OVERHEAT
INNOVATIVE STRATEGIES FOR CONTAINERSHIP FIRES PREVENTION AND MANAGEMENT

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ABSTRACT

This deliverable defines the planning and methodology for simulation and demonstration activities under Work Package 7 (WP7) of the OVERHEAT project. WP7 aims to validate the technologies developed in WP4, WP5, and WP6 through a two-step approach: initial evaluation in controlled environments using advanced simulators, followed by real-world demonstrations with operational stakeholders to confirm their effectiveness and added value.

Five validation scenarios, combining simulations, live demonstrations, or both, will be implemented across Italy, Spain, France, Germany, and Poland. These exercises will assess the integrated OVERHEAT technological ecosystem, including:

- IoT-based fire detection sensors,
- Autonomous drones for fire confirmation and situational awareness,
- A digital platform for aggregating and analysing multi-source data to support emergency decision-making,

The document details the scenarios for each exercise, specifying objectives, technologies involved, actors, operational conditions, and practical arrangements. It serves as a common reference framework to ensure coherent, efficient execution of validation activities across all participating partners.

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ACRONYMS

Acronym	Meaning
AI	Artificial Intelligence
AIS	Automatic Identification System
API	Application Programming Interface
AToN	Aid to Navigation (anything like buoys, lighthouses, radar beacons, pseudo buoys with AIS etc.)
CARS	Controllers Acceptance Rating Scale
CINEA	European Climate, Infrastructure and Environment Executive Agency
CROSS	Regional Operational Centre for Surveillance and Rescue (France)
DS	Digital Solution
EC	European Commission
ECDIS	Electronic Chart Display and Information System; IMO-regulated user terminal on board vessels for electronic charts replacing paper charts
EMSA	European Maritime Safety Agency
ENSM	École Nationale Supérieure Maritime
ETA	Estimated Time of Arrival
EU	European Union
EX	Example
FRB	Fast Rescue Boat
GMDSS	Global Maritime Distress and Safety System
GNSS	Global Navigation Satellite System

Acronym	Meaning
IHO	International Hydrographic Organisation
IMO	International Maritime Organisation
IN	Innovative Navigation
IoT	Internet of Things
IP54 / IP55	Ingress Protection ratings (technical protection standards)
KPA	Key Performance Area
LAN	Local Area Network
LTE	Long-Term Evolution
MES	Marine Evacuation System
OPS	Operational Procedures / Operations
PCC	Project Coordination Committee
PoC	Proof of Concept
PoR	Port (or Place) of Refuge
PPU	Pilot Portable Unit; tablet and positioning system used by maritime pilots with ECDIS
PRQ	Post Run Questionnaire
PSQ	Post Simulation Questionnaire
RT	Real Time
RTK	Real-Time Kinematic
RTS	Real Time Simulation
SAR	Search and Rescue

Acronym	Meaning
SATI	SHAPE Automation Trust Index
SHOM	Service Hydrographique et Océanographique de la Marine
S-100	IHO universal standard for digital navigational charts and data, replacing S-57
S-101	Electronic Navigational Chart (ENC) Product Specification
S-102	Bathymetric Surface Product Specification
TBD	To Be Defined
UAV	Unmanned Aerial Vehicle
UAS	Unmanned Aerial System
VEMG	Validation Exercise Management Group
VHF	Very High Frequency
VTS	Vessel Traffic Services; shore-side traffic control service operated by maritime authorities and harbour masters
WAN	Wide Area Network
WP	Work Package

1. INTRODUCTION

1.1. Context

The main objective of the OVERHEAT project, funded by the Horizon Europe programme, is to prevent and manage fires on board container ships, mitigating impacts, by integrating innovative and interconnected solutions. Fires on this type of ship represent a major risk to the safety of crews and cargo, port infrastructure and the environment.

To meet this challenge, several Work Packages (WPs) have been implemented, including:

- **WP4:** Development of advanced surveillance and sensing technologies (IoT sensors, drones, autonomous systems).
- **WP5:** collection of user needs and definition of functional and regulatory requirements.
- **WP6** : integration of technological solutions into a single ECDIS-based digital solution (DS), enabling a global situational overview and the coordination of all stakeholders.
- **WP7** : validation of the whole thing by simulations and demonstrations in different European operational contexts.

1.2. Objectives of WP7

Work Package 7 (WP7) aims to test, validate and demonstrate the solutions developed in the previous WPs.

The specific objectives are:

- Implement virtual simulations to evaluate the performance of technologies in controlled environments.
- Organize demonstrations in real conditions in three countries (Italy, France, Spain).
- Verify the operational relevance, robustness and added value of the solutions for end users.
- Check for enhancements of mitigating outcomes using early fire detection.
- Capitalize on the results to provide recommendations and good practices at European level.

1.3. Link with other Work Packages (WP4, WP5, WP6)

WP7 is the validation and experimentation phase of the solutions from the other lots:

- Sensor and drone technologies (WP4) are tested in different simulated and real-world scenarios.
- The user requirements and needs defined in WP5 could serve as a reference framework for the evaluation.
- The integrated digital solution (WP6) is at the heart of most simulations and demonstrations, as it allows for the aggregation of data in near real-time.

- The WP5.4 (Ontology) compiles the different entities which were defined / produced by the other WPs involved in the Overheat fire management processes, their relationships with the types of data and protocol used to communicate entities, It is also one important input for the project.

Thus, WP7 is not an isolated lot, but the culmination of the project's development chain.

1.4. Deliverable Target Audience

This deliverable is mainly intended for:

- The consortium partners, in order to have a common plan to coordinate simulation and demonstration activities.
- End users and operational stakeholders (maritime authorities, ports, shipping companies, rescue services), to ensure that scenarios and tests meet their real needs.
- Responsible Legislation to verify current Port (or Place) of Refuge regulations.

1.5. Purpose of the document

This deliverable describes the simulation and demonstration scenarios defined for each of the project's use cases.

Some scenarios are only simulated in a close-to-life environment, while others are also physically implemented in ports. These scenarios cover a wide range of use cases, from dock to offshore.

This document also includes:

- information on the technologies tested,
- the objectives of the simulations and demonstrations,
- as well as the milestones and key steps necessary for them to run smoothly.

It thus constitutes a common operational reference for all partners involved in tasks T7.2 to T7.6, providing them with a clear and structured methodology to ensure a rapid, coherent and efficient implementation of the planned activities

2. SIMULATION AND DEMONSTRATION CONTEXT

2.1. General objectives of simulations and demonstration in OVERHEAT

The simulations aim to validate the integrated OVERHEAT system under controlled conditions before real-world demonstrations. The objectives of the validation scenarios include:

- Assessing the interoperability between IoT sensors, autonomous drones, and the Digital Solution.
- Verifying the ability to detect thermal anomalies and fires in containers using edge AI sensors and drone-based inspection.
- Testing automated mission planning and emergency procedures in maritime and port environments.

OVERHEAT will combine simulations and tests in real conditions to allow a structured approach for the validation of the overall system.

The different sub-systems of OVERHEAT will be simulated and progressively assembled in the final demonstrators to facilitate the validation of the system and its components. The errors are easier to detect at the simulation stage than in the final prototype validation one. Moreover, simulation enables the testing of multiple scenarios, full control over all scenario variables (weather, traffic, failures…), the ability to replay tests under different conditions, and comprehensive recording of all relevant data with a reduced cost.

The WP5.4 proposes a system structuration in components. WP7.1 builds on this architecture and the assembly of components, in line with the different use cases covered in WP7.

2.2. Technologies developed and tested

As presented in *Table 1*, the technologies integrated into the OVERHEAT system and addressed within WP7 are outlined in a structured manner. For each component, the table specifies its functional role, the partner responsible for its development or integration, and the corresponding reference document. This overview provides a shared basis for understanding the overall system architecture, the interactions between hardware and software components, and the range of technologies that are currently tested or will be evaluated during the experimentation phases.

Technologies	Description	Responsible	Reference document
IoT Edge AI fire detection and drone inspection management, IT for data management and data sharing	Early detection of fire or fire precursors inside a container, management of drone operations, management of data and data sharing with the Digital Solution	Peopletrust	D4.4
Autonomous drone	Equipped with wide-angle, telephoto, and thermal cameras for fire detection and situational awareness. Features RTK positioning and IP54 protection	TopView	D4.1
Recharging station of autonomous drone.	Automated recharging station with IP55 protection, quick-charging module, and environmental sensors (wind, rainfall, temperature, humidity). Vessel version includes a tilting mechanism providing stabilization during take-off and landing and Starlink connectivity.	TopView	D4.1

Mission Planning Software	Cloud-based platform for autonomous flight route planning, real-time monitoring, and integration with IoT alerts. Includes API for interoperability with the OVERHEAT Control Room.	TopView	D4.2
AI Algorithm for Thermal Anomaly Detection	Processes thermal and visual data to confirm fire presence based on predefined thresholds and container recognition.	TopView	D4.2
Data server	Provides data to the users terminals, Installed in ports and can be simulated in ENSM and IMAT	BrestPort, ENSM, IMAT	D6.1 & D6.2
VTS	Harbour master User terminal, Installed in ports; will also be simulated in the subcontractor's lab.	SeaTopic & BrestPort	D6.2
ECDIS	Captain' user terminal, Installed on board a vessel; will be simulated in the subcontractor's lab; a prototype will also be installed in ENSM.	SeaTopic, BrestPort, ENSM	D6.1 & D6.2
PPU	Pilots' mobile user terminal, Installed on board vessels for the pilotage.	SeaTopic, BrestPort	D6.2

Table 1- Table listing the technologies tested and which will be tested in WP7

3. VALIDATION Activities: Simulation And Demonstration exercises

3.1. List of use cases

Within WP7 of the OVERHEAT project, five complementary validation scenarios implementing several use cases across Europe, covering a wide range of operational contexts related to container ship fire prevention, detection and emergency management.

These use cases are deployed in Italy, Spain, France, Germany and Poland, and combine real-time simulations, virtual scenarios and real-world demonstrations.

Together, they aim to validate the OVERHEAT technological ecosystem, including IoT fire detection sensors, autonomous drones, and the integrated Digital Solution, under diverse regulatory, operational and environmental conditions.

Five validation scenarios are implemented across the different OVERHEAT use cases. In Italy, the validation focuses on the early detection and monitoring of container fires on board ships using IoT sensors and drones, as well as on validating the integration of the Digital Solution. This scenario includes simulation activities carried out between February and March 2026, followed by a demonstration phase scheduled for April 2026, under the responsibility of IMAT.

In Spain, the validation scenario aims to assess fire detection and response in a real port environment, with a particular focus on the interoperability between IoT sensors, drones and the Digital Solution. This demonstration is planned for February 2026 and is led by Fundación Valenciaport.

The French use case concentrates on demonstrating Digital SAR assistance during vessel distress situations and validating the Digital Solution for situational awareness and access to ports of refuge. This scenario includes laboratory and functional tests conducted from January to April 2026, followed by operational tests between April and May 2026, coordinated by ENSM.

In Germany, the validation scenario is based on simulation activities aimed at supporting decision-making for Ports of Refuge. It involves comparing real incident scenarios with optimised situations enabled by early fire detection technologies. These simulations will be carried out throughout WP7 in 2026 under the responsibility of ISaSS.

Finally, the Polish use case evaluates the use of UAV-based inspection during port approach and assesses the feasibility of early anomaly detection prior to docking. Simulation activities for this scenario are planned between February and March 2026 and are led by ILOT.

3.1.1. Global vision of the five use cases

Italian use case – On-board container fire detection and monitoring

Objective

The Italian use case focuses on early detection and monitoring of container fires on board containerships, both at sea and in harbour. It evaluates how IoT sensors and drones can improve situational awareness, reduce crew workload and enhance safety compared to current practices.

Approach & timeline

- Combination of real-time simulation and physical demonstration
- Real-time simulations performed on the IMAT Challenger bridge simulator
- Real fire demonstration on a firefighting field using a real container
- Planned execution between February and April 2026

Key technologies

- IoT Edge AI fire detection sensors installed in containers
- Autonomous drones with thermal and optical cameras
- Mission planning software and AI-based thermal anomaly detection
- Integrated Digital Solution interfaced with bridge systems (ECDIS, PPU)

Spanish use case – Port-side container fire response

Objective

The Spanish use case validates the operational performance and interoperability of OVERHEAT technologies in a real port environment, focusing on fire detection and response for a container ship berthed at quay.

Approach & timeline

- One real-world demonstration preceded by virtual simulations
- Demonstration conducted in the Port of Sagunto (Intersagunto Terminal)
- The Digital Solution will not be used during the demonstration; however, recorded data from the trials may be used by WP6 to support and further develop an early prototype (version 0.3).

- Planned execution: February 2026

Key technologies

- IoT thermal sensors installed on quay containers
- Autonomous drone inspections with thermal and visual imagery
- Data recording and offline integration into the Digital Solution
- Coordination with firefighters, port authority and terminal operator

French use case – Digital SAR assistance and port of refuge access

Objective

The French use case demonstrates the added value of the Digital Solution as a shared situational awareness tool during a Search and Rescue (SAR) operation involving a vessel in distress approaching a port of refuge.

Approach & timeline

- Progressive validation through laboratory tests, functional tests and operational tests
- Scenario located near Brest, in a high-traffic and complex navigational area
- Operational validation planned between early and mid-2026

Key technologies

- Digital Solution based on S-100 e-Navigation standards
- VTS, ECDIS and PPU user terminals
- Integration of drone video streams and fire sensor data
- Port data servers, AIS, met-ocean and hydrographic data

German use case – Port of Refuge decision-making simulation

Objective
The German use case focuses on strategic and regulatory decision-making by analysing historical maritime incidents and comparing them with hypothetical scenarios involving earlier fire detection and mandatory access to Ports of Refuge.

Approach & timeline

- Pure simulation-based use case
- Comparison between real incidents and alternative optimised routes
- Executed within the WP7 timeframe, independent of physical demonstrations

Key technologies

- Simulation and analytical tools using historical incident data
- Integration of OVERHEAT assumptions (early fire detection, improved coordination)
- Quantitative and qualitative assessment of risk reduction and response efficiency

Polish use case – UAV-based inspection during approach phase

Objective
The Polish use case evaluates whether UAV-based inspections can reliably detect thermal anomalies on container ships before port entry, supporting port authorities in early decision-making.

Approach & timeline

- Scenario based simulation between Italy and Poland
- Vessel simulated in IMAT, UAV and airspace simulated by ILOT
- Scheduled alongside the Italian simulations in February–March 2026

Key technologies

- Advanced simulation environments and Digital-Twin modelling
- Mission planning and mission management algorithms
- Data based tests and data exchange between maritime and UAV simulators
- Interfaces with the OVERHEAT command and decision-support logic

Each use case is described in detail in the corresponding subsections of Section 3.

3.2. ITALIAN use case

This section is aimed at describing, the general organisation of the Validation exercise: location, whole duration, number of validation scenarios etc.

It is important to highlight that in order to perform the objectives reported in the Grant agreement, Italian use case validation will be composed by one Real Time Simulation and one Demonstration.

The real time simulation will be conducted on IMAT Challenger simulator, described in the next section, instead demonstration will be conducted on IMAT firefighting field with a real container, IoT sensors and real fire.

3.2.1. Exercise Scope and Justification

The Italian use case concerns mainly works on on-board container ship fires and other container problematic/issues related the safer navigation and on preventing the negative cascade effects in/out of the vessels.

In order to investigate these aspects will be used two type of validation represented by Real Time Simulation and Demonstration. So the Italian use case will use different scenarios in order to allows the tests.

The Real Time Simulation (RTS) will implement different situations:

1. Early Warning: the use of the collaborative systems (IoT sensors and UAS) will be for monitoring the containers on the weather deck. In case an alarm is raised by the sensors, the UAS using the I.A. algorithms, will return a temperature matrix able to detect if a container is warmer than the surrounding area.

2. Fire Monitoring: the use of the UAS will be for monitoring the fire and humans in danger in order to provide a good situational awareness to the rescue/fire teams.

One simulator will be used for the project purposes: the IMAT Challenger simulator, used for seafarers and master training. During the project this simulator will be used to reproduce all the aspects present on the bridge in order to conduct a Real Time simulation.

Instead, the Demonstration will implement other objectives in order to integrate and complete the research making by RTS.

One of the goals is to test the three different IoT sensors developed by the OVERHEAT project and installed on a real container.

Another goal is to use UAVs to replace humans in demanding and / or dangerous task such as fire/human detection.

3.2.2. VALIDATION SCENARIOS

3.2.2.1. Route and Harbour Information

To ensure that the simulation fully reflects the actual conditions existing in the port of Genoa (*Figure 1*), IMAT asked WARTSILA-TRANSAS to completely remodel the area, starting from the topographical surveys obtained (*Figure 2*). These surveys highlight all the changes made to the Cantiere Antico (70m jetty), Calata Olii Minerali (new arm), and the filling between Calata Canepa and Calata Ponte Ronco.

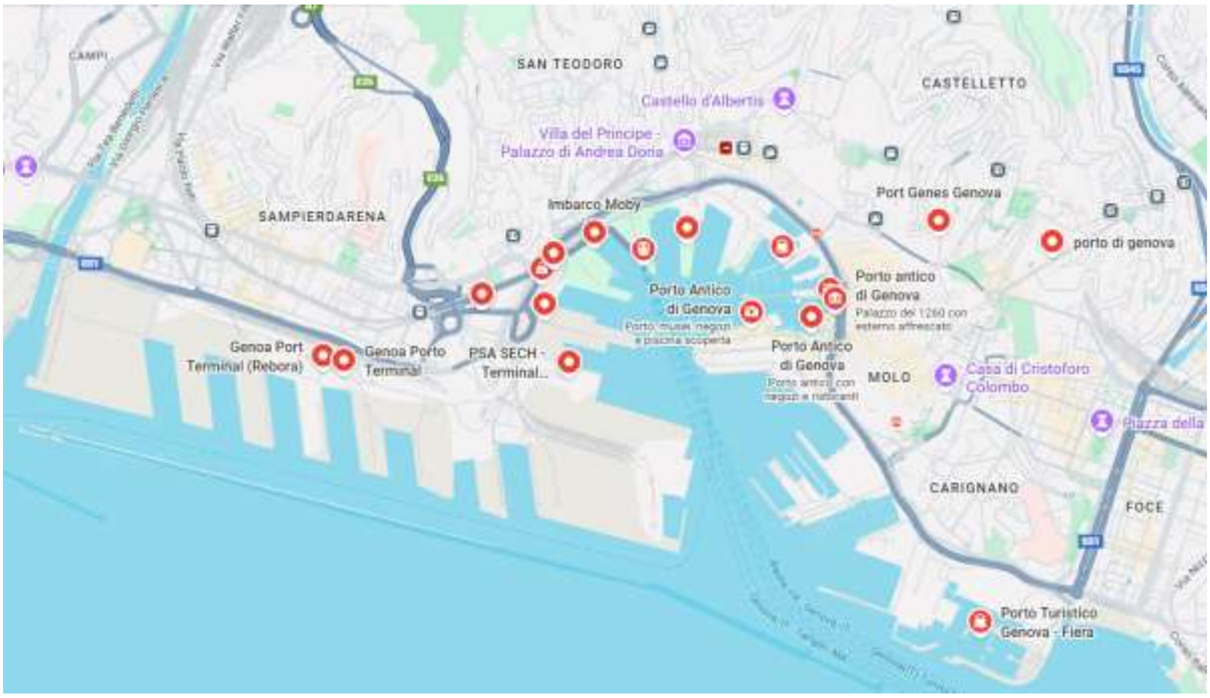


Figure 1- Overview of the Port of Genoa area (Google Maps)

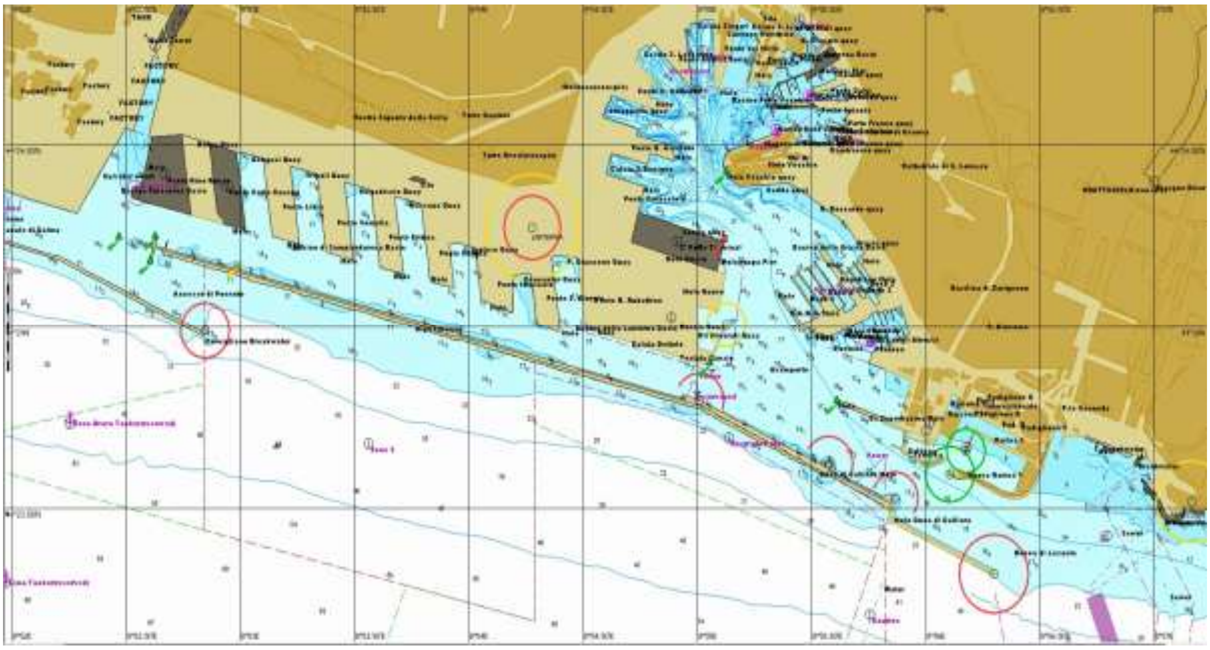


Figure 2- WARTSILA port modelling of the Port of Genoa

As shown in *Figure 3*, the main measurements of the areas modelled by WÄRTSILÄ-TRANSAS are presented. These measurements were obtained by indexing and consolidating the information provided by the Western Ligurian Sea Port Authority and previously reviewed in the earlier sections.

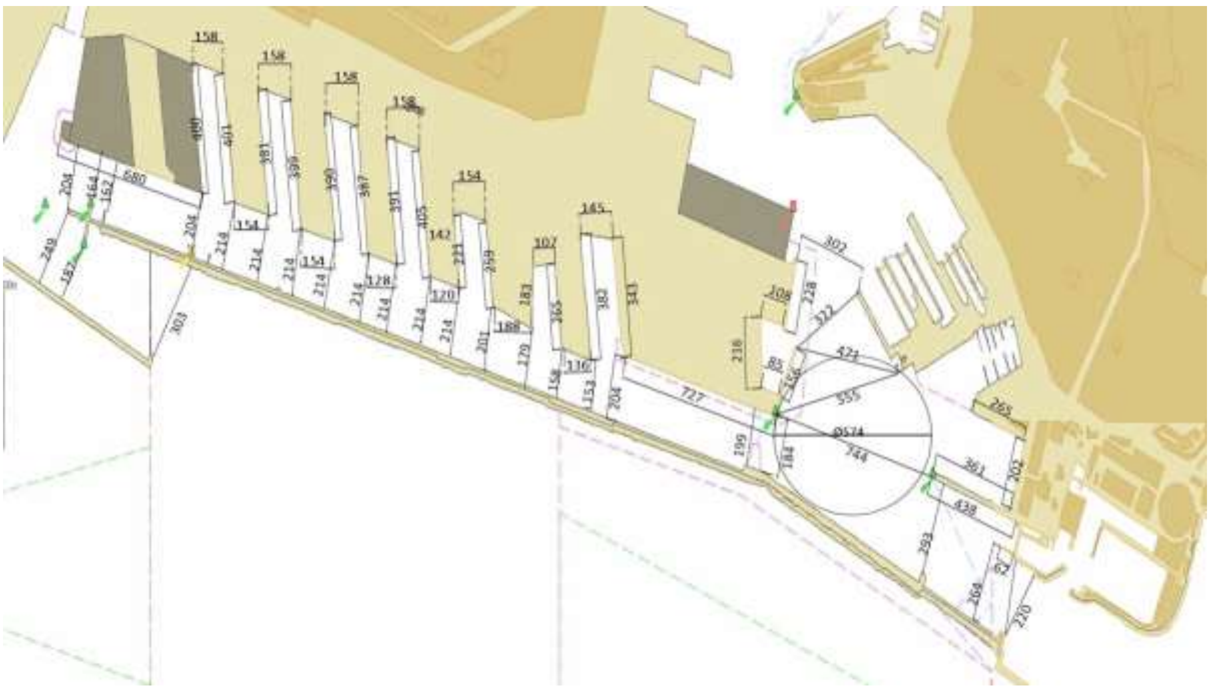


Figure 3- Main geometric dimensions of the Port of Genoa areas modelled by WÄRTSILÄ-TRANSAS

As illustrated in (*Figures 4 and 5*), the Bettolo terminal is selected as the reference area for the simulations, as it is the dedicated terminal for container ship operations within the Port of Genoa. Given that container vessels are used for the project scenarios, this terminal provides a representative and operationally relevant environment for the simulation activities.

Figure 4- Overview of the Bettolo container terminal

Figure 5- Bettolo terminal – WÄRTSILÄ port model of the Port of Genoa

Below the link to Bettolo terminal:

[Bettolo - Genoa Mediterranean Gateway - Autorità di Sistema Portuale Mar Ligure Occidentale]

The following conditions are used for the simulations:

1. The Bettolo terminal (*Figures 6 and 7*) has 37 bollards with a SWL of approximately 120 tons, all equipped with 1600x800mm x 2-meter-wide fenders. Installing all these targets would significantly burden the NTP 5000 software, so, also on the advice of WARTSILA-TRANSAS, a fender zone (*Figure 8*) was developed that spans the entire terminal, 1.60 meters wide from the edge of the quay. Only those fenders that are normally used during the regular mooring of the vessels being simulated will be installed.

2. In the Genoa port basin (passenger port, commercial port, and Sampierdarena), the current always flows in an EAST-WEST direction (*Figures 9 and 10*);

3. All the mathematical models of the vessels used to transit the Sampierdarena Channel reflect the main characteristics of the vessels studied, thus providing satisfactory results for the objective. However, it should be noted that they do not have the same manoeuvrability and speed control response as the ships being simulated.

4. The sail areas used by the Simulation Complex (SIMULATORS) are those reported in the Summary of Simulation Reports and were taken from the maneuvering booklets provided by Transas-Wartsila along with all the ship models used in the simulations.

5. The PASSENGER SHIP_10 model used for the transiting vessel reflects the main dimensions of length, beam, draft, and windage area, and is satisfactory for the actual purpose of the simulation. However, it should be noted that the propulsion is not adequate for the ship model being simulated (in fact, we simulated a model with two azipods and three bow thrusters instead of a single-propeller pitch propeller with a bow and a stern thruster, which therefore does not correspond to the manoeuvrability of a Jolly series vessel).

6. The CAR CARRIER_7 model used for the transiting vessel reflects the main dimensions of length, beam, draft, and windage area, except for the centreboard. However, for the actual purpose of the simulation, it is satisfactory. Finally, it should be noted that the propulsion is not adequate for the ship model being simulated (in fact, we simulated a single-propeller model with one bow and one stern thruster instead of a twin-propeller with two bow thrusters, which therefore does not correspond to the manoeuvrability of an ECO series ship).

7. All maneuvers performed in the simulation will be aided by the ship's PPU.

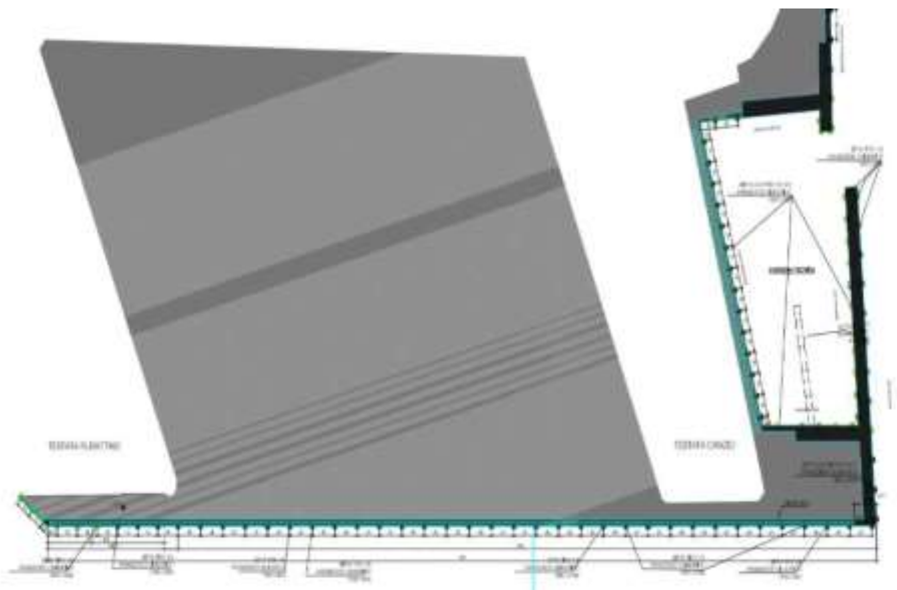


Figure 6- Bettolo terminal: bollard and fender arrangement

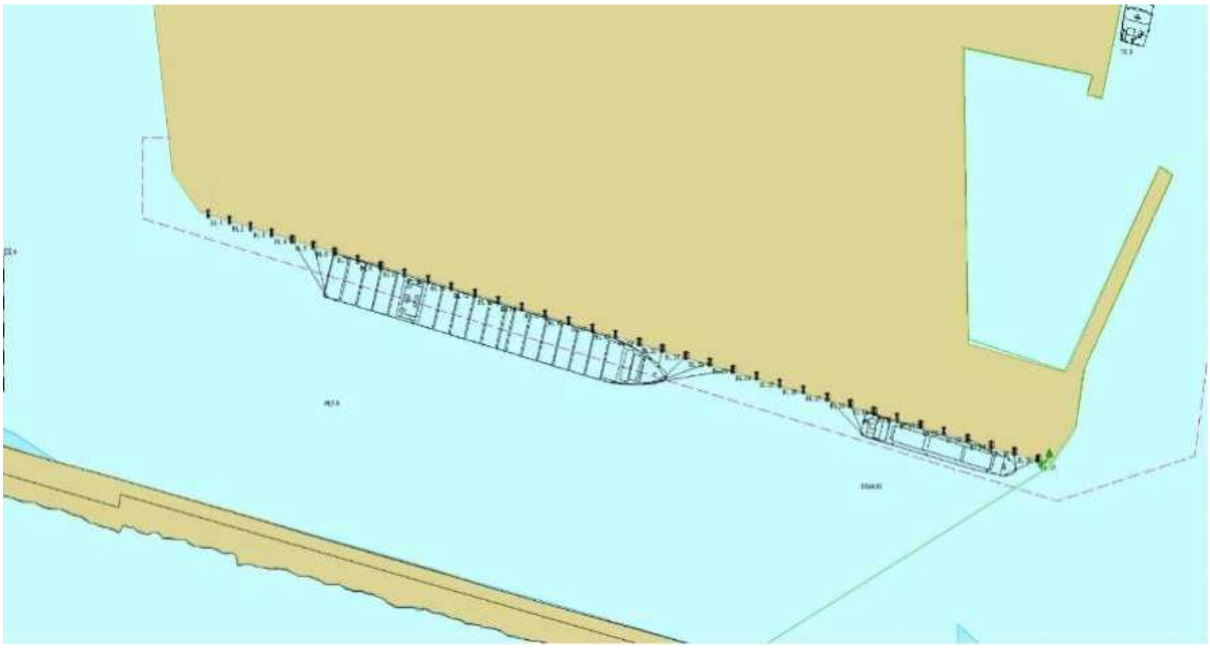


Figure 7- Detailed view of mooring infrastructure at the Bettolo terminal

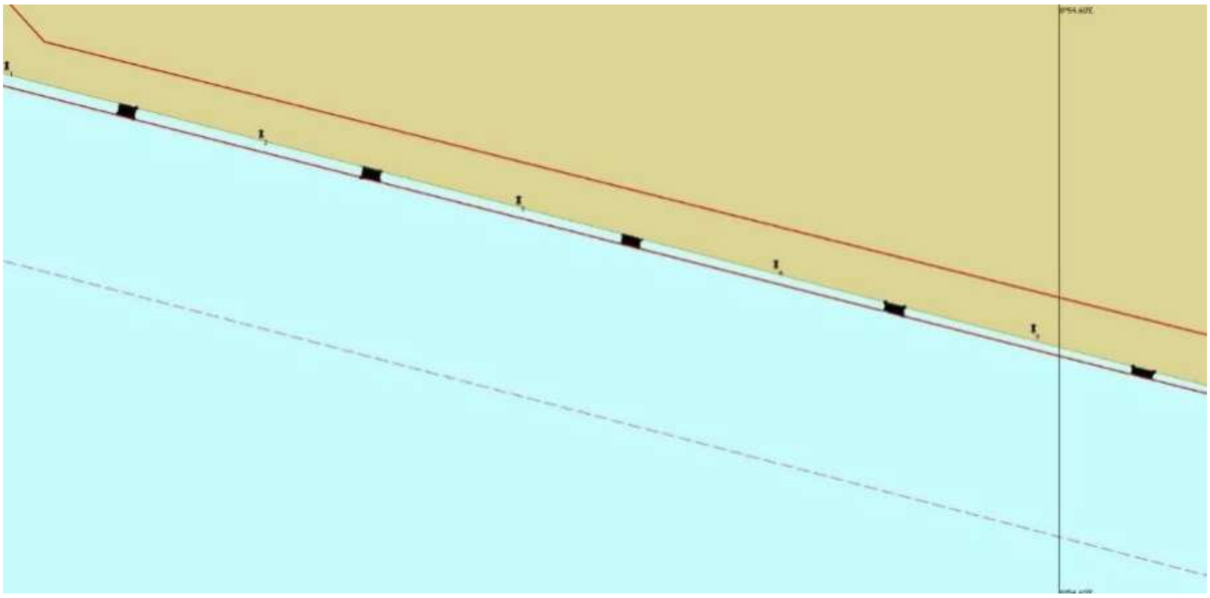


Figure 8- Continuous fender zone implemented for simulation purposes

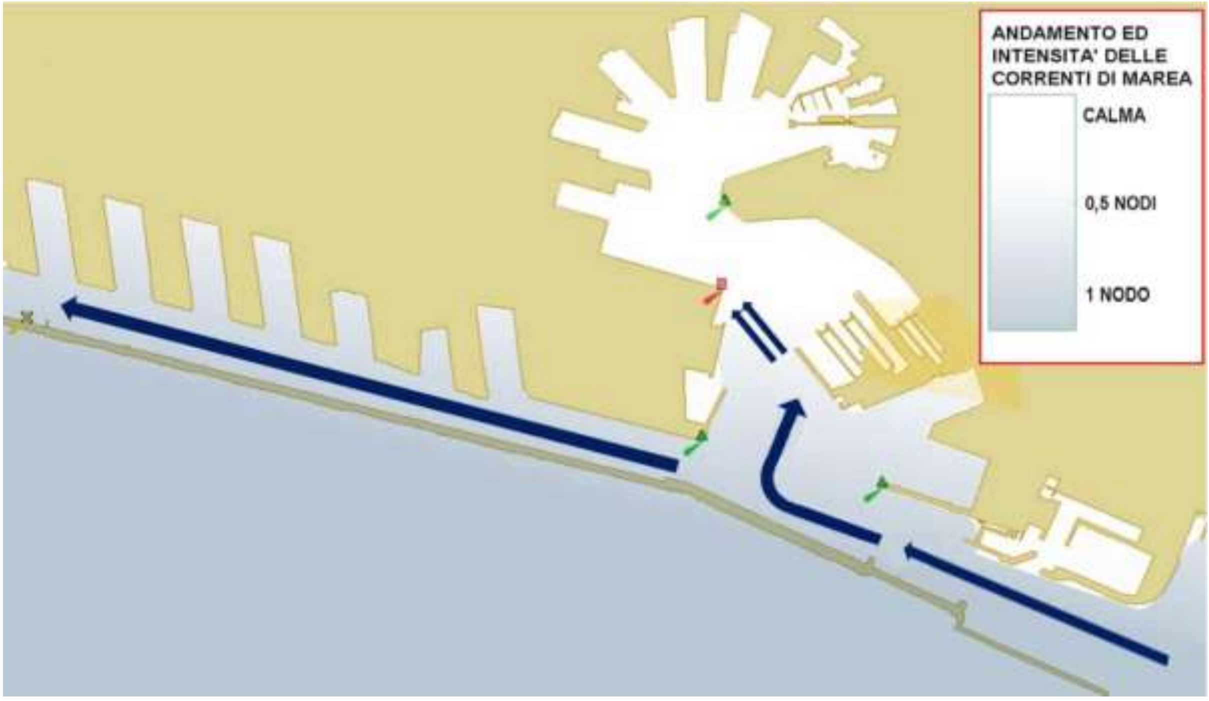


Figure 9- Prevailing current direction in the Port of Genoa basin

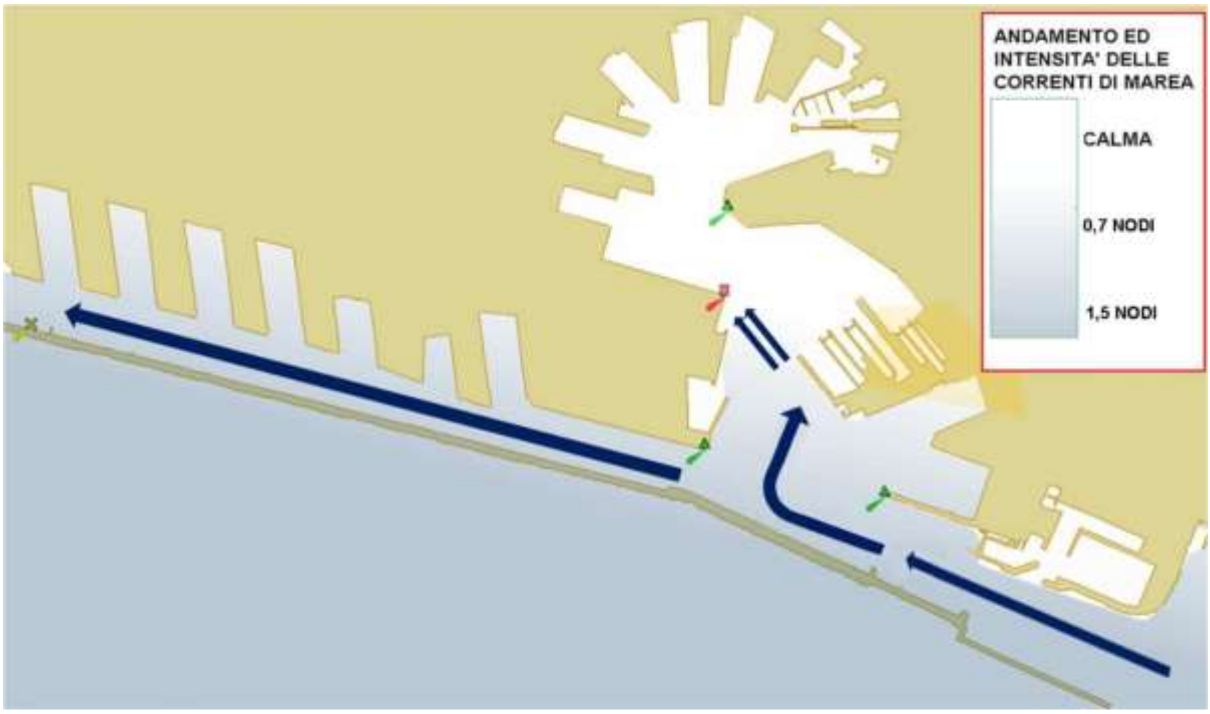


Figure 10- Hydrodynamic conditions applied in the Genoa port simulations

Three types of ships will be used during validation, as described in *figure 11 to 15*:

CAT A - CONTAINER SHIP_ 15 (270m x 43m x 11,5m)

The first transit vessel model used for the simulation (LOA:270 B:43m), is the CONTAINER_SHIP 15, which is used with the following configuration:

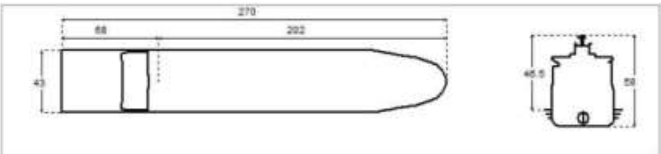
Partial Load 1: Drafts 11.50m even keel;

PILOT CARD

Ship name	Container ship 15 IMAT 270m 3.0.1.0 *			Date	10.06.2022
IMO Number	9312779	Call Sign	3ECF9	Year built	2006
Load Condition	Part load				
Displacement	70620.55 tons		Draft forward	11.5 m / 37 ft 9 in	
Deadweight	35590.03 tons		Draft forward extreme	11.5 m / 37 ft 9 in	
Capacity			Draft after	11.5 m / 37 ft 9 in	
Air draft	46.5 m / 152 ft 11 in		Draft after extreme	11.5 m / 37 ft 9 in	

Ship's Particulars

Length overall	270 m	Type of bow	Bulbous
Breadth	43 m	Type of stern	Transom
Anchor(s) (No./types)	2 (PortBow / StbdBow)		
No. of shackles	14 / 14		(1 shackle =27.5 m / 15 fathoms)
Max. rate of heaving, m/min	9.48 / 9.48		



Steering characteristics

Steering device(s) (type/No.)	Semisuspended / 1	Number of bow thrusters	1
Maximum angle	35	Power	2000 kW
Rudder angle for neutral effect	0.49 degrees	Number of stern thrusters	N/A
Hard over to over(2 pumps)	14 seconds	Power	N/A
Flanking Rudder(s)	0	Auxiliary Steering Device(s)	N/A

Stopping			Turning circle	
Description	Full Time	Head reach	Ordered Engine: 100%, Ordered rudder: 35 degrees	
FAH to FAS	448.6 s	11.52 cbls	Advance	4.87 cbls
HAH to HAS	489.6 s	8.15 cbls	Transfer	2.53 cbls
SAH to SAS	588.6 s	7.77 cbls	Tactical diameter	5.93 cbls

Main Engine(s)

Type of Main Engine	Low speed diesel	Number of propellers	1
Number of Main Engine(s)	1	Propeller rotation	Right
Maximum power per shaft	1 x 69600 kW	Propeller type	FPP
Astern power	23.06 % ahead	Min. RPM	25
Time limit astern	N/A	Emergency FAH to FAS	108.2 seconds

Engine Telegraph Table

Engine Order	Speed, knots	Engine power, kW	RPM	Pitch ratio
"FSAH"	27.5	63512	104	1.02
"FAH"	17.2	16330	65	1.02
"HAH"	12.7	6957	48	1.02
"SAH"	10.6	4213	40	1.02
"DSAH"	7.1	1490	27	1.02
"DSAS"	-4.9	1443	-27	1.02
"SAS"	-7.2	4057	-40	1.02
"HAS"	-8.6	6689	-48	1.02
"FAS"	-11.7	15665	-65	1.02

Figure 11- Pilot Card Partial Load: L 270m x B 43m – Drafts 11.5m even keel

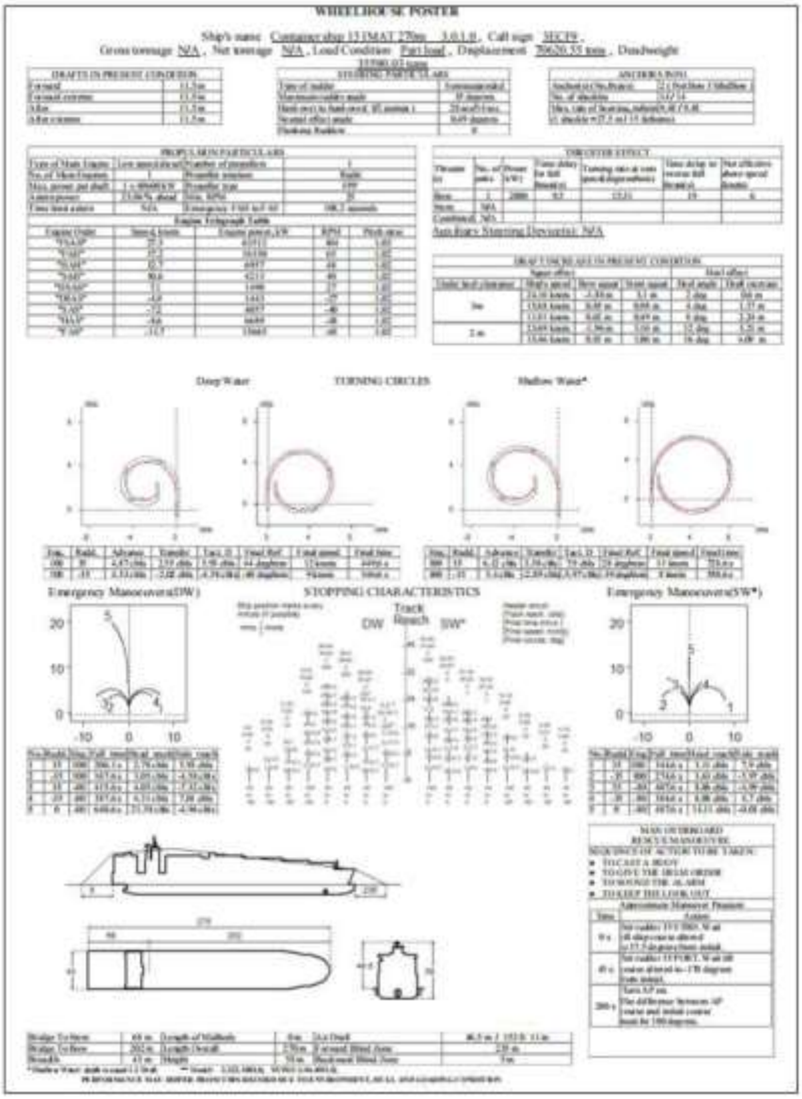


Figure 12- Wheelhouse Poster Partial Load: L 270m x B 43m - Drafts 11.50m even keel

CAT B - CONTAINER SHIP_ 15 (304m x 40m x 12,50m)

The ship model moored at the Bettolo terminal quay used for the simulation (LOA:304 B:40m), is the CONTAINER SHIP_15 Pl, which is used in only one configuration:

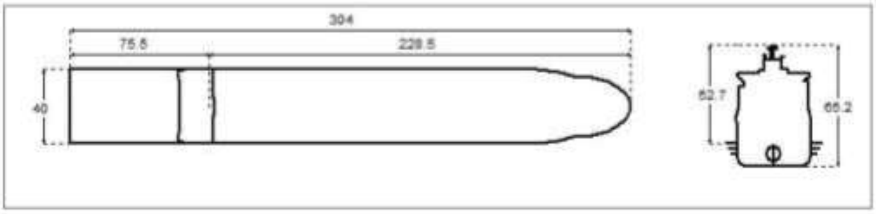
Condition Load 1: Drafts 12.50m evenkeel;

Windage area: 8466 m²

Figure 13- CAT B - CONTAINER SHIP_ 15

PILOT CARD					
Ship name	Container ship 15 (6500 TEU) 3.0.1.0 *			Date	30.06.2020
IMO Number	9312779	Call Sign	3ECF9	Year built	2006
Load Condition	Part load 2				
Displacement	90223.99 tons		Draft forward	12.5 m / 41 ft 1 in	
Deadweight	80855 tons		Draft forward extreme	12.5 m / 41 ft 1 in	
Capacity			Draft after	12.5 m / 41 ft 1 in	
Air draft	52.71 m / 173 ft 4 in		Draft after extreme	12.5 m / 41 ft 1 in	

Ship's Particulars			
Length overall	304 m	Type of bow	Bulbous
Breadth	40 m	Type of stern	Transom
Anchor(s) (No./types)	2 (PortBow / StbdBow)		
No. of shackles	14 / 14		(1 shackle ~27.5 m / 15 fathoms)
Max. rate of heaving, m/min	9.48 / 9.48		



Steering characteristics			
Steering device(s) (type/No.)	Semisuspended / 1	Number of bow thrusters	1
Maximum angle	35	Power	2000 kW
Rudder angle for neutral effect	0.52 degrees	Number of stern thrusters	N/A
Hard over to over(2 pumps)	14 seconds	Power	N/A
Flanking Rudder(s)	0	Auxiliary Steering Device(s)	N/A

Stopping			Turning circle	
Description	Full Time	Head reach	Ordered Engine: 100%, Ordered rudder: 35 degrees	
FAH to FAS	511.6 s	11.93 cbls	Advance	5.57 cbls
HAH to HAS	591.6 s	9.14 cbls	Transfer	2.98 cbls
SAH to SAS	717.6 s	8.84 cbls	Tactical diameter	6.87 cbls

Main Engine(s)			
Type of Main Engine	Low speed diesel	Number of propellers	1
Number of Main Engine(s)	1	Propeller rotation	Right
Maximum power per shaft	1 x 69600 kW	Propeller type	FPP
Astern power	23.06 % ahead	Min. RPM	25
Time limit astern	N/A	Emergency FAH to FAS	90.6 seconds

Engine Telegraph Table

Engine Order	Speed, knots	Engine power, kW	RPM	Pitch ratio
"FSAH"	26.2	63942	104	1.02
"FAH"	16.4	16430	65	1.02
"HAH"	12.1	6996	48	1.02
"SAH"	10.1	4240	40	1.02
"DSAH"	6.8	1499	27	1.02
"DSAS"	-4.7	1448	-27	1.02
"SAS"	-6.9	4075	-40	1.02
"HAS"	-8.3	6711	-48	1.02
"FAS"	-11.2	15722	-65	1.02

Figure 14- Pilot Card Full Load: CONTAINER SHIP 15 Pl - L 304m x B 40m - Drafts: 12,5m evenkeel

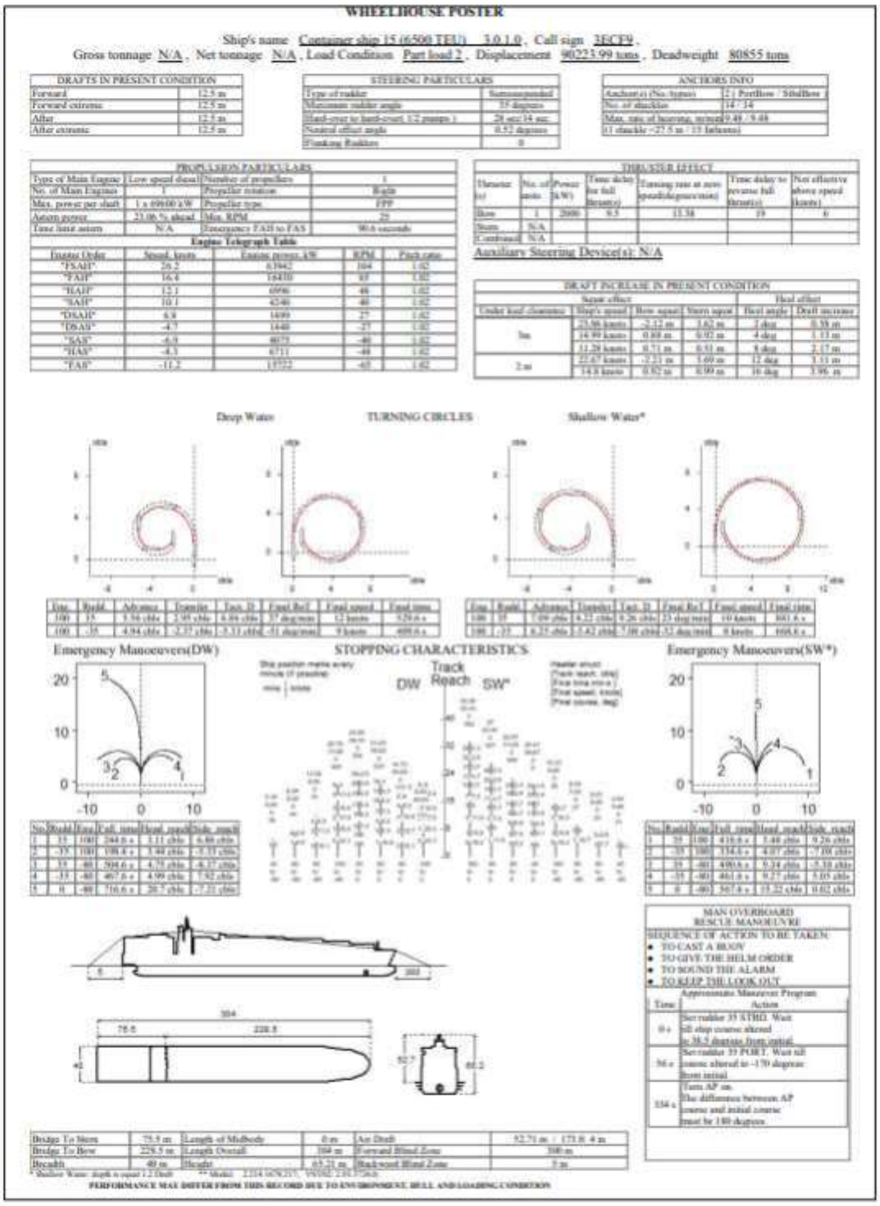


Figure 15- Wheelhouse Poster Full Load: CONTAINER SHIP 15Pl - L 304m x B 40m - Drafts: 12,5m evenkeel

3.2.2.2. Platform Configuration

IMAT can boast within its facility the presence of one of the largest SIMULATION COMPLEX in the world consisting of:

- 4 bridge simulators (360° external view): CHALLENGER, EXPLORER, POLARIS and TUGBOAT;
- 2 engine room simulators: ATLANTIS and NEPTUNE;
- 21 Mini Bridge Simulators (Pseudo-ships);
- 258 Workstations (ECDIS, RADAR, GMDSS, HV, ECR, engine workshop etc.).

The different simulators allow to consider all the most important scenarios in the world with different types of ships and engines.

Simulation complex (*Figure 16*) means that all simulators cited above are connected in the same intranet in order to offer all of them in the same scenario. In that way it is possible reproduce the real aspects in a simulation environment. All professional roles (Master, deck officers, engineer officers, Tugboat master, pilot) in simulation environment can provide their duties like they do on board. In the end also the Pseudo-ships are used in the simulation environment in order to reproduce a real environment with the interaction with other ships.

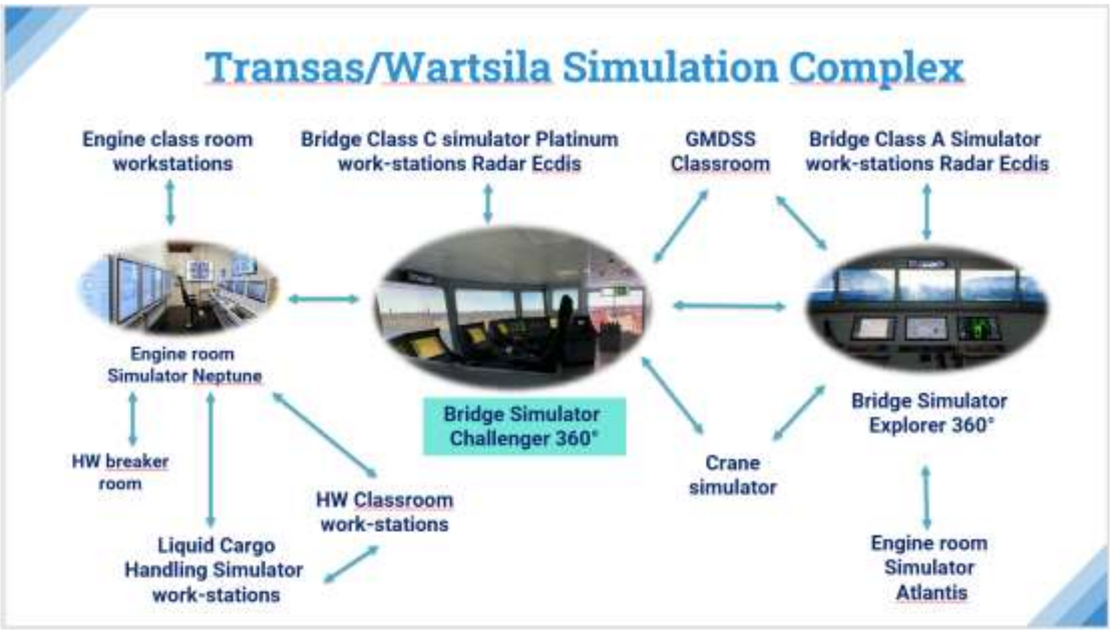


Figure 16- Transas/Wartsila Simulation Complex

WARTSILA CHALLENGER is a simulator with 360° external vision, recently installed. This simulator is the first and only one of its kind in the world. As a real command bridge we find all the necessary navigation aids and provided by the current rules, but not only. In fact IMAT has asked Wartsila for specific developments in order to reproduce all the aspects present on the command bridge (including the bridge flaps) in order to conduct a real Real Time simulation.

The CHALLENGER simulator (*Figure 17 and 18*) can be used for all the courses described in the following paragraphs, moreover thanks to its exclusive functionalities and innovations it can also be used for the following aspects:

- OFFSHORE SIMULATION
- DYNAMIC POSITION
- ANCHOR HANDLING
- OIL SPILL RESPONSE

All this makes it as complex as unique in the world. The CHALLENGER simulator, thanks to its unique structure, gives the possibility to take over the steering of the ship even from the flaps and to have a customized view for this kind of experience.

Figure 17- CHALLENGER Real Time Simulators (1)

Figure 18- CHALLENGER Real Time Simulators (2)

Outdoor areas

IMAT has different external areas of support to the main structure in order to carry out the practical operations of the different courses in particular:

- two large fire fields, classified Green Flag, with the reproduction of OFA section ship distributed on three levels. These structures allow the realization of the courses of Fire Fighting and Fire Fighting High Risk (*Figure 19 and 20*);
- two floating platforms dedicated to the PSCRB courses and FRB, built on a private lake of about 150000 sqm;
- two swimming pools with a surface of about 250 square meters, with a depth not inferior to 3,50 meters in correspondence of the vertical to the fixed platform for diving. This platform is positioned at a height of 3 meters on the water surface, and is built and certified according to safety standards in force. These structures allow the realization of courses including Survival and Rescue and MES "Marine Evacuation System".

Figure 19- Firefighting field (1)

Figure 20- Firefighting field (2)

As illustrated in *Figure 21*, a real container will be used during the demonstration phase in order to test and validate the objectives described in the following paragraph under realistic operational conditions.

Figure 21- Real container used for the demonstration and testing activities

Portable Data Gateway

The Portable Data Gateway (*Figure 22*) is a portable case equipped with all the components required to reproduce a fully functional support network, mirroring the architecture that would be deployed aboard a vessel.

The system collects data from sensors, decodes the binary payloads transmitted by the devices, and forwards the resulting information to the Overheat cloud platform for further processing.

The case is essential for demonstration activities, as real-world environments often make it impractical to install and configure the complete support infrastructure.

To ensure operational fidelity, the kit includes a dedicated computer, an LTE modem for mobile connectivity, a LoRa router for sensor communication, a compact weather station, a local display, an optional external display for presenting the graphical interface, and standard input peripherals such as keyboard and mouse.

This integrated setup enables realistic testing, controlled simulations, and reliable validation of system behaviour across all relevant scenarios.

Figure 22- Portable data gateway

Container sensors

The sensor (*Figure 23 and Table 2*) unit designed for container deployment integrates a network of BME688-based electronic noses capable of detecting and characterising air quality variations associated with early fire signatures. An onboard microcontroller manages data acquisition, performs preprocessing, and encodes the sensor readings before transmitting them via LoRa to the support infrastructure. The device also incorporates a BLE module that enables short-range communication for configuration, diagnostics, and local testing during field operations. Each unit is battery-powered and engineered to operate autonomously for approximately six to eight hours, ensuring reliable functionality throughout demonstration activities and time-constrained operational scenarios.

Figure 23- Sensor unit for early fire detection inside containers

Technologies	Description	Responsible	Reference document
IoT Edge AI sensors	Sensors equipped with BME688 modules analyse air composition to detect volatile compounds associated with early fire development. Using trained gas-analysis models, they recognise characteristic odour patterns, differentiate them from normal environmental conditions, and promptly report anomalies to the monitoring system, enabling rapid identification of potential fire events.	Peopletrust	D4.4

Table 2- IoT Edge AI sensors description

Simulation Bridge workstation

The bridge workstation consists of a dedicated PC and software placed on the simulator's control deck, equipped with a display used to visualise the operational dashboard.

This interface provides real-time status information from all deployed sensors, presenting environmental measurements, communication activity, and device health in a consolidated view.

When an alarm condition is detected, the dashboard automatically presents a highlighted popup in red, clearly indicating the affected sensor, the data that triggered the alert, and all available contextual details concerning the sensor's position and identification.

This workstation serves as the primary monitoring point during demonstration scenarios, enabling operators to observe system behaviour, validate alarm handling procedures, and assess the responsiveness of the integrated detection network.

Drones and thermal camera

The drone-based monitoring solution implemented in the Italian use case relies on a set of complementary technologies enabling autonomous operation, thermal surveillance, and data integration. As illustrated in (*Figures 24 and 25*) and summarised in (*Table 3)*, this solution combines an autonomous drone equipped with thermal and visual sensors, a dedicated recharging station ensuring continuous availability, mission planning software for autonomous flight management, and AI algorithms for thermal anomaly detection. Together, these components support end-to-end drone operations, from mission execution to data analysis and integration with the OVERHEAT digital ecosystem, providing an effective tool for fire detection and situational awareness in port environments.

Figure 24- Recharging station of autonomous drone

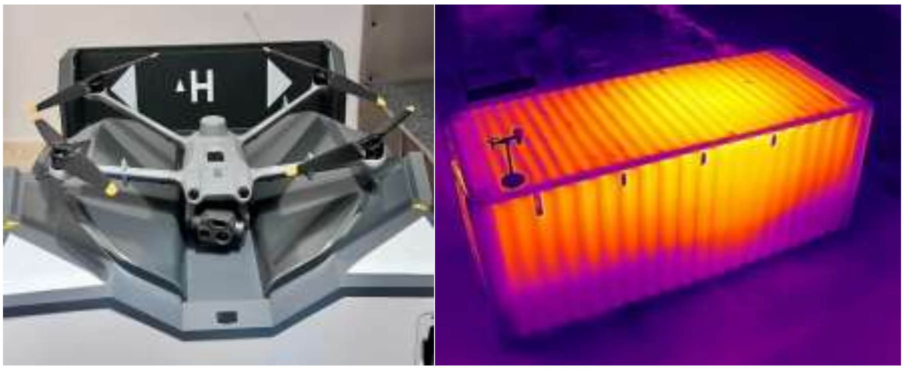


Figure 25- Drone and its thermal vision

Technologies	Description	Responsible	Reference document
Autonomous drone	Equipped with wide-angle, telephoto, and thermal cameras for fire detection and situational awareness. Features RTK positioning and IP54 protection for maritime conditions.	TopView	D4.1
Recharging station of autonomous drone	Automated recharging station with IP55 protection, quick-charging module, and environmental sensors (wind, rainfall, temperature, humidity). Vessel version includes a tilting mechanism for dynamic stabilization and Starlink connectivity.	TopView	D4.1
Mission Planning Software	Cloud-based platform for autonomous flight route planning, real-time monitoring, and integration with IoT alerts. Includes API for interoperability with the OVERHEAT Control Room.	TopView	D4.2
AI Algorithm for Thermal Anomaly Detection	Processes thermal and visual data to confirm fire presence based on predefined thresholds and container recognition.	TopView	D4.2

Table 3- Description of the technologies used in the Italian use case

3.2.2.3. Reference & Solution Scenarios

Baseline Scenario represent current procedures without the use of new technology. Instead, Solution scenario represent new procedures supported by new technology.

The comparison of these two scenarios ensure to study the improvements or worsenings due to the new technology.

The Solution Scenario will be repeated taking into account several variables that are described in *Table 4*.

In order to test the new concept is not required to consider other traffic in the simulation environment. So IMAT simulator will be used standalone. Of course if there were to be the necessary other traffic can be introduced in the RTS.

A set of 14 validation scenarios have been defined in order to address several validation objectives identified for this RTS. These scenarios are built on 3 Independent Variables. Due to exercise duration constraints, it was not possible to cover all possible combinations. Particularly, the simulation runs will be focus on the scenarios related to Ship categories A and B (porta container with different dimension described in the previous chapter). The below summarizes the Operational Scenarios that will be used during RTS.

	New Technology		Ship CAT		Vis. Cond.		Wind Cond.		Status		Scenarios' Type
	Si	No	A	B	VC1	VC2	WC1	WC2	Harbour	On-route	
SCN-OVERHEAT-VALP-001		X	X		X		X		X		Baseline AH (VC1;WC1)
SCN-OVERHEAT-VALP-002	X		X		X		X		X		Solution AH (VC1;WC1)
SCN-OVERHEAT-VALP-003	X		X		X			X	X		Solution AH (VC1;WC2)
SCN-OVERHEAT-VALP-004		X	X			X	X		X		Baseline AH (VC2;WC1)
SCN-OVERHEAT-VALP-005	X		X			X	X		X		Solution AH (VC2;WC1)
SCN-OVERHEAT-VALP-006	X		X			X		X	X		Solution AH (VC2;WC2)
SCN-OVERHEAT-VALP-007		X	X		X		X			X	Baseline AE (VC1;WC1)
SCN-OVERHEAT-VALP-008	X		X		X		X			X	Solution AE (VC1;WC1)
SCN-OVERHEAT-VALP-009	X		X		X			X		X	Solution AE (VC1;WC2)
SCN-OVERHEAT-VALP-0010		X	X			X	X			X	Baseline AE (VC2;WC1)
SCN-OVERHEAT-VALP-0011	X		X			X	X			X	Solution AE (VC2;WC1)
SCN-OVERHEAT-VALP-0012	X		X			X		X		X	Solution AE (VC2;WC2)
SCN-OVERHEAT-VALP-0013	X			X	X		X		X		Solution AH (VC1;WC1)
SCN-OVERHEAT-VALP-0014	X			X	X		X			X	Solution AE (VC1;WC1)
SCN-OVERHEAT-VALP-0015											Spare

Table 4- Validation Scenarios

Following the detailed information about variables reported in the table:

Ship CAT:

- CAT A – CONTAINER SHIP_ 15 (270m x 43m x 11,5m);
- CAT B – CONTAINER SHIP_ 15 (304m x 40m x 12,50m).

Vis. Cond:

- VC1 – Normal Visibility;
- VC2 – Low Visibility.

Wind Cond:

- WC1 – No Wind;
- WC2 – Moderate wind.

Status

- Harbour;
- On-route.

3.2.2.4. Validation Run

Number of run depends on the number of scenario to develop, type of scenario (Training, baseline or solution) and mainly on the number of the involved master. In a real environment in deck area are presents around 5 or 6 officer in rotation. During some period is present only one in the deck in order to perform watchkeeping. So consequently, we have chosen to consider two officers in the simulation in order to perform old and new tasks.

Two masters are involved in the simulation, their belong to IMAT company. So, training / familiarization with simulator is not required. *Table 5* shows type of scenario and Masters position rotation scheme to be respected during the exercise. The rotation is required in order to collect feedback from the different involved Masters in each proposed organisation. Here below the table shown different colours that mean the several scenarios that will be developed during the validation.

run ID	Master Position		Scenario	Measured /Training	Type
	Master	Official			
TS_01	Mr Orange	Mr Blue	SCN-OVERHEAT-VALP-001	Measured	Baseline AH (VC1;WC1)
TS_02	Mr Orange	Mr Blue	SCN-OVERHEAT-VALP-002	Measured	Solution AH (VC1;WC1)
TS_03	Mr Orange	Mr Blue	SCN-OVERHEAT-VALP-003	Measured	Solution AH (VC1;WC2)
TS_04	Mr Orange	Mr Blue	SCN-OVERHEAT-VALP-004	Measured	Baseline AH (VC2;WC1)
TS_05	Mr Orange	Mr Blue	SCN-OVERHEAT-VALP-005	Measured	Solution AH (VC2;WC1)
TS_06	Mr Orange	Mr Blue	SCN-OVERHEAT-VALP-006	Measured	Solution AH (VC2;WC2)
TS_07	Mr Blue	Mr Orange	SCN-OVERHEAT-VALP-007	Measured	Baseline AE (VC1;WC1)

TS_08	Mr Blue	Mr Orange	SCN-OVERHEAT-VALP-008	Measured	Solution AE (VC1;WC1)
TS_09	Mr Blue	Mr Orange	SCN-OVERHEAT-VALP-009	Measured	Solution AE (VC1;WC2)
TS_10	Mr Blue	Mr Orange	SCN-OVERHEAT-VALP-0010	Measured	Baseline AE (VC2;WC1)
TS_11	Mr Blue	Mr Orange	SCN-OVERHEAT-VALP-0011	Measured	Solution AE (VC2;WC1)
TS_12	Mr Blue	Mr Orange	SCN-OVERHEAT-VALP-0012	Measured	Solution AE (VC2;WC2)
TS_13	Mr Orange	Mr Blue	SCN-OVERHEAT-VALP-0013	Measured	Solution AH (VC1;WC1)
TS_14	Mr Blue	Mr Orange	SCN-OVERHEAT-VALP-0014	Measured	Solution AE (VC1;WC1)
TS_15	Mr Orange	Mr Blue	Spare	Measured	Spare

Table 5- Run Organisation

The organisation could be considered wholly or partially based on the number of masters available for the simulation and exercise duration.

3.2.3. Validation approach

3.2.3.1. Validation objectives, indicators and metrics

Cargo fires are one of the most important threats for the ship. Currently, there are no requirements for the installation of fixed fire detection systems above the weather deck of a container ship. The ship's fire safety above the weather deck relies primarily on visual detection by the crew and is therefore dependent on the overview/visibility of the containerised cargo from the bridge, weather conditions, location of the container in question (i.e. line of sight to the affected container), general crew rounds, container inspections during voyage and series of other environmental (solar heat, steam, machinery, etc…) and managerial factors that extremely reduce the situation awareness of the crew.

The OVERHEAT project aims at developing digital solutions in order to prevent accidents, at assessing and mitigating the risks of hazards through a predictive approach and developing an assessment framework to identify, describe and structure a global safety culture which will be replicated in other regions of OVERHEAT. The solution developed by OVERHEAT, thanks to fire prevention and the decrease of container loss, aims at reducing the negative impact on coastal zones, marine protected area and harm to marine mammals.

Consequently, the objectives listed in *Table 6* will be assessed within the Italian use case through RTS activities and demonstration exercises.

RTS Objectives:

1. To assess the acceptability of the OVERHEAT solution under different scenarios;
2. To assess the feasibility of the Digital Solution as an integrated system.
3. To assess of the use of the IoT sensors and UAS for monitoring the containers and to provide early fire detection;
4. To assess the safety in baseline and solution scenarios
5. The assess that the fire detection information are correctly shown by the Digital Solution to the bridge team;
6. The use of the UAS will be for monitoring the fire and humans in danger in order to provide a good situational awareness to the rescue/fire teams (Fire Monitoring);
7. To measure bridge team Workload and Situational Awareness about the fire incident;

Demonstration Objectives:

1. To assess the acceptability of the OVERHEAT solution under demonstration environment.
2. To assess the feasibility of the Digital Solution as an integrated system;
3. To assess of the use of the IoT sensors and UAS for monitoring the containers and to provide early fire detection;
4. To evaluate the safety of the involved actors in the exercise.
5. To evaluate the management and response to the fire incident.

6. The assess that the fire detection information are correctly shown by the Digital Solution to the bridge team;
7. Test the IoT sensors and UAS themselves
8. To measure the time in which the fire is detected by the IoT sensors

Low level Objectives ID	Low level Objectives description	KPA	Success Criteria	Data Collection Methods	VAL
OBJ-RTS-OVERHEAT-VALP-001	To assess the acceptability of the OVERHEAT solution under different scenarios;	Safety, Human Performance, Acceptability	Positive feedback from the involved actors	Questionnaires Debriefings Observation Data recordings	RTS + DEMO
OBJ-DEM-OVERHEAT-VALP-002	To assess the feasibility of the Digital Solution as an integrated system	Safety, Human Performance	Positive feedback from the involved actors The information are correctly shown on the interface	Questionnaires Debriefings Observation	RTS + DEMO
OBJ-DEM-OVERHEAT-VALP-003	To assess of the use of the IoT sensors and UAS for monitoring the containers and to provide early fire detection;	Safety, Human Performance	The systems provide correct data and on time	Debriefings Observation Data recordings	RTS + DEMO
OBJ-DEM-OVERHEAT-VALP-004	To assess the safety in baseline and solution scenarios	Safety, Human Performance	The safety is increased with respect to the baseline scenario	Questionnaires Debriefings Observation	RTS + DEMO
OBJ-DEM-OVERHEAT-VALP-005	The assess that the fire detection information are correctly shown by the Digital Solution to the bridge team;	Safety, Human Performance, Acceptability	Positive feedback from the involved actors The information are correctly shown on the interface	Questionnaires Debriefings Observation	RTS + DEMO
OBJ-DEM-OVERHEAT-VALP-006	To measure bridge team Workload about the fire	Safety, Human Performance,	Positive feedback from the involved actors	Questionnaires Debriefings Observation	RTS + DEMO

	incident comparing with baseline scenario;				
OBJ-DEM-OVERHEAT-VALP-007	To measure bridge team Situational Awareness about the fire incident comparing with baseline scenario;	Safety, Human Performance,	Positive feedback from the involved actors	Questionnaires Debriefings Observation	RTS + DEMO
OBJ-DEM-OVERHEAT-VALP-008	The use of the UAS will be for monitoring the fire and humans in danger in order to provide a good situational awareness to the rescue/fire teams (Fire Monitoring);	Safety, Human Performance	Positive feedback from the involved actors	Debriefings Observation Data recordings	RTS + DEMO
OBJ-DEM-OVERHEAT-VALP-009	To evaluate the management and response to the fire incident	Safety, Human Performance	Positive feedback from the involved actors	Debriefings Observation Questionnaires	DEMO
OBJ-DEM-OVERHEAT-VALP-010	Test the IoT sensors and UAS themselves	Safety, Human Performance	Positive feedback from the involved actors	Debriefings Observation Questionnaires	DEMO
OBJ-DEM-OVERHEAT-VALP-011	To measure the time in which the fire is detected by the IoT sensors	Safety, Human Performance	Positive feedback from the involved actors	Debriefings Observation Questionnaires	DEMO

Table 6- Validation objectives, indicators and data collection methods

3.2.3.2. Actors involved and roles

The preparation of the Validations exercise (RTS and Demonstration) requires the involvement and the cooperation of different actors with specific skills, roles, responsibilities and tasks. The key actors of the team form the Validation Exercise Management Group (VEMG).

Table 7 summarises the activities carried out by the VEMG members during the preparation phase, as well as their respective roles in these preparatory activities.

ACTOR	ROLE
Exercise Manager	• Manages the preparation process in order to ensure the execution of the exercise in line with objectives and timeline.
Exercise Technical Coordinator	• Manage RTS and Demonstration according to project requirements and schedule; • Organises regular Technical and Operational Tests, according to the project schedule.
Exercise Operational Leader (OPL)	• Supports the definition of the operational scenario applied. • Contributes to the definition of Masters working methods and operational procedures. • Supports the definition and evaluation of the traffic samples. • Coordinates the Master availability during tests and exercise. • Manages the training preparation.
Scenario Preparator	• Prepares the operational scenarios for the exercise. • Prepares the traffic samples for tests, training and exercise. • Implements non nominal events in the traffic samples if needed.
Human Factors Analyst	• Contributes to define the exercise's organisation. • Contributes to selects the data collection methods applied. • Prepares data collection tools (observation grids, scripts for debriefings, questionnaires). • Contributes to define the recording specifications. • Defines non nominal events to be introduced in the traffic samples, if needed.

	• Defines experimental design and agenda of the exercise. • Defines the Masters seating plan according to the experimental design.
Safety Analyst	• Contributes to selects the data collection methods applied. • Prepares data collection materials (observation grids, scripts for debriefings, questionnaires). • Contributes to define the recording specifications. • Contributes to define experimental design and agenda of the exercise. • Defines non nominal events to be introduced in the traffic samples, if needed.
Other Analyst	• The other analyst will be decided based on the exercises and analyses needs.

Table 7- Actors involved and roles

3.2.3.3. Entrance criteria

The following needs to be completed prior to commencement of the exercise:

- Integrated platform accepted;
- Platform configuration done and scenarios available for execution;
- Operational staff available for the execution of the scenarios;
- Technical exercise staff available for the arrangements to be done for each activity;
- Exercise training and briefings performed;
- Data collection instruments ready: questionnaires and recording systems.

3.2.3.4. Exit Criteria

The following criteria should be met to close the validation exercise execution and to consider it as successful:

- Completion of at least the 90% of the exercise scenarios;
- Availability of the data recorded for analysis;
- Availability of the questionnaires and feedback information from the Masters;
- 90% of the objectives have to be validated.

3.2.4. Exercises Planning and management

3.2.4.1. Validation schedule

Table 8 presents the planned timeline of validation activities, detailing the scheduling of each task from the preparation phase through execution, analysis and reporting across the 2025–2026 period.

Activity	2025				2026										
	September	October	November	December	January	February	March	April	May	June	July	August	September	October	November
Validation Plan Preparation															
Scenario Preparation															
Platform Testing															
Platform Update															
Training															
Validation Execution															
Analysis and Reporting															

Table 8- Validation schedule

Real Time Simulation schedule:

- 09/02/2026 – 11/02/2026 (Start test for both Italian and Polish validation - 3 days)
- 23/02/2026 – 25/02/2025 (Final test for both Italian and Polish validation - 3 days)
- 02/03/2026 – 04/03/2025 (Italian Simulation 2,5 days)
- 04/03/2026 – 06/03/2025 (Polish Simulation 2,5 days)

Demonstration Schedule:

- 20/04/2026 – 24/04/2026 (Demonstration on firefighting field).

3.2.4.2. Preparatory activities

Preparation steps for the Validation exercises (RTS and Demonstration) are:

- Selection of tools and associated objects relevant for the OVERHEAT;
- updating of the platform;
- official prototype testing by experts;
- official prototype testing/approval by Masters;
- preparation of data gathering tools, questionnaires, structured interviews and other appropriate survey tools;
- preparation of presentation and training materials;
- selection/invitation of Masters to be involved as experimental subjects;
- preparation of the site and room hosting the exercise.

3.2.4.3. Execution activities

Execution activities for the Validation exercises (RTS and Demonstration) are:

- Training activity,
- Runs execution (with related observational activities),
- Post run data collection, according techniques to be defined (post-run debriefing, questionnaires),
- Post exercise data collection, according techniques to be defined (post-exercise debriefing, questionnaires, focus groups).

3.2.4.4. Post execution activities

Post-execution activities for the Validation exercises (RTS and Demonstration) are:

- Sorting and cataloguing information from recorded materials (videos/audios, data log, questionnaires, etc);
- Analysis of recorded materials (videos/audios, data log, questionnaires, etc) for first evidences comprehension;
- Comparison of data gathered from different techniques or sources (first evidence refinement);
- Elaboration of final results of the exercise for each validation objective;

The results will be then integrated into the Exercise Report.

3.2.4.5. Human Resources

To perform this validation exercise, several skills are required from the participants:

- Good knowledge of OVERHEAT concept;
- Comprehensive understanding of the maritime Network (actors, standard operational procedures, etc.);
- Good knowledge of the harbour and on-route operational context and of its relationship with the other operational contexts (supply chain);
- Broad experience in operational concept analysis;
- Good validation expertise (methodologies, techniques and associated tools, practitioners). Specifically, knowledge of the validation techniques.
- Broad experience in data analysis;

3.2.4.6. Training

These validation exercises (RTS and Demonstration) will be carried out by exercise and validation expert with background in the use of the different validation platforms, as well as operational staff with knowledge of the maritime and firefighting environment. However, since the validation exercise will need the development of new technology some effort will be allocated in training activities.

Besides, since the operational staff could not be familiarised with the validation technique, additional training sessions will be defined for increasing the knowhow of the validation technique itself. Training activities will be carried out during Test as well as the first Validation day if needed.

In particular, the following training sessions will be conducted:

- Introduction: Present the exercise;
- Theoretical training on new system functionality;
- Theoretical training on exercise scenarios;
- Practical instruction on validation;
- Practical training on exercise scenarios and new technology. This part of training activities is based on several simulation runs execution.

3.2.4.7. Risks

The identified risks are:

- Platform not available.
- No availability of Masters/Officers for the execution of the validation exercises;
- Masters not achieving the expertise required for the execution of the validation exercises.
- Mitigation actions:
- Schedule the exercise outside the summer period where human resources availability is more limited.

- Promote in the exercise the use of Masters with background in the scenario and in exercise processes.
- Schedule the exercise well in advance.

3.2.4.8. Errors and Observation handling

During the execution of the validation exercises, some technical problems could lead to the cancellation of some runs. Backup sessions such as the "spare" scenario have been planned to be able to re-run the affected validation scenarios if necessary.

3.2.5. Analysis Specification

3.2.5.1. Data collection methods

Quantitative and qualitative data collection techniques will be used to assess the exercise objectives for both the simulation and demonstration activities, as detailed in *Table 9*.

Data Collection Methods	Qualitative / Quantitative	Objective / Subjective
Over the shoulder Observations	Qualitative	Subjective
Questionnaires	Quantitative	Subjective
Debriefings	Qualitative	Subjective
System data Collection	Quantitative	Objective

Table 9- Data collection methods

Involved actors will also have the opportunity to provide in-depth feedback once the measured runs have concluded. Two types of questionnaires will be used, one to be filled in after each run (Post Run Questionnaire - PRQ), and one to be filled in at the end of the validation activity (Post Simulation Questionnaire – PSQ). Both PRQ and PSQ will include standard tools and ad-hoc OPS-related questions, addressing what the human actors experienced during the runs and general issues and possible suggestions addressing the investigated concept at a more comprehensive level. Observations will be recorded by the validation team and assessment experts during measured runs to capture events or comments made by participants that may be valuable to support other data. Debrief sessions will allow the participants to discuss their opinions and experiences at the close of each day of runs. The output will support the findings of the PRQ and PSQ in the Validation Report.

The core sections of both PRQ and PSQ will consist of industry standard human scales, which will generate numerical data on a range of human aspects. The individual methods to be used in PRQ and PSQ for each metric are listed in the T*able 10*:

Metrics/Indicators	Direct Collection Feedback	Type of Measurement
Workload	Post Run Questionnaires (PRQ) Post Simulation Questionnaire (PSQ) Debriefing	Bedford scale Thoughts and Feelings from involved actors (Focus Group, Interviews) Thoughts and Feelings from validation team and assessment Experts (Over the shoulder observations)
Situational Awareness	Post Run Questionnaires (PRQ) Post Simulation Questionnaire (PSQ) Debriefing	Thoughts and Feelings from involved actors (Focus Group, Interviews) Thoughts and Feelings from validation team and assessment Experts (Over the shoulder observations) Expert opinion (debriefing, interview, questionnaire items)
Safety	Post Run Questionnaires (PRQ) Post Simulation Questionnaire (PSQ) Debriefing	Thoughts and Feelings from validation team and assessment Experts (Over the shoulder observations) Expert opinion (debriefing, interview, questionnaire items)
Acceptability	Post Simulation Questionnaire (PSQ) Debriefing	Controllers Acceptance Rating Scale (CARS) Thoughts and Feelings from validation team and assessment Experts (Over the shoulder observations) Expert opinion (debriefing, interview, questionnaire items)

Trust and confidence	Post Simulation Questionnaire (PSQ) Debriefing	SHAPE Automation Trust Index (SATI) Thoughts and Feelings from validation team and assessment Experts (Over the shoulder observations) Expert opinion (debriefing, interview, questionnaire items)

Table 10- Human performance metrics and measurement methods used in PRQ and PSQ

The analysis will take into account both objective and subjective information. The subjective information will be processed in order to obtain and estimate of the acceptability of tested solutions. This will supply answers to outstanding Human Factor and safety issues related to the concept.

Regarding the qualitative data collected by observations, questionnaires and debriefings, they will be analysed by using the operational and Human Factors knowledge. Data from questionnaires will be analysed through the answers reflect to ad hoc scales to check the level of agreement / disagreement of the involved actors with the submitted questions. The objective information will be used as supplementary to the subjective information. Quantitative data will be collected by extraction from system log. The measures will be employed to assess the exercise evaluation criteria (validation objectives).

3.2.5.2. Observational Techniques

Observational techniques are based on the idea of understanding the users' behaviour in their social context. Sometimes their work is so standardised and automated that the users are not aware of what they actually do when working. As consequence they are not able to describe in detail the way they accomplish their tasks, so data collected through techniques based on feedback collection (such as interviews and questionnaires) risk to be partial and/or not perfectly reliable. On the contrary direct observation can provide detailed, complete and reliable information on the way the activity is carried out, especially if further commented and discussed with users observed. In some cases, it is also possible to collect users' past experiences and stories, that can be detailed in terms of scenarios thanks to the availability of the same tools really used in the past and to a context that is quite close to the past one.

Direct observation allows a high quantity of data to be gathered, specifically qualitative data that cannot be collected with other methods. The main strength of direct observation is the possibility to capture the difference between the normative way of working and the actual one, highlighting the existence and the relevance of common practices of work, personal strategies, standard deviations from official rules, informal rules, common behaviours neither controllers are aware of, and so on.

3.2.5.3. Questionnaires

The questionnaires that will be submitted to the Masters are:

- Post run Questionnaire, the questionnaire designed to elicit user perception of the feeling to perform the task as well as how certain characteristics of the task contributed to the overall workload and, to assess users' subjective satisfaction with specific aspects;
- Post exercise Questionnaire, the questionnaire to elicit global user perception of usability and acceptability.

3.2.5.4. Debriefings

Debriefings allow, due to the free-form nature of the interaction, to collect unexpected viewpoints may be identified which may be otherwise overlooked if a more structured approach were adopted.

During the debriefing Masters/Officers will be provided with different kinds of information and will be asked to:

- Discuss about the performance of the procedures (accuracy, representation, reliability and so on);
- Reason about their activity performed with the information provided by the new procedure;
- Make a comparison between the activity carried out with or without the support of the new procedure;
- Asked to envision the use of the information provided by the procedure and the effectiveness of the procedure itself.

What is important to notice is that debriefings and over-the-shoulders observations are deeply interconnected techniques. This means that on one hand, data collected though the observations are then verified and discussed during the debriefings, and from the other hand insights emerged during the debriefings are then used to guide the following observations. This combination of techniques is proved to ensure the correctness and the reliability of the results obtained.

3.2.5.5. System Data Collection

Quantitative data will be collected by extraction from exercise platform log.

The measures will be employed to assess the exercise evaluation criteria (validation objectives). In respect with these criteria, the analysis will provide a response about the statistical significance of the observed differences between the baseline and the different organisations as well as between organisations themselves.

3.2.5.6. Data logging requirements

All parameters expected to be logged and that are directly available from IMAT simulator are reported in the below:

- LAT: Latitude
- LON: Longitude
- GS: Ground Speed
- Heading
- Pitch Angle
- Roll Angle
- Ground Elevation
- Time
- W/V Speed
- W/V Direction
- Lateral Error over predicted track
- Vertical Error over predicted track
- Stick Load Factor
- Stick Roll Rate

All parameters can be made available in a .txt or cvs format.

3.3. SPANISH use case

3.3.1. Exercise Scope and Justification

The validation of the Spanish use case focuses on testing the interoperability and operational performance of the OVERHEAT technologies in a real port environment, specifically in the Port of Sagunto. The aim is to evaluate the effectiveness of the integrated system (IoT sensors ans drones) in detecting, monitoring, and managing a fire on a containership berthed at the terminal. The exercise will validate the coordination between different stakeholders (firefighters, Port Authority, Harbour Master, and ship's crew) and the added value of digital tools for situational awareness and decision support.

3.3.2. Validation scenarios

3.3.2.1. Route and Harbour Information

The Spanish demonstration will take place in the Port of Sagunto, at the Intersagunto Container Terminal. The validation area will be located on a restricted section of the quay, separated from commercial operations but maintaining realistic distances and layout of container stacks.

Within this area, two or three sectors will be defined to structure the drone flight route and to ensure safe separation between the test, port operations and observation points for participants.

3.3.2.2. Platform Configuration

Three main technological platforms will be involved in the demonstration.

First, **IoT thermal sensors** provided by PeopleTrust will be installed on each container participating in the test, at minimum on the bottom container where the real fire will be ignited and on the top container where smoke will be simulated. These sensors will monitor the evolution of temperature over time and will generate alarms in case of abnormal thermal behaviour, providing an objective measurement of how early and how reliably a thermal anomaly can be detected.

Second, an **autonomous drone** operated by TopView, equipped with thermal and optical cameras, will carry out inspection flights over the container blocks, following a predefined route across the sectors defined in the test area. The drone will be operated from a dedicated take-off and landing zone within the restricted area, ensuring safe operations while enabling consistent coverage of the incident containers from different angles and heights.

Finally, the **Digital Solution** developed by SeaTopic will not be used in real time on site during the Spanish demo due to the tight schedule. Instead, all relevant data, including sensor logs, drone mission data and imagery, will be recorded locally during the exercise and subsequently exported to the Digital Solution team for offline integration and analysis in the context of WP6 and WP7.

3.3.2.3. Traffic Information

The demonstration will take place in a restricted area of the Intersagunto terminal in the Port of Sagunto, while normal port operations continue nearby. Traffic of trucks and handling equipment around the test zone will be controlled or redirected by the terminal and the Port Authority to ensure safety. The exact level of surrounding traffic and any additional simulated movements are still under discussion and this information is not yet available.

3.3.2.4. Dependent and Independent variables

Independent variables include the position of the incident containers within the stack (bottom container with real fire and top container with simulated smoke), the layout of the container blocks and the prevailing weather conditions (wind, visibility, temperature), as well as the fire load characteristics, which are not yet fully defined.

Dependent variables focus on the performance of the technologies and the response, such as time to detect the anomaly, completeness and duration of the drone mission, reliability of data transmission and qualitative aspects of coordination and situational awareness. Detailed quantitative targets for these variables are not yet available.

3.3.2.5. Reference & Solution Scenarios

In the reference scenario, a container fire on the quay is detected and managed using only existing procedures and resources in the Port of Sagunto, without IoT sensors, drone support or Digital Solution.

In the solution scenario, the same type of incident is addressed with IoT thermal sensors providing early temperature-based alarms and a drone inspecting the container blocks along a predefined route, while data from the Spanish demo are later used for offline integration into the Digital Solution.

3.3.2.6. Validation Run

The validation will consist of a single main run in which several container blocks are set up in a restricted area, IoT sensors are installed on the selected containers, a controlled real fire is ignited in the bottom container and smoke is simulated in the top container, while the drone flies a predefined route over the test area and the Valencia Firefighters intervene on the incident container. During this run, all relevant data from sensors and drone will be recorded locally for subsequent analysis and later provision to the Digital Solution team.

The exact number and duration of drone flights, the final sensor configurations and the detailed fire load are still being defined and are not yet available.

3.3.3. Validation approach

Virtual simulations will precede the real demonstration of the Spanish use case and will focus on validating data flows, mission logic and communication protocols between technologies and actors. The simulation phase will also allow testing the Digital Solution interface under controlled conditions and validating the alert algorithms of IoT sensors and drones. The results of the simulation will serve to fine-tune the configuration of sensors, flight plans and coordination procedures for the real demonstration in the Port of Sagunto, where the Digital Solution will not operate live on site but will later ingest and analyse the data collected during the exercise.

3.3.3.1. Validation objectives, indicators and metrics

Validation objectives :

- Demonstrate early fire detection capability and improved situational awareness during port operations.
- Test the effectiveness of drone aerial support in risk evaluation and operational coordination.
- Assess how the OVERHEAT system can improve coordination and reduce reaction times among port stakeholders compared with current procedures.
- Validate, through simulations and offline analysis of demonstration data, the integration and interoperability of IoT temperature sensors, drone-based inspection and the Digital Solution.

Performance indicators :

Table 11 presents the key performance indicators used to assess the system's operational effectiveness.

Criteria	Expected Metric
Time to detect fire	min
Drone mission duration	min
Data transmission reliability	%
Communication latency	seconds

Table 11- Performance indicators

3.3.3.2. Actors involved and roles

Table 12 outlines the main actors involved in the pilot and their respective roles.

Actor	Role
VALENCIAPORT FOUNDATION	Coordination, liaison with APV and partners, reporting
VALENCIA FIREFIGTHERS	Operational response and safety validation
PORT AUTHORITY OF VALENCIA	Support for emergency coordination within the port area
ISSNOVA	Methodological and evaluation support
TOPVIEW	Drone operation and data management
PEOPLETRUST	IoT sensors installation and data analysis
CIRCOE	Scenario design, performance evaluation
SEATOPIC	Developing DS, receiving and processing recorded data for offline analysis

Table 12- Actors and roles

3.3.3.3. Exercise Tool, Validation Technique

The validation of the Spanish use case will rely on a combination of virtual simulations and one real-life demonstration.

The technologies involved are: IoT Edge AI sensors for temperature monitoring of containers located in the quay area, autonomous drones equipped with thermal and optical cameras for aerial inspection of the container blocks; and the Digital Solution (DS), which will be used in virtual simulations and for offline ingestion and analysis of the data recorded during the demonstration, integrating sensor and drone data with manual inputs to support situational awareness and performance assessment.

3.3.3.4. Entrance criteria

The demonstration will start only if:

- IoT sensors are correctly installed, powered and tested.
- Drone has completed pre-flight checks, the predefined route is uploaded, and the take-off/landing zone is secured.
- The test area is isolated from normal terminal operations, with safety perimeters and access routes agreed with APV and Intersagunto.
- Valencia Firefighters, APV and Intersagunto are present and ready to intervene.
- Weather and visibility conditions are within the limits established by the drone operator and safety authorities.

If any of these conditions is not met, the validation run might be postponed or cancelled.

3.3.3.5. Exit Criteria

Table 13 presents the exit criteria used to assess whether the pilot objectives have been successfully achieved.

EXPECTED RESULT	EVALUATION CRITERIA
Early detection of fire by sensors	min
Successful drone mission and image capture	100% of planed area covered
Reliable recording of sensor and drone data	Percentage of valid data recorded
Effective coordination among stakeholders	Positive feedback from all entities
Validation of system scalability	System operates under port operational conditions

Table 13- Criteria and results

3.3.4. Exercises Planning and management

3.3.4.1. Validation schedule

- **Step 1: Setup & calibration**: Installation of IoT sensors on the selected containers and configuration of the drone system, including safety checks and verification of the predefined flight route.
- **Step 2: Virtual simulation**: Digital validation of data flows, mission logic and communication protocols prior to the real demonstration.
- **Step 3: Fire demonstration**: Controlled ignition of a real fire in the bottom container and simulated smoke in the top container of a stack, conducted in a restricted area of the terminal.
- **Step 4: Post-exercise analysis**: Local data retrieval, performance evaluation and subsequent offline integration into the Digital Solution for analysis within WP6 and WP7.

The exercise will take place in February 2026.

3.3.4.2. Preparatory activities

Working hypotheses :

- The combination of IoT thermal sensors and drone-based inspection enables earlier detection of fire-related thermal anomalies compared to traditional observation methods.
- The use of drones equipped with thermal and optical cameras provides enhanced situational awareness during the evolution of the incident, complementing the operational activities of firefighters.
- IoT sensors installed on the containers allow continuous temperature monitoring and automatic alerting when abnormal heating occurs.
- The Digital Solution (DS) will not operate live during the Spanish demonstration, but will later ingest and analyse the data collected on site. Under full operational conditions, the DS would integrate heterogeneous data (sensors, drone imagery and manual inputs) to provide a shared operational picture for emergency responders.
- The system is expected to improve communication and coordination among port stakeholders by providing earlier information and better situational awareness, although this aspect will be validated through offline analysis rather than real-time use during the Sagunto demo.

3.3.4.3. Execution activities

The Spanish use case will consist of one single demonstration run in the restricted test area of the Intersagunto terminal.

Before ignition, IoT sensors will be installed on the selected containers and the drone system will be configured and tested.

The exercise will start with the controlled ignition of a real fire in the bottom container and the simulation of smoke in the top container.

During the incident, the sensors will monitor temperature development, and the drone will follow its predefined route to capture thermal and optical imagery.

The Valencia Firefighters will intervene following established safety procedures, while all relevant sensor and drone data will be recorded locally for later analysis.

Operational details such as the exact number of drone flights and the duration of the exercise are still to be defined.

3.3.4.4. Post execution activities

Following the demonstration, the recorded data will be retrieved from the sensor units and drone systems for consolidation and technical analysis. The information will be provided to the Digital Solution (DS) development team for offline integration within WP6 and WP7.

A debriefing session will be conducted with all involved actors (FVP, APV, Intersagunto, firefighters, technology partners) to gather operational observations, identify lessons learned and assess the performance of the technologies. These findings will feed into the evaluation activities of WP7 and into the refinement of procedures and system configurations. Additional post-processing or follow-up tests, if required, are still to be defined.

3.3.4.5. Roles & Responsibilities in the exercise

Table 14 summarises the roles and responsibilities of each actor involved in the exercise.

ACTOR	ROLE
VALENCIAPORT FOUNDATION	Coordination of the preparation and execution of the demonstration; liaison with APV, Intersagunto and all participating partners.
VALENCIA FIREFIGTHERS	Operational intervention on the bottom container; implementation of emergency procedures and safety measures
PORT AUTHORITY OF VALENCIA	Establishment of safety perimeters; access control; support to overall coordination during the exercise.
ISSNOVA	Support to methodological evaluation and collection of lessons learned.
TOPVIEW	Drone mission planning, execution and data capture (thermal and optical); operation of take-off and landing area.
PEOPLETRUST	Installation, configuration and monitoring of IoT sensors on the containers; retrieval of recorded sensor data.
CIRCOE	Support to validation design and consolidation of performance evaluation results.
SEATOPIC	Offline processing and analysis of data collected during the demo (sensor logs, drone data).

Table 14- Roles & responsibilities

3.3.4.6. Human Resources

The exercise will involve personnel from FVP, APV, Intersagunto, Valencia Firefighters, TopView, PeopleTrust, SeaTopic, CIRCOE and ISSNOVA. Each organisation will designate the number of participants required for their respective roles.

Expected profiles include firefighters and command officers, drone operators, sensor technicians, safety coordinators, port staff and observers. The exact number of people attending from each partner, both during the preparation phase and on the day of the demonstration, is still to be confirmed.

3.3.4.7. Training

All involved personnel will receive a briefing on the demonstration scenario, safety rules and operational procedures before the exercise starts. Drone operators and sensor technicians will validate their system configurations on site, and firefighters will review access routes and intervention steps.

Additional training requirements, such as familiarisation with the port environment, fire load handling or communication procedures, are currently under discussion and not yet defined.

3.3.4.8. Risks

The main risks associated with the demonstration include unfavourable weather conditions that may prevent drone flights, delays or malfunctions in sensor or drone hardware, safety risks related to the ignition of a real fire in a container and potential interference with port operations.

Mitigation measures include establishing strict safety perimeters, validating equipment prior to the run, coordinating closely with APV and Intersagunto and maintaining alternative plans for the fire load.

3.3.4.9. Errors and Observation handling

Any issues, anomalies or unexpected events occurring during the demonstration will be noted by the organisations involved and discussed in the post-exercise debriefing.

Recorded data from sensors and drones will be reviewed to identify possible irregularities in detection or mission execution. Relevant observations will be shared with the technology partners for their consideration.

3.3.5. Analysis Specification

3.3.5.1. Data collection methods

This information is not available yet.

3.3.5.2. Observational Techniques

This information is not available yet.

3.3.5.3. Questionnaires

This information is not available yet.

3.3.5.4. Debriefings

This information is not available yet.

3.3.5.5. System Data Collection

This information is not available yet.

3.3.5.6. Analysis method

This information is not available yet.

3.4. GERMAN use case

3.4.1. Exercise Scope and Justification

The simulation within the scope of the OVERHEAT WP7.4 task focuses on analysing and comparing the efficiency of decision-making and responses in maritime emergency situations involving vessels in distress.

The scenario is to compare real maritime incidents, considering the actual routes or tow paths taken, with hypothetical alternative routes representing the shortest route to the nearest port of refuge, assuming that granting of refuge would have been mandatory. Furthermore, taking early fire detection within the scope of OVERHEAT into account, the scenario could be changed in a way that the request for support could be sent hours earlier and other Port of Refuge (PoR) might be nearer.

This comparison will help to assess how enforcement of regulations, improved coordination and OVERHEAT results could have reduced the environmental, safety and security impacts in future real-life events.

3.4.2. Validation scenarios

3.4.2.1. General Scenario Description

German Use Case - Port or Place of Refuge (PoR).

Within OVERHEAT Task WP7.4, the simulation aims to examine how decisions are taken and how response measures unfold during maritime emergency situations involving vessels in distress. It compares a real incident, including the routes or towing paths that were actually used, with alternative scenarios based on the shortest possible route to the nearest ports of refuge. These alternatives assume that access to a port of refuge would have been granted in line with EU or IMO regulations In addition, by considering early fire detection as developed within the OVERHEAT project, the simulation also explores how a request for assistance sent earlier could influence response options and allow different ports to be reached at an earlier stage

3.4.2.2. Scenario Variants

As mentioned above, three variants of the same scenario are thought of today:

1. simulate the real incident to prove simulation is feasible
2. simulate with mandatory places of refuge (nearest suitable ones)
3. simulate same incidents with early fire detection

3.4.3. Validation approach

3.4.3.1. Working Hypotheses

Regulatory Framework Assumption

It is presumed that EU Member States are obliged under a harmonized regulation to provide access to a designated Port of Refuge for vessels in distress, ensuring immediate shelter and assistance. This assumption allows comparison between real accident scenarios, where access was denied or delayed, and hypothetical cases under a consistent EU regulatory framework.

Vessel and Route Conditions

The vessel modelled in the simulation follows the real routes sailed or towed during historical incidents. For comparative purposes, alternative shortest routes to nearest designated Port of Refuge are calculated using identical environmental conditions (weather, sea state, cargo type).

Environmental and Operational Context

Environmental and operational parameters (e.g. wind speed, wave height, distance from coast, vessel stability) are probably be aligned with historical data from the actual incident. The simulation environment reproduces real-world operational challenges faced by the crew and authorities at the time of each accident.

Fire Scenario Assumption

For the fire-related simulation, it is assumed that onboard firefighting capability can be enhanced through improved training, pre-planned emergency procedures, and rehearsed crew coordination. These factors could be treated as variables affecting fire spread rate, containment time, and overall damage mitigation.

3.4.3.2. Specific Validation Objectives

Evaluate Decision-Making and Regulatory Impact

To evaluate how different decision-making approaches and regulatory frameworks (e.g., mandatory EU provision of Ports of Refuge) influences the outcomes of maritime emergencies involving vessels in distress.

Assess Risk Reduction through Port-of-Refuge Accessibility

To quantify potential reductions in environmental and safety risks by comparing actual historical vessel routes with hypothetical shortest routes to nearest suitable Ports of Refuge.

Analyse the Effect of Enhanced Firefighting Preparedness

To assess how improved crew training, enhanced firefighting competence, and pre-drilled emergency response plans affect the spread and containment of onboard fires.

Identify Critical Factors Influencing Emergency Outcomes

To identify operational, organisational, and cultural factors (such as coordination efficiency and decision latency) that significantly impact the success or failure of emergency management at sea.

Support Evidence-Based Recommendations

To generate simulation-based insights that support evidence-based recommendations for EU and national authorities regarding regulatory design, preparedness measures, and safety culture improvements.

3.4.4. Exercises Planning and management

Since this activity is independent from physical demonstration regarding weather conditions and availability of vessels or devices, the timeline is anticipated within foreseen OVERHEAT WP7 tasks. The simulation is heavily dependent on the real vessel incidents which can be simulated with data available. The exact geographical context is determined when discussions about simulation go in greater detail.

For the simulation of the scenarios itself, applicable historic examples of vessels in distress will be chosen depending upon reports published and data available of such incidents. From all the information available the information needed for a calculation is extracted and subsequeltly inserted into a tool to gain numbers regarding a closer PoR than the actual PoR used thus less time is comsumed for the passage to the PoR to provide shelter and for land-based assistence. This part provides quantitative results.

3.4.4.1. Validation schedule

- simulate the real incident to prove simulation is feasible
- simulate with mandatory places of refuge (nearest suitable ones)
- simulate with early fire detection

3.4.4.2. Roles & Responsibilities in the exercise

- ISaSS —Lead and support at simulation execution and documentation
- ISL — Simulation execution and documentation

3.4.5. Analysis Specification

3.4.5.1. Expected results

A tool fed with data from historic events and feasible alternatives to enhance the situation will provide these results.

- Reduced time needed between accident and arrival at PoR: A measurable reduction in the duration and impact of emergencies when access to a Port of Refuge is granted promptly under a harmonized EU framework with mandatory use of a PoR. Shorter response and coordination times between maritime authorities, ports, and rescue coordination centers.
- Less time needed for a passage (own propulsion or towed) of a vessel in distress might also include less loss of containers, less bunker spilled and less human lives endangered. A quantitative result is anticipated to be calculated using a linear framework.

- Improved containment performance: Delayed or reduced spread of fire due to calculation of use of OVERHEAT IoT Sensors and Drones.

Qualitative Results

By discussing the gained quantitative results with results from OVERHEAT Task 2.3 (Best practice for fire prevention and fight) and Task 3.3 (Safety culture) from interviews and surveys, results regarding following topics might emerge:

- Comparison of metrics: Statistical differences between real incidents (actual routes and responses) and simulated “ideal” scenarios (shortest access routes, immediate coordination).
- Better understanding of safety culture in decision-making.
- Insights into coordination gaps.
- Enhanced training, following improved pre-defined emergency procedures, better means of communication and preparedness guidelines.

Please note: both lists regarding results named may not be exhaustive and may also be subject to change with new insights and findings unveiled while performing the simulation task.

3.5. FRENCH use case

3.5.1. Exercise Scope and Justification

The French use case represents the use of the Digital System (DS) when a vessel in distress approaches the port of refuge, accompanied by maritime pilots on board and by a rescue vessel. This use case focuses on the rescue component of the overall "fire risk management" scenario addressed by the project.

The French scenario will demonstrate the added value of OVERHEAT and its "Digital System" that allows sharing the same, global, picture of the situation all along the rescue operation and route to the port would drastically improve safety of the SAR - (Search and Rescue) intervention.

3.5.2. Validation scenarios

The scenario takes place in the cross point of the Atlantic or British Channel (*Figure 26*), an intense traffic area linking South and North Europe, as well as trans-Atlantic traffic. The vessel with fire on board is close to the coast, and close to the port of Brest.

Figure 26- Location of the French scenario

The French scenario takes place at the entrance of the British Channel, one of the most intense traffic areas in Europe.

The vessel in distress in close to the coast, rocky and dangerous. Weather and sea conditions are rough. Decision is taken to ask for assistance. The captain alerts the French surveillance agency in charge of the area: the Cross. The Cross station "Corsen" is the closest. It takes the communication with the Ship captain.

With current technologies, the 1st exchange between them uses VHF (channel 16 sending the key words "mayday mayday mayday", adding the name of the vessel, its location, the nature of the accident). With this little verbal information, the CROSS must estimate the situation and coordinate the rescue, contacting concerned parties (the rescue vessel, the fire intervention teams and the PREMAR (regional maritime administration).

Decision is taken to join the next port: Brest. Exchanges are now initiated with the captain of the port and the pilots. They define a ship rescue strategy, taking in consideration the local traffic, weather and sea conditions, hydrographical conditions (tides, water level, under keel clearance etc.) to estimate the best operational conditions including arrival time to take in charge the vessel in the port approach and area. Five teams are now involved: the captain and the crew, the CROSS; the rescue vessel, the harbour master, the pilots, and PREMAR (the French body which takes in charge the overall coordination).

With current technologies, the main information on the evolution of the situation on board is vocal, by VHF. Each team (on board, on land) has its own, partial, vision of the situation, built around the location of the vessel and surrounding traffic and hydrographical conditions ; all other information transits through external channels (e.g. sea conditions). The situational picture is hardly set up and shared among all parties; real time is currently impossible.

Figure 27 summarises the digital SAR assistance scenario.

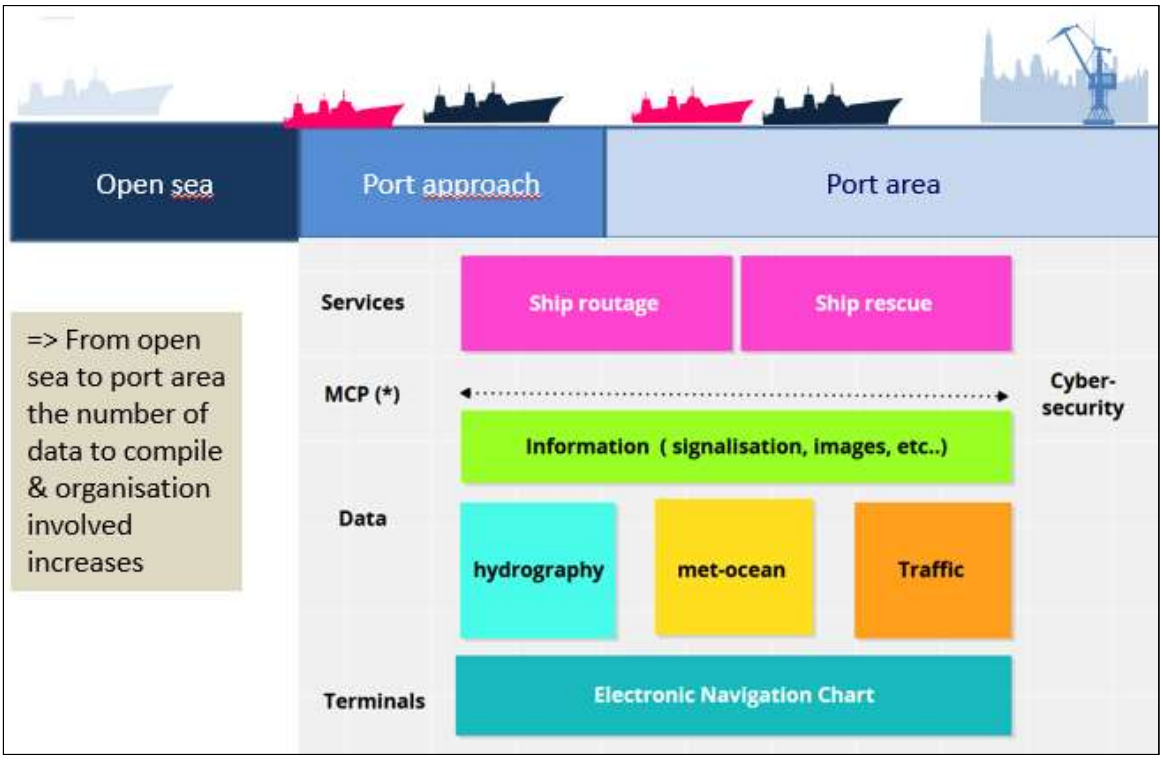


Figure 27- The digital SAR assistance scenario

3.5.2.1. Route and Harbour Information

The scenario starts from the entrance channel of BrestPort (*Figure 28*), at the boarding point of the pilots. The entrance channel is a dangerous area, rocky, frequently windy, with strong currents and wind.

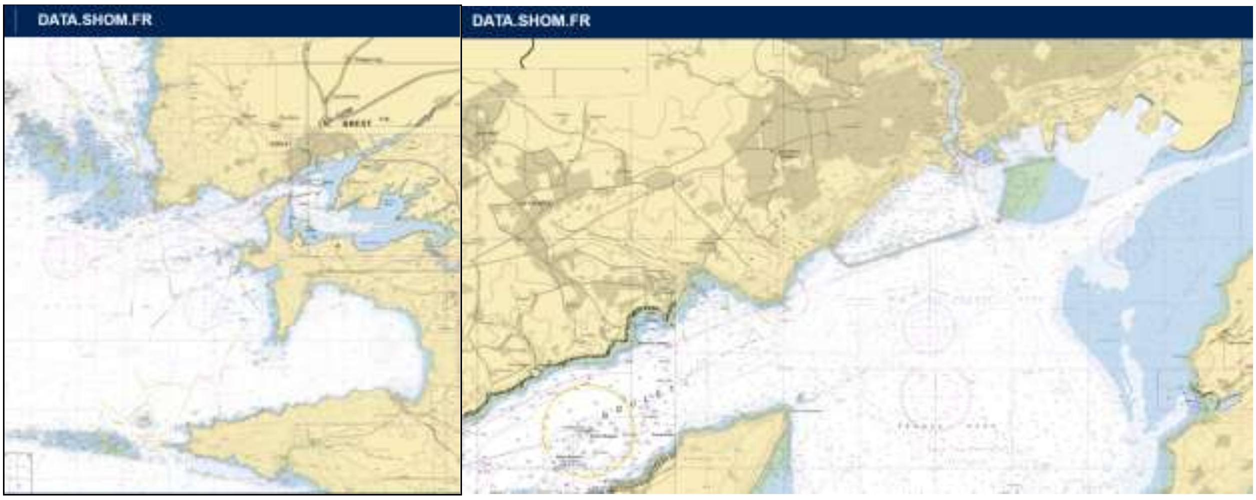


Figure 28- Detailed charts of BrestPort entrance channel

The vessel is routed from its location, through the entry channel to the berth of destination (*Figure 29*). Virtual Aids to Navigation (AToNs) will be installed to "visualize" the last part of the channel, close to the berth.

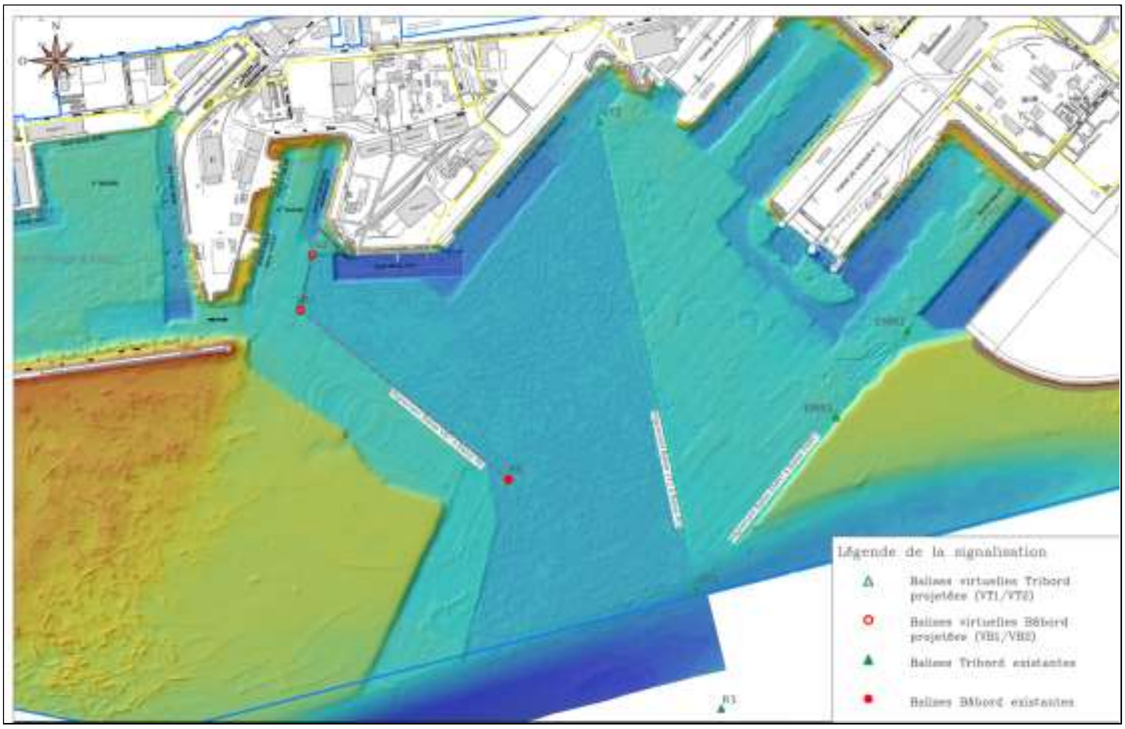


Figure 29- Route to the berth of destination with virtual signalisation of the channel

3.5.2.2. Validation methodology

The validation methodology for the French use case follows a **progressive, risk-controlled and modular approach**, ensuring that each component of DS is validated individually and integrated in the test bed to setup progressively the "Digital SAR" (Search and Rescue) assistance chain.

This procedure is applied for three levels of validation environments (*Figure 30*):

- The Factory tests are passed in a "controlled environment", in Innovative Navigation test bed, with registered and pre-qualified data sets
- The Functional tests are passed first in IN's test lab within a simulated environment but with "real" data received from sensors and data servers. To be more and more realistic this test environment will progressively reproduce the network configurations that will be setup in the operational platforms of BrestPort and ENSM.
  The same Functional tests are then passed in the environments of BrestPort and ENSM, so identified errors can be easily analysed and resolved. At this step, the ECDIS and PPU are not installed on board a vessel.
- The Operational validation phase involves the real environment of the French scenario: VTS in the port (harbour master office) and the ECDIS and the PPU are on board vessels.

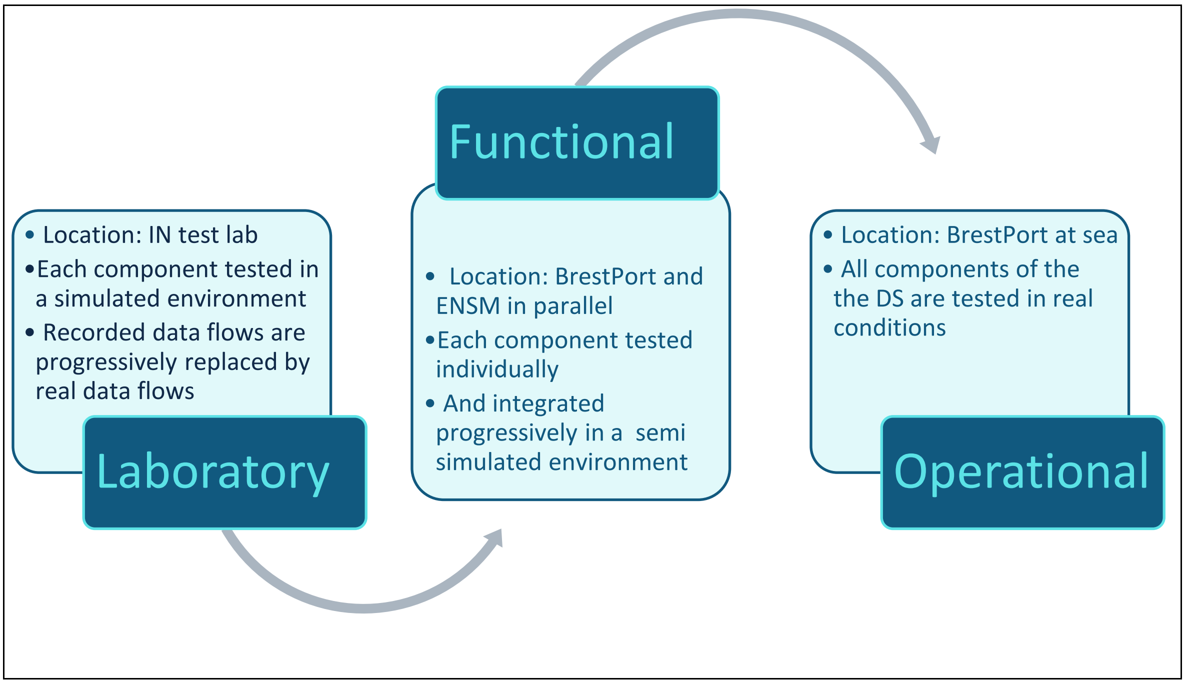


Figure 30- French scenario - Validation methodology

3.5.2.3. Platform Configuration

The French use case aims at validating the management and exchange of information between the different bodies involved in the ship rescue operation:

- The harbour master, equipped with a VTS, having access to all local information required to prepare the call of the rescued/ rescue vessels and sharing this information with these vessels and teams in the port
- The captain of the vessel in distress equipped with an ECDIS system, receiving information from local sensors and from the harbour master and transmitting information on the situational picture to the harbour master and the rescue teams on board the rescue vessel
- The pilots on board the vessel in distress which can access directly in real time to the port data server and thus guide the ship captain to the berth of destination

The *Figure 31* represents the way the validation campaigns are being carried out, from lab to operational tests, covering in each case the set of data to be processed by the equipment:

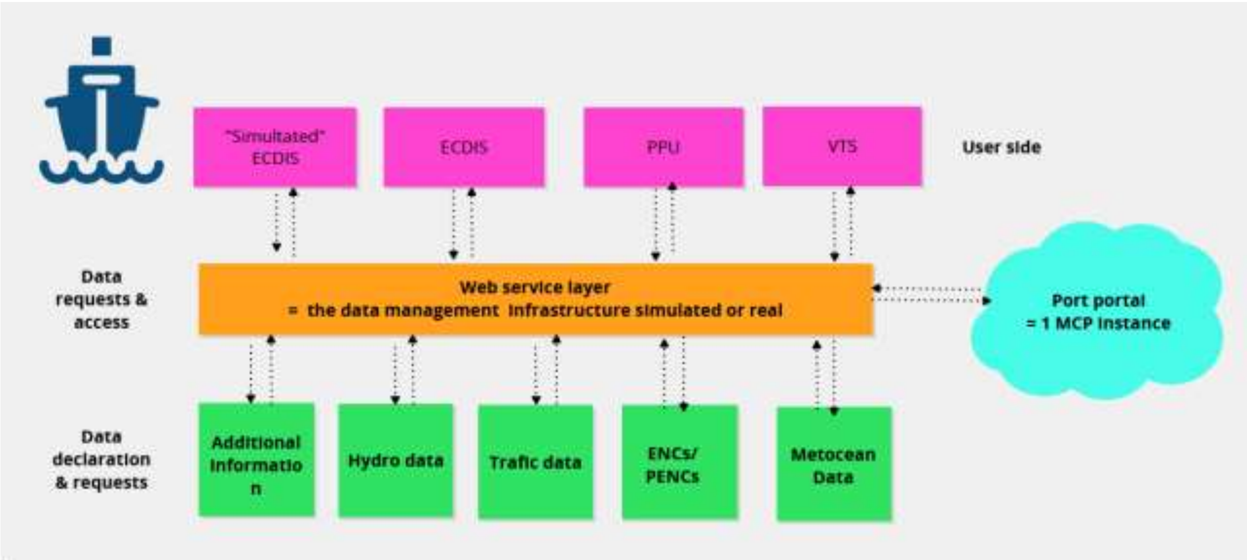


Figure 31- Overview of the test and validation infrastructure and data sets

As introduced in the previous paragraph, the validation campaign is organised in 3 main phases (*Figure 32*):

1. Laboratory tests of the DS components and of the DS: achieved in the lab of the expert's support company "Innovative Navigation",
2. Functional acceptance tests are achieved in IN's lab before the installation of the DS components in BrestPort and ENSM . It uses real sensor information, and the possibility to use the IN's lab

environment to validate each component behaviour and each data stream , producing a reference scenario. The same tests are then passed in BrestPort and ENSM, in their own offices.
3. Operational tests in BrestPort, in real conditions with the ECDIS and the PPU on board a vessel at sea

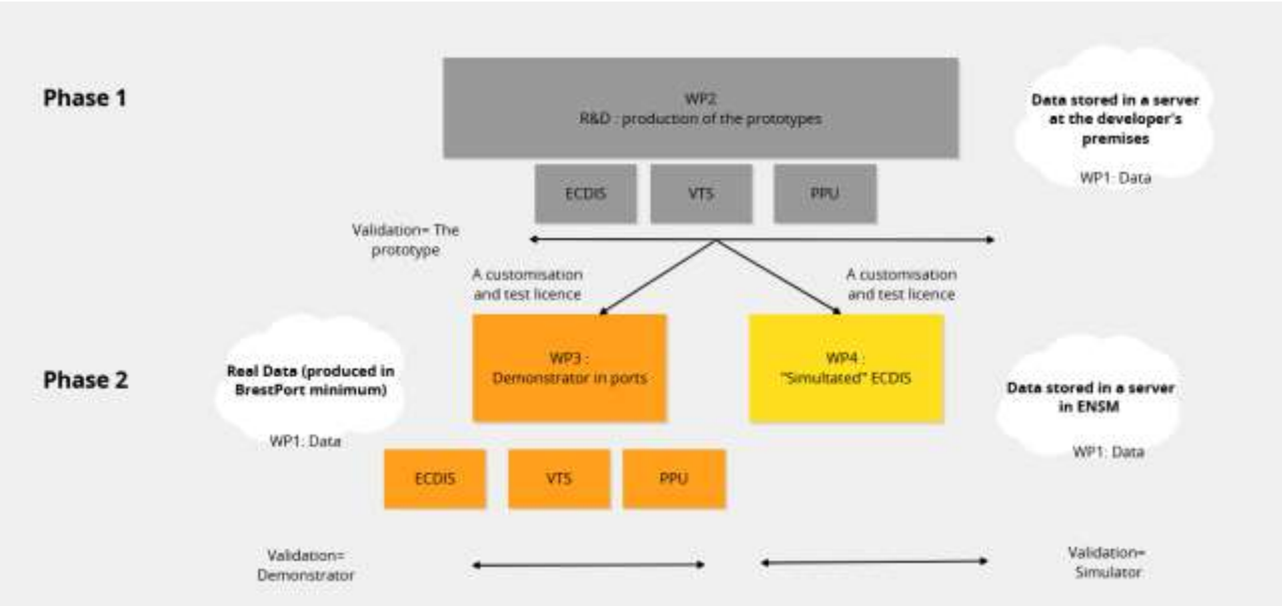


Figure 32- Overview of the Factory (Phase 1) and Functional/ Operational test environments

Note:

- the ECDIS in ENSM can be used as an ECDIS on board a remote "simulated" vessel
- the ECDIS in ENSM can receive data from sensors installed in BrestPort and on board the vessel

The different platforms used for the validation of the French use case are described hereafter.

Laboratory tests platform in IN's premises

IN owns a development and test platform, later on named "Factory reference test environment" (*Figure 33*).

In this platform , each component of the DS is tested first in a simulated environment and then with real data received through internet from external parties (part of the real operational scenario).

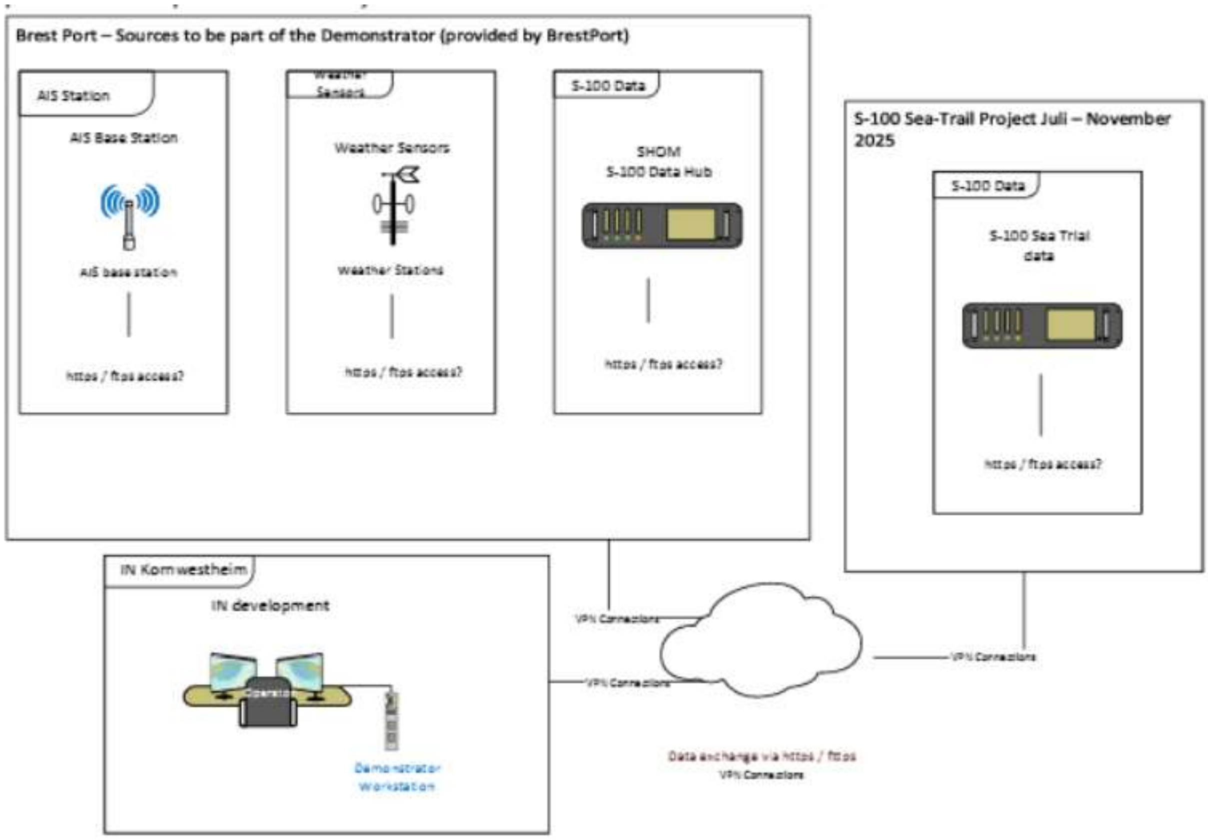


Figure 33- Laboratory tests environment

- The VTS and ECDIS prototypes: receive data recorded in a local server; the VTS (and ECDIS) can themselves be simulated to test the behaviour of the other component.
- The data recorded **can progressively be replaced by real data** provided by BrestPort and the drone/ sensors data providers. This allows testing the VTS and the ECDIS functionalities one by one.

The experts' lab is equipped with:

- A data server in which can be stored recorded sets of data, previously validated for their conformance to standard in terms of data formats and transmission protocols.

- Workstations used to develop and configure progressively the prototype users' equipment (ECDIS of ENSM, ECDIS, /VTS/-PPU of BrestPort) close to their final configuration and environment
- An internet connection to the external world and a LAN

In that way, the prototypes ECDIS, VTS and PPU are developed and tested :

- first with recorded data, for reference tests
- then with "real data" provided by real / final data sources

At the end of the development the configuration of the test environment is representative of the real installation in BrestPort and ENSM centers. Moreover, it will always be possible to use the reference test environment to test one of the prototypes with registered / qualified data sets and the reference workstation.

Note:

- Recordings from BrestPort environment will also be used for unitary tests to be close to realistic traffic situations but free of data format or data transmission errors. These are:
  - AIS
  - S-100 data
  - Weather sensor data
- Related IN components in "Replay Mode" will also be used in a second step to feed these recordings into the factory test environment components.
- The inhouse LAN is used instead of WAN/VPN infrastructure

Functional test platform is a partly simulated environment represented in *Figure 34*

- It introduces progressively data streams provided by real sensors, and the concerned data management layers in the users' equipments
- The local LAN infrastructure is progressively adapted to simulate the final users' environment
- The last step is the installation of the equipment in BrestPort and ENSM. The same validation scenario can be passed to verify that no variation / issue is introduced.

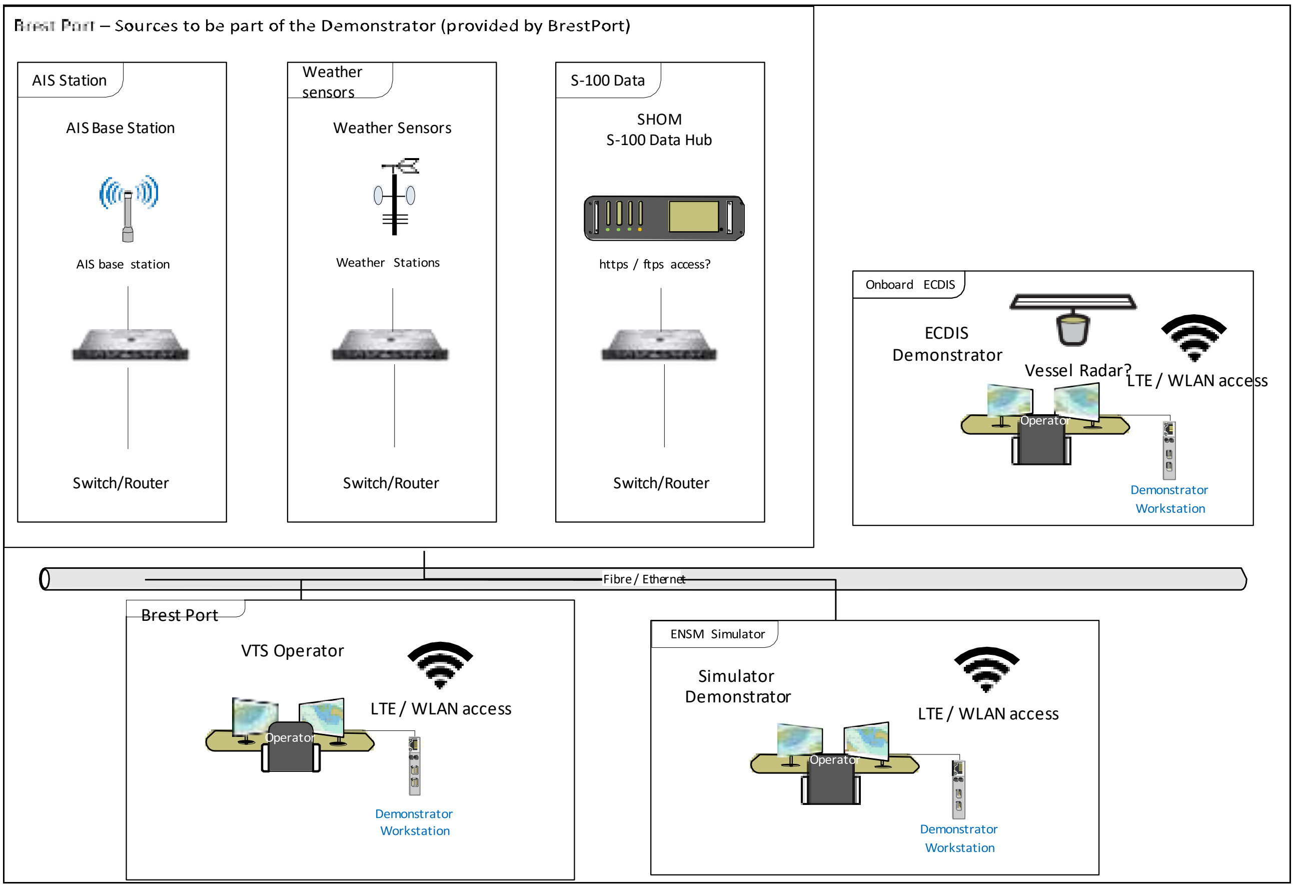


Figure 34- Functional test environment – Interconnecting BrestPort, ENSM and IN test beds

BrestPort functional test platform:

For these “functional tests”, BrestPort site is equipped with :

- The prototypes of the users’ equipment: ECDIS, VTS, PPU and a workstation that will be used by the DS system administrators/maintenance for configuration and maintenance purposes.
- An internet connection and a LAN
- A wireless network
- Different sensors deployed in the port area:
  - AIS base stations
  - Meteorological and hydrographic measurement stations
  - Connection to the metocean service provider’s databases (Shom, SEAMAPHOR)

ENSM functional test environment

In this configuration, ENSM is equipped with:

The prototype of ECDIS also connected to a LAN and to Internet
A data server which has recorded data of the drone, fire sensors, and ports navigation (all data including met-ocean data)
A Full Mission Bridge simulator

The pictures below show the Bridge Simulator and MARNIS simulator which can create various environmental conditions to test the ECDIS.

The prototype ECDIS delivered to ENSM is supposed to behave as a real ECDIS, which will be installed in a simulated vessel, to validate its use in simulated operational conditions. This configuration allows to test the ECDIS either with:

Recorded data provided by BrestPort (including drone and fire sensor data)
Real data provided by BrestPort and by PeopleTrust/Topview for the drone and fire sensors.
Several environmental and traffic conditions simulated in ENSM bridge simulator

So, the ENSM Bridge simulator will be used as an intermediatory step between the technical (IN's Lab) and real-world demonstration (BrestPort).

Also, the ENSM ECDIS will be used on board a "distant" simulated vessel

Note: All sensors are connected to the DS via a secure network. Transmission of the respective data streams will be accomplished by secure protocols or via a VPN connection.

Figure 35 represent ENSM MARINS simulator that is composed of two bridges and a control room. This platform allows reproducing and controlling numerous conditions including navigation, communications, metocean, failures, or traffic to test prototypes in different contexts. Also, all the variables of the exercises and video cameras are recorded allowing detailed analysis through replays or navigational/operational data.

Figure 35- Bridge simulator and trainer's room in ENSM MARINS

To benefit from this test environment, it is expected to test the ECDIS with different context scenarios (met-ocean conditions, traffic) and with real one transmitted by the sensors in BrestPort and by the drones and fire sensors (*Figure 36*).

The DS will be installed in the simulator as a new equipment. The DS will receive all the navigational data from the simulator as in a real ship using IEC 61162 standard called "Digital interfaces for navigational equipment within a ship". Figure below, introduces the different modules composing the simulator and the tested prototypes. The existing modules of the simulator are presented in white. The modules coming from WP4, that is sensors and drone, are in blue. Red modules are the DS coming from WP6. An internet connection is available to access port data.

Data formats will have to be checked before functional and operational tests in this configuration.

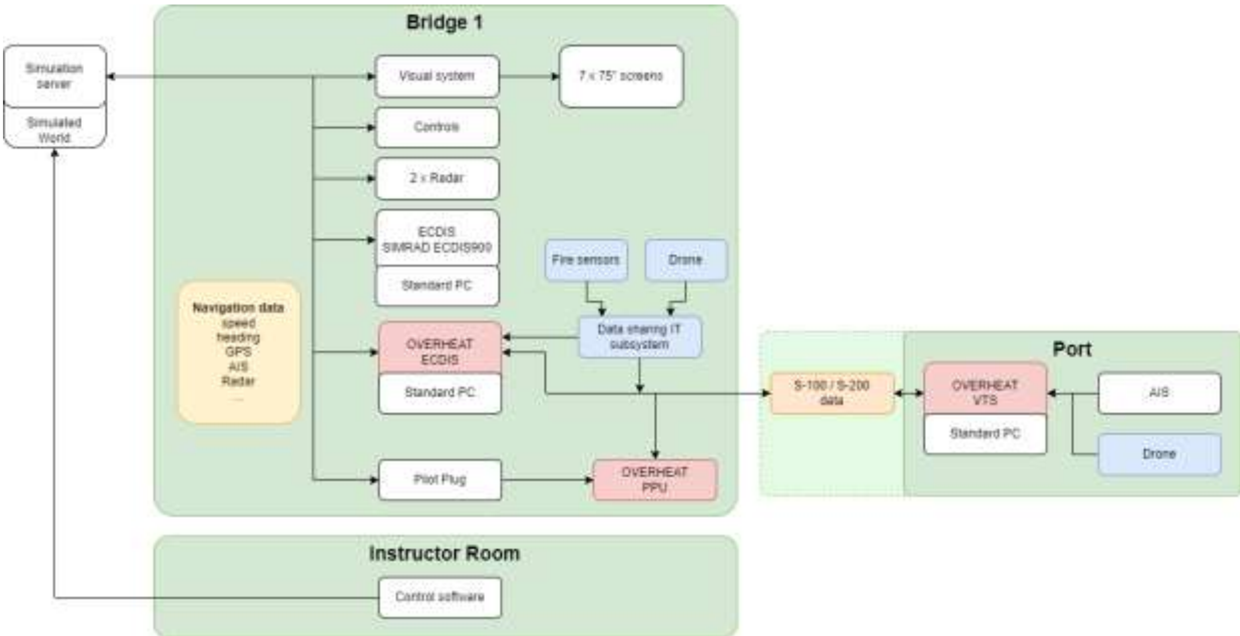


Figure 36- ECDIS test environment with simulated and real operational data

MARINS simulator allows making the connection between Italian demo where the sensors and drone are tested as isolated modules and real-world demonstration. In French scenario, sensors and drone streams of data will be connected to the DS to test the full chain of information. The simulator allows testing all the technical requirements with creating unlimited simulated operational scenarios that will be impossible in real world as precise weather and traffic conditions with a reduced cost. These scenarios can be played unlimited times with different users.

Another similar configuration is represented in *Figure 37*, with two ECDIS, one in BrestPort, one in ENSM, simulating the vessel in distress and the rescue vessel.

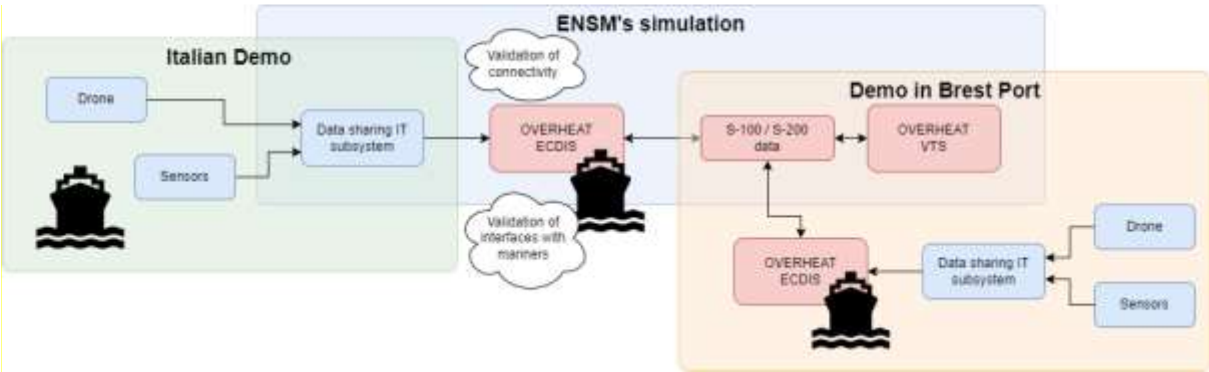


Figure 37- Dual ECDIS configuration simulating a distress vessel and a rescue vessel

Operational test platform: a real test/ validation environment

At this step, the prototype VTS, ECDIS and PPU for pilots are validated in real operational conditions in BrestPort.

The platform is composed of:

- The VTS station installed in the harbour master office
- The ECDIS installed on board a test vessel (not integrated in the bridge)
- The pilot PPU terminal used in the pilots' office (preparation of the route) and on board the test vessel

The test vessel itself which can be either a commercial vessel or a service vessel (tugs, pilot vessels, hydrographic survey vessels).

3.5.2.4. Validation platforms summary

Figures 15 to 17 present the testing framework used to validate the system, covering laboratory, functional and operational tests, from simulated environments to real deployments at BrestPort and ENSM.

Laboratory tests

	Components tested	Tests environment	Test goal
Laboratory tests (a simulated world)	Data server	Data sets are recorded in the test lab of the experts developing the DS. Then real data are delivered by BrestPort.	To validate that the data formats are correct, the transmission is correct and data processing chains are correct
	VTS	The VTS is prototyped in the developers' lab. The equipment reproduces the functionalities of a real VTS	To test that the equipment correctly receives, visualises and transmits the data sets involved in the French use case
	ECDIS	The ECDIS is prototyped in the developers' lab. The equipment reproduces the functionalities of a real ECDIS.	To test that the equipment correctly receives, visualises and transmits the data sets involved in the French use case.
	PPU	The PPU is prototyped in the developers' lab. The equipment reproduces the functionalities of a real PPU	To test that the equipment correctly receives, visualises and transmits the data sets involved in the French use case.

Table 15- Validation platform

Functional tests IN labs

Name	Components tested	Tests environment	Test goal
Functional tests -IN lab	VTS – ECDIS data exchange and sharing	The prototypes are tested in a partly simulated world in the experts' lab (Innovative Navigation)	To test that the equipment correctly process, visualise and exchange navigation and metocean data recorded in the server and then real data
	Drone-ECDIS communicati on	The prototype ECDIS is installed in the developers' lab.	To test that the ECDIS receives, and visualises the drone video stream to the VTS station.

		The video stream is recorded in a local server and then received through internet	
	Drone-ECDIS-VTS communication	The ECDIS and VTS prototypes are installed in the developer's lab.	To test that the ECDIS transmits the drone-video stream in real time and that the VTS receives and visualises the stream. The stream is first recorded and then is received through Internet.

Table 16- Functional tests IN labs

Operational tests

Name	Components tested	Tests environment	Test goal
Operational test in BrestPort and ENSM	ECDIS-VTS in BrestPort	The data server, the VTS, the ECDIS and the PPU are progressively replaced by the equipment installed in BrestPort and ENSM *At this step, it will be possible to use the ECDIS prototype to "simulate" operational conditions*	To validate that the equipment installed in BrestPort are processing and exchanging navigational and environmental data according to the French use case.
	Drone-ECDIS-VTS	Registered; then real drone and fire sensors streams. The ECDIS and VTS prototypes installed in BrestPort The ECDIS prototype installed in ENSM	To test that the ECDIS transmits the drone video stream in real time and that the VTS receives and visualises the stream
Operational tests in ENSM	ECDIS in a standalone configuration	Registered drone streams; then real drone streams, fire sensors streams. The ECDIS and VTS prototypes installed in BrestPort The ECDIS prototype installed in ENSM	To test that the ECDIS transmits the drone video stream in real time and that the VTS receives and visualises the stream

Table 17- Operational tests

3.5.2.5. Traffic and environmental data in the test area

3.5.2.5.1. Overview

Table 18 is a summary of data that will be used and tested in the French Scenario, in all 3 test phases. The table also mentions the data owner and the test procedure.

Data	Manager	Source and access Description	Test procedure
Port ENC and bathy-metry	BrestPort	BrestPort provides a cloud to download the data IN stores the data in a server	Data have been validated before delivery IN validates the visualisation of the ENC In case of error, comparison with “reference data” registered in IN lab server
AIS	Harbour master BrestPort	Two AIS stations installed in BrestPort area of responsibility	IN validates the visualisation of AIS data on the 3 user terminals
Virtual signalisation of the port channel	Harbour master/ Pilots	Signalisation by « AToN » technology (1 AIS transmitter installed in BrestPort with specified characteristics	Harbour master and Pilots validate the GPS position and characteristics IN tests the AIS signals reception on the 3 users' equipment
Tide	Harbour master & Shom	Tide watch port sensor installed in BrestPort Shom tide watch reference delivered on the server https://data.shom.fr	IN validates the access and visualisation of RT data on the 3 users equipment IN validates the access and visualisation of RT, forecast and historical data on all 3 equipment
Currents and swell	BrestPort	ADCP Nortek Data provider (ACTIMAR) « SEAMAPHOR » server	IN validates the access and visualisation of RT data on the 3 users equipment IN validates the access and visualisation of RT, forecast

			and historical data on all 3 users equipment
Wind	BrestPort	3 wind speed measurement masts installed in BrestPort	BrestPort provides the GPS position and access modalities IN validates the access and visualisation of RT data in a dedicated window
Fire sensors	PeopleTrust	Information from OVERHEAT's 'developed fire sensors	
Drone information	TopView	Drone data are recorded in a "reference server" and delivered in RT by PeopleTrust	IN validates the visualisation of drone data on the 3 users' equipment in a dedicated window
Route planning	BrestPort and ENSM	One functionality of the VTS, ECDIS and PPU is to prepare a route and calculate the ETA to the port	IN and the users validate the functionality on the users' equipment
RTK positioning	BrestPort	Provider not yet selected	Not critical for OVERHEAT tests GNSS used as baseline
5G	BrestPort	Provider not yet selected	Not critical for OVERHEAT tests 4G can be used as baseline

Table 18- List of data, data sources and tests objectives

The following paragraph provides more information on the data infrastructure to be provided by BrestPort.

3.5.2.5.2. Port ENC and bathymetry

The port ENC and bathymetry data are stored on a server in IN premises. Data are supposed to be delivered in S-101 and S-102 formats respectively.

The validation procedure of these two data sets is as follows:

1. Factory tests: IN validates that the data format is correct by comparing the visualisation of BrestPort data and reference data (pre-qualified sets of S-101 and S-102 data) in the 3 types of user's equipment.
2. Functional tests: S-101 and S-102 data being qualified through the factory test, the functional tests aim at validating

- The safety functionalities provided by the VTS/ ECDIS kernel: the operator can define safety areas (where navigation is allowed), safety criteria (maximum draught to cross an area).
- The visualisation of additional layers (following paragraphs) as layers on top of the ENC and bathymetric data.
- At this step, BrestPort and ENSM will specify the desired configuration of their future ECDIS/ VTS prototypes (user interfaces and key functionalities.

3. Operational tests: The VTS/ ECDIS prototypes being already configured and tested they are installed in BrestPort and ENSM environments. The validation of the ENC and bathymetric layers consists to replay the validation scenarios in this final operational environment.

3.5.2.5.3. AIS (traffic information) and AIS AIS AToNs (signalisation of the channel)

BrestPort will be equipped with a minimum of

- Two AIS base stations and a VHF antenna to receive AIS signals of the vessel in the area covered by the VHF station
- An AIS AToN infrastructure necessary to ensure a virtual signalisation of the port access channel to the berth. This is a very critical infrastructure to ensure safe access to the commerce terminal knowing that the channel is narrow and there is no fix balisage to guide the pilots to the berths.
- A web access to a commercial service providing AIS signal outside the jurisdiction of BrestPort

This infrastructure is composed of :

- An AIS Shore Station/ transmitter that will send the AIS messages of the virtual boys signalling the channel
- Software to configure and transmit the Message 21 (characteristics of the virtual buoys)
- An integration module with VTS / port management system

3- A web access to a “commercial” server providing AIS signals outside the port jurisdiction

Configuration:

- AIS input data are received in accordance with ITU-R M.1371 standard using NMEA format.
- An AIS proxy will serve as single point for clients to access a network of the various AIS sources. These sources can be connected as follows (depending on the equipment:
- AIS transponders (e.g. base stations) with a TCP/IP interface
- AIS transponders (e.g. base stations or AIS receivers) with a NMEA interface – this information requires an AIS proxy connected to these devices
- AIS networks with TCP/IP interface where AIS NMEA data can be received
- For the commercial AIS system, the DEMONSTRATOR will use:
- SOAP or REST interface, for traffic information
- SOAP or REST interface or via IVEF interface for attribute management database

Note:

- The advantage of the AISproxy is the capability to detect doublets and filter the information, thus, any information received is transmitted exactly one time to the client, independent of the number of base stations forwarding the message.
- The Traffic Management Service is a piece of software that generates warnings and alarms for track-track or track- geography (positions, lines, zones, corridors) conflicts.

Tests specifications:

For this “AIS module”, the validation tests (XXX-AIS AToN- TEST YYYY)

- The reception and visualisation of the AIS signals produced by the vessels and the AToNs
- The correct location, MMSI messages sent by the virtual AToNs
- The configuration of the AToNs
- The reception of the alerts
- The visualisation of traffic information (AIS) received from a commercial service provider

3.5.2.5.4. Met-ocean sensors and models

BrestPort will provide data provided by:

- Anemometers (wind measurements): 4 stations are installed closed to the harbour master office, to the pilot office, two at critical areas of the of the port (the offshore wind energy terminal
- One ADCP installed close to the Offshore Wind Terminal providing RT data on currents and swells
- The database and server of a met-ocean service provider, providing RT, historical and forecast data over the BrestPort area

Metocean data management

Met-ocean data will provide from 2 different sources:

- A current and swell sensor installed close to BrestPort. For this configuration data will be collected through classical interfaces for sensors (a proxy)
- A web service provided by an external data provider. For this configuration JSON protocol and HTTP requests are used.

The web server provides access to modelled data in historical mode, forecast mode or real time. Both sources will be tested.

Tests specifications:

For this “Met-ocean module”, the validation tests (XXX-Metocean- test no yyy, XXX for FActory, FUnctional or Operational tests) will cover:

- Data quality and characteristics,

- The sensor data access through the above mentioned interfaces
- Data quality and data formats
- Processing and visualisation by the ECDIS, VTS and PPU. Met-ocean data are yet “non S-100” data (not yet validated by S-100 IHO groups). They are visualised in dedicated windows on user’s terminals

3.5.2.5.5. Drone information

The management of drones is an important component of the project. Drones are used to record and transmit video streams of the situation on board the vessel to the Overheat DS. These are not S-100 data. However this data can be managed as “a mobile sensor”.

The following paragraphs defines the roles, DS interfaces, data format and communication protocols.

Roles and responsibilities

Drones information is managed by Topview and interfaces to the DS are managed jointly by PeopleTrust and Innovative Navigation (under SeaTopic coordination).

- Any additional information necessary to validate accurate visualization, synchronization, and alignment of the information to drone’s the demonstrator.

DS Interface specifications

The drone-DS interface provides real-time drone telemetry needed for visualization, alignment and sensor fusion within the Digital Solution. The interface must support:

- JSON-based REST API (preferred)
- Multi-drone operation through drone-specific identifiers
- Near real-time transmission of position and attitude values

Communication protocol specifications

The REST API shall manage one endpoint per drone.

- [3] Endpoint format: GET /api/v1/drones/{droneId}/telemetry
- Response Format: JSON
- Content-Type: application/json
- Update Frequency: At least 2 Hz (recommended: 5–10 Hz depending on drone capabilities)

Data format specifications

All fields required for the Digital Solution are listed below. All values must follow the units and types described in *Table 19*.

Field	Description	Type	Unit	Notes
mode_code	Aircraft operational state	integer	–	DJI-compatible enumerator
latitude	Geographic latitude	float	degrees	WGS84
longitude	Geographic longitude	float	degrees	WGS84
height	Absolute altitude	float	meters	Above mean sea level
attitude_pitch	Drone pitch angle	float	degrees	Range ±180°
attitude_roll	Drone roll angle	float	degrees	Range ±180°
attitude_head	Drone yaw / heading	float	degrees	0–360°
gimbal_pitch	Gimbal pitch angle	float	degrees	Range −180° to +180°
gimbal_roll	Gimbal roll angle	float	degrees	Range −180° to +180°
gimbal_yaw	Gimbal yaw angle	float	degrees	Range −180° to +180°
zoom_factor	Camera zoom level	float	–	Linear factor

Table 19- Data format specifications

All numeric values must use the dot (.) decimal separator.

Tests specifications:

For this “Drone module”, the validation tests (FA or FU or OP-Drone- test no yyyy) will validate:

- Conformance of communication protocols (analysed on a workstation 1st)
- Conformance of data formats (analysed on a workstation)
- Correct processing and visualisation of drone data on the ECDIS, VTS, PPU (*Figure 38*)

Figure 38- Visualisation of drone data on an ECDIS/ VTS

3.5.2.5.6. Route planning and ETA

One high level functionality of the VTS and the ECDIS is to calculate a route in advance and the respective arrival time (ETA) at specific locations shown in the display (*Figure 39*).

Figure 39- Example of route planning on the ECDIS/ VTS and PPU user interface

Pre-defined route to a destination can be assigned to a track on the chart, for example by a right mouse click via the context menu. The route will be visualized in the ECDIS/ VTS/ PPU displays.

This function will be tested through the factory tests (as part of the VTS/ ECDIS functionalities) and used during the operational validation phase in real conditions to calculate the route and the ETA to the berth of destination.

3.5.2.5.7. Other features Data sharing – setup a mobile LTE Router network

To establish a reliable and high-speed network IN proposes using mobile LTE routers for seamless internet connectivity in remote or mobile environments.

Configuration of the data sharing network:

1. **Prerequisite:** LTE routers must be selected according to target performance, compatibility, and cost.
2. **Installation:** LTE routers are installed at designated locations, ensuring optimal signal strength and coverage.
3. **Configuration:** the network settings are fixed, including SSID, security protocols, and bandwidth management.
4. **Testing:**

- Factory test: IN will test the network to ensure stable and high-speed internet connectivity.
- Functional tests: IN will test the network with drone data exchange (one most bandwidth consuming scenario). In a second step, the same or similar infrastructure is replicated in BrestPort
- Functional and operational tests: BrestPort will test the network in their environment, previous to pass the whole validation campaign.

3.5.2.6. Validation Run

The validation campaign is structured in 3 phases. The validation scenarios that will be passed, recorded, validated (ok, nok) to be used as references for the following steps, including users' feedback, as described in *Table 20 and 21*.

3.5.2.6.1. Validation campaigns – nomenclature and characteristics

Validation step	Label	Configuration	Goal
Factory tests	FA-component-test-no	Data sets are recorded in the test lab of IN	To test all data types are processed correctly by the VTS, ECDIS, PPU It is the "Reference test campaign"
Functional tests	FU-component-test-no	Data produced by real sensors and servers. The prototypes are installed in the developers' lab. Then in BrestPort and ENSM	To test that the data are correct, and that they are processed and visualised correctly To test the data exchange / sharing between the equipment
Operational tests	OP-component-test-no	The data server, the VTS, the ECDIS and the PPU are in their operational environment at sea and on land Possible to use the ENSM prototype to "simulate" a real size ECDIS	To validate an operational use of the Overheat DS DEMONSTRATOR by BrestPort (harbour master, pilots, port operators) and vessel officers in ENSM

Table 20- Summary table of validation campaigns

The validation campaign will be structured as follows

Validation step	Component	Simulated world	Test goal
Individual tests	Data server	Data sets are recorded in the test lab of the experts developing the DS	To validate that the data formats are correct, the transmission is correct and data processing chains are correct
	VTS	The VTS is simulated in the developers' lab. The equipment reproduces the functionalities of a real VTS	To test that the equipment correctly receives, visualises and transmits the data sets involved in the French use case
	ECDIS	The ECDIS is 1st simulated in the developers' lab. The equipment reproduces the functionalities of a real ECDIS. In a second step, a prototype of the ECDIS is installed in a bridge simulator in ENSM for testing with maritime officerss	To test that the equipment correctly receives, visualises and transmits the data sets involved in the French use case. To validate that the interfaces are suitable for operational use and that mariners can easily understand and interact with the system. To assess the acceptability of the solution and gather the impressions of maritime professionals
	PPU	The PPU is simulated in the developers' lab.. The equipment reproduces the functionalities of a real PPU	To test that the equipment correctly receives, visualises and transmits the data sets involved in the French use case.
Functional tests	VTS – ECDIS communication	The prototypes installed in the developers' lab.	To test that the equipment exchange data stored in the server are correctly processed and visualised

	Drone-ECDIS communication	The ECDIS prototype installed in the developers' lab.	To test that the ECDIS receives, visualises and transmits the drone video stream in real time
	Drone-ECDIS-VTS communication	The ECDIS and VTS prototypes installed in the developers' lab.	To test that the ECDIS transmits the drone video stream in real time and that the VTS receives and visualises the stream
Operational tests	ECDIS-VTS communication according to the French use case	The data server, the VTS, the ECDIS and the PPU are progressively replaced by the prototypes installed in BrestPort and ENSM At this step, it will be possible to use the ENSM prototype to "simulate" a real size ECDIS	To validate the prototype equipments installed in BrestPort and in ENSM To validate an operational use of the systems by port and vessel officers
	Drone-ECDIS-VTS communication	Registered drone streams; then real drone streams. The ECDIS and VTS prototypes installed in BrestPort The ECDIS prototype installed in ENSM	To test that the ECDIS transmits the drone video stream in real time and that the VTS receives and visualises the stream

Table 21- Validation Run

3.5.2.6.2. Added value of the approach

The validation methodology defined will allow :

<u>1) Testing the functionalities of the expected DS</u>

The use of the "Reference environment of the developers' lab to test the general functionalities of the VTS, ECDIS and PPU, using pre-qualified data sets stored in their data server. A progressive integration in the developers' lab of real data sets sent by BrestPort and by the drone operator, so that the IN lab infrastructure becomes closer and closer to the infrastructures in BrestPort and ENSM. The installation (and test) of the ECDIS in ENSM/ BrestPort using first registered qualified data and then real data. Finally the validation in real operational environment during which it will always be possible to come back to the Reference environment.

2) Demonstrating the added value of Overheat DS compared to current situation

Each actor will test the DS in a real operational environment and thus be able to qualify the added value of integrated digital solutions compared to his/her current one. All the actors involved will test the data information capabilities of the DS as a whole and its performance, reliability in case of rescue situation

3.5.3. Validation approach

3.5.3.1. Validation objectives, indicators and metrics

The French use case aims at validating the exchange of information between the different bodies involved:

- The harbour master, equipped with a VTS, having access to all local information required to prepare the call of the rescued/ rescue vessels and sharing this information with these vessels and teams in the port
- The captain of the vessel in distress equipped with an ECDIS system, receiving information from local sensors and from the harbour master and transmitting information on the situational picture to the harbour master and the rescue teams on board the rescue vessel
- The pilots on board the vessel in distress which can access directly in real time to the port data server and thus guide the ship captain to the berth of destination

The specific objective is to test the "**Digital SAR assistance" capacities of OVERHEAT DS, using the S-100 e-navigation model of the IHO/IMO and IoT models for drones and sensors.**

Therefore, the validation phase of the French scenario focuses on this digital "SAR assistance service" with its sea-land data/ information exchange in case of ship distress situation (an unmanageable fire on board situation on a container ship) (*Figure 40*).

The objective is to demonstrate the S-100 DS capabilities of this innovative "digital SAR assistant" to share the complete situational picture of the accident between all concerned parties, and this, from the location of the vessel up to the quay or anchoring area allocated by the harbour master for the ship.

The specific objectives are to validate the digital cornerstones of the scenario:

- The information exchange between the harbour master, the ship in distress and the pilots on board, using the new IHO/IMO S-100 e-navigation data model to exchange a real time (RT) picture of the situation on board the vessel (sent by the drone and sensors integrated into the ship's IoT network) and met-ocean conditions around the vessel and in the port of destination

- The additional capacity of the harbour master to prepare the call exploiting the hydrographic, meteo and oceanographical conditions in the port at the estimated time of arrival plus information sent by the drones and the sensors

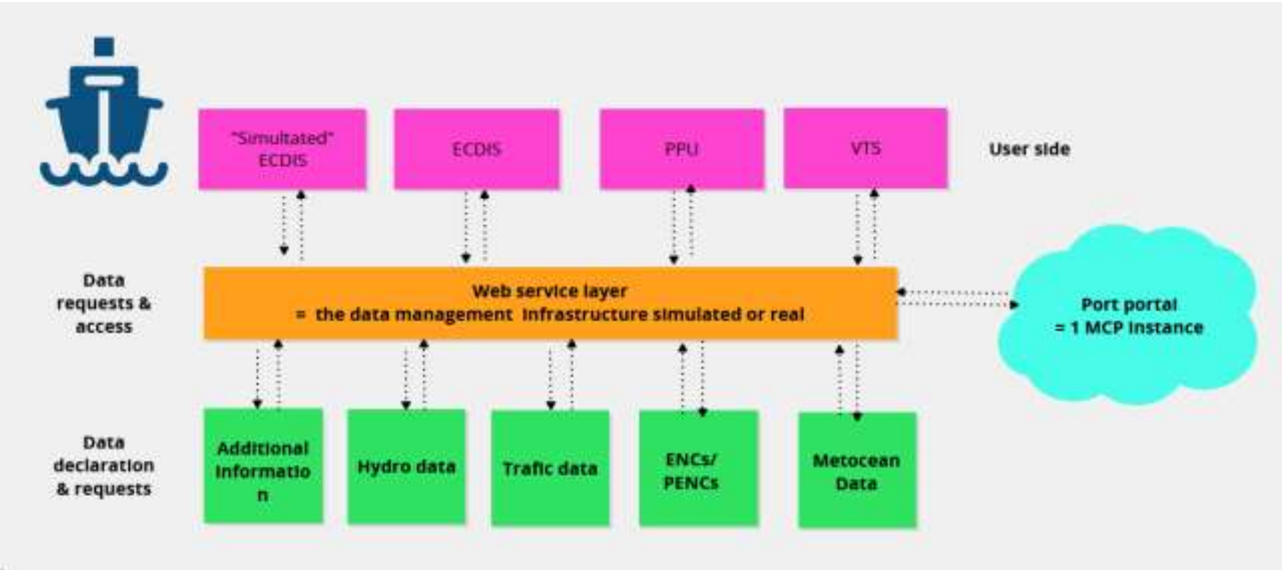


Figure 40- Data exchange in the digital SAR assistant scenario

The success criteria will be detailed for each test of the validation campaign according to the steps described in *Table 21*.

The performance indicators can only be defined during the development phase. A complement to the test and validation document will be produced.

3.5.3.2. Actors involved and roles

As described in the WP5.4 "Ontology" document and in *Table 22*, the French scenario involves the following actors:

Actors	Role	Relation	Equipment
The surveillance agency closest to the ship in distress	Receives the distress signal from the ship in distress	Communication (by VHF) with the Captain of the ship in distress	VTS station VHF radio
Captain of the ship in distress	Sends periodically additional / updated information on the situation on board	Communication (ECDIS-VTS) with a) the surveillance Agency b) the rescue vessel c) the port of refuge	ECDIS (drones and sensors on board)
The Captain of the rescue vessel	Receives the GPS position of the ship and additional information	Communication (ECDIS-VTS) with: a) the surveillance Agency b) the ship in distress c) the port of refuge	ECDIS
Harbour master of the port of refuge	Receives a demand for assistance from the surveillance agency Prepares the ship call conditions	Communication (VTS) with: a) the VTS of the surveillance Agency b) the ECDIS of the ship in distress c) the ECDIS of the rescue ship	VTS Port data server providing access to local navigation and met-ocean conditions
Maritime Pilots	Receives call for assistance from the harbour master	Communication with: a) the VTS of the harbour master b) the ECDIS of the ship in distress	PPU Port data server providing access to local navigation and met-ocean conditions
Rescue teams in BrestPort	Receives call for assistance from the harbour master	Communication with the harbour master	Portable tablet Port data server providing access to local navigation and met-ocean conditions

Table 22- Actors and roles

3.5.3.3. Exercise Tool, Validation Technique

The task D5.2 “Digital Solutions Requirements” will serve as guide for validation. In the section 4 of the D5.2 “Technical Requirements Validation” a checklist was developed, which will be used for testing and validating the DS.

The validation tools will allow testing the different components , data and protocols of the DS, in comparison with the “Reference test environment set up and test campaigns carried out in IN premises:

- The S-100 enabled user terminals (ECDIS, VTS, PPU): their capability to process, visualise and transmit the set of data covered by the DS
- Real Time information provided by “non S-100” equipment: drone, fire detection sensors on board, met-ocean and AIS sensors in the port
- Conformance of the digital infrastructures and cybersecurity n BrestPort and ENSM

Analysis methodology:

- Production of the validation campaigns: the set of tests scenarios is structured for each DS module, passed in the Reference Environment (Factory Tests) and logs registered as “reference” for the following phases
- Validation campaigns: all data exchanges are compared with the reference logs registered during the Factory Tests
- Analysis: the tests are qualified as passed or failed; there is no ambiguity
- Human feedback: is collected and evaluated in real time
- Final users’ evaluation will be produced and analysed for eventual corrections or improvements.

Errors and observations management:

- Any deviation triggers return to the reference environment (IN premises)
- Replay mode is used to reproduce and analyse the error
- Corrections applied are documented and re-tested in BrestPort and ENSM environments

Final deliverables of the validation campaigns:

- Laboratory tests campaigns and tests reports (IN)
- Functional tests reports (IN + BrestPort + ENSM)
- Operational tests reports (IN+ BrestPort+ ENSM)
- Consolidated validation report for WP7.2 (IN+ BrestPort + ENSM)

3.5.3.4. Entrance criteria

The goal of the OVERHEAT validation phase is to assess the added value of the Digital Solutions implemented in the project, in comparison with the current situation, as summarised in *Table 23*.

Current situation	Risks and challenges	Overheat solution	Solution to be tested
Fire on board is detected by human inspection or alerts	The alert comes too late and the situation can't be shared with rescue teams	Alert detected early and transmitted to the captain who can send a picture of the situation to the coastal VTS station	• Sensors' alerts management • Drone image • Digital communication with coastal surveillance agencies
Rescue scenario	The rescuing vessel, the coastal surveillance agency, the vessel in distress and the port of refuge communicate by VHF only	The situation on board is shared between all parties The vessel in distress, the rescue vessel, the port of refuge and the pilots share a route to the port and an updated picture of the situation	• Sharing of routing information to the port of refuge • Sharing of local conditions in the port of refuge • Share information on environmental conditions to agree on a final berth of destination
Rescue scenario/ Access to the port of refuge	All parties communicate by VHF only No way to exchange in real time the situation in the port of refuge, and in particular the signalization of the last access channel to the berth.	The pilots, he vessel in distress, the rescue vessel, the port of refuge and the pilots share the visualization of the route to the berth of destination through "Virtual AToNs" (Aids to Navigation)	• Sharing of routing information to the port of refuge through digital AToNs • Sharing of local conditions at the berth of destination (tide and bathymetry) • Share information on environmental conditions (wind, currents)

Table 23- Comparison between the current situation and Overheat

3.5.3.5. Exit Criteria

Preliminary tests: carried out in IN premises (Reference environment) and then in BrestPort and in ENSM (functional tests step):

- All data formats are validated
- All communication channels are validated
- Involved staff is trained by IN
- Safety and cybersecurity procedures are validated

Validation campaigns (in functional and operational environment):

- All data exchanged without errors
- The situational picture is visualized on the users terminals
- Drone data streams are correctly processed and visualised on the user terminals
- Logs show correct time stamps

The exit criteria are then factual:

- All required data streams are exchanged without error:
- data streams are recorded and analysed during the validation operation, covering the set of data represented in Figure 40: .
- Data streams are conform to the Reference Tests Campaign (the reference scenario, registered during the Factory tests in the experts 'lab (Innovative Navigation)
- No error visualised and register in the equipment' logs
- The situational picture is conform to the effective data sets composing the scenario for the VTS, the ECDIS and the PPU installed in BrestPort, in comparison with the "Reference scenarios" (Factory tests)

Log files: The logs files of the equipment are analysed and compared to the Reference logs.
User validation: the users check the behaviour of their terminals and the representation as well as access to the set of expected data.
The user's evaluation reports and feedback are gathered in a dedicated cloud space. One goal is to gather life reactions and not bother the users with questionnaires. The expert team "Innovative Navigation" will manage these feedback to apply corrections or simply improvements of the users' interfaces. Periodic Progress meetings will be organised with the users to analyse their comments.

The preliminary training session on all the functionalities of the ECDIS, VTS and PPU will be provided by Innovative Navigation to ensure that these functionalities are well mastered and correctly tested.

3.5.4. Exercises Planning and management

3.5.4.1. Validation schedule

Table 24 presents the validation schedule, detailing the successive milestones, test modules and timelines from laboratory testing to operational deployment.

Milestone	Test module and description	Date of completion
1	Laboratory tests in the developers' lab of the functionalities of the VTS, ECDIS and PPU, using registered data stored in their data server. Output: • Factory test campaigns and tests results of the factory VTS, ECDIS, PPU • Low level (unitary) reference tests results for the following phases	2026-01-30
2	Test in the developer's lab of the prototype VTS, ECDIS, PPU, replacing progressively the simulators by prototypes, and registered data by real data provided by BrestPort and by the drone operator Output: • Individual test campaigns and tests results of the protype VTS, ECDIS, PPU • Functional test campaigns and tests results of the prototype VTS-ECDIS-PPU communication (data exchange)- High level (functional) "reference test results" for following phases	2026-02-28
3 a	Test of prototype VTS, ECDIS and PPU equipment in BrestPort using registered data and then real data (including drone data) Output: • Unitary test campaigns and tests results of the protype VTS, ECDIS, PPU installed in BrestPort offices • Functional test campaigns and tests results of the prototype VTS-ECDIS-PPU communication (data exchange, including drone data)	2026-04-30

3b	In parallel of 3 a, Test of the prototype ECDIS in ENSM using registered data and then real data (including fire sensors and drone data) Output: • Individual test campaigns and tests results of the protype ENSM ECDIS	2026-04-30
4a	Test of prototype VTS, ECDIS and PPU equipment in BrestPort in real conditions using real sensors data : • VTS installed in the harbour master office • PPU and ECDIS installed on a vessel	2026-04-30
4b	Test of the ENSM prototype communication with the VTS of BrestPort and with real data including drone and sensors data Output: • Operational test campaigns and tests results of the prototype ECDIS communication (data exchange, including drone and fire data) In that configuration, the ECDIS can also receive data from the simulator (to be confirmed)	2026-05-30

Table 24- Validation schedule

Conclusion

In that way, IN and ENSM labs can be used as a “reference test beds”, after checking eventual discordance between simulated and real world.

3.5.4.2. Preparatory activities

For the French scenario, the expert group "Innovative Navigation" will assist SeaTopic, BrestPort and ENSM to:

- Specify the test infrastructure ensuring fast, reliable and secured communication
- Provide detailed specifications of the test campaigns (series of tests, including tests environments and test results) that will be carried out for each phase of the validation process

ENSM and BrestPort are charged to:

- Prepare the test infrastructure, according to the specifications agreed between IN, ENSM, BrestPort
- Provide IN the list and characteristics of each data that will be part of the test
- Verify the quality and the format of the data provided for the tests

All:

- Follow strictly the procedures defined to carry out the 3 steps of the validation, from factory to functional and operational tests.

3.5.4.3. Execution activities

For each validation step in Innovative Navigation, BrestPort and ENSM:

1. Guarantee that their infrastructure is conform to the test environments defined:

- The test infrastructure
- The data sets provided (that shall have been tested during the factory tests in IN premises)
- The test campaign (series of tests and expected results) and conditions (when, duration)

IN will provide the full test campaigns for the laboratory, functional and operational tests in Brest and ENSM

3.5.4.4. Post execution activities

As explained in previous paragraphs, the expert group “Innovative Navigation” will support all the tests phases, including the production of test campaign specifications (list of tests and configuration, initial situation, final situation, approval criteria etc) and the analyses of the test results, during all 3 validation phases.

BrestPort and ENSM are responsible for providing the defined infrastructure, including data streams, in the right format defined jointly with IN.

At the end of each validation phase, IN, BrestPort and ENSM will jointly produce a validation report in which possible future evolutions of the DS will be considered. After the operational validation phase and the demonstration, a conclusion meeting will be organized with the users to produce a feedback document.

This final feedback, shared with the users will be exploited to enhance the Overheat DS and envisage further operational use of the system.

3.5.4.5. Human Resources

Every party involved will provide its own staff

BrestPort, ENSM and SeaTopic are engaged to work jointly with IN on the validation campaigns from their specifications to the validation run.

IN acts as an expertise support teams (assistance to the partners)

The “final users” are involved for the functional and operational validation steps only, to provide feedback and advice on the configuration, functionalities, user interface…

3.5.4.6. Training

The expert support company “Innovative Navigation” will provide a complete training module for BrestPort and for ENSM.

It covers:

- The ECDIS, VTS, PPU functionalities and configuration tools
- The “ideal” architecture of the BrestPort and ENSM infrastructure to support the test and beyond the use of the prototypes
- The data characteristics: data sets, formats, protocols and interfaces to the users equipment.

3.5.4.7. Risks

The validation procedures is set to avoid risks of divergence between laboratory tests and operational ones, and risks to not be able to ensure the demonstrations.

MARINS simulator is not available. To reduce this risk, other ENSM's bridge simulator could be used exploring their capacities and limitations.

In case of divergence, the procedure is to come back to the reference laboratory tests to identify the problem and find corrective actions (either on the user side or on the IN side).

3.5.4.8. Errors and Observation handling

At each stage of the validation process, the tests are recorded, analysed so that as said in previous paragraphs, errors or remarks are handled immediately (by batchs).

3.5.5. Analysis Specification

3.5.5.1. Data collection methods

All tests, during the 3 phases are recorded by IN in the following way (part of their internal quality procedure):

- Record of all tests results, labelled by "test serie- test name- test result" knowing that an additional context of the test is specified for each "test sery" (lab, functional, operational) and test name (precise environment, goal , result) of each test
- Analysis of the results by involved parties ad corrective actions
- Corrective actions

3.5.5.2. Observational Techniques

The validation of the scenario relies upon the effective data reception, treatment and exchange between the parties involved (the VTS operator (the Harbour master, the ship in distress (the Captain of the ship) and the maritime pilots. The messages exchanged are stored and time stamped, as they will be in real scenario.

The tests scenario (configuration, data processed, results) are recorded so that they can be replayed in "simulated environments" to check and optimize each step of the rescue scenario.

3.5.5.3. Questionnaires/ reports

Innovative Navigation is responsible for the production of:

- laboratory tests reports (both unitary tests and functional tests)
- functional tests reports
- Operational tests reports

BrestPort with support of IN is responsible for contributing to the production of validation reports for all 3 steps of the validation process in Brest Port (unitary, functional and operational) with inputs of the “validation team”.

ENSM with support of is responsible for contributing to the production of validation reports for all 3 steps of the validation process in ENSM (unitary, functional and operational) with inputs of their “validation team”.

3.5.5.4. Debriefings

At the end of each step of the unitary, functional and operational tests, debriefing meetings are organized to analyse:

- Anomalies and their origin
- Corrective actions applied
- Additional tests to be implemented

Moreover, specific meetings can be organized in case of misunderstanding between the actors involved of the expected results of the tests or of the expected test infrastructure.

3.6. POLISH use case

3.6.1. Exercise Scope and Justification

The primary objective of this validation exercise is to assess the performance of a specialized UAV system in executing an OVERHEAT inspection mission for vessels approaching a Harbour. The underlying assumption is that UAV deployment may offer an efficient method for identifying potential onboard anomalies prior to port entry.

Given the complexity of the inspection scenario, it is essential to evaluate the mission across multiple technical dimensions, including port approach procedures, UAV flight path planning, inspection execution, and decision-making based on sensor data. The simulation results will determine whether the UAV system may meet the operational requirements of the inspection mission and may highlight both strengths and limitations of the proposed approach.

3.6.2. Validation scenarios

Initial Simulation: The first step involves simulating a vessel's approach to the Port of Gdynia using data provided by the IMAT simulator, with visualization part in the ILOT simulator. This task aims to verify seamless data integration between the two simulation platforms.

Scenario Development: Subsequent simulations will model various operational scenarios, including the occurrence of temperature anomalies onboard the vessel. These anomalies will be designed to be detectable by simulated sensors mounted on the UAV conducting the inspection.

All simulation data will be systematically recorded and time-stamped to facilitate precise offline analysis and identification of potential errors or system limitations.

3.6.2.1. Route and Harbour Information

The simulation scenario assumes that a drone docking station is located within the Port of Gdynia area (*Figure 41*). The optimal placement of this station will be determined through further analysis, considering multiple factors, including:

Physical accessibility – ensuring feasible transportation and traffic flow to the site.

Administrative ownership – compliance with property rights and management regulations.

Human access restrictions – minimizing interference from personnel and maintaining security.

Continuous power supply – availability of a reliable 24/7 electrical connection.

Network connectivity – preferably via wired internet for stable communication.

Unobstructed airspace – clear vertical access above the dock, free from cranes or other obstacles.

Air traffic compliance – alignment with local aviation regulations and restricted zones.

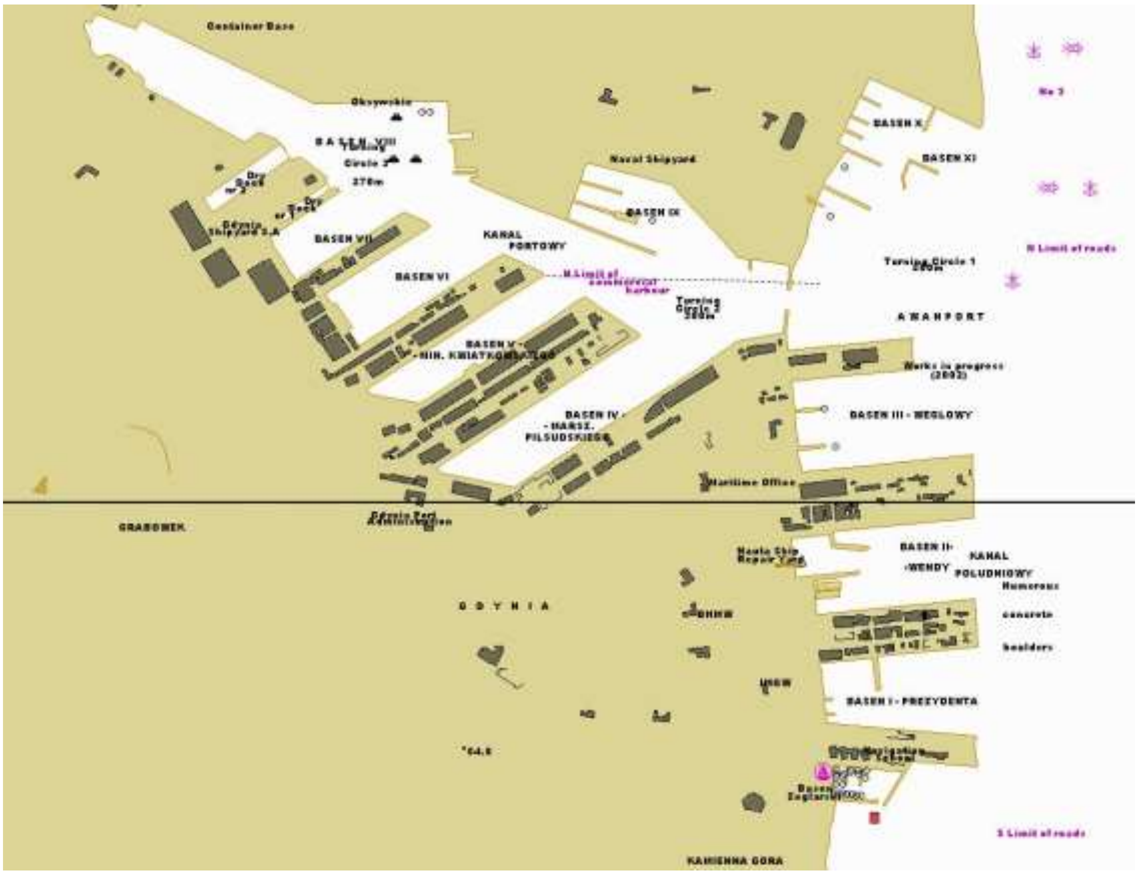


Figure 41- Administrative map of Port Gdynia in IMAT simulation environment

3.6.2.2. Platform Configuration

Simulation assumes following configuration:

- Docking station with drone located at fixed position at Gdynia Harbour
- Cargo vessel of different types that are approaching to harbour dock with different routes (1 route per vessel)
- Different weather conditions:
    - Wind speed (3 magnitudes that are within operational scope of drone)
        - No wind
        - Low wind
        - High wind
    - Different wind direction
        - Aligned with vessel route
        - Opposite to vessel route
        - Lateral to vessel route
    - Sea heave level
        - Low
        - Medium
        - High

3.6.2.3. Traffic Information

Maritime traffic will be simulated by IMAT simulator.

Air traffic, constraints, air corridors will be simulated according to actual polish air traffic situation (PANSA) by ILOT simulator.

3.6.2.4. Dependent and Independent variables

Data format exchange: ILOT simulation will be based on data recorded by IMAT simulator.

Data set will be dependent on the simulated scenario.

3.6.2.5. Reference & Solution Scenarios

In the **reference scenario** the UAS is performing its routine flight to check the ship traffic flows and/or emergency situations. The UAS starts the flight from a port hangar located ashore. The ship is close to the Gdynia port in the Baltic Sea at the anchor waiting for the clearance of the authority port for entering and start the port operations. During the inspection, the UAS (equipped with thermal camera) detects the anomalies of temperature of a container located on the weather deck of the vessel. The UAS sends an alarm to the Gdynia port authority that, via VHF, establish a contact with the ship asking them the check the container with the anomaly. After few minutes, the ship confirm fire on bord. The UAS continue to monitor the cascade effects of this situation, a man is detected unconscious/locked on the weather deck. In the meanwhile, the Gdynia port authority starts the operations to prepare an emergency quay and calls the port firefighters. In the same time, Gdynia port authority informs, via VHF, on the general channel, the other ships of the emergency. The crew on board the ship (rescue/fire teams) starts the operation to extinguish the fire. The ship enters in the port guided by the Gdynia pilot and the firefighters goes on board the ship to support the crew of the ship. Finally, the human is promptly rescued and the fire is under control.

The goal of this use case is to test the use of UAS from ashore to replace human in demanding and/or dangerous tasks such as fire/human detection. The system is composed of a self-charging drone, recovered on its hangar ashore, from which it takes off and executes its missions, mainly consisting in optical/thermal images and video stream acquisition and vision algorithm capable to detect possible thermal anomalies over the vessel/containers. This is assumed as a real-time operation and the UAV is able to detect cascade effects (e.g. if an human is locked/unconscious on the weather deck). At this stage, the fire/rescue team can promptly receive an assessment of the situational awareness.

The **solution scenario** will try to recreate reference scenario to the extent of possible technologies usage within simulation environment. As the main goal of simulation is assessment whether UAS technologies can provide efficient method for increasing safety operation of the vessels approaching to port, some elements that are not directly relevant to assessment may be omitted in the simulation.

3.6.2.6. Validation Run

Initial schedule:

09/02/2026 – 11/02/2026 (Start test for both Italian and Polish validation - 3 days)
23/02/2026 – 25/02/2025 (Final test for both Italian and Polish validation - 3 days)
02/03/2026 – 04/03/2025 (Italian Validation 2,5 days)
04/03/2026 – 06/03/2025 (Polish Validation 2,5 days)

3.6.3. Validation approach

Following hypothesis are considered for this simulation :

A system consisting of a multi-channel detection and on-board sensors could improve port safety. Early detection of temperature anomalies on ships would enable port authorities to respond quickly and make appropriate decisions.

The use of drones equipped with thermal cameras can provide real-time visualization and assessment of the fire evolution, complementing traditional firefighting operations.

A drone could inspect the required part of a ship with sufficient precision and in time before the ship enters port.

The procedures in the event of a fire being detected on a ship would allow for the safe and effective conduct of the entire mission.

3.6.3.1. Validation objectives, indicators and metrics

- **Evaluate the Applicability of Drone-Based Fire Detection:** Assess the feasibility and effectiveness of using UAV-mounted thermal imaging systems to detect temperature anomalies on the outermost layer of shipping containers prior to Harbour entry, with a focus on early fire hazard identification and vessel clearance decision-making.
- **Estimate Mission Duration Under Gdynia Operational Conditions:** Analyze mission timelines by factoring in:
  - Atmospheric and meteorological influences: wind, waves level
  - Inspection distance from the port
  - Scanning duration per container, considering UAV movement (stationary hovering vs. dynamic flight)
  - Structural layout and accessibility of container stacks
- **Define UAV Performance Requirements and Fleet Size**
- **Identify Critical Distances and Safety Thresholds**: Establish spatial benchmarks for:
  - Minimum safe distance from port for initiating inspection and corrective action
  - Buffer zones for vessel holding or rerouting
- **Develop and Optimize Entry & Emergency Response Procedures:** Specify and evaluate:
  - Standard operating procedures (SOPs) for vessel entry authorization
  - Emergency intervention protocols in case of detected fire risks
  - Potential evacuation and containment responses depending on vessel position and available time margin

3.6.3.2. Actors involved and roles

IMAT – cargo vessel simulation.

- Test scenario implementation (with variants included)
- Port traffic implementation
- Vessel position and orientation transfer to ILOT

ILOT – drone simulation

- Port and environment visualization
- Test scenario implementation (with variants included)
- IMAT’s vessel visualization with position and orientation
- Inspection UAV visualization
- Inspection UAV navigation (automatic + manual)

TopView – Command Center

- Interface specification between drone and Overheat Command Center

3.6.3.3. Exercise Tool, Validation Technique

IMAT simulator (Challenger) – deck department

ILOT simulator (VBS4, Matlab, Python, mission planner)

Technique: Data based simulation in Italy and Poland, data exchanged between simulators.

3.6.3.4. Entrance criteria

Success criteria:

- Full vessel inspection completed within the available time window
- Thermal anomalies detected with accuracy on container surfaces
- Real-time data transmission without loss of connectivity
- Takeoff time and flight path calculated in mission module allows for mission fulfil
- Adequate inspection coverage, considering ship size and container layout
- UAV energy consumption is within planned operational margins
- Fast and clear decision-making by port authorities following UAV inspection
- Thermal sensor's parameters such as resolution and view angles prove adequate to achieve the desired measurement accuracy
- Readiness of the validated system for operational deployment

3.6.3.5. Exit Criteria

Operational Feasibility

- Confirmation that UAVs can effectively perform thermal inspections of container vessels under near real-world conditions.
- Verification that mission planning algorithms can accurately determine optimal launch windows and flight paths.

Decision-Making Support

- Timely and accurate communication of inspection results to port authorities.
- Clear decision pathways for vessel clearance, holding, or rerouting based on UAV data.

System Performance Metrics

- Drone system metrics e.g. energy consumption, total mission time, inspection mission window
- Drone system soft-validation based on simulated parameters
- Assessment of time margins available for intervention before vessel clearance procedures
- Vision system metrics

Mission Efficiency

- Total Mission Duration: From launch to return
- Inspection Coverage: Percentage of container surface area scanned.
- Operator Time Utilization: Time spent in manual inspection vs. total mission time.

Environmental Adaptability

- Weather Tolerance: Maximum wind speed and precipitation levels under which UAV can operate effectively.
- Visibility Thresholds: Influence of vision system parameters

Decision Accuracy

- Response Time: Time from anomaly detection to authority notification and action.

System Scalability

- Fleet Coordination: Ability to manage multiple UAVs simultaneously.
- Docking Station Utilization: Turnaround time between missions, requirements on number of docking stations.

3.6.4. Analysis Specification

3.6.4.1. Data collection methods

Data format exchange format will be specified between IMAT and ILOT. Only electronic form of data acquisition is assumed. Both simulation environments allow for dynamic definition of logging schemes. For UAV system simulation analysis purposes file-oriented data sets will be utilized.

For UAV system simulation, default data set required from IMAT simulator is specified as following:

- LAT: Latitude
- LON: Longitude
- GS: Ground Speed
- Heading
- Heading Rate
- Pitch Angle
- Pitch Rate
- Roll Angle
- Roll Rate
- Ground Elevation
- Time
- W/V Speed

4. NEXT STEP : SIMULATION AND DEMONSTRATION REPORT

The next phase of WP7 will consist of consolidating the outcomes of all simulations and real-world demonstrations into a comprehensive **Simulation and Demonstration Report (D7.2)**. This deliverable will analyse the performance of the OVERHEAT technologies, evaluate their operational relevance in diverse European contexts, and assess their contribution to improved fire detection, response efficiency, and overall safety.

Building on the methodology and scenarios defined in the present deliverable (D7.1), the upcoming report will include:

1. Comparison of simulation and demonstration outcomes

A detailed comparison between the results obtained during virtual simulations and those collected from real-world demonstrations. This analysis will help assess whether controlled simulated conditions reflect the operational reality encountered in ports and maritime environments.

2. Assessment of technology performance

Each technology (IoT sensors, autonomous drones, Digital Solution, communication tools) will be evaluated against the validation indicators established in D7.1, including detection time, data reliability, mission execution, and interoperability.

3. Cross-country analysis of use cases

The report will synthesise observations from all five use cases (Italy, Spain, France, Poland, Germany) to identify common strengths, limitations, and context-specific challenges. This comparison will support the identification of systemic issues and best practices applicable across Europe.

4. Lessons learned and recommendations

Based on the collected evidence, the report will formulate recommendations for:

- technological adjustments,
- procedural improvements for emergency management,
- operational guidelines for end users,
- and contributions to potential regulatory discussions (EU or IMO level) regarding fire management and places of refuge.

5. Contribution to OVERHEAT impact and future exploitation

The findings of the Simulation and Demonstration Report will feed the broader exploitation, standardisation, and dissemination activities of the project, strengthening the case for the adoption of OVERHEAT solutions by maritime authorities, ports, and shipping companies.

OVERHEAT

INNOVATIVE STRATEGIES FOR CONTAINERSHIP FIRES PREVENTION AND MANAGEMENT

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