OVERHEAT

INNOVATIVE STRATEGIES FOR CONTAINERSHIP FIRES PREVENTION AND MANAGEMENT

Deliverable title:	End user requirements
Deliverable ID:	D5.1
Document version:	V0.7
Partner responsible:	ENSM
Due date:	31 March 2025
Status:	Final

Funded by the European Union

This project has received funding from the European Union's Horizon Europe research and innovation programme under Grant Agreement Project No: 101076633. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.

Document Control Sheet

Deliverable number	**D5.1**
Deliverable name	**End user requirements**
Dissemination Level	**PU**
Call	**HORIZON-CL5-2022-D6-01**
Topic	**HORIZON-CL5-2022-D6-01-08-Safer navigation and tackling containership fires**
Consortium Coordinator	**IMAT**
Partner responsible for the deliverable	**ENSM**
Edition	**0.7**

Authors of the document

Authors of the document - Representatives of beneficiaries involved in the project		
Name/Beneficiary	Position/Title within the project	Date
Pedro Merino Laso / ENSM	ENSM PoC	28/02/2025
Hasan Ahmad	ENSM	28/02/2025

Reviewers of the document

Appointed reviewers of the document - Representatives of beneficiaries involved in the project		
Name/Beneficiary	Position/Title within the project	Date
Marcus Engler	Researcher at ISL	21/10/2024
Fabienne Vallee	Port of Brest	18/11/2024
Marco Pasciuto	IMAT	06/12/2024
Valentina Lasco	IMAT	06/12/2024
Adam Liberacki	ILOT	11/05/2025
Théo Delferrière	CIRCOE	27/03/2025
Vittorio Sangermano	ISSNOVA	10/04/2025

Responsible for the document approval

List of people approving the document - Representatives of beneficiaries involved in the project		
Name/Beneficiary	Position/Title within the project	Date
Marco Pasciuto/IMAT	OVERHEAT Project Manager and WP1 Leader	04/01/2025
Vittorio Sangermano/ISSNOVA	ISSNOVA PoC	04/01/2025
Bartosz Dziugiel/ILOT	ILOT PoC	04/01/2025
Holger Kramer/ISL	ISL PoC	04/01/2025
Fabienne Vallee/ Brest Port	Brest Port PoC	04/01/2025

Rafael Company/VPF	VPF PoC	04/01/2025
Stefano Ricci/DITS	DITS PoC	04/01/2025
Théo Delferriere/CIRCOE	CIRCOE PoC	04/01/2025
Diego Cioce/AKKODIS	AKKODIS PoC	04/01/2025
Pedro Merino-Laso/ENSM	ENSM PoC	04/01/2025
Massimiliano Siliberti/GTS	GTS PoC	04/01/2025
Gunnar Tietze/SeaTopic	SeaTopic PoC	04/01/2025
Massimo Capozza/PeopleTrust	PeopleTrust PoC	04/01/2025
Dominic Kudlacek/ISaSS	ISaSS PoC	04/01/2025
Francesco Russo/TopView	TopView PoC	04/01/2025
José Miguel Basset Blesa/VFF	VFF PoC	04/01/2025
Simone Panfiglio/Caronte	Caronte PoC	04/01/2025

OVERHEAT is a Horizon Europe project supported by the European Union under grant agreement no. 101076633.

ABSTRACT

The Overheat project aims to enhance maritime fire safety by developing a Digital Solution (DS) that integrates real-time situational awareness (SA), advanced fire detection, and emergency coordination tools. This document outlines end-user requirements based on extensive surveys, interviews and workshops with multiple types of end users from vessels, ports, firefighters, and authorities such as ship captains, bridge officers, firefighters, port officials, and other maritime stakeholders. Each actor has different needs because they have distinct purposes and in consequence, they make varied use of data. Findings reveal a strong demand for Internet of Things (IoT) based fire tracking, Unmanned Aerial Vehicle (UAV) assisted infrared (IR) monitoring, and improved data-sharing capabilities via Electronic Chart Display and Information Systems (ECDIS). Additionally, the transition to the S-100 standard is expected to enhance SA and interoperability. The DS will address current gaps in fire response through automation, standardized communication protocols, and real-time data integration, ultimately improving maritime safety and decision-making. This task has analysed and formalize the demands of these users based on the inputs of WP2. This task also investigates ergonomics and how information should be represented in different contexts.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS

AIS – Automatic Identification System
COP – Common Operational Picture
DG – Dangerous Goods
DS – Digital Solution
ECDIS – Electronic Chart Display and Information Systems
ENC – Electronic Navigational Charts
GI – Geospatial Information
HSSC – Hydrographic Services and Standards Committee
IACS – International Association of Classification Societies
IALA – International Association of Marine Aids to Navigation and Lighthouse
IEC – International Electronics Commission
IHO – International Electronics Commission
IMO – International Maritime Organization
IoT – Internet of Things
IR – Infrared
ISO – International Organization for Standardization
MRCC – Maritime Rescue Coordination Center
NIPWG – Nautical Information Provision Working Group
OGC – Open Geospatial Consortium
RNCs – Raster Navigational Charts
SA – Situational Awareness
S-100WG – S-100 Working Group
S-101PT – S-101 Project Team
S-102PT – S-102 Project Team
SOA – Service-Oriented Architecture
SOLAS – International Convention for the Safety of Life at Sea
SSA – Shared Situational Awareness
TWCWG – Tides, Water Level and Currents Working Group
UAV – Unmanned Aerial Vehicle
UI – User Interface
UML – Unified Modeling Language
VHF – Very High Frequency
VTS – Vessel Traffic Service
WWWNWS-SC – Sub-Committee on the World-Wide Navigational Warning Service

INTRODUCTION

Fire incidents on cargo ships present a critical challenge in maritime safety, necessitating robust detection, response, and coordination mechanisms. The Overheat project addresses these challenges by designing a DS that integrates sensor-based fire monitoring, UAV surveillance, and real-time data-sharing via ECDIS. This deliverable, D5.1, consolidates end-user requirements gathered through surveys, interviews, and workshops with maritime professionals. The study identifies key areas for improvement, including the need for automated fire tracking, enhanced SA tools, and seamless interoperability with existing maritime safety frameworks. It presents the methodology used to gather user requirements, analyze existing gaps, and assess technological feasibility. The results highlight the critical role of advanced fire detection and management methods based on the current limitations in precise fire localization and fire type assessment. To address these gaps, the DS integrates IoT-based fire monitoring with UAV-assisted IR imaging, real-time sensor fusion, S-100 data standards and SOA to enhance SSA and firefighting coordination. By leveraging advanced digital systems and standardized data exchange protocols, the DS aims to streamline fire response procedures, improve coordination among vessels, ports, and emergency responders, and support the future of digitalized maritime safety operations. Future work will focus on refining the system through simulations and real-world trials at selected European ports: Genova port (Italy), Brest port (France), Valencia port (Spain), Bremen port (Germany) and Gdynia port (Poland).

Methodology description

To develop the DS tailored to maritime fire safety, a structured user research methodology was employed, guided by Kathy Baxter's "A Practical Guide to User Research Methods" (2015) (Kathy Baxter, 2015). This approach ensured that the DS aligns with real-world user needs, operational challenges, and technological constraints. It involved identifying key functions of the DS and creating realistic scenarios to understand user interactions and challenges. The methodology incorporates a combination of qualitative and quantitative research techniques, including surveys, interviews, and workshops with maritime professionals. These methods were selected to capture diverse perspectives, ranging from ship captains and firefighters to port authorities and emergency responders.

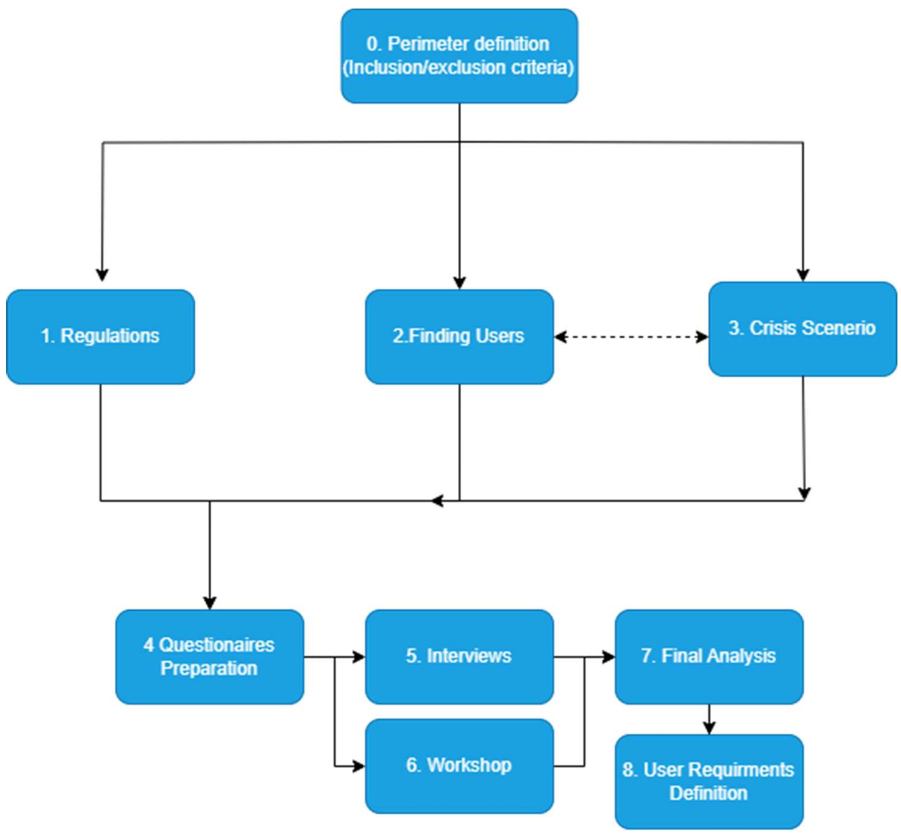


Figure 1: Methodology

The methodology is briefly explained below:

Perimeter Definition/Scope (Inclusion and exclusion criteria)

This section outlines the boundaries of the task by specifying what is included (Inclusion Criteria) and what is excluded (Exclusion Criteria), ensuring clarity on the scope of work

Inclusion Criteria

I. Fire management for Cargo ships only
II. Fire management only includes fire detection and firefighting part

III. The Cargo ships being studied are only the one which have obligations to have ECDIS, so the research is focused on the use of ECDIS only
IV. The fire can occur within the Cargo space (regardless of the nature of goods it contains, for example dangerous goods (DG), non-dangerous goods, declared/mis declared goods etc.)
V. Include all relevant stakeholders that are directly impacted by or involved in maritime operations and emergency responses, such as:
   a. Maritime operators and vessel crews
   b. Port authorities and harbour managers
   c. Emergency responders (e.g., firefighters, assistance crew)
   d. Regulatory and environmental agencies

Exclusion Criteria

I. Exclude passenger ships, fishing vessels, and other non-cargo ships from the research scope.
II. Exclude cargo ships that are not required to have or do not have ECDIS installed.
III. Exclude fires that are unrelated to cargo operations or are specific to non-cargo vessels.
IV. Exclude scenarios that do not involve maritime operations or where fire management is not relevant to cargo ship operations.
V. Exclude ships that do not adhere to the International Convention for the Safety of Life at Sea (SOLAS) regulations or are not required to do so.
VI. Exclude ships lacking in necessary fire management technology integration relevant to the study's focus

Regulations, Standards and Good Practices

The regulations, standards and good practices are required as they play a crucial role in the development of a fire management system for cargo ships. Regulations, established by public authorities, ensure that fire detection and firefighting systems comply with legal requirements and safety protocols, safeguarding both the crew, ships and the environment. Standards, developed through consensus by recognized bodies like International Electronics Commission (IHO), International Maritime Organization (IMO) and International Electronics Commission (IEC), provide consistent guidelines and technical specifications that promote reliability, interoperability, and effectiveness of the system. Good practices, shaped by industry experience and governance principles, help in optimizing implementation, ensuring that the system operates efficiently in real-world scenarios and meets the highest safety and operational standards. Together, these frameworks are essential for ensuring that the fire management system not only meets legal and technical requirements but also achieves the best possible outcomes in protecting life, property, and the marine environment.

Finding Users and user categorization

In this section, the book Understanding your Users, a practical guide to user research methods (Kathy Baxter, 2015) was used to guide the approach. To identify the end users of the fire management system for cargo ships, it began by understanding the key functions of the DS and the known challenges it aims to address. Identifying potential end users requires asking: Who are the intended users of this solution? This involves creating user personas based on demographics, behaviors, needs, and pain points. To ensure a user-centered design, users were categorized into three distinct types: **primary, secondary, and tertiary**. This typology enabled us to examine the diverse roles and interactions each user group would have with the system. Subsequently, comprehensive user profiles and detailed personas were developed for each category. This systematic approach guaranteed that the DS design prioritizes user needs, enhancing its effectiveness and usability.

Crisis Scenario Making, Crisis Scenario Analysis, Examples

In the third section, crisis scenarios were created for fire detection and firefighting based on the user personas developed earlier and used cases delivered by task 2.1 from WP2. To do this, a scenario template by (Paul McInerney, 2003) was used which included several key elements such as title of the situation, the initial situation, method to address the situation and execution path. Scenarios are instrumental in bringing users to life during product development. They allow to evaluate the system early in the process, helping to determine whether the system meets user needs and integrates smoothly into the user's workflow. Scenarios fostered questionnaire development, simulating real-world situations to gather end-user requirements aligned with Overheat DS's core objectives. This approach ensured that the crisis scenarios reflect real-world situations and support the development of an effective fire management system.

Questionnaire Preparation

In the fourth step of the research, data collection methodology was optimized by adopting a mixed-methods approach, synthesizing both qualitative and quantitative techniques. Although the preference lied in qualitative inquiry, quantitative data was supplemented to provide a comprehensive understanding. Specifically, the methodology entails in-depth interviews to explore themes and perspectives and survey questionnaires to gather numerical data and identify trends. The interviews were semi-structured. The questionnaire was designed so that relevant crisis scenarios could be presented in the interview, and participants could be asked how they would respond. Additionally, questions were added to seek feedback on what improvements the users would like to see as for the DS. This approach ensured to gather targeted insights from each user group to refine the solution.

Interviews and Surveys

The interviews and surveys with end users based on the developed questionnaires were conducted. The interviews were conducted face-to-face and virtually via Microsoft Teams. Each interview lasted between 40 minutes and 1 hour while for the survey it was 8 minutes of presentational video followed by a survey of 20 minutes. The questionnaire was designed to address specific aspects of the fire management system and DS, with questions applicable to all end users. This approach ensured to capture a comprehensive range of perspectives and requirements. During the interviews, participants were presented with relevant crisis scenarios related to fire detection and response. They were asked to describe their responses to these scenarios and provide feedback on potential DS in the context of our project objectives.

Workshops

In this section, the results of workshops organized with key stakeholders and experts are presented. The primary aim of these workshops was to discuss the OVERHEAT DS in detail and gather additional insights and suggestions. This also included a summary of user feedback related to various aspects of the system, such as fire detection display features in ECDIS and the acceptance of UAV feed etc. This involved engagement with participants to explore any discrepancies or areas that require further clarification.

Further recommendations and suggestions from experts were collected to enhance the system's design and functionality. This involved discussion regarding prioritizing features, and addressing any gaps identified. Using the feedback from the workshops, the system requirements were refined and finalized, ensuring that they align with both user needs and technical feasibility and project's objectives.

As a brief format of the workshop, it included:

- Presentation: A presentation on the OVERHEAT project and the DS
- Discussion Sessions: Group discussions and question answers were facilitated to explore the findings and gather additional input
- Feedback Collection: Structured methods such as surveys forms were used to capture expert opinions and suggestions.
- Results: The collected data underwent thorough analysis, yielding final results that enhanced the system design and incorporated valuable stakeholder feedback.

Final Analysis

In the final analysis phase, the findings from the interviews, surveys, and workshops were synthesized. This involved integration of feedback and insights from various sources to build a comprehensive understanding of user needs and system requirements. The most significant patterns and issues identified throughout the research are highlighted. It is to ensure that the refined requirements align with user needs and project objectives. The last step is to develop actionable user recommendations for system improvements based on the analysis. This provides a clear and actionable set of conclusions to guide the final development and implementation of the system.

User Requirements Definition

In the final step of the research is focused on defining the user requirements. This involved documenting the needs and specifications identified in final analysis through interviews, surveys, and workshops. These requirements are organized into categories, such as functional and non-functional, to ensure all aspects are covered comprehensively. The requirements were then prioritized based on their significance and impact on the system's effectiveness and user satisfaction.

Following this, the requirements were reviewed and validated with stakeholders and end-users to confirm their accuracy and relevance. The culmination of this process is detailed and formal requirements document that will serve as the foundation for the system's development and implementation, ensuring that all user needs are clearly communicated and addressed.

1. Section – 1 Regulations/Standards/Good Practices

1.1. Regulations

Regulation is defined as intentional and direct interventions by public-sector actors in the economic activities of private-sector actors, shaping their behavior and outcomes to achieve specific goals. (Koop, 2017)

So, it can be deduced that regulations are:

1. **Intentional intervention:** Public-sector actors (government agencies, regulators, etc.) deliberately and actively intervene in the economic activities of private-sector actors (businesses, organizations, etc.).
2. **Direct intervention:** The public sector directly influences or shapes the behavior, decisions, or outcomes of private-sector actors, often through explicit rules, standards, or guidelines.
3. **Economic activities:** The focus is on regulating aspects of private-sector economic activities, such as production, distribution, pricing, or innovation.

To define standard, International Organization for Standardization (ISO) and IEC are referred, and they define standard as:

"A document established by consensus and approved by a recognized body that provides for common and repeated use, rules, guidelines or characteristics for activities, or their results aimed at achieving the optimum degree of order in a given context." (ISO, 2004)

While good practices are a tool used to promote good governance and regulate through sense-making processes in Europeanization processes (Vettoretto, 2009).

For maritime industry, there are mainly 3 organizations which publish regulations, standards and good practices. These are:

I. IMO (SOLAS Agreement, STCW and Resolutions)
II. IHO (Specifications)
III. IEC (Standard 61174)

An ECDIS display must be type-approved by a Classification Society or recognized maritime safety organization established within a flag country or by a classification society authorized by a flag state to undertake ECDIS type approvals. Some examples of Classification Societies are ABS, Bureau Veritas, DNV, and ClassNK. Most of them are part of International Association of Classification Societies (IACS).

Table 1 explains the concerned regulations by IMO which deals with our scope of work i.e. ECDIS and Fire Management. The SOLAS Convention serves as a perfect standard for ensuring safety of life at sea. (IMO, 2024). For the research, the relevant chapters and their regulations from the SOLAS are Chapter II (fire detection and management) and Chapter V (navigation) (IMO, 2024).

Part	Regulation	Title	Summary
Part A - General	Regulation 1	Application	Applies to ships built on or after 1 July 2002. Ships constructed before that date must comply with the previous chapter, with some revised requirements.
	Regulation 2	Fire Safety Objectives and Functional Requirements	Provides the fire safety objectives and functional requirements for the chapter.

	Regulation 3	Definitions	Defines the terms used throughout the chapter.
Part B - Prevention of Fire and Explosion	Regulation 4	Probability of Ignition	Focuses on preventing the ignition of combustible materials or flammable liquids.
	Regulation 5	Fire Growth Potential	Limits fire growth potential in all spaces of the ship.
	Regulation 6	Smoke Generation Potential and Toxicity	Reduces the hazard to life from smoke and toxic products generated during a fire in spaces where people normally work or live.
Part C - Suppression of Fire	Regulation 7	Detection and Alarm	Ensures fire detection in the space of origin and provides alarms for safe escape and fire-fighting activities.
	Regulation 8	Control of Smoke Spread	Controls the spread of smoke to minimize hazards.
	Regulation 9	Containment of Fire	Ensures containment of fire in the space of origin.
	Regulation 10	Fire Fighting	Focuses on the suppression and swift extinguishing of a fire in the space of origin.
	Regulation 11	Structural Integrity	Prevents the collapse of ship structures due to heat-induced strength deterioration.
Part D - Escape	Regulation 12	Notification of Crew and Passengers	Provides notification to crew and passengers of a fire for safe evacuation.
	Regulation 13	Means of Escape	Provides means of escape to ensure safe and swift evacuation to the lifeboat and life raft embarkation deck.
Part E - Operational Requirements	Regulation 14	Operational Readiness and Maintenance	Maintains and monitors the effectiveness of the ship's fire safety measures.
	Regulation 15	Instructions, Onboard Training, and Drills	Mitigates the consequences of fire through proper instructions, training, and drills for onboard personnel.
	Regulation 16	Operations	Provides information and instructions for proper ship and cargo handling operations related to fire safety.
Part F - Alternative Design and Arrangements	Regulation 17	Alternative Design and Arrangements	Provides a methodology for approving alternative designs and arrangements for fire safety.
Part G - Special Requirements	Regulation 18	Helicopter Facilities	Provides additional fire safety measures for ships fitted with helicopter facilities.
	Regulation 19	Carriage of Dangerous Goods	Provides additional fire safety measures for ships carrying dangerous goods.
	Regulation 20	Protection of Vehicle, Special Category, and Ro-Ro Spaces	Provides additional fire safety measures for ships fitted with vehicle, special category, and ro-ro spaces
	Regulation 21	Casualty Threshold, Safe Return to Port, and Safe Areas	Establishes design criteria for a ship's safe return to port after a casualty and provides functional requirements for safe areas.
	Regulation 22	Design Criteria for Systems to Remain Operational After Fire	Provides design criteria for systems required to remain operational to support orderly evacuation and abandonment
	Regulation 23	Safety Centre on Passenger Ships	Provides a space to assist with the management of emergency situations

Table 1: SOLAS Chapter II-2 parts details

As this task concerns only with fire detection and firefighting, so part C-Suppression of Fire (regulation 7, regulation 8, regulation 9, 10), Part D- Escape (regulation 12), Part-E Operational Requirements (regulation 14 and 15), Part F-Alternative Design and Arrangements (regulation 17) and Part G- Special Requirements (regulation 22) are mainly concerned. For the regulations from chapter V, the concerned regulations are regulation 7, 8, 9, 18, 19, and 27.
For the details, SOLAS Regulations are referred (https://www.imo.org/en/About/Conventions/Pages/International-Convention-for-the-Safety-of-Life-at-Sea-(SOLAS),-1974.aspx).

ECDIS which is the main concern in this task is a mandatory system for most of the vessels that need to apply SOLAS requirements. Figure 2 shows the impacted vessels and the date since this system is required for them.

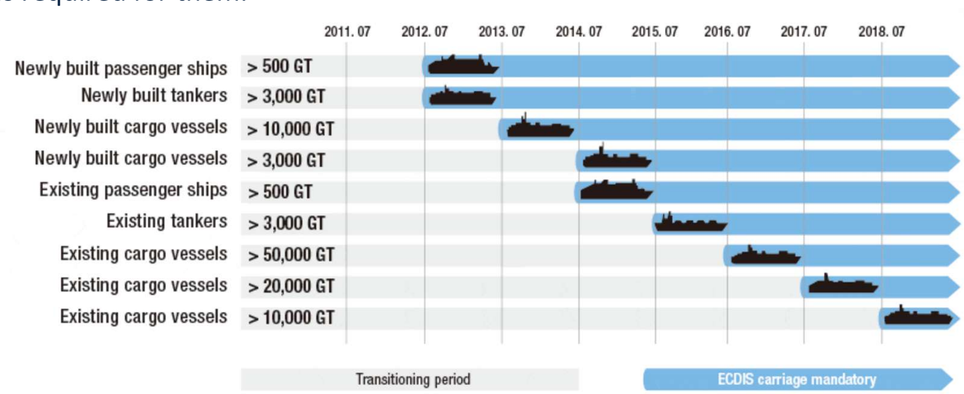


Figure 2 ECDIS Requirements by Vessel Size

1.2. Good Practices

The integration of ECDIS into maritime navigation is governed by SOLAS regulations and IMO guidance, ensuring compliance, safety, and operational efficiency. Key aspects of good practices include:

- Compliance with SOLAS Requirements: ECDIS must be type-approved, use up-to-date Electronic Navigational Charts (ENC), maintain compatibility with IHO standards, and have independent backup arrangements.
- Operational Guidelines: IMO's Guidance for Good Practice consolidates best practices for ECDIS software maintenance, operational anomaly management, and transitioning from paper charts to digital navigation.
- Integration Considerations: Proper adaptation of voyage planning, shift handovers, ECDIS settings, and combined use with paper charts is crucial for safe operations.
- Training and Human Factors: Crew members must receive appropriate ECDIS training to ensure effective use and compliance with regulatory requirements.

1.3. Section – 1.3 Standards

Standards should encapsulate the use of best practice methods and procedures. They should include guidance on how to implement efficient production methods and optimize the quality of an organization's products and services and should also enable interoperability between disparate technologies through the use of common interfaces. (IHO, October 2023)

The IMO requires ECDIS to conform to specific performance standards to meet the chart carriage requirements specified in the SOLAS Convention. IHO standards are explained in this document. For standard on IEC 61174, please refer to the website of IEC.

1.3.1. IHO Standards Background

The IHO is the intergovernmental organization responsible for developing international standards related to hydrographic services as defined in SOLAS regulation V/9. Under its remit, and in support of the relevant performance standards for ECDIS adopted by the IMO, the IHO maintains the following set of standards related to ECDIS (IHO, Feb 2020):

- S-57 - Transfer Standard for Digital Hydrographic Data (including the Product Specification for ENC)
- S-52 - Chart Content and Display Aspects of ECDIS;
- S-64 - Test Data Sets for ECDIS
- S-58 - ENC Validation Checks
- S-61 - Product Specification for Raster Navigational Charts (RNC)
- S-62 - Data Producer Codes
- S-63 - Data Protection Scheme
- S-65 - ENCs: Production, Maintenance and Distribution Guidance
- S-11 Part A - Guidance for the Preparation and Maintenance of International (INT) Chart and ENC Schemes.

The S-57 Standard, the current cornerstone for digital hydrographic data, and the new S-100 Standard will be reviewed and explored, respectively, in this study.

1.3.2. S-57 Standard

The S-57 "Transfer Standard for Digital Hydrographic Data" is a key standard developed by the IHO for the exchange of digital hydrographic data. It is primarily used for the production and distribution of ENCs between national hydrographic offices, manufacturers, mariners, and other data users. The main purpose of the S-57 standard is to provide a comprehensive framework for the creation and distribution of ENCs. This includes detailed specifications for the descriptions of objects, attributes, data encoding formats, product specifications, and updating profiles. Essentially, the S-57 standard dictates how ENCs should be produced, ensuring consistency and interoperability across different platforms and devices.

1.3.3. S-100 Universal Hydrographic Data Model

S-100 Universal Hydrographic Data Model is the most important standard and is developed by IHO has developed to address future demands for digital products and services. This comprehensive model is designed to support a wide range of applications in hydrography and beyond. Central to the S-100 framework is the IHO Geospatial Information (GI) Registry, which contains several registers that manage lists of concepts, feature attributes, metadata, and other resources. These registers are essential for developing product specifications, allowing for greater interoperability and flexibility in creating new digital marine products. S-100 serves as the foundation for next-generation ENCs and supports the integration of additional data layers, facilitating enhanced navigation, marine spatial planning, and environmental protection.

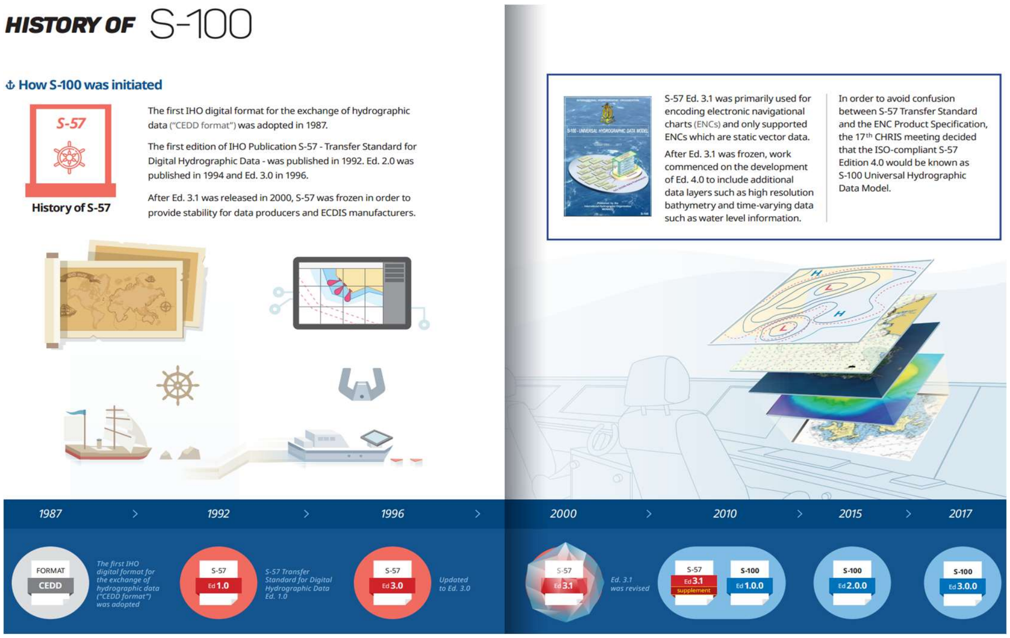


Figure 3: History of S-100 taken from (IHO, October 2023)

Figure 3, sourced from the IHO's publication (IHO, October 2023) offers a clear visualization of the S-100 Standard's framework:

Figure 4: S-100 Universal Hydrographic Data Model (IHO, October 2023)

S-100 will eventually replace S-57. The IMO's adoption of the revised Resolution MSC.530(106) on Performance Standards for ECDIS at its 108th Session in May 2024 underscores the global commitment to S-100 implementation. From January 1, 2026, S-100

ECDIS will be legal for use, with a transition period until January 1, 2029, after which all new systems must comply with the updated IMO ECDIS Performance Standards.

Although S-57 has many good aspects, it has some limitations (IHO, October 2023):

I. S-57 has been used almost exclusively for encoding ENCs for use in ECDIS.
II. S-57 is not a contemporary standard that is widely accepted in the GIS domain.
III. It has an inflexible maintenance regime. Freezing standards for lengthy periods is counterproductive.
IV. As presently structured, it cannot support future requirements (for example, gridded bathymetry, or time-varying information).
V. Embedding the data model within the encapsulation that is, file format) restricts the flexibility and capability of using a wider range of transfer mechanisms.
VI. It is regarded by some as a limited standard focused exclusively for the production and exchange of ENC data.

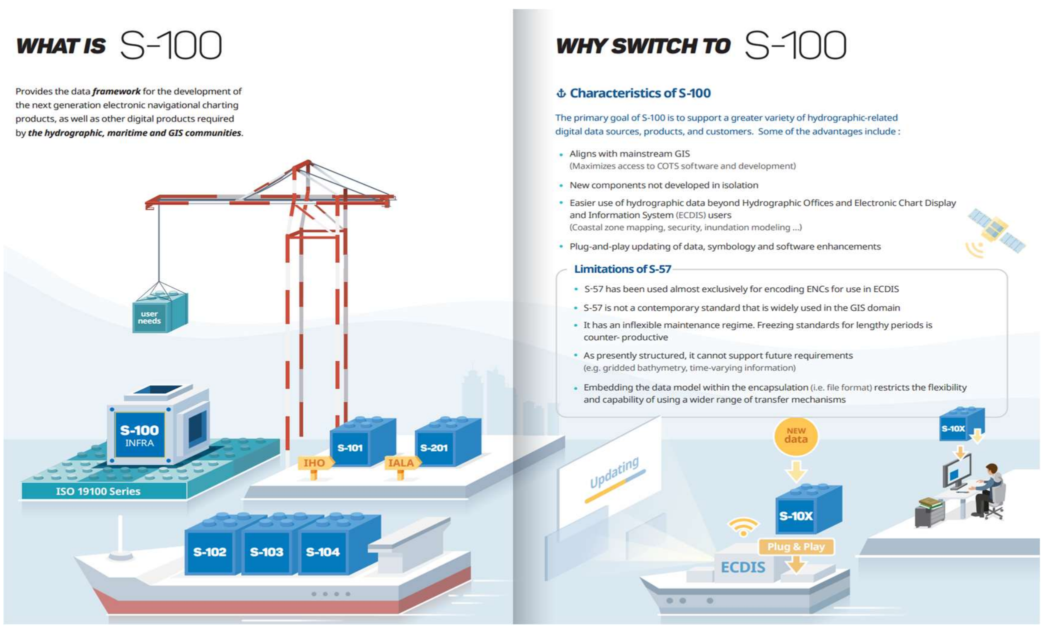


Figure 5: S-100 and limitations of S-57 (KHOA, May 2017)

The transition from S-57 to S-100 will be carefully monitored by the IHO to ensure that existing S-57 users, particularly ENC stakeholders, are not adversely affected. S-57 will continue to exist as the designated format for ENC data for the foreseeable future. In the meantime, all existing and potential users of hydrographic information and data are encouraged to use S-100 as the basis for new applications, seeking input to the further development of the standard if their particular requirements are not yet catered for.

Furthermore, S-100 provides a framework of components that can be used by interested communities to develop their own maritime geospatial products and services, and it will enable us to utilize the flexibility of S-100 for our DS in project OVERHEAT. The S-100 standard was developed with insights gained from the S-57 standard, leveraging experience to improve digital hydrographic data management. Documented using the Unified Modeling

Language (UML), S-100 employs class, object, and package diagrams to define its framework. The standard aligns with the ISO 19100 series, which forms the basis for many contemporary geospatial standards and initiatives, including those by the Open Geospatial Consortium (OGC). An integral part of S-100 is the IHO GI Registry, which supports its implementation.

The Objective of S-100 are:

i. To comply with the emerging ISO standards for geographic information being produced by ISO TC 211
ii. To provide support for a greater variety of marine or hydrographic-related digital data, products and customers
iii. To separate the data content from the encoding format, enabling format neutral product specifications
iv. To enable manageable flexibility that can accommodate change. The intention is that product specifications will be allowed to evolve through extension without the need to publish new versions of existing product specifications
v. To provide an ISO-conformant registry managed by the IHO containing registers such as feature concept dictionaries and product feature catalogues that are flexible and capable of managed expansion
vi. To provide separate registers for different user communities.

1.3.4. S-100 Products

The products of S-100 by IHO are as:

Product Code	Product Name	Scope	Responsible Body
S-101	Electronic Navigational Chart (ENC)	Specifies content, structure, data encoding, metadata for S-101 ENC data; includes portrayal requirements for ECDIS. Supersedes S-57 ENC PS.	S-100 Working Group (S-100WG) / S-101 Project Team (S-101PT)
S-102	Bathymetric Surface	Provides bathymetric coverage layer based on Bathymetric Attributed Grid (BAG) for navigation and other purposes.	S-100WG / S-102 Project Team (S-102PT)
S-104	Water Level Information for Surface Navigation	Encapsulates tidal and water level data for use in ECDIS or dynamic tide applications. Critical for route planning and port entry.	Tides, Water Level and Currents Working Group (TWCWG)
S-111	Surface Currents	Provides surface current information to complement the S-101 ENC for navigation safety.	TWCWG
S-121	Maritime Limits and Boundaries	Encodes digital maritime boundary information, including maritime limits, zones, and boundaries as per UNCLOS.	S-100WG / S-121PT
S-122	Marine Protected Areas (MPAs)	Encodes information on Marine Protected Areas for use in ECDIS and other systems; MPAs are protected areas of seas, oceans, estuaries, or large lakes.	Nautical Information Provision Working Group (NIPWG)
S-123	Marine Radio Services	Indicates location, availability, type of radio communications, frequencies, and content for navigational information and other maritime radio communications.	NIPWG
S-124	Navigational Warnings	Creates datasets for navigational warnings, primarily for ECDIS; contains urgent information relevant to safe navigation.	Sub-Committee on the World-Wide Navigational Warning Service (WWWNWS-SC)
S-125	Marine Aids to Navigation (AtoN)	Describes navigational features including lights, marks, and local Automatic Identification System (AIS) messages; complements S-101 ENC.	NIPWG

S-126	Marine Physical Environment	Describes marine and terrestrial topography, currents, tides, weather, and other environmental conditions; complements S-101 ENC.	NIPWG
S-127	Marine Traffic Management	Covers Vessel Traffic Service (VTS), pilotage, routeing systems, and ship reporting systems; complements S-101 ENC.	NIPWG
S-128	Catalogue of Nautical Products	Exchange of catalogues of printed and digital nautical products; assesses applications for navigation and e-Navigation services.	NIPWG
S-129	Under Keel Clearance Management (UKCM)	Provides digital data format for maritime safety and efficiency of marine traffic; enables exchange between Under Keel Clearance Management System and onboard navigation systems.	S-100WG / S-129PT
S-130	Polygonal Demarcations of Global Sea Areas	Supports digital coordinates for global sea area limits; uses unique numerical identifiers.	Hydrographic Services and Standards Committee (HSSC) / S-130PT
S-131	Marine Harbour Infrastructure	Describes layout of port facilities and availability of port services; facilitates berth-to-berth navigation and voyage planning.	NIPWG
S-164	IHO Test Data Sets for S-100 ECDIS	Provides test data sets for ECDIS testing requirements as outlined in IEC 61174 standard.	-

Table 2: Products of S-100

The other S-100 products are:

- International Association of Marine Aids to Navigation and Lighthouse (IALA) (S-201 to S-299):
    - S-201 Aids to Navigation Information
    - S-210 Inter-VTS Exchange Format
    - S-211 Port Call Message Format
    - S-212 VTS Digital Service
    - S-230 Application Specific Messages
    - S-240 DGNSS Station Almanac
    - S-245 eLoran ASF Data
    - S-246 eLoran Station Almanac
    - S-247 Differential eLoran Reference Station Almanac

For details and other standards, please refer to website of IHO (https://iho.int/en/s-100-based-product-specifications).

For our task, following products have been identified as relevant:

- S-101 ENC
- S-104 Water Level Information
- S-111 Surface Currents
- S-124 (Navigational Warnings)
- S-125 Marine Aids to Navigation (AtoN)
- S-126 Marine Physical Environment
- S-129 (Under Keel Clearance Management)
- S-131 Marine Harbor Infrastructure
- S-164 IHO Test Data Sets for S-100 ECDIS
- S-201 Aids to Navigation Information
- S-421 Route Plan (IEC-TC80)

2. Section 2 – Finding Users and User Categorization

This section presents various end-user profiles involved in cargo fire management, focusing on their roles and needs. Understanding the DS from the user's perspective is crucial in the initial project stage, involving addressing key questions (Kathy Baxter, 2015) to ensure the solution effectively meets user needs and expectations.

2.1. Key Functions of the DS

The first step is to clearly identify and document the primary functions that the DS is planned to offer. This will help in aligning the user research with the product's core objectives. Understanding these functions allows to focus on features that are most relevant to potential users. DS system is comprised of three distinct subsystems.

1. ECDIS on Board
2. VTS Interface on Ground
3. PPU (Portable Pilot Unit)

Based on the objectives of the OVERHEAT project and tasks 5.1, following are the potential features of the product:

Type of DS	Description
ECDIS on Board	**Integration with Onboard Sensors:** Gathers data from fire detection sensors to identify potential fires
	Integration with Vessel Drone: Gathers data (pictures/feeds) from Drone on vessel regarding fire detection and fire management
	Real-Time Alerts: Generates alerts for the crew, indicating the precise location of the fire.
	Compliance with S-100 Standard: Compliance with S-100 meaning integration with multiple layers of data, including environmental and navigational information.
VTS Interface on Ground	**Real-Time Data Monitoring:** Provides real-time monitoring of maritime conditions such as traffic data, drone data from port, and fire incidents, integrating data from multiple sources.
	Integration with On Ground Drone: Gathers data (pictures/feeds) from Drone on ground/port regarding fire detection and fire management
	Alert Management: Manages alerts related to fire incidents, providing notifications to relevant authorities and agencies.
	Coordination Interface: Facilitates communication and coordination between maritime rescue coordinators, traffic, rescue teams in sea and on-ground response teams.
	Compliance with S-100 Standard: Compliance with S-100 meaning integration with multiple layers of data, including environmental and navigational information.
PPU (Portable Pilot Unit)	**Integration with Drone(s):** Interfaces with drone on vessel and/or drone on port for aerial surveillance and assessment of fire incidents. Provides live video feeds or thermal imaging to assist with SA.
	Real-Time Data Sharing: Enables the sharing of critical data between on-board and ground systems, enhancing SA.
	Compliance with S-100 Standard: Compliance with S-100 meaning integration with multiple layers of data, including environmental and navigational information.

Table 3: Key Functions of the DS

2.2. Identifying Potential End Users

To ensure the DS effectively addresses user needs, intended users were identified by creating detailed user personas based on demographics, behaviours, needs, and pain points. This user-centric approach guided the research and development process, ensuring alignment between the collected requirements and user needs. The primary users interacting with the ECDIS, VTS interface, and PPU modules were those involved in coordinating firefighting, search and rescue missions, and overall maritime safety.

S.No	Potential End Users	Examples of End Users	Missions	Missons concerned with OVERHEAT
1	Personals on board	Ship's Captain and Bridge Officers, Navigators, Engine Room Crew	Command and overall safety of the ship, Safe navigation of the vessel, Operation and maintenance of engine systems, Ensuring compliance with safety protocols	- Oversee firefighting operations and external agency coordination - Monitor ECDIS fire alerts for safe passage - Coordinate engine room fire response and prevention - Ensure procedural compliance and safety measures
2	Port/VTS	Harbor Master, VTS Operator	Monitor and manage vessel traffic	Monitor and manage vessel traffic
			essential navigational assistance	essential navigational assistance
			Coordinating responses during fire incidents on ships.	Coordinating responses during fire incidents on ships.
			Inspections of vessels entering ports	Ensuring that ships comply with safety regulations, which includes readiness for fire emergencies.
3	Pilots (Harbor Pilots)		Guiding ships in and out of ports	Assisting in maneuvering the vessel to a safe location during a fire emergency.
4	Rescue and Assistance Vessels	Firefighters	Rescue Crew, Fights the fire	Rescue Crew, Fights the fire
5	Maritime Rescue Coordination Centres (MRCC)	CROSS (Centres Régionaux Opérationnels de Surveillance et de Sauvetage)	Search and rescue	Search and rescue (coordination)
			Monitoring of sea traffic	
			Monitoring of pollution	Monitoring of pollution (loss of containers)
			Monitoring of fishing operations	
			Broadcasting of maritime safety information	Broadcasting of maritime safety information?
			Marine Environment Survey	Surveying the marine environment, especially after a fire to assess damage and pollution.
			Alert management	Managing alerts related to fire incidents and coordinating the response.
6	Rescue Institutions	Société Nationale de Sauvetage en Mer (SNSM), Naval & Air Forces, firefighters	Sea rescue	Sea rescue
			Rescue on the coast	Rescue on the coast
			Civil security and demonstrations, Protection, Deterrence, Intervention	Protection
7	On Route/Nearby Traffic (other merchant ships)	Any merchant ship near the accidented ship	Standby rescue operations and providing assistance during a fire.	Standby rescue operations and providing assistance during a fire.

8	Institutions	Affaires Maritimes	Accelerating Ecological Transition	
			Deploying Marine Renewable Energy	
			Advancing Maritime Data, Knowledge, and Innovation	
			Enhancing Maritime Surveillance and Safety	Enhancing Maritime Surveillance and Safety
			Supporting Maritime Economy, Employment, and Interests	

Table 4: Potential End Users

Following user identification, the subsequent step involves creating comprehensive user profiles and personas. This process enables the development of realistic scenarios, facilitating the collection of essential information through interviews or surveys. By gathering valuable insights into user needs and behaviours, overall user experience can ultimately be enhanced and to find the right solution.

2.3. User Profiling and User Personas

Developing user profiles was a fundamental step in creating a solution that met the needs of its intended users. A user profile is a detailed description of the users' attributes, which helped to understand who they were and what they required from the solution. This understanding was crucial for tailoring the solution's features and functionality to their specific needs.

The key components include in user profiling are:

I. Job Title (for example, Ship's Captain, master, chief engineer, sailor etc.)
II. Experience (for example, >16 years, 1~5 years of maritime experience etc.)
III. Level of Education (for example, Maritime School Graduate, Certifications etc.)
IV. Key Tasks (for example, Ship's Captain: Oversees all operations on the vessel)
V. Age Range (for example: 18-25, 26-35 years etc.)

These profiles are important to understand the user needs, development of the DS and users' requirement.

Another important step is to categorizing users in primary, secondary and tertiary categories. These are:

User Category	Role/Title	Interaction with DS
Primary Users	Ship's Captain and Bridge Officers, Navigators	Regularly use the module to monitor fire detection data, view sensor and drone feeds, and integrate this information into navigation decisions and ensure safety procedures are followed
	Fire Fighters and Assistance Crew	Provide assistance during Maritime fires
	Pilots (Harbor Pilots)	Uses module data to ensure vessels dock safely in the port
	VTS Officials, Port operators, Harbor Masters	Communication hub, to coordinate responses, provide guidance, and manage the traffic
Secondary Users	Institutions (Ex : In France, Affaires Maritimes)	Use the module's data for compliance checks and to support maritime safety measures and coordinate rescue missions
	Engine Room Crew	Use the module to receive alerts and monitor data related to fires near the engine room.

Tertiary Users	On Route/Nearby Traffic (Other Merchant Ships)	Indirectly affected by module's data, adjusting navigation or offering assistance if needed.
	MRCC	Access data from the module to coordinate responses, provide guidance, and manage alerts
	Rescue Services such as Société Nationale de Sauvetage en Mer (SNSM), Navy and Air Force, Firefighters	Use the module for managing search and rescue operations or providing aerial support in fire emergencies, by accessing data and coordinating with other units.
	Maritime Regulatory Bodies and Decision-Makers (IMO, IHO, Cedre etc.)	Involved in decisions regarding module implementation and integration into safety protocols.

Table 5: Types of Users

Note: Here on route/nearby traffic ships can be a same cargo ship as of vessel in distress but as per the scope of this task, but they are being considered rescue vessels other than the subject vessel as tertiary user in this case.

For this study, primary users will be the initial focus. Secondary and tertiary users will be considered subsequently, contingent upon available resources and time. Moreover, it is quite possible that any user can user have multiple responsibilities especially in the case of users on board the vessels.

While user personas are fictional individuals created to represent specific user types, they brought life to user profiles and enabled the research to connect with them on a personal level. By incorporating personas into the design process, more effective, user-centered scenarios were created to find solutions that meet the needs of the target audience. A template was developed for the User Personas as shown below:

Persona Element	Details
1. Identity	
- Age	Age
- Demographic Data	Representative characteristics, e.g., occupation, location, etc.
2. Status	Primary, secondary or tertiary user
3. Goals	Specific objectives related to the product
4. Skill Set	
- Education	Level and field of education
- Training	Relevant training or certifications
- Specialized Skills	Specific skills pertinent to the job or product usage
5. Tasks	
- Frequency	How often the tasks are performed
- Importance	The significance of the tasks in the user's role
- Duration	The time required to complete the tasks
6. Relationships	Associations with secondary and tertiary stakeholders
7. Requirements	
- Technical Requirements	Necessary conditions like specific devices, interfaces or OS
- Training or Education Needs	Any training or education required to use the product
8. Expectations	
- Understanding of Product	How the user thinks the product should work
- Information Organization	How the user organizes or accesses information in their job

Table 6: User Persona Template

Based on the user profiles and template, personas were developed for each user type, detailed in Annex-A. These user personas based on the user profiles will help to make scenarios for which in turn guided to make right interview questions.

3. Section 3–Scenarios/Use Cases

Following the development of personas, the next stage involved creating scenarios. Scenarios, often referred to as "use cases," are narratives centered around the personas developed during the user research phase. These scenarios align with the guiding principles identified and serve as detailed stories that describe how a particular persona completes a task or behaves in a specific situation. A well-crafted scenario includes a setting, actors, objectives or goals, a sequence of events, and concludes with a result.

3.1. Benefits of Scenarios

Scenarios are instrumental in bringing users to life during product development. They allow for early system evaluation, helping determine whether the system meets user needs and integrates smoothly into the user's workflow.

3.2. Components of a Scenario

A typical scenario includes:

- The individual user (persona)
- The task or situation
- The user's desired outcome/goal
- Procedure and task flow information
- A time interval
- Envisioned features/functionality needed by the user

Scenarios are essential tools for understanding user needs and behaviours. They help identify critical tasks, exceptions, and rare events that impact user experience. By creating scenarios, we can:

- Describe ideal task completion
- Anticipate problems and user reactions
- Inform design decisions
- Validate user requirements

A scenario template can ensure consistency and completeness. The recommended template includes (Paul McInerney, 2003):

i. Title: A general description of the situation
ii. Situation/Task: Initial situation, challenge, and user goal
iii. Method to Address the Situation: Generic, technology-neutral steps for task completion
iv. Execution Path: Narrative describing task completion, user goal achievement, and specific features or technology used

To develop realistic scenarios for this study, extreme cargo ships fire cases derived from historical data based on task 2.1 were utilized. To inform the scenarios, a short list of historical extreme fire-related incidents involving cargo ships are compiled, which will serve as use cases for the research. These cases include:

Ship Name	Size of Ship	Date of Fire	Cause of Fire	Loss	Location	Flag	Route
MSC Flaminia (Cedre, 2013)	300 m (6750 TEU)	14/07/2012	Explosion, Fire but the exact reason is still unknown	- 3 Crew deaths - Unknown number of containers overboard, Over $100 m	Atlantic Ocean, SW of English Channel	German	Charleston (US) to Antwerp (Belgium)
Maersk Honam (MAERSK, 2020)	340.5 m (15,226 TEU)	06/03/2018	Fire, due to DG	- 5 killed, $400 m	Arabian Sea, approximately 900 nautical miles (1,700 km) southeast of Salalah, Oman	Singaporean	Singapore to Suez (via the Arabian Sea)
Felicity Ace (Voiles et Voiliers, 2022)	200 m	16/02/2022	Possible lithium battery ignition	1,100 Porsches, 189 Bentleys, Audis, Lamborghinis, about $155m	90 nautical miles southwest of Faial Island, Azores	Panama	Germany to USA
MV Fremantle Highway (20 Minutes, 2023)	199 m (6,200 cars)	25/07/2023	Overheating of Lithium Ion Batteries	- 1 crew member -approx. 2800 cars, $150 m	off the island of Ameland in the northern Netherlands.	Panama	en route from Germany to Port Said in Egypt

Table 7: Use Cases for Scenarios

The above cases are shortlisted based on based on:

- Fire Detection Scenarios (for fires from lithium-ion batteries such as Felicity Ace, MV Fremantle Highway)
- Fire Detection Scenarios (for fires from DG such as Maersk Honam)
- Fire Fighting Scenarios (for fires such as use case of MSC Flaminia)

Aligning with the task objectives and user personas, a scenario template is developed, incorporating critical use cases and crisis scenarios outlined in Annex-B.

4. Section 4– Questionnaire Preparation

In the fourth section, data-gathering methodology is refined by adopting a mixed-methods approach that combines both qualitative and quantitative data collection. While the preference remains on qualitative insights, the value of incorporating quantitative data is recognized to support the findings with measurable evidence.

This step involved designing and preparing questionnaires for use in both interviews and surveys. The interviews were semi-structured, featuring a set of core questions that remain consistent across all participants to ensure comparability, while also including tailored questions that are specific to each type of end user. This structure allowed for both in-depth exploration of individual perspectives and standardization for data analysis.

During the interviews, relevant crisis scenarios were presented, reflecting real-world maritime incidents originating from the most prevalent causes of fire such as misdeclaration of DG, human errors, lithium-ion battery fires etc. and asked participants how they would respond. This helped to understand their decision-making processes under pressure and what tools they would need in such situations. Participants' preferences were also explored, and feedback was gathered on potential improvements to the DS, particularly with respect to the key objectives of fire detection and fire management and S-100 standard.

In addition to qualitative responses, quantitative survey questions were incorporated to capture user satisfaction, frequency of use of specific systems, and perceived effectiveness of current fire management tools. This helped to quantify the users' experiences and evaluate trends across different user groups.

By combining these methods, targeted insights were aimed to be gathered from each user group, ensuring that their feedback directly informs the refinement of the DS. This approach not only allowed to validate the needs and preferences of the users but also aligned with the broader goal of developing a more effective, user-centered fire detection and management solution.

The questionnaire had mainly two sections.

- General Section: To gather general demographic data, jobs and responsibilities
- Fire Assessment and Response: To gather user feedback on fire emergencies
- SA: To gather feedback on enhancing coordination and decision making
- S-100 Integration: for transitioning from S-57 to S-100 to optimize response
- Desired technological improvements/digital solution: User open ended suggestions

The detailed questionnaire is attached in Annex-C.

5. Section 5– Interviews and survey

Interviews and surveys were conducted with end users based on the developed questionnaires. These interviews were conducted either face-to-face or virtually via Teams. They helped to gather in-depth insights into user needs. Each interview lasted between 40 minutes and 1 hour while the surveys were completed within approximately 20 minutes.

The questionnaires were designed to address specific aspects of the Shared Situational Awareness (SSA), fire management system and transition of S-57 to S-100, with questions applicable to all end users and additional questions tailored to each user type. This approach ensured to capture a comprehensive range of perspectives and requirements. Microsoft Forms were used for the surveys and posted them on LinkedIn and created flyers, shared with Overheat partners in annual meeting and on emails.

Figure 6 LinkedIn Post and flyer for Survey participation

During the interviews, participants were presented with relevant questions related to fire detection, response, SSA, UAV Imagery, ECDIS sharing, transitioning of S-57 to S-100, and user recommendations. To systematically analyze the qualitative data collected from the interviews, template approach to text analysis was employed, as outlined by (Benjamin F. Crabtree, 1992). For survey data analysis Power BI was used. This method involved several key steps. Based on user personas and project objectives, key themes were established such as fire detection, firefighting, SSA, and system integration of ECDIS. The data was coded. Each response was tagged with the appropriate theme to facilitate analysis. Consistent application of the coding framework helped in comparing responses and identifying common patterns. Patterns and trends within and across categories were looked for, with a focus on common challenges and suggestions from different user personas. Insights were drawn regarding user needs and system effectiveness, informing potential improvements to the fire management system. Findings were summarized in a structured format, highlighting key insights and recommendations. Visual aids such as graphs and bar charts are used to illustrate trends. The results are linked back to the project objectives to explain how the insights will guide the development and enhancement of the fire management system with ECDIS.

6. Section 6 – Workshops

6.1. User Engagement and Workshop Structure

To gather end-user insights and refine the Overheat Project's DS requirements, three workshops were conducted at ENSM, Nantes. These workshops focused on maritime fires, fire management, SA, and details on OVERHEAT Project. It involved a diverse group of 34 participants with extensive maritime and firefighting experience.

Figure 7 Workshops held at ENSM, Nantes

6.2. Participants and Expertise

The workshops brought together professionals from various maritime domains, ensuring a well-rounded discussion on fire safety challenges and the DS. The participants included:

- Ship Captains
- Firefighters
- Tugboat Captains
- Bridge Officers & Navigators
- Other ship captains (military, passenger ships etc.)
- Students with Navigational Experience

Each session included presentations on fire detection technologies, SA tools, and emergency coordination challenges. Scenario-based discussions were fruitful on past fire incidents and how improved DS (such as UAV surveillance, IoT sensors, and ECDIS integration) could enhance response efforts. Q&A and open discussions took place where participants shared their real-world experiences, identified limitations in current fire detection and management systems, and provided recommendations for improvement. Survey-based user requirements were collected, allowing participants to formally document their needs and expectations for the Overheat Project's proposed digital solutions.

6.3. Key Outcomes

The workshops facilitated valuable discussions on fire detection limitations, the role of real-time data integration and digitalization, and the need for enhanced SA in maritime firefighting. Participants emphasized that **IoT sensors, and UAV**, when combined with **S-100** based data visualization, could significantly **enhance SSA** and enable proactive, data-driven firefighting strategies. Participants also highlighted challenges in **communication, response coordination, and technological gaps in existing fire management systems**, reinforcing the need for **a unified digital platform** to enhance decision-making and emergency response.

6.4. Additional Works

To support the development of the Overheat Project's DS, additional research has been conducted and submitted for publication in peer-reviewed conferences. These papers explore **SSA, data integration, and decision support for maritime fire management**.

6.4.1. IEEE CogSIMA 2025 – Cognitive and Computational Aspects of Situation Management

Paper: ***Enhanced SSA and Decision Support in Maritime Firefighting: Insights from the Overheat Project***

This paper focuses on SSA in maritime firefighting and the challenges of managing fire incidents on container ships. It highlights how human error and outdated coordination methods impact fire response effectiveness. The research applies **Endsley's three-level SA model** to maritime fire scenarios and proposes a collaborative digital platform to enhance SSA through real-time data exchange. The Overheat Project's DS is introduced, detailing its architecture and integration of vessel and shore-based data systems to provide a Common Operational Picture (COP) for all stakeholders. The study underscores the importance of **integrating real-time fire detection data** for improved decision-making and response strategies.

Below figure 5 explains the COP in case of DS being utilized in case of ship on fire.

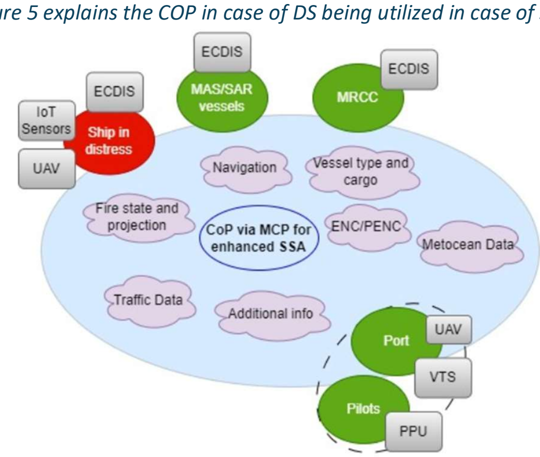


Figure 8 COP with OVERHEAT's DS

6.4.2. OCEANS 2025 Brest – Global Maritime Technology and Safety Conference

Paper: ***Enhanced Information System and Data Management for Maritime Fire Safety***

This paper highlights the critical role of real-time data visualization, IoT sensors, UAV-assisted thermal imaging, and AI-driven decision support in mitigating fire risks aboard cargo ships. The study emphasizes the integration of S-100 standard-based data sharing and Service-Oriented Architecture (SOA) to improve interoperability between offshore and onshore fire response systems. It presents a DS framework divided into Vessel DS and Port DS, ensuring coordinated fire management operations. It demonstrates the importance of SSA among ship crews, port authorities, and emergency responders.

It discusses case studies of past maritime fire incidents, reinforcing the necessity of improved fire management techniques, particularly in handling misdeclared DG. Future work includes validating these systems through simulations and real-world trials at European ports. By leveraging state-of-the-art information systems and maritime data management strategies, the Overheat Project aim to enhance fire risk mitigation, SA and emergency response efficiency, contributing to safer maritime operations and reduced environmental impact from ship fires. Below figure 9 explains the simplified model:

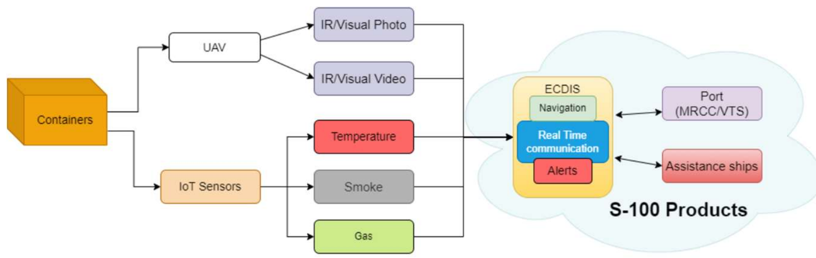


Figure 9 Simplified representation of the Digital Information System

7. Section 7 - Final Analysis

This section provides a final analysis of the DS from collected data from interviews, surveys and workshops. It focuses on its role in addressing the challenges faced by three primary user groups first Ship Captains, Bridge Officers, Navigators, second Firefighters, pilots, and third for Port official such as VTS Officials and harbour masters. The DS integrates real-time data, IoT-enabled sensors, UAV and S-100-based visualization to improve SA, fire detection, and response coordination. The following outlines the specific requirements identified.

7.1. General Section

There is a total of 45 respondents which ranges from Ship Captains, Bridge Officers, Navigators, Firefighters, pilots and maritime experts. These also include students but with wide navigational and field experience. Some of them also have faced fire events. The respondents have navigated in **multiple type of ships such** as **Cargo Ships, Cargo ships with dangerous goods**, **firefighting and assistance ships.** It also includes few individuals from military and passenger ships. 25% of the ship captains, bridge officers and navigators and 38% of the students have served in firefighting or assistance vessels.

27% of the respondents are experts having more than 16 years of experience, 29% are between medium to senior career level with experience ranging from 5 to 16 years and 33% with 1-4 years of experience. 33% of these respondents have faced fire events ranging from 1~5 events.

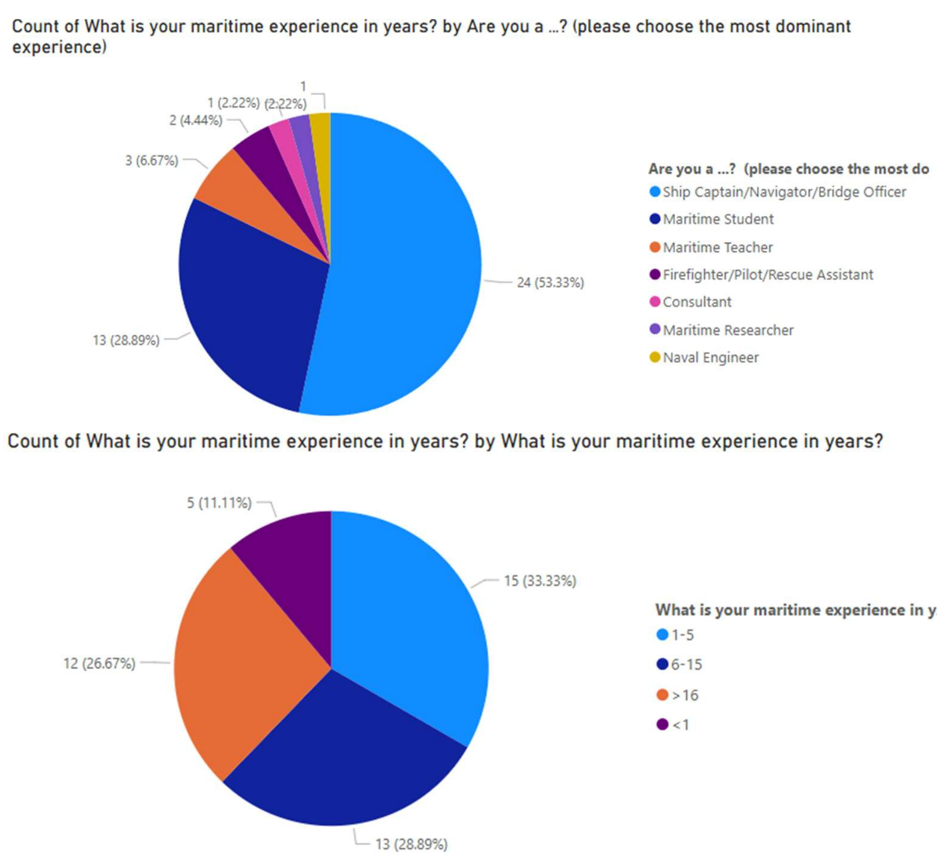


Figure 10 Respondents category and experience

7.2. Fire Assessment and Response

Majority of respondents use Very High Frequency (VHF) and mobile phones during fire emergencies while some use only VHF. Few also uses emails along with VHF and phone, but VHF remains the most common answer. It implies there is no standard method as there are plenty of options for communication available but VHF and mobile phone are preferred depending on the country and availability. For example, in Spain, during fire emergencies firefighters only use mobiles while in France, preference is given to VHF.

The respondents said they use smoke detectors and sensors (temperature, gas, etc.) to detect fire. Several other methods are also suggested. Visual detection, often combined with other methods, is also a common response. Portable IR cameras are also suggested as valuable tools. However, a significant portion of respondents express doubt about the possibility of **precisely locating a fire's origin**, stating that it is quite impossible**.** This is fortified with response to another question that majority of the respondents want to locate the origin of fire in the event of fire, or they would proceed to investigate with the crew. The needs for **advanced detection** and **SA tools** are highlighted.

To assess the severity of fire, **the location of fire, type of cargo** and **temperature** of the container is important to know. Based on these insights, a comprehensive fire assessment system should prioritize real-time fire location tracking, cargo classification, and continuous temperature monitoring. To assess the type of fire, the answers centre around several key pieces of information: **colour of the flame, density of smoke, colour of smoke**, and **type of cargo**. Major response was received for colour of flame and smoke, density of smoke and type of cargo.

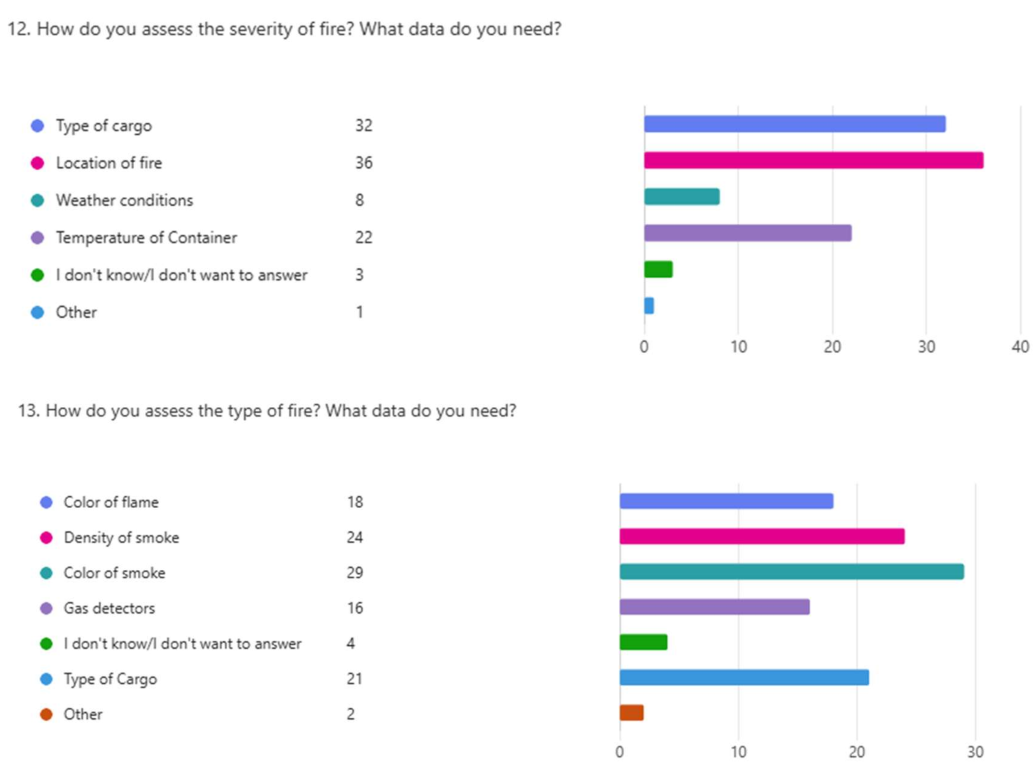


Figure 11 Parameters for severity and type of fire

The inability to precisely locate a fire remains a critical challenge, despite the use of smoke detectors, temperature and gas sensors, and IR cameras. This underscores the need for enhanced fire detection through IoT sensors and UAV-assisted visual and IR monitoring. Assessing fire severity and type depends on fire location, cargo type, container temperature, and flame and smoke characteristics (colour, density), requiring real-time data integration, sensor-based alerts, and access to cargo databases. A robust fire digital system should combine real-time visual and sensor data, automate fire location tracking with UAVs, and minimize human exposure to hazardous areas, ultimately improving maritime fire safety and emergency response.

The ideal time to gather global information during a fire operation should be less than **15 minutes** as there is 77% consensus for it and should not be more than **30 minutes**. Then to call for external assistance during firefighting, parameters such as **severity of fire, DG, chances of explosion** and **availability of firefighting equipment** and its efficiency are important. Complying that in case of above mention scenarios, the DS must give the option to call of external aid. To choose which actors need to be called in such a case, the majority consensus results for **MRCC/VTS, Assisting/firefighting ships, nearby ships, ship owners and ship operators**. Of all the answers, MRCC/VTS remains the most common answers.

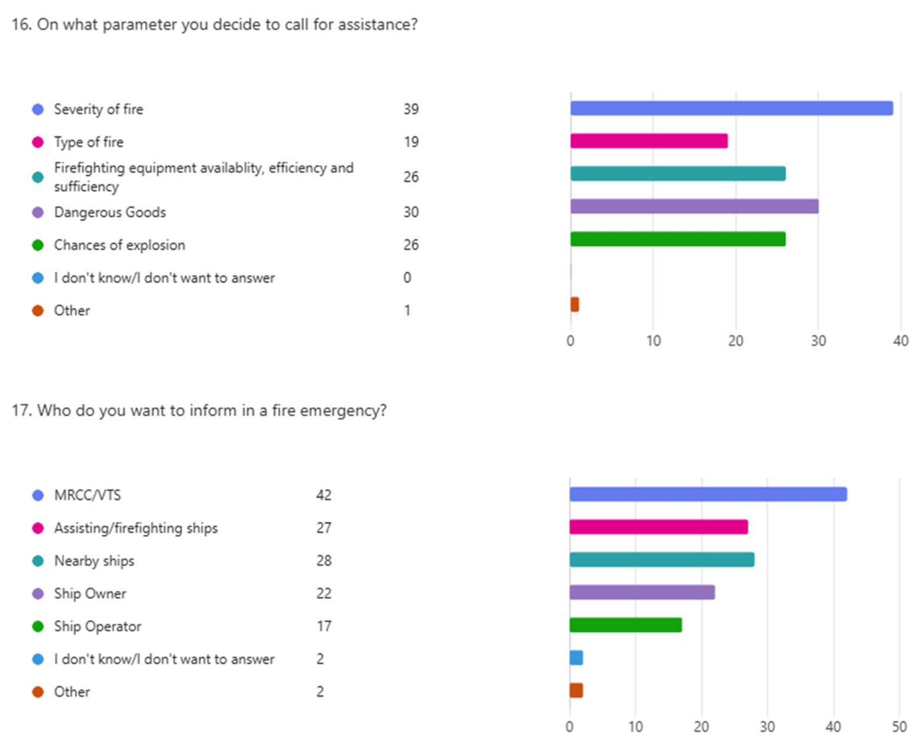


Figure 12 Parameters to call for external aid and actors

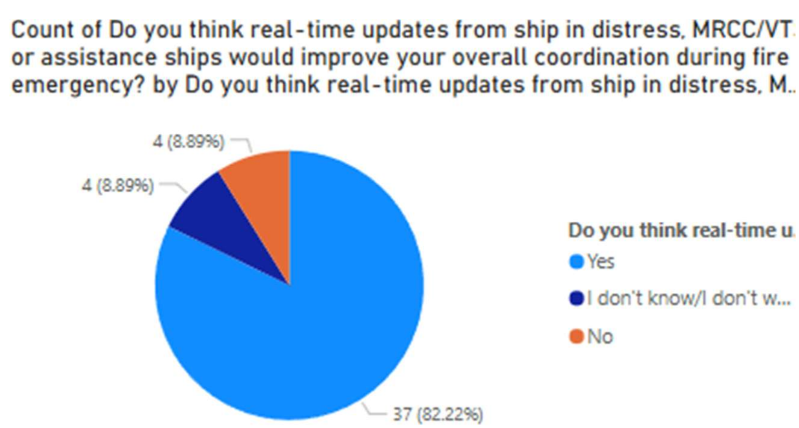
Currently, the biggest challenges in managing traffic nearby a fire operation are prioritizing rescue and assistance vessels, monitoring and predicting the spread of fire and communicating exclusion zones to all vessels in real-time.

The respondents identified several shortcomings in current fire detection and firefighting capabilities. They want better tools and technologies to **pinpoint the origin of fires**, **address accessibility challenges, enhance visual detection**, **provide real-time updates**, **improve sensor technology,** and utilize **UAVs with IR cameras**. It is also fortified with the answers that 84% respondents want an advanced firefighting system with notifications and type of fire and some wants at least an advanced firefighting system with notifications**.**

The findings highlight the lack of a **standardized communication method** during fire emergencies, with VHF and mobile phones being the most commonly used tools, varying by country. Fire detection largely relies on smoke detectors, temperature and gas sensors, and visual detection, but precisely locating a fire remains a major challenge, reinforcing the need for IoT sensors-based fire tracking and UAV-assisted IR monitoring. Firefighters prioritize real-time fire location tracking, cargo classification, and continuous temperature monitoring to assess fire severity, while flame colour, smoke density, and cargo type are key indicators for fire type assessment. Most respondents agree that SA must be established within **15 minutes**, and in severe cases, the system should facilitate **automatic alerts** to MRCC/VTS, firefighting and assistance ships, and relevant actors. These insights confirm the necessity of a digitally integrated fire management system such as the DS that enhances detection, improves coordination, and minimizes human exposure to hazardous conditions.

7.3. Situational Awareness (SA)

For SA section, 89% of the users want an automated system to share real time updates. The important piece of information they consider are **navigational data, type and location of fire, and sensors data**. Several also opted for **visual/IR camera output**. 82% of the respondents believe that sharing real time updates will **improve overall coordination** during fire emergencies. This is specially emphasized by firefighters as well. Hence **increasing SA** can directly increase the efficiency during a fire operation. 38% of the respondents exchange with other actors all the time during a fire operation while 33% of the respondents do it only based on the severity of fire.



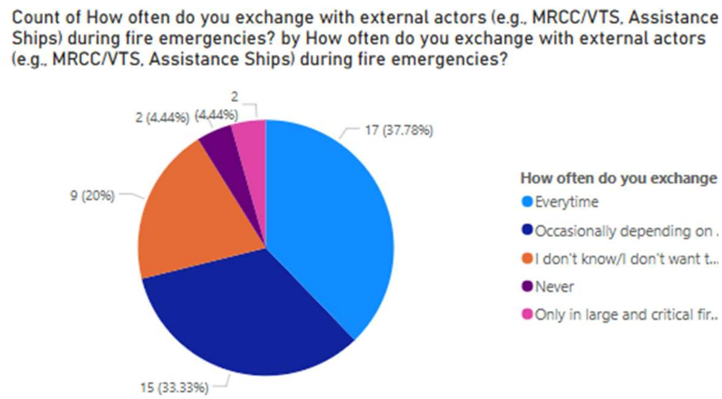


Figure 13 Real-time exchange

When asked about their preferences about VHF/phone over ECDIS during fire operation, the majority preferred VHF/phone. Several users opted to prefer ECDIS for quicker decision making while one of the most common answers for ECDIS preferences were real-time data/visual representation and UAV images/videos. So, if real-time data/visual presentation, UAV images, quicker decision making are the characteristics of ECDIS, the user would prefer ECDIS. Majority (73%) preferred ECDIS to share, manage and combine all kind of fire data. About 76% wants to have UAV images/videos for fire detection, monitoring and firefighting and 69% want to have UAV in assistance vessels and ports.

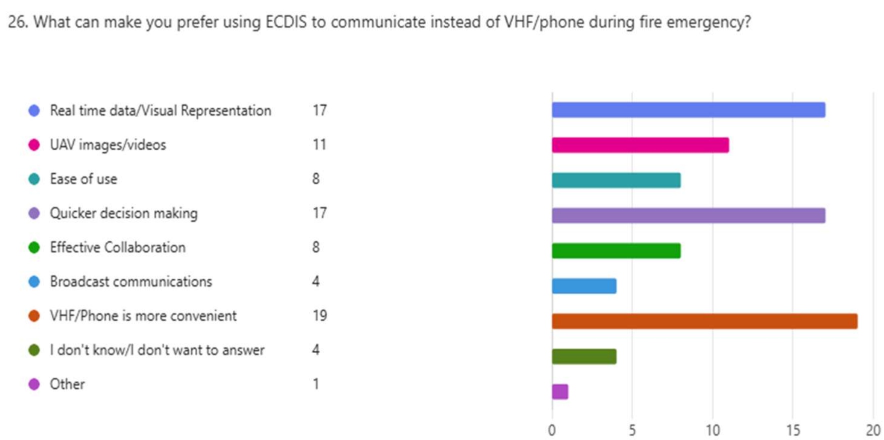


Figure 14 Preference of Users for ECIDS

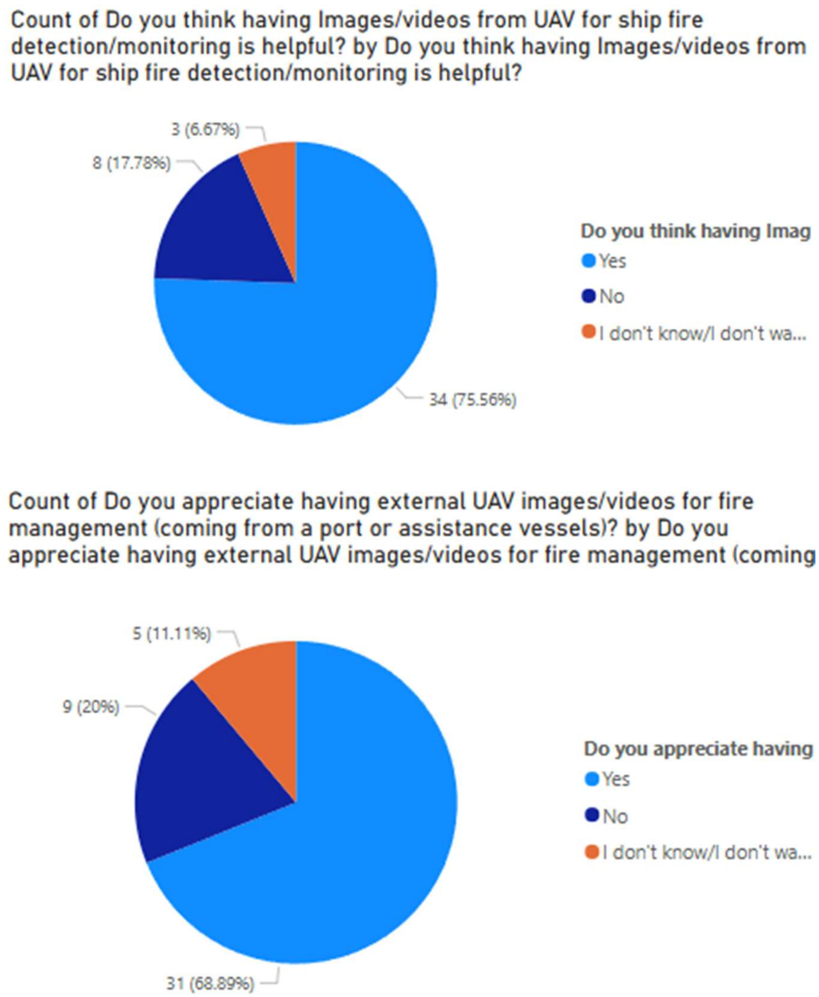
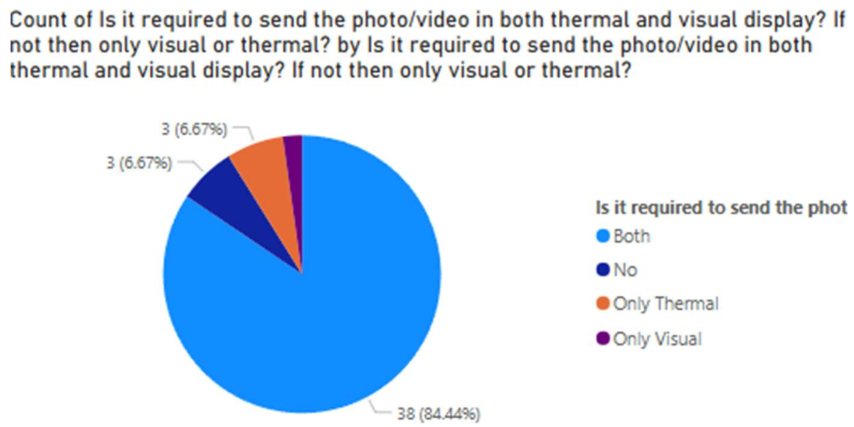


Figure 15 UAV requirement

44% of the respondents, want to send UAV images and videos from the ECDIS, while 38% want to share it from interface than the ECDIS. 56% are in favour of sharing both the UAV photos and videos. 84% is agreed to share both physical and thermal photos and videos. 44% want to share just the important photos and chunks of videos while, 38% want to share live stream and photos. There is 47% score in favour of having the updated picture and videos after each 10 minutes and 22% in favour of updating after every 30 minutes. Majority are in opinion that lack of real time and sensor data, visuals (such as UAV images/videos), limited communication channels such as VHF and phones limits the COP with external actors while firefighters say that lack of real time fire data and visuals make it difficult to be situationally aware. Some ship captains and navigators also pointed out lack of navigational data being one of the factors.

Figure 16 Preference of UAV images and videos

The results highlight that SA during fire emergencies is highly dependent on automated real-time data sharing, UAV integration, and effective communication tools. A significant majority (89%) prefers an automated system for real-time updates, with navigational data, fire location and type, sensor data, and visual/IR camera outputs being critical. The preference for ECDIS as a centralized platform (73%) suggests a need for integrated fire data management, although VHF/phone remains preferred for immediate communication. UAVs are seen as essential, with 76% wanting UAV images/videos for fire monitoring and 69% advocating UAVs in assistance vessels and ports. The real-time sharing of fire visuals and sensor data is crucial, with 56% supporting the transmission of both UAV photos and videos, and 84% agreeing on sharing both physical and thermal imagery. Delays in updating situational data (such as images and sensor readings) are a concern, with real-time or frequent updates (every 10 minutes) being preferred by nearly half of respondents. The overall conclusion is that a lack of real-time sensor and visual data, along with limited communication channels, remains a major barrier to effective coordination, and addressing these gaps through automation, UAV integration, and centralized data-sharing platforms like ECDIS will significantly enhance SA and fire response efficiency.



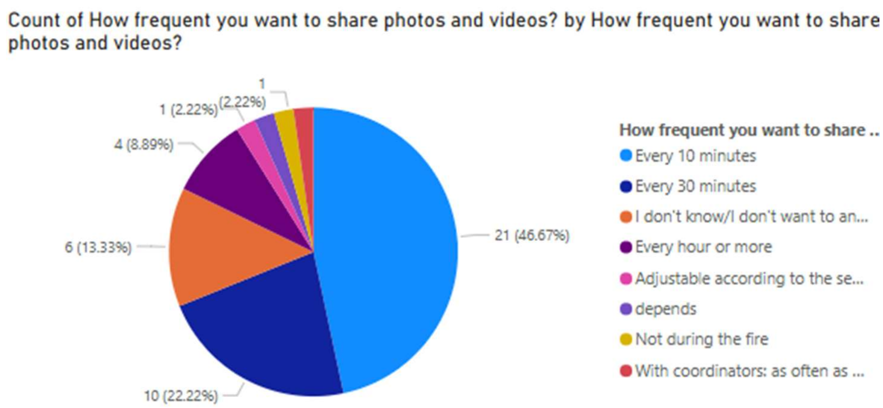


Figure 17 Type and frequency of UAV update

So, to enhance coordination, the DS must facilitate **automated updates at intervals with range 10–30 minutes**, provide options for **selected key visuals and sharing both live streams and photos** and ensure receiving updates from **UAVs** deployed at both assistance vessels and ports. Additionally, it should minimize reliance on VHF/phone communication during fire operation, **replacing them with ECDIS for COP** to enable shared real-time fire data visualizations, ultimately improving emergency response efficiency and decision-making.

7.4. S-100 Integration

The findings indicate that a majority of respondents (over 50%) are aware of S-100 products, and 78% find accessing these layers through ECDIS or other interfaces useful for fire emergencies. This highlights a strong preference for integrating S-100 data into existing maritime navigation systems. Furthermore, 71% believe that S-100 products will improve SA during fire emergencies. The prioritization of **S101-ENC, S102 (Bathymetry), S111 (Surface Currents), S127 (Traffic Management), and S412 (Weather Overlays)** shows a clear preference for layers that enhance navigation and environmental awareness. However, firefighters prioritize **S124 (Navigational Warnings)** over surface currents, suggesting that warning systems are more critical for their specific needs.

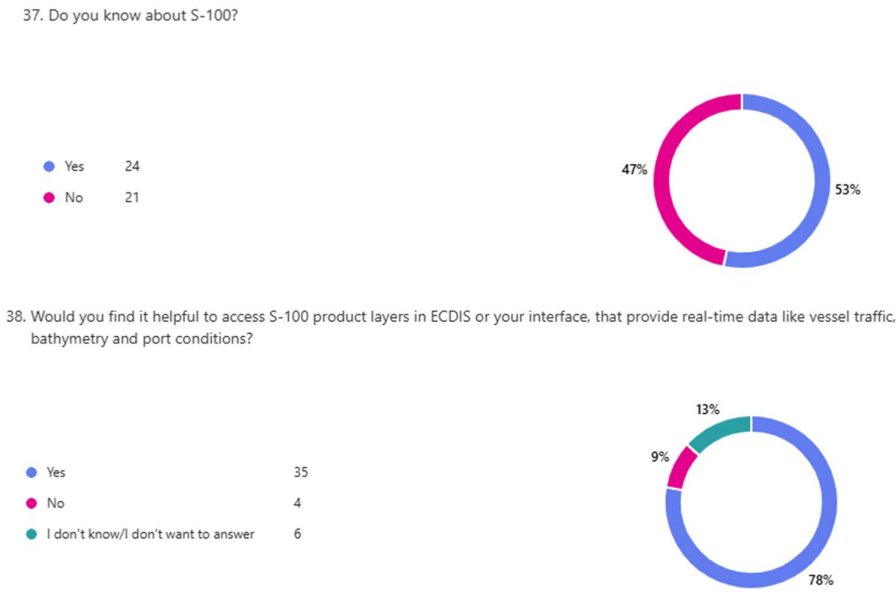


Figure 18 S-100 and S-100 Layers

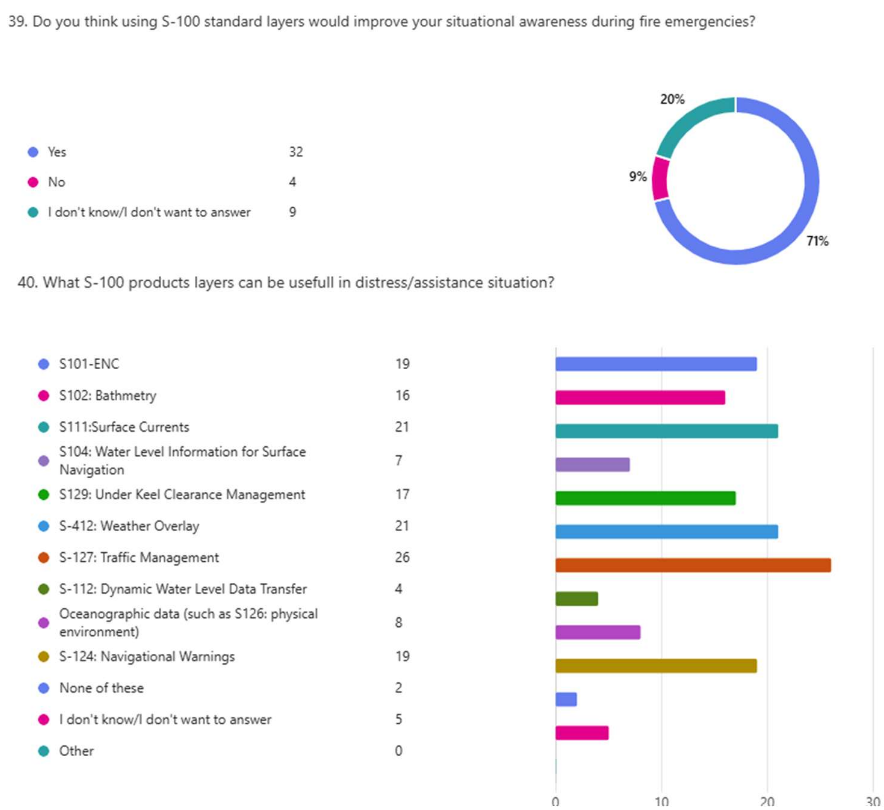


Figure 19 S-100 as SA tool and preferred layers for fire emergencies

The responses to the question about anticipated challenges in adopting S-100 reveal a blend of enthusiasm and apprehension regarding the new S-100 standard. Users recognize the potential for enhanced communication and improved environmental awareness through a single, integrated interface. However, they express significant concerns about **information overload**, highlighting the critical need for comprehensive and repeated training. **Cybersecurity** vulnerabilities, particularly the risk of hacking and spoofing, are a major worry, emphasizing the necessity for robust security measures. **System compatibility and integration** issues are also prominent, suggesting a need for thorough assessments and potential infrastructure upgrades. Finally, users highlight the need for **organizational and cultural changes** to support the adoption of the new standard. This includes convincing ship owners and companies to invest in the necessary training and infrastructure Furthermore, the cost of training and implementation, especially for existing ECDIS S-57 users, presents a barrier Overcoming these challenges requires a structured approach, including targeted training programs, phased system integration, enhanced cybersecurity measures, and clear communication of S-100's benefits to stakeholders. Therefore, the DS should prioritize user-friendly interfaces, comprehensive training programs, and strong security protocols to encourage widespread adoption.

7.5. Users Opinion

This section explains about the open ended discussions and questions answers. When asked about how ECDIS can be improved to better support SA, the respondents replied with the concept of a dedicated fire emergency display, as it would prevent information overload on the primary navigation screen. Some users suggested simplified interfaces and prioritization of fire-related data and providing visuals and facilitating rapid communication. The users also suggested high-resolution screens, live video integration, and 3D visualization**.** These insights suggest that ECDIS modifications should focus on clarity, accessibility, and real-time data integration allowing for adaptability to optimize fire emergency response.

The above concept is supported when respondents were asked about customizable dashboards for visualizing fire-related data. While some users appreciate the flexibility of customizable dashboards citing the need to display fire location, affected cargo types, materials involved, and time from detection, many prioritize a clear, standardized layout to minimize confusion and maximize efficiency during emergencies. The preference for a separate fire information screen, rather than cluttering the main ECDIS display, is a recurring theme. A few suggest that instead of customization, overlaying fire-related data on ECDIS would be more effective. **A middle-ground solution could be offering optional overlays on ECDIS while keeping core functionalities standardized.**

When asked about specific improvements users would want in DS, the feedback suggests that users seek enhanced fire detection, real-time tracking, and decision-support systems in digital fire management solutions. Precise fire location tracking such as fire location and type, thermal imaging, and 3D visualization are key priorities for improving SA. Standardization of procedures across ECDIS platforms is also crucial to ensure uniformity in fire response. While UAVs are seen as beneficial, users acknowledge their limitations due to weather conditions and highlight the need for adaptation to maritime environments. Overall, an **integrated, user-friendly system with real-time data, clear visualization, and decision-support features would greatly improve fire management at sea.**

When asked about current lacks in ECDIS technical requirements, the responses indicate several technical shortcomings in ECDIS, with the most critical being cybersecurity risks, communication protocol inefficiencies, and complex system settings. Users also highlight technical reliability issues, wiring concerns, and an overly complicated user interface (UI). To improve ECDIS, the DS should focus on enhancing **cybersecurity protections** to prevent unauthorized access, standardizing and improving **communication protocols** for better interoperability, **simplifying system settings** and UI design to improve usability, ensuring hardware reliability, including addressing wiring and power supply concerns.

When asked about potential issues after being connected to the internet, the dominant concern is **cybersecurity** and the potential for **unreliable or manipulated data** entering the ECDIS system. **Connectivity issues**, particularly gaps in coverage and the trustworthiness of data, also emerge as significant challenges. Development and implementation of internet-connected digital solution should prioritize robust cybersecurity measures to protect against hacking and data manipulation, as well as ensure reliable connectivity and data validation to maintain the integrity of the information displayed.

7.6. Special Comments

This section is based on the special comments from interviews and meetings with officials.

7.6.1. Port Officials

The feedback gathered during interviews with port officials highlights several key challenges and validates the need for a DS for fire management. For example, the port of Le Havre's (HAROPA) geographic location and safer navigation conditions make it an important hub for emergency response, handling 3-4 casualties per year, with 25% of them caused by fire. The port authorities recognize the potential benefits of this solution, having already used drone imagery to assess structural risks, such as deck collapse. Multiple agencies, including firefighters and the national navy, currently operate drones, reinforcing the need for a shared system for SA.

A major challenge identified is the lack of precise container location data, as ports only receive a manifest listing the cargo but not exact container positions. This aligns with previous survey responses where users emphasized fire location tracking and cargo identification as critical features for the DS. Currently, ports must contact shipping companies manually, causing delays in firefighting response.

Furthermore, differences in port organization at national and international levels create inconsistencies in fire response protocols. Since firefighters are external agents but undergo specialized vessel firefighting training, a COP through the DS could standardize fire response coordination across different actors. These insights confirm that the Overheat DS could play a crucial role in enhancing coordination, improving response efficiency, and ensuring all stakeholders operate under a unified fire management system.

7.6.2. Firefighters

Based on the insights from firefighters they face challenges with identifying cargo types and locating fires within containers, hindering effective response. They emphasize the need for real-time data on materials and container positions. Thermal imaging is crucial, but container walls obstruct visibility. UAVs equipped with thermal cameras are seen as vital for fire monitoring. However, skilled pilots and the ability to match the ship's speed are necessary.

IoT sensors within containers could provide early detection and critical data like temperature and gas levels.

For firefighters in Spain, communication is primarily via phone, limiting image and video sharing. VHF use is limited, with emergency services relying on separate radio networks. A shared visual interface could significantly improve situational awareness. Firefighters need access to live fire images, videos, and data on surrounding conditions, fire classification, cargo type, and dangerous goods. **Training** is crucial for firefighters to effectively use digital interfaces. **A common language** and standardized procedures are essential for efficient coordination. They also emphasize the UAV should be able to track their movement with the ships as well as their reliability and robustness in terms of preventing unexpected shutdowns or uncontrolled descents.

So, the DS should focus on real-time UAV and sensor data integration providing thermal imaging, cargo identification, and fire classification. COP interface for allowing firefighters, ship crews, and ports to share live images and videos. Automated fire and cargo tracking should be made available. Training for firefighters, so they can easily adopt the system with standardized procedures. Bridging the gap between firefighters, ships, and port authorities by reducing reliance on phone-based reporting to have enhanced communication.

8. Section 8 – User Requirements Definition

The DS must be designed for people on board containerships, firefighters and other assistance vessels, port officials such as VTS officials, harbor master and pilots. The details of identified user requirements are explained in next subsections.

8.1. Compliance with regulations, standards and good practices

The DS shall comply with relevant regulations, standards, and good practices to ensure legal, technical, and operational effectiveness. Regulations set by authorities such as IMO, IHO, and IEC define fire detection, firefighting, and safety requirements, which the DS shall adhere to for compliance. Additionally, the DS shall integrate recognized standards to ensure interoperability, reliability, and efficiency within maritime operations. This includes compliance with the S-100 framework for seamless data exchange, adherence to cybersecurity protocols for secure communication, and alignment with international firefighting procedures for effective emergency response. Moreover, since ECDIS is a critical component of maritime navigation, the DS shall align with ECDIS requirements to ensure smooth integration, maintain standardized display formats, and avoid excessive information overload for the crew.

8.2. Fire Assessment and Response

8.2.1. Fire Detection & Monitoring

I. The DS shall integrate IoT-based fire detection systems that provide real-time alerts integrated with existing systems.

II. It shall support various fire detection methods, including smoke detectors, temperature and gas sensors, and IR cameras.

III. UAV-assisted monitoring with thermal and optical imaging shall be incorporated for enhanced detection.

8.2.2. Fire Location & Severity Assessment

I. The system shall enable precise fire location tracking. For this, sensor data and UAV visual feeds shall be used.

II. The DS shall provide real-time updates on container temperatures, smoke/flame characteristics (color, density), and cargo type.

III. The interface shall display automated fire severity classification, using a combination of IoT sensors and UAV analytics.

8.2.3. Decision Support for Firefighting Strategy

I. The DS may include recommendations for firefighting techniques based on fire classification (solid, gas, liquid, metal, etc.).

II. It shall alert users when specific cargo types (e.g., DG such as lithium-ion batteries, hazardous chemicals) require specialized extinguishing methods.

III. It shall facilitate automated alerts when firefighting efforts are ineffective, or fire spread is detected.

8.2.4. Emergency Response Coordination

I. The DS shall allow emergency response of fire incidents within 15 minutes.

II. The DS shall include an automated option to request external aid when fire severity, DG, explosion risks, or inadequate firefighting equipment are detected.

III. The DS shall provide a predefined communication protocol for contacting relevant actors, including MRCC/VTS, assisting firefighting ships, nearby vessels, ship owners, and ship operators.

8.3. Situational Awareness (SA) & Communication

8.3.1. Real-Time Data Sharing & Visualization

I. The DS shall provide real-time updates on fire location, navigational hazards, sensor data, and UAV imagery. It should also accommodate option to automate the process.

II. The DS shall provide a centralized platform (e.g., ECDIS) to manage and display fire-related data, including UAV live feeds, thermal imagery, and alerts in a prioritized window.

III. The DS shall provide users with updated fire-related visuals and sensor data every 10–30 minutes.

8.3.2. Communication & Information Exchange

I. The DS shall minimize reliance on VHF/phone-based coordination through a primary interface (e.g. ECDIS or VTS interface).

II. The DS shall enable ship crews, firefighting teams, ports, and authorities can access and share real-time fire data.

III. The DS interface shall support both UAV photo and video transmission, with an option to share critical snapshots and important parts of videos, or live-streamed feeds.

8.3.3. Standardization & Usability

I. The DS shall have a dedicated fire emergency display to avoid cluttering the main navigation screen. The separate screen for UAV operator can fulfill the purpose.

II. The DS shall allow for standardized overlays on ECDIS rather than fully customizable dashboards to maintain operational clarity.

III. The DS shall support a multilingual interface with standardized fire response terminology to facilitate coordination between international teams.

8.4. S-100 Integration & Data Management

8.4.1. Incorporation of S-100 Layers

I. The DS shall integrate S-100 product layers, prioritizing S101 (ENC), S102 (Bathymetry), S111 (Surface Currents), S127 (Traffic Management), and S412 (Weather Overlays).

II. Firefighters and assistance vessels should have access to S124 (Navigational Warnings) for critical safety alerts.

III. The DS shall provide seamless access to S-100 data from ECDIS or other interfaces for enhanced fire response planning.

8.4.2. Mitigation of Adoption Challenges

I. The DS shall address concerns about information overload by implementing user-friendly features.

II. The DS shall be integrated with training modules to ensure smooth adoption by different maritime users.

III. The DS shall be implemented with cybersecurity measures to prevent hacking, spoofing, and unauthorized data access.

8.5. Technical Enhancements & Security

8.5.1. ECDIS & Digital Fire Management System

I. The DS shall enhance ECDIS to display fire-related data without interfering with navigation functionalities.
II. The DS shall provide high-resolution displays, real-time video feeds, and optional 3D visualizations for improved decision-making.
III. The DS shall include predefined fire management procedures to standardize response protocols across different vessel types.

8.5.2. Cybersecurity & Connectivity

I. The DS shall include robust cybersecurity protections to prevent unauthorized data access and manipulation.
II. The DS shall incorporate adapted security measures for data transmission between ships, ports, and firefighting and assistance teams.
III. The DS shall ensure reliable connectivity for real-time updates while mitigating risks of data loss or delays.

8.6. Special Considerations from Port Officials & Firefighters

8.6.1. Port Coordination & Fire Response

I. The DS shall provide automated fire location tracking to compensate for the lack of precise container position data at ports.
II. The DS shall enable seamless coordination between ships, ports, and external firefighting agencies by centralizing real-time data sharing.
III. The DS shall facilitate automated notifications to port authorities, eliminating the need for manual cargo information retrieval.

8.6.2. Firefighter-Specific Requirements

I. The DS shall integrate UAV-based fire monitoring while ensuring they are equipped to lock the motion with ships.
II. The DS shall support early fire detection through IoT sensors installed in the containers. They should provide pertinent data as temperature or fire type.
III. The DS shall provide a visual interface allowing to share live fire imagery and sensor updates for improved SA.
IV. The DS shall be implemented with training programs to familiarize users with the system and standardize fire response protocols.

8.7. Non-Functional Requirements

These are non-functional requirements which are system qualities & constraints and tell how the DS should perform.

8.7.1. Regulatory Compliance & Standardization

I. The DS shall comply with IMO, IHO, and IEC regulations to ensure adherence to international maritime safety standards.
II. The DS shall align with ECDIS requirements to avoid disrupting navigational workflows.
III. The DS shall follow cybersecurity best practices to prevent hacking, spoofing, and unauthorized data manipulation.

8.7.2. System Performance & Reliability

I. The DS shall operate with minimal latency, ensuring real-time data processing for effective firefighting response.
II. The DS shall be resilient to harsh maritime conditions, including high winds, water exposure, and electronic interference.
III. The DS shall have enough redundancy to prevent data loss during connectivity disruptions.

8.7.3. Usability & Training

I. The DS shall have an intuitive interface that minimizes cognitive overload during emergencies.
II. The DS shall be customizable, allowing users to choose between overlaying fire data on ECDIS or using a separate fire emergency display.
III. The DS shall provide comprehensive training programs for ship crews, firefighters, and maritime authorities.
IV. The DS shall have a common language standard to facilitate clear communication across multinational crews.

8.7.4. Security & Data Protection

I. The DS shall implement encryption and access control measures to secure sensitive fire response data.
II. The DS shall validate real-time sensor and UAV data to prevent the use of false or manipulated information.
III. The DS shall comply with GDPR and maritime data privacy regulations if required.

8.7.5. Scalability & Future Integration

I. The DS shall be scalable, allowing integration with new sensors, AI-based fire prediction tools, and future S-100 data layers.
II. The DS shall support interoperability with existing fire management systems used by ports, ships, and emergency services.

CONCLUSIONS

The user requirements gathered, emphasize the urgent need for a digital fire management system that enhances fire detection, improves real-time SA, and facilitates coordinated emergency response. The Overheat DS must incorporate IoT-based fire monitoring, UAV-assisted surveillance, and real-time data-sharing capabilities via primary interface, ensuring minimal human exposure to hazardous conditions. Standardizing communication and integrating S-100 data will significantly improve interoperability and decision-making during maritime fire emergencies. Addressing cybersecurity concerns and ensuring usability through training and user-friendly interfaces will be critical for widespread adoption. By bridging existing technological and procedural gaps, the DS will contribute to a safer and more resilient maritime fire response ecosystem.

References

1. 20 Minutes. (2023, 03 08). *Fremantle Highway fire: 'An electrical battery fire is almost impossible to extinguish on a ship'*. Retrieved from 20 minutes: https://www.20minutes.fr/planete/environnement/4047936-20230803-incendie-fremantle-higwhay-feu-batterie-electrique-quasi-impossible-eteindre-navire
2. Benjamin F. Crabtree, W. L. (1992). A template approach to text analysis:Doing Qualitative Research. 93-109.
3. Cedre. (2013, 08 26). *MSC Flaminia*. Retrieved from Cedre: https://wwz.cedre.fr/en/Resources/Spills/Spills/MSC-Flaminia
4. IHO. (Feb 2020). Information on IHO Standards Related to ENC and ECDIS. Monaco.
5. IHO. (October 2023). *S-100 Universal Hydrographic Data Model.* Monaco: International Hydrographic Organization.
6. IMO. (1995, 11 23). *RESOLUTION A.817(19).* Retrieved from https://media.liscr.com/marketing/liscr/media/liscr/online%20library/maritime/a.817(19).pdf
7. IMO. (2006, 12 5). *ADOPTION OF THE REVISED PERFORMANCE STANDARDS FOR.* Retrieved from https://wwwcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/MSCResolutions/MSC.232(82).pdf
8. IMO. (2024). *Brief History of IMO.* Retrieved from IMO: https://www.imo.org/en/About/HistoryOfIMO/Pages/Default.aspx
9. IMO. (2024). *Chapter V - Safety of navigation*. Retrieved from IMO Rules: https://www.imorules.com/SOLAS_REGV.html
10. IMO. (2024, July 01). *IMO*. Retrieved from https://www.imo.org/en/About/Conventions/Pages/International-Convention-for-the-Safety-of-Life-at-Sea-(SOLAS),-1974.aspx
11. ISO. (2004). ISO/IEC Guide 2:2004. ISO.
12. Kathy Baxter, C. C. (2015). UNDERSTANDING YOUR USERS- A Practical Guide to User Research Methods. Waltham: Morgan Kaufmann.
13. KHOA. (May 2017). *S-100 brochure.* Busan.
14. Koop, C. L. (2017). What is regulation?: An interdisciplinary concept analysis. . *Regulation & Governance,*, 95-108.
15. MAERSK. (2020, 10 20). *Statement on the investigation of the tragic fire on the Maersk Honam*. Retrieved from MAERSK: https://www.maersk.com/news/articles/2020/10/20/statement-maersk-honam
16. Paul McInerney, M. J. (2003). Scenarios in practice. Lauderdale.
17. Vettoretto, L. (2009). A Preliminary Critique of the Best and Good Practices Approach in European Spatial Planning and Policy-making. *European Planning Studies* , 1067-1083.
18. Voiles et Voiliers. (2022, 03 02). *Felicity Ace. The burning ship loaded with 4,000 luxury cars sank off the coast of the Azores*. Retrieved from https://voilesetvoiliers.ouest-france.fr/securite-en-mer/accident-en-mer/felicity-ace-le-navire-en-feu-charge-de-4-000-voitures-de-luxe-a-coule-au-large-des-acores-e780b4d8-9a2c-11ec-9acb-1f509311c936

ANNEX

List of Annexes:

Annex-A	User Personas
Annex-B	Scenarios or Use Cases
Annex-C	Questionnaire

Annex-A: User Personas

Primary User Personas

Identity	Ship's Captain
Age	50 years
Demographic Data	Experienced maritime professional, based in a major shipping port.
Status	Primary User
Goals	Ensure the safety of the vessel and crew, efficiently manage emergencies, and optimize navigation during incidents.
Skill Set	Maritime Academy Graduate, Advanced Certificates in Maritime Safety and Navigation. Extensive experience in vessel command and emergency management.
Tasks	Overseeing all vessel operations, making strategic decisions during emergencies, coordinating with crew and external agencies. High frequency, high importance, and ongoing.
Relationships	Works closely with the chief engineer, bridge officers and navigators. Regularly communicates with rescue coordinators and port authorities.
Requirements	Needs real-time fire and sensor data, seamless integration with navigation systems, high reliability and accuracy of data.
Expectations	Expects clear, actionable data that integrates well with existing systems, facilitates quick decision-making during emergencies.

Identity	Fire fighter
Age	35 years
Demographic Data	Maritime firefighter responsible for fire suppression, hazard assessment, and emergency response onboard vessels or in port operations.
Status	Primary User
Goals	Rapidly assess and respond to fire incidents, ensure crew safety, and contain fire spread effectively.
Skill Set	Firefighting and Hazardous Material Training, Thermal Imaging and Fire Suppression Techniques, Emergency Coordination, Maritime Safety Compliance.
Tasks	Locating and suppressing fires, assessing fire severity, coordinating with ship crews and emergency response teams, utilizing UAVs and thermal imaging for fire assessment. High importance, time-sensitive tasks.
Relationships	Works closely with ship crews, emergency response units, port authorities, and MRCC/VTS operators.
Requirements	Needs real-time fire location tracking, access to cargo type and hazardous material data, UAV thermal imagery, and effective communication tools for coordination.
Expectations	Expects a system that provides immediate fire alerts, assists in decision-making with fire classification and suppression techniques, and enhances situational awareness for a coordinated response.

Identity	Navigator
Age	32 years
Demographic Data	Maritime navigator on a cargo vessel, specializes in route planning.
Status	Primary User
Goals	Ensure safe navigation, integrate fire and sensor data into navigation decisions, and avoid hazards.

Skill Set	Maritime Navigation Degree, Certifications in Advanced Navigation and ECDIS. Skilled in route planning and real-time data integration.
Tasks	Planning and monitoring navigation routes, integrating fire data, coordinating with the captain. Frequent, high importance tasks.
Relationships	Coordinates with the captain, safety officers, and external agencies.
Requirements	Requires accurate and real-time fire data, integration with navigation systems, and reliable communication channels.
Expectations	Expects accurate fire data integration with navigation systems to adjust routes effectively.

Identity	**Harbour Pilot**
Age	38 years
Demographic Data	Experienced harbor pilot guiding ships in and out of ports using PPU
Status	Primary User
Goals	Guide ships safely during port maneuvers, adjust navigation based on fire data.
Skill Set	Maritime Piloting Certification, Advanced Training in Port Operations. Experienced in maneuvering ships and managing emergencies.
Tasks	Guiding ships during port maneuvers, adjusting navigation routes based on traffic
Relationships	Coordinates with the captain and officers for safe navigation, works closely with port control and other harbor services for smooth operations, Involved in emergency coordination during incidents like fires on board
Requirements	Reliable communication systems, access to real-time ECDIS data during maneuvers, Regular updates on port safety protocols and emergency procedures
Expectations	Expects the ECDIS module in PPU to provide clear, real-time and dynamic updates on vessel positioning and hazards, especially in emergency scenarios like fires. Organizes navigation information based on the immediate needs of the ship's location and potential threats.

Identity	**Coordinator (VTS)**
Age	40 years
Demographic Data	Vessel Traffic Services (VTS) operator responsible for monitoring and managing maritime traffic, ensuring navigational safety, and coordinating vessel movements
Status	Primary User
Goals	Monitor vessel traffic, ensure safe navigation, assist in emergency situations, and coordinate with relevant maritime authorities..
Skill Set	Maritime Traffic Monitoring, Radar and AIS Proficiency, Emergency Communication and Coordination, Knowledge of IMO and IALA regulations.
Tasks	Monitoring vessel movements, issuing navigational warnings, assisting in traffic management, relaying emergency information to rescue teams, and ensuring vessels comply with safety protocols. High importance, frequent tasks.
Relationships	Coordinates with ship captains, pilots, port authorities, MRCC, and emergency response teams.
Requirements	Needs real-time fire alerts, integration with AIS/ECDIS systems, and direct communication tools to relay critical information to vessels and response teams.
Expectations	Expects accurate, real-time situational awareness tools to monitor incidents, provide timely warnings, and facilitate coordinated emergency response.

ANNEX-B: Scenario/Use Cases

This annex explains about the scenarios developed keeping in view the project objectives by keeping in view some of the related extreme incidents of fires in cargo ships as described in main file of task 5.1.

1. Ship's Captain

To design a scenario for the fire detection for Ship's Captain for fire from DG, we proceed with the use case of Maersk Honam:

Attribute	Details
Title	Managing a Dangerous Goods Fire Incident Without Advanced Digital Solutions
Situation/Task	A Captain is in command of the container ship *Oceanic Spirit*, carrying a large load of cargo, including dangerous goods, as it sails near the Brest port. While en route to the port, a fire breaks out in cargo hold No. 3, where dangerous goods classified under IMO Class 9 are stored. The fire is believed to have been caused by the decomposition of these dangerous goods, generating intense heat and rapidly spreading out of control. Captain is tasked with containing the fire, ensuring the safety of the crew, and coordinating with French maritime authorities such as MRCC/CROSS and Affairs Maritime and rescue services such as SNSM. However, without advanced digital solutions such as UAV live surveillance, sensor integration, and fire progression updates, managing the situation proves to be extremely difficult.
Method to Address the Situation	1. At around 15:00 GMT, Captain receives an alarm indicating a potential fire in cargo hold No. 3, but the ship's current fire detection system does not provide precise information about the fire's exact location or its intensity. The captain suspects that the fire might have originated from a block of 54 containers carrying dangerous goods. However, without real-time sensor data and reliance on S-57 ENCs onboard, which are designed primarily for navigational purposes, does not allow Captain to access enhanced spatial data or dynamically visualize the external environment. The captain's situational awareness is limited to basic navigational data, while the fire continues to escalate. It is impossible to determine how the fire is progressing inside the hold. The crew conducts manual inspections, but the thick smoke and the dangerous nature of the cargo make it difficult to assess the situation safely.
	2.Captain orders the crew to activate the ship's CO2 fire suppression system, but with no sensor integration to automate and optimize the system, it is unclear whether the CO2 is effectively targeting the fire. The crew continues to manually fight the fire, but their efforts are hampered by limited visibility and the unknown severity of the situation inside the hold. The lack of real-time fire detection data prevents Captain from adjusting the firefighting strategy as the fire spreads. The danger posed by the hazardous materials further complicates the firefighting efforts, and the crew's safety is at serious risk.
	3.Captain sends a distress signal to the CROSS, and Affairs Maritime, requesting assistance from nearby rescue vessels. However, the absence of live UAV surveillance means that neither Captain nor the authorities have a real-time aerial view of the fire's progression. This lack of visual data complicates coordination efforts, as Captain cannot accurately describe the fire's location or provide up-to-date information on the situation. The S-57 standard only supports basic navigational data, limiting the captain's ability to integrate updated spatial data, environmental conditions, traffic data or external factors into the decision-making process. The firefighting efforts remain disjointed, and the coordination with external rescue services is less effective due to the limited data available.
	4.The fire continues to spread uncontrollably within the cargo hold. The crew struggles to contain the blaze as it intensifies, and the fire detection system offers no further updates. Without sensor data to monitor temperature changes or

	detect the exact location of the fire, Captain is forced to rely on manual inspections, which expose the crew to significant danger. The inflexibility of S-57 means that Captain cannot incorporate dynamic updates into the navigational system, which is critical during emergencies like fires. The absence of UAV surveillance and sensor integration leaves the captain with an incomplete picture of the situation, making it nearly impossible to make informed decisions. The delayed response from the external rescue services adds to the complexity of the situation
	5.The firefighting efforts are unsuccessful, and the fire spreads to other parts of the ship. The crew is eventually forced to abandon the vessel as the fire becomes uncontrollable. The lack of advanced digital solutions, such as real-time UAV surveillance, sensor integration, S-100 and automated fire suppression systems, severely hindered Captain's ability to manage the situation.
Execution Path	Captain's ability to manage the fire incident is severely limited by the lack of advanced digital solutions. Without real-time data from sensors, the captain cannot pinpoint the fire's exact location or monitor its progression. Moreover, S-57 standard, which lacks support for dynamic spatial data integration that could assist with external coordination during the crisis. The absence of UAV surveillance prevents the captain from obtaining a visual overview of the fire, and the lack of automated systems makes firefighting efforts less effective. Coordination with authorities and rescue services is also hampered by the limited information the captain can provide.

Table 1 Scenario for fire detection for Ship's Captain for fire from DG

To design a scenario for the Ship's Captain for fire detection due to Lithium-Ion battery, we proceed with the use case of Felicity Ace:

Attribute	Details
Title	Managing a Lithium-Ion Battery Fire Without Advanced Digital Solutions
Situation/Task	Captain is in command of the Oceanic Spirit, a large roll-on/roll-off vessel carrying vehicles, including electric vehicles equipped with lithium-ion batteries, as it sails in the North Atlantic in route to Rotterdam. Around 20:00 GMT, while navigating through rough seas, the crew reports smoke rising from the car deck, and soon after, fire alarms go off, indicating a fire on Deck 5. The cargo consists of several electric vehicles, and it's suspected that a lithium-ion battery has caught fire. Lithium-ion battery fires are notoriously difficult to extinguish and pose a serious risk of thermal runaway. Captain must contain the fire, ensure the crew's safety, and coordinate with the nearest maritime authorities (MRCC/CROSS) and rescue services. The situation is compounded by the lack of advanced digital solutions such as UAV surveillance, sensor integration, nighttime and automated fire suppression, limiting Captain's options for managing the fire effectively.
Method to Address the Situation	1.The fire alarm system detects smoke in the car deck but lacks precision about the exact source. There is no system cannot differentiate between a regular vehicle fire and a lithium-ion battery fire because there is no visual aid to see it (like in the case of drone having thermal imaging camera), leaving Captain without vital information about the nature and severity of the fire. Lithium-ion battery fires require special handling due to their high risk of reignition and thermal runaway, but without advanced sensor integration, Captain is forced to rely on manual inspections and standard firefighting measures, which may be ineffective against the specific risks posed by the battery fire.
	2.The crew manually inspects the affected area but is met with thick smoke, no daylight, extreme heat, and the danger of a spreading fire. Without real-time thermal imaging updates, it's impossible to confirm the exact location or intensity of the fire. This delays the crew's response, as they cannot pinpoint which vehicle or battery pack is the source. Captain orders the use of the ship's CO_2 fire suppression system, but CO_2 is known to be less effective against lithium-ion battery fires due to the risk of reignition

	3.With the fire escalating, Captain sends a distress signal to CROSS and nearby rescue vessels. However, without UAV surveillance to monitor the fire's progression, neither Captain nor the authorities have a clear visual of the situation and all lack situational awareness. The lack of real-time aerial views or thermal imagery makes it impossible to assess whether the fire is spreading to other decks or vehicles. The crew is forced to continue fighting the fire blindly, with no data available to guide their efforts or adjust the strategy based on evolving conditions.
	4.The lithium-ion battery fire reaches a critical point, entering thermal runaway, where the heat generated by the burning batteries triggers adjacent batteries to ignite. The ship's fire detection system does not provide updates, and without sensor integration, Captain cannot track the spread of the fire across the deck. Manual firefighting efforts are not enough to contain the situation, and the lack of situational awareness renders fire suppression ineffective leaving the crew increasingly vulnerable as the fire spreads uncontrollably.
	5.With no real-time sensor data or UAV surveillance to monitor the fire, and the standard fire suppression systems proving ineffective, Captain is forced to make the difficult decision to abandon the vessel. The fire has spread to multiple decks, endangering the crew, who are now evacuating. The absence of advanced digital solutions such as real-time UAV visuals, and integrated fire suppression has severely hindered Captain's ability to manage the situation.
Execution Path	Captain's ability to contain and manage the lithium-ion battery fire is severely limited by the lack of advanced digital tools. Without sensor integration to provide real-time data on the fire's location or intensity, the captain is forced to rely on manual inspections and outdated firefighting techniques. The absence of UAV surveillance means that the captain cannot gain a comprehensive view of the fire's spread or communicate effectively with external rescue services. Furthermore, the standard CO2 fire suppression system is not optimized for handling lithium-ion battery fires, leaving the crew with inadequate tools to control the blaze. The situation deteriorates as the fire enters thermal runaway, ultimately forcing the abandonment of the vessel due to the lack of advanced digital solutions

Table 2 Scenario fire detection for Ship's Captain for fire from Lithium Ion Batteries

For the firefighting use cases crisis scenario, we take use case of MSC Flaminia:

Attribute	Details
Title	Managing an Unexplained Explosion and Fire at Sea
Situation/Task	A Captain is commanding a large container ship, *Atlantic Voyager*, carrying nearly 3,000 containers through the English Channel near the coast of Le Harve. Midway through the journey, a sudden explosion occurs in one of the cargo holds. The source of the explosion is unknown, and the fire begins to spread rapidly. Without a sophisticated fire detection system and no live feeds from UAV, Captain faces delays in locating the fire's origin, assessing its severity, and directing firefighting efforts.
Method to Address the Situation	1. Captain is alerted to the explosion and orders an immediate inspection of the cargo hold. Due to the lack of a real-time fire detection system, crew members are dispatched to manually assess the damage, risking their safety.
	2. With no precise information on the fire's location or intensity, the captain activates the ship's fire suppression systems, relying on limited reports from the crew.
	3.Captain sends out a distress signal to nearby ships and maritime authorities, providing only partial information due to the lack of real-time updates.
	4. The captain tries to coordinate the crew's efforts to contain the fire, but the absence of detailed detection data hampers the captain's ability to make effective decisions.
Execution Path	Due to delays in detecting and pinpointing the fire, Captain's response is hindered. As the fire continues to spread, the crew is eventually forced to abandon the ship. The situation highlights the need for an integrated fire detection system and UAV surveillance feeds that provides real-time data to enhance decision-making and crew safety.

Table 3 Scenario fire firefighting for Ship's Captain

2. Harbour Pilot

To design a scenario for fire detection from DG for Harbour Pilot of the ship, we proceed with the use case of Maersk Honam:

Attribute	Details
Title	Navigating a Ship in Port During a Fire Incident with Limited Real-Time Data and Communication
Situation/Task	A 38-year-old harbor pilot is tasked with guiding the cargo vessel Ocean Voyager safely into the Port of Brest. While the vessel is approaching the port, an emergency fire alert is received from the captain, indicating that a fire has broken out in one of the forward cargo holds containing DGs'. The pilot's task is to safely guide the ship through port maneuvers while adjusting navigation to avoid hazards and ensuring that the vessel's position and stability are maintained during firefighting efforts. However, the pilot is hampered by the absence of real-time fire data in both the ECDIS and the PPU he has, limited information from the crew, and fragmented updates from port authorities.
Method to Address the Situation	1.As the vessel reaches near the port, the pilot receives a notification of a fire on board but lacks detailed information about its exact location and severity. The ECDIS system onboard does not display any sort of fire data, and the pilot must rely on verbal communication with the captain and crew to assess the situation. Without real-time updates and no means to see the fire progression while sitting in the bridge, the pilot's situational awareness is limited, complicating the task of adjusting the vessel's route safely into port while keeping the fire and any potential hazards in mind.
	2.The pilot works closely with the captain to adjust the ship's navigation route, but the lack of accurate fire data and static ENC from S-57 complicates decision-making. The pilot communicates with port control services to ensure that tugboats and emergency services are on standby. However, due to limited real-time data, the pilot must make decisions based on fragmented reports from the crew, which delays adjustments to the ship's navigation. The pilot also faces challenges coordinating with port authorities regarding safe docking procedures, as the full extent of the fire's impact on the ship's stability is unclear
	3.The absence of real-time fire data integration within the ship ECDIS and pilot's PPU make it difficult for the pilot to fully understand the risks posed by the fire. The pilot has no information on how the fire might affect the vessel's structural integrity or its maneuverability. Additionally, the lack of UAV surveillance or sensor data from the fire-affected cargo hold means that the pilot must rely on guesswork and incomplete reports. The pilot's ability to adjust the ship's route safely while factoring in fire-related risks is limited, increasing the potential for accidents or delayed response.
	4.As the ship nears the port, the pilot continues to coordinate with the captain, crew, and port control to organize an emergency response. However, the reduced situational awareness slow down coordination efforts, and the pilot struggles to keep all involved parties informed of the ship's position and the fire's impact. The absence of a live surveillance, dynamic navigational and integrated real-time fire data complicates the pilot's ability to guide the vessel effectively. The pilot must also ensure that tugboats are prepared for immediate assistance, but the lack of situational awareness further complicates these efforts.
	5.Despite the pilot's efforts to guide the vessel safely into port, the absence of real-time fire data in the ECDIS, PPU and the limited communication between the ship, port authorities, and emergency services lead to delays and inefficiencies. The lack of comprehensive situational awareness increases the risks associated with the maneuver, as the pilot must rely on incomplete and outdated information to adjust the ship's route. This scenario highlights the need for live feeds, real-time fire detection data, and enhanced coordination between harbor pilots, port control, and onboard crew during emergencies.
Execution Path	The pilot's ability to safely navigate the ship into port during a fire incident is significantly constrained by the lack of real-time fire data integration into the navigation system and reduced situational awareness and collaboration with the ship and port authorities. This scenario emphasizes the need for advanced digital solutions that provide real-time updates, integrate fire detection with navigation systems, and improve coordination between onboard crew and port services.

Table 4 Scenario for fire detection from DG for Harbour Pilot

This scenario illustrates the challenges faced by a harbour pilot in navigating a vessel during a fire incident without real-time fire data making the pilot less aware of the situation, highlighting the need for detailed and current information for safe navigation.

To design another scenario for the Harbour Pilot for fire detection for fire from lithium-ion batteries, we proceed with the use case of Felicity Ace:

Attribute	Details
Title	Guiding a Fire-Damaged Vessel Without Advanced Navigational Support
Situation/Task	A Harbour Pilot at port of Brest is tasked with guiding the Oceanic Spirit at 20:00 GMT to a safe docking location after the vessel reports a fire involving lithium-ion batteries on Deck 5. The ship is experiencing mechanical and operational difficulties due to the ongoing fire. The Pilot must assist in bringing the ship safely into port, but without access to advanced digital navigational tools, real-time UAV surveillance, or sensor integration, navigating the vessel and managing the safety of the port is increasingly difficult. The fire continues to spread, and visibility is poor due to smoke and absence of daylight, making the task even more challenging.
Method to Address the Situation	1.As the Harbour Pilot boards the ship, there is no real-time data available on the fire's current status or its impact on the ship’s critical systems. Without UAV surveillance or sensor integration, the Pilot cannot assess whether the fire poses a risk to the port’s infrastructure or whether it is safe to guide
	2. The Harbour Pilot attempts to assess the risks involved in maneuvering the ship. However, the lack of advanced navigation systems (S-100 data integration) means there is no updated information on environmental conditions, such as wind speed or tidal currents, no live thermal imaging feeds from UAV, which could impact smoke dispersion or fire progression. Without real-time data, the Pilot can only rely on visual observations and outdated charts, making the navigation process riskier.
	3. As the fire intensifies, thick smoke from the lithium-ion battery fire reduces visibility around the ship, making it difficult to steer. The absence of real-time thermal imaging or aerial UAV surveillance means the Harbour Pilot has no clear overview of the situation, increasing the chances of misjudging the ship's approach to the port. The outdated systems provide no real-time feedback on fire hotspots or structural integrity, leaving the Pilot to rely on manual guidance under hazardous conditions.
	4. The Harbour Pilot communicates with port authorities to prepare for docking, but without advanced digital tools, it is challenging to provide up-to-date information on the fire’s progression or the ship’s condition. The lack of real-time data integration between the ship and the port delays the coordination process, and the Pilot must make crucial decisions without knowing the full extent of the fire's impact on the ship’s hull and systems.
	Despite the challenges, the Harbour Pilot manages to bring the ship into port. However, the lack of real time fire updates and surveillance has increased the risks throughout the maneuvering process. The Pilot's ability to make informed decisions was limited by poor visibility, outdated charts, and incomplete data on the fire’s progression, ultimately hindering the efficiency of the firefighting and evacuation efforts.
Execution Path	The Harbour Pilot’s ability to safely navigate the Oceanic Spirit into port is significantly hindered by the absence of advanced digital tools like real-time UAV surveillance, S-100 navigation standards, and sensor integration. Without these systems, the Pilot must rely on outdated charts, poor visibility, and manual observations, which increase the risks during critical maneuvers. The lack of coordination tools with port authorities further complicates the docking process, leading to delays in firefighting and evacuation efforts.

Table 5 Scenario for fire detection from Lithium Ion Batteries for Harbour Pilot

This scenario illustrates the challenges faced by a harbour pilot in navigating a vessel during a fire incident from lithium-ion batteries without real-time fire data making the pilot less aware of the situation, highlighting the need for detailed and current information for safe navigation.

3. Fire Fighters

To design a fire detection scenario for the Fire fighters for ship on fire from DG, we proceed with the use case of MAERKS Honam:

Attribute	Details
Title	Coordinating Fire Response for a Cargo Ship Fire from a Firefighting Ship with Limited Situational Awareness
Situation/Task	Firefighters operate from firefighting and assistance ships and are deployed when a cargo ship reports a fire. Upon receiving an alert, they must assess the situation remotely, coordinate with maritime authorities (MRCC, VTS, port officials), and deploy firefighting resources. In the absence of real-time fire data, UAV surveillance, and automated suppression systems, their ability to respond effectively is significantly constrained.
Method to Address the Situation	1. The firefighting ship is dispatched after receiving a fire distress call from the affected cargo ship via MRCC or VTS. However, the lack of real-time fire location tracking, cargo type identification, and fire severity assessment delays response planning. Firefighters rely on limited radio communications with the distressed vessel's crew to assess risks before arriving.
	2. As the firefighting ship approaches, firefighters lack UAV-assisted infrared monitoring, making it difficult to assess fire progression, cargo risks, and toxic gas emissions from a safe distance. The absence of a shared digital fire coordination platform forces reliance on VHF or phone-based updates, leading to potential miscommunication.
	3. Without integrated fire suppression feedback from the distressed ship, firefighters must rely on external water cannons and foam-based systems, often with limited awareness of internal fire spread. The inability to view live UAV imagery or sensor data from the cargo ship's fire detection system makes it challenging to optimize firefighting efforts.
	4. Firefighters must maintain continuous communication with MRCC, VTS, nearby vessels, and port authorities, yet they lack a centralized fire data interface to monitor updates in real time. The manual process of requesting container manifests and hazardous materials information delays strategic decision-making.
Execution Path	The lack of real-time fire monitoring, UAV-assisted reconnaissance, and automated fire suppression tracking significantly hinders firefighting efficiency. This scenario underscores the urgent need for a Digital Fire Management System (DS) that integrates UAV feeds, IoT-based fire detection, real-time ship-to-firefighting vessel data sharing, and automated fire progression tracking. Enhanced coordination through a shared COP will enable faster, data-driven firefighting responses.

Table 6 Scenario for fire detection from DG for fire fighters

This scenario focuses on the challenges faced by the Fire fighters in coordinating fire response efforts without real-time data, showing how without sensors integration and UAV, processes can slow down critical decisions and impact crew safety.

To design a fire detection scenario for the Fire fighters amidst fire from lithium-ion batteries, we proceed with the use case of Felicity Ace:

Attribute	Details
Title	Ensuring Crew Safety and Compliance During a Lithium-Ion Battery Fire Without Advanced Digital Solutions
Situation/Task	The Safety Officer on board the Oceanic Spirit is responsible for ensuring the crew's safety and compliance with maritime safety regulations during a fire on Deck 5, involving lithium-ion batteries from electric vehicles. With no access to advanced digital systems like integrated sensors, real-time data, the Safety Officer must manage evacuation protocols and fire response while navigating communication challenges and outdated safety systems.

Method to Address the Situation	1. The Safety Officer begins by inspecting fire alarms and ordering the crew to gather at muster stations. However, without precise sensor data or advanced safety monitoring, it is impossible to assess the fire's severity. The officer must rely on manual safety checks, which are dangerous due to the thick smoke and the unknown threat from thermal runaway in the lithium-ion batteries.
	2. With no advanced fire suppression systems, the Safety Officer assists in deploying the ship's CO2 system. However, CO2 is ineffective against lithium-ion battery fires, and the lack of integrated safety protocols means the crew remains exposed to toxic fumes and heat. The officer is unable to adjust safety measures based on real-time data, which puts the crew in further danger
	3. As the fire spreads, the Safety Officer must ensure the crew is evacuated from dangerous areas. Without UAV surveillance or real-time communication tools, the officer struggles to maintain a clear understanding of the fire's progression and cannot efficiently coordinate evacuation efforts. The reliance on manual inspections to determine safe zones exposes the crew to significant risk
	4. The Safety Officer must document the incident and ensure that all safety protocols are followed. However, without automated systems that provide exact situational awareness and reports, gathering necessary data is a manual and time-consuming process. The outdated systems provide little support in assessing whether the fire response is compliant with safety regulations, adding complexity to the situation.
Execution Path	The Safety Officer's ability to ensure crew safety and compliance during the fire is severely limited by the lack of advanced digital tools. Without sensor data or automated safety systems, the officer must rely on manual checks, which are slow and dangerous. The lack of UAV surveillance makes it impossible to monitor evacuation efforts effectively, and the crew's safety is jeopardized as a result. Compliance reporting is hindered by the lack of situational awareness.

Table 7 Scenario for fire detection from lithium ion batteries for fire fighters

For the firefighting crisis scenario for the fire fighter, we take use case of MSC Flaminia:

Attribute	Details
Title	Coordinating Fire Response for a Lithium-Ion Battery Fire from a Firefighting Ship Without Advanced Digital Solutions
Situation/Task	Firefighters aboard a firefighting vessel are deployed to combat a lithium-ion battery fire on Deck 5 of the Oceanic Spirit, a cargo ship transporting electric vehicles. Due to the absence of real-time data integration, UAV surveillance, and automated fire suppression tracking, the firefighting team must rely on manual coordination, limited sensor data, and verbal updates from the ship's crew. The high risk of thermal runaway, toxic gas emissions, and re-ignition makes response planning difficult.
Method to Address the Situation	1. The firefighting ship is dispatched upon receiving a fire distress call via MRCC or VTS. However, limited information on fire severity, cargo type, and fire progression delays response preparation. The absence of UAV surveillance and real-time thermal imaging prevents the team from conducting an early remote assessment before arrival.
	2. As the firefighting vessel approaches, firefighters lack sensor data on toxic gas levels, battery thermal runaway status, and fire spread patterns. The crew on the affected cargo ship provides verbal updates via VHF or phone, but without a shared real-time data interface, miscommunication risks are high.
	3. Given that lithium-ion batteries require specialized firefighting techniques, the firefighting team must use water-based cooling methods rather than standard CO2 suppression, which is ineffective. However, the absence of automated fire suppression feedback from the cargo ship makes it difficult to determine whether firefighting efforts are effective. Without UAV-assisted monitoring, firefighters have no visibility of the fire's internal progression or whether it is contained.
	4. Firefighters must maintain continuous coordination with MRCC, VTS, and port authorities. However, manual information exchange via radio and phone calls slows

	down decision-making. Lack of digital cargo manifests and fire tracking tools delays identification of hazardous materials, further complicating suppression efforts
Execution Path	The lack of UAV-assisted infrared monitoring, sensor-based fire tracking, and automated suppression feedback hinders the firefighting ship's ability to respond efficiently. Miscommunication, slow data access, and the inability to remotely assess fire severity and toxic gas risks put both the firefighting crew and the distressed cargo ship at risk. The incident highlights the urgent need for a Digital Fire Management System (DS) that enables real-time UAV-assisted fire tracking, IoT-based sensor integration, automated fire severity alerts, and a shared operational picture for external response teams. Implementing these technologies would drastically improve firefighting coordination, efficiency, and crew safety.

Table 8 Scenario for fire fighting for fire fighters

4. Navigator

To design a fire detection scenario for the Navigator of the ship from a fire from DG, we proceed with the use case of MAERKS Honam:

Attribute	Details
Title	Navigating Through a Fire Emergency with limited detection tools and situational Awareness
Situation/Task	A maritime navigator, responsible for planning and monitoring the navigation of a large cargo vessel *Ocean Voyager*, which is currently sailing near the Port of Brest. While conducting routine navigation checks, the navigator is informed by the crew/safety officer about a fire outbreak in one of the forward cargo holds, which is suspected to have originated from dangerous goods stored in the hold. The navigator's task is to adjust the ship's route to ensure safe navigation while avoiding potential hazards and coordinating with the captain, safety officer, and external agencies. However, the task is complicated by limited fire detection systems, a lack of UAV surveillance, and outdated tools that restrict his situational awareness.
Method to Address the Situation	1. Upon receiving the fire alert, the navigator's begins assessing the ship's current position and potential hazards, such as nearby vessels and landmasses. The lack of real-time fire detection integration such as sensors and UAV surveillance feed into the navigation system means the navigator must rely on verbal updates and fragmented reports from the safety officer and crew. The Navigator cannot visualize the fire's location within the navigation system, forcing to make route adjustments based on incomplete information and relying on crew reports. The absence of detailed detection data, navigational and traffic data complicates their ability to steer the ship safely away from danger while considering the fire's impact on the vessel.
	2. The navigator works closely with the captain and safety officer/crew/firefighters to ensure that navigational decisions align with the firefighting strategy. However, the absence of advanced detection systems and real-time monitoring tools limits the accuracy of the information received. Without UAV surveillance, the navigator cannot get a broader view of the fire's impact on the ship, and without sensor-based updates, the crew is left guessing about the fire's progression. These limitations force the navigator to make conservative route adjustments, prioritizing safety over speed, but potentially prolonging the emergency.
	3. The navigator's ability to make informed navigation decisions is compromised by the lack of advanced navigational and fire detection data and tools. The current systems on board do not provide him with real-time data on the fire's progress, forcing him to rely on delayed and incomplete information from the crew. The lack of UAV surveillance further limits his situational awareness, as he cannot visually confirm the extent of the damage or how the fire is affecting different parts of the ship. These constraints make it difficult for the navigator to anticipate potential risks and adjust the ship's course proactively.
	4.The navigator's coordinates with the captain who communicates with external agencies, such as the MRCC/CROSS and Affairs Maritime to inform them of the fire and the ship's route adjustments. However, without accurate real-time data, the navigator

	struggles to provide detailed updates on the ship's condition. The reliance on outdated systems, such as the S-57 standard, means that the navigator cannot integrate dynamic external data streams, such as real-time traffic or weather updates, into his navigational decisions. This fragmented approach slows down the coordination process and limits the effectiveness of external assistance.
	5.Due to the limited detection systems and lack of real-time data, navigation adjustments are made with incomplete information, reducing the overall effectiveness of the ship's response to the fire. The inability to access real-time situational awareness tools, such as UAV surveillance and advanced sensor data, hampers the navigator's ability to adjust the ship's route safely and efficiently.
Execution Path	The navigator's ability to navigate safely through the fire incident is significantly limited by the lack of real-time fire detection data, UAV surveillance, and advanced monitoring systems. The reliance on current systems, including the S-57 standard, prevents the navigator from visualizing the full scope of the emergency and making proactive navigation decisions.

Table 9 Scenario for fire detection from DG for navigators

To design a fire detection scenario for the Navigator amidst fire from lithium-ion batteries, we proceed with the use case of Felicity Ace:

Attribute	Details
Title	Navigating Through a Fire Emergency Without Advanced Situational Awareness Tools
Situation/Task	The Navigator on the Oceanic Spirit is responsible for adjusting the ship's course and ensuring safe navigation while the fire rages on Deck 5. The fire involves lithium-ion batteries, which complicates the situation due to the risk of thermal runaway. Without advanced tools like real-time UAV surveillance, sensor integration, or S-100-compliant digital navigation systems, the Navigator's ability to make informed decisions is severely compromised.
Method to Address the Situation	1. The Navigator receives reports of the fire on Deck 5 but has no access to UAV surveillance or real-time data from the affected area. The static S-57 navigational system provides no information on fire hazards or external environmental conditions, limiting situational awareness.
	2. With limited information, the Navigator tries to adjust the ship's course to avoid worsening the situation, such as moving the ship into safer waters or closer to rescue teams. However, without real-time data on the fire's spread or wind conditions that could affect smoke dispersion, these adjustments are based on estimates, potentially increasing the danger.
	3. The Navigator attempts to coordinate with the Ship Captain to communicate with CROSS and rescue services, but without UAV visuals or advanced communication tools, providing accurate updates is difficult. They are unable to inform authorities about external conditions, fire progression, or nearby hazards, making coordination inefficient.
	4. The Navigator continues to steer the vessel while the fire progresses, but the lack of real-time navigational and environmental data makes it challenging to avoid obstacles or determine the safest course of action. The challenge of heavy traffic near the port is also there. The static systems hinder the ability to respond quickly to external conditions such as weather changes or nearby traffic.
Execution Path	The Navigator's ability to safely guide the ship through the fire emergency is limited by the lack of advanced situational awareness tools. Without real-time data from UAVs, sensors, or S-100-compliant systems, and lack of situational awareness, navigation is based on incomplete information, increasing the risk of further danger. Coordination with external authorities is less effective, and the lack of environmental data prevents optimal decision-making.

Table 10 Scenario for fire detection from lithium ion batteris for navigators

For the firefighting crisis scenario for the Navigator, we take use case of MSC Flaminia:

Attribute	Details
Title	Navigating During an Emergency Fire Incident with Limited Situational Awareness
Situation/Task	Navigator is responsible for the safe navigation of the container ship *Atlantic Voyager* when an explosion occurs in a cargo hold, triggering a fire. As the fire spreads and the ship begins to list, he needs to adjust the course of the ship to avoid worsening the situation. However, his ability to maintain situational awareness is severely compromised, not only by the lack of real-time fire detection systems such as data from sensors and IR cameras, lack of UAV surveillance feeds but also by the current S-57 standard used for the ship's navigational charts. Without the enhanced data integration and dynamic updates provided by S-100, he struggles to make informed decisions.
Method to Address the Situation	1.He receives a report of the explosion and fire but lacks real-time, detailed information about the fire's exact location and progression. The ship's navigational system, based on the S-57 standard, only provides static charts without the ability to overlay dynamic data such as fire detection sensor outputs or environmental conditions. This limits the navigator's situational awareness, making it harder to understand the full scope of the threat.
	2.As the ship begins to list and visibility decreases, the navigator tries to adjust the course, but without S-100's advanced data integration (e.g., layers of data such as traffic data) and without real time fire alerts, his situational awareness is severely constrained. He makes navigational decisions based on limited, static data.
	3.He communicates with the captain, chief engineer and crew, but the fragmented information and current charting system make it difficult to coordinate effective responses. He cannot access any UAV surveillance feeds and additional dynamic data layers that would help him anticipate how the fire might affect the ship's navigation, stability and surrounding environment. He does not have access to a comprehensive view, with fire detection/firefighting data overlaid on navigational charts, giving him a clearer picture of the situation.
	4.Without the enhanced situational awareness that S-100 provides, the navigator's navigation adjustments are less effective. The fire continues to spread, and the ship's list worsens, ultimately forcing the crew to abandon the vessel. The lack of real-time data integration hampers his ability to respond effectively to the emergency.
Execution Path	Navigator's ability to navigate safely during the fire is hindered by both the lack of real-time fire detection data and the limitations of the S-57 standard. This scenario underscores the need for upgrading to the S-100 standard, which would allow for better integration of real-time data, dynamic data integration and environmental information, which would provide, real-time updates, and advanced risk assessment tools, significantly improving SA during emergencies.

Table 11 Scenario for fire fighting for navigators

5. VTS Coordinator

To design a fire detection scenario from the fire from DG, for the Coordinator of the VTS, we proceed with the use case of MAERKS Honam:

Attribute	Details
Title	Coordinating Fire Response for a Cargo Ship Fire Involving Dangerous Goods with Limited SA
Situation/Task	A VTS Operator at the Port of Brest is responsible for monitoring maritime traffic and assisting with emergency coordination. A fire has broken out on the Ocean Spirit, carrying IMO Class 9 dangerous goods in its forward cargo holds. The operator's role is to facilitate communication between the ship, firefighting vessels, and MRCC, ensure navigational safety, and support fire response efforts. However, outdated S-57 charts, lack of UAV surveillance, and limited fire tracking data make coordination difficult.
Method to Address the Situation	1. The VTS operator receives a fire distress signal from the Ocean Spirit's captain, but no real-time fire tracking or UAV surveillance is available. The operator must rely on manual updates from the ship's crew and coordinate with MRCC and port authorities to dispatch firefighting vessels.

	2. The VTS operator reroutes nearby vessels to avoid interference with firefighting efforts. However, without integrated fire detection data, it is difficult to assess the fire's spread and ensure safe distances. Lack of drone surveillance prevents real-time monitoring of hazards such as explosions or structural collapses.
	3. The VTS operator acts as an information relay, updating MRCC and firefighting teams about ship status, but verbal updates are delayed and prone to misinterpretation. Without an integrated fire tracking system, the operator struggles to guide rescue efforts effectively.
	4. The VTS operator must decide whether to allow the Ocean Spirit to enter the port for controlled firefighting or direct it to a safer offshore area. Without accurate fire progression data, real time traffic, this decision carries risks. Port facilities lack immediate access to cargo-specific data, requiring time-consuming coordination with shipping companies to assess DG risks.
Execution Path	The VTS operator's ability to coordinate fire response is hindered by limited situational awareness, slow information relay, and lack of UAV-assisted fire monitoring. Miscommunication, lack of cargo tracking, and outdated navigation tools delay response efforts. An integrated digital solution with UAV-assisted fire tracking, real-time cargo identification, and automated alerts would significantly improve response coordination, navigation safety, and firefighting efficiency.

Table 12 Scenario for fire detection from DG for VTS operator

This scenario emphasizes the complexity of coordinating a multi-agency fire response with limited data from the vessel, highlighting the need for real-time information to ensure efficient resource allocation and effective communication.

To design a fire detection scenario for the Coordinator at VTS amidst fire from lithium-ion batteries, we proceed with the use case of Felicity Ace:

Attribute	Details
Title	Coordinating a Response for a Lithium-Ion Battery Fire on a Cargo Ship Without Real-Time Data
Situation/Task	A VTS Operator at the Port of Brest is monitoring maritime traffic when an alert is received from the Ocean Spirit, reporting a fire on Deck 5 caused by lithium-ion batteries. The fire poses extreme risks due to thermal runaway, toxic fumes, and re-ignition hazards. The VTS operator must coordinate maritime traffic, assist emergency response teams, and facilitate communication between the ship, firefighting vessels, and MRCC, but lack of real-time fire monitoring tools and UAV surveillance complicates coordination.
Method to Address the Situation	1. The VTS operator receives a distress call but has no real-time UAV images or sensor-based fire tracking. The only available data comes from delayed reports from the ship's crew, making it difficult to determine fire severity and spread.
	2. The operator reroutes ships away from the danger zone, but without an integrated fire tracking system, it is difficult to predict how the fire might escalate. Lack of toxic gas sensors and UAV-assisted monitoring prevents early detection of airborne hazards affecting nearby vessels..
	3. The VTS operator acts as an intermediary between the Ocean Spirit, MRCC, and responding firefighting ships, but the absence of shared real-time fire data and visual feeds results in slow decision-making and miscommunication risks. Firefighting vessels approach the ship without precise fire location data, increasing risks.
	4. The VTS operator must decide whether to direct the ship toward port or keep it offshore. Without UAV-assisted thermal imaging, it is impossible to assess structural damage or toxic fume risks. Miscommunication with MRCC and firefighting teams further delays crucial actions.
Execution Path	The VTS operator's effectiveness is significantly reduced due to the lack of real-time fire tracking, UAV-assisted monitoring, and automated hazard detection. Firefighting coordination is slow and relies on manual updates, increasing risks for responders. A digital fire management solution with UAV-based fire tracking, integrated sensor data, and a shared situational awareness platform would drastically enhance response efficiency and safety.

Table 13 Scenario for fire detection from lithium-ion batteries for VTS operator

Annex-C Questionaire

OVERHEAT project

OVERHEAT HORIZON research project aims to develop a digital solution to enhance fire detection, prevention, and management on container ships. This innovative approach will leverage the power of drones equipped with IR cameras and IoT sensors equipped on container ships and integrated with ECDIS to increase shared situational awareness and optimize fire detection and response efforts. The same type of solution will be made for VTS and pilots' PPU. S-100 standard will be utilized for real time data exchange. The questionaire is based upon two distribution of users. Onboard (ship captains, bridge officers,navigators, fire fighters, pilots etc.) and Port users (MRCC/VTS operators, Harbour Master etc.). As a key stakeholder in the maritime industry, your insights are invaluable to the success of this project. By participating in this brief survey, you will contribute to the solution that can save lives, protect the environment, and mitigate substantial financial losses from ship fires. Please take out few minutes first to watch the video to understand the project. Thank you!
Introductory video: https://youtu.be/A7KsxFQXBws. Website: https://overheat-project.eu/

This work has received funding from HORIZON Europe with grant agreement No. 101076633 under European Union's Horizon Europe Innovation Actions Framework Programme.

Your data remains confidential

Required

Section 1: General

1. What is your name?

2. What is your age? *

- ◯ 18-24
- ◯ 25-34
- ◯ 35-44
- ◯ >44
- ◯ I dont know/I dont want to answer

3. Are you a ...? (please choose the most dominant experience) *

- ◯ Ship Captain/Navigator/Bridge Officer
- ◯ Firefighter/Pilot/Rescue Assistant
- ◯ MRCC/VTS Operator
- ◯ Maritime Teacher
- ◯ Maritime Student
- ◯ Other

4. What is your maritime experience in years? *

- <1
- 1-5
- 6-15
- >16

5. You have navigated in what type of ship? Multiple answers are accepted *

- [ ] Cargo ships
- [ ] Cargo ships with dangerous goods (coal, batteries, hazardous chemicals etc.)
- [ ] Firefighting/tugboats/rescue/assistance ships
- [ ] Other (Passenger Ships, military ships etc.)
- [ ] My job is onshore
- [ ] Never navigated

6. Did you encounter fire incidents during your daily operations? How many? *

- No
- Yes, < 5
- Yes, 5 - 10
- Yes, > 10

Fire Assessment and Response

7. Do you have available sensors readings of cargo temperature, in the bridge room to detect fires ? *

Fire Detection

- ◯ Yes
- ◯ No
- ◯ I don't know/I don't want to answer

8. What systems do you currently use for managing a ship fire incident? *

Fire Detection

- ☐ VHF
- ☐ Phone
- ☐ E-mail
- ☐ ECDIS/VTS monitoring system
- ☐ I dont know/I dont want to answer
- ☐ Other

9. In case of fire, do you receive any alarm signal on ECDIS screen ? *

Fire Detection

- ◯ Yes
- ◯ No
- ◯ I don't know/I don't want to answer

10. What is the first step after fire or smoke detection? *

Fire detection

- ◯ Proceed to investigate with crew and equipment
- ◯ Assess the fire type and severity
- ◯ Locate the origin
- ◯ Notify the captain
- ◯ Call for external aid
- ◯ Initiate firefighting
- ◯ I don't know/I don't want to answer
- ◯ Other

11. How would you pinpoint the origin of fire in cargo hold? *

Fire detection

- ☐ Visual Detection
- ☐ Portable IR Cameras
- ☐ Sensors (Temperature, gas etc.)
- ☐ Smoke Detector
- ☐ It is quite impossible to locate origin of fire precisely
- ☐ I don't know/I don't want to answer
- ☐ Other

12. How do you assess the severity of fire? What data do you need? *

Fire assessment

- ☐ Type of cargo
- ☐ Location of fire
- ☐ Weather conditions
- ☐ Temperature of Container
- ☐ I don't know/I don't want to answer
- ☐ Other

13. How do you assess the type of fire? What data do you need? *

Fire assessment

- [ ] Color of flame
- [ ] Density of smoke
- [ ] Color of smoke
- [ ] Gas detectors
- [ ] I don't know/I don't want to answer
- [ ] Type of Cargo
- [ ] Other

14. How long does it typically take to gather sufficient information to decide on firefighting strategies? *

Fire assessment

- ◯ 20 minutes
- ◯ 40 minutes
- ◯ 60 minutes or more
- ◯ I don't know/I don't want to answer
- ◯ Other

15. What should be the ideal time to gather global information?

Fire assessment

- ◯ 15 minutes
- ◯ 30 minutes
- ◯ 45 minutes or more
- ◯ I don't know/I don't want to answer
- ◯ Other

16. On what parameter you decide to call for assistance? *

Fire Response

- [ ] Severity of fire
- [ ] Type of fire
- [ ] Firefighting equipment availablity, efficiency and sufficiency
- [ ] Dangerous Goods
- [ ] Chances of explosion
- [ ] I don't know/I don't want to answer
- [ ] Other

17. Who do you want to inform in a fire emergency? *

Fire Response

- [ ] MRCC/VTS
- [ ] Assisting/firefighting ships
- [ ] Nearby ships
- [ ] Ship Owner
- [ ] Ship Operator
- [ ] I don't know/I don't want to answer
- [ ] Other

18. What are the biggest challenges in managing nearby traffic when a ship is on fire?

Fire Response

- [ ] Communicating exclusion zones to all vessels in real-time
- [ ] Monitoring and predicting the spread of fire, smoke or debris
- [ ] Coordinating traffic rerouting with nearby vessels and authorities
- [ ] Prioritizing rescue and assistance vessel access
- [ ] I don't know/I don't want to answer
- [ ] Other

19. Do you need additional information in case of a fire from dangerous goods such as lithium ion batteries, self heating chemicals etc. If yes, please specify in others as well

- ☐ Yes
- ☐ No
- ☐ I don't know/I don't want to answer
- ☐ Other

20. What lacks in fire detection and fire monitoring/firefighting? *

- ☐ Real time updates
- ☐ Sensors
- ☐ UAV equiped with IR Cameras
- ☐ Inaccesiblity
- ☐ Lack of visual detection
- ☐ Difficulty in pinpointing the origin
- ☐ I don't know/I don't want to answer
- ☐ Other

21. Will you appreciate a system with advance fire notification management and fire type identification assistance? *

- ◯ Yes, just notifications
- ◯ Yes, notifications and type of fire
- ◯ No
- ◯ I don't know/I don't want to answer

Situational Awareness

22. Do you find it interesting to share real-time fire update automatically? *

- ◯ Yes
- ◯ No
- ◯ I don't know/I don't want to answer

23. What are the most important piece of information related to fire you consider essential? *

Please select 3 options.

- ☐ Navigational data (location of ship, course, etc.)
- ☐ Fire connected sensors
- ☐ Visual/IR cameras
- ☐ Type of Fire
- ☐ Location of Fire
- ☐ I don't know/I don't want to answer
- ☐ Other

24. How often do you exchange with external actors (e.g., MRCC/VTS, Assistance Ships) during fire emergencies?

- ◯ Everytime
- ◯ Occasionally depending on fire severity
- ◯ Only in large and critical fires such as lithium batteries or self hazardous chemicals
- ◯ Never
- ◯ I don't know/I don't want to answer
- ◯ Other

25. Do you think real-time updates from ship in distress, MRCC/VTS or assistance ships would improve your overall coordination during fire emergency? *

- ◯ Yes
- ◯ No
- ◯ I don't know/I don't want to answer

26. What can make you prefer using ECDIS to communicate instead of VHF/phone during fire emergency? *

- ☐ Real time data/Visual Representation
- ☐ UAV images/videos
- ☐ Ease of use
- ☐ Quicker decision making
- ☐ Effective Collaboration
- ☐ Broadcast communications
- ☐ VHF/Phone is more convenient
- ☐ I don't know/I don't want to answer
- ☐ Other

27. Which features would be most helpful in managing nearby traffic during a fire incident? *

- ☐ Real-time updates on fire location and exclusion zones displayed on ECDIS.
- ☐ Automated alerts to nearby vessels via ECDIS
- ☐ Live aerial views of the fire scene from UAVs
- ☐ Type, severity and origin of fire
- ☐ I don't know/I don't want to answer
- ☐ Other

28. Do you find it interesting for ECDIS to share, manage and combine different types of fire data? *

- ☐ Yes
- ☐ No
- ☐ I don't know/I don't want to answer

29. Do you think having Images/videos from UAV for ship fire detection/monitoring is helpful? *

- ◯ Yes
- ◯ No
- ◯ I don't know/I don't want to answer

30. Do you appreciate having external UAV images/videos for fire management (coming from a port or assistance vessels)? *

- ◯ Yes
- ◯ No
- ◯ I don't know/I don't want to answer

31. Will you find useful to send and receive UAV images and videos with other actors (Port (MRCC/VTS), ships, assistance services, etc.) from ECDIS? *

- ◯ Yes
- ◯ No, not with ECDIS
- ◯ No, not at all
- ◯ I don't know/I don't want to answer

32. Are photos from UAV enough for you in case of fire onboard or video is important as well? *

- ◯ Yes
- ◯ No, video is also important
- ◯ I don't know/I don't want to answer

33. Is it required to send the photo/video in both thermal and visual display? If not then only visual or thermal? *

- ◯ Both
- ◯ Only Visual
- ◯ Only Thermal
- ◯ No

34. Do you want real-time sharing of photos and live stream videos by UAV with all other actors (MRCC/VTS, ships, assistance services) in fire emergency? *

- ◯ Yes
- ◯ Just important photos and parts of videos
- ◯ No
- ◯ I don't know/I don't want to answer

35. How frequent you want to share photos and videos? *

- ◯ Every 10 minutes
- ◯ Every 30 minutes
- ◯ Every hour or more
- ◯ I don't know/I don't want to answer
- ◯ Other

36. What communication or data-sharing issues challenges you to maintain a common operational picture with external agencies? *

- ☐ Lack of real-time data integration
- ☐ Lack of navigational data
- ☐ Lack of sensor data
- ☐ Lack of visuals/photo/video
- ☐ Complicated display interface
- ☐ Limited communication channels (VHF,phone etc.)
- ☐ I don't know/I don't want to answer
- ☐ Other

Transitioning from S-57 to S-100 standard for ECDIS cartography

37. Do you know about S-100? *

- ◯ Yes
- ◯ No

38. Would you find it helpful to access S-100 product layers in ECDIS or your interface, that provide real-time data like vessel traffic, bathymetry and port conditions? *

- ◯ Yes
- ◯ No
- ◯ I don't know/I don't want to answer

39. Do you think using S-100 standard layers would improve your situational awareness during fire emergencies? *

- ◯ Yes
- ◯ No
- ◯ I don't know/I don't want to answer

40. What S-100 products layers can be usefull in distress/assistance situation? *

Please select at most 5 options.

- ☐ S101-ENC
- ☐ S102: Bathmetry
- ☐ S111:Surface Currents
- ☐ S104: Water Level Information for Surface Navigation
- ☐ S129: Under Keel Clearance Management
- ☐ S-412: Weather Overlay
- ☐ S-127: Traffic Management
- ☐ S-112: Dynamic Water Level Data Transfer
- ☐ Oceanographic data (such as S126: physical environment)
- ☐ S-124: Navigational Warnings
- ☐ None of these
- ☐ I don't know/I don't want to answer
- ☐ Other

41. What challenges do you anticipate in adopting S-100 and how they can be mitigated?

Your opinion matters!

42. How can the ECDIS display be enhanced to better support situational awareness during fire emergencies?
Desired improvements

43. What specific improvements would you want in digital system for fire management?
Desired improvements

44. Would you prefer customizable dashboards for visualizing fire-related data? If yes, what features should be customizable? *
Data visualization requirment

45. Do you identify lacks in nowadays technical requirements for ECDIS?
Desired improvements

- [ ] Technical problems
- [ ] Settings
- [ ] Wiring
- [ ] Communications protocols
- [ ] Cybersecurity
- [ ] I don't know/I don't want to answer
- [ ] Other

46. New S-100 ECDIS will be connected to internet. Do you anticipate potential issues? (connectivity, cybersecurity...)
Desired improvements

INNOVATIVE STRATEGIES FOR CONTAINERSHIP FIRES PREVENTION AND MANAGEMENT

Funded by the European Union

This project has received funding from the European Union's Horizon Europe research and innovation programme under Grant Agreement Project No: 101076633. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.