Ref. Ares(2023)2099542 - 23/03/2023

PROJECT DELIVERABLE REPORT

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

D8.1 Report on Pilot Sites Preparation and Assessment

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**	44 months
Project URL	https://palaemonproject.eu/		
Project Coordinator	AIRBUS DEFENCE AND SPACE SAS		
Deliverable	D8.1 Report on Pilot Sites Preparation and Assessment		
Work Package	WP8 – PALAEMON Application Field Trials, Evaluation and Outcomes		
Date of Delivery	**Contractual** M44	**Actual**	M44
Nature	R - Report	**Dissemination Level**	PU-PUBLIC
Lead Beneficiary	UAEGEAN (UAEG)		
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Keywords	ELYROS F/B ANEK, Ship Evacuation, Smart Evacuation Management piloting, Pilot Sites Preparation, Pilot Sites survey, Pilot Sites Assessment, Pilot Final Areas		

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Revision History

Version	Date	Responsible	Description/Remarks/Reason for changes
0.5	01.09.22	UAegean	Initial version sent to the Consortium
0.6	31.10.23	UAegean	Version with the definitive pilot design (sent it to the Consortium)
0.7	21.02.23	UAegean	Version ready for internal review
1.0	22.02.23	UAegean	Final version after incorporating reviewers' comments

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Abbreviations

6DoF	6-degree-of-freedom
AE	Acoustic Emission
API	Application programming interface
AR	Augmented Reality
CMS	Condition Monitoring System
COTS	Commercial Off-The-Shelf
CPRI	Common Public Radio Interface
DFB	Data Fusion Bus
DFB	Data fusion bus
DoA	Description of Action
DSS	Decision Support System
DSS	Decision Support System
eCPRI	Evolved Common Public Radio Interface
EMSA	European Maritime Safety Agency
EPC	Evolved Packet Core
FMAGDM	Fuzzy Multi-Attribute Group Decision Making
GA	General Alarm
GCS	Ground Control Station
HMI	Human Machine Interface
ICT	Information Communications Technology
ICT	Information and Communications Technology
IMO	International Maritime Organization
IMO	International Maritime Organization
IMU	Inertial Measurement Units
IOT	Internet of Things
ISM	International Safety Management

ISO	International Organization for Standardization
LCA	Life cycle assessment
LSA	International Life-Saving Appliance Code
LSA	Life Saving Appliances
MCPTT	Mission Critical Push To Talk
MEV	Massive Evacuation Vessel
MOB	Man Overboard
NDT	Non-destructive tests
PA	Public Address System
PaMEAS	Passengers Mustering and Evacuation Process Automation System
PEC	Passenger evacuation capacity
PEET	Pilot Exercise Evaluation Team
PIMM	PALAMEON Incident Management Module
PIMM	PALAEMON Incident Management Module
PTT	Push-to-talk
RCC	Rescue Coordination Centres
RoPax	Roll-on/roll-off passenger
RTLS	Real-Time Location System
SA	Standalone
SB	Smart Bracelet
SEM	Smart Evacuation Management
SHM	Structural Health Monitoring
SME	Small and medium-sized enterprises
SMS	Safety Management System tool
SOLAS	International Convention for the Safety of Life at Sea
SOP	Standard Operating procedure

SRAP	Smart Risk Assessment Platform
SRAP	Smart Risk Assessment Platform
STCW	Standards of Training, Certification and Watchkeeping for Seafarers
TOPSIS	Technique of Ordered Preference by Similarity to Ideal Solution
TRL	Technology Readiness Levels
UAS	Unmanned Airborne System
UAV	Unmanned Aerial Vehicle
USAR	Urban Search and Rescue
VDR	Voyage data report
VHF	Very High Frequency
VR	Virtual Reality
VRG	Voyage Report Generator
VTOL	Vertical take-off and landing
VTS	Vessel Traffic Services
Weather Forecast Tool	WFT
WSM	Weather Service map

Executive Summary

The PALAEMON project has planned to conduct two end-to-end trials, each in a different European city (Athens and Spain), involving end-users. The Athens pilot will implement four use cases related to an incident that occurs on board ELYROS F/B, requiring the passengers to muster and prepare for embarkation. A subset of the PALAEMON ecosystem will be deployed onboard ELYROS based on the maturity and deployability of the various modules of the ecosystem, called the Smart Evacuation Management (SEM) platform. This platform will be utilised to ensure a capable response, involving organising the crew, guiding passengers to a secure area, and addressing any unexpected concerns. Consecutively, the primary objectives of the pilot are two-fold: firstly, to test the effectiveness of the SEM approach in a real-world setting, and secondly, collect network, service, and performance KPIs to evaluate the platform against predefined criteria.

This deliverable is part of WP8, which is dedicated to testing the integrated SEM platform through the pilot and facilitating the evaluation of the trial result, specifically T8.1 Pilot Organization Set-up and Preparation. The aim of this task is to organise and set-up each pilot, handling all elements of each pilot site as well as the preparation aspects for performing the pilot operation at a later task.

This deliverable initially presents the site survey conducted on ELYROS before the PALAEMON SEM platform application trial (Greece) to determine the best deployment approach based on the ship operator's need and focuses on the preparations undertaken for the trial, which led to the selection of the final pilot areas. Moreover, this deliverable presents the validation actions (in the form of simulation exercises) executed to ensure the SEM platform was capable of handling the pilot requirements onboard ELYROS. Finally, the report discusses the factors that led to a more restricted area of the ship being eventually available for piloting.

1 Introduction

This is the initial Deliverable of PALAEMON WP8 “Application Field Trials, Evaluation and Outcomes”, the last Work Package of the project. WP8 was about the pilot application of the main project achievements, as they have been summarised in the Deliverables of the following WPs:

- WP4: PALAEMON Mass Evacuation Vessel
- WP5-WP6-WP7 (WP5: PALAEMON on-board mustering tools and services - WP6: PALAEMON Back-End Infrastructure - WP7: PALAEMON Integrated System and Technology Validation Trials.

In essence, as described in the GA, the pilot activities should prove the feasibility and maturity of the outcomes of previous WPs through demonstration and testing in a relevant ship environment. Since the project has the two-fold objective of developing:

a) A mass centralised evacuation system, “based on a radical re-thinking of Mass Evacuation Vessels (MEVs)” and,
b) An intelligent ecosystem of critical components “providing real-time access to and representation of data to establish appropriate evacuation strategies for optimizing the operational planning of the evacuation process on damaged or flooded vessels”,

the pilot action has been implemented in two locations, under different settings:

I. In Spain, in the shipyard of Astander, a key Consortium participant, where the PAALEMON MEV construct has been tested through simulations and trails in close sea
II. In Greece (Port of Piraeus) where an operational version of PALAEMON Data Ecosystem supporting the needs of the evacuation operations has been successfully deployed onboard of a passenger ship provided by ANEK Lines, an international shipping company, operating in the South of Europe, and end-user member of the Consortium (ELYROS F/B).

As a result, the work in WP8 has been splitted into two parts, carried out by different actors and under different demonstration and testing principles. Consequently, the reporting on WP8 piloting action has been also organised in two groups of deliverables:

WP8 Deliverables - Series A (MEV)	PALAEMON Application Field Trials, Evaluation and Outcomes - Mass Evacuation MEV
WP8 Deliverables - Series B (SEM)	PALAEMON Application Field Trials, Evaluation and Outcomes - Smart Evacuation Management | SME (where the term Smart Evacuation Management refers to the operational version of PALAEMON Data Ecosystem

In short, the Deliverables of WP8 are segregated in two distinct groups, the first reporting to the MEV pilot action and the second one to the SEM pilot, as shown in the following Table:

WP8 Deliverables - Series A (MEV)					
#	**Deliverable Title**	Lead beneficiary	Type	Dissemination level	Due Date[1]
D8.1	Report on Pilot Sites Preparation and Assessment: MEV Trial		R	Confidential	M44
D8.2	Operational Pilot Sites: MEV Trial		R	Confidential	M44
D8.3	PALAEMON application trial 1: MEV Trial		R&DEM	Confidential	M44
D8.6	PALAEMON Consolidated Pilots Evaluation: MEV Trial		R	Public	M44
D8.7	Operation Manual, Recommendations and Best Practices: MEV Trial		R	Public	M44
D8.8	Public release WP8: MEV Trial		R	Public	M44

WP8 Deliverables - Series B (SEM)					
#	**Deliverable Title**	Lead beneficiary	Type	Dissemination level	Due Date[2]
D8.1	Report on Pilot Sites Preparation and Assessment: SEM Trial	UAEGEAN	R	Public	M44
D8.2	Operational Pilot Sites: SEM Trial	UAEGEAN	R	Public	M44
D8.4-5	PALAEMON application trial 2 and 3: SEM Trial	UAEGEAN	R&DEM	Public	M44
D8.6	PALAEMON Consolidated Pilots Evaluation: SEM Trial	UAEGEAN	R	Public	M44
D8.7	Operation Manual, Recommendations and Best Practices: SEM	UAEGEAN	R	Public	M44

[1] See Second GA amendment
[2] See Second GA amendment

	Trial				
D8.8	Public release WP8: SEM Trial	UAEGEAN	R	Public	M44

The Deliverable that follows is the **“edition SEM" of** the **Deliverable “Report on Pilot Sites Preparation and Assessment”**, and the **first of the Series B (SEM) of the WP8 Deliverables**. It provides the results of the test sites survey and the preparation actions that took place to enable the trials. It is the outcome of the Task 8.1 “Pilot Organization Set-up and Preparation (M20-M40) which focused on the initial organisation, set up of the SEM pilot action and preparation for pilot deployment. The Task, as it will be illustrated in the following chapters, has surveyed two Ferries provided from ANEK Lines, the Hellenic Spirit F/B and the ELYROS F/B, and selected the second option under the criterion of the frequency of port-calls in Piraeus, i.e., the average time of docking in the Port of Piraeus where the support to pilot deployment may be more effective because of the proximity with the premises of the main pilot actors: UAegean, NTUA, Ericsson, Athonet, JOAFG, KT etc.

The PALAEMON Smart Evacuation Management (SEM) approach was designed to be demonstrated with respect to its capacity of improving the evacuation and mustering capacity of two different vessels and under different conditions. However, the project has since developed a more comprehensive understanding of the entire evacuation process, including its multiple stages and facets. This process begins with the report and reconnaissance of an accident and ends with the embarkation of passengers and crew to the available life-saving appliances, in the event that the evacuation plan is launched. The SEM platform is capable of supporting the entire life-cycle of a ship evacuation process, including the management and monitoring of the mustering sub-process, as well as every other evacuation procedure in accordance with the ship evacuation plan. As a result, the corresponding Tasks T8.4 and T8.5 (entitled “Passenger Evacuation Demo|” and “Passenger Mustering Demo”, respectively) where merged into a single task, the planning of which is described in this deliverable.

In more detail, this Deliverable includes the following chapters:

Chapter 2 presents in brief the features of the operational version of PALAEMON Data Ecosystem that will be available onboard ELYROS F/B and tested through the specific actions undertaken in WP8 -- named “Smart Evacuation Management platform”.

Chapter 3 includes site surveys and the selection of the specific ship areas where the unified “Passengers Evacuation and Mustering Demo” will be deployed.

Chapter 4 describes a simulation trial of the deployment of Smart Evacuation Management platform functionality in the selected areas of the ship, used as a validator.

Chapter 5 reports on the necessary adjustments that have been made in the selected pilot areas, on the basis of the results of the simulation trials, the ongoing conversation between the technical pilot partners and the operators (ANEK Lines, Piraeus Port Authority), and the requirements and constraints imposed by the ship operator. Additionally, this chapter draws

on conclusions from previous trials, as reported in the relevant literature, and an analysis of the applying evacuation plan and the procedures conducted during routine mustering-evacuation drills, to provide: a) a first approximation of the proper WP8 Smart Evacuation Management pilot strategy, including the reconnaissance of the specificities of the pilot environment and the various trial constraints (operational, technological, ethical, etc.), b) an architecture plan for the necessary “sensing” and network infrastructure equipment to be deployed by the project onboard the ship, c) a time plan. These three major outcomes of the Deliverable 8.1 [7] led to the next step (Task 8.2) where a further design and validation of the pilot strategy and plan took place. They also have been used as compass for the actual pilot implementation that followed (Task 8.4-5), and as the canvas to adjust the depth and coverage of trail to envisioned opportunities, available resources and imposed constraints.

2 The Evacuation-Mustering Pilot Enabler: the PALAEMON Data Ecosystem in action - aka “Smart Evacuation Management platform”

This chapter presents in brief the features of the operational version of PALAEMON Data Ecosystem that will be available onboard ELYROS F/B.

ELYROS is the second newest Greek ferry, being part of ANEK Lines fleet, following Asterion II. She is a motor Ro-Ro/Passenger ferry boat, built in 1998 at Mitsubishi Heavy Industries shipyard at Shimonoseki, Japan, and put into service by ANEK in 2008. She holds a total of 1.874 passengers and 620 vehicles. She has 323 passenger aircraft type seats and 776 beds and reaches speeds of up to 24 knots. ELYROS has been awarded by Ship Pax Awards 2009 for a very extensive rebuilding of the former Japanese ferry Sunflower Tsukuba.

Figure 1. F/B ELYROS

The PALAEMON Reference Architecture was defined in WP2 (Use Case Driven Requirements Engineering and Architecture), namely in D2.7 (PALAEMON Architecture - v2). The integration of all these modules was organised by WP7 (T7.1-PALAEMON Communications Platform]). Furthermore, an interoperability layer was designed under

the same WP (T7.3-Uniform Data Exchange Modules). The resulting PALAEMON Data Ecosystem is described in detail in the final deliverable of WP7 D7.7 [9].

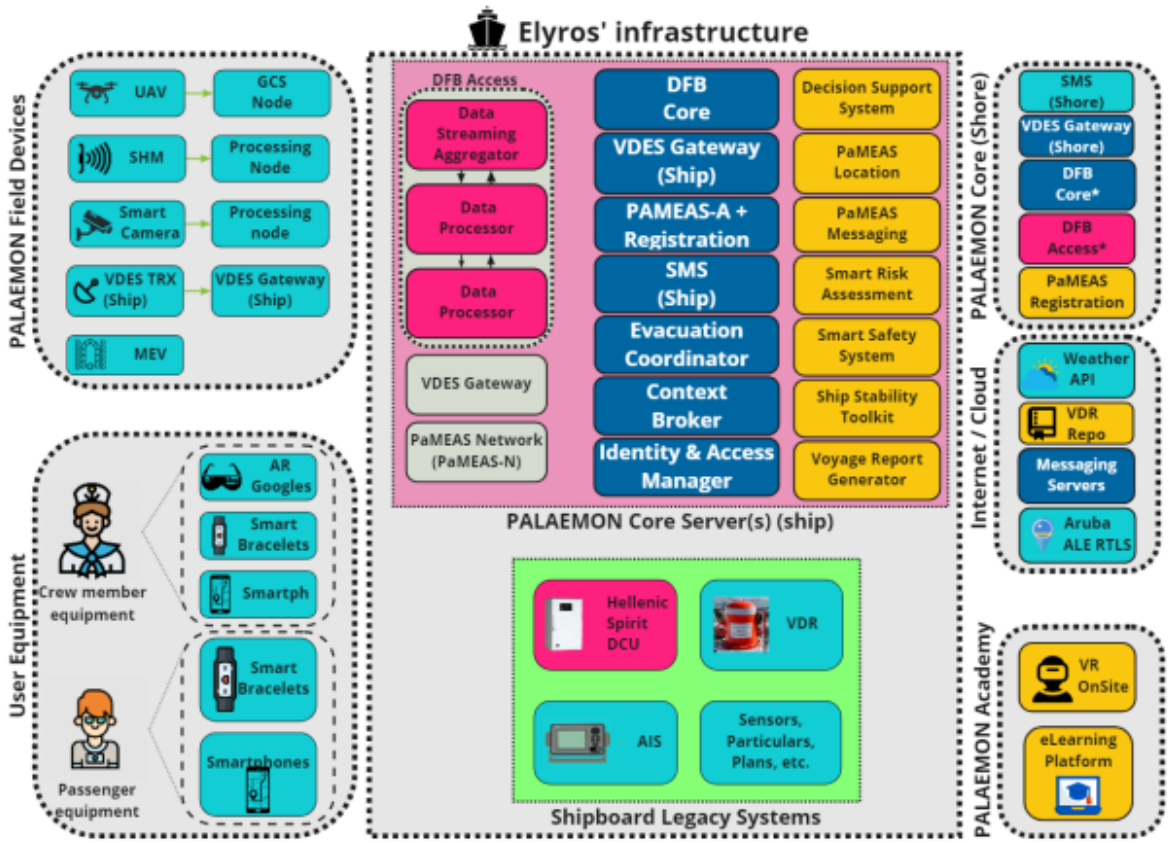

Figure 2 PALAEMON Data Ecosystem

This ecosystem defines the interactions between a plethora of modules implemented in the context of PALAEMON. From these modules, based on their deployability onboard ELYROS, their operational maturity and finally their impact on the evacuation-mustering process, which is the focus of WP8 (as described specifically in T8.4 and T8.5), a subset of these modules was integrated and selected for piloting.

This operational version of the PALAEMON Data Ecosystem is referenced as the **Smart Evacuation Management (SEM) platform**. The SEM platform approach utilises new ICT technology to improve the evacuation process on passenger ships by embedding a platform onboard coupled with a network architecture using advanced networking technologies (5G, WiFi6, BLE beacons). The key features of the SEM platform functionality are presented in the following table:

Table 1. PALAEMON SEM Functionality

#	Smart Evacuation Management Functionality
1	Notify the Bridge about detected incidents

2	Advise on which actions should follow up according to international regulations and the company's playbook
3	Support the decision making processes of the Bridge via: advice based on IMO regulations, real time risk assessments including advices on mustering or embarkation initiation
4	Provide an one stop overview of the current status of the vessel (weather report, ship stability data)
5	Track passengers and crew position onboard, in real time, under privacy safeguards (indoor positioning via people location coordinates and geofence proximity).
6	Generate personalised, location-based, alerts and notifications to the passengers (a complement to the Public Address System - PA), which are sent to their cell phones.
7	Guide passengers to reach assigned muster stations via personalised multimedia messages, generated based on the passengers location at the moment the mustering instruction is given, adhering to the ships primary evacuation plan, and updated in case parts of these paths (geofences) become unavailable (due to evolution of the emergency incident, e.g. fire spreading, heavy smoke in areas etc).
8	Support the detection of passenger issues and address incidents during evacuation
9	Assist the Bridge with the allocation of resources (via automated crew assignment recommendations implemented over Tabu Search)
10	Optimise with the coordination of the crew efforts in real time (via 5G enabled MCPTT) during the whole lifecycle of an incident (from the early pre-evacuation stages, i.e. the reconnaissance of an accident, to the embarkation of passengers and crew to LSAs)
11	Monitor how the crew members perform the assigned tasks.

2.1 SEM Platform Architecture

The SEM platform is implemented by a series of ICT modules, integrated to implement the necessary functionality, coupled by a 5G Standalone (SA) mobile network, a Wi-Fi 6 network and an array of BLE beacons. Furthermore, the system is designed in such a way that it supports the plugin of different indoor positioning systems, to pinpoint the exact location of the users with the highest degree of accuracy. Finally, the users interact with the system using 5G enabled mobile phones equipped with Passenger and Crew specific mobile apps.

The aforementioned functionality is implemented via the orchestration of a series of microservices (each with a varying degree of granularity) which integrate to provide the necessary features of the SEM platform.

Table 2. PALAEMON SEM Platform Modules

#	PALAEMON Component	Responsible Partner	Composite or Standalone
SME Core functionality			
1	Safety Management System (SMS)	DANAOS	standalone
2	Smart Risk Assessment Platform (SRAP)	NTUA	standalone
3	PIMM + DSS (includes Visualization Tools)	KT	standalone
4	PALAEMON Evacuation Coordinator	ATOS	standalone
5	PALAEMON Voyage Report Generator	ATOS	standalone
6	PALAEMON Data Fusion Bus (DFB)	ITML - ATOS	standalone
8	PaMEAS-A microservices architecture	UAegean	composite
9	PaMEAS-A RTLS	UAegean	composite
10	MCPTT Tactilon Suite	Airbus	standalone
11	PaMEAS-Cell Athonet 5G Core	Athonet - UAegean	standalone
12	Smart Bracelets	ADV	standalone
SME Network functionality			
13	PaMEAS-W Beacons and Access Points for location tracking	UAegean	standalone
14	PaMEAS-Cell for fast and reliable communications	Ericsson - Athonet-UAegean	standalone
SME UE functionality			
15	PALAEMON mobile app	UAegean	standalone
16	Tactilon Agnet mobile app	Airbus	standalone

The **SMS** module implements a marine-ISM-specific document management tool where safety practices, policies and guidelines will be digitised, stored and processed. Additionally, it acts as a remote storage facility for reports generated by the SEM platform. The **SRAP**[3] module assesses the risk for three main stages/phases of the evacuation process (decision to sound the General Alarm, monitoring the mustering of passengers and decision to

[3] The exact way SRAP is functioning is presented in the deliverables D3.9 Development of Risk Assessment Platform (V1) [13] and D3.10 Development of Risk Assessment Platform (V2) [14].

abandon the ship) and publishes recommendations to the rest of the modules. PIMM implements the user interfaces (UIs) via which the users interact with all of the components of the SEM platform. **DSS** implements a Decision Support System that helps the Master and Bridge Command Team take more appropriate decisions, based on a greater awareness of the evacuation status. The Evacuation Coordinator maintains the status of the overall SEM platform and exposes endpoints to update it. The **Voyage Report Generator** enables the creation of detailed reports after the end of the emergency incident and transmits them to the SMS module for analysis and reference. The **Data Fusion Bus** (DFB) is responsible for the preprocessing and providing data to the rest of the modules of the SEM platform acting as a message queue and a persistence layer. **PaMEAS-A** is implemented via the orchestration of a series of microservices (each with a varying degree of granularity) which integrate to provide the core business logic of the SEM platform implementing the majority of the SEM functionality. **PaMEAS-A RTLS** consists of a set of microservices integrated to provide the platform with the real time tracing of the passengers and crew members onboard ELYROS. **MCPTT Tactilon Suite** implements a Mission Critical Push to Talk (MCPTT) service which is integrated by the SEM platform to enable high reliability and low-latency push to talk and messaging functionalities between the crew and the bridge. **PaMEAS-Cell** Athonet 5G Core implements the necessary logic to deploy a 5G SA network on board ELYROS. **Smart Bracelets** enable the tracing of the biometrics of the passengers (or crew members) as well as help request functionalities. **PaMEAS-W Beacons** (BLE) and **Access Points** (AP) implements a network necessary for the indoor positioning and location tracking of the passengers and crew under privacy guarantees. **PaMEAS-Cell** implements a 5G StandAlone (SA) network providing the SEM platform with a fast and reliable communications channel between the bridge, crew and passengers. The **PALAEMON mobile app** enables the direct communication between the passengers and the bridge/crew members as well as the tracing of the location of the users via integrating with the BLE/AP network and the RTLS microservices. Finally, the **Tactilon Agnet mobile app** enables the direct communication channel between the bridge and the crew members by implementing the necessary functionality to integrate the users' mobile device with the MCPTT Tactilon Suite.

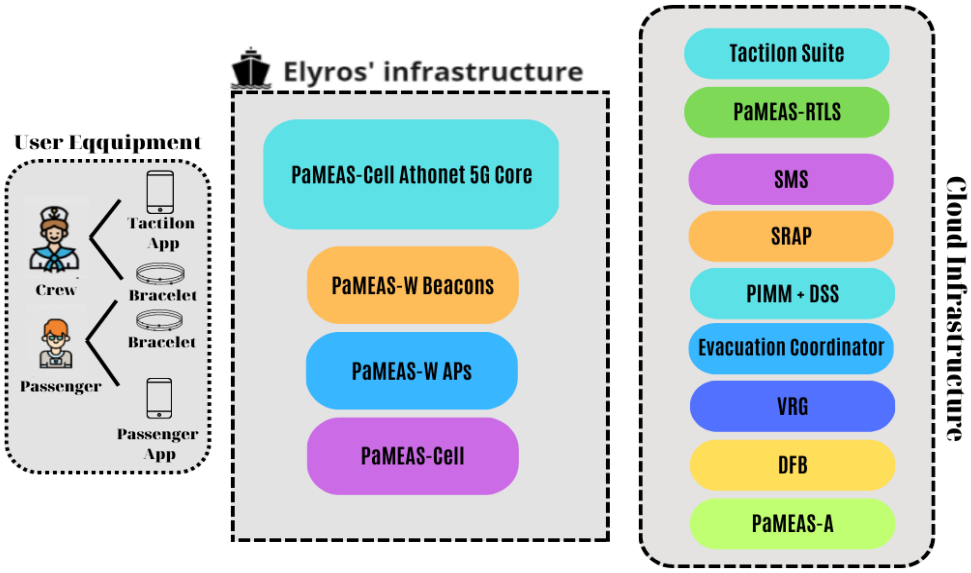

Figure 3. PALAEMON SEM Architecture

Using these modules the SEM platform is capable of implementing all the necessary functions (as described in the table above) to cater for the whole life cycle of the management of an emergency incident onboard, from the communication of its detection to the bridge and the coordination with the crew members to the safe guidance of the passengers to the mustering stations, their counting and their embarkation to the LSAs.

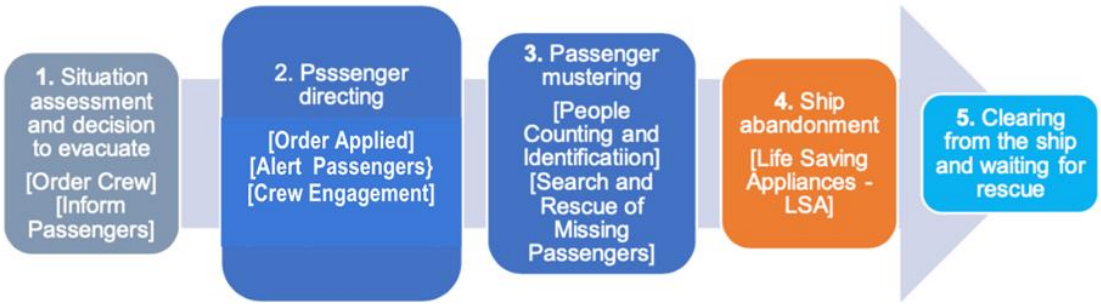

Figure 4. The progression of a ship evacuation process

3. Site Surveys

In this chapter, the focus is on the selection of specific areas on the ELYROS ship where the "Passengers Evacuation and Mustering Demo" will be executed, and a detailed description of these areas is provided based on site surveys conducted for this purpose. The selection of appropriate areas is critical for ensuring that the demo is carried out safely and efficiently.

To provide context for the selection process, the chapter begins with a brief overview of the ELYROS upper decks[4] which include Decks 7 to 11. The characteristics of each deck are outlined, including the areas that are accessible to passengers and those that are not.

The chapter then delves into the selection process for the demo areas, detailing the factors that were considered when choosing the appropriate locations. The safety and accessibility of the areas, as well as their proximity to necessary equipment and resources, were all taken into account.

The selected areas are described in detail, including the specific decks and locations on each deck. The Mustering Stations on Deck 7 and the Evacuation areas, which are crucial for emergency situations, are highlighted as key areas for the demo. The descriptions are accompanied by figures providing a visual aid for readers to better understand the selected areas.

3.1 ELYROS Upper Decks overview

The ELYROS Upper Decks span from Decks 7 to 11, each with its own unique features. Deck 11 is the highest deck and primarily houses auxiliary spaces such as antennas that are inaccessible to passengers. On Deck 10, passengers are also not allowed in areas such as the pet kennels, the chief engineer's and Muster's rooms, the ship's office, the wheelhouse, and the data room.

Deck 9 comprises both crew and passenger cabins, with a shaded deck housing restaurants and seating areas for passengers and crew, as well as engine opening areas and another data room. **Deck 8** includes passenger cabins, an open deck, an atrium lounge, additional passenger seating areas, and engine opening areas. **Deck 7** features several passenger seating areas, an aft lounge, restaurants, and various shops. The Mustering Stations critical for emergency situations are also located on this deck, along with areas used for evacuating the population. During an evacuation, the ship's MEVs (Marine Evacuation Vessels) are lowered to Deck 7, and passengers embark on these vessels through this deck.

Understanding the layout of the ship is important for identifying the essential areas during an emergency, such as the Mustering Stations and MEV areas on Deck 7, which are critical for passenger safety during an evacuation. It's also essential to know which areas are inaccessible to passengers, like Decks 10 and 11, to exclude them from demonstration areas. By taking these factors into account, the selection of specific ship areas for the "Passengers Evacuation and Mustering Demo" can be made with precision, efficiency, and safety.

In addition, the designated locations of crew members and passengers during an emergency, as outlined in the ELYROS day evacuation plan, should be considered. Crew members are expected to be at the ship's offices and wheelhouse on Deck 10,

[4]Since the Lower and Garage Decks of the ship are not typically occupied by passengers during a voyage, they will not be further analysed.

crew cabins and seating areas on Deck 9, and public spaces on Deck 7. Passengers are expected to be in public areas on Decks 7, 8, and 9, while the night evacuation plan designates most passengers and crew in their cabins on Deck 8 and 9, respectively. Finally, an important factor in selecting demo areas is the proximity to the ship's data room located on Decks 9 and 10.

Table 3. Allocation of Passengers on Decks

Deck No	Nighttime Presence		Daytime Presence	
	Passenger	Crew	Passengers	Crew
11	no	no	no	maybe
10	no	yes	no	yes
9	yes	yes	yes	yes
8	yes	yes	yes	yes
7	yes	yes	yes	yes

After carefully considering all the relevant factors, the following **areas were selected for the pilot** execution:

Table 4. Selected Pilot Areas

Selected Space	Deck
Crew seating area (VIP restaurant)	Deck 9
Passenger cabins	Deck 8
Public spaces	Deck 7
Mustering Station	Deck 7
MEVs	Deck 7

In the following section, we provide a detailed description of each of these areas together with a visual representation of each one.

3.2 Selected Pilot areas

The designated demo areas at ELYROS F/B are as follows:

- **Deck 7**: MVZ[5] D, MVZ C, MVZ B (includes landing areas of Staircases S1 and S3)
- **Deck 7** - MVZ B Muster Station for the needs of the Pilot (capacity 460 persons)
- **Deck 8**: Passenger cabins - a maximum number of 5 cabins - and landing areas of Staircases S1 and S3
- **Deck 9**: Crew seating area (or VIP Restaurant) and landing areas of S1 and S3
- Staircases (Vertical Structures): S1 9-8-7, S3 9-8-7

Demo scenarios will require passengers to move from MVZ D to MVZ C and then to MVZ B on Deck 7, or from their cabins on Deck 8 to the main muster station of the demo (MVZ B on Deck 7) through Staircases S1 8-7 and S3 8-7. The crew seating area (or VIP restaurant) on Deck 9 also leads to the main pilot muster station through Staircases S1 9-8-7 and S3 9-8-7. Finally, two evacuation areas with MEVs (with capacity 300 persons each) can be accessed directly from the main muster station of the demo.
Crew members will need to move across all designated demo areas to perform assigned tasks such as assisting passengers.

The figure below displays the selected areas (in yellow) on Decks 7, 8, and 9 of the ship.

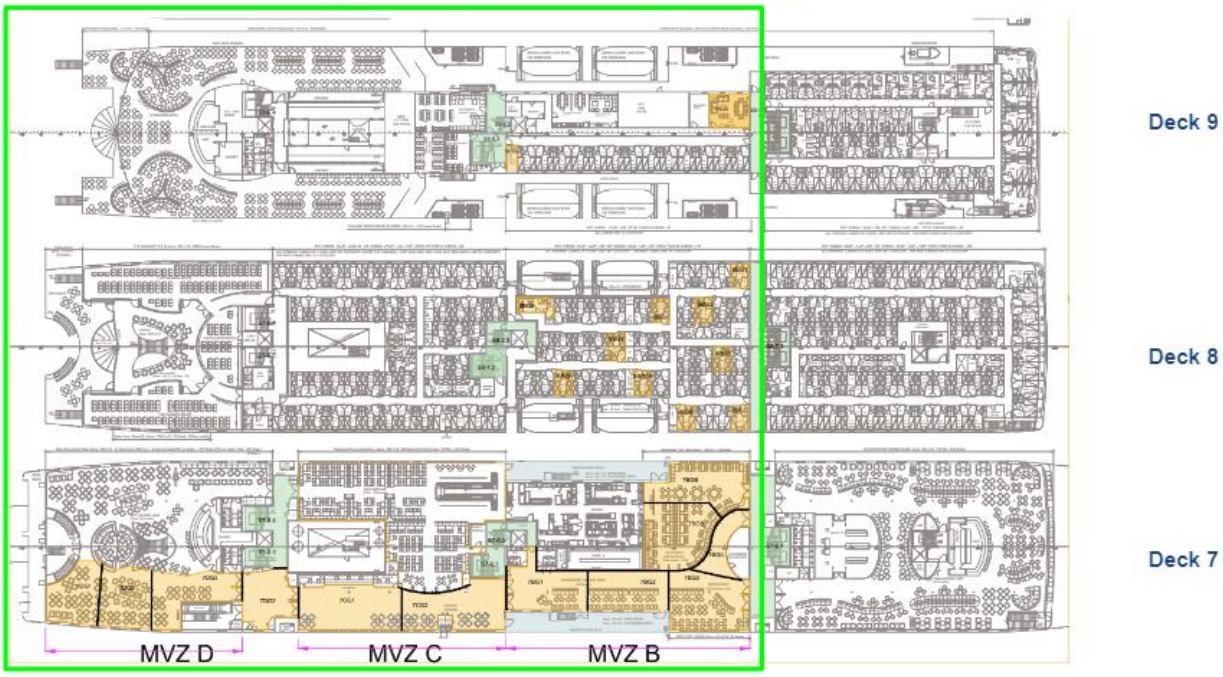

Figure 5. Selected Areas Map

[5]Here MVZ refers refer to main vertical zones based on the definition of SOLAS Consolidated Edition 2004: “These sections into which the hull, superstructure, and deckhouses are divided by “A” class divisions, the mean length of which on any deck does not in general exceed 40 m.” (SOLAS)

3.3 Selected Pilot areas in detail

3.3.1 Deck 7

The image below provides a closer view of the selected areas on Deck 7 of the ship.

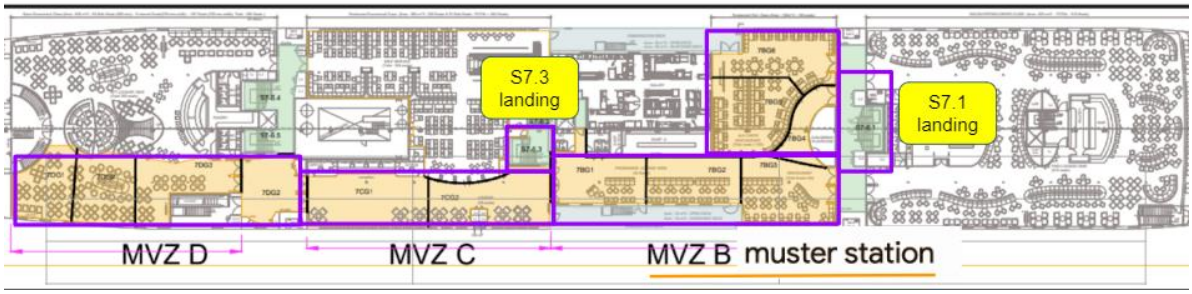

Figure 6. Deck 7

The table below presents a brief overview of the characteristics of the different areas on Deck 7.

Table 5. Deck 7 Pilot Area Characteristics

Demo Areas on Deck 7	Characteristics
MVZ D (plus the Hallway between D and C)	340 m^2 | 2.5 m (false-ceiling height)
MVZ C (includes S3 staircase landing area which serves evacuees from Decks 8 and 9)	260 m^2 | 2.5 m (false-ceiling height)
MVZ B (includes S1 staircase landing area, which serves evacuees from Decks 8 and 9)	630 m^2 | 2.5 m (false-ceiling height)
Total Deck 7 Pilot Area	1230 m^2

3.3.1 Deck 8

The image below provides a closer view of the selected areas on Deck 8 of the ship.

Figure 7. Deck 8

The table below presents a brief overview of the characteristics of the different areas on Deck 8

Table 6. Deck 8 Pilot Area Characteristics

Demo Areas on Deck 8	Characteristics
cabin 1	8207 (2P) 10 m^2 | 2.1 m
cabin 2	8201 (2P) 10 m^2 | 2.1 m
cabin 3	8283 (4P) 10 m^2 | 2.1 m
Staircase S8-7.1 landing area, which serves evacuees from Decks 8 and 9	36 m^2 | 2.5 m (height)
Staircase S8-7.3 landing area, which serves evacuees from Decks 8 and 9	24 m^2 | 2.5 m (height)

3.3.1 Deck 9

The image below provides a closer view of the selected areas on Deck 9 of the ship.

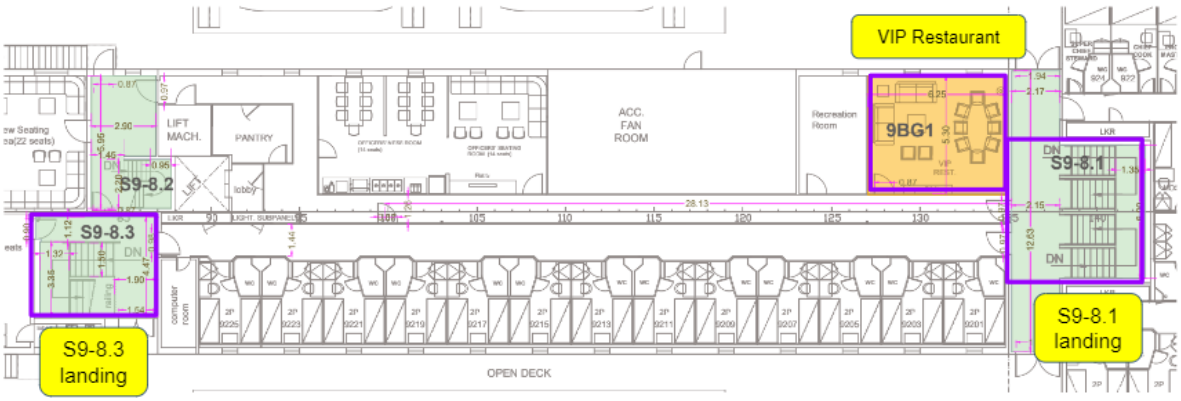

Figure 8. Deck 9

The table below presents a brief overview of the characteristics of the different areas on Deck 9.

Table 7. Deck 9 Pilot Area Characteristics

Demo Areas on Deck 9	Characteristics
MVZ B VIP Restaurant	34 m^2 | 2.4 m (height)
Staircase S9-8.1 landing area, which serves evacuees from Deck 9	36 m^2 | 2.5 m (height)
Staircase S9-8.3 landing area, which serves evacuees from Deck 9	24 m^2 | 2.5 m (height)

4. Smart Evacuation Management Simulations (in-context). Smart Evacuation Management Simulations (in-context)

This chapter provides a detailed account of a series of simulation validations that were conducted to evaluate the applicability of the SEM platform in the context of ELYROS. The simulations were designed to demonstrate the SEM platform's ability to meet the key functional requirements of the system and to show that its implementation is both resilient and scalable enough to be applied in real-world emergency situations. Specifically, the simulations aimed to test the SEM platform's ability to successfully manage a **large amount of real-time data** (i.e., hundreds of passengers) and provide a comprehensive overview of the mustering process through user-friendly interfaces.

4.1. SEM Simulations Objectives

The purpose of conducting the SEM platform simulation testing was to confirm that the system was prepared for deployment on ELYROS for piloting. The validation process

ensured that the SEM platform was capable of handling an emergency situation that could occur on the ship, providing the user with all necessary information regarding the progression of the mustering.

Specifically, the simulation exercises verified that the SEM platform achieves the following objectives.

Table 8. Simulation Objectives

Simulation Objective	Description
SO1	handle the **large volume of location data** generated by hundreds of passengers moving inside the spaces of ELYROS during the mustering process
SO2	generates the **correct mustering instructions** for the passengers based on their current (simulated) location
SO3	provides **accurate passenger counts and identification** in assembly stations via user-friendly UIs.

Overall, the SEM platform simulation testing was critical to ensuring that the platform was ready for deployment and could effectively support emergency evacuation situations on ELYROS.

4.2 SEM Simulation Methodology and Limitations

To achieve the aforementioned objectives the methodology of performance testing was adopted. Specifically, Performance testing is a type of software testing that is used to evaluate the performance characteristics of a system, application or component, such as scalability, stability, and resource usage. The goal of performance testing is to ensure that the software can handle the expected workload and user traffic, and that it meets the performance requirements that were specified.

Performance testing can take many forms, including load testing, stress testing, and endurance testing. Load testing is used to measure the system's behaviour under normal or expected workloads. Stress testing is used to measure the system's behaviour under extreme or unexpected workloads. Endurance testing is used to measure the system's behaviour over an extended period of time to ensure that it can maintain performance and stability over time. During performance testing, test cases are designed to simulate real-world usage scenarios and are executed using automated testing tools or manual testing methods. The test results are then analysed to determine if the system is performing as expected and if there are any bottlenecks or issues that need to be addressed. For the PALAEMON SEM platform, **load and stress testing were combined** as the normal and extreme workloads are identical (meaning the same number of passengers are generating data in the system in all cases).

To verify the proper functionality of the SEM platform under load testing, specific software was developed (**PaMEAS Passenger Location Simulator**) to simulate the movement of passengers on board the ship. In detail, this software was used to simulate the movement of **700 passengers** on board the decks of ELYROS, starting from random locations on the decks of the ship and heading towards their assigned muster station.

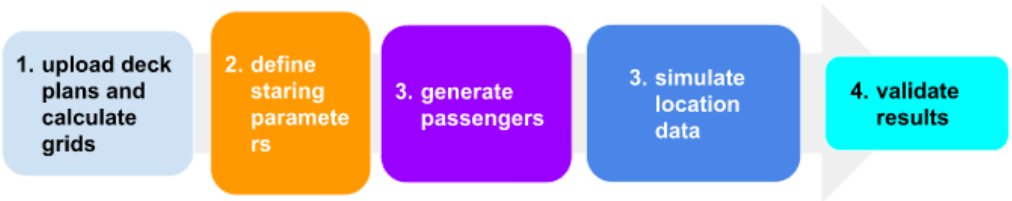

Figure 9. Passenger Simulator Execution Flow

The movement of passengers onboard ELYROS was simulated using the vessel's floor plans to create a grid with walls acting as blocking barriers. The grid was then inputted into the simulation software that randomly generated the passengers at various starting locations and utilised the A*-algorithm[6] to determine their path to their designated muster stations. Additionally, the software enables the random assignment of movement speeds to the passengers and allows for the specification of the percentage of passengers who require evacuation assistance or will display health issues.

Table 9. Simulation Stages

Simulation Input	Simulation Execution	Simulation Finish
• Vessels floor plan • Initialization parameters (percentage of passengers to exhibit health issues)	• Virtual Passenger Generation • Path Assignment • Speed Assignment • Movement Simulation • Tester triggers events (e.g. mustering instructions)	• Virtual Passengers gathered at MS

Once the paths are assigned, the simulation software continuously broadcasts new location data for each passenger to the PALAEMON SEM platform every 3-5 seconds, ensuring that the passengers adhered to their predetermined path mimicking the behaviour of the Real Time Location system that will be deployed on ELYROS. Passengers with mobility issues remain stationary while passengers exhibiting abnormal behaviour start moving and eventually exhibit incidents before reaching the muster station.

[6] The A* algorithm is a popular pathfinding algorithm commonly used in computer science and game development to find the shortest path between two points on a grid

As a result using this software it is possible to ensure that the SEM platform can cope with large volumes of data, correctly updating the location of passengers as these are generated by the simulator and monitor the progression of the mustering. Furthermore, using the simulation software, it is also possible to validate key functional requirements of the SEM platform. Specifically, through the SEM platform's user interface, emergency alerts and mustering instructions can be initiated and transmitted to the users. The platform logs the transmission of these messages, allowing users to verify that the transmitted instructions adhere to the ship's emergency plan. Finally, the functionality of the SEM platform UIs can be validated using the simulated passenger location data and to evaluate the platform's capacity to oversee the progression of the mustering process in a comprehensive and user-friendly manner.

4.2.1 Limitations

We must clarify at this point that the purpose of the PaMEAS Passenger Location Simulator is to assist with the validation of the SEM platform facilitating via appropriate tests that the system behaves correctly and can handle the expected stress load. The Simulator was not designed as a fully-fledged passenger flow simulation software (like those that can be found in the literature [1], [2], [3]) and are used to evaluate a ships design with the purpose of improving passenger flows. As a result, this software doesn't adjust the passengers' speeds when spaces become crowded, doesn't take into consideration various behavioural models that affect passenger movement during evacuation and so on. Furthermore, it cannot be used as a tool to measure the effect of the SEM platform on the evacuation process or be used to evaluate the effectiveness of the evacuation plan implemented by the SEM platform.

The PaMEAS Passenger Location Simulator was designed with the piloting scenarios that would be executed on ELYROS F/B in mind. The active piloting plan when the Simulator software was implemented included Decks 7,8 and 9. According to the ship's evacuation plan passengers from these decks muster at the three mustering stations available on Deck 7. Additionally, this software was designed and implemented, with the working assumption that access to only one of these three mustering stations would be permitted for piloting (these decisions were later revised as explained in detail in Chapter 6). As a result, to ensure that the simulation would be as close to the piloting process as possible the simulation moves passengers from all Decks to the active (according to the piloting plan) muster station, Muster Station B, deviating slightly from the ships emergency evacuation plan.

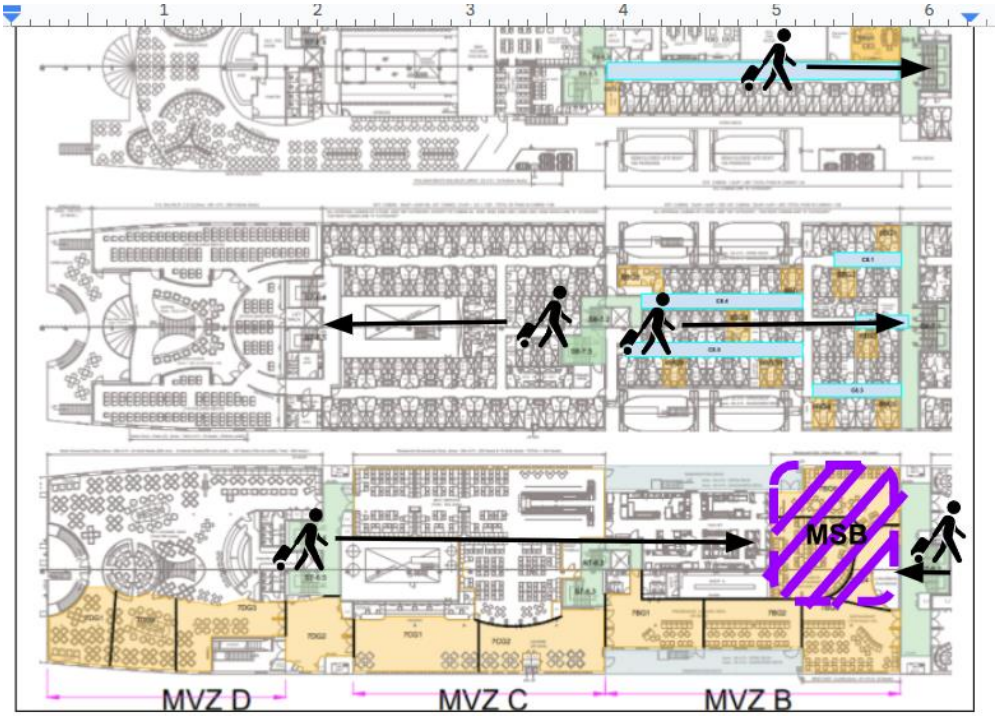

Figure 10. Simulation Passenger Movements

The specific use cases this simulation software can be used for are displayed in the following table, comparing its functionality with more generic type of passenger flow simulation software.

Table 10. Simulation use cases

#	Simulation Use Case	Result
1	Validate that the platform can handle varying number of passenger location data and evaluate its performance	yes
2	Enable the validation of the mustering instructions sent to the passengers	yes
3	Enable the validation of the proper real time counting of the passengers in designated areas	yes
4	Enable the validation of the ships evacuation plan design	no
5	Enable the validation of the times required to complete the mustering process	no
6	Enable the validation of the ability of the platform to identify and locate passengers needing assistance (passengers with health, mobility issues etc.) and stranded passengers (not following the evacuation plan)	yes
7	Enable the validation of the effect of the SEM platform to the improvement of the mustering & evacuation process	no

4.3 SEM Simulation Execution

4.3.1 SEM Simulation instructions

In this section, the process for conducting a simulation test is outlined. The PaMEAS Passenger Location Simulator is used to generate, update, and calculate the mustering paths of passengers in real-time, which requires considerable computational power and resources. To address this, the simulation software is deployed in four separate instances, and it is recommended to use all three to conduct stress tests.

The initiation of the simulation of passengers' locations can be initiated via the following REST call (port numbers ranging from 7011 to 7013):

```
curl --request POST \
  --url http://195.251.134.91:7011/runEmulation \
  --header 'Content-Type: application/json' \
  --data '{
    "noOfData" : "200",
    "positionError" : "0.5",
    "pathErrorPrcntg" : "0",
    "deck" : 7,
    "oxygenProblemPrnctg" : 1,
    "heartProblemPrnctg" : 1
}'
```

In this context, "noOfData" refers to the number of virtual users that will be generated, "positionError" denotes the percentage of position error that will be simulated by the module, "pathErrorPrcntg" denotes the percentage of passengers that will not follow their assigned paths but will stop their movement at random locations, "deck" denotes the deck where the virtual passengers will be generated, "oxygenProblemPrnctg" denotes the percentage of virtual passengers that will have simulated issues with their oxygen levels (as would be captured by smart bracelets in real-life situations), and finally "heartProblemPrctg" denotes the percentage of virtual passengers that will have simulated issues with their heart rate (as would be captured by smart bracelets in real-life situations).

As previously mentioned, the SEM platform records the messages sent to passengers and crew, which can be analyzed after an incident on the vessel. This feature is especially helpful when verifying the mustering instructions generated and transmitted by the system. By comparing these message logs with the current location of a user, it is possible to ensure that the system transmits the correct mustering instructions to the passengers based on their latest location (generated by the simulator). Access to these message logs can be obtained through a simple REST call:

```
curl --request GET \
  --url http://195.251.134.105:9096/entry/
```

4.3.2 SEM Simulation Execution

Using the instructions presented in the previous section a load/stress test of the SEM platform to validate the use cases presented above is executed as follows:

- The user inputs the starting parameters of the simulation software via the REST calls described in the previous section
- Next, the user monitors the process via accessing the SEM platforms UIs.
- The user validates the progress of the mustering process, by verifying the percentage of the passengers safely counted at the muster stations in real time.
- (Optionally) the user verifies the messages generated and transmitted by the SEM platform towards the passengers.

In more detail, the SEM platform enables the bridge to manage the evacuation process and visualise in real time the movement of the passengers onboard ELYROS via specific build UIs. This user interface module is called PIMM. PIMM is used to monitor the execution of stress testing in real time and is accessible through a public URL (https://pimm.konnekt-able.com/). Users are required to authenticate with a set of credentials provided for testing purposes (admin, asdf1234). Using these UIs a typical execution of a stress test with 700 passengers look as follows:

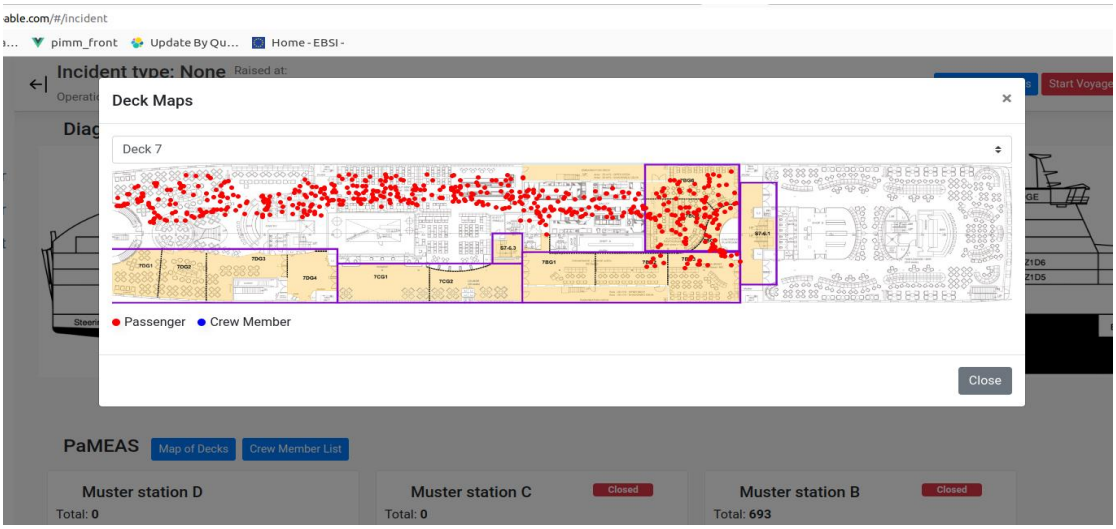

Figure 11. Simulated Passenger initial distribution

- **Step 1:** user initiate the execution of the test by making the appropriate REST calls
- **Step 2**: the user accesses the "map of decks"[7] interface and reviews the location of the passengers in real time.
- **Step 3**: the user reviews the initial distribution of the passengers on the decks of the ship. These passengers are generated based on the initial input provided by the user in step 1.

[7] The map of decks interface is accessible from the PIMM landing page by clicking "Incident Assessment" on the sidebar and then tapping the "map of decks" button.

- **Step 4**: the user monitors the progression of the passengers towards the muster station (MSB)

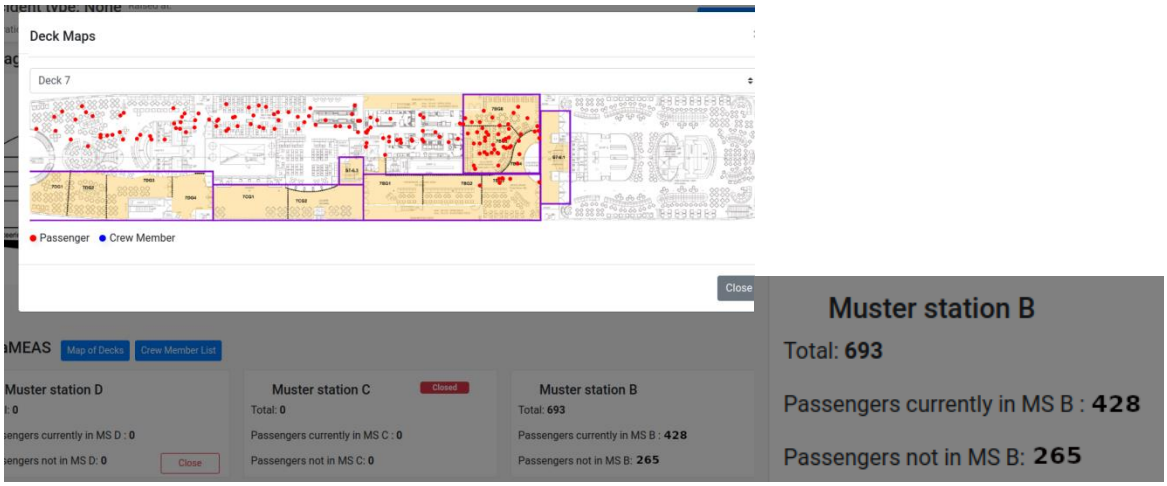

Figure 12. Passengers Progressing to Muster Station (PIMM UI)

- **Step 5:** the user verifies that eventually (in approximately 15 minutes, depending on the number of passengers generated and the randomised speeds assigned to the passengers) all passengers reach MSB and the mustering is completed (assuming that during the test initialization the user didn't request for passengers to become trapped, or exhibit health issues).

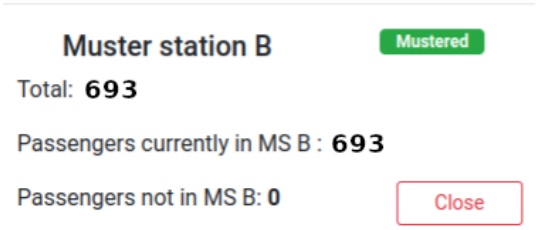

Figure 13. Mustering Completed

- **(optionally) Step 6:** the user can request the calculation and transmission of the mustering instructions to the simulated passengers by clicking the "Passenger Mustering" button on the central PIMM UI. These instructions are calculated based on the current location of each passenger and are optimised to provide the best evacuation path.

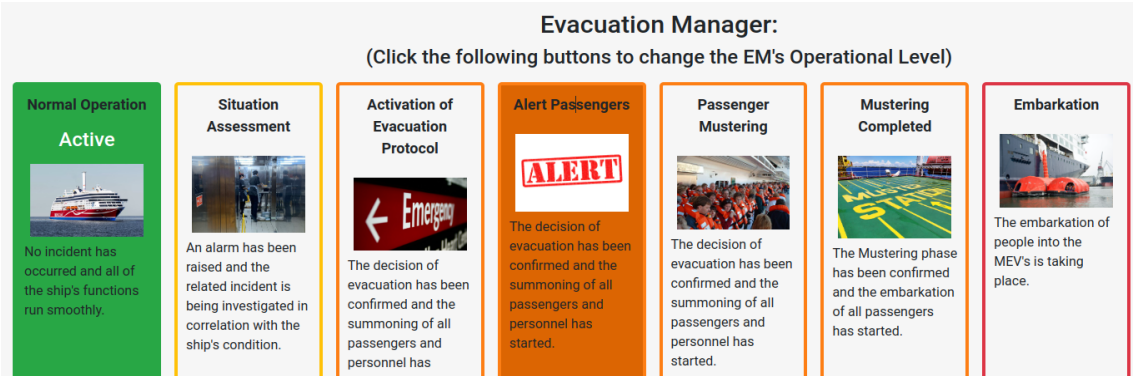

Figure 14. PIMM activation of transmission of mustering instructions

- **(optionally) Step 7:** the user requests via the appropriate REST call the logs of the messages sent to the passengers during step 6, and use them to validate that the mustering instructions transmitted follow the SEM platforms evacuation plan.

4.4 SEM Simulation Outcomes

The original deployment of the SEM platform was able to handle approximately a hundred concurrent simulated passengers moving around the ship. Despite this, real life conditions require a much higher number of passengers being handled by the system without performance issues. However, the microservice architecture used in the SEM platform provides great potential for scalability. By breaking down the system into smaller, independent services that can communicate with each other, it becomes possible to deploy additional instances of specific microservices as needed to handle increased loads.

This means that the SEM platform can scale horizontally, allowing for more instances of a particular microservice to be deployed as needed, rather than vertically, where more resources are added to a single instance.

Table 11. Simulation Validation Results

#	Simulation Use Case	Result (pass/fail)
1	Validate that the platform can handle varying number of passenger location data and evaluate its performance	**pass**
2	Enable the validation of the mustering instructions sent to the passengers	**pass**
3	Enable the validation of the proper real time counting of the passengers in designated areas	**pass**
4	Enable the validation of the ability of the platform to identify and locate passengers needing assistance (passengers with health, mobility issues etc.) and stranded passengers (not following the evacuation plan)	**pass**

As a result, in order to handle larger numbers of passengers, **the system was scaled** by deploying **additional instances of key microservices,** such as the RTLS API manager, and adding a load balancer in front of them to distribute the load evenly. This approach allowed the SEM platform to scale up to handle up to **700 concurrent** simulated passengers, with minimal impact on performance.

The following figure displays the process of scaling the SEM platform microservices to enable it to handle the expected data load. The key microservices in play are the RTLS API

service[8], the DBProxy service[9] and of course the Simulator service (which generates the load for testing the system). It was observed that despite the increase in load from 400 to 700 passengers three instances of the RTLS API and four instances of the DBProxy service were enough to handle the load. As the load increases further only scaling of the simulation software was necessary providing enough validation that the SEM platform is scalable enough to handle the expected data loads of a real-life scenario, as it can quickly and easily scale to handle increased loads and ensure that all passengers are accounted for and safely evacuated.

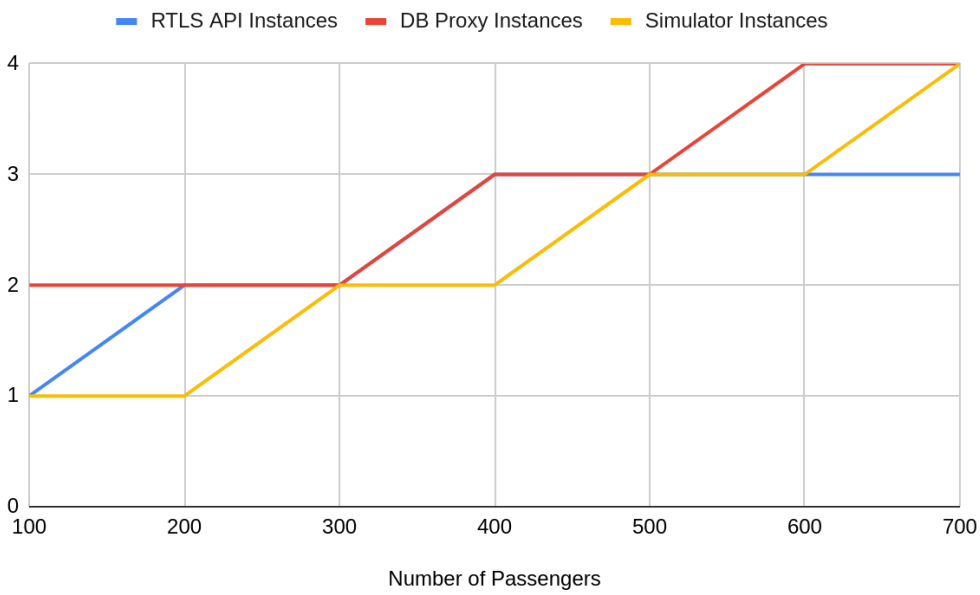

Figure 15. SEM Platform Scalability

5. Smart Evacuation Management Pilot Strategy and Plan

The results of the **simulation** trials presented in Chapter 5 **demonstrated the capacity of the SEM platform to handle the evacuation and mustering processes on the selected pilot spaces of ELYROS** (Deck 7, 8 and 9 as those were described in chapter 4). Furthermore, they provided validation that the SEM platform operates as expected when applied in this setting. Specifically, through these simulation efforts it was possible to verify that the SEM platform is capable of handling large volumes of user location data moving around the spaces of ELYROS and successfully generating the proper mustering instructions based on their current locations. Furthermore, the demonstrations exhibited the capacity of the platform to accurately and instantly count the passengers gathered at the mustering stations as well as identify stranded passengers.

[8] the RTLS API service is the PALAEMON service responsible for receiving the generated location data by the indoor positioning system deployed by PALAEMON and taking the necessary actions to update the passengers locations

[9] the DBProxy service is a PALAEMON service responsible for the providing access and updating the passenger and crew profiles.

However, it was necessary to make adjustments to the selected pilot areas. The adjustments were made based on the results of simulation trials, ongoing conversations between technical pilot partners and operators, and requirements and constraints imposed by the ship operator. The chapter draws on conclusions from previous trials and an analysis of the evacuation plan and procedures conducted during routine mustering-evacuation drills. Furthermore, the chapter provides a first approximation of the proper pilot strategy, an architecture plan for necessary equipment deployment, and a time plan. These outcomes led to the next step of further design and validation of the pilot strategy and plan. They also served as a compass for the actual pilot implementation that followed and guided the adjustment of trail depth and coverage to envisioned opportunities, available resources, and imposed constraints.

5.1 Adjusting piloting areas

In order to provide the SEM platform functionality on all three decks (Deck 7, 8 and 9) the following components of network equipment are necessary:

Table 12. SEM Component Deployment Requirements

SEM Component	Deployment Actions	Deck
5G Core Server	Data Room Rack	9
5G Radio Dots	Ceiling, wiring	7,8,9
Wifi 6 AP	Ceiling, wiring	7,8,9
BLE beacons	Ceiling, calibration	7,8,9

Specifically, after the site survey conducted the specific deployment requirements to support the SEM platform are presented in the following table:

Table 13. SEM Component Deployment Modules per Deck and MVZ

Location	Component	Number
Deck 9 - Data Room - MVZB	Servers	3
Deck 9 - MVZB	Wireless APs	5
Deck 9 - MVZB	Radio Dots	3
Deck 9 - MVZB	BLE beacons	10
Deck 8 - MVZB	Wireless APs	6
Deck 8 - MVZB	Radio Dots	2
Deck 8 - MVZB	BLE beacons	16

Deck 7 - MVZD	Wireless APs	4
Deck 7 - MVZD	Radio Dots	2
Deck 7 - MVZD	BLE beacons	10
Deck 7 - MVZC	Wireless APs	4
Deck 7 - MVZC	Radio Dots	2
Deck 7 - MVZC	BLE beacons	10
Deck 7 - MVZB	Wireless APs	8
Deck 7 - MVZB	Radio Dots	2
Deck 7 - MVZB	BLE beacons	16

Deploying the equipment for covering all originally envisioned spaces on Decks 7,8 and 9 described in chapter 4 was considered as a **risk** to the normal operation and safety of the ship as this endeavour would necessarily take place during the crew's resting times which could result in unexpected consequences about the safety of the ship[10]. ELYROS at the time of these discussions was executing daily journeys from the port of Piraeus to the port of Chania. As a result, the crew of the vessel was burdened with exhausting duties (operating the vessel with safety, and catering for thousands of passengers during the journey and maintaining the vessel in the highest capacity to prepare it for the next journey only a few hours after arriving at the destination).

For these reasons, after ongoing conversations between the technical pilot partners and the operators (ANEK Lines) as well as the Piraeus Port authority and under the requirements and constraints imposed by the ship operator the selected piloting spaces were to be adjusted to a single deck. Additionally, it was mandated to only allow a few passengers/actors to participate as the interruption of normal procedures due to a large number of people onboard would pose a security risk as well.

The deck selection process that followed ensured that the final piloting area would take into consideration the following factors:

1. The ships evacuation plan
2. The procedures conducted during routine mustering-evacuation drills
3. Review of evacuation literature
4. Proximity to LSA

[10] Installation of these components by an external crew was also proposed but was not possible without the presence of key crew members (ship's electricians, inspections by chief engineer) that must oversee all such installations on the vessel to ensure they are not interfering with the rest of the equipment.

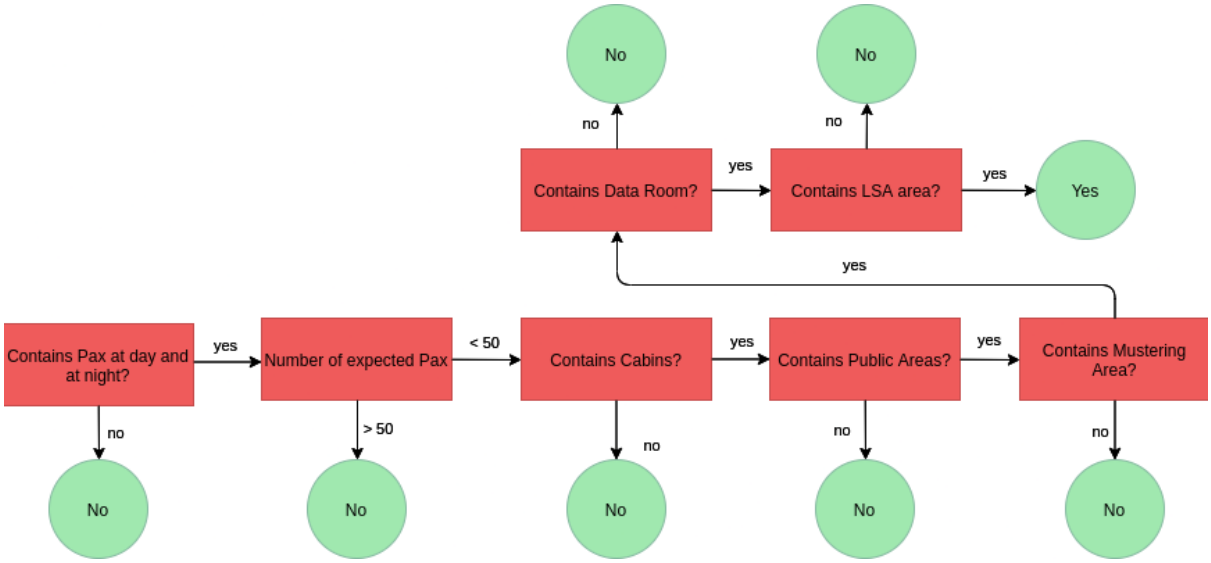

Figure 16. Pilot Deck Selection Decision Tree

5.1.1 Evaluating the ships evacuation plan

The ships evacuation plan stipulates that at the proposed piloting areas of Deck 9 a small number of passengers is normally located during daytime approximately 14 - 20 passengers (mostly located at the pullman seating area) as shown in the following figure.

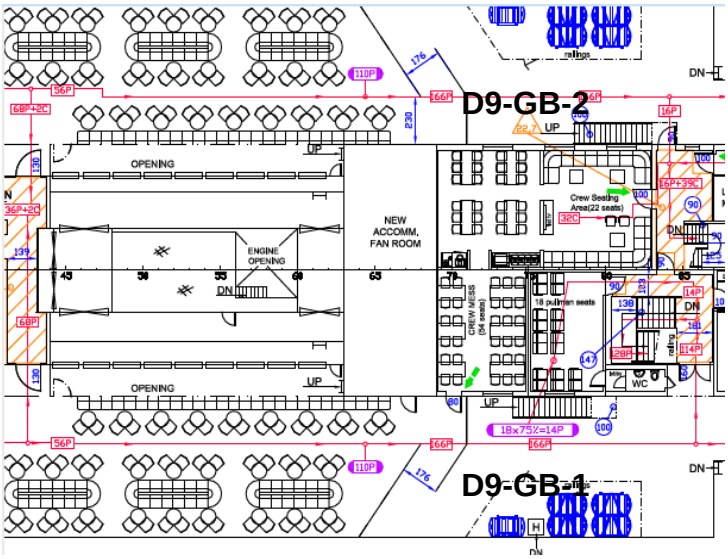

Figure 17. ELYROS evacuation plan for Deck 9 pilot areas

However, there is a much higher passenger count expected on the areas of Deck 8 and Deck 9. Furthermore, according to the evacuation plan of ELYROS the passengers of Deck 9 pass through the two staircases on their way to the muster station two decks down. During routine drills it is not an uncommon practice to gather the passengers at the landing area of these staircases in groups with the assistance of a crew member and then progress them towards the muster stations of Deck 7.

5.1.2 Consolidating the literature

An additional factor to consider when selecting the most appropriate piloting area is that of the utility of the spaces the area contains. Studies [4][5] have shown a significant difference in the Response time distribution (RTD) of passengers located in the ship's public areas and those located at the ship's cabins (this time difference is even greater in cruise ships than on ferries). Additionally, it has been shown [6] that passengers' evacuation times and habits differ when they operate alone or in big enough groups. The areas of Deck 9 contain territories where passengers can be expected to reside alone (e.g. in their cabins) and areas where they operate in large groups (e.g. restaurant area). On the other hand Deck 8 contains only areas where passengers can be expected to be alone or in small family groups. Diametrically, Deck 7 contains only areas where passengers are expected to operate in large groups (e.g. restaurants, shops etc.). For this reason, it is important to include piloting areas that contain both public areas and cabins for the evaluation of the SEM platform. From the available piloting areas Deck 7 contains only public areas and Deck 8 only cabins. Only Deck 9 contains both public areas and cabins.

5.1.3 Proximity to LSA

The lifecycle of the SEM platform concludes with the direction of the passengers to the LSAs and their eventual embarkation. As a result, access to the LSAs should be considered as an important factor for the selection of the final piloting areas. Deck 7 contains access to the actual LSA of ELYROS. However, Deck 9 is the resting place of the LSAs (prior to them being lowered down to Deck 7 for embarkation). As a result, both Decks 7 and Deck 9 fulfil this requirement.

5.1.4 Deck selection

After careful consideration of the above reasons and considering additional factors[11], **Deck 9 was selected as the piloting area** that will be used to evaluate and demonstrate the capacity of the SEMP platform.

In detail the final piloting areas of the SEM platform is presented in the following image where the piloting space has been broken into virtual perimeters (geofences). These geofences make it easier to collaborate on the details of the pilot as well as make it easier to define the evacuation routes for the purposes of the piloting.

[11] An additional (but critical) factor in deciding the final piloting area is that of the disruption of the ships normal operation. The data room where the servers of the SEM platform must be deployed are located on Deck 9. Additionally, many of the SEM components that need to be deployed on ELYROS require wiring to these servers. As a result, the proximity of the piloting areas of Deck 9 to the data room is a significant factor.

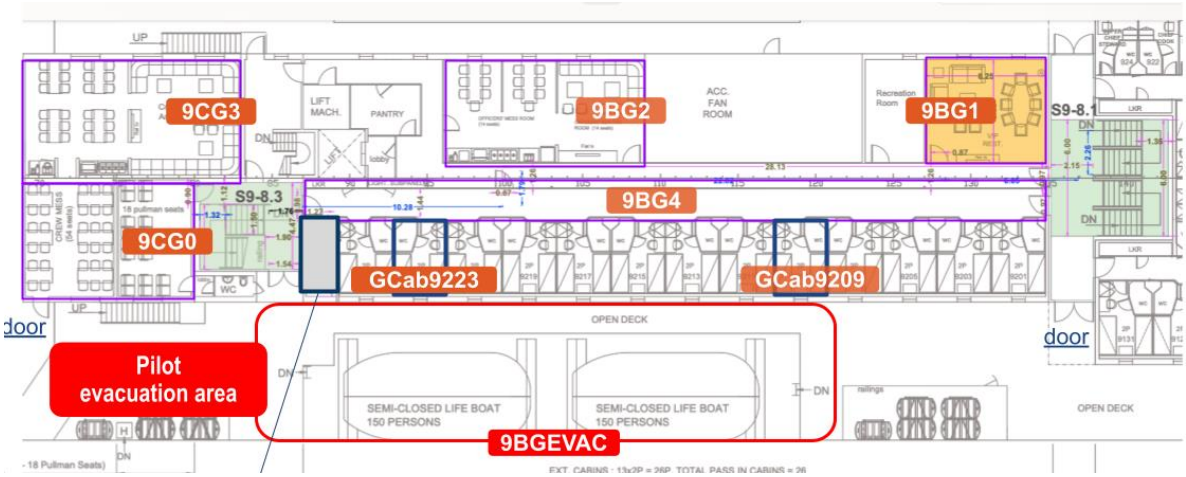

Figure 18. ELYROS Final Piloting Area

As can be seen from the figure above this area consists of the elements presented in the following table:

Table 14. Deck 9 Pilot Area Characteristics

Pilot Areas on Deck 9	Length	Width	Surface	Description
9BG1	6.54	5.30	34.15	VIP lounge
9BG2	10.30	5.30	54.59	Restaurant
9CG3	38.45	2.97	101.00	Restaurant Corridor
9CG0	8.68	6.20	53.61	Mustering Station (staircase)
9BG4	38.45	2.97	101.00	Cabin Corridor
GCab9223	2.75	3.85	10.5	Cabin
GCab9209	2.75	3.85	10.5	Cabin
S9-8.1	6.00	6.00	36.00	Staircase
9BGEVAC	28.88	7.79	224.97	LSA embarkation area

As presented on the table above, geofence **9CG0** will act in the piloting exercises as the **Muster Station**. The decision was taken due to the semantics of this area (size and proximity to other areas) and is in line with the drill practice of gathering passengers in this

area to guide them to the decks below (and eventually the actual muster stations located on Deck 7).

Finally, since only Deck 9 was eventually selected as the piloting area the ships mustering plan needed to be redefined in such a way that would make the evacuation process as closely related to a real emergency incident as possible. The definition of the piloting emergency evacuation plan can be considered as a directed graph with the aforementioned geofences acting as its nodes and its edges denoting the movement of the passengers from one geofence to the next.

Table 15. Deck 9 Primary Evacuation Paths

Starting Geofence	Edges	Ending Geofence
9BG2	9BG3, 9BG4	9CGO
9BG3	S9-8.1, 9BG4	9CG0
S9-8.1	9BG4	9CG0
9BG4	-	9CG0
GCab9223	9BG4	9CG0
GCab9209	9BG4	9CG0

5.2 Pilot Strategy approximation

The SEM platform must provide the following functionality:

1. Emergency Assessment (Includes: Emergency Inspection & Reconnaissance)
    - displays a triggered alarm notification.
    - launch the Evacuation Procedures or continue the assessment of the situation.
2. Activation of the Evacuation Procedure (Includes: Crew Positioning Verification, Launch of the Evacuation Procedure, i.e., EC presses the “Alert Passengers” button)
    - Alert Messages delivered to the Passengers and Crew
3. Mustering (Includes Passenger Notification, Issue and Incident Management)
    - confirms that all passengers are gathered at the muster stations.
4. Embarkation (to LSAs)

Based on this high level requirements which will be further expanded on D8.6b [10] that introduces the functional, operational and technical requirements of the platform the following first approximation of piloting exercises was designed:

Table 16. Pilot Scenarios/Exercises

Name	Actions
PreEvac1	● Emergency Assessment Task Management ● Assign situation assessment tasks to an emergency team ● Collect responses from the emergency team ● Visualise the responses received from the emergency team
PreEvac2	Dispatch two firefighting teams to reduce and contain the fire
PreEvac3	● Instruct Crew to reach their designated positions for Evacuation. ● Obtain the list of emergency teams and their current position. ● Verify positions
Must1	Augmented GA alarm - Direct the move of a group of passengers from area x to muster station: ● Alert Messages to Passengers (different languages) ● Notify Passengers and track their positions. ● Help passengers trapped in their cabin
Must2	Instruct passengers about alternative escape routes
Must3	Assist a passenger remained behind
Must4	Face an incident - involvement of the medical team
Must5	Mustering progress reporting - Passenger leaving a muster station
Embark1	Evacuations groups and Embarkation Preparation

These piloting scenarios/exercises should be executed in **two phases**:

1. The **first phase (pre-piloting)** aims at gathering feedback about targeted operations of the SEM platform and the second phase aims at evaluating the capabilities of the platform in the execution of a realistic end-to-end scenario.
2. The **second phase (piloting phase)** is designed to be executed into **two runs**. The first run will aim at gathering of the necessary measurements to evaluate the SEM platform KPIs and the second run will act as the SEM platforms demo in which end-users will be invited to evaluate the system.

5.3 Architecture plan for necessary equipment deployment,

As mentioned in section 6.1 to support the SEM platform the following network infrastructure must be deployed on Deck 9.

Table 17. SEM Component Deployment Modules on Deck 9

Location	Component	Number
Deck 9 - Data Room - MVZB	Servers	3
Deck 9 - MVZB	Wireless APs	5
Deck 9 - MVZB	Radio Dots	3
Deck 9 - MVZB	BLE beacons	10

Specifically, the deployment of the WiFi access points is presented in the following figure

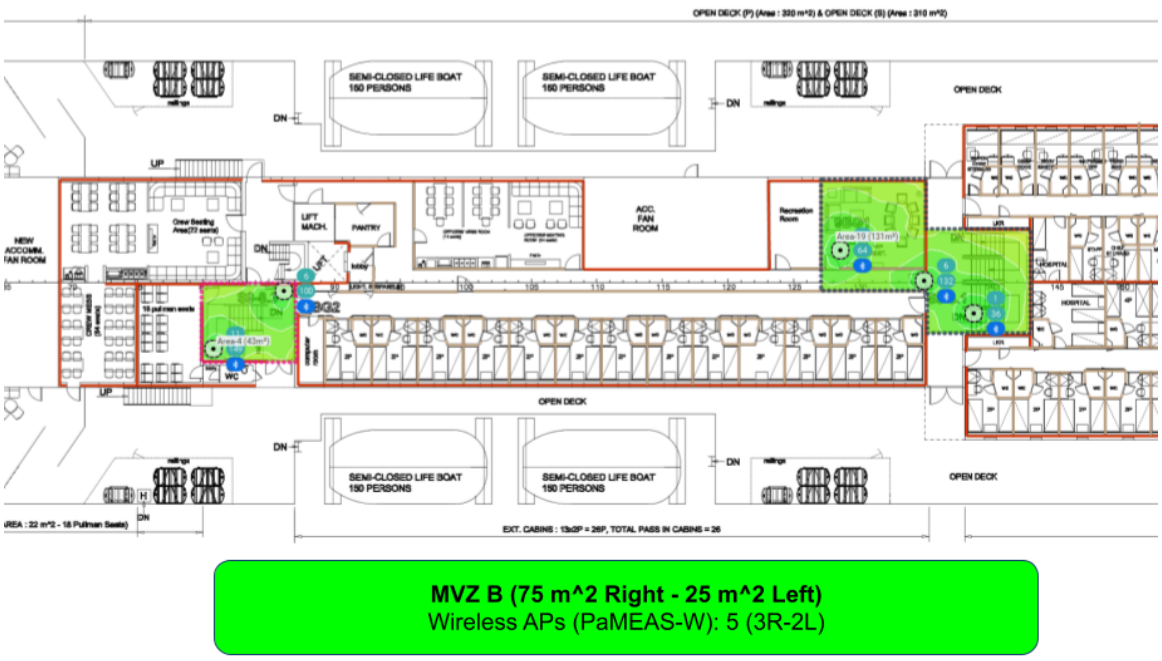

Figure 19. SEM Platform WiFi deployment on Deck 9

With respect to the requirements for the Private 5G Network for Emergency Messaging the following components will be installed:

- Network Core (Fully-on-site)
  - Athonet 5G Core
  - Pre-installed Dell R640 server
  - 10GB Ethernet port
- Cell RANs

- Ericsson Radio Dots
- Radio Frequencies
- 3390-3410 MHz (GR Ministry of Digital Governance)
- 3500-3520 MHz (NOVA)

Specifically, the topology of the 5G Network components is presented in the following figure.

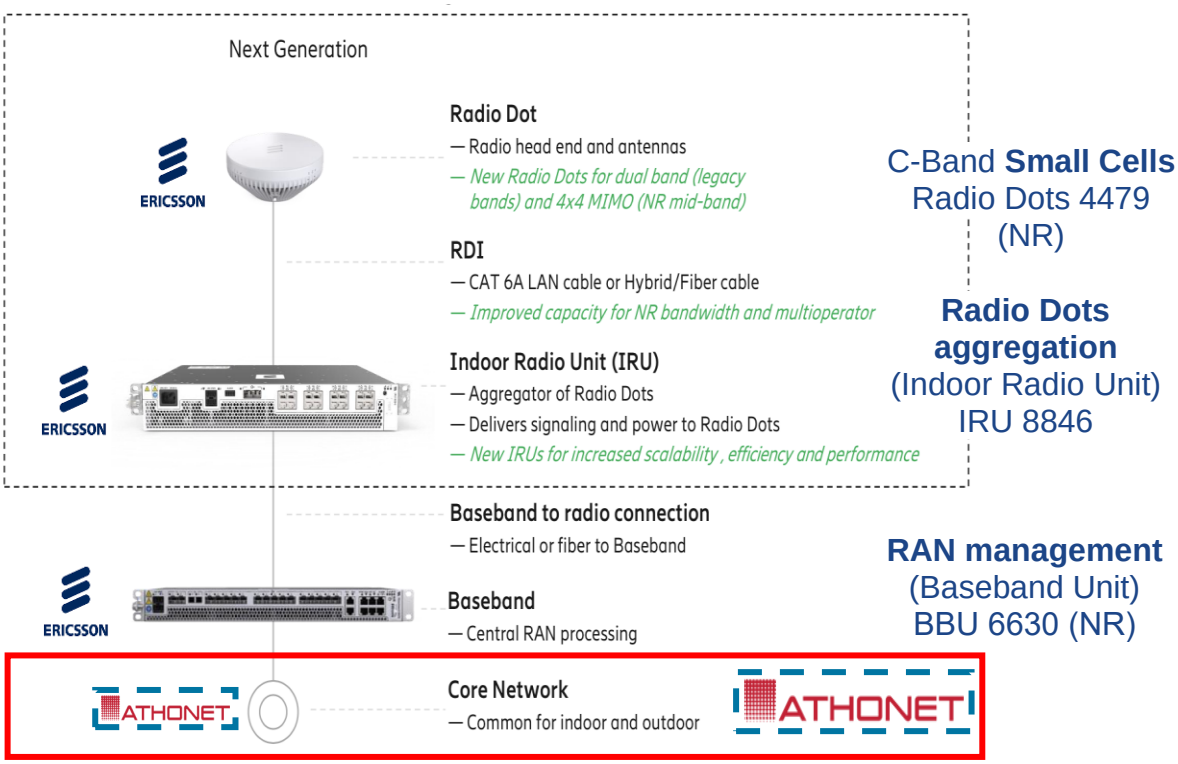

Figure 20. SEM 5G core network topology

In detail, the server provided by Athonet (pre-installed Dell server, Dell R640, with 10GB Ethernet port) will be hosted in ELYROS Data Room of Deck 9 and the necessary Cell RAN's will be deployed as follows:

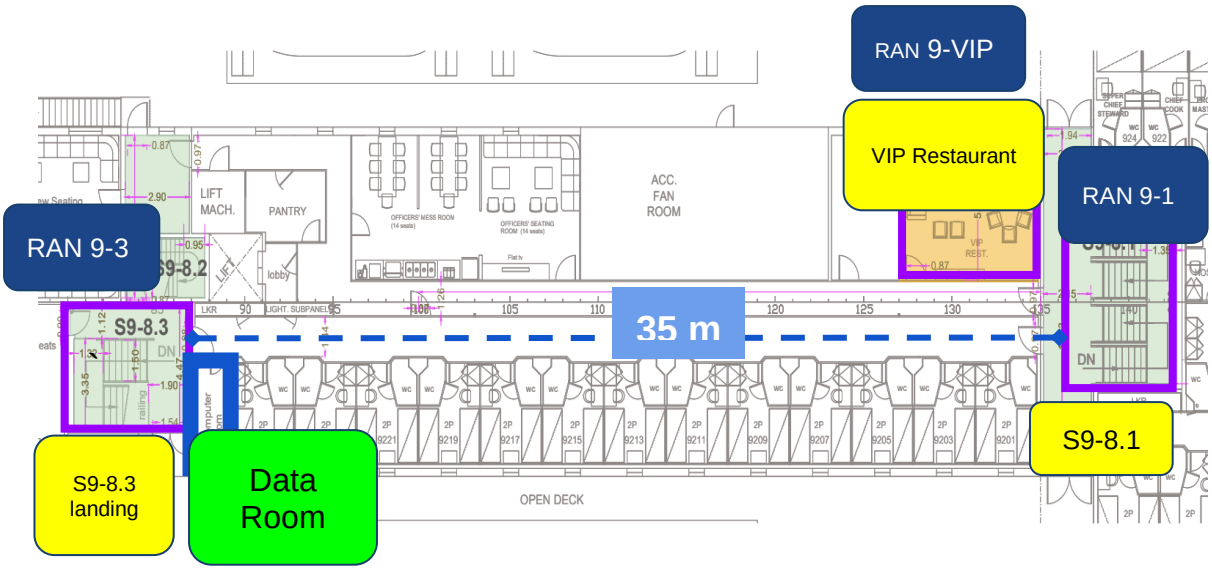

Figure 21. SEM Cell RAN network topology

Finally, the deployment of the BLE beacons is designed to be executed as follows:

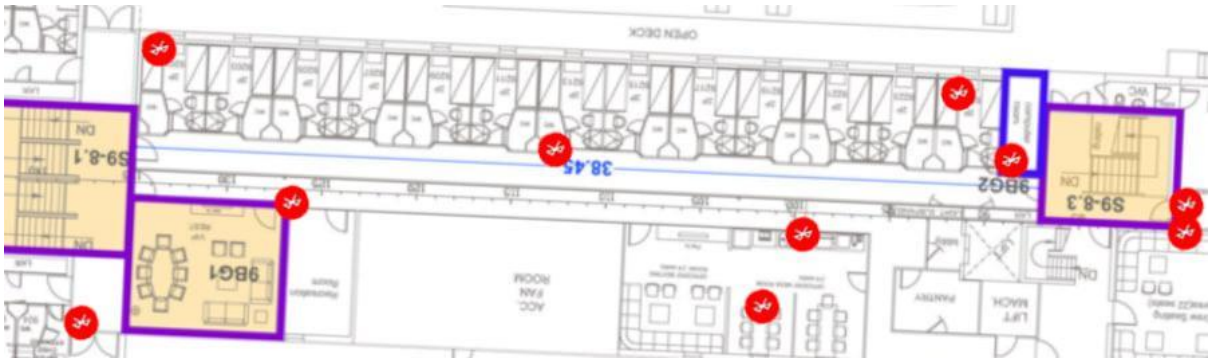

Figure 22. SEM BLE network topology

5.4 Time plan

The pilot exercises execution of the SEM platform was achieved in January 2023 instead of November 2022 as was originally planned. While at the originally planned execution time the SEM system had achieved significant progress and promised very interesting results for three specific reasons, listed below, for which the Pilot team could not be held accountable for the execution of the piloting was eventually slightly delayed:

- Delays in the delivery of the network equipment due to the disruption of the global supply chains (some of the equipment comes from China, so transport delays were more significant than expected).
- Delays in the Pilot set-up and preparation due to the fact that the exceptionally intensive touristic period in Greece required the continuous back-and-forth routing of the ship, between the port of Chania and Piraeus, in the same day.

- Delays in the provision of mobile devices that can interconnect with the deployed onboard 5G SA (standalone) network.

As a result, a 2 month extension was agreed to complete the SEM pilot with success. Following the approval of this extension a very detailed piloting action time plan was agreed between the partners presented in the following tables:

Table 18. Preparation Pilot Run Time plan

Task Name	Start Date - End Date
Pre-Pilot Run	Oct 2022 - November 2022
Pilot Run A1	November 2022 - December 2023
Pilot Run A2	December 2023 - January 2023

This plan is based on the availability of the pilot areas of ELYROS and it is designed in two phases. The first phase spanning from November to December 2022 is intended to validate the proper functionality of all of the SEM components deployed on ELYROS. Additionally, the goal of these exercises is to gather measurements about the effectiveness of the platform. The next set of piloting exercises, from December 2022 to January 2023, is intended to validate the SEM platform in real circumstances covering all of the functional requirements of the system as those are expressed in D2.5 [12] and will be further expanded upon on D8.6 [10]. Finally, the second Pilot Run A2 is intended to act as the **Demo** of the SEM platform. On these dates end users will be invited to participate, review the functionality of the system in action under real circumstances and will be asked to evaluate the functionality and added value of the system in interviews which will be recorded and made available.

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