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LASH FIRE

Deliverable D08.2

Fire hazard mapping visualization tool with fire hazard matching integrated

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Abstract

This report describes the Fire Hazard Matching tool one of the main results of the LASHFIRE project related to automatic screening and management of cargo fire hazards.

The hazard mapping tool is a software that enables the visualization of risky 'hot' zones and different hazard types of cargo as a support element to identify hazards associated to each zone of the ship according to the cargo unit's position at planning and real level.

The Fire Hazard Matching tool is able to evaluate fire risk associated to all cargo units of a given ship loading configuration using an easy-to-use graphical interface that can be run both in computers and hand-held devices (mobile phones or tablets). It is developed as a standalone visualization and interaction module for the Stowage Planning Tool, the overall software tool result of action 8-A.

The Fire Hazard Matching tool is currently available at https://lashfire.cimne.com/login.aspx

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Co-authors:	África Marrero, Sergio Valero		
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Approved by	Erik Styhr Petersen on 2022-01-19	Robert Rylander on 2021-08-11	Maria Hjohlman on 2022-01-31

Involved partners

No.	Short name	Full name of Partner	Name and contact info of persons involved
16	CIM	Centre Internacional de Mètodes Numèrics en Enginyeria	Ángel Priegue, cruchi@cimne.upc.edu África Marrero, amarrero@cimne.upc.edu Sergio Valero, svalero@cimne.upc.edu

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Contents

1 Executive summary

This report describes the Fire Hazard Matching tool, one of the main results of the LASHFIRE project related to automatic screening and management of cargo fire hazards.

According to the grant agreement the tool needs to include:

- Fire hazard matching by association of specific hazards to cargo units, according to input from T08.2 and T08.3,
- Development of integration software, fed by the database (T08.2) and with consideration to the identification technologies selected (T08.3).
- Development of hazard mapping tool with visualization of risky 'hot' zones and different hazard types of cargo.
- Support element to identify hazards associated to each zone of the ship according to the cargo unit's position (at planning and real level).
- Development of software to integrate feeds from identification of units on the deck and calculation of their associated hazard probabilities.

In short, the Fire Hazard Matching tool is a software that enables the visualization and identification of hazards associated to a load plan configuration according to the characteristics of the cargo units.

The tool is able to evaluate fire risk associated to all cargo units of a given ship loading configuration using an easy-to-use graphical interface that can be run both in computers and hand-held devices (mobile phones or tablets).

1.1 Problem definition

Results from previous projects such as EMSA FIRESAFE indicated that it was clear that a lot of unwanted incidents on the cargo spaces of Ro-ro cargo/Ro-pax passenger ships are due to malfunction of so-called Reefer-units.

The final goal for action A of WP08 is to describe a system of systems solution that can identify and screen cargo for known hazards or anomalies and position the cargo/vehicle on its way from the terminal to it is parked/secured onboard a ships deck.

As of today, no system as the one proposed here is on the market, neither has one been identified to be under development. There are different project and solutions around the world, that could be part of a solution, but there are no standards to lean on. They are stand-alone and not to the project's knowledge designed with interoperability in mind.

Usage of such technologies can enhance the current fire safety routines and systems around the handling of cargo/vehicles. The growing number of alternative powered vehicles (APV) will make the situation on-board the ship more complex than it is today, both in regard to the ship's stability and fire safety, since battery electric vehicle are heavier than the majority of today's vehicles with internal combustion engines (ICE). The mixture of hazards that will make it more complicated to extinguish a fire, since the means of controlling and extinguish the fire might need combinations of solutions and techniques. Digitalization, robustification and automation is currently in a strong development trend, which creates the possibility for innovation of new systems and evolution of today's systems.

1.2 Technical approach

The specification of the Fire Hazard Matching Tool aimed to create a system for automatic screening of cargo to identify fire hazards featuring risk-based load planning. The approach to fulfil this goal is

described as a system of systems, where many subsystems have some operational overlaps where they can hand over information and together solve challenges in the operational context of loading/off-loading a ship.

1.3 Results and achievements

The matching and mapping Tool, also as included in the description of work of the LASH FIRE Grant Agreement, associates specific hazards to cargo units according to T08.2 (implemented through interfaces with the algorithm that distributes the cargo supporting fire risk management) and T08.3 (Assessment of cargo identification technologies).

The tool shows information useful to the users, e.g. position of cargo, type of cargo stated in the cargo manifest and possible hazards connected with the type of cargo etc. Examples of information obtained from sensors can also be used to assist both the crew in the fire control room as well as the fire fighters on the deck via portable devices e.g. rugged smartphone/tablet.

In this report we show all the functions implemented of the Fire Hazard Matching tool, the main result of task T08.5. Some of the requirements will not be implemented in the scope of the Fire Hazard Matching tool and will be part of the implementation of the Visualization Aid in task T08.6.

1.4 Contribution to LASH FIRE objectives

The Fire Hazard Matching tool is part of the system of systems approach with open interfaces to other systems, and in LASH FIRE the interoperability with the other WPs and a future data exchange with other systems.

In LASH FIRE WP08, the objective of the action A is to develop and demonstrate a technical solution for automatic screening of cargo to identify fire hazards and develop, utilize and experimentally validate a digital logistics management tool featuring risk-based load planning. This report covers the different software technologies that will be used for the implementation and testing of the fire hazard matching tool, that will be a useful and practical software tool to achieve this objective.

The fire hazard matching tool is a system that could be interconnected to other systems to meet the challenge that the stevedores and/or the crew on-board have every day when identifying cargo and its corresponding hazards, secure loading operation and stowage of such goods/vehicle, all in all to increase the safety of passengers, crew and the ship by enabling early detection of fire hazards or anomalies.

1.5 Exploitation and implementation

The Fire Hazard Matching tool, as a result of the project, is not a final product that can be exploited by operators in a real environment. The software does not yet include capabilities such as optimization and simulation that will be added in the Visualization Aid (task T08.6) into the Stowage Planning tool which is the final goal of action 8-A.

The final tool (Fire Hazard Matching tool + Visualization Aid) will be demonstrated in a controlled environment in the LASHFIRE Pilots that will take place during the last year of the project.

2 List of symbols and abbreviations

APV	Alternative Powered Vehicle
CA	Case (Use Case)
CSV	Comma-Separated Values
DB	DataBase
EMSA	European Maritime Safety Administration
ICE	Internal combustion engines
IR	Internal Report
Ro-ro	Roll On Roll Off cargo ship
Ro-pax	Roll On Roll Off passenger ship
SW	Software
SVG	Scalable Vector Graphics
WP	Work Package

3 Introduction

Main author of the chapter: Angel Priegue, CIM

Results from previous projects such as EMSA FIRESAFE (Ref LASH FIRE D4.01 Review of accident causes and hazard identification report) indicated that it was clear that a lot of unwanted incidents on the cargo spaces of Ro-ro cargo/Ro-pax passenger ships are due to malfunction of so-called Reefer-units.

There are other issues that could be detected if we integrate feeds from identification of cargo units on the deck with information from administrative documents of the voyage (i.e cargo manifest) to calculate associated hazard probabilities during sea voyage. This would enhance the effectiveness of traditional firefighting patrol rounds.

The objective of LASH FIRE task T08.5 is the integration & development of the software modules necessary for the implementation of the fire hazard matching and mapping tool. This report describes the implementation of the Fire Hazard Matching tool, a tool able to evaluate fire risk associated to all cargo units of a given ship loading configuration using an easy-to-use graphical interface that can be run both in computers and hand-held devices (mobile phones or tablets).

The following figure show the components that are part of the risk-based stowage planning tool:

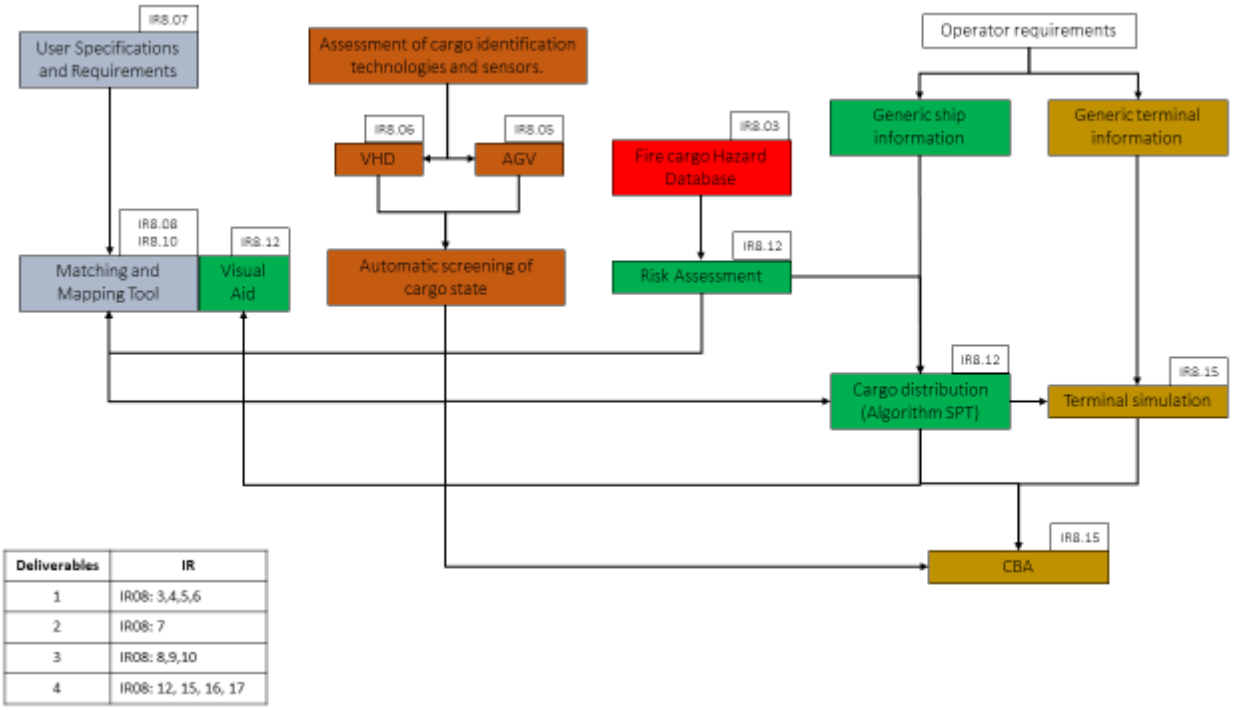

Figure 1 SW/HW components of the risk-based load planning tool

The contents of this deliverable D08.3 are located in the blue boxes in the left of the figure. The deliverable also will include requirements on technology for ignition prevention detectors, evaluation parameters and scenario definition for further prototyping and testing.

The figure also shows that the functionalities of the Matching and Mapping Tool and Visualization Aid are built as a continuum block. The final result of the development will result in a standalone visualization and interaction module for the Stowage Planning Tool, the overall software tool result of action 8-A. In this sense the work is split between the Fire Hazard Matching Tool (Task T08.5) and

Visualization Aid (Task T08.6). Some of the functionalities of the final tool will only be developed in the scope of task T08.6 as they require more interaction with modules that are not yet in place. This deliverable will show all requirements of the tool but will develop as use cases only the ones that fit into the scope of task T08.5.

Matching and mapping tool (TASK T08.5) will display: Ship information, Cargo information, Dangerous Goods information and the result of the initial risk assessment and risk level of all cargo units for each deck.

The mobile system screening a cargo deck is intended to reduce the risk of fires erupting during the voyage. By sending information of temperatures and fire hazards in combination with their location to the crew fires can be prevented at an early stage.

Even if the VHD and AGV modules are not yet in place at this moment the tool has implemented the functionality to display this kind of information. Images and data shown are realistic examples and not obtained from real devices.

Visualization Aid (TASK T08.6) will start from the tool developed in Task T08.5. The tool will be updated to show Stowage Planning Tool results and cargo status in real time using VHD and AGV real input. Functionalities related to manual tracking of the cargo units will also be implemented in the scope of this task.

Task T08.6 involves other software modules besides the Visualization Aid. In fact, an alternative way of working with the Stowage Planning Tool, a plug-in for existing software used by ship owners, will be implemented as part of the task.

A list of requirements (Ref LASH FIRE D08.3 Development of fire hazard mapping visualization tool with fire hazard matching integrated) for the Stowage Planning Tool were obtained during project meetings interviews with people working in the Ro-Pax industry and as a result of meetings and workshops of the LASH FIRE project. Some of them will be met in the implementation of the Fire Hazard Matching Tool in the scope of task T08.5. The other requirements will be implemented in the Visualization Aid in the scope of task T08.6 and will be specified in deliverable D08.4 Stowage planning optimization and visualization aid. The next figure represents the distribution of software modules between the Fire Hazard Matching Tool and Visualization Aid.

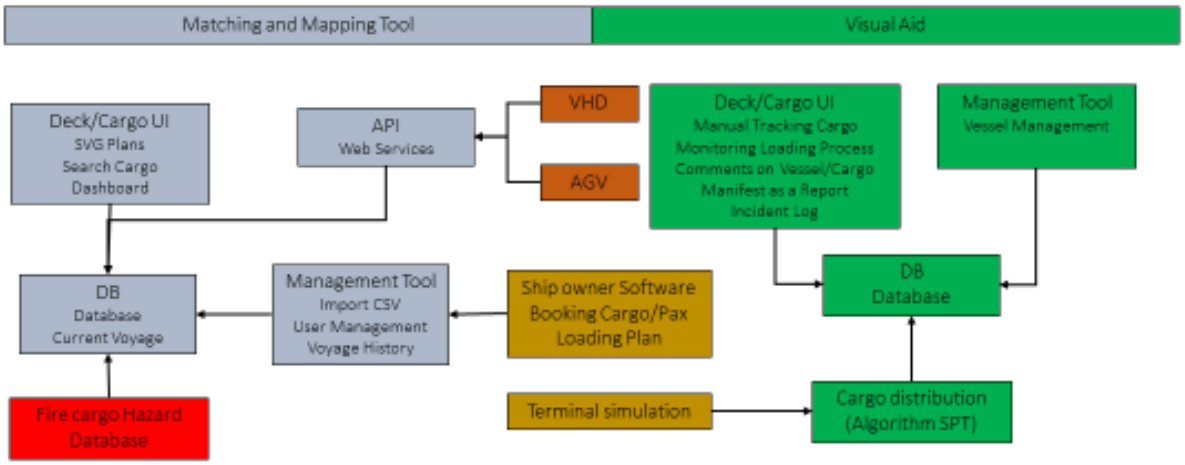

Figure 2 Distribution of modules of the risk-based load planning tool

4 Use Cases and Hazard Conditions

Main author of the chapter: Angel Priegue, CIM

4.1 Users and Roles

The different types of actors/roles that participate in the system are described below. By classifying the actors according to their role in the system, it can be clearly seen that we have users who actually interact with the application and other actors who are information providers, but both are equally important.

Table 1. Types of users and data flows

	Although in real scenarios we can consider a considerable number of actors (**Cargo/Travel office staff,** Loading **Officer,** Deck **crew, Chief deck officer, Bosun, Captain, …)** for the software system we will perform an abstraction to 2 types of access levels. Initially we will only consider 2 user levels with access to the software system. A **normal user,** who will only be able to perform read operations and will not be able to modify any data and an **administrator user that** will be able to make all kind of operations available by the system.
 	**Cargo Fire Hazard DB is** a database where the fire hazard level related to every cargo unit is stored according to the type of vehicle and goods transported. **Cargo Manifest DB,** this database is initially generated by the Charges/Travel office, and it defines the characteristics of the vehicles to be loaded. **SW oriented DB**, this database is hosted in the backend of the system and is the primary database of the application. This is where the arrangement of the vehicles within the ship, users who can access and the log of the actions performed are stored. **Deck layout,** in the backend will also host the different geometric layouts of the ships, so that they can be represented by the tool.
	Sensors are considered as actors that do not interact with the system as human users, but feed information to the tool. Through an API provided by the system, the sensor provider will have an end point to fill the SW oriented database.

The use cases of **normal users** (read operations), **administrator users** (write operations) and **sensor users** (input of data from external sensors) are defined as described in figures 3, 4 and 5.

Normal User

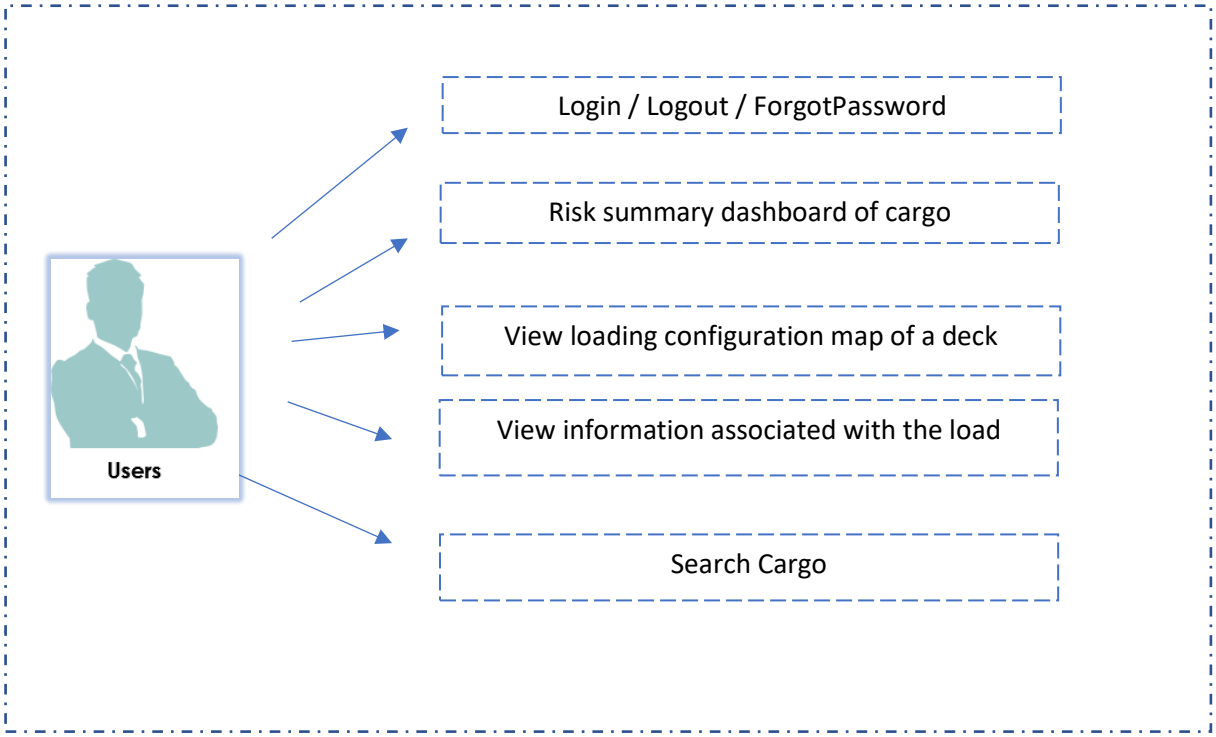

Figure 3. Normal user use cases

Administrator User

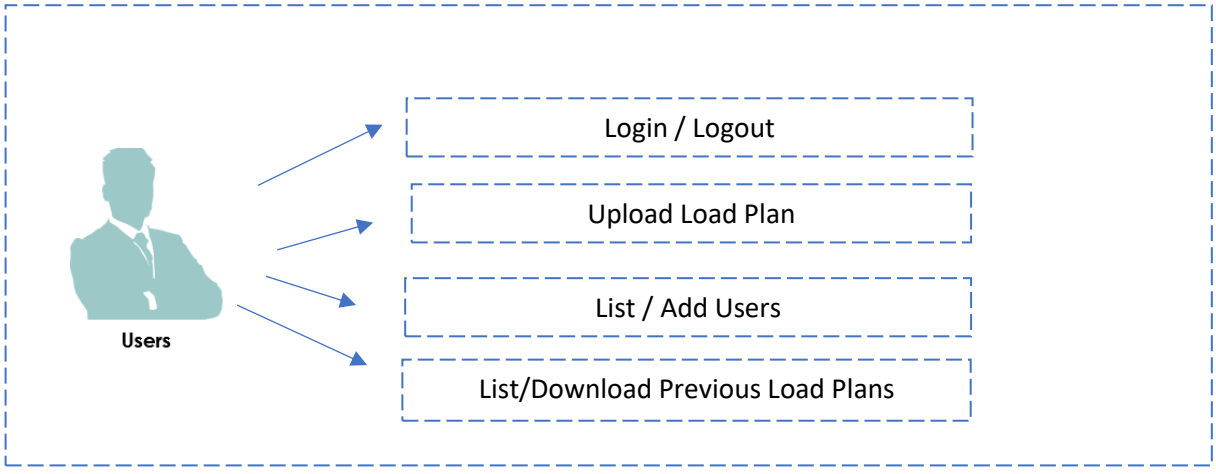

Figure 4. Administrator user use cases

Sensor User

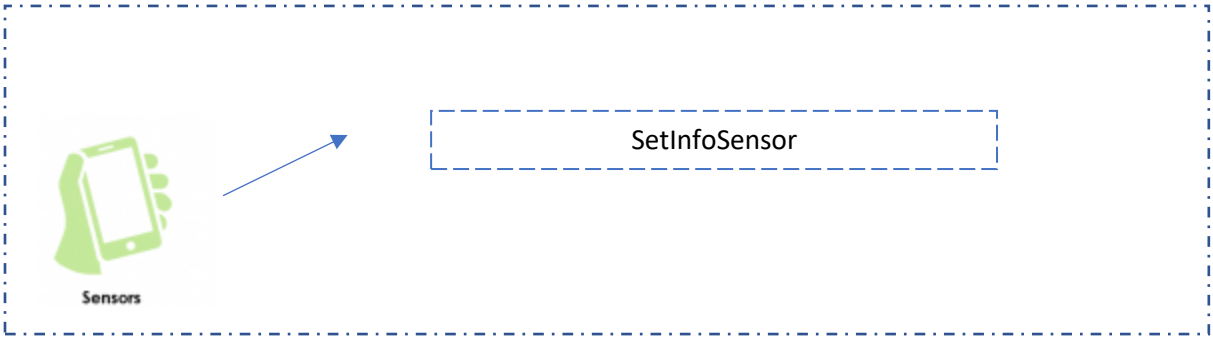

Figure 5. Sensor user use cases

4.2 Hazard Database

From the point of view of the fire hazard matching tool, the hazard database is only a data source that contains rules to establish the fire risk level of the cargo. The tool will display in different colors and highlight different risk scenarios according to the conditions.

Visually there are 3 levels of fire hazard levels catalogued (high, medium and low), represented with 3 colors (red, yellow and green) respectively. These three levels are based on a combination of two elements, **frequency** and **severity,** (internally, each one of them is subdivided into 5 sublevels). Consider the frequency as the probability of fire being started at the cargo unit and the severity as depending on the type of material and the history of fires produced in the past.

To see more detailed rules of the Hazard database go to D08.1 Definition and parametrization of critical fire hazards, classification of cargoes, transport units, engines, fuels and ships and identification methodologies.

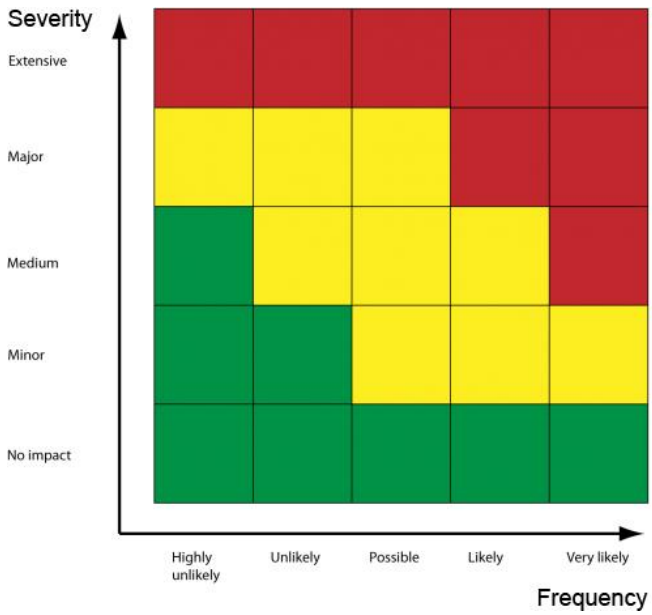

Figure 6. Hazard Levels

In order to properly assess whether fire accidents in each cargo unit are relevant, we must know how many units of that type of cargo are transported in order to evaluate their impact. For this purpose, information on the cargo transported during one year was requested from the operators and a pattern was obtained of what is the average of each type of cargo transported in a typical ship. This helps us to develop the frequency of occurrence of an accident per unit of cargo. The pattern used is the one shown below (the general data of the cargo transported during a year is confidential, that is why only the pattern resulting from the analysis is shown), in order to perform the Risk Assessment, we have only selected from the pattern, the type of cargo where the Fire Hazard Database shows that an accident has occurred in the same.

$$Frequency\ of\ occurrence\ i = \frac{\sum_{j=0}^{n} Fire\ accidents_i}{Units\ i\ on\ the\ Lash\ Fire\ general\ ship \cdot \sum_{j=0}^{n} routes}$$

i : Type of cargo

j: years (2013/2020)

General Cargo:

Table 2. Types of General Cargo Units carried by a ship

	Units carried by the ship
Conventional vehicle Bus	2
Conventional vehicle Car	63
Conventional vehicle Truck	41
New energy carrier Electrical vehicle	4
Reefer unit Value	8
Special vehicle trailer	32
Special vehicle RVs	10
Special vehicle Tractor	4

Dangerous Goods:

Table 3. Types of Dangerous Cargo Units carried by a ship

	Units carried by the ship
Dangerous goods Corrosive substances	1
Dangerous goods Explosive	1
Dangerous goods Flammable liquid	1
Dangerous goods Flammable solid	1
Dangerous goods Gas	1
Dangerous goods Miscellaneous dangerous substances and articles	1
Dangerous goods Undeclared DG	1

For each type of load, the causes that have produced the fire in the load have been analyzed, classifying them in causes of origin:

- Electrical
- Overheating
- Leakage of liquids
- Mechanical
- Other

In addition to each type of failure, the severity of the accidents has been analyzed, within each category, for the severity the following scale has been used.

According to IMO definitions (IMO's "Casualty Investigation Code" in its updated version and IMO Circular MSC-MEPC.3/Circ.3), severity is classified into the following levels: Marine accident is considered any marine casualty or marine incident. An accident does not include a deliberate act or omission, with the intention to cause harm to the safety of a ship, an individual or the environment.

Accidents may be classified (in order of severity) as follows:

- very serious marine casualties
- serious marine casualties
- less serious casualties
- marine incidents
- near miss

The results of the analysis can be summarized in the following tables.

Table 4. Base risk levels for general cargo units

Cargo unit (general cargo)	Frequency of occurrence	Frequency of occurrence per NM	Base Risk Level
Reefer unit Value	8,1577E-07	2,2129E-16	100%
Conventional vehicle Bus	4,7586E-07	1,2909E-16	80%
Conventional vehicle Truck	1,5168E-07	4,1146E-17	60%
Special vehicle RVs	7,9311E-08	2,1514E-17	40%
Conventional vehicle Car	6,9077E-08	1,8738E-17	40%
Special vehicle Tractor	3,9655E-08	1,0757E-17	30%
New energy carrier Electrical vehicle*	2,9741E-08	8,0679E-18	30%
Special vehicle trailer	3,8376E-09	1,041E-18	10%

Table 5. Base risk levels for dangerous cargo units

Cargo unit (dangerous cargo)	Frequency of occurrence	Frequency of occurrence per NM	Base Risk Level
Dangerous goods Flammable solid	5,9483E-07	1,6136E-16	90%
Dangerous goods Flammable liquid	3,569E-07	9,6815E-17	70%
Dangerous goods Miscellaneous dangerous substances and articles	2,3793E-07	6,4543E-17	60%
Dangerous goods Corrosive substances	1,1897E-07	3,2272E-17	50%
Dangerous goods Explosive	1,1897E-07	3,2272E-17	50%
Dangerous goods Gas	1,1897E-07	3,2272E-17	50%
Dangerous goods Undeclared DG	1,1897E-07	3,2272E-17	50%

The base risk level is the measure used in the Fire Hazard Matching Tool to display visually the different risk levels of each cargo unit in the ship.

More details on the risk assessment calculations can be found in deliverables D08.1 Definition and parametrization of critical fire hazards, classification of cargoes, transport units, engines, fuels and ships and identification methodologies and D08.4 Stowage planning optimization and visualization aid.

5 Application Flow and Functions

Main author of the chapter: Angel Priegue, CIM

5.1 Screen Flow Diagram

In this section a description of the different screens and the navigation flow between them will be described.

Access to the main screen is done through a **login screen** that allows the user through their credentials (login and password) to access its content.

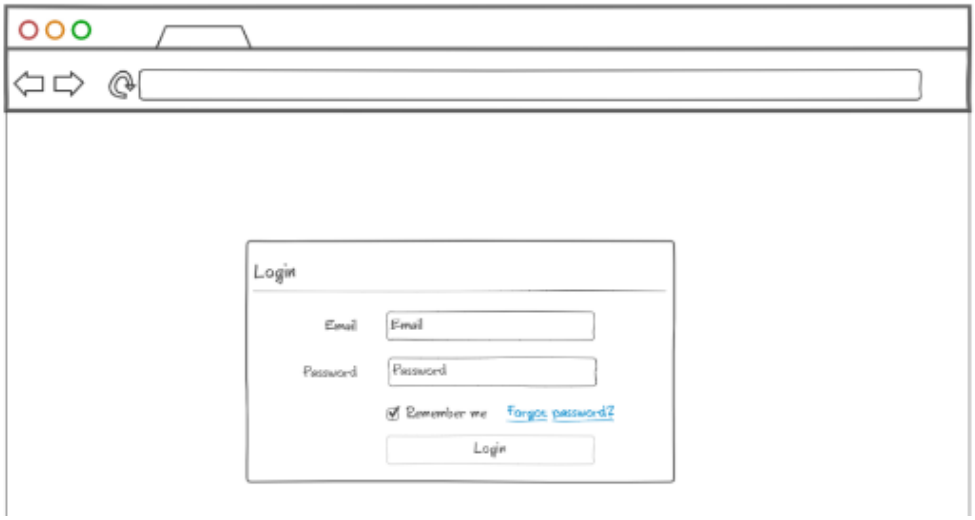

Figure 7. Login screen

A “Remember password” option is enabled with its typical functionality. In the event that the user does not remember his password, he can navigate to the **forgot password** screen, where the user is asked to enter his email so that the system will send him an email reminding him of it, and thus be able to go back to the **login screen.**

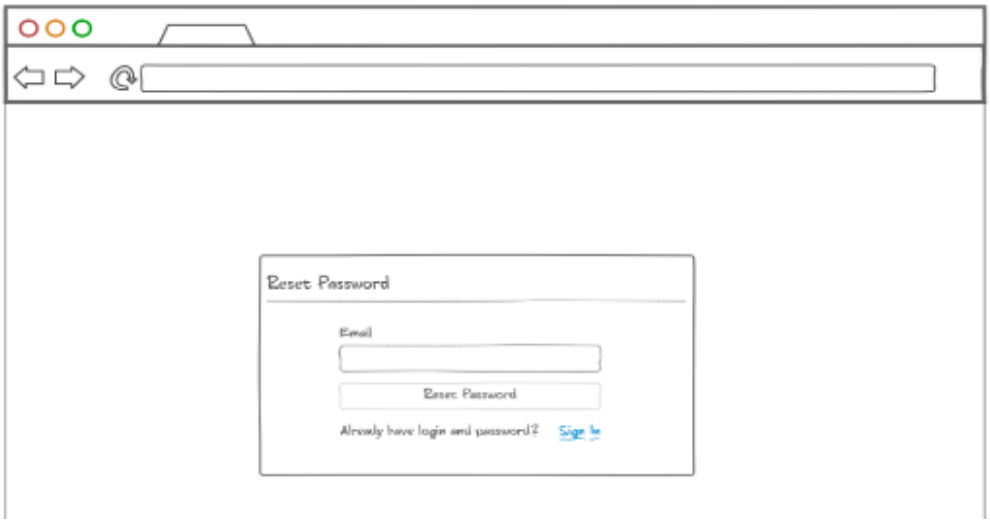

Figure 8. Forgot password

Once the user has entered his credentials, the system automatically redirects him to the **Summary of cargo/risk dashboard screen,** from this screen the user can see a summary of the ship's cargo and an overall fire risk score. The information in this dashboard is displayed in a very visual way so that the alert level can be quickly seen according to the cargo of the ship. Specifically, the data that can be viewed are the following:

• Total No of bookings / Total No. of chassis/export cars / Total Length (m), Total goods (Kg), Total Weight (Kg).

• Global score of fire risk / graph of the total load units according to risk level.

• Detailed summary according to vehicle type (table)

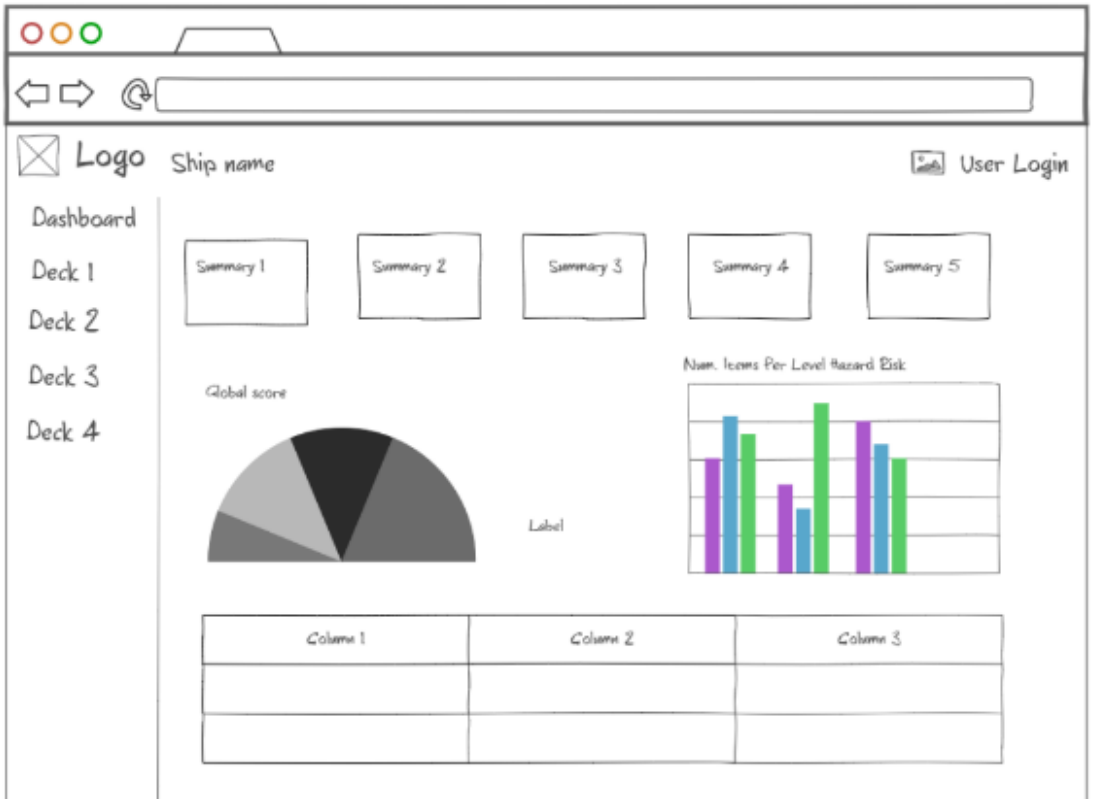

Figure 9. Summary of cargo/risk dashboard screen

To go to the **deck work screen**, go to the menu on the left.

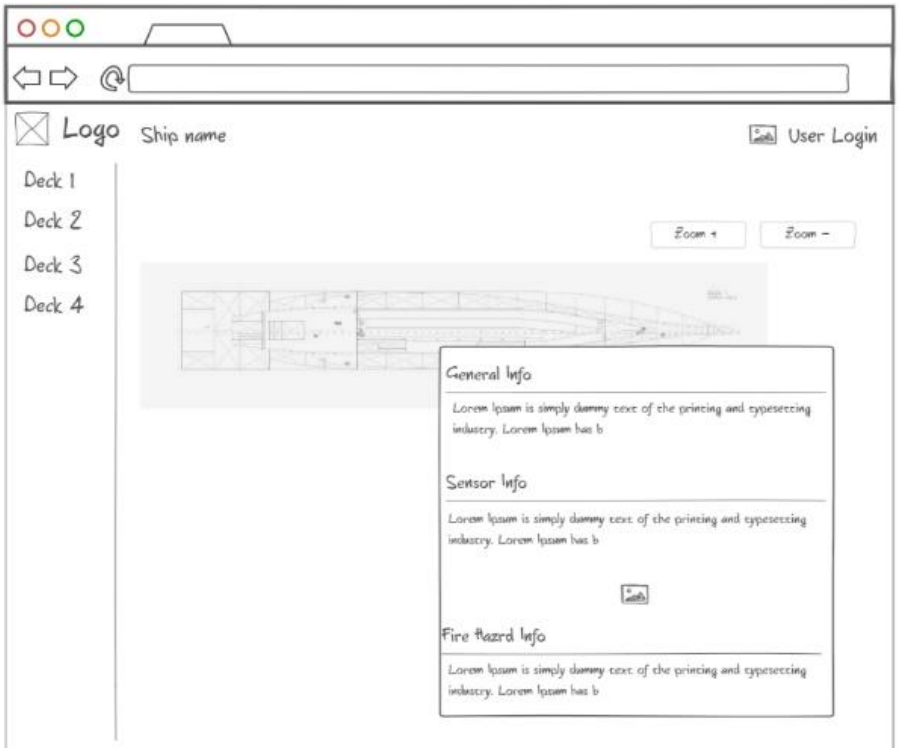

Figure 10. Deck work screen

On the left side is the menu to select the different decks of the ship. At the top of the screen is the name of the ship to which the user is associated, and the username that has started the session.

In this section of the screen users can **logout** and terminate the session. Once we are in the deck work screen, we can visualize the vector graphic that represents the deck, where we can perform the zoom tasks with the buttons located in the upper right part of the canvas.

Users can see the cargo transported in the deck and, by clicking on one of these elements, a pop-up window appears where users can see the associated information of the cargo unit divided into 3 sections (general information, sensor information, hazard information).

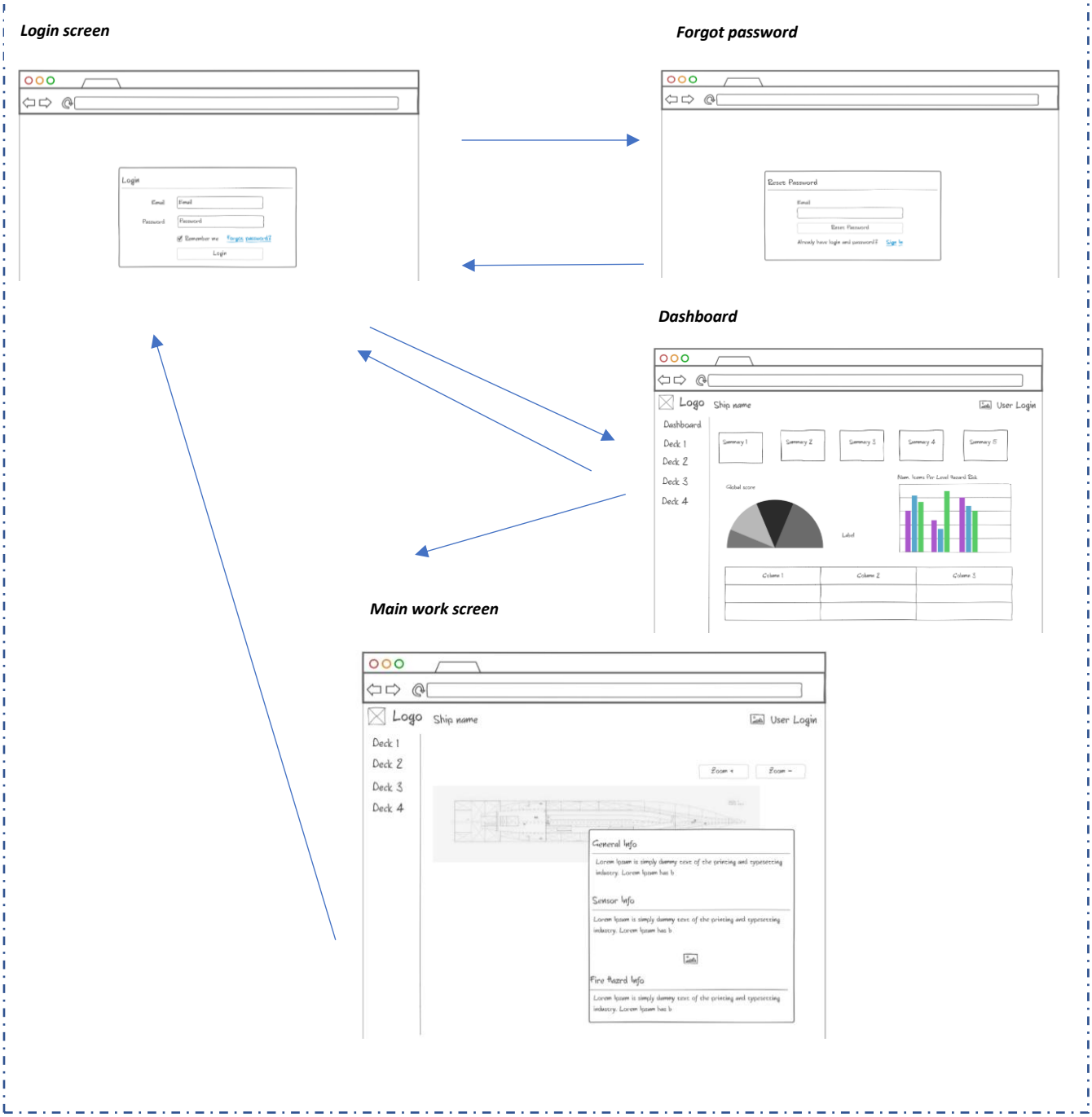

Figure 11. Screen flow diagram

5.2 Description of Functionalities

The first feature that the tool offers, once the user is accredited, is access to the dashboard. The dashboard is a data query operation that allows the user to see the summary of the ship's cargo status and the risks of fire through some graphs.

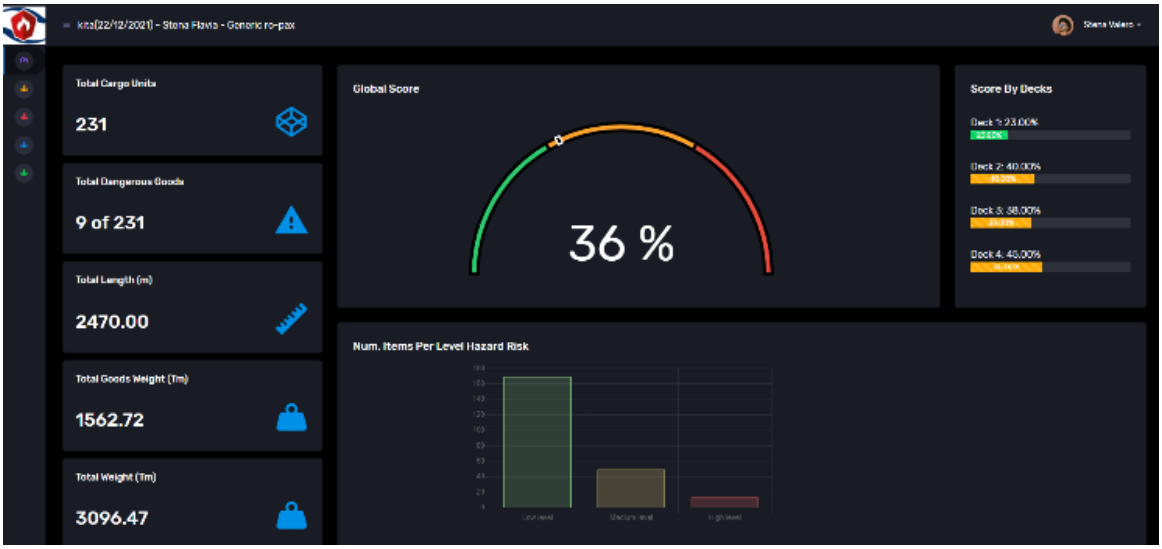

Figure 12. Dashboard

Info
- Total No of bookings / Total No. of chassis/export cars / Total Length (m), Total goods (Kg), Total Weight (Kg). - Global score of fire risk / graph of the total cargo units according to risk level. - Detailed summary according to vehicle type (table)

All this added information is extracted from the cargo manifest and the global score is calculated considering the risk assessment scores from the hazard database which gives the tool a risk score for each cargo unit depending on the type of cargo.

The formula used to calculate global risk scores for decks and ships scores of the cargo units is the calculation of the average score but taking also into account the empty slots of the ship with a score of 0%.

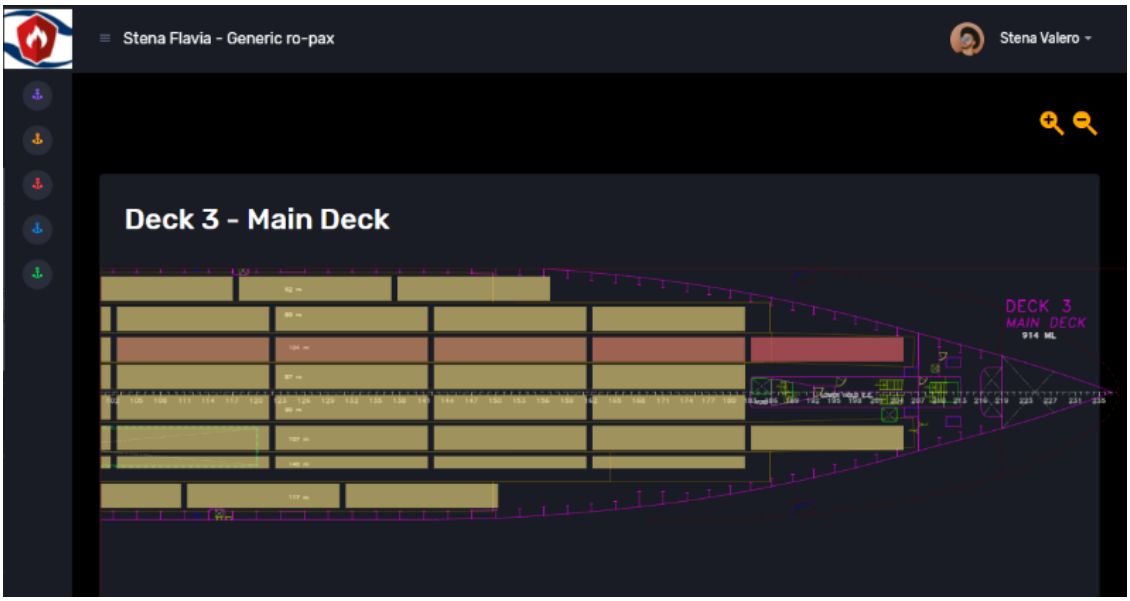

Figure 13. Main work screen

The main functionality of the tool is to visualize the ship's cargo and see the risk level in the event of a fire using a color map. The granularity of the cargo visualization is defined at the deck level, that is, the user has to select the deck in order to see the detail of the cargo. The visualization of the deck is shown through an SVG vector file and has the basic functionalities of zooming and moving the graphic on the canvas, for a better visualization of the entire deck. Figure 10 shows deck number 3, or “main-deck”, of the ship Stena Flavia. The cargo is identified within the deck graphic by rectangles. The color indicates the risk level of starting a fire. 3 levels of risk are considered, the highest level being red and the lowest being green.

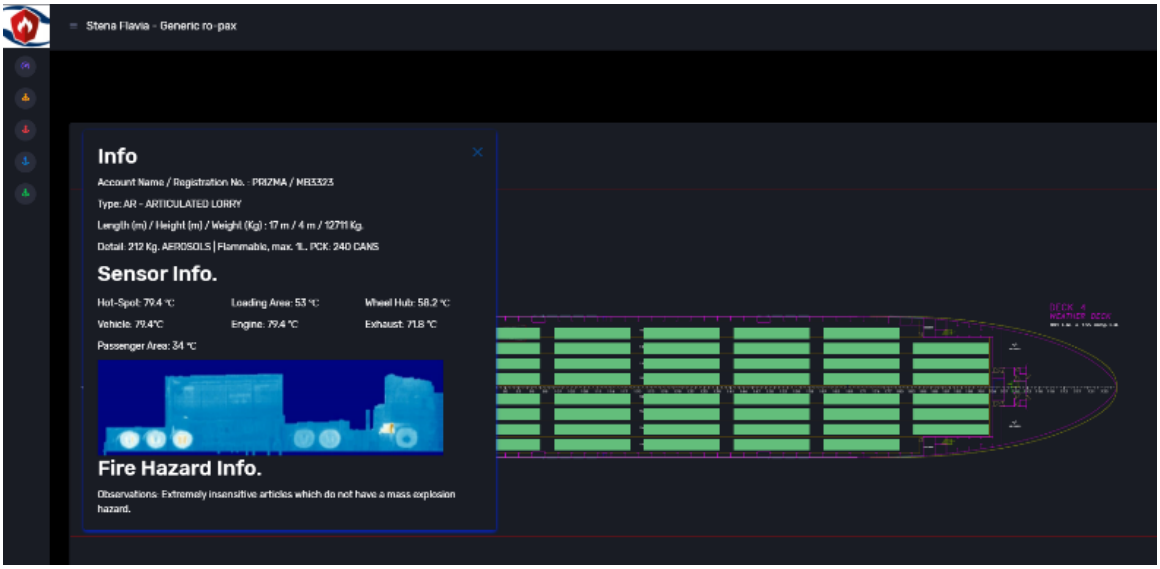

Figure 14. Detail info cargo

The cargo can be selected to view the associated information and see the reason why the level of risk has been considered. These are the fields that can be seen:

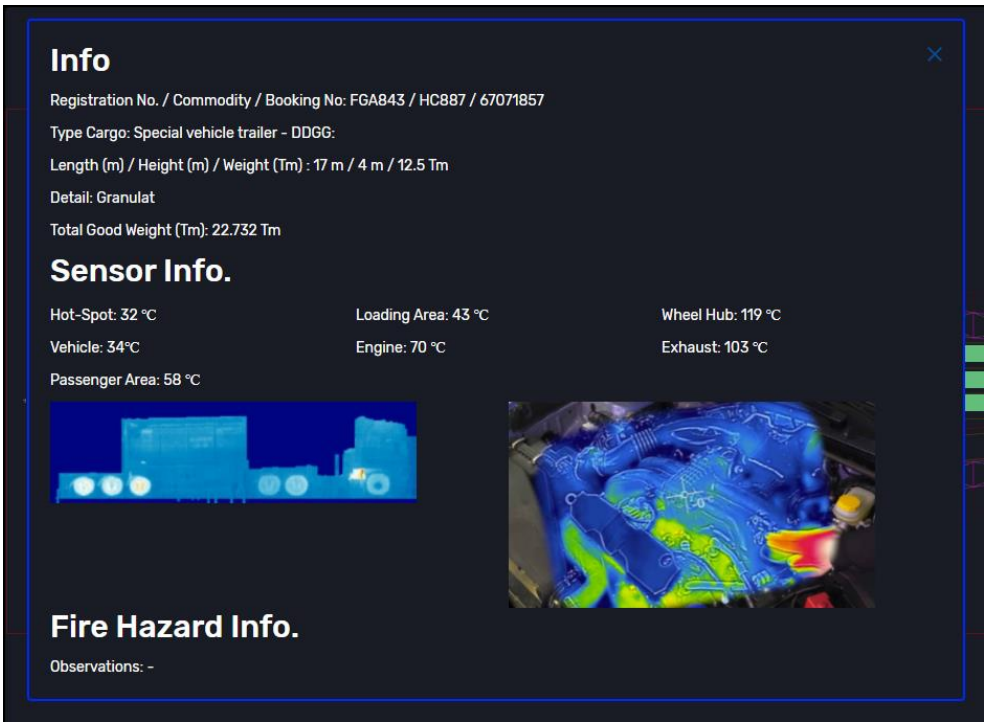

Figure 15. Zoom Detail info cargo

General Info
This section shows the information in reference to the cargo unit: account name, registration, type of vehicle, length, height, weight, details of cargo.
Sensor Info
This section shows all the information regarding the temperature sensor arc, with the inclusion of the thermal graph apart from the values.
Fire Hazard Info
This section shows the reason why the hazard level has been assigned to this cargo.

6 Fire Hazard matching/mapping tool

Main author of the chapter: Angel Priegue, CIM

6.1 Screen Captures

The prototype of the Fire Hazard Matching tool is currently available at https://lashfire.cimne.com/login.aspx,

User's email and password are already pre-filled in the fields for the purposes of easier and faster tests. Test environment includes the following users:

Normal users:

- stena@lashfire.com,
- magnolia@lashfire.com,

Admin users:

- adminstena@lashfire.com
- adminmagnolia@lashfire.com

All users have the same password: 12345678

Logically, this behavior will not be like this in the production environment during the demonstration phase of the LASHFIRE project but at this stage the tool can be evaluated with simple access data.

The following figures (18 to 24) show screen captures of the tool with the different functions described in previous sections of this report.

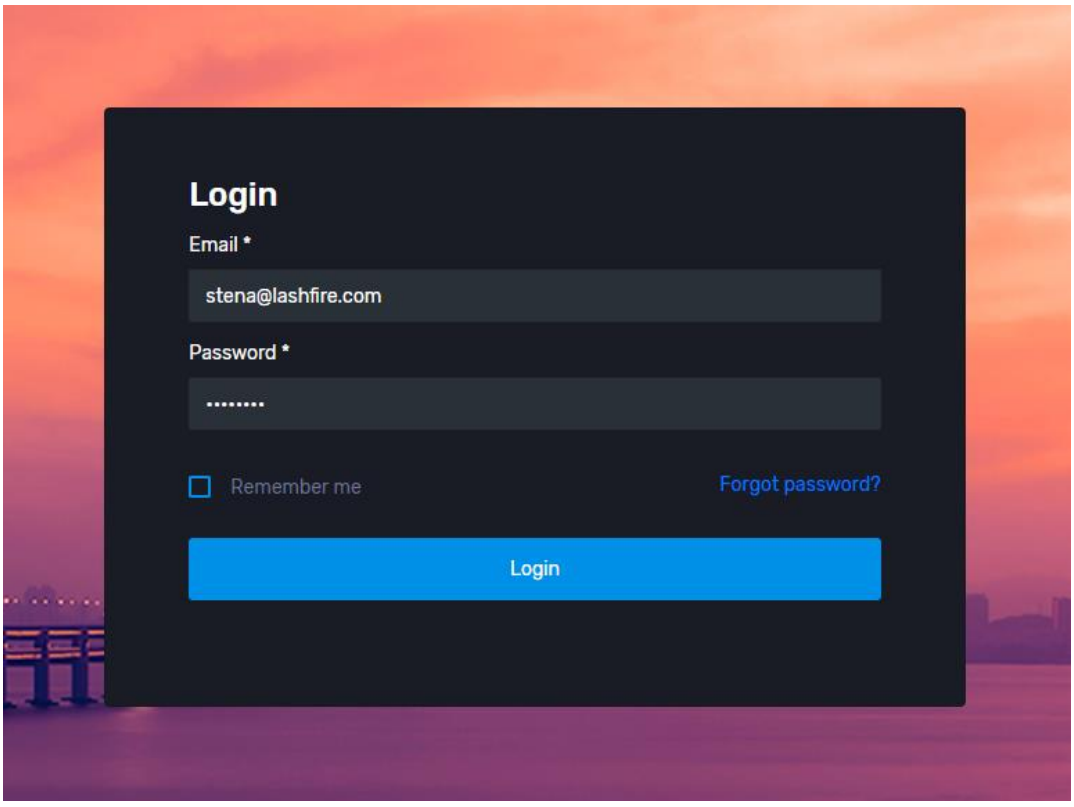

Figure 16. Login screen

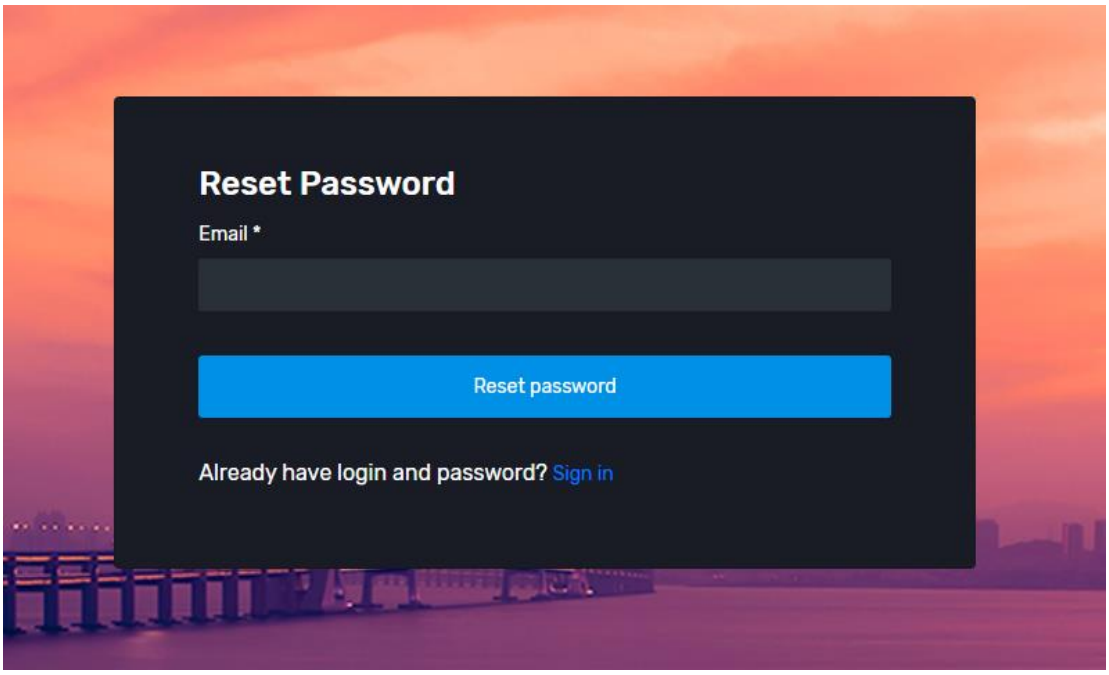

Figure 17. - Reset password screen

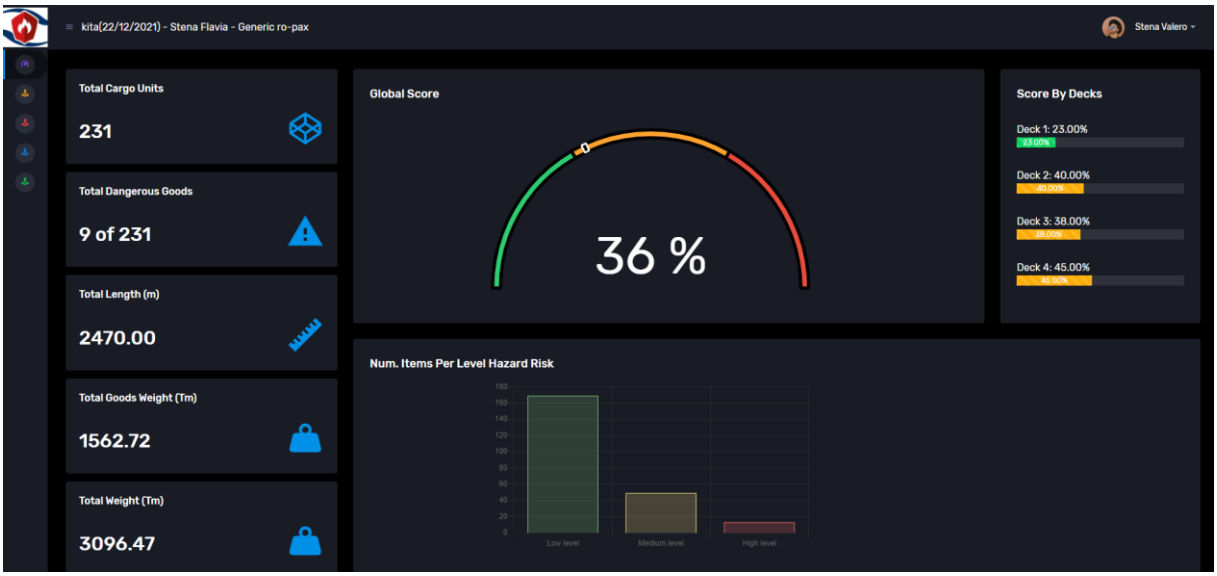

Figure 18. Dashboard

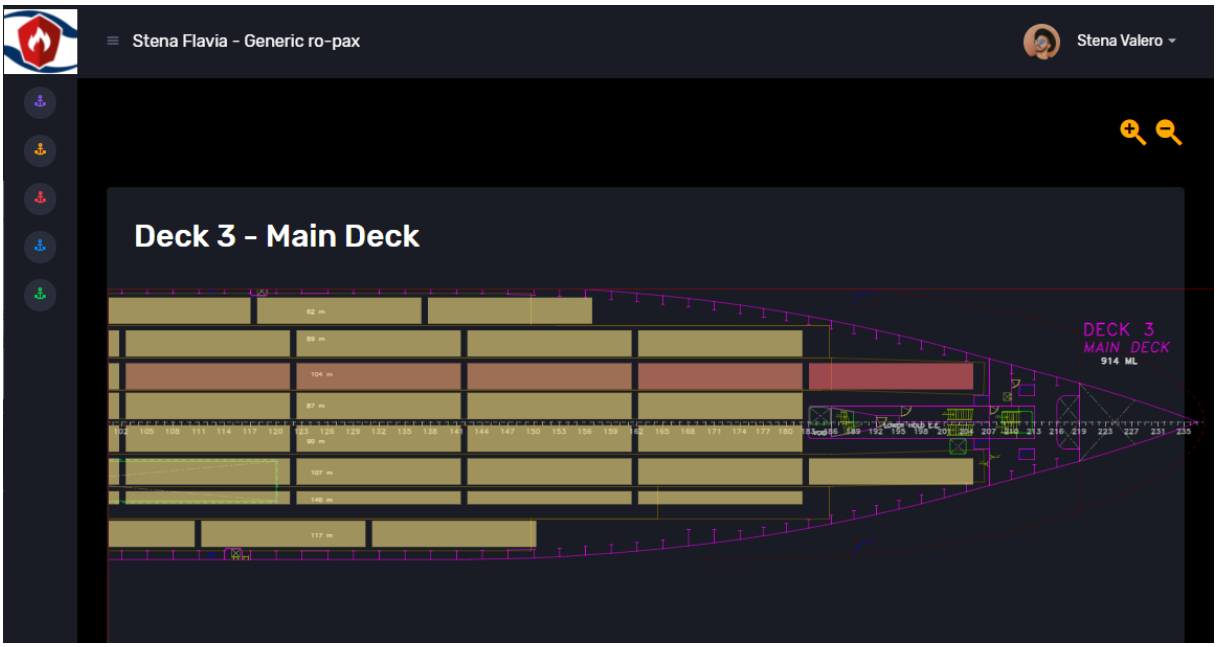

Figure 19.Main work screen

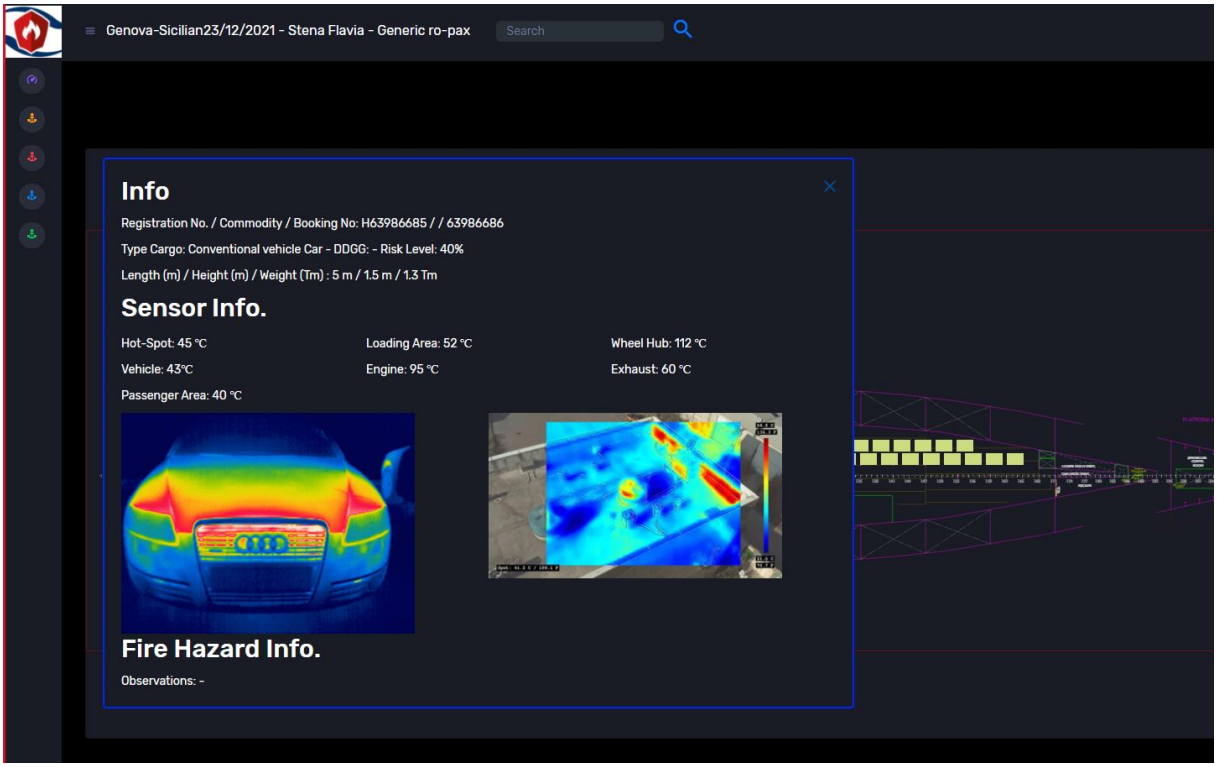

Figure 20. Screen to view information about the cargo

All these screens are designed to run on handheld devices as it is shown on the next image:

Figure 21. Screen capture on a tablet device

7 Conclusion

Main author of the chapter: Angel Priegue, CIM

We have shown in this report a description of the Fire Hazard Matching tool, developed as the main result of T08.5 in the context of action 8-A of WP8. This report provides the final picture of the implementation of the tool with working screens of the tool.

Following its requirements, the software enables the visualization and identification of hazards associated to each zone of the ship according to the characteristics of the cargo units located there. The tool is able to evaluate fire risk associated to all cargo units of a given ship loading configuration using an easy-to-use graphical interface that can be run both in computers and hand-held devices (mobile phones or tablets).

The tool is part of the action 8-A system of systems approach with open interfaces to other systems, and in LASH FIRE the interoperability with the other WPs and a future data exchange with other systems. The final result of the action will be the Stowage Planning Tool that will include the Visualization Aid module. Some of the visual UI requirements of the tool are not implemented in the Fire Hazard Matching tool in the scope of task T08.5 as they will be implemented in the Visualization Aid in task T08.6. This report only defines the description of software technologies that have been used for the implementation and testing of the fire hazard matching tool.

8 References

[1] SVG: Scalable Vector Graphics
https://developer.mozilla.org/en-US/docs/Web/SVG

[2] Mozilla Web Docs. (n.d.). *HTML5.*
https://developer.mozilla.org/es/docs/HTML/HTML5

[3] Mozilla Web Docs. (n.d.). *CSS: Cascading Style Sheets.*
https://developer.mozilla.org/en-US/docs/Web/CSS

9 Indexes

9.1 Index of tables

9.2 Index of figures