## PROJECT DELIVERABLE REPORT

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

# D3.15 WP3 Public release

A holistic passenger ship evacuation and rescue ecosystem

MG-2-2-2018

Marine Accident Response

## Document Information

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| 2.0 | 2022/02/25 | JU | Review and Release |

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## Abbreviations

| | |
|---|---|
| BRM | Bridge Team Resource Management |
| DB | Data Base |
| HMI | Human–Machine interface |
| IMO | International Maritime Organization |
| ISM | International Safety Management |
| MQTT | Message Queuing Telemetry |
| SMS | Safety Management System |
| SOLAS | International Convention for the Safety of Life at Sea |
| SSS | Smart Safety System |
| STCW | Standards of Training, Certification and Watch keeping for Seafarers |
| SWH | Significant Wave Height |
| VHF | Very high frequency |

# 1 Summary

Due to an increasing demand for cruise capacity by the consumer, the aspect of safety is gaining much more importance in connection with the increasing size of the operators. Therefore, both technical and operational requirements as well as the increased safety needs of the customers. In this project, namely within WP3's (PALAEMON Intelligence Framework – AI Services and Algorithms) activities, we aim to develop new assistance system that maintain higher standards for evacuating of a particularly large ship in the event of an accident.

This involved the expertise of shipbuilders, cruise operators, classification societies, sensor and technology companies and a multidisciplinary group of innovators.

In order to facilitate operational planning in the event of a necessary evacuation, the system is to provide and process important ship status data in real time.

Thus, for the intelligent rescue system of PALAEMON both innovative methods to increase ship safety are being developed by the consortium as well as assistance modules for the detection, localization and counting of persons and monitoring of critical ship data during an accident. This enables such passenger ships to the necessary measures can be taken in an emergency.

## 2 Introduction

In the project (see WP structure in (Consortium, 2019)Fehler! Verweisquelle konnte nicht gefunden werden.), the need for various applications, but also for structural improvements will be investigated. The goal is to achieve a successful and time-efficient evacuation, in which the use of various the use of various assistance systems takes place.

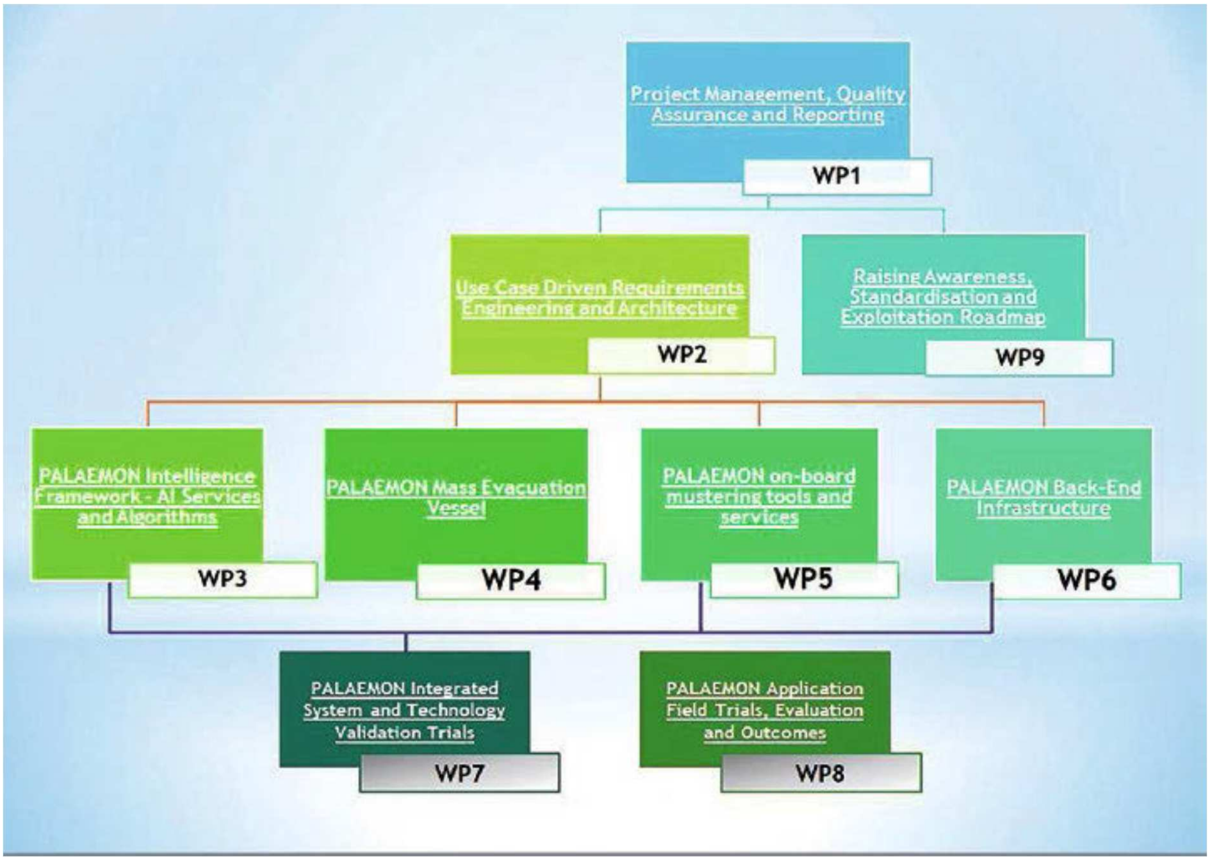


*Figure 1PALAEMON Project Overview – WP Structure*

The regulations of the International Maritime Organization (IMO) (IMO, 2021) and the flag states provide the legal framework for the evacuation of a passenger ship from construction to equipment and operation to operation. Since some of these regulations cannot be implemented directly, these regulations are by the classification societies into the class regulations, in order to design the practical implementation and to meet the specified time frame. Construction and equipment are a fixed value in the life of a passenger ship, but not the operation. In Chapter IX of the Annex to the SOLAS Convention (IMO, www.imorules.com, 2021)a mandatory system for the organization of security measures (SMS) within the framework of the International Code for the Organization of Safe Ship Operation (ISM Code) (IMO, www.imo.org, 2021) is adopted.

### 2.1 Scope of WP3

This work package is divided into two main areas (Consortium, 2019)assistance systems and crew training but also relation to pilots and passengers evacuation as well. The education or training of the crew, to prepare them for stressful situations. For stressful situations. Since an emergency is obviously a stressful situation, the ability to make rational decisions is the ability to make rational decisions to make rational decisions, to receive and interpret information is often severely limited. Reducing stress can be achieved in different ways, e.g., by early provision of sufficient information and escape guidance.

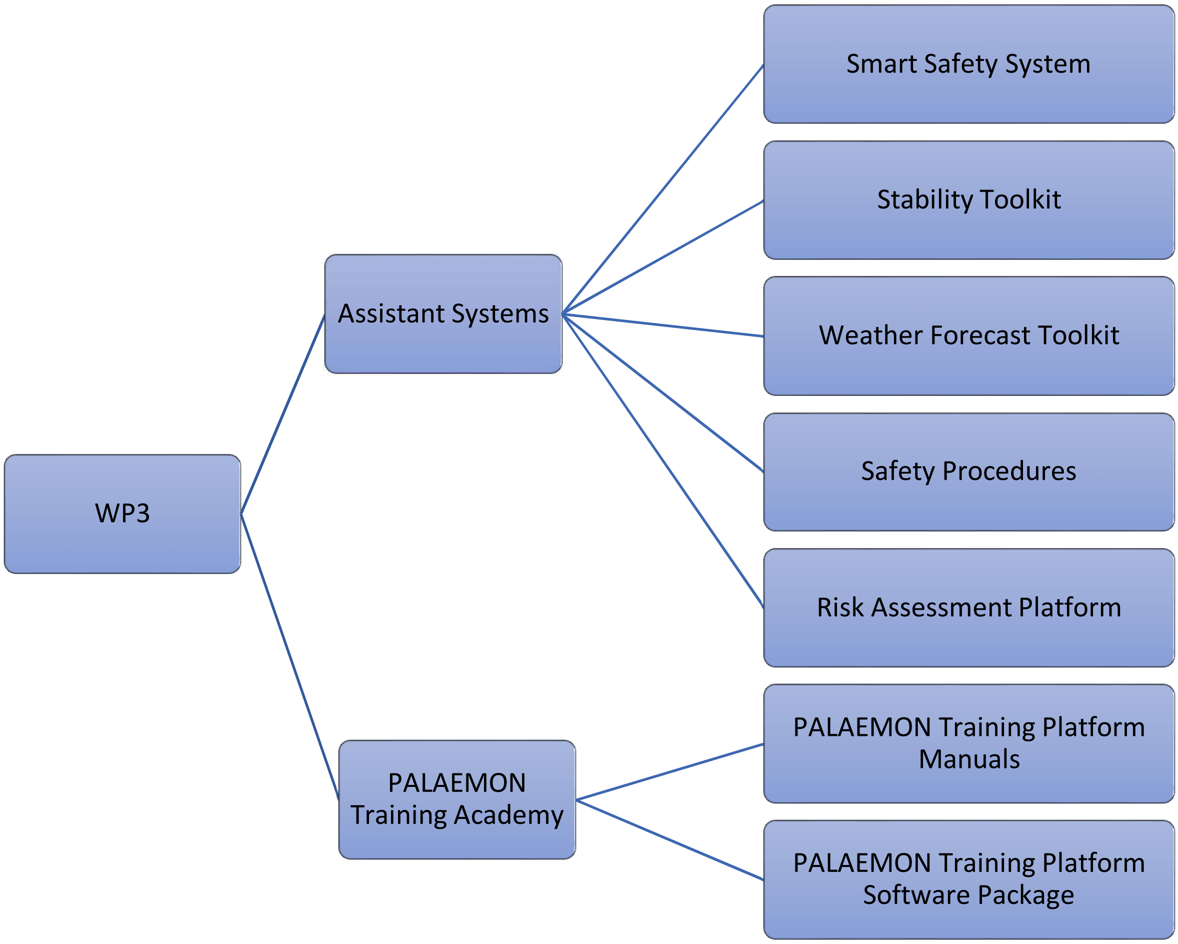


*Figure 2 Structure of WP3*

The Master and the crew have to make important decisions, as they have the ultimate responsibility during the entire time on board. This includes, e.g., the decision whether the passengers must have to leave the ship or not. It is a decision in which many lives are at stake. To facilitate this type of decisions, the Master on a passenger ship should have a Decision Support System, consisting of contingency plans with various foreseeable scenarios (See: SOLAS, 2009, Chap. III Life-saving equipment and precautions). As a matter of fact, one of the tasks in WP6 (PALAEMON Back-end infrastructure) copes with the implementation of our own version of DSS, harnessing the elements introduced in the scope of the project. The reader might take a look at deliverable D6.4 (Consortium, 2019)to get a deeper acquaintance on this. SOLAS also has guidelines for the safety crew to follow safety crew and drills for practice to be better prepared for an emergency. However, current assistance systems still lack rapid exchange of information, clarity and timeliness to make such decisions safely and decisions safely and efficiently. The goal of this work package is to make various decisions incurring the evacuation process and their follow-up actions clear and easier to follow by the Master and his crew. Also to give easy and manageable access to the responsible persons in order to carry out a safe and efficient evacuation process.

## 2.2 Software Development and architecture

One of the important aspects is the information about the condition and development during an evacuation. This exchange of information happens nowadays by means of VHF and on-board communication such as on-board telephones or loudspeakers (push to talk system). These communication channels are suitable, but they require clear communication clear communication, a calm and sufficient time to exchange all relevant information. to exchange all relevant information. information. When using these tools, the mental state of the crew members plays a role, involved in the communication plays a major role. During an emergency, rapid communication and the exclusion of misunderstandings are of high relevance.

The Mater and his/her officers, especially at the management level, need all the information about the respective status of the evacuation and its possible development, if foreseeable.

On the basis of the SOLAS and Standards of Training, Certification and Watch keeping (STCW) (IMO, www.imo.org, 2021) Conventions in support of Guidelines that relate to fire prevention, navigational safety, training and emergency planning is being conducted in which existing safety systems on board on board will be analysed and the introduction of new improved technology to support simpler and faster communication of the safety systems in accordance with SOLAS chapters II-1 and II-2 is planned. The changes also provide regulatory flexibility so that ship designers can meet all future safety challenges. This implies the possibility for PALAEMON to develop a new internal system that handles all security matters in a clear and unambiguous user-friendly interface (alarm management system, both mobile and centralized solution).

The core of this system is the diversity of information, but also its clarity and accuracy. The so-called "Decision Support System" (DSS) helps the management level follow the event and act accordingly.

## 2.3 Algorithmic Assistance

The management of an evacuation is a crucial task for the officers and the crew on board. To determine an appropriate information flow management and interaction layout for the crew and the officers, a study to collect data on different and diverse options has been conducted.

This is to determine which information is necessary for the evacuation, the most important inputs were:

- Weather events (Consortium, 2019),
- Number and location of passengers, addressed as part of Passengers Mustering and Evacuation Process Automation System (PaMEAS), object of analysis in D5.10 (PaMEAS Design Principles and Technical Architecture v2) (Consortium, 2019).
- Condition and obstruction of passengers,
- Corresponding additional hazards (such as smoke, fire, leakage, etc.), monitoring as part of the shipboard legacy systems,
- General conditions of the ship (position, equipment, crew, etc.).

All this important information can assist the Master and the officers, when dealing with decisions that can carry out a safe evacuation for the passenger and crew.

# 3 Developed systems

This deliverable presents (as stated in the GA) the following Deliverable and Systems:

- D3.1: SSS (Smart Safety System) (Consortium, 2019)
- D3.4: STK (Stability Toolkit) (Consortium, 2019)
- D3.6: WFT (Weather forecast Toolkit) (Consortium, 2019)
- D3.8: Modelling of Safety Procedures (Consortium, 2019)

The various assistance systems, created in the scope of the project, are managed by an internal central system and integrated into the on-board existing network. Furthermore, the system is presented as a gadget, so that the user can select only the information they need. The entire information network communicates with the DSS central system and calculates a corresponding recommendation for action for the management level.

This type of "Machine-to Machine" (M2M) communication offers the advantage that even with different programming languages with one "library" can be used to communicate can be used. Subsequently, the various system defined by the team, regarding the development of test scenarios, process parameters, environment parameters and interfaces for the Smart Safety system, are collected and supporting the definition of KPIs for the pilots.

The system communicates in real time, so that all the safety systems available on board and the crew in the event of an emergency and fast information about current situations can be provided.

## 3.1 Smart Safety System (SSS)

The general model is tested in an arranged test system developed, which includes the study of the ship design possible. The test system will be based on a simulated ship design. The training system will be based on the analysis of various past ship emergencies to be as close to reality as possible. This will support the project with various data support, collected through tests, analyses and evaluations to develop one of the latest and safest innovations in the field of passenger transportation at sea.

When working with the information influx, generated by the new technology supported by the technology supported by the project, the information must be filtered and adapted to human behaviour and flexibility. This means that the way the user behaves and interacts with the new technologies should be taken into account. The aspect to be investigated is the relationship of human behaviour in interaction with several systems and artificial intelligence provided by the project partners. Therefore, the University plans to use the new system, to integrate it into a BRM (Bridge Team Resource Management) with external users, in order to recognize the extent to which information is processed in stressful situations. can be processed in stressful situations.

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 layout of the SSS is divided into three main parts of frames, as displayed in (Consortium, 2019)The team overview is shown in the top left-hand corner, the log is directly below and the main area on the right side shows the different functions. As they can be used in different ways, the 5 windows are introduced afterwards.

This module gives an overview of the evacuation status and the current status of the evacuation progress. It also provides an interface for the connection between the Master and the evacuation team. The information is provided as an input in the (DSS) decision support system.

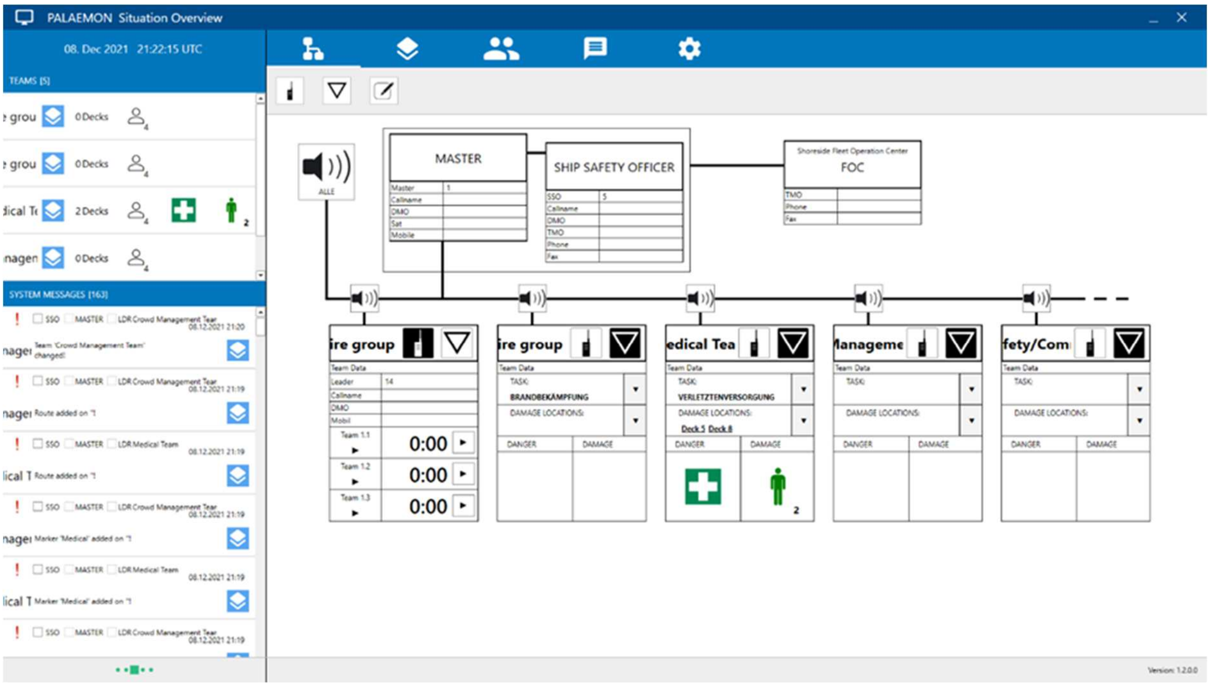


*Figure 3 Interface of Team deployment and communication process*

(Consortium, 2019)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:

The arrangement is used to check the given functions. Crew members are listed in (Consortium, 2019)as a crew list. The list can be seen as a pool of all available persons for the setup in (Consortium, 2019)The important feature of the SSS is the deck plan arrangement with safety tools to enable changes and information transfer.

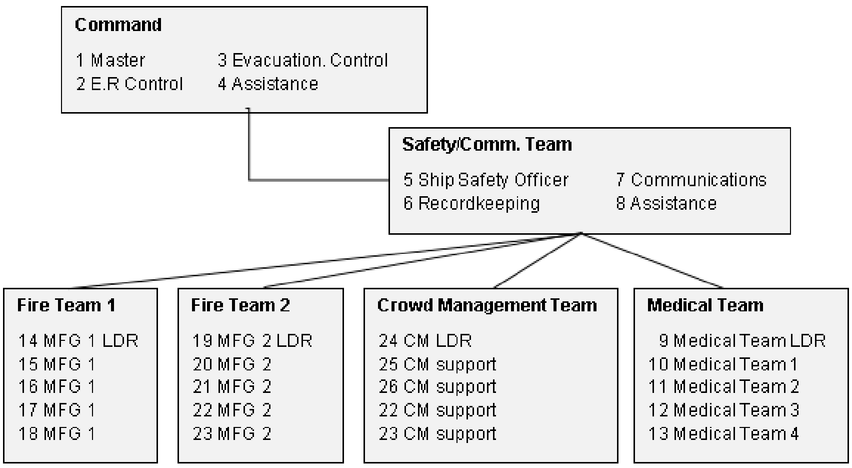


*Figure 4 Team apportionment SSS*

| Architect component specification SSS (Smart Safety System) | |
|---|---|
| Service Name | Smart Safety System (SSS) |
| Functions | This module provides an overview of the evacuation status and the current status of the of the evacuation progress. It also provides an interface for the connection between the master and the evacuation team. is provided. The information is stored as a gadget in the (DSS) decision support system. provided. |
| Input Connections & Interfaces (component that provides the input) | Officers and crew members provide information and can rely on sensors (e.g., wristbands) and also to communication devices (e.g., tablet or Bluetooth receiver). |
| Output Connections & Interfaces (component that displays the displays the result) | DSS interface (graphical interface) |
| Architecture concept for data determination (HMI, Human Machine Interface) |  |

*Table 1 Architect Component Specification SSS*

The various layout and interfaces within SSS would be giving the crew the possibility to address dangerous processes and location either manually or through censoring system. All information assigned in the software will be saved and registered within a log file that will be then provided to the DSS and can be handled accordingly. Depended on the test that will be done in the next step modification will be added or disclosed as their needs stats.

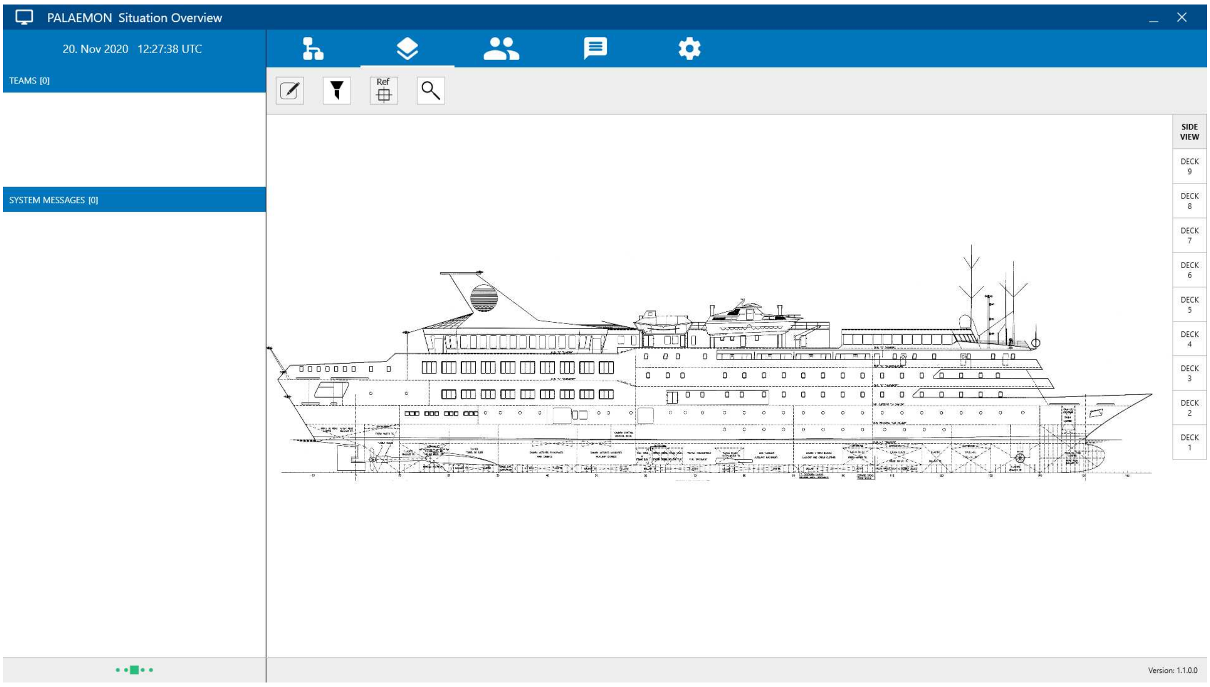


*Figure 5 Ship Level and Information Management No 1*

All information added will be registered and can be assigned to specific team leader or Crew Group/member. Also, restriction or assigning a new Muster station in case of deficiency or obstacles can be assign in matter of second and the easiness of drag and drop method. (See figure 5)

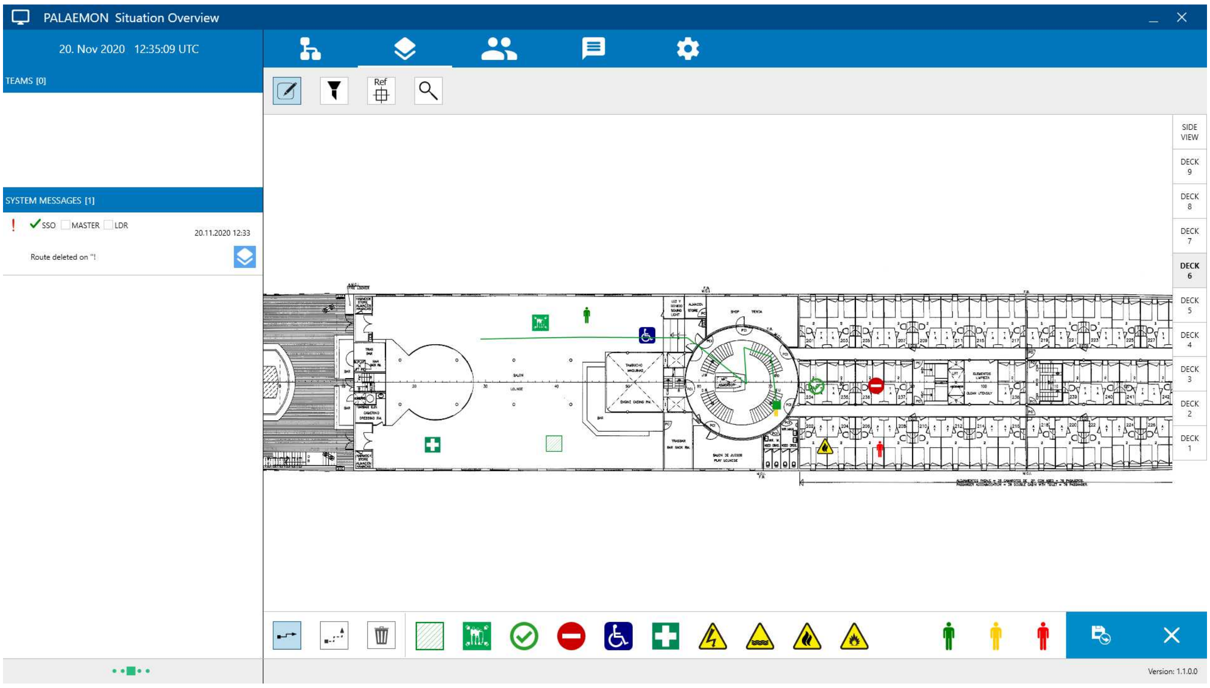


*Figure 6 Ship Level and Information Management No 2*

### 3.2 Ship Stability Toolkit (STK)

The Stability Toolkit is listening to the Data Fusion Bus, that is, the communications core of the PALAEMON Framework, for the required input data. This data consists of navigational data from the ships legacy system, weather data from the weather service and the ships actual floating conditions from the Ship Health Monitoring System, as we can observe in (Consortium, 2019)Based on this information, the Stability Toolkit will calculate the maximum motions of the vessel, which are likely to be expected. The calculated values for the six degrees of freedom, heave, sway, pitch, yaw, surge and roll are then published to the Data Fusion Bus, from where they are displayed in the PALAEMON Incident Management Module (PIMM) dashboard.

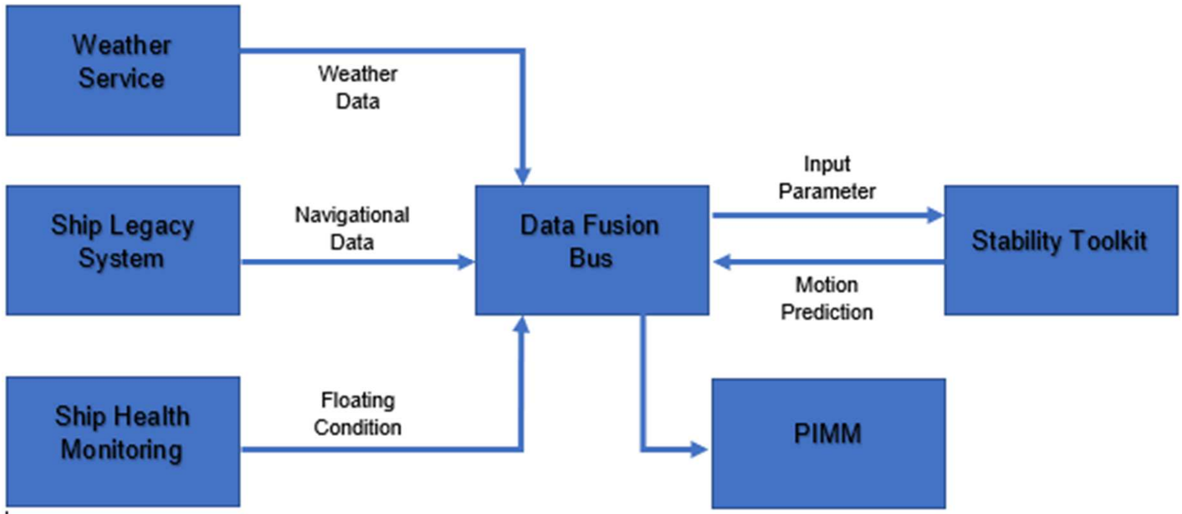


*Figure 7 SST Data Flow*

The outputs are generated automatically every minute, or if the input parameters are changed above a given threshold. Apart from the automatic input and calculation, there will be also the possibility to enter the data manually, to check if some changes will reduce the ship motions and therefore ease the evacuation process.

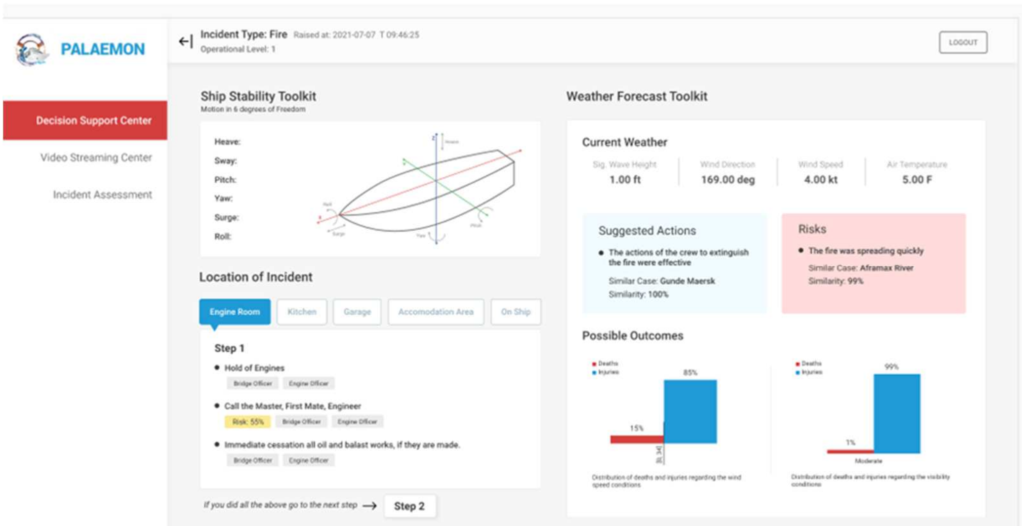


*Figure 8 Stability Toolkit output on the PIMM dashboard*

### 3.3 Weather forecast Toolkit (WFT)

The main purpose of the Weather Forecast Toolkit is to is to identify the most appropriate set of actions that meets the needs of the corresponding incident case considering the weather conditions and utilising past incident cases. Moreover, the WFT identifies potential risks for human life using historical data to raise awareness of Master and crew members decision-makers (Consortium, 2019).

As can be seen in (Consortium, 2019), T3.3 Weather Forecasting Toolkit is strongly related to the WP3: PALAEMON Intelligence Framework - AI Services and Algorithms, WP6: PALAEMON Back-End Infrastructure and WP7: PALAEMON Integrated System and Technology Validation Trials. Several components may use the output produced by the WFT. Specifically, T3.3: Weather Forecasting toolkit is also related to T6.2: PALAEMON Data Fusion Middleware, T6.4: Development of PALAEMON On-Board Decision Support System, T6.5: PALAEMON Incident Management Module and T7.4: VDES Deployment. The WFT will retrieve the data (e.g., weather conditions) from the Data Fusion Bus (DFB) to provide its output. As a refresher, DFB abridges the central part of the PALAEMON Communications Platform, responsible for gathering the information from all components (e.g., weather data, sensors, smartphones), and storing this data into a persistence system that guarantee the further availability of all data. More information about DFB can be found in D6.2 (PALAEMON Data Fusion Middleware) (Consortium, 2019). The VDES (which stands for Very High Frequency – VHF - Data Exchange System) will provide the weather conditions at the incident time through the DFB. Furthermore, the PALAEMON Incident Management Module (PIMM) dashboard will display the WFT output. Moreover, the WFT will deliver to the PALAEMON DSS the course of actions for further analysis.

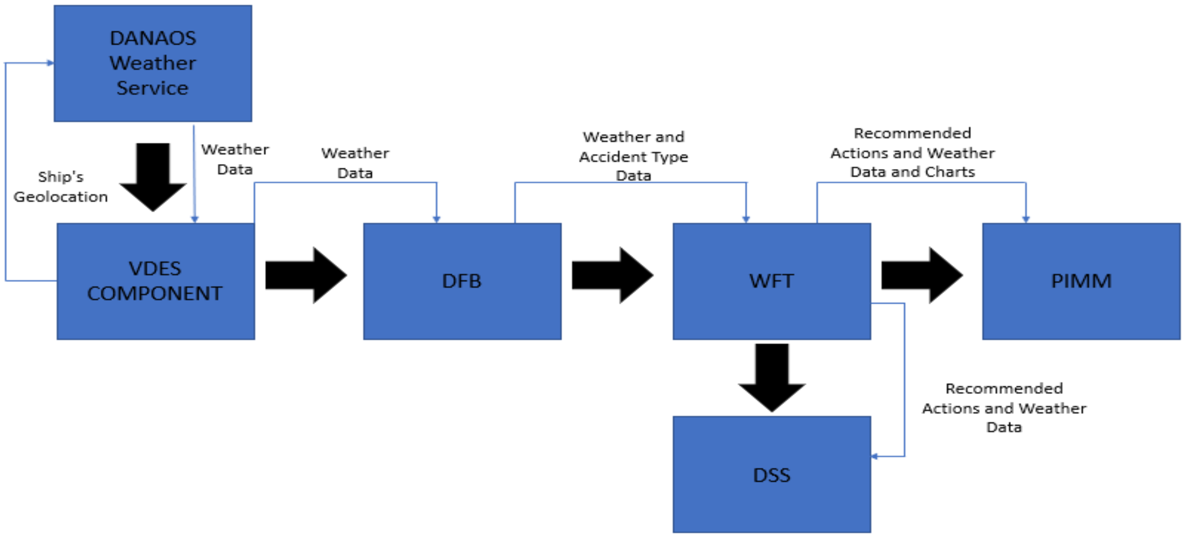


*Figure 9 PALAEMON WFT information pipeline*

In (Consortium, 2019)9, se present an alternative view that encompasses a closer view to weather data acquisition. We can see as several components intervene in the pipeline, distinguishing up to three different tiers: on the one hand, the ship infrastructure establishes a VDES link with the shore to exchange the data. Moreover, at shore level, we use a regular Internet connection to get the data from a public service interface carried out by DANAOS. To came up with this solution we collaborated with partners from ATOS, DANAOS, ANEK, WIS, ITML and THALIT.

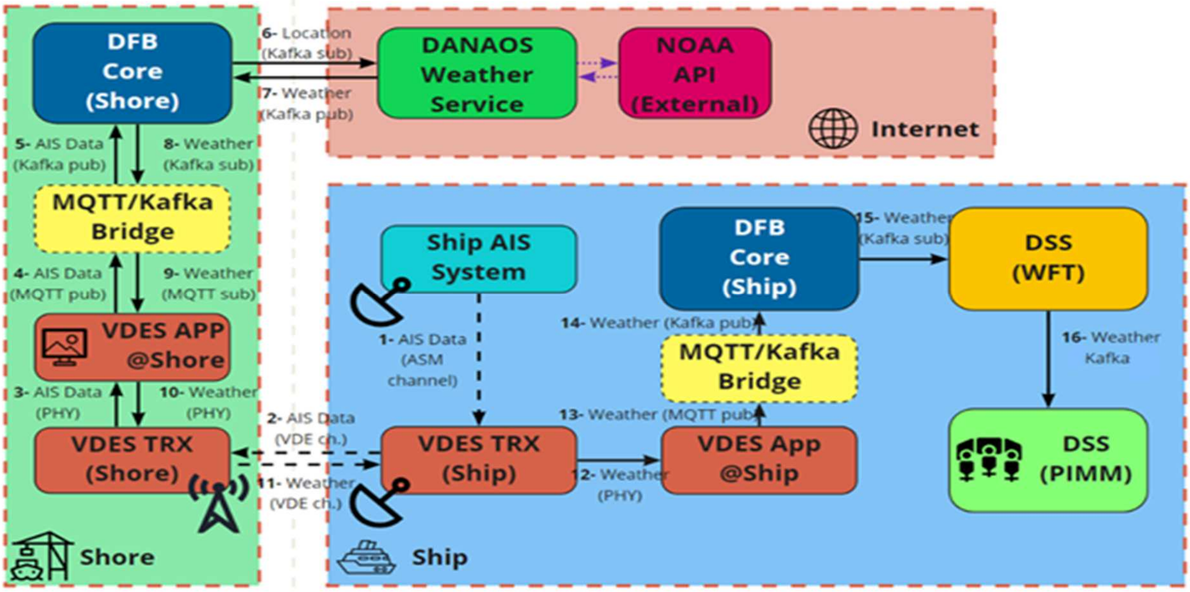


*Figure 10 Weather Forecast Data Real-time workflow*

The WFT also provides the weather conditions at the incident time (e.g., wind speed, wind direction, Wind Waves, Significant Wave height – SWH , etc.) displayed at the PIMM's dashboard, as shown in **Fehler! Verweisquelle konnte nicht gefunden werden.** ~~(Consortium, 2019).~~. Furthermore, WFT aggregates all the incidents at the dataset based on the wind speed (first bar chart) and the visibility conditions at the incident time (the second bar chart) and provides charts that show the expected percentages of injuries and deaths for each incident. To aggregate the cases based on the wind speed, we use the following categorization. The first category includes accidents with light or moderate wind speed conditions, i.e., (0, 34] Knots, whereas the second contains cases with strong wind speed conditions, i.e., (34, 130] Knots. Regarding the visibility conditions, we use the following categorization, good (more than 5 nautical miles), moderate (between 2 and 5 nautical miles), poor (between 1 and 2 nautical miles), and very poor or foggy visibility conditions (less than 1 nautical mile) (Consortium, 2019).

| Architect component specification WFT (Weather Forecast Toolkit) | |
|---|---|
| Service Name | Weather Forecast Toolkit (WFT) |
| Functions | The main purpose of the Weather Forecast Toolkit is to is to identify the most appropriate set of actions that meet the needs of the corresponding incident case considering the weather conditions and utilising past incident cases. Moreover, the WFT identifies potential risks for human life using historical data to raise the awareness of the crew members. |
| Input Connections & Interfaces (component that provides the input) | DFB (see Figure 10) |
| Output Connections & Interfaces (component that displays the displays the result) | PALAEMON Incident Management Module (PIMM) interface (graphical interface) |

*Table 2 Architect component specification WFT*

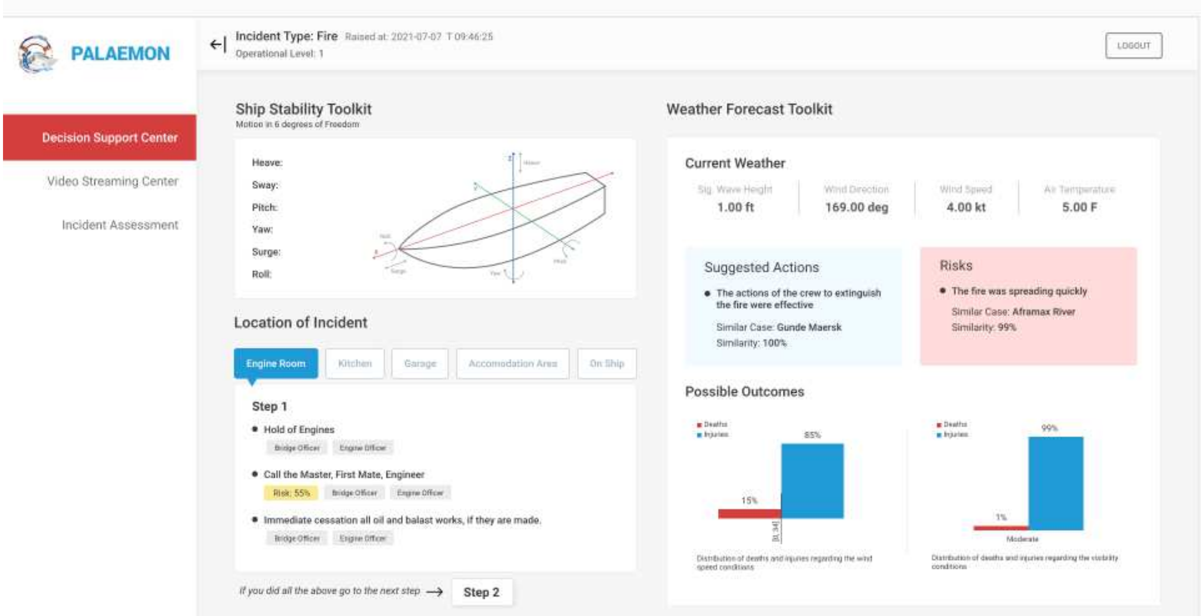


*Figure 11 PIMM dashboard layout including WFT visualization*

## 3.4 Safety Procedure Model

According to the Description of Action (DoA), in this task a Safety Management System (SMS)' administrator tool, following on International Safety Management (ISM) principals, for automation in controlling and updating emergency guides was developed for the documentation of safety procedures with the least of human intervention. Safety procedures modelling framework is digitally translated into PALAEMON SMS tool (ISM compliant SMS administrator). PALAEMON SMS tool is a component of the integrated PALAEMON system. For the sake of illustration, (Consortium, 2019)**Fehler! Verweisquelle konnte nicht gefunden werden.** displays the main layout of the SMS dashboard.

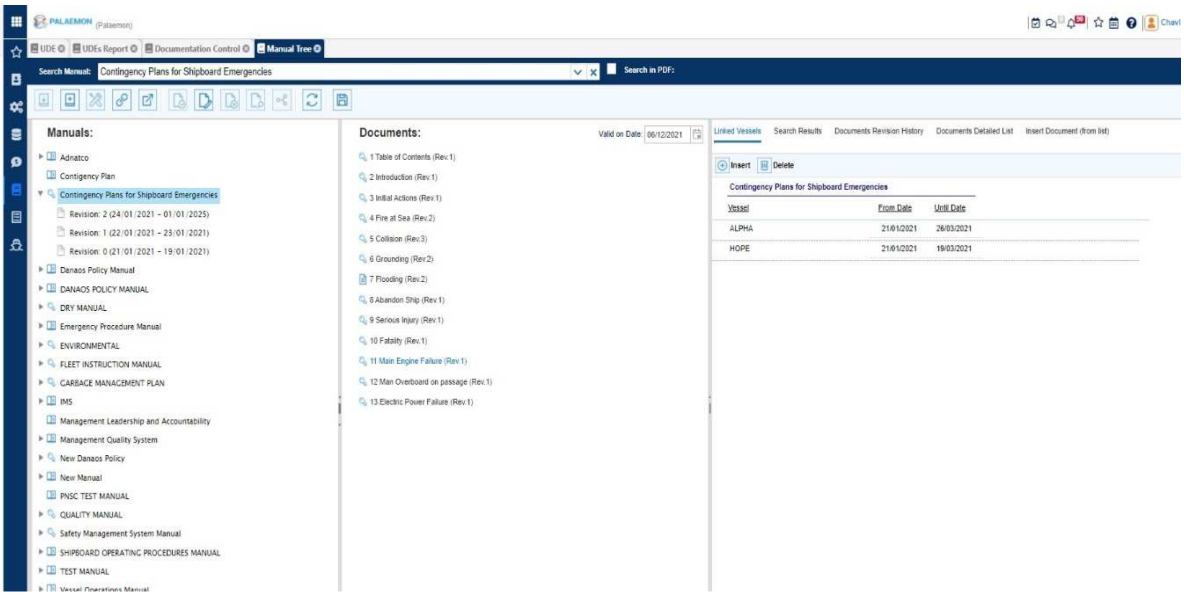


*Figure 12 Safety documents control board in PALAEMON SMS tool*

Technically speaking, SMS Tool comprises of three main components:

1. SMS ashore is a standalone program hosted in the offshore serves of the management company of the vessel (and all the fleet).
2. SMS on-board is a replica of the SMS ashore program hosted in a remote server on-board the vessel and integrated with PALAEMON ecosystem.
3. SMS synchro engine is dedicated to an activation of a bridge connectivity between office ashore and vessel (SMS instances) for versioning control.

PALAEMON SMS tool spans across all phases of the incident management and evacuation process (see  (Consortium, 2019)3).

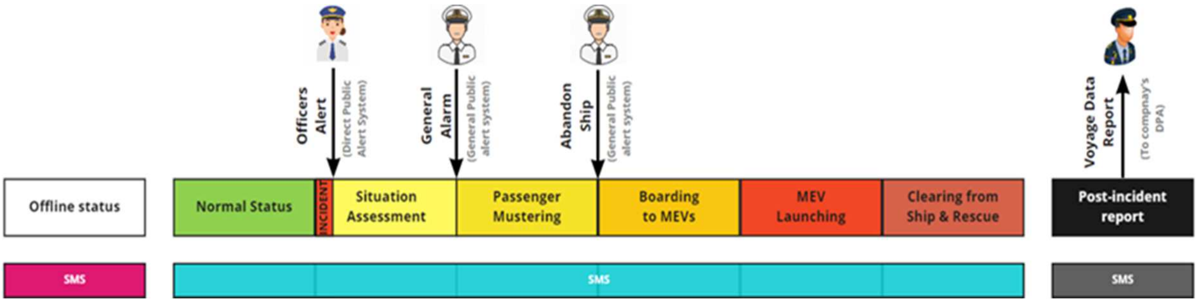


*Figure 13 SMS tool interaction with evacuation process phases*

PALAEMON SMS tool has the following core functionalities:

- Structuring safety information (e.g., safety manuals, checklists, etc.)
- Digitalize procedures and associate response plan breakdown with response owners (Dynamic safety task list). For this purpose, interface with PALAEMON DSS and PIMM
- Bridge connectivity between office ashore and vessel for versioning control.
- Hold triggers for updates and control changes following post-incident investigation, safety procedures configuration and change management policy. In the scope of PALAEMON, this functionality is highlighted with a versioning update following lesson learnt registry in post-incident analysis. This functionality is semi-automated enabling an interface with incident related data captured on-board and recorded in PALAEMON Voyage Report Generator (VRG)

Integration of SMS tool in PALAEMON ecosystem and connection with other PALAEMON components is pictured in (Consortium, 2019).

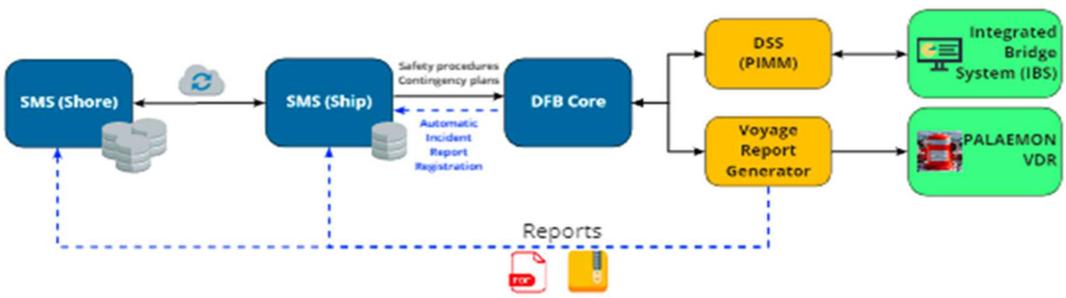


*Figure 14 SMS tool as integrated part of PALAEMON system*

In terms of safety procedures modelling (safety content structuring) a team comprising of end-users (i.e., ANEK, OELSR) and subject matter experts on safety modelling (i.e., JOAFG, AST, ADMES) worked on safety procedures on-board to understand and structure models of safety management and response strategies to incidents. As a first step, the team looked on regulations and IMO conventions (SOLAS) and studied procedures as documented in end users' safety management systems. Relying on the expert judgement from captains and officers of ANEK and OELSR, the team has conducted a set of dedicated internal meetings to work on the modelling of the safety procedure and align content with PALAEMON use cases and digital solutions. The result of team's study was the delivery of an internal document offering a reference of related regulation, providing explicitly a description of muster list and contingency plans and associating safety duties with owners (crew on-board). The PALAEMON's safety content configuration was further delivered to SMS digital tool to be administrated and managed within the PALAEMON system across all emergency and evacuation life cycle, starting from the emergency assessment and the incident response (evacuation) and concluding with the incident analysis. All this process is duly outlined in (Consortium, 2019)

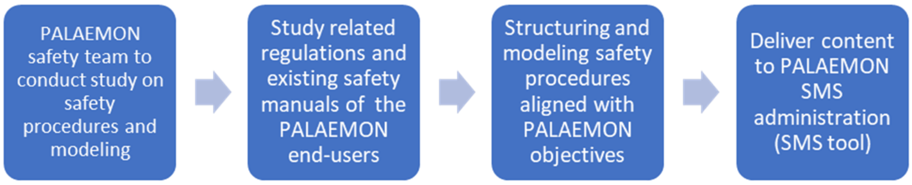


*Figure 15 Process flow of Safety Content Modelling*

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