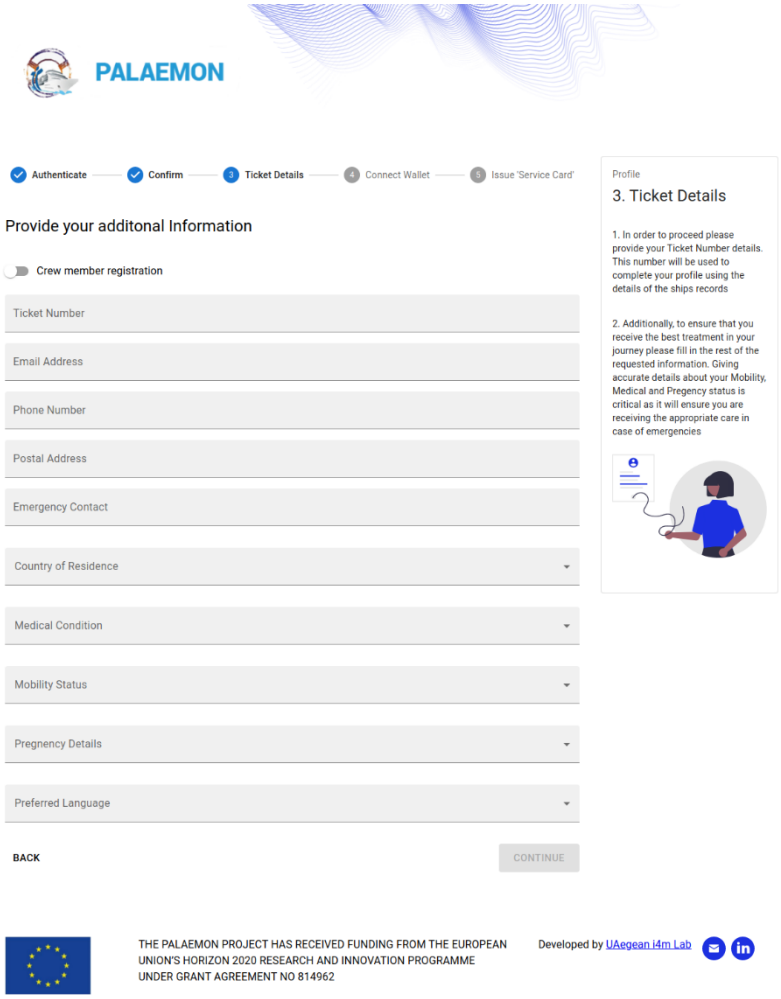

Figure 19 Provision of Passenger details

3. Crew members are required to complete their registration by declaring their professional information details (e.g., Emergency Situation assigned Role).

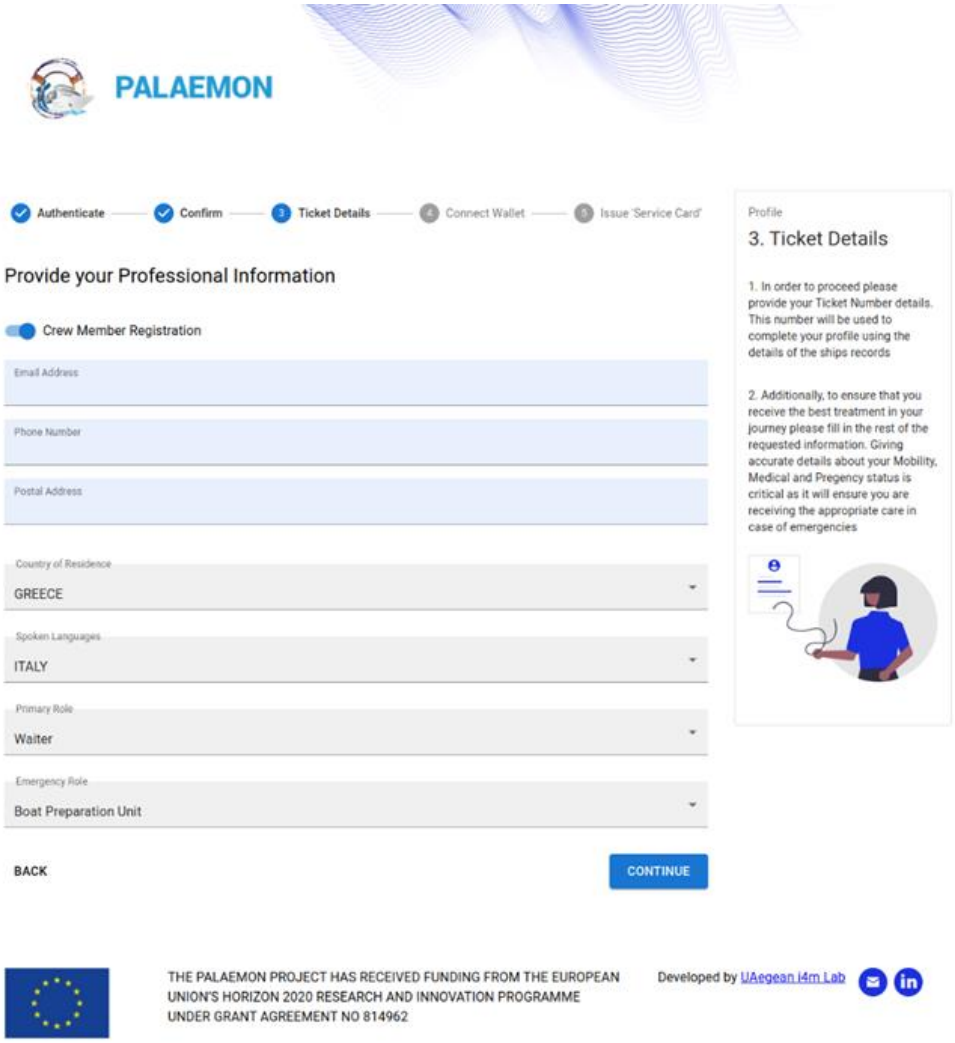

Figure 20 Provision of Crew Member details

4. At the end of this process, the users are issued with a “PALAEMON Service Card”. This “Card” is implemented as a W3C Verifiable Credential and allows the user to instantly authenticate (and additionally prove their profile attributes, e.g., role) at any PALAEMON enabled service without the need for access to an external eID System or maintenance of an internal PALAEMON Identity Provider (IDP) that would burden the users with credential management.

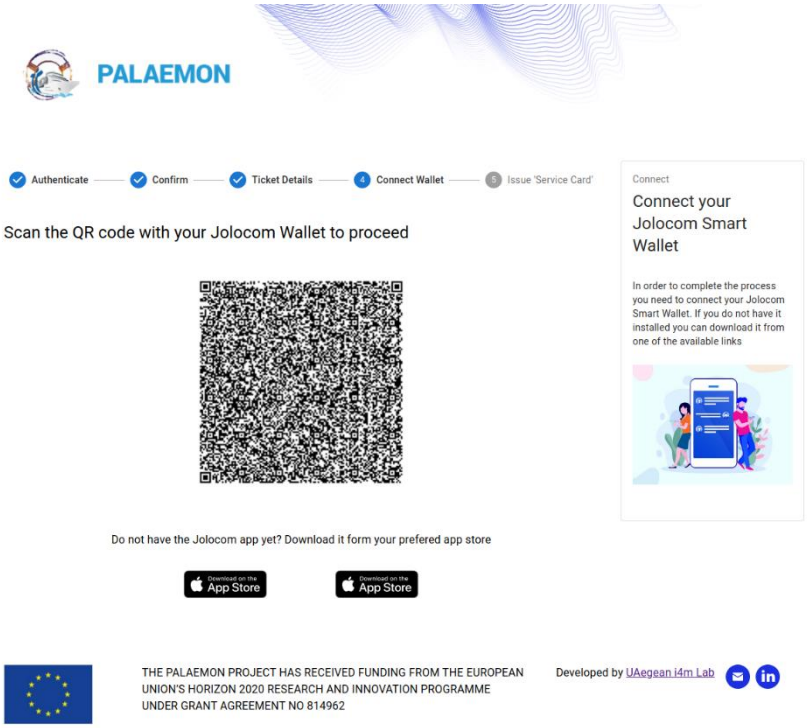

Figure 21 Pairing of PALAEMON Wallet app to session

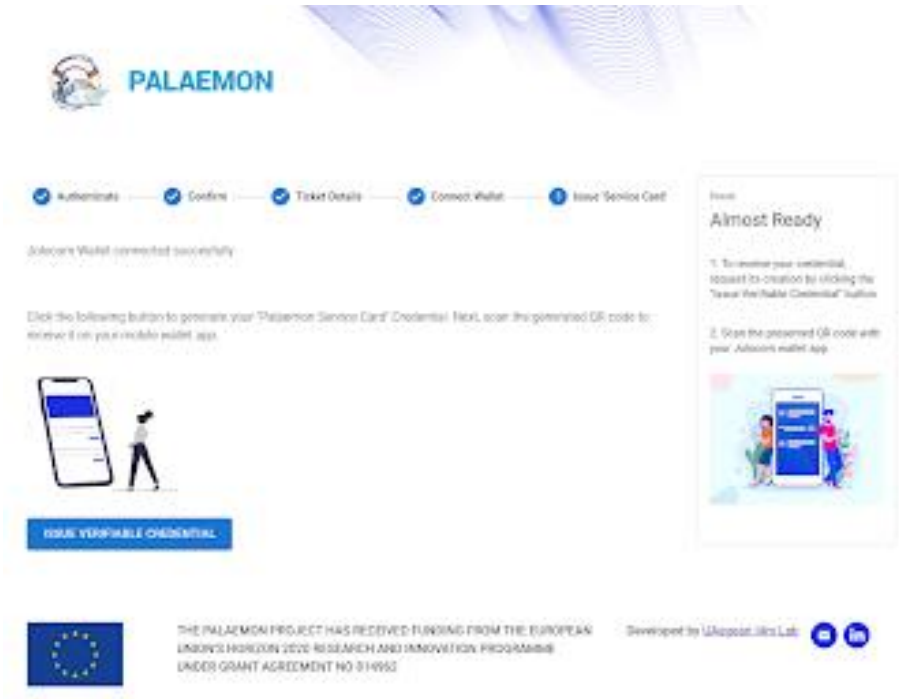

Figure 22 Request of Creation of "PALAEMON Service Card"

Figure 23 Transmission of "PALAEMON Service Card"

3.5.1.2. Embarkation Registration process: flow and screenshots

1. The user's (Passenger or Crew) profile is completed once the user registers the devices they are equipped with. To ensure the accuracy of this information, this part of the registration takes place during the embarkation of the user, via the Embarkation Registration Service. This service is implemented as a web service that is only accessible on the Ships intranet (to ensure that the devices are only registered during embarkation) usually via the mobile browser of the user.
2. To access this service the user is requested to authenticate by presenting their previously issued "PALAEMON Service Card".

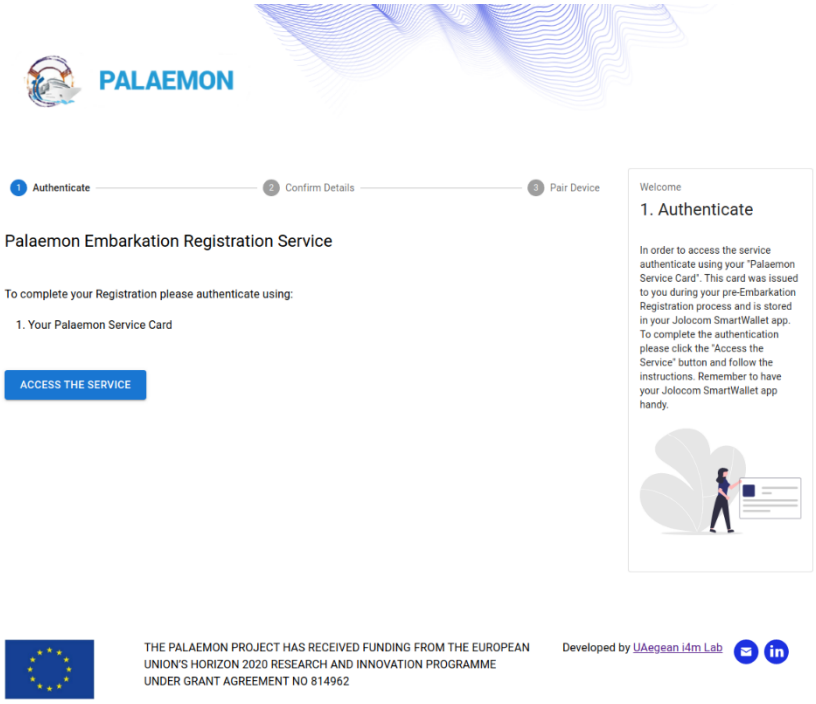

Figure 24 Embarkation Service Access

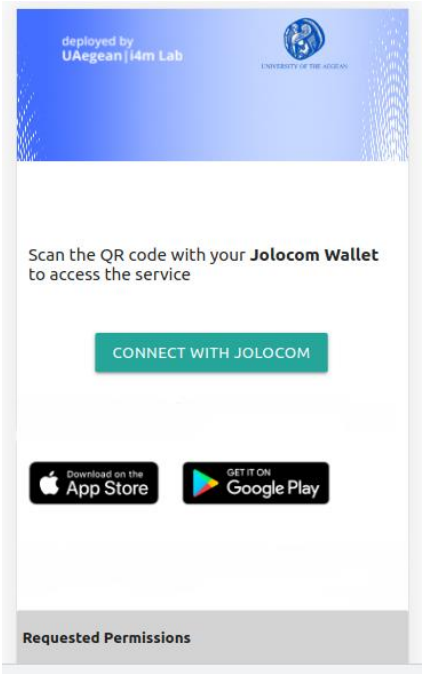

Figure 25 "PALAEMON Service Card" Disclosure Request

3. Next, the user is requested to confirm the accuracy of the received information.

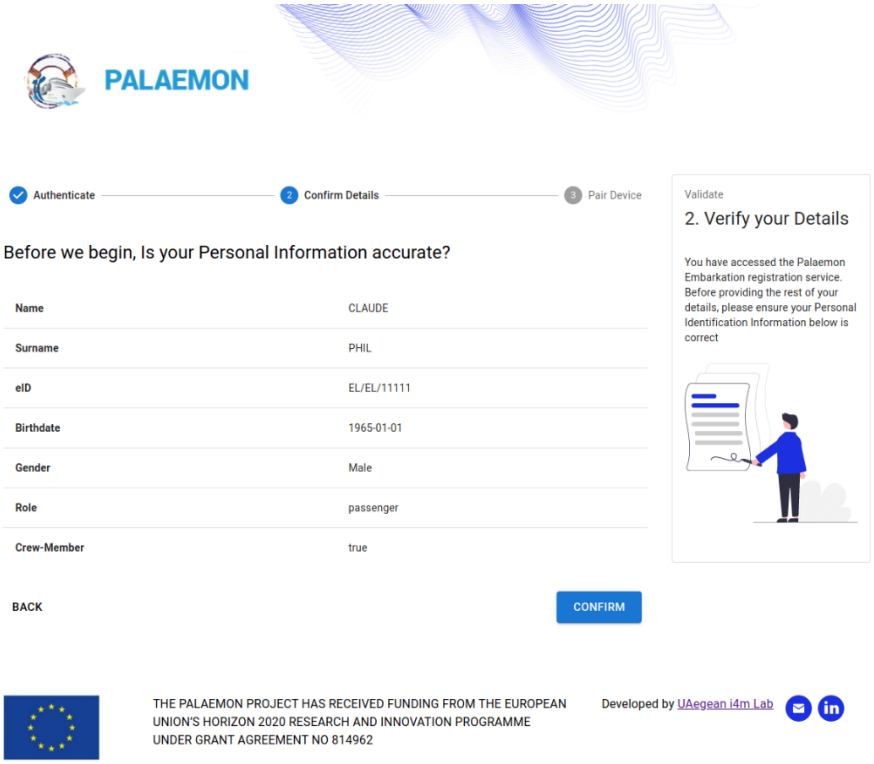

Figure 26 Profile Confirmation

4. After confirming their profile information, the user is requested to pair their device to their PMS profile. This results in the registration of the digital fingerprint of their device that essentially acts as the “digital doppelganger” of the user in the premises of the vessel enabling access to location sensitive services (most importantly the Emergency Evacuation Service). To do so, the user (passenger or crew) is requested to scan a QR code (or click on a deep link) with a suitably implemented mobile app (PALAEMON Registration mobile app). This results in the sending of the information defining the digital fingerprint of their device (MAC address, IMSI, MSISDN, IMEI) to the PMS and including it in the user’s profile.

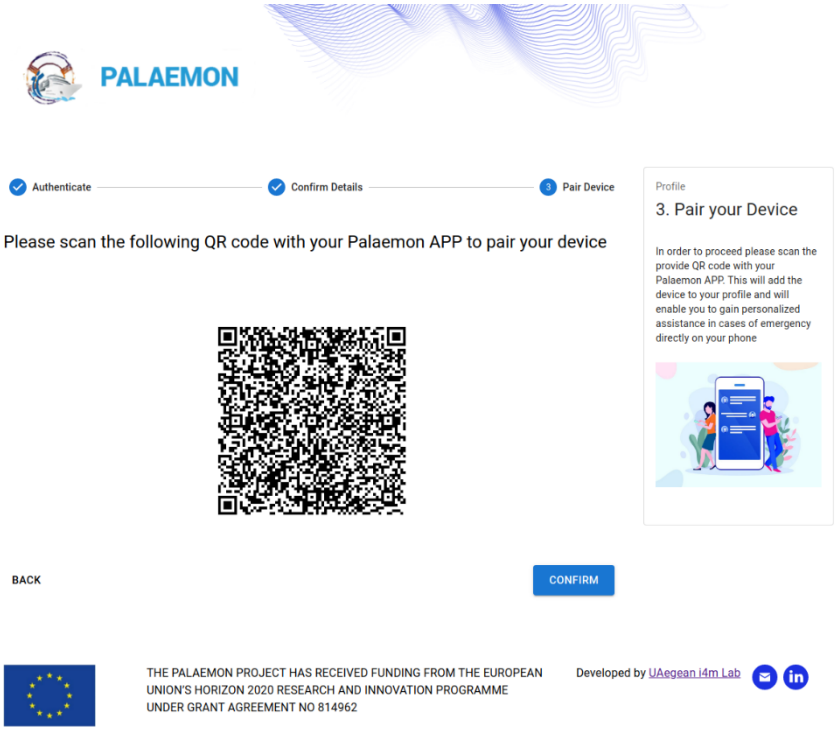

Figure 27 Digital Fingerprint sharing request

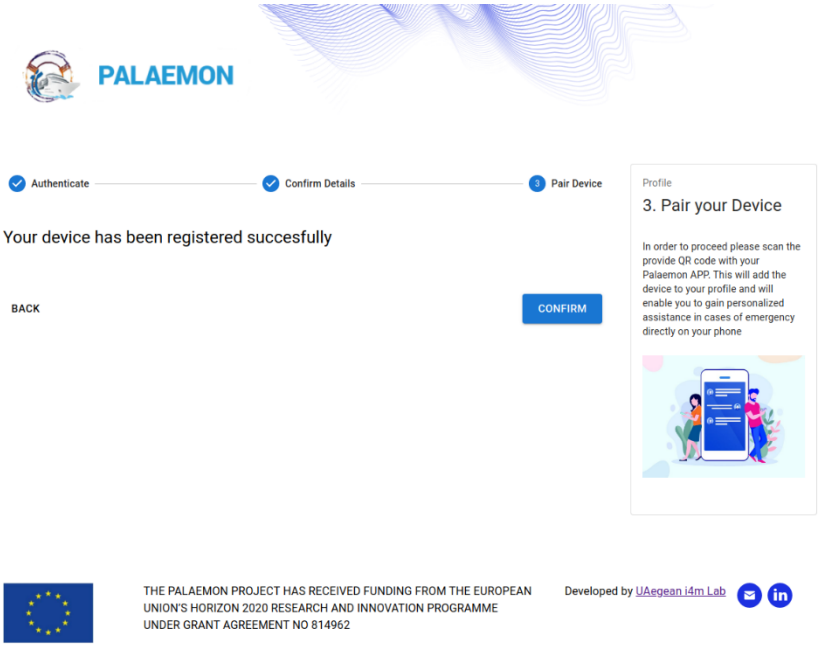

Figure 28 Registration Completed

3.5.2 PALAEMON Wallet app

The PALAEMON Wallet app implements all the necessary functionalities of a Digital Identity Wallet. Furthermore, it follows the principles of Self Sovereign Identity[16] (SSI)

[16] Mühle, Alexander; Grüner, Andreas; Gayvoronskaya, Tatiana; Meinel, Christoph (2018). "A survey on essential components of a self-sovereign identity". *Computer Science Review*. **30** (1): 80–86.

and enables not only the management of the necessary cryptographic keys for the user but also (via appropriate UIs) empowers the user to receive, store and disclose W3C compliant Verifiable Credentials attesting to the attributes of the wallet holder. It enables the owner to have data sovereignty and portability (a property especially significant in PALAEMON). Via the PALAEMON Wallet app, the user can maintain the possession and prove the ownership of their Identity (as implemented by the aforementioned "PALAEMON Service Card" issued to the user by the PMS). Additionally, the PALAEMON Wallet app ensures that all actions involving the user's personal identification information are carried out under the user's explicit and non-repudiable consent (since it requires biometrics authentication in order to disclose the user's profile to a third party). In the current version, the PALAEMON Wallet app is implemented by the use of the Jolocom Smart Wallet[17], an SSI Digital Identity Wallet that is not only W3C compliant but also complies with the respective EU initiatives in the field[18].

More details about the Jolocom Smart Wallet app (including demos and screenshots) can be found in the following White Paper[19].

3.5.3 PaMEAS Messaging Service and Mobile Application

The PaMEAS Messaging Service implements the core communication facilities between the PALAEMON backend system and the passenger and crew of the vessel with the intent of improving the communication flows in cases of emergencies and effectively expediting the evacuation procedures.

As a result, the PaMEAS Messaging Service enhances the evacuation protocols already in place by displaying clear messages (alert, warning and notifications) personalised for each user based on the ship's evacuation status and the user's current location and finally the users' role (i.e. crew with specific emergency duties or passenger with mobility problems).

To implement this functionality the PaMEAS Messaging Service consists of the following components:

- PaMEAS Messaging Backend Service.
- PaMEAS Messaging Mobile App.

3.5.3.2 PaMEAS Messaging Mobile App

The **PaMEAS Messaging Mobile App** consists of an interface where text messages, images or videos received through the service are being displayed. It is accessible after the embarkation service has taken place. Upon opening, an HTTP connection to the Server automatically occurs that contains the device's MACAddress. After the connection is opened, the application automatically subscribes to the aforementioned topics. It is then able to receive and display messages from the messaging service. If the initial connection is lost the application retries to connect to the server anew. After receiving a message, the application sends a confirmation to the server. If it failed to receive a message, the message is resent.

A first version of the PaMEAS Messaging Mobile App for the passengers has been implemented using hybrid technologies (React Native[20]) in order to facilitate the testing of the PaMEAS Messaging Backend Service. In the following, screenshots of delivering "General

[17] https://jolocom.io/
[18] https://ec.europa.eu/cefdigital/wiki/pages/viewpage.action?pageId=379913698
[19] JOLOCOM – A Decentralized, Open-Source Solution for Digital Identity and Access Management – White Paper
[20] https://reactnative.dev/

Alert" messages from the Backend Service to two different users (having declared different languages as their preferred means of communication) are presented.

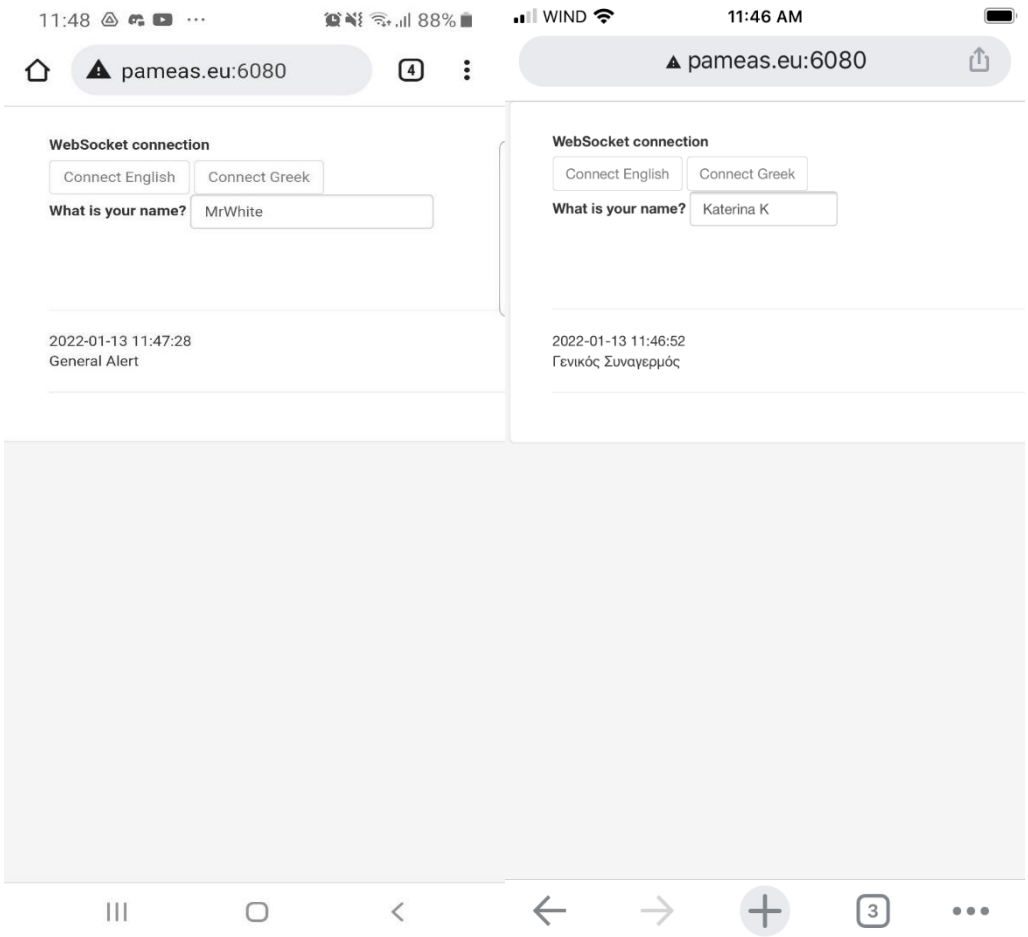

Figure 29 Users receive an alert text message on their phones in their preferred language.

3.5.4 Aruba Meridian app

The Aruba Meridian app[21] plays an important role to PaMEAS as it enables the provision of the users (passengers and crew) with location-based information such as Maps, Directions and Proximity based data. In detail, the Meridian app supports:

- **Static Wayfinding**: It enables users to easily set a starting point and a destination and receive through the app real time (turn by turn) instructions with respect to reaching their destination.
- **Blue dot Wayfinding**: By utilising Bluetooth Low Energy (BLE) beacons the Meridian app enables the user to instantly visualise their location with respect to preconfigured floor maps, significantly increasing the user's awareness especially in cases of emergencies. Additionally, it enables location sharing between users (e.g., passengers and crew) with an expected accuracy of 3-5 metres.
- **Asset Tracking**: If paired with compatible tags the Meridian app can enable the tracking of assets to instantly provide the users with the location of critical assets visualised on a floor map. This feature is especially useful in case of location

[21] https://www.arubanetworks.com/products/location-services/app-platform/

emergency equipment during evacuation procedures (by both the passengers and the crew). The expected proximity is again 3-5 metres.

- **Campaigns**: The Meridian app can integrate with BLE beacons to instantly push notifications to the device of the user in case of emergencies, providing them with location specification context as a parallel channel to the PALAEMON messaging apps.

Furthermore, the Meridian stack provides a Software Development Kit (SDK) that can be utilised to enhance existing applications with the aforementioned features. Of course, for the Meridian app to provide this functionality it needs to be paired with a backend service: the Aruba Meridian software-as-a-service (SaaS) solution that is part of Aruba's location services portfolio.

More details about the Aruba Meridian app (including screenshots) can be found in the following datasheet[22].

3.6 AR/VR HMI

The goal of the AR/VR HMI is to allow the the users to access live ship information in form of virtual controls. For the VR, the users could be immersed within a virtual environment, similar to a ship's deck. For the Mixed Reality, the users could add to their actual surroundings virtual 3D objects, similar to the ones found on an actual ship.

Users can interact with the virtual objects in a similar way as the real ones. Moreover, the 3D objects allow direct connection with the ship's subsystems by connecting to Data Fusion Bus (as described in D6.2 PALAEMON Data Fusion Middleware). Each of the virtual 3D objects can be customized to connect to several modules such as:

- PIMM (as described in Chapter 3.3),
- DSS (as described in Chapter 3.3.2),
- WFT (as described in Chapter 3.3.1), but not limited to them.

The implementation allows future modules to be added within the HMI.

The purpose for implementing such control using AR and VR technology is to allow the appropriate crew members to deploy and allow direct interaction with ship's systems by analysing and deciding the appropriate set of actions while monitoring all the relevant parameters.

There might be cases where some parts of the ship might be damaged or some corridors leading to the actual ship's deck might become temporary unaccesible. The Captain can access the virtual deck or can deploy it's own Mixed reality deck by using one of the HMI versions provided within this deliverable.

The HMI allows the Captain to consider weather conditions, past incident cases, ship stability parameters when possible issues or alerts are triggered by the ship. Therefore leading to quicker reactions.

Along the virtual objects deployment, the Captain and Crewmembers have access to the Widgets developed and described in in detail in deliverable D5.4 - PALAEMON AR Glasses component but, we can mention some examples:

- Waves length and height (integration with D3.4 Development of Ship Stability Toolkit)
- Temperature and Weather status (integration with D3.6 Development of PALAEMON weather forecast tool)
- Ship's Roll, Pitch, Yaw, Speed and direction (integration with D6.1 Ship Structural Monitoring Ecosystem)

[22] ARUBA location services datasheet - https://www.arubanetworks.com/assets/ds/DS_MeridianPlatform.pdf

- Task list (integration with D6.4 Development of PALAEMON On-Board Decision Support System)
- Alerts (integration with D6.5 PALAEMON Incident Management Module (PIMM))

In terms of technologies associated with the AR/VR HMI the following platforms and devices were foreseen:

- For Virtual Reality (VR)- We offer an Android OS based application deployed on Oculus Quest 1 and 2 headsets. They offer a completely egocentric representation of the 3D simulated virtual environment while proving to be a cost/effective solution.
- For Mixed Reality (MR) – We offer a Universal Windows Platform approach deployed on Hololens 2 headsets. They have been proved of being the most advanced commercial solution available at present time.

As per simulations, we have selected the above headsets to allow crew members to freely move within simulated 3D world or real world and to easily interact with the 3D objects by using their own hands. A more detailed presentation of the User Interface can be accessed within the the deliverable D3.11 PALAEMON TRAINING Platform Software Package (V2).

The actual HMI setup can be adapted to each user needs.

Below there are presented configurations of HMI screens within the Virtual Reality environment:

Figure 30 VR HMI - Setup with 2 interactive screens(center) and a screen console (right)

Figure 31 VR HMI - Setup with 3 interactive Screen totems

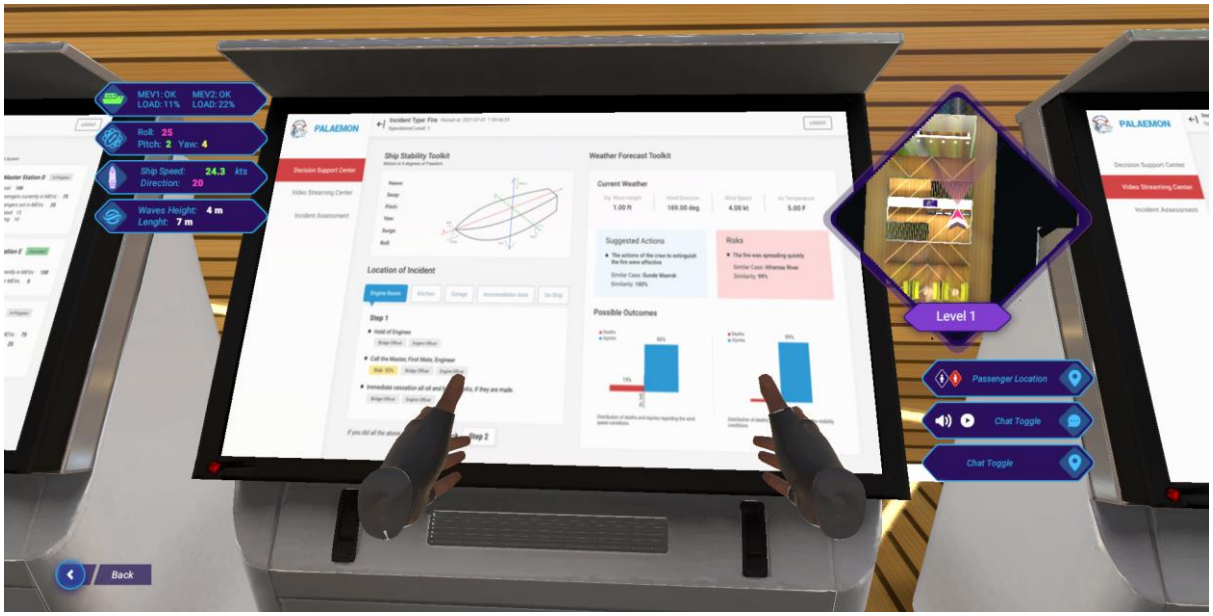

Figure 32 VR HMI – Detailed view of the PIMM - DSS

Figure 33 VR HMI – Detailed view of the PIMM – Smart Cameras and MVP

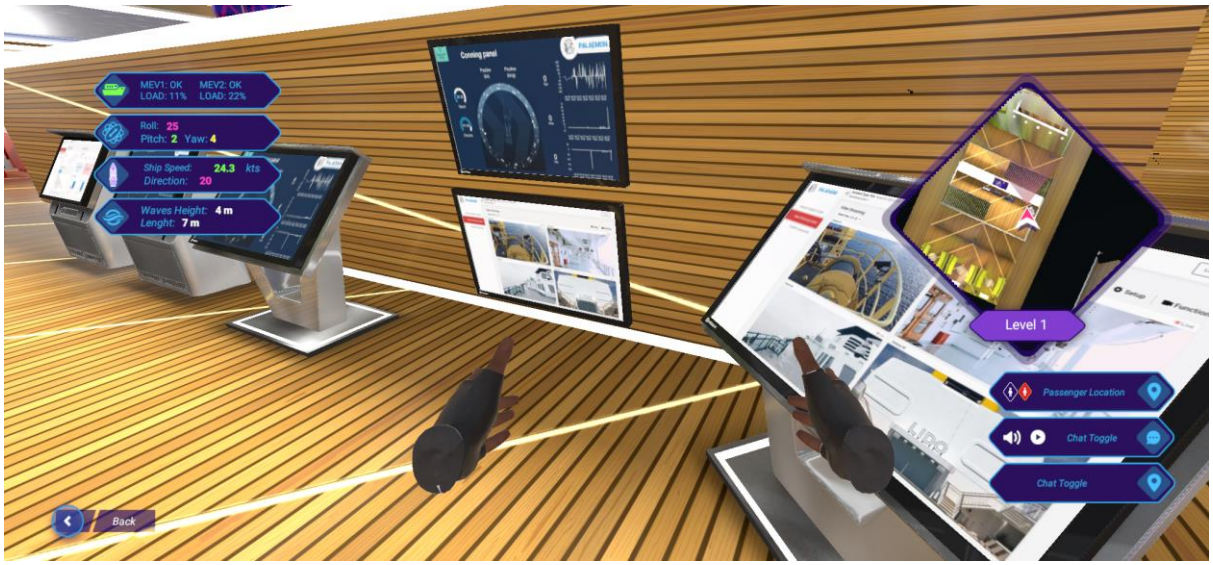

Figure 34 VR HMI – A complex setup done from several virtual devices

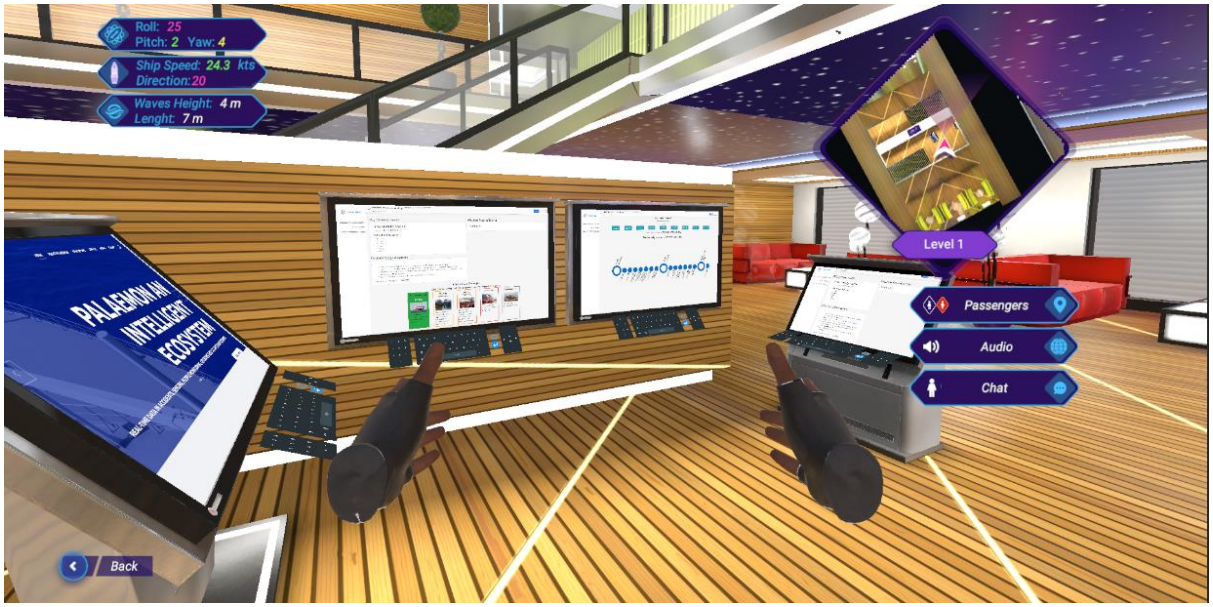

Figure 35 VR HMI – Actual VR experience with Widgets and Virtual HMIs

Augmented Reality HMI (AR) component will use the HoloLens 2 device from Microsoft as supporting headset.

Unlike other AR devices, HoloLens 2 headsets provide a seamless way of experiencing mixed reality environments since it locks the content to the user's peripheral. Headsets allow crew members to freely move their hands and enable special gestures. By using gestures, interactions are enabled.

Natural User Interface (NUI) designers have already started to explore their potential and have already implemented gestures.

Below there are presented configurations of HMI screens within a real environment using Augmented Interface and 3D Objects:

Figure 36 AR HMI – Virtual Screen displayed in real environment

An overall view of a Virtual screen can be viewed. The placement must take in consideration the actual environment. It should not cover important areas since the rendered object can cover important real objects or routes. We are using 3D mapping when placing the 3D objects to lock them in place (location, rotation, scale). The Screens will remember also the activities performed even if you move away from them.

Figure 37 AR HMI – Virtual interactive console displayed in real environment

Additionally, when placing the virtual objects, we take in consideration the depth factor. If a real object will be moved between the 3D object and the headset, we will use the HMIs depth cam to mask the rendered.

Figure 38 AR HMI – Displaying virtual screens in real environment

Above we display a sample of how several displays cand be placed within a real environment and provide real-time information about the ship's Incident list and Evacuation Manager.

Figure 39 AR HMI –Virtual Screens displayd within a real environment

3.7 Smart Camera

The Smart Camera (SC) nodes gather visual information about people in different areas, monitor people's actions and inform the crew with updated notifications (or alarms, in case a particular event has been detected). All the information, such as number of people in the area, people running / stampede, trapped people in staircases, etc. is processed by the PALAEMON Smart Risk Assessment Platform and the Decision Support System. Besides, from the video feed, crew can "manually" confirm if there is an emergency, and people need to be evacuated from a surveillance area.

Smart Cameras lean on a Graphical User Interface (GUI) to carry out several setup actions, for installation and later operation. An SC device provide video feeds for the supervision of the crew through the GUI. From the GUI, the admin can configure relevant parameters for the optimal surveillance of an area. Finally, the SC system (nodes + central server) logs all actions and videos for post-incident processing.

In the deliverable D5.18 - Smart Cameras Component v2.0 all the technicalities, hardware modules and software components plus computer vision artificial intelligence algorithms are explained in detail.

The GUI is a key element to take advantage and make use of the SC nodes easily. It has been designed so that the end-user or installation technician can control, communicate, and interact with the SC node in a simply and intuitively way.

The GUI is done via a webserver module inside each SC node, with 2 components, a front-end, visually appealing, and a back-end to interchange data with the video processing and PALAEMON central system.

The GUI includes two different interfaces depending on user roles: end-users (crew) and admin (for the technician). The admin interface has more privileges and parameters to modify the system configuration, while the end-user interface controls only the display of information. There are multiple SC settings that might be changed from the webserver such as region of

interest definitions, thresholds for the detection of anomalous behaviour, etc. related to the algorithms processing: parameters related to camera configuration such as brightness, contrast, etc.; and parameters related to PALAEMON integration such as length of video clips, maximum number of video clips stored locally, etc.

Next, we show the interface for the main webpages of the SC nodes.

3.7.1 Log-in page, user roles and new users' registration

In this section we review the welcome webpage, user roles and registration of new users. The GUI includes a first-time welcome screen (Figure 32) that allows to access the SC node. Figure below shows the welcome screen with the name of current SC node, date, and fields for user/password to enter into the system.

Figure 40 Smart Cameras Welcome page

Legal information and disclaimer about the use of the GUI system are also shown/accessible from the welcome page showing that this project received EU Funds from the H2020 program.

The next figure shows the registration screenshot where the user must enter his credentials correctly in order to access/log-in to the GUI.

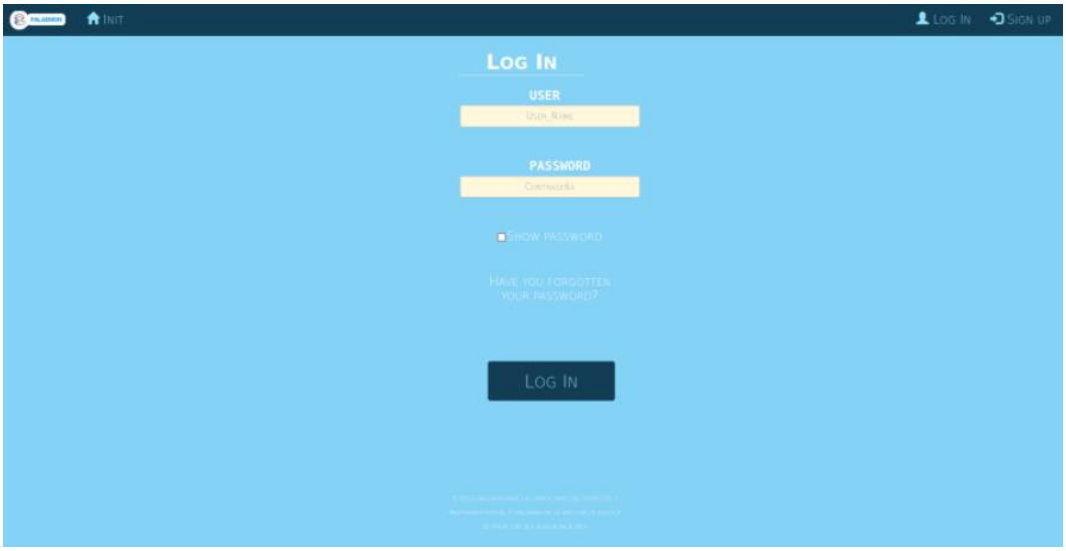

Figure 41 Log-in page

Only admin users are capable to create new users with the role of admin or end-users. Any user can change their password. Once entering the system, the admin users will have access to all the system settings as shown in the figure below. New parameters or values can be easily added to the GUI in the back-end / front-end of the webserver. This setup should be done once in the installation step by the technician. Later, it can be modified by any admin/technician accessing remotely the SC node.

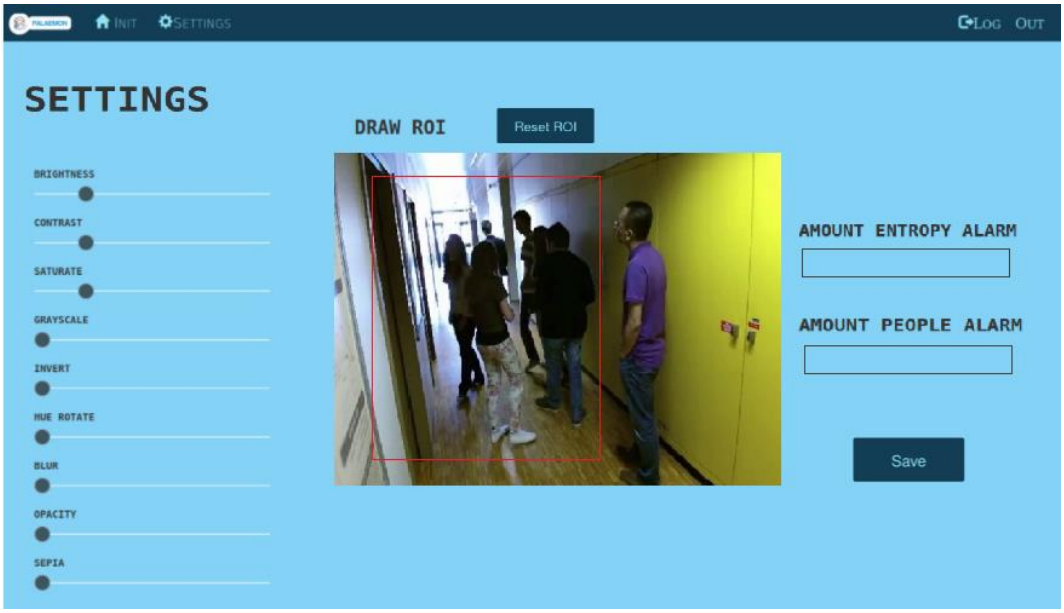

Figure 42 Smart Cameras Settings webpage

Any user accessing the remote webserver of a SC node will see a screen with the processing of the video stream done in the SC node (like in Figure 35). This is the most relevant GUI webpage, where the user can watch the real-time video streaming of the camera, with the current frame of the video processed people bounding-boxes detection in yellow, within defined region of interest (i.e., red rectangles). The displayed image is populated with information about current detected situation. Hence, there are several texts, one indicating the alert level and another to show the detection of anomalous events, for example, trapped people.

Figure 43 Canvas webpage showing the videoframes processed

At any time, the remote web user can stop the real-time video stream to review the current frame processing. This pause makes it possible to detect and see some details in the area under surveillance. Pressing the button play/pause of the webpage, the visualization frame returns to real-time monitoring.

When the HW of the SC includes an RGB-D camera such as Intel D435[23] , the GUI can show the depth view as shown in the figure below. Hence, in case external illumination is not working, instead of a black RGB image the GUI can show a depth image. Though this image is not being processed by the people detector it could be used by the crew to know the state of these areas.

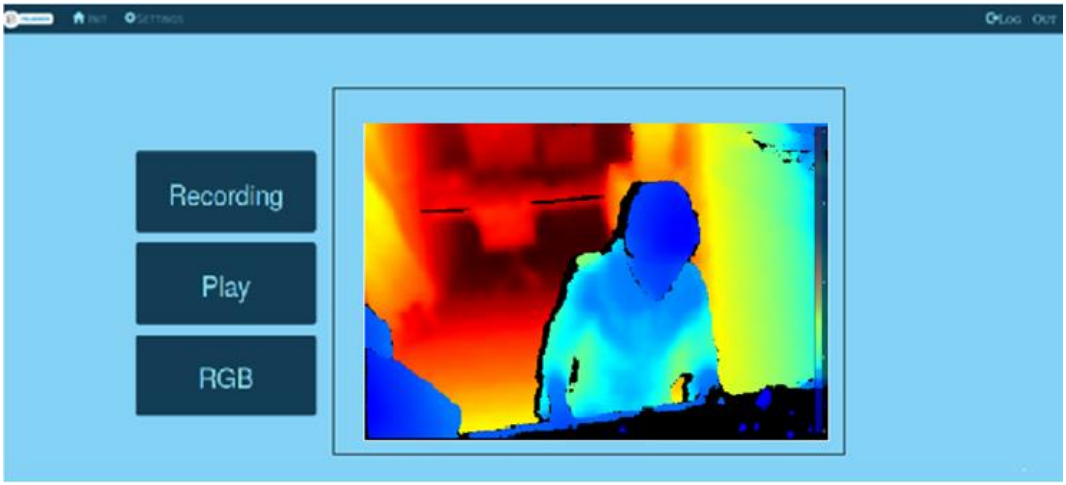

Figure 44 Depth image from an SC node with an Intel D435 camera

3.8 PALAEMON Voyage Report Generator

The so-called PALAEMON Voyage Report Generator has been conceived to mimic the operation of a regular Voyage Data Recorder (VDR), the current part of the International Maritime Organization (IMO) Regulation. The main purpose behind this element is to behave as a “black-box”, gathering all available information during an incident, and assisting during incident investigation. That is, unlike the previous components covered in this report, the

[23] Intel Depth Camera D435 specifications - https://www.intelrealsense.com/depth-camera-d435/

usage phase of these “reports” comes after the voyage has concluded. Should the reader need a deeper explanation about this component, he/she must refer to D7.1 “PALAEMON Communications Platform”.

Technically speaking, the Voyage Report, i.e., the output of this component, is a combination of two elements. On the one hand, a legible document (i.e., PDF format) where all the visually displayable information will be reflected. The information will be mainly taken from Data Fusion Bus, where all data flows during a voyage. Here, the people designated to investigate an incident (e.g., Designated Person Ashore) will have a quick overview of the voyage. Besides this document, all the information generated will be compiled and served in a compressed (e.g., ZIP file), hence investigators will have access to the full data produced in the voyage.

List of elements compiled in the Voyage Report:

- Voyage ID – Unique identifier to label a particular voyage
- Voyage Description – For example, number of passengers and crew members, expected times (departure and return, etc.), fuel consumption, etc.
- Ship position displayed on a map (it is possible to print a pop-up with the timestamp at the moment of the incident)
- Passenger and Crew lists - duly anonymized, for the sake of GDPR compliance. For the sake of disclosure.
- Evacuation ship status timeline – reflecting the transition shifts in a visual way
- Data from Sensors (e.g., Ship Health Monitoring, weather, and sea conditions, etc.) are plotted in a visual and easily interpretable manner.

As mentioned above, aside from the report itself, the Voyage Report Generator also includes additional files that contain all the information generated by the different sources and, for obvious reason, do not fit into a PDF-like document. Namely, they will be compiled together into a single “zip-like” file that abridges all the information. Furthermore, for security reasons, we can protect this file with e.g., a password, thus ensuring that only appropriate users can open and read its content.

Below we enumerate some of the elements that will be included in this part.

- Video clips from smart cameras and ship’s Closed-Circuit Television (CCTV), triggered at the moment an incident was identified at the bridge.
- Audio recordings captured from AR glasses and PaMEAS User Equipment (i.e., smartphones)
- Sensor-based data was captured from various data sources. They will be kept in “easily-parseable” formats (e.g., JSON, CSV, etc.).

4 Conclusions

In this deliverable, we presented a summation of all interfaces and HMIs that allow datasets to be viewed graphically and combined with others, to improve the understanding of the end-user and identify possible solutions in many different scenarios related to passenger ship evacuation and rescue cases.

Apart from the legacy displays/monitors that can be seen in a real scenario (e.g. AIS, IBS 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.

A summary of HMIs and their intended functionality that was presented in this Deliverable is summarized in the following list:

- **Weather Forecasting Tool**: used by the bridge crew to identify the most appropriate set of actions that meet the needs of the corresponding incident case considering the weather conditions and utilizing past incident cases.
- **Decision Support System**: DSS UI helps the Master to take the proper actions after a grounding, fire, or collision incident of the ship, in order to avoid the adverse consequences of the incident and avert the problem that may drive to an evacuation of the ship
- **PALAEMON Incident Management Module**: Through its friendly Graphical User Interface, access is provided to critical PALAEMON components, to be used by the Master and the Bridge Team. Besides, this components acts as a visualization hub, displaying the information of many other Smart Evacuation Services.
- **Smart Safety System**: The system aims to improve the safety evacuation system on board passenger ships and to provide information on the condition and all relevant information during the evacuation process. All crew members on board should have access to this information.
- **Voyage Report Generator**: The output of this component is a legible document (i.e., PDF format) where all the visually displayable information will be reflected, alongside a compressed file that includes all the information gathered by the platform during a voyage. It is addressed for potential post-incident analysis/investigations.
- **PaMEAS**: collects the location of the passengers (and crew) in cases of emergencies and provides them with personalised evacuation instructions and assistance.
- **AR** enables users (i.e., crew members) and stakeholders to further assess and train various skills and aspects concerned to passengers and the ship, and improve overall safety in transfer and boarding infrastructure.
- **Smart Camera:** The Smart Camera (SC) nodes gather visual information about people in different areas, monitor people's actions and inform the crew with updated data. All the information, such as the number of people in the area, many people running, trapped people in staircases, etc. is processed by the PALAEMON DSS and provided to the bridge crew.
- **PALAEMON Core Monitoring**: A GUI intended for system administrators to monitor and manage the PALAMEON Core platform.

Finally, it is worth highlighting that we have not completed the integration of all the components at the time of writing this report (M32- January 2022). Any potential modification or addition may be duly documented in WP7 or WP8 deliverables, as these integration and validation stages may lead to spot operation or layout changes.