



Deliverable not yet approved by CINEA

Deliverable title:	Automated System Requirements
Deliverable ID:	D5.3
Document version:	1.0
Partner responsible:	TopView
Due date:	31 December 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.



D5.3

Document Control Sheet

Deliverable number	D5.3
Deliverable name	Automated System 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	TOPVIEW
Edition	1.0

Authors of the document

Authors of the document - Representatives of beneficiaries involved in the project		
Name/Beneficiary	Position/Title within the project	Date
Francesco Russo/TopView S.r.l.	TopView PoC	09/12/2025
Lorenzo Porricelli/TopView S.r.l.	TopView Researcher	09/12/2025
Mariano Iadaresta/TopView S.r.l.	TopView Researcher	09/12/2025
Graziano Gagliarde/TopView S.r.l.	TopView Researcher	09/12/2025
Gianluca Luisi/TopView S.r.l.	TopView Researcher	09/12/2025
Alberto Mennella/TopView S.r.l.	TopView Researcher	09/12/2025

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	18/12/2025
Pedro Merino Laso / ENSM	ENSM PoC	18/12/2025
Massimo Capozza	People Trust	18/12/2025
Gunnar Tietze/SeaTopic	SeaTopic PoC	18/12/2025
Fabienne Vallee/ Brest Port	Brest Port PoC	18/12/2025
Vittorio Sangermano/ISSNOVA	ISSNOVA PoC	18/12/2025
Marco Pasciuto / IMAT	Project Manager	18/12/2025
Diego Esposito / IMAT	IMAT chief engineer	18/12/2025



D5.3

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	31/12/2025
Vittorio Sangermano/ISSNOVA	ISSNOVA PoC	31/12/2025
Bartosz Dziugiel/ILOT	ILOT PoC	31/12/2025
Holger Kramer/ISL	ISL PoC	31/12/2025
Fabienne Vallee/ Brest Port	Brest Port PoC	31/12/2025
Rafael Company/VPF	VPF PoC	31/12/2025
Stefano Ricci/DITS	DITS PoC	31/12/2025
Théo Delferriere/CIRCOE	CIRCOE PoC	31/12/2025
Diego Ciocce/AKKODIS	AKKODIS PoC	31/12/2025
Pedro Merino-Laso/ENSM	ENSM PoC	31/12/2025
Massimiliano Siliberti/GTS	GTS PoC	31/12/2025
Gunnar Tietze/SeaTopic	SeaTopic PoC	31/12/2025
Massimo Capozza/PeopleTrust	PeopleTrust PoC	31/12/2025
Dominic Kudlacek/ISaSS	ISaSS PoC	31/12/2025
José Miguel Basset Blesa/VFF	VFF PoC	31/12/2025
Simone Panfiglio/Caronte	Caronte PoC	31/12/2025

OVERHEAT is a Horizon Europe project supported by the European Union under grant agreement no. 101076633. The information contained in this document is a property of the OVERHEAT consortium and it shall not be reproduced, disclosed, modified or communicated to any third party without the prior written consent of the consortium.

Views and opinions expressed in the document are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.



ABSTRACT

The OVERHEAT project aims to enhance maritime safety by deploying an integrated system that combines IoT sensors, unmanned aerial vehicles (UAVs), and external data sources such as cartographic and meteorological information. These diverse inputs enable early detection and rapid response to fire risks aboard containerships.

This deliverable defines the technical foundation for automated subsystems by converting previously identified end-user requirements into precise specifications. It addresses critical aspects such as data harmonization, interoperability among subsystems, and seamless integration with vessel infrastructures and shore-based systems.

Furthermore, the document introduces a comprehensive validation framework, including test specifications, to ensure that the automated systems meet operational performance targets and comply with relevant standards. These measures support the evaluation of prototype solutions and lay the groundwork for scalable, reliable deployment in real-world maritime environments.



TABLE OF CONTENTS

ABSTRACT	4
TABLE OF CONTENTS	5
LIST OF FIGURES	7
LIST OF TABLES	7
ACRONYMS	8
INTRODUCTION	9
1. REGULATIONS AND STANDARDS OVERVIEW	9
2. AUTOMATED SYSTEM REQUIREMENTS	12
2.1 General Requirements	13
2.2 Autonomous UAS Requirements	14
2.3 IoT Sensors Requirements	16
2.4 Interface and architecture requirements	18
2.5 Standard and Regulation Compliance	20
3. INTERACTION BETWEEN SUBSYSTEMS	22
3.1 Standard operational flow	23
3.2 System Failures and manual flight	24
4. TECHNICAL REQUIREMENTS VALIDATION	26
ANNEX 1 - DATA FORMAT EXAMPLES	28
Datagrams	28
Data logs	32
Data streams	33
Data Recording	34



D5.3

REFERENCES.....35



LIST OF FIGURES

Figure 3-1 Standard Operational Workflow - UML sequence diagram	23
Figure 3-2 System Failures and manual flight - UML sequence diagram	25

LIST OF TABLES

Table 1-1 Key Standards and Regulations.....	11
Table 4-1 Technical Requirements Validation tests.....	26
Table A.0-1 – Sensor status report object definition	28
Table A.0-2 – Timestamp object definition.....	29
Table A.0-3 – Identification object definition	29
Table A.0-4 – Status object definition.....	29
Table A.0-5 – Localization object definition.....	29
Table A.0-6 – Drone status report object definition	30
Table A.0-7 – Timestamp object definition.....	30
Table A.0-8 – Identification object definition	30
Table A.0-9 – Status object definition.....	31
Table A.0-10 – Docking station status report object definition.....	31
Table A.0-11 – Timestamp object definition.....	31
Table A.0-12 – Identification object definition	32
Table A.0-13 – Status object definition.....	32
Table A.0-14 – Data log definition	32
Table A.0-15 – Log summary definition	32
Table A.0-16 – Data stream object definition.....	33
Table A.0-17 – Timestamp object definition.....	33
Table A.0-18 – Identification object definition	33



ACRONYMS

API – Application Programming Interface
BVLOS – Beyond Visual Line of Sight
ECDIS – Electronic Chart Display and Information System
EU – European Union
GDPR – General Data Protection Regulation
IEC – International Electrotechnical Commission
IHO – International Hydrographic Organization
IMO – International Maritime Organization
IP – Ingress Protection
ISO – International Organization for Standardization
LoRa – Long Range (wireless communication protocol)
MQTT – Message Queuing Telemetry Transport
NMEA – National Marine Electronics Association
RTK – Real-Time Kinematic (positioning)
RTSP – Real-Time Streaming Protocol
SPD – Surge Protection Device
SORA – Specific Operations Risk Assessment
UAS – Unmanned Aircraft System
UAV – Unmanned Aerial Vehicle
URI – Uniform Resource Identifier
WEEE – Waste Electrical and Electronic Equipment Directive



INTRODUCTION

This deliverable, Automated System Requirements (D5.3), defines the technical specifications for the OVERHEAT project's automated subsystems, which integrate IoT sensors, Unmanned Aircraft Systems (UAS), and supporting digital solutions to improve fire detection and response in maritime environments.

The document builds upon end-user requirements identified in Deliverable 5.1 and translates them into actionable technical requirements that ensure interoperability, data harmonization, and compliance with international standards. It also addresses integration within vessel architectures and land-based systems, providing a foundation for prototype development and validation.

In addition to requirement definitions, this deliverable includes test specifications to verify system performance under operational conditions, supporting the evaluation of reliability, safety, and regulatory compliance.

1. Regulations and standards overview

Autonomous Unmanned Aircraft Systems (UAS) and IoT sensors deployed in maritime and industrial environments must comply with a robust regulatory and standardization framework to ensure safety, interoperability, and cybersecurity. In Europe, the European Union Aviation Safety Agency (EASA) provides the primary regulatory basis for UAS operations through:

- Commission Implementing Regulation (EU) 2019/947 – Defines operational rules for UAS, categorizing operations into Open, Specific, and Certified based on risk. Autonomous and BVLOS (Beyond Visual Line of Sight) missions typically fall under the Specific category, requiring a risk assessment and operational authorization.
- Commission Delegated Regulation (EU) 2019/945 – Establishes requirements for UAS design, manufacturing, CE marking, and remote identification.
- U-space Regulations (EU 2021/664, 2021/665, 2021/666) – Introduce a digital traffic management ecosystem for drones, enabling safe integration into controlled airspace and supporting advanced services such as dynamic airspace access and conflict resolution.

For risk-based approvals, the Specific Operations Risk Assessment (SORA) methodology is widely applied, ensuring that autonomous operations meet acceptable safety levels. Technical compliance is supported by the European UAS Standards Coordination Group (EUSCG), which aligns ISO, IEC, and CEN standards for UAS systems.

The Overheat's IoT sensors deployed in containers are designed according to the following directives and standards:

- Directive 2011/65/EU – Restriction of hazardous substances in electrical and electronic equipment (RoHS).
- Directive 2014/35/EU – Electrical equipment designed for use within certain voltage limits (Low Voltage Directive).
- Directive 2014/30/EU – Electromagnetic compatibility.
- Directive 2014/53/EU – Radio equipment and telecommunications terminal equipment.
- ISO 6346 – Container identification standard for associating sensor IDs with container IDs.
- IEC 60529 – Ingress Protection (IP) rating for dust and water resistance.
- WEEE Directive – Waste Electrical and Electronic Equipment disposal requirements.



D5.3

Moreover, IoT sensors integrated into these workflows should adhere to IEC 62443 for industrial cybersecurity and ISO/IEC 30141 for IoT reference architecture, ensuring secure data exchange, resilience, and interoperability. Additionally, GDPR governs personal and operational data protection, requiring secure storage, transmission, and deletion protocols.

Although the sensors used in the demonstration phase are prototypes and not certified for the above-mentioned regulations and standards, they are designed to meet all relevant requirements. These standards collectively address airworthiness, operational safety, cybersecurity, and data integrity, forming the foundation for reliable autonomous UAS and IoT sensor deployments in maritime safety systems.

Domain	Regulation / Standard	Scope
UAS Operations	Regulation (EU) 2019/947	Rules and procedures for UAS operation; defines Open, Specific, Certified categories.
UAS Design & Manufacturing	Regulation (EU) 2019/945	Requirements for UAS design, production, CE marking, and remote ID.
Airspace Integration	Regulation (EU) 2021/664 (U-space)	Framework for UAS traffic management and BVLOS operations.
Risk Assessment	SORA (Specific Operations Risk Assessment)	Methodology for risk-based approval of UAS operations.
Cybersecurity (IoT & UAS)	IEC 62443	Industrial cybersecurity for networked systems, including IoT sensors.
IoT Architecture	ISO/IEC 30141	Reference architecture for IoT systems ensuring interoperability.
Data Protection	GDPR	Compliance for personal and operational data collected by UAS/IoT.
Standards Coordination	EUSCG Rolling Development Plan	Catalogue of UAS-related standards for compliance demonstration.
Domain	Regulation / Standard	Scope
Electrical & Electronic Equipment	Directive 2011/65/EU (RoHS)	Restriction of hazardous substances in electrical and electronic equipment.
Electrical Safety	Directive 2014/35/EU (Low Voltage Directive)	Electrical equipment designed for use within certain voltage limits.
Electromagnetic Compatibility	Directive 2014/30/EU	Requirements for electromagnetic compatibility of devices.
Radio Equipment	Directive 2014/53/EU	Radio equipment and telecommunications terminal equipment compliance.



D5.3

Container Identification	ISO 6346	Standard for container identification and association with sensor IDs.
Environmental Protection	IEC 60529	Ingress Protection (IP) rating for dust and water resistance.
Waste Management	WEEE Directive	Disposal requirements for Waste Electrical and Electronic Equipment.

Table 1-1 Key Standards and Regulations



2. Automated System Requirements

This section explains how user requirements identified in previous stages are systematically transformed into technical requirements (TRs) for the OVERHEAT's Automated System.

The purpose of defining TRs is to establish a clear bridge between operational expectations and technical implementation, ensuring that the developed solution meets real-world needs while complying with international standards.

The requirements presented in this document complete and expand those introduced in D5.2, and focused on Digital Solution, providing a more detailed and comprehensive specification set that supports the integration of IoT sensors, UAS operations, and automated workflows within the OVERHEAT architecture.

Category	Brief Description
General Requirements	Requirements describing the workflow at the basis of the automated system such as mission triggering, data synchronization, and coordination between IoT sensors, UAS, and control platforms.
Autonomous UAS Requirements	Specifications for drone and hangar and operational requirements for missions, fail-safe procedures, AI-based fire detection, and compliance with operational standards.
IoT Sensors Requirements	Specifications for sensor design, installation, communication protocols, power supply, and environmental protection.
Interface and architecture requirements	Detailed requirements about interface protocols and data
Standard and Regulation Compliance	Compliance with standards, directives and EU regulations.

All TRs are structured using the standardized format shown below to ensure clarity and traceability throughout the development and validation phases.

Identifier	REQ-OVERHEAT-D5.3-XXXX
Requirement	<i>Requirement statement</i>
Status	<Defined> <Validated> <Modified> <Deleted>
Rationale	<i>Why requirement is stated</i>
Category	XXXX
Additional Comment	<i>If any</i>

The status of each requirement will be assessed using the following three checking criteria:

- Defined: The TR has been defined
- Validated: The TR has been validated in its initial form
- Modified: The TR has been validated with adaptations
- Deleted: The TR has been deleted because it has been declared irrelevant

The identified TRs are stated in following subsections.



D5.3

2.1 General Requirements

Identifier	REQ-OVERHEAT-D5.3-0001
Requirement	The system shall automatically trigger a UAS mission when an IoT sensor detects a fire precursor or anomaly inside a container. The alert shall include container ID, timestamp, and anomaly type, and be transmitted securely to the UAS mission planning software.
Status	<Defined>
Rationale	Ensures rapid UAS deployment for early fire detection.
Category	General requirements
Additional Comment	-

Identifier	REQ-OVERHEAT-D5.3-0002
Requirement	The system shall ensure real-time synchronization of mission status, telemetry, and media files between vessel DS, port DS, and the cloud platform.
Status	<Defined>
Rationale	Maintains shared situational awareness across stakeholders.
Category	General requirements
Additional Comment	-

Identifier	REQ-OVERHEAT-D5.3-0003
Requirement	The UAS mission planning software shall support automatic selection and execution of a predefined flight plan upon receiving an IoT alert, without requiring manual intervention, except for operator override.
Status	<Defined>
Rationale	Reduces response time and human workload.
Category	General requirements
Additional Comment	-

Identifier	REQ-OVERHEAT-D5.3-0004
Requirement	The UAS shall capture thermal and visual images during the mission and upload them in real time. The AI algorithm shall confirm fire presence when temperature thresholds are exceeded, and container identification is validated.
Status	<Defined>
Rationale	Provides automated fire confirmation and visual evidence.
Category	General requirements
Additional Comment	-



D5.3

2.2 Autonomous UAS Requirements

Identifier	REQ-OVERHEAT-D5.3-0005
Requirement	The UAS hangar shall achieve an ingress protection level of at least IP55 to ensure resistance against dust and water in maritime environments.
Status	<Defined>
Rationale	Guarantees durability and reliability under harsh conditions.
Category	Autonomous UAS Requirements
Additional Comment	IEC 60529 compliance required.

Identifier	REQ-OVERHEAT-D5.3-0006
Requirement	The UAS hangar shall include a quick-charging module capable of charging the drone battery from 20% to 90% within 32 minutes.
Status	<Defined>
Rationale	Ensures rapid turnaround for continuous operations.
Category	Autonomous UAS Requirements
Additional Comment	Charging performance must be validated under maritime conditions.

Identifier	REQ-OVERHEAT-D5.3-0007
Requirement	The UAS hangar shall integrate environmental sensors (wind speed, rainfall, temperature, humidity) to monitor real-time conditions and prevent unsafe take-off or landing.
Status	<Defined>
Rationale	Enhances operational safety and decision-making.
Category	Autonomous UAS Requirements
Additional Comment	Wind speed threshold: max 8 m/s (Beaufort scale 5).

Identifier	REQ-OVERHEAT-D5.3-0008
Requirement	The vessel version of the UAS hangar shall include a two-axis tilting mechanism to compensate for vessel movement during take-off and landing.
Status	<Defined>
Rationale	Ensures stability and precision in dynamic maritime environments.
Category	Autonomous UAS Requirements
Additional Comment	Tilting range: $\pm 30^\circ$ roll and pitch.

Identifier	REQ-OVERHEAT-D5.3-0009
Requirement	The UAS hangar shall provide satellite-based internet connectivity (e.g., Starlink) for remote operations and real-time data transmission.
Status	<Defined>
Rationale	Enables uninterrupted communication in open-sea conditions.
Category	Autonomous UAS Requirements
Additional Comment	Self-orienting antenna required for automatic satellite acquisition.



D5.3

Identifier	REQ-OVERHEAT-D5.3-0010
Requirement	The UAS hangar shall include an emergency stop button and LED indicators to signal operational states and warnings.
Status	<Defined>
Rationale	Provides safety measures for personnel during maintenance and operations.
Category	Autonomous UAS Requirements
Additional Comment	LED colour codes must follow documented normal and warning states.

Identifier	REQ-OVERHEAT-D5.3-0011
Requirement	The drone shall feature omnidirectional obstacle avoidance (six-directional sensing) and RTK positioning for precise navigation.
Status	<Defined>
Rationale	Ensures safe and accurate autonomous flight in complex environments.
Category	Autonomous UAS Requirements
Additional Comment	IP54 protection level required for drone.

Identifier	REQ-OVERHEAT-D5.3-0012
Requirement	The drone shall include a multi-sensor payload (wide-angle, telephoto, thermal cameras) for fire detection and situational awareness.
Status	<Defined>
Rationale	Provides comprehensive visual and thermal data for emergency response.
Category	Autonomous UAS Requirements
Additional Comment	Thermal camera resolution: 640×512; telephoto zoom: 28× continuous.

Identifier	REQ-OVERHEAT-D5.3-0013
Requirement	The UAS hangar and drone shall support a notification mechanism to alert about scheduled maintenance intervals (e.g., every 6 months or 1500 flights).
Status	<Defined>
Rationale	Maintains system reliability and reduces operational risks.
Category	Autonomous UAS Requirements
Additional Comment	

Identifier	REQ-OVERHEAT-D5.3-0014
Requirement	The UAS hangar shall include surge protection devices (SPD) and backup battery systems to ensure uninterrupted operation during power fluctuations.
Status	<Defined>
Rationale	Protects system integrity and ensures continuity during emergencies.
Category	Autonomous UAS Requirements



D5.3

Additional Comment	-
---------------------------	---

Identifier	REQ-OVERHEAT-D5.3-0015
Requirement	In case of mission planning software failure, the system shall maintain C2 link and allow manual control via remote controller or emergency procedures (Return to Home, alternate landing site).
Status	<Defined>
Rationale	Ensures resiliency and safety during system failures.
Category	Autonomous UAS Requirements
Additional Comment	

2.3 IoT Sensors Requirements

Identifier	REQ-OVERHEAT-D5.3-0016
Requirement	The IoT sensor shall be designed to replace standard ISO container vents without requiring structural modifications to the container.
Status	<Defined>
Rationale	Facilitates easy installation and retrofitting on existing containers.
Category	IoT Sensors Requirements
Additional Comment	Magnetic mounting for demo phase; screw mounting for operational phase.

Identifier	REQ-OVERHEAT-D5.3-0017
Requirement	The IoT sensor shall support LoRa communication for alarm transmission when only a few containers are equipped, and BLE for collaborative communication when most containers are equipped.
Status	<Defined>
Rationale	Ensures flexible communication strategies for different deployment scenarios.
Category	IoT Sensors Requirements
Additional Comment	BLE also used for configuration and test alarms.

Identifier	REQ-OVERHEAT-D5.3-0018
Requirement	The IoT sensor shall support high-capacity, low self-discharge batteries (e.g., thionyl chloride) for operational phase.
Status	<Defined>
Rationale	Guarantees power autonomy and operational reliability.
Category	Power Supply
Additional Comment	Battery health monitoring required.

Identifier	REQ-OVERHEAT-D5.3-0019
Requirement	The IoT sensor shall provide visual (flashing light) and audible (horn) alarms to assist crew in locating the affected container.



D5.3

Status	<Defined>
Rationale	Enhances situational awareness during fire detection.
Category	IoT Sensors Requirements
Additional Comment	Alarm activation must be remotely controllable via app.

Identifier	REQ-OVERHEAT-D5.3-0020
Requirement	The IoT sensor shall expose its ID via a QR code and printed label, and allow manual or automated association with ISO 6346 container ID.
Status	<Defined>
Rationale	Enables accurate mapping of alarms to container positions.
Category	IoT Sensors Requirements
Additional Comment	Future automation via smartphone app recommended.

Identifier	REQ-OVERHEAT-D5.3-0021
Requirement	The IoT sensor shall allow triggering and stopping of test alarms via a mobile application to verify correct installation and communication.
Status	<Defined>
Rationale	Ensures proper functioning before operational use.
Category	IoT Sensors Requirements
Additional Comment	Test results must confirm LoRa gateway acknowledgment.

Identifier	REQ-OVERHEAT-D5.3-0022
Requirement	The IoT sensor shall provide battery level monitoring and support recharging procedures using a dedicated charger.
Status	<Defined>
Rationale	Maintains readiness for demonstrations and operational phases.
Category	IoT Sensors Requirements
Additional Comment	Charger must include safety features and display charge percentage.

Identifier	REQ-OVERHEAT-D5.3-0023
Requirement	The IoT sensor shall meet an IP65 rating for operational units.
Status	<Defined>
Rationale	Guarantees durability in maritime environments.
Category	IoT Sensors Requirements
Additional Comment	High IP grade recommended and suitable for permanent installation on vessel

Identifier	REQ-OVERHEAT-D5.3-0024
Requirement	The IoT sensor shall integrate gas detection capable of identifying fire precursors before ignition.
Status	<Defined>
Rationale	Enables early fire detection and prevention.
Category	IoT Sensors Requirements



D5.3

Additional Comment	Sensor training for AI-based gas detection capability
---------------------------	---

2.4 Interface and architecture requirements

Identifier	REQ-OVERHEAT-D5.3-0025
Requirement	The real-time synchronization of mission status, telemetry, and media files between vessel DS, port DS, and the cloud platform shall use secure protocols (MQTT, HTTPS, WebSocket)
Status	<Defined>
Rationale	Guarantees confidentiality, integrity, and low-latency communication, which is critical for mission coordination and situational awareness in maritime environments
Category	Interface and architecture requirements
Additional Comment	

Identifier	REQ-OVERHEAT-D5.3-0026
Requirement	The interface shall resemble a web client-server architecture, supporting hierarchical catalogues and URI-based resource identification.
Status	<Defined>
Rationale	Simplifies integration and future upgrades using standard web paradigms.
Category	Interface and architecture requirements
Additional Comment	Facilitates modular design and resource navigation.

Identifier	REQ-OVERHEAT-D5.3-0027
Requirement	The interface shall provide data catalogues for ECDIS to browse and select resources (e.g., logs, recordings).
Status	<Defined>
Rationale	Enables efficient data access and retrieval for situational awareness.
Category	Interface and architecture requirements
Additional Comment	Catalogues organized hierarchically for usability.

Identifier	REQ-OVERHEAT-D5.3-0028
Requirement	The interface shall allow subscription mechanisms for push data types (datagrams, streams) to optimize bandwidth and deliver only relevant information.
Status	<Defined>
Rationale	Reduces unnecessary data transmission and improves responsiveness.
Category	Interface and architecture requirements
Additional Comment	Supports selective channel subscriptions.

Identifier	REQ-OVERHEAT-D5.3-0029
-------------------	-------------------------------



D5.3

Requirement	The interface shall implement these functions: discovery, identification, authentication, authorization, and secure disconnection.
Status	<Defined>
Rationale	Ensures secure and efficient data exchange between systems.
Category	Interface and architecture requirements
Additional Comment	Includes encryption key exchange for secure sessions.

Identifier	REQ-OVERHEAT-D5.3-0030
Requirement	The RTSP video streaming interface shall support graceful degradation under low bandwidth conditions by reducing resolution or switching to snapshots.
Status	<Defined>
Rationale	Maintains operational capability even with limited connectivity.
Category	Interface and architecture requirements
Additional Comment	Automatic fallback mechanism required.

Identifier	REQ-OVERHEAT-D5.3-0031
Requirement	The interface shall support four main data types: datagrams, data logs, data streams, and data recordings.
Status	<Defined>
Rationale	Covers all operational scenarios for fire detection and response.
Category	Interface and architecture requirements
Additional Comment	An example of this data is provided in Annex 1 of this document.

Identifier	REQ-OVERHEAT-D5.3-0032
Requirement	The interface shall ensure interoperability with maritime and IT networking standards by supporting: <ul style="list-style-type: none"> • TCP/IP over Ethernet LAN for general data exchange and integration with standard IT infrastructure. • NMEA OneNet for high-bandwidth maritime applications such as video streaming and sensor data transfer. • IEC 61162-450 for reliable Ethernet-based communication between bridge systems, ensuring compatibility with existing ECDIS installations. • IEC 61162-460 for advanced secure networking and high-speed data exchange (up to 1 Gbps) in integrated bridge systems.
Status	<Defined>
Rationale	Guarantees that the OVERHEAT system can operate seamlessly across standard IT networks and specialized maritime communication environments, ensuring compliance and future proofing.
Category	Interface and architecture requirements
Additional Comment	-



D5.3

Identifier	REQ-OVERHEAT-D5.3-0033
Requirement	The interface shall include a target_URI property for future data mirroring on ground servers to support post-incident analysis.
Status	<Defined>
Rationale	Enables long-term data retention and forensic investigation.
Category	Interface and architecture requirements
Additional Comment	URI must follow secure HTTPS protocol.

Identifier	REQ-OVERHEAT-D5.3-0034
Requirement	The automated system shall provide compatibility through APIs to integrate with commonly used loading master software platforms, ensuring seamless data exchange for operational planning and cargo management.
Status	<Defined>
Rationale	Fosters commercial exploitation of Overheat Solution
Category	Business Requirements
Additional Comment	Integration should support leading platforms such as Easycon and NAPA, using secure RESTful APIs and authentication mechanisms for data integrity.

2.5 Standard and Regulation Compliance

Identifier	REQ-OVERHEAT-D5.3-0035
Requirement	The system shall comply with IEC 62443 for industrial cybersecurity of IoT and UAS components.
Status	<Defined>
Rationale	Protects against cyber threats and ensures secure data exchange.
Category	Standard and Regulation Compliance
Additional Comment	Includes authentication and encryption protocols.

Identifier	REQ-OVERHEAT-D5.3-0036
Requirement	The system shall adopt ISO/IEC 30141 IoT reference architecture to ensure interoperability.
Status	<Defined>
Rationale	Facilitates integration of heterogeneous IoT and UAS subsystems.
Category	Standard and Regulation Compliance
Additional Comment	Supports modular design for future upgrades.

Identifier	REQ-OVERHEAT-D5.3-0037
Requirement	The system shall comply with GDPR for protection of operational and personal data collected by IoT and UAS systems.
Status	<Defined>
Rationale	Ensures legal compliance for data privacy and security.



D5.3

Category	Standard and Regulation Compliance
Additional Comment	Includes secure storage, transmission, and deletion protocols.

Identifier	REQ-OVERHEAT-D5.3-0038
Requirement	The automated system shall comply with Regulation (EU) 2019/947 for UAS operational rules, including BVLOS missions under the Specific category.
Status	<Defined>
Rationale	Ensures legal operation of autonomous drone missions in maritime environments.
Category	Standard and Regulation Compliance
Additional Comment	Requires risk assessment and operational authorization.

Identifier	REQ-OVERHEAT-D5.3-0039
Requirement	The UAS shall comply with Regulation (EU) 2019/945 for design, CE marking, and remote identification.
Status	<Defined>
Rationale	Guarantees conformity with EU manufacturing and safety standards.
Category	Standard and Regulation Compliance
Additional Comment	Applies to final production units.

Identifier	REQ-OVERHEAT-D5.3-0040
Requirement	The system shall integrate U-space services as per Regulations (EU) 2021/664, 2021/665, and 2021/666 for drone traffic management.
Status	<Defined>
Rationale	Enables safe integration of drones into controlled airspace.
Category	Standard and Regulation Compliance
Additional Comment	Supports dynamic airspace access and conflict resolution.

Identifier	REQ-OVERHEAT-D5.3-0041
Requirement	The IoT sensor shall comply with WEEE disposal requirements and include provisions for safe disposal of lithium batteries.
Status	<Defined>
Rationale	Ensures environmental compliance and safety.
Category	Standard and Regulation Compliance
Additional Comment	Local disposal regulations must be followed.



3. Interaction between subsystems

This section provides a detailed description of the interactions among the key subsystems involved in the automated fire detection and UAS mission workflow. The interactions are illustrated using UML sequence diagrams to capture the dynamic behaviour and message exchanges between components.

Two primary use cases are addressed:

1. Standard operational flow
Represents the operational flow where IoT sensors detect anomalies, alerts are transmitted to the Vessel Digital Solution (DS) and a UAS mission is automatically triggered. The UAS executes a predefined flight plan, captures thermal and visual data, and the AI algorithm confirms fire presence without requiring manual intervention.
2. System failure and Manual Flight
Covers scenarios where automated processes encounter failures or require human oversight. In this case, the operator intervenes to select or modify the flight plan, manually trigger the UAS mission, or override system decisions. This ensures mission continuity and safety under exceptional conditions.

The diagrams highlight:

- Subsystem roles: IoT Sensor, Alert Service, Vessel DS, UAS, AI Fire Detection Algorithm, Operator.
- Message flows: Alert creation, secure transmission, mission triggering, data synchronization, and fire confirmation.
- Recovery mechanisms: Manual overrides and fallback procedures for critical failures.



3.1 Standard operational flow

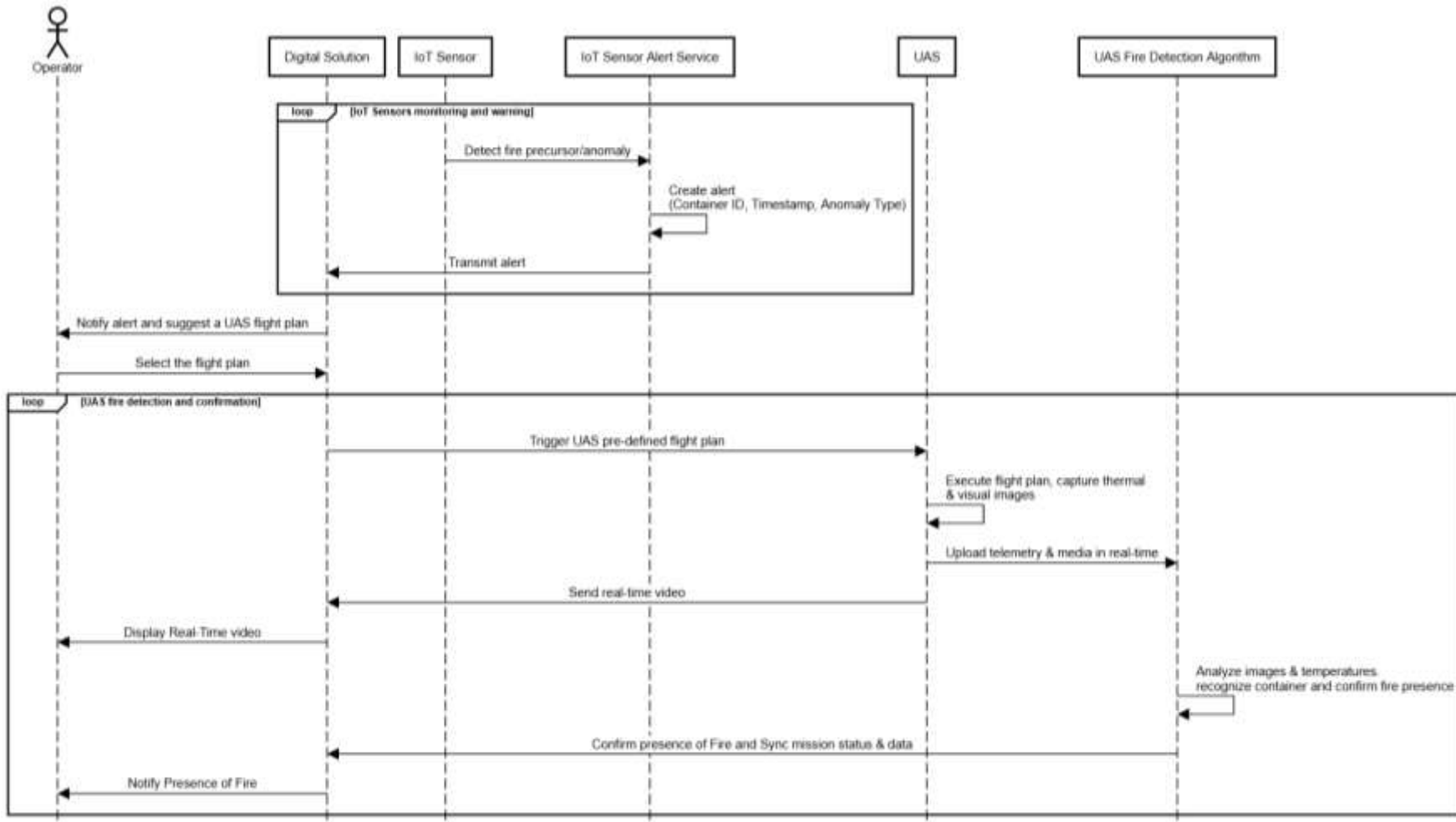


Figure 3-1 Standard Operational Workflow - UML sequence diagram



D5.3

The sequence diagram illustrates the end-to-end process for detecting fire precursors using IoT sensors and confirming fire presence through an automated UAS mission.

1. IoT Monitoring and Alerting
 - IoT sensors continuously monitor containers for fire precursors or anomalies.
 - When an anomaly is detected, the IoT Sensor Alert Service creates an alert containing Container ID, Timestamp, Anomaly Type
 - This alert is transmitted to the Vessel Digital Solution (DS).
2. Operator Notification and Flight Plan Selection
 - The Vessel DS notifies the Operator about the alert and suggests a predefined UAS flight plan.
 - The Operator reviews and selects the flight plan.
3. UAS Mission Execution and Fire Detection
 - The Vessel DS triggers the UAS to execute the selected flight plan.
 - The UAS performs the mission, capturing thermal and visual images.
 - Real-time video is streamed back to the Vessel DS, which displays it to the Operator.
4. AI-Based Fire Confirmation
 - The UAS Fire Detection Algorithm receives telemetry and media in real time.
 - It analyses images and temperature data, validates container identification, and confirms fire presence.
 - Once confirmed, the algorithm updates the Vessel DS with mission status and fire confirmation.
5. Fire confirmation notification
 - The Vessel DS notifies the Operator of confirmed fire presence, enabling timely response.

3.2 System Failures and manual flight

This sequence diagram, titled "Manual Flight Recovery After Error," illustrates the interaction between an Operator, a Vessel Display System (Vessel DS), and an Unmanned Aerial System (UAS) during a flight operation. Initially, the Operator selects a predefined flight plan, which the Vessel DS then triggers on the UAS. If the UAS cannot start the flight, it reports an error back to the Vessel DS, which in turn notifies the Operator and suggests switching to manual flight mode. Following this, the Operator initiates manual flight, and the UAS switches to manual flight mode. During manual flight, there is continuous real-time monitoring where the UAS streams telemetry and video data to the Vessel DS, which displays the live video feed to the Operator.



D5.3

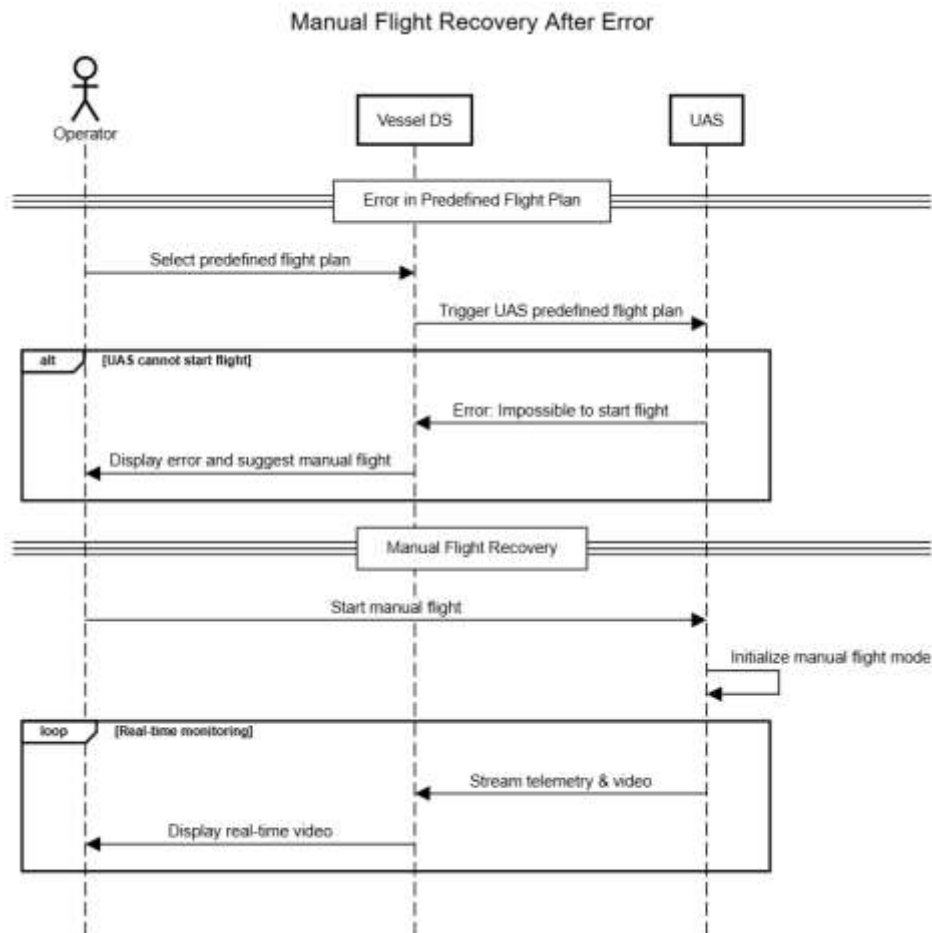


Figure 3-2 System Failures and manual flight - UML sequence diagram

This sequence ensures that the Operator maintains control and situational awareness in case of predefined flight plan errors.



4. Technical Requirements Validation

To verify that the Automated System meets the defined technical requirements under simulated or real operational conditions, the following test specification is established. The fulfilment of each requirement will be assessed using the following three checking criteria:

- OK (Requirement Achieved): The requirement has been fully met and validated
- POK (Requirement Partially Achieved or Modified): The requirement has been partially met, or its original scope was modified during the testing process
- NOK (Requirement Not Achieved nor Validated): The requirement has not been met and could not be validated

Table 4-1 Technical Requirements Validation tests

Validation ID	Requirements ID	Description	OK/POK/NOK	Comments
VAL-001	REQ-OVERHEAT-D5.3-0001	Verify automatic triggering of UAS mission upon IoT sensor anomaly detection	OK / POK / NOK	UAS mission starts within 60 seconds of IoT alert; Alert includes container ID, timestamp, anomaly type
VAL-002	REQ-OVERHEAT-D5.3-0002	Real-time synchronization of mission status, telemetry, and media files	OK / POK / NOK	Data synchronized across vessel DS, port DS, and cloud within 30 seconds
VAL-003	REQ-OVERHEAT-D5.3-0003	Automatic flight plan execution upon IoT alert	OK / POK / NOK	Predefined flight plan executed without manual intervention; operator override available
VAL-004	REQ-OVERHEAT-D5.3-0004, 0012	UAS captures thermal/visual images and AI confirms fire	OK / POK / NOK	Thermal and visual images uploaded in real-time; AI confirms fire when temperature > threshold
VAL-005	REQ-OVERHEAT-D5.3-0006	Quick-charging module	OK / POK / NOK	Drone battery charges from 20% to 90% in ≤ 32 minutes
VAL-006	REQ-OVERHEAT-D5.3-0007	Environmental sensors in hangar	OK / POK / NOK	Sensors accurately report wind, rain, temperature, humidity



D5.3

VAL-007	REQ-OVERHEAT-D5.3-0008	Two-axis tilting mechanism	OK / POK / NOK	Tilting range $\pm 30^\circ$ roll/pitch compensates vessel movement
VAL-008	REQ-OVERHEAT-D5.3-0009	Satellite-based connectivity	OK / POK / NOK	Continuous data transmission via satellite link
VAL-009	REQ-OVERHEAT-D5.3-0010	Emergency stop & LED indicators	OK / POK / NOK	Emergency stop functional; LED states match documented codes in user manual
VAL-010	REQ-OVERHEAT-D5.3-0011	Obstacle avoidance & RTK positioning	OK / POK / NOK	Drone avoids obstacles in all directions;
VAL-011	REQ-OVERHEAT-D5.3-0015	Surge protection & backup battery	OK / POK / NOK	Hangar operates during power fluctuations for ≥ 30 min
VAL-012	REQ-OVERHEAT-D5.3-0015	Manual control fallback	OK / POK / NOK	Operator can assume manual control; C2 link maintained
VAL-013	REQ-OVERHEAT-D5.3-0016–0024	IoT sensor requirements	OK / POK / NOK	Sensor meets installation, communication, power, alarm, IP65, and gas detection specs
VAL-014	REQ-OVERHEAT-D5.3-0025–0033	Interface & architecture	OK / POK / NOK	Secure protocols (MQTT, HTTPS), subscription mechanism, graceful degradation



Annex 1 - DATA FORMAT EXAMPLES

In the following sub-sections, some data format examples are provided, according to the format foreseen at the interface between the “Sensors and drone management subsystem” and the “Data sharing IT subsystem”, i.e., at the level of the interface control document ICD_4.4_4.5. The information is provided as an anticipation of the data formats that will be defined between the “Data sharing IT subsystem” and the ECDIS, and that will be defined in the interface control document ICD_4.5_ECDIS to be provided in the framework of WP6.

Datagrams

The data format described hereafter refers to the so-called *payload* of the datagram, i.e., to the core information that are brought by the datagram and that be conveyed, in principle, over any transport protocols.

The payload format foreseen complies with the JSON standard. In principle, other data format standards that can be converted to JSON (e.g., XML) can be used. The S-100 Universal Hydrographic Data Model appear to prefer the use of XML, although JSON is generally easier to parse and to represent on a web interface, especially when AJAX is used to present a user interface that automatically updates when an event occurs, e.g., when an alarm has to be displayed.

Datagrams are used to provide status reports regarding the status of sensors and drones. A status report for a sensor is an object that includes the following sub-objects:

- *Timestamp object*. It provides the reference time of the status report.
- *Identification object*. It provides the identification of the status report, of the vessel, of the container, and of the sensor;
- *Status object*. It provides the current status of the sensor, including any values measured by it;
- *Localization object*. It allows to localize within the vessel the sensor (and therefore the container) relevant to the report;
- *Target_URI*. It is intended as a growth capability for future use.

The above information can be also represented as shown in the following table.

Table A.0-1 – Sensor status report object definition

Property	Data type	Description
timestamp	Object	It provides the reference time of the status report
identification	Object	It provides the identification of the vessel, of the container, and of the sensor
status	Object	It provides the current status of the sensor, including any values measured by it. This may be null if the target_UR property is populated
localization	Object	It allows to localize within the vessel the sensor (and therefore the container) relevant to the report. This may be null if the target_URI property is populated



D5.3

target_URI	String	Null. This is a growth capability allowing to identify the URI of a data server on ground where the same data are mirrored, so that they remain available for after-fire investigations even in the case the equipment on the vessel is damaged or the vessel is decommissioned
------------	--------	---

The objects embedded in the sensor status report object are defined as follows.

Table A.0-2 – Timestamp object definition

Property	Data type	Description
date	String	Date of the report, DD:MM:YYYY format
time	String	Time of the report, hh:mm:ss format
offset	String	Time offset with respect to UTCT, hh:mm:ss format. To be added to the time property to convert it to UTC

Table A.0-3 – Identification object definition

Property	Data type	Description
report_number	Integer	Conventional identifier of the report (e.g., sequence number assigned when the report is generated)
vessel	Integer	IMO number of the vessel
container	String	ISO 6346 container identifier
sensor	String	Unique identifier of the sensor

Table A.0-4 – Status object definition

Property	Data type	Description
status	String	Values allowed: “alarm”; “warning”; “caution”; “failure”
type	String	Sensor type (e.g., gas sensor; temperature sensor; etc.)
readings	Object	A list of name/value pairs representing the data measured by the sensor. It depends on the sensor type
settings	Object	A list of name/value pairs representing the current settings in use by the sensor (e.g., temperature thresholds that determine the status). It depends on the sensor type
diagnostics	Object	A list of name/value pairs representing diagnostics information about the sensor (e.g. current percentage of the battery charge). It depends on the sensor type

Table A.0-5 – Localization object definition

Property	Data type	Description
deck_number	Integer	Number of the deck where the sensor is located
deck_name	String	Conventional deck name (if applicable)
deck_number_uncertainty	Integer	Uncertainty on the deck localization (\pm number of decks)
stern_distance	Integer	Estimated distance in meters from the stern of that deck (always positive)



D5.3

stern_distance_uncertainty	Integer	Estimated uncertainty (\pm meters) on the stern_distance
centerline_distance	Integer	Estimated distance in meters from the centerline of the vessel (positive = port; negative = starboard)
centerline_distance_uncertainty	Integer	Estimated uncertainty (\pm meters) on the centerline_distance
stacking_level	Integer	Estimated position of the container in the stack (1 = floor)
stacking_level_uncertainty	Integer	Estimated uncertainty on the position of the container in the stack (\pm number of levels)

A status report for a drone is an object that includes the following sub-objects:

- *Timestamp object*. It provides the reference time of the status report;
- *Identification object*. It provides the identification of the status report, of the vessel, and of the drone;
- *Status object*. It provides the current status of the drone, including any values measured by it. Localization information are part of the status report;
- *Target_URI*. It is intended as a growth capability for future use.

The above information can be also represented as shown in the following table.

Table A.0-6 – Drone status report object definition

Property	Data type	Description
timestamp	Object	It provides the reference time of the status report
identification	Object	It provides the identification of the vessel and of the drone
status	Object	It provides the current status of the drone, including any values measured by it. This may be null if the target_URI property is populated
target_URI	String	Null. This is a growth capability allowing to identify the URI of a data server on ground where the same data are mirrored, so that they remain available for after-fire investigations even in the case the equipment on the vessel is damaged or the vessel is decommissioned

The objects embedded in the drone status report object are defined as follows.

Table A.0-7 – Timestamp object definition

Property	Data type	Description
date	String	Date of the report, DD:MM:YYYY format
time	String	Time of the report, hh:mm:ss format
offset	String	Time offset with respect to UTCT, hh:mm:ss format. To be added to the time property to convert it to UTC

Table A.0-8 – Identification object definition

Property	Data type	Description
----------	-----------	-------------



D5.3

report_number	Integer	Conventional identifier of the report (e.g., sequence number assigned when the report is generated)
vessel	Integer	IMO number of the vessel
operator_id	String	Drone Operator Registration Number as provided by the relevant national authority
drone_id	String	Unique identifier of the drone, compliant with standard ANSI/CTA-2063-A

Table A.0-9 – Status object definition

Property	Data type	Description
altitude	Integer	Altitude in meters
speed	Integer	Speed in km/h
battery	Integer	Charge status of the battery, in percentage
latitude	Floating	Latitude in decimal degrees
longitude	Floating	Longitude in decimal degrees
drone_status	String	Values allowed: "off"; "charging"; "in flight"; "ready to fly"

A status report for a docking station is an object that includes the following sub-objects:

- *Timestamp object*. It provides the reference time of the status report;
- *Identification object*. It provides the identification of the status report, of the vessel, and of the docking station;
- *Status object*. It provides the current status of the docking station, including any values measured by it;
- *Target_URI*. It is intended as a growth capability for future use.

The above information can be also represented as shown in the following table.

Table A.0-10 – Docking station status report object definition

Property	Data type	Description
timestamp	Object	It provides the reference time of the status report
identification	Object	It provides the identification of the vessel and of the docking station
status	Object	It provides the current status of the docking station, including any values measured by it. This may be null if the target_URI property is populated
target_URI	String	Null. This is a growth capability allowing to identify the URI of a data server on ground where the same data are mirrored, so that they remain available for after-fire investigations even in the case the equipment on the vessel is damaged or the vessel is decommissioned

The objects embedded in the drone status report object are defined as follows.

Table A.0-11 – Timestamp object definition



D5.3

Property	Data type	Description
date	String	Date of the report, DD:MM:YYYY format
time	String	Time of the report, hh:mm:ss format
offset	String	Time offset with respect to UTCt, hh:mm:ss format. To be added to the time property to convert it to UTC

Table A.0-12 – Identification object definition

Property	Data type	Description
report_number	Integer	Conventional identifier of the report (e.g., sequence number assigned when the report is generated)
vessel	Integer	IMO number of the vessel
docking_station_id	String	Unique identifier of the docking station

Table A.0-13 – Status object definition

Property	Data type	Description
status	String	e.g., “active”
temperature	Integer	Temperature in °C
cock_battery	Integer	Charge status of the battery, in percentage
connection	String	e.g., “stable”
cover_status	String	Values allowed: “open”; “closed”
wind_speed	Integer	Wind speed In km/h
rain	Boolean	True if rainfall is present

Data logs

Data logs are arrays of datagrams collected through a defined time interval. They are defined as follows.

Table A.0-14 – Data log definition

Property	Data type	Description
log_summary	Object	Summary of the datagrams contained in the log
datagrams	Array of objects	Datagram objects in the log. . This may be null if the target_URI property is populated
target_URI	String	Null. This is a growth capability allowing to identify the URI of a data server on ground where the same data are mirrored, so that they remain available for after-fire investigations even in the case the equipment on the vessel is damaged or the vessel is decommissioned

Table A.0-15 – Log summary definition

Property	Data type	Description
log_number	Integer	Conventional identifier of the log (e.g., sequence number assigned when the log is generated)
start_time	Object	Timestamp of the first datagram in the log



D5.3

end_time	Object	Timestamp of the last datagram in the log
datagrams_number	Integer	Number of datagrams in the log
identifications	Array of objects	Identifications contained in all datagrams (not repeated if multiple datagrams have the same identification object)

Data streams

Data streams are provided by a streaming server located on ground. In the case of video streams, RTSP streaming is used, with video feeds compressed using efficient codecs like H.264 or H.265. The encoded video is packaged into a suitable format for streaming, typically using formats like MP4 or MKV.

Each data stream is managed through an object that includes the following sub-objects:

- *Timestamp object*. It provides the reference time of the data stream (beginning time);
- *Identification object*. It provides the identification of the data stream, of the vessel, of the source (drone or docking station) and of the data stream type (e.g., optical vs. infrared);
- *Target URI*. It provides the URI of the streaming server where the data stream can be obtained.

The above information can be also represented as shown in the following table.

Table A.0-16 – Data stream object definition

Property	Data type	Description
beginning_timestamp	Object	It provides the reference time of the data stream (beginning time)
identification	Object	It provides the identification of the data stream, of the vessel, and of the source
target_URI	String	It provides the URI of the streaming server where the data stream can be obtained.

The objects embedded in the data stream object are defined as follows.

Table A.0-17 – Timestamp object definition

Property	Data type	Description
date	String	Date of the data stream, DD:MM:YYYY format
time	String	Time of the data stream, hh:mm:ss format
offset	String	Time offset with respect to UTCT, hh:mm:ss format. To be added to the time property to convert it to UTC

Table A.0-18 – Identification object definition

Property	Data type	Description
data_stream_number	Integer	Conventional identifier of the data stream (e.g., sequence number assigned when the data stream is generated)
vessel	Integer	IMO number of the vessel



D5.3

operator_id	String	Drone Operator Registration Number as provided by the relevant national authority. May be null if the data stream is relevant to a docking station.
drone_id	String	Unique identifier of the drone, compliant with standard ANSI/CTA-2063-A. May be null if the data stream is relevant to a docking station.
docking_station_id	String	Unique identifier of the docking station. May be null if the data stream is relevant to a drone.
Type	String	Values allowed: "optical"; "infrared"

Data Recording

Each data recording is managed through an object that includes the following sub-objects:

- *Timestamp object*. It provides the reference time of the data stream (beginning time);
- *Timestamp object*. It provides the reference time of the data stream (end time);
- *Identification object*. It provides the identification of the data stream, of the vessel, of the source (drone or docking station) and of the data stream type (e.g., optical vs. infrared);
- *Target URI*. It provides the URI of the streaming server where the data stream can be obtained.



REFERENCES

1. OVERHEAT D4.1 – User Manual of the UAS Recharging Station
2. OVERHEAT D4.2 – User Manual of the UAS Recharging Station software
3. OVERHEAT D4.4 - User manuals for the IoT sensors
4. Deliverable 5.1 - End User Requirements, OVERHEAT Project
5. Deliverable 5.2 – Digital Solution Requirements



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.