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Overwatch

End-users requirements

Deliverable 1.1

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Authors: **José BORGES, Joaquim SILVA, João AFONSO**
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Author(s)	Borges, J., Silva, J., Afonso, J.
Co-Author(s)	Capitulino, J., Baldaia, S., Fernandes, H., Wrzosek, E., Ryznar, A., Kobierzycka, A., Dąbrowska, K., Gordy, C., Silva, H., Fontes, H., Rossi, C., Arnaudo, E., Polidori, B., Covas, G., Ferreira, B., Geipel, K., Novac, I., Vella, G., Nicoletti, T.
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Deliverable abstract	The OVERWATCH project aims to enhance crisis management by developing an integrated holographic system to improve communication, information gathering, and coordination among disaster response teams. This deliverable focuses on the project's objectives, scope, and expected outcomes for managing wildfires and floods, emphasizing innovative technologies like artificial intelligence, drones, augmented reality, and the Copernicus Emergency Management Services. The report discusses the requirements for the OVERWATCH technologies, including the artificial intelligence backend management system, augmented reality, earth observation, drone technologies and fallback communication system. The report also highlights the significance of disaster management, particularly in light of climate change, and identifies the end-users requirements. The project seeks to create a more resilient and capable response infrastructure, reduce the risk to humans and material goods, and provide better situational awareness and coordinated efforts. The report serves as a roadmap for developing OVERWATCH technologies and aims to mitigate the adverse impacts of natural hazards, benefitting economic stability, the environment, and human lives.

[1] Nature of the deliverable: **R** = Report, **P** = Prototype, **D** = Demonstrator, **O** = Other

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List of authors, coauthors and reviewers (All)

Number	Name	Role	Organisation
1	José BORGES	Author	CINAMIL
2	Joaquim SILVA	Author	CINAMIL
3	João AFONSO	Author	CINAMIL
4	João CAPITULINO	Coauthor	CINAMIL
5	Sónia BALDAIA	Coauthor	CINAMIL
6	Hélio FERNANDES	Coauthor	CINAMIL
7	Emil WRZOSEK	Coauthor	CBK PAN
8	Anna RYZNAR	Coauthor	CBK PAN
9	Anna KOBIERZYCKA	Coauthor	CBK PAN
10	Katarzyna DĄBROWSKA	Coauthor	CBK PAN
11	Clayton GORDY	Coauthor	HOLO

12	Hugo SILVA	Coauthor	INESC
13	Helder FONTES	Coauthor	INESC
14	Claudio ROSSI	Coauthor	Links
15	Edoardo ARNAUDO	Coauthor	Links
16	Brendan POLIDORI	Coauthor	Links
17	Guilherme COVAS	Coauthor	ISQ
18	Bruno FERREIRA	Coauthor	ISQ
19	Kenneth GEIPEL	Coauthor	Robotto
20	Iuliu NOVAC	Coauthor	Robotto
21	Giuseppe VELLA	Coauthor	Engineering
22	Tommaso NICOLETTI	Coauthor	Engineering
23	Jakub RYZENKO	Internal reviewer	CBK PAN
24	Vanina FISSORE	Reviewer	ITHACA
25	Nelson MATOS	Reviewer	ISQ

Acronyms and abbreviations

AI	Artificial intelligence
AR	Augmented reality
BPL	Broadband over power lines
C2	Command and control
CH	Chapter
CBI	Composite burned index
COTS	Commercial of the shelve
D	Deliverable
DM	Decision-making
DSM	Digital Surface Model
DTM	Digital Terrain Model
ECS	Emergency communication systems
EGNOS	European geostationary navigation overlay service
EUB	End-users board
EO	Earth observation
EMS	Emergency management and security
ER	Emergency resonders
FR	First responder
FSX	Full-scale exercise [an exercise that involves multiple organisations or functions and includes actual activities (ISO22300:2021, n.d.)]
GCS	Ground control station
GIS	Geographic information systems
GNSS	Global navigation satellite system
GPS	Global Positioning System
LIDAR	Laser imaging, detection, and ranging
HAS	High Accuracy Service
ISAR	Interactive streaming for augmented reality
OSNMA	Open service navigation message authentication
NBR	Normalised burn ratio
NGO	Non-governmental organisations
R&D	Research and development
SA	Situational awareness
SAR	Search and rescue
SART	Situation assessment and reconnaissance teams

SDK	Software development kit
SotA	State of the art
TO	Theatre of operations
VR	Virtual reality
XR	Extended reality

Executive Summary

The OVERWATCH project seeks to develop an integrated holographic crisis management system to enhance communication, information gathering, and coordination among disaster response teams. The project's primary objectives include creating a more intuitive, decentralised, informed, and precise tool for managing several types of disasters. The project also intends to ensure a safer, more resilient, and capable response infrastructure while reducing the risk to humans and material goods by providing better situational awareness and coordinated efforts.

This deliverable focuses on creating scenarios and use cases for managing wildfires and floods and identifying end-users' requirements. It underscores the significance of disaster management, particularly in light of climate change, and outlines the project's objectives, scope, and expected outcomes. The report highlights the use of digital technologies such as artificial intelligence, drones, augmented reality, and existing services provided by the Copernicus Emergency Management Services (EMS) to achieve these goals.

The requirements are organised in terms of the OVERWATCH technologies: earth observation, drone technologies, fallback communication system, artificial intelligence-based backend management system, and augmented reality.

The core concept of augmented reality (AR) technology in OVERWATCH aims to allow real-time rendering of high-quality, realistic virtual objects that can be overlaid on the physical surroundings. The AR must support interaction with the physical environment through gestures, voice commands, or other input methods while accurately tracking the user's position and orientation for a precise overlay of AR content. It should display information in multiple data layers generated by the artificial intelligence backend management system (AIMS), support various platforms, and have reliable object recognition and tracking. The OVERWATCH should support training, scenario and use case simulations, voice assistants, offline access, external sensors, and integration with the AIMS.

The concept of the AIMS will be to manage the OVERWATCH system, e.g., provide real-time situational awareness (SA) and support emergency responders in decision-making and resource allocation. AIMS will use artificial intelligence algorithms to collect and analyse real-time data from internal and external sources such as the Copernicus EMS, diverse satellite imagery, and other remote sensing data and provide critical information to emergency responders. AIMS will facilitate and coordinate the operation and use of drones, allocate resources based on the severity and potential spread of the natural hazard, and provide support in managing emergencies along the response and recovery phases. AIMS will generate maps, 3D models, reports, and visualisations that support decision-making and provide situational awareness to all emergency responders, enabling them to make informed decisions in real-time and coordinated responses. AIMS will also support multiple languages, integrate with external sensors and data sources, provide real-time updates and early warning alerts to emergency responders based on changing conditions, and provide situational awareness to residents in the theatre of operations. The AIMS won't command any emergency response operation or override the commander in charge of operations in any way.

The drone technologies (DT) will support emergency responders in collecting data using an aerial perspective. The drones will operate in diverse visibility conditions, flying autonomously or remotely piloted, using flight control and stabilisation systems, navigating safely, detecting adverse weather, carrying advanced payloads, and following topography, while maintaining a safe flying ceiling. They must also have elementary on-board real-time processing of data from sensors, recharge or swap batteries quickly, and provide fixings and interfaces for payloads. The emergency command and control commander must also explicitly clear drone operations while complying with national/regional authorities' regulations.

The OVERWATCH will utilize earth observation (EO) and GIS data to collect, process, and integrate real-time data to produce updated maps and visualizations that will supply the SA dashboards for emergency responders. The Overwatch will use EO to support risk assessment, provide historical data on past natural hazards, and identify areas where natural hazards have the potential to cause significant damage or loss of life. However, the EO module of OVERWATCH will not likely provide 100% accurate predictions or real-time data nor replace emergency responders' judgment and decision-making skills.

Using a tethered drone with a fallback communication system, the OVERWATCH will provide redundant communication channels for emergency responders in blackout regions. The tethered drone will need a reliable connection with the ground control station and a payload to support Wi-Fi communications, including a satellite broadband link for communication hotspots. The ground control station system should have a user-friendly interface and high-speed data transfer capabilities. In areas with communication blackouts, the system should be able to identify, provide remote access, and log activity for analysis and reporting. However, the system will have limitations, such as the tethered drone's operating distance and weather conditions.

This deliverable D1.1 emphasizes improving disaster management through innovative technologies that aid information gathering, communication, and coordination between disaster response teams. The report aims to provide the basis for developing technologies and emphasises the importance of creating a safer, more resilient, and more efficient response infrastructure to address the challenges posed by natural hazards, such as wildfires and floods. The deliverable will serve policymakers, stakeholders, and the public with valuable insights into disaster management. It will also serve as a roadmap for developing the OVERWATCH technologies to create more robust and comprehensive disaster management strategies by identifying key challenges and requirements for effective crisis management. Eventually, it is expected that OVERWATCH will contribute to mitigating the adverse impacts of natural hazards, specifically wildfires and floods, on human lives, benefiting economic stability and the environment, thereby creating a more sustainable future.

1. Introduction

1.1. Overview of the OVERWATCH project

Climate change is causing increased natural hazards, resulting in death, displacement, destruction, and economic impact. Forest fires and floods represent a significant risk in the European Union (EU) Member States. The project aims to create a more intuitive, decentralised, informed, and precise tool for several types of disasters, deployable in several phases of a natural disaster. The project will ensure a safer, more resilient, and capable response infrastructure, carrying out the crisis operation more cohesively. Disaster management and control are crucial to mitigate the effects of these events.

The OVERWATCH project aims to develop an Integrated holographic crisis management map, supported by European Global Navigation Satellite System (EGNSS) and Copernicus Emergency Management and Security (EMS) services, to improve communication, information gathering, and coordination among disaster response teams. The system will use digital technologies, such as artificial intelligence, drones, and augmented reality, to provide accurate data and improve performance.

The project addresses the complexity of disaster management and control, which involves information and communication with several players to have a high-fidelity awareness of the situation to implement adequate and effective measures. The project will develop a reliable and efficient communications infrastructure enabling solutions such as OVERWATCH to gather and disseminate information for improved situational awareness.

The project will combine several services offered by EGNSS and Copernicus EMS with digital technologies, providing the necessary data and performance to make this system a valuable resource for environmental, citizen, and infrastructure protection.

OVERWATCH aims to create a TRL 7 prototype validated through two demonstrations in different countries. This prototype will enhance the disaster response team's capabilities, enabling them to deploy air, water, and ground assets through decision support tools integrated into an immersive and decentralised command platform. The project will also focus on pre-disaster planning, mitigation operations during the disaster, and relief, rehabilitation, and reconstruction.

The project's desired end state will be to reduce the risk to humans and material goods by providing better situational awareness and coordinated efforts.

1.2. Purpose of the document

This document aims to comprehensively understand the terminology, state-of-the-art, possible scenarios, use cases, and end-user requirements for crisis and emergency management and control of wildfires and floods.

The document explores the challenges posed by natural hazards such as wildfires and floods and highlights the importance of disaster management in climate change. By identifying the essential requirements and best practices for effective crisis management, this document aims to provide a roadmap for the consortium in developing the subsequent tasks in the OVERWATCH project. It also seeks to provide a valuable resource for policymakers, stakeholders, and the public to create more robust and comprehensive disaster management strategies. Ultimately, OVERWATCH aims to promote a coordinated and collaborative approach to disaster management that can help mitigate the adverse impacts of natural hazards on communities, economies, and the environment.

The document will identify end-user requirements for crisis and emergency management and control, providing valuable insights into the needs and expectations of disaster response teams, policymakers, and other stakeholders.

The use cases developed in this deliverable will provide testing baselines for the OVERWATCH technologies in two full-scale exercises (FSX). The project will deliver the FSX in the context of two pilots at the end of the project, one in Portugal for wildfires and the other in Poland for flood hazards.

The OVERWATCH seeks to mitigate the adverse impacts of natural hazards on human lives, economic stability, and the environment, creating a safer, more resilient, and sustainable future.

1.3. Structure of the document

The deliverable report, this document, follows the following structure,

- Chapter 1, this chapter, provides an overview of the OVERWATCH project and states its primary purposes. It also provides the structure of this report.
- Chapter 2 provides terminology and respective definitions for the project, as required when reading the document.
- Chapter 3 outlines the state-of-the-art analysis performed by the project team to identify the gaps and opportunities for developing the OVERWATCH technologies.
- Chapter 4 describes the methodology and objectives for collecting the use cases and end-user requirements. The chapter also analyses the stakeholders and presents a strategy to address them. It also lists the meetings and workshops between the end users and the project team.
- Chapter 5 revises some R&D projects in the same scientific area as OVERWATCH, financed by the EU and some Member States in the past.
- Chapter 6 develops the scenarios used to guide the work with end-users to collect the use cases and requirements that will support implementing OVERWATCH.
- Chapter 7 initially provides a template for collecting the use cases. It then presents the use cases collected from the end users and desk research activities for wildfires and floods.
- Chapter 8 initially provides the structure for presenting the functional and non-functional requirements. It then lists all requirements collected from the end users based on the scenarios and use cases, then developed and organised by the OVERWATCH team following criteria of technologies and priority.
- Chapter 9, the last chapter, provides conclusions and remarks for deliverable D1.1.

2. Glossary

This chapter aims to define some terminology used throughout this document. Specialised language can often create confusion or misunderstanding, particularly for those unfamiliar with the field. Therefore, it is essential to establish a common understanding of the key terms used in this document.

This chapter presents a comprehensive list of the technical terms and jargon used in the document. It provides clear and concise definitions for each concept based on existing literature. It may also provide examples of how these terms are used in context to help readers better understand their meaning and relevance.

By clearly defining the key terminology used in this document, readers will better understand the concepts and ideas presented in subsequent chapters. Such an effort will help to ensure a more accurate and precise understanding of the issues discussed, making it easier to apply this knowledge in real-world situations.

Affected area

A location that has been impacted by a disruptive event (incident, accident, disaster) (ISO22300:2021, n.d.)

After-action report / final exercise report

A document that records, describes and analyses the actual disruption or exercise, drawing on debriefs and reports from observers, and derives lessons from it. (ISO22300:2021, n.d.)

Area at risk

A location that could be affected by a disruptive event (incident, accident, disaster). (ISO22300:2021, n.d.)

Assessment

A qualitative or quantitative approach to determine the nature and extent of risk by analysing potential hazards and evaluating existing conditions of exposure and vulnerability that together could harm people, property, services, livelihoods and the environment on which they depend. (DRIVER+, 2014)

Basic services

Services that are needed for all of society to function effectively. Examples of basic services include water supply, sanitation, health care, education, housing, and food supply. They also include services provided by critical infrastructure such as electricity, telecommunications, transport, finance or waste management that are needed for society to function. (UNDRR, 2015)

Business continuity

The capability of an organisation to continue the delivery of products and services within acceptable time frames at a predefined capacity during a disruption. (ISO22300:2021, n.d.)

Capacity

The combination of all the strengths, attributes and resources available within an organisation, community or society to manage and reduce disaster risks and strengthen resilience. Capacity may include infrastructure, institutions, human knowledge and skills, and collective attributes such as social relationships, leadership and management. (UNDRR, 2015)

The combination of all the strengths and resources available within an organisation, community or society that can reduce the level of risk or the effects of a crisis. (ISO22300:2021, n.d.)

Capability (emergency management)

The overall ability to effectively manage prevention, preparedness, response and recovery before, during and after potentially destabilising or disruptive events. (ISO22300:2021, n.d.)

Capacity development

The process by which people, organisations and society systematically stimulate and develop their capacities over time to achieve social and economic goals, including through the improvement of knowledge, skills, systems, and institutions. Capacity development is a concept that extends the term of capacity building to encompass all aspects of creating and sustaining capacity growth over time. It involves learning and various types of training but also continuous efforts to develop institutions, political awareness, financial resources, technology systems, and the broader social and cultural enabling environment. (UNDRR, 2015)

Civil protection

Measures taken and systems implemented to preserve the lives and health of citizens, their properties and their environment from undesired events, such as accidents, emergencies and disasters. (ISO22300:2021, n.d.)

Command & control (C2)

Activities of target-oriented decision-making, situation assessment, planning, implementing decisions and controlling the effects of implementation on the incident. This process is repeated continuously. (ISO22300:2021, n.d.)

Crisis

Unstable condition involving an impending abrupt or significant change that requires urgent attention and action to protect life, assets, property or the environment. (DRIVER+, 2014)

Crisis management

Crisis management involves the management of preparedness, mitigation response, and continuity or recovery in the event of an incident, as well as management of the overall programme through training, rehearsals and reviews to ensure the preparedness, response and continuity plans stay current and up-to-date. (DRIVER+, 2014)

Disaster

Severe disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts. The effect of the disaster can be immediate and localised but is often widespread and could last for an extended time. The effect may test or exceed the capacity of a community or society to cope using its resources and, therefore, may require assistance from external sources, which could include neighbouring jurisdictions or those at the national or international levels. (UNDRR, 2015)

Disaster management

The organisation, planning and application of measures preparing for, responding to and recovering from disasters. Disaster management may not altogether avert or eliminate the threats; it focuses on creating and implementing preparedness and other plans to decrease the impact of disasters and "build back better". Failure to develop and apply a plan could damage life, assets and lost revenue. (UNDRR, 2015)

Early warning system

An interrelated set of hazard warning, risk assessment, communication and preparedness activities that enable individuals, communities, businesses and others to take timely action to reduce their risks. (UNDRR, 2015)

Emergency

An emergency is usually a disruption or condition that can often be anticipated or prepared for, but seldom exactly foreseen. (DRIVER+, 2014)

Emergency communication system (ECS)

A system that enables individuals or groups to communicate quickly and effectively in emergencies, e.g., natural disasters, such as wildfires or floods, medical emergencies, security incidents, or any other situation that requires urgent communication. The ECS includes a public warning system.

Emergency management

The organisation and management of resources and responsibilities for addressing all aspects of emergencies and effectively responding to a hazardous event or a disaster. (UNDRR, 2015)

Emergency responders (ER)

In this project, "emergency responders" refer to personnel involved in responding to an emergency, including first responders as well as other specialised teams such as hazardous materials (hazmat) response, search and rescue (SAR) teams, and disaster response teams. Emergency responders may also include non-governmental organisations (NGO), private companies, and volunteers providing support during emergencies.

First responders (FR)

A first responder is a certified member of an authority entitled to respond first to the scene of an emergency. (DRIVER+, 2014)

Forecast

A definite statement or statistical estimate of the likely occurrence of a future hazardous event or conditions for a specific area. In meteorology, a forecast refers to a future condition, whereas a warning refers to a potential occurrence of a hazardous event. (UNDRR, 2015)

Hazard

A natural, technological, or social phenomenon that poses a threat (CCAHA, 2023)

A process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation. This may include the latent property or the inherent capability of an agent or substance, which makes it capable of causing adverse effects to people or the environment under exposure conditions (UNGA 2016, WHO 2009).

Local emergency management authority

Authority of the affected area or country that carries out general management and coordination of all disaster response activities. (DRIVER+, 2014)

Operational capacity

The set of available capacities deployed to an operations theatre to effectively respond to a hazardous event or a disaster and definitively resolve an emergency situation.

Theatre of operations (TO)

An operational area that the C2 geographically defines for the conduct or support of specific combat operations. Multiple TO normally will be geographically separated and focused on different missions and usually have significant size, requiring operation in depth and over extended periods. Adapted from (JP3-0, 2017)

People (population) at risk

All individuals in the area who could be affected by an incident. (ISO22300:2021, n.d.)

Preparedness

The knowledge and capacities developed by governments, professional response and recovery organisations, communities and individuals to effectively anticipate, respond to, and recover from, the impacts of likely, imminent or current disasters. (UNDRR, 2015)

Public warning system

A set of protocols, processes and technologies based on the public warning policy to deliver notification and alert messages in a developing emergency situation to people at risk and to first responders. (ISO22300:2021, n.d.)

Resilience

The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions. (UNDRR, 2015)

Response

Actions taken during or immediately after a disaster to save lives, reduce health impacts, ensure public safety and meet the basic subsistence needs of the people affected. (UNDRR, 2015)

Risk (disaster)

The potential loss of life, injury, or destroyed or damaged assets could occur to a system, society or community in a specific period, determined probabilistically as a function of hazard, exposure, vulnerability and capacity. The definition of disaster risk reflects hazardous events and disasters as the outcome of continuously present risk conditions. Disaster risk comprises different types of potential losses, often difficult to quantify. Nevertheless, with knowledge of the prevailing hazards and population and socioeconomic development patterns, disaster risks can be assessed and mapped, in broad terms at least. It is important to consider the social and economic contexts in which disaster risks occur and that people do not necessarily share the same perceptions of risk and their underlying risk factors. (UNDRR, 2023)

Risk management (disaster)

Disaster risk management is the application of disaster risk reduction policies and strategies to prevent new disaster risks, reduce existing disaster risks and manage residual risk, contributing to the strengthening of resilience and reduction of disaster losses. Disaster risk management actions can be distinguished between prospective disaster risk management, corrective disaster risk management and compensatory disaster risk management, also called residual risk management. (UNDRR, 2015)

Situational awareness

State of individual and/or collective knowledge relating to past and current events, their implications and potential future developments. (DRIVER+, 2014)

Use of force continuum

Increasing or decreasing the level of force applied as a continuum relative to the adversary's response, using the amount of force reasonable and necessary. The amount of force used should be the minimum reasonable amount needed to eliminate the threat presented, thereby minimising the risk and severity of any injury that can occur. Escalation/de-escalation of force response with a level of force should be appropriate to the situation at hand, acknowledging that the response can move from one part of the continuum to another in seconds. (ISO22300:2021, n.d.)

Vulnerability

The conditions determined by physical, social, economic and environmental factors or processes increase a community's susceptibility to the impact of hazards. (UNDRR, 2015)

Wildfires

The concept adopted in this project includes forest fires and other uncontrolled fires that may burn diverse land cover, natural or artificial.

3. OVERWATCH technologies

The crisis and emergency management and control field has rapidly evolved in recent years, with the introduction of emergent technologies, such as artificial intelligence (AI), automation, and approaches to better respond to disasters and natural hazards. This chapter aims to identify state-of-the-art crisis and emergency management, providing an overview of the latest advancements and trends.

The chapter will explore the different aspects of supporting technologies for crisis and emergency management. It will highlight the latest tools and technologies for disaster risk reduction, early warning systems, crisis communication, and post-disaster recovery. Additionally, the chapter will examine case studies of successful crisis and emergency management initiatives, providing valuable insights into best practices and lessons learned.

By identifying the state-of-the-art in crisis and emergency management, this chapter will support the OVERWATCH project to understand better the latest tools and techniques used in the field. It will also provide insights into the challenges faced by disaster management agencies and stakeholders and how innovation and collaboration address these challenges.

OVERWATCH components/systems that will be tested and validated in the correspondent pilot to facilitate reaching the goals set. One or more of the following components/systems will be listed: earth observation (EO), drones (DR), fallback communication system (FCS), artificial intelligence-based backend management system (AIMS), and augmented reality (AR).

Overall, this chapter serves as an essential reference for the project, providing a comprehensive overview of the latest developments and trends in the field and providing the gaps for developing the OVERWATCH technologies. It will help readers stay up-to-date with the latest advancements and best practices, improving their ability to respond to disasters and natural hazards promptly and effectively.

3.1. Interactive holographic asset map management tool

Immersive technologies aim to extend the reality experienced by users. Virtual Reality (VR) and Augmented Reality (AR) are two subsets of such immersive technologies which provide either entirely virtual environments or virtual content superimposed on the real world, respectively (Milgram, 1994). These human-machine interactive technologies leverage visual, auditory and/or haptic information in convincing ways to bolster sensory conditions for specific purposes. While often considered most useful in the entertainment sector, VR/AR technologies have considerable value in various environments, such as healthcare, education, planning, or industrial design (Vigkos, 2022) (Bottani, 2019).

Any targeted use of these technologies can benefit from the unique immersive medium that VR/AR provides as an information delivery tool. These tools' main advantage is manipulating and interacting with holographic content in real-time (Papakostas, 2021), allowing novel perspectives, increased awareness, and better situational understanding; these features leverage more informed decision-making (DM). In addition, such content can be from various origins and of different formats, allowing users with individually tailored access to information to deploy in neutral locations quickly. AR technologies offer considerable benefit for such purposes, as virtualised real-time information is superimposed among real environmental objects, which enhances the real world (Papakostas, 2021).

Responding to natural disasters presents a dynamic environment where semantic-driven geographic asset management and DM are crucial, requiring comprehensive information readily available and visualised meaningfully. While useful, two-dimensional visualisation (e.g., on a computer screen) fails to capture realistic and immersive aspects provided by AR technologies. The latter is beneficial for personnel who deploy assets as they can be updated in real-time in AR space with how a situation is evolving, both passively concerning environmental information and actively concerning the management of field assets. AR visualisation of floods on local infrastructure (Haynes, 2018) benefits natural disaster information delivery, albeit on smartphone devices. Additionally, entirely virtual environments have provided training for airborne firefighters by offering enhanced field viewing (Clifford, 2018). More situationally meaningful, dedicated AR solutions are used to visualise geographic terrain data for military tactical asset management. They are used to good effect (Airbus, n.d.), including virtual climate simulations and drone-acquired imagery (BIS, 2023). OVERWATCH project will provide an analogous theoretical approach, which aims to integrate and visualise AR geospatial, live asset maps, and drone-derived data to create a comprehensive tool for asset management during natural disasters. Here, such technologies will expand beyond the current state of the art by providing superior-quality holographic content for easy interaction. Accordingly, the AR solutions developed in this project will leverage the OVERWATCH platform's increased connectivity and data-sharing capabilities to offer a quality AR environment to drive impactful experiences for users.

Accordingly, facilitating holographic visualisation is the coordinated work of several tools, primarily consisting of a VR/AR client device which receives data streams for visual display in three-dimensional (3D) space. As mentioned above, various client devices, ranging from smartphones to wearable devices, are currently used for this purpose. The latter devices benefit users by allowing a degree of hands-free usage. Market leaders in these wearable devices currently are, e.g., the HoloLens 2 (Microsoft, Microsoft HoloLens 2, n.d.) and Meta Quest 2 (Meta, n.d.) for AR and VR, respectively. Data flow to these devices constitutes the second component common in the scenarios mentioned above, which typically involves some VR/AR application receiving and rendering images locally on the device. However, the device's comparatively poor performance abilities limit such processes on these client devices. Poor computing performance on these devices imposes an upper limit on the resolution and quality of holographic content, directly influencing situational usage. Offloading the computationally heavy rendering processes to a nearby server/computer and streaming the rendered content to the device bypass this limitation. Indeed, these processes are currently being used, such as by Microsoft (Microsoft, Remote Rendering, n.d.) Azure Remote Rendering or NVIDIA's CloudXR solution (NVIDIA, n.d.). However, streaming the entire application to the client device is more beneficial, which ensures even higher resolution and operability as the application ties to the 3D object. For users visualising 3D content, this latter feature provides high quality. This project will use this remote rendering and application streaming methodology of Holo-Light (Holo-Light, n.d.), facilitated by their interactive streaming for augmented reality (ISAR) SDK technology. Using an ISAR-enabled AR application, the data from the information management systems produced by this project will be visualised in a three-dimensional augmented reality space for C2 personnel. The OVERWATCH AR technologies will therefore provide a unique human-machine interface environment whereby users can be better informed during natural disasters and respond and deploy assets appropriately.

3.2. The fallback communication network

The advent of tethered drones began in 2016 as they were involved in the military system. A drone is a general term for any unmanned aerial vehicle operating autonomously or remotely. A tethered drone is an aerial vehicle tethered to the ground. It consists of a base station on the ground and the drone connected to the station through the tether (cable). The drone can be operated remotely to perform specific tasks. Tethered drones can be used for various applications, although most focus on aerial observation and telecommunications. Tethered drones are perfect for data capture and telemetry due to the reliability of tethered connections. In OVERWATCH, the tethered drone will physically support the antennas and communications equipment of the fallback communications system.

Figure 1 – Conceptualisation of the OVERWATCH fallback communication system integrated into an operational theatre.

The tethered drone systems consist of three fundamental components: the ground control station (GCS), whose core function is to provide power and convert power, and dual broadband over powerline (BPL) suited for dual-comm links, as well as control the drone take-off and landing, the aerial component which corresponds to the drone itself and the tether cable that will connect the drone with the GCS.

The communications system will be fully integrated with the tethered drone system, consisting of the aerial and ground components, interconnected by the optic fibre and BPL links provided by the drone tether described above. The drone payload will contemplate the antennas and the necessary hardware to operate as Wi-Fi and 5G transceivers, creating a local wireless Internet hotspot for the drone GCSs and other systems in range.

The ground component will establish an internet backhaul link using the LEO (Low Earth Orbit) satellite communications hardware and provide local wired connectivity to nearby systems such as drone GCSs and on-site command centres. It will also house part of the 5G processing hardware that uses the functional splits made possible by O-RAN (Open Radio Access Technologies) to reduce the aerial component's complexity, power consumption and weight. The reasoning is the lower the payload, the higher the tethered drone can fly to overcome obstacles and improve radio line-of-sight to its users.

The main advantage of using tethered drone technology is to overcome the following limitations: the flight time limitation, most of the VTOL (vertical take-off and landing) drones used in emergency scenarios, e.g., wildfires, floods, and earthquakes, have a flight ceiling time of 30-45 minutes, limiting their use over extended periods. Most of the time is required to halt the mission, land the drone, and exchange batteries. Another limitation is regarding safety.

The fact that the drone has a tether makes its aerial presence more predictable and therefore prevents the drone from being in places where it can put people or infrastructure at risk. Also, the fact that there is a tethered drone means it is static, can contribute to increasing situational awareness, and does not require significant skills for the operation. Finally, it allows flight at higher altitudes than comparable cell-on-wheels solutions based on masts that can help overcome obstacles such as trees and buildings, improving the radio Line-of-Sight to the user equipment.

Together, the tethered drone and the communications systems will result in the OVERWATCH fallback communications system (FCS) for emergencies, for cases in which existing communications infrastructures may collapse or provide insufficient coverage.

In this context, the OVERWATCH FCS will be instantiated by a tethered drone placed near the control stations of the mapping drones for providing connectivity in case of communications failure. The tethered drone will provide a local communications cell (mainly using Wi-Fi, but possibly also 5G depending on spectrum availability) connected to the Internet through a LEO satellite backhaul link.

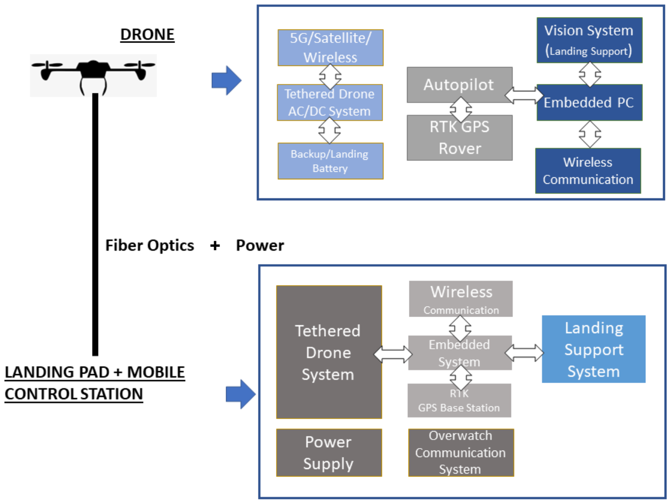

Figure 2 – Components of the fallback communications system[2].

Beyond providing fallback connectivity, its internet link through satellite backhaul aims at complementing legacy emergency networks, usually voice-based, such as TETRA. By supporting new use cases that demand broadband and low latency communications such as the operation of robotic platforms for massive and automated collection of information, and support for the operation of holographic systems for better situational awareness.

3.3. Backend management system

The backend management system for a decision support system (DSS) is responsible for managing the data and processing logic that powers the DSS. It typically includes a database management system, as well as tools for data processing, analysis, and reporting.

1. The key components of a backend management system for a DSS should include:
2. Data storage: The system needs to store large volumes of data in a way that is efficient, secure, and easily accessible. This often requires a database that fits the needs of the outcoming data consignee
3. Data integration: The system needs to be able to integrate data from multiple sources, including both internal and external data sources. This may require tools such as ETL (extract, transform, load) software to convert data into a common format.
4. Data processing and analysis: The system needs to be able to process and analyse large volumes of data to generate insights and support decision-making. This may require tools such as data mining software or statistical analysis packages.

[2] The Vision System represented in the block diagram is used by the tethered drone for auxiliary porposes related to the landing system.

5. Reporting and visualisation: The system needs to be able to generate reports and visualisations to communicate insights to users. This may require tools such as business intelligence software or dashboarding tools.
6. Security and access control: The system needs to be secure and only allow authorised users to access sensitive data. This may require tools such as identity server.

Overall, a backend management system for a DSS is a critical component that enables the system to function effectively and provide valuable insights to decision-makers. It requires careful planning, design, and implementation to ensure that it meets the needs of the organisation and its users.

Designing and developing a backend management platform for data management can be a complex process. The platform needs to be able to handle data ingestion, harmonisation, standardisation, and processing, while also providing a user-friendly interface for managing the data.

Such platform should have a management backend that include:

1. A data ingestion module that is responsible for ingesting data from different sources into the platform.
2. An harmonisation module responsible for transforming the ingested data into a consistent format. This module should be able to import and handle data mapping, data cleaning, and data transformation.
3. A standardisation module is responsible for ensuring that the data is standardised to a specific format shared with the others, towards to the data visualisation
4. A processing module responsible for processing the data into actionable insights

The outcome of the previous module should allow to have:

1. A Situational Awareness providing interfaces both in 2D and 3D, allowing operators to visualise the impact of flooding and fire events. This could involve using high-resolution video and image outcome from the different inputs.
2. A Terrain Mapping that is able to map the terrain using drones and other remote devices such satellite outcome, allowing operators to manage missions more effectively.
3. Rescue Asset Deployment giving the ability to deploy rescue assets based on the severity of the incident and the capabilities required for a safe rescue operation.
4. Augmented Reality (AR) allowing operators to use AR devices to immerse themselves in real incidents and perform corrections on operations.
5. Asset and Operator Monitoring, to monitor the location of assets and operators in real-time, providing status updates on the mission.

The platform would enable different types of users to manage information sources, integrate new ones, and collaborate with other crisis management systems to create a comprehensive crisis response system. It's also important to ensure that the platform is designed with security in mind, to protect sensitive information and prevent unauthorised access.

And ultimately the OVERWATCH will leverage Copernicus and EGNSS data along with other sources of data such as drones and digital cartography. This will allow the system to collect a wide variety of information that can be extrapolated using artificial intelligence techniques to provide valuable insights.

The system's management backend will store this information, and it will be directly linked with the AR user interaction and display module. This will allow users to interact with the system in real-time, visualising the information gathered from different sources and providing a more comprehensive understanding of the data.

The use of state-of-the-art AI techniques will enable the system to process and analyse large amounts of data efficiently and effectively, providing insights that would be difficult or impossible to obtain manually. This can help in various areas, such as monitoring and predicting natural disasters, managing agricultural activities, and urban planning.

Overall, the OVERWATCH system appears to be a promising system that can provide valuable insights by leveraging different sources of data and utilising advanced AI techniques.

3.4. Mapping subsystems

Emergency management systems rely heavily on collecting and distributing Earth Observation (EO) data, which has become increasingly important recently. The Copernicus EMS program is a European initiative that offers geographical mapping services for natural disasters. The geospatial information is derived from satellite observations, supplemented by data from open sources or direct observation on the ground. The Copernicus EMS is a valuable tool for land monitoring. It provides various products such as reference, delineation, and grading maps generated before, during, and after an event. However, developing these products can still take several days due to administrative and technical processes, which can be problematic in the case of fast-moving disasters such as wildfires or flash floods. The following subsections revise state-of-the-art for automated forest fire and flood mapping using satellite data.

3.4.1. Burned area delineation and severity estimation

In recent years, European countries have experienced an increase in the frequency and severity of wildfires, which have had significant negative impacts on the environment, human health, and the economy. After a wildfire is extinguished, it is crucial for competent public agencies to assess the extent of the burnt areas and the degree of damage sustained in each sub-area to estimate economic losses and plan for comprehensive environmental restoration. The Copernicus emergency management service (EMS) provides support for wildfire census operations in Europe (Mouillot, Rambal, & Joffre, 2002). This service provides reliable information on the impacted areas through delineation and grading maps. The delineation maps are used to determine the boundaries of the areas that have been hit by wildfires, while the grading maps assess the severity of the environmental damages. EMS experts assign a severity level between 0 and 4 to each sub-area hit by a wildfire, with 0 corresponding to unburned sub-areas and 4 representing wholly destroyed sub-areas. Intermediate levels represent sub-areas with negligible (1), moderate (2), or high (3) damages. However, the process of assigning damage levels is currently done manually through a comparison of pre- and post-wildfire imagery, which can be time-consuming and subjective. To address this issue, an automatic comparison of imagery taken in similar conditions could provide more accurate and precise estimations, thus facilitating the work of EMS (Mouillot, Rambal, & Joffre, 2002) experts.

Automatic monitoring of wildfire progression and identification of burned areas using machine learning algorithms is a common practice (Badea, Vertan, Florea, Florea, & Bădoiu, 2016) (Xu & Zhong, 2017). However, determining the level of damage sustained in affected areas typically involves a manual estimation process, which can be complex and time-consuming. This process often requires comparing pre- and post-wildfire imagery of the affected areas captured by drones or satellites, and in some cases, images from on-site missions are also used. In order to define a level of severity, first, the burned areas must be identified in an image. Therefore, the first step usually involves a binary classification algorithm that distinguishes between burned and unburned sub-areas, while a second step assigns a severity index to each cell, using techniques such as regression algorithms to assign a severity/damage level of 1 to 4 to the identified burned sub-areas. (Farasin, Colomba, & Garza, 2020). While some automated systems have been developed for inferring severity/damage maps for burned areas, these approaches still rely on comparing pre- and post-wildfire imagery and may require specific preprocessing techniques and expert manual selection of imagery to obtain comparable results (Miller & Thode, 2007).

Other very effective yet simple approaches include ad hoc spectral indices. In the literature, two indices are commonly used to evaluate the severity of damage caused by wildfires. The choice of index depends on whether the data is collected manually through ground inspections or remotely using sensors like drones or satellites. The first index is the Composite Burned Index (CBI) (Lutes, et al., 2012), which considers several factors such as soil condition and colour, vegetation or fuel consumed, resprouting of burned plants, the establishment of new colonising species, and blackening or scorching of trees. While CBI provides a more detailed index than the EMS, its computation can be costly, particularly for large areas, as it is based on manually acquired data. The second index is the Normalized Burn Ratio (NBR) (Navarro, et al., 2017), an appropriate index for identifying fires using remotely sensed imagery. The difference in NBR values between pre- and post-wildfire images of the same area allows for estimating soil variations caused by the wildfire, known as delta Normalised Burnt Ratio (dNBR) (Lutes, et al., 2012). However, the thresholds used to determine severity levels can vary among acquisitions and may depend on the soil.

In general, the current techniques for estimating the severity of wildfire damage rely on indices derived from satellite spectral bands, such as dNBR, RdNBR, NBR, and dNDVI. These techniques often involve computing thresholds or utilising machine learning methods, and they typically require a comparison of pre- and post-wildfire satellite imagery, which may not always be available. Additionally, they rely on region-specific empirical thresholds, making them less generalisable. In this project, the main goal will be to overcome these limitations by obtaining more general and robust approaches applicable on a pan-European scale while also requiring less supervision and fewer resources, such as the single post-wildfire image as input.

3.4.2. Flood delineation from remote sensing data

Information is critical during flood events, and near real-time Earth Observations (EO) can improve the assessment of affected areas more efficiently. Remote sensing, either from aerial or satellite acquisitions, is becoming crucial for detecting and monitoring natural hazards, as well as supporting restoration and adaptation (Oddo & Bolten, 2019). SAR imagery is particularly valuable for water and soil moisture analysis as it is not sensitive to light, less affected by atmosphere or clouds, and sensitive to the physical and dielectric properties of the traversed materials (Curlander & Mcdonough, 1991). However, most flood mapping using remote sensing is carried out through manual or semi-automated approaches, which are complex and time-consuming and rely heavily on domain experts' annotations (Molinari, Menoni, & Ballio, 2017). Recent advances in standard image processing and supervised machine-learning approaches have improved this process. Deep convolutional neural networks have been particularly effective in pixel-wise classification of flooded or not flooded areas. However, these solutions rely heavily on large amounts of annotated data, often limited to a geographical scope or only provide weak annotations.

Considering available datasets and resources, aerial and remote sensing datasets have limited resources and extension, specifically for disaster management and flood delineation. Many available datasets focus on land cover classification, considering single cities with few Very-High Resolution (VHR) imageries in multiple bands. Open datasets for disaster management and flood delineation, like xBD (Gupta, et al., 2019) and FloodNet (Rahnemoonfar, et al., 2020), provide images in the visible spectrum, limiting the accuracy of annotations. Scarce availability of Synthetic Aperture Radar (SAR) datasets and lack of annotations and robust ground truths are major obstacles in machine learning analysis for flood mapping. Among existing resources, the SEN12-FLOOD (Rambour, et al., 2020) and the Sen1floods11 (Bonafilia, Tellman, Anderson, & Issenberg, 2020) datasets provide co-

registered optical and SAR images time series for the detection of flood events with worldwide coverage. Another similar resource is the ETCI 2021 dataset (Paul & Ganju, 2021), which includes more than 30,000 raw Sentinel-1 SAR tiles from five different geographical regions. However, most datasets lack actual flood events and hydrography maps or segmentation masks to differentiate flood events from permanent water bodies. To address these issues, the MMFlood dataset (Montello, Arnaudo, & Rossi, 2022) uses Copernicus EMS ground truth to generate masks from high-quality activations produced using SAR imagery, which only includes flooded areas. The dataset also includes DEM and hydrography maps, where available, to exploit additional modalities.
Focusing on the methodology, existing studies have employed a wide range of algorithms and data sources. Among the various satellite instruments, most of the literature on flood mapping revolves around using Synthetic Aperture Radar (SAR) data from different satellite networks like TerraSAR-X, RADARSAT, COSMO-SkyMed, and Sentinel-1 (Kramer, 1994). Sentinel-1 is considered one of the most convenient options today, as it offers worldwide coverage at the medium-high spatial resolution, short revisit times, and open data availability.
Earlier works in this field mainly use masking and thresholding combined with detailed data preprocessing (Martinis, Twele, & Voigt, 2009), or a Fuzzy Logic approach (Twele, Cao, Plank, & Martinis, 2016). With the increasing use of Artificial Intelligence and Deep Learning techniques in the field of Computer Vision, many supervised machine learning classifiers have been devised and exploited for these tasks. For instance, previous works have proposed Support Vector Machines (Ireland, Volpi, & Petropoulos, 2015), Fully Convolutional Neural Networks (Kang, Xiang, Wang, Wan, & You, 2018), Bayesian Networks (Kussul, Shelestov, & Skakun, 2011), Deep Belief Networks (Bayik, et al., 2018), or Random Forests (Palomba, Farasin, & Rossi, 2020). Currently, deep learning solutions have mostly focused on flood delineation on ground level or through drone and aerial imagery. Numerous studies have been conducted on remote sensing Synthetic Aperture Radar (SAR) data, which includes tasks like image despeckling (Lattari, et al., 2019), and detecting large objects like ships (Wei, et al., 2020). Researchers have found SAR imagery to be highly informative and have leveraged additional data sources to enhance the quality of results. For instance, optical data like Sentinel-2 has been used in conjunction with SAR imagery for land cover classification (Sumbul, et al., 2021). Moreover, other data modalities such as Automatic Identification Systems (AIS) (Lang, Wu, & Xu, 2018) have also been exploited to supplement vessel detection through domain adaptation and data fusion techniques (Galdelli, Mancini, Ferrà, & Tassetti, 2021). Although classical machine learning techniques have proven to be effective in various tasks, convolutional neural networks (CNNs) have emerged as the leading architecture, with encoder-decoder modules like U-Net and multi-scale extraction methods like DeepLab gaining popularity in recent years. These techniques offer more precise results with a higher degree of accuracy, making them an attractive option for flood mapping.

3.4.3. Accurate, robust, and secured positioning using GNSS

Most global navigation satellite system (GNSS) receivers can provide position information in a wide range of environmental conditions, although the level of accuracy may vary. The accuracy of GNSS receivers is influenced not only by environmental factors but also by the receiver's characteristics and ability to utilise available services. However, while accuracy is important, it is not the only critical factor to consider when using positioning information for emergency services or to locate first responders. Reliability is also key, as the information must be trustworthy and consistent.

Initially designed to enable the automated aircraft approach without the need for ground infrastructure, european geostationary navigation overlay service (EGNOS) has expanded its scope to support safety-critical applications in general. Its main goal is to enhance GNSS-based positioning from both the accuracy and reliability perspectives. EGNOS provides corrections and integrity information for the GNSS signal across the European continent through space and ground segments. The space segment comprises geostationary satellites broadcasting corrections and integrity information for GNSS satellites in the E1 frequency. The ground segment is a network of stations and facilities that collect measurements from GNSS satellites and process them to compute a set of corrections transmitted to EGNOS satellites. These corrections apply to clocks, ephemeris, and ionospheric errors for each GNSS satellite in view, while the integrity information ensures the corrections' trustworthiness. Moreover, EGNOS can alert users to GNSS satellite faults or anomalies detected in a short timeframe of 6 seconds. The concept of integrity is critical for system reliability, defined as the level of trust a user has in a given position or velocity value provided by a location system.

Galileo is expanding its range of spatial services by introducing two new services to its existing constellation, including the Galileo High Accuracy Service (HAS) on E6 (GSA, 2022) and the Galileo Open Service Navigation Message Authentication (OSNMA) on E1 (EUSPA, 2022).

The Galileo OSNMA data authentication function, also known as the Open Service Navigation Message Authentication, is a feature of the Galileo global navigation satellite system that provides additional security and reliability for users. This feature enables Galileo receivers to verify the authenticity and integrity of navigation messages, making it much more difficult for malicious actors to interfere with navigation data. OSNMA encrypts navigation messages with a secret key. This key authenticates and validates the messages, ensuring they are not corrupted or spoofed. One of the primary benefits of the Galileo OSNMA aided signal is increased resilience against jamming and spoofing attacks, which are becoming increasingly common in the modern era of technology. With the OSNMA signal, Galileo users can ensure their navigation data is accurate and reliable, even in challenging environments where other signals may be disrupted.

The OSNMA signal can be used with other navigation systems like GPS to provide even greater redundancy and robustness.

The OVERWATCH project aims to develop positioning modules on drones capable of processing Galileo signals on the E1 and E6 bands to utilise these new services currently being tested. Galileo is poised to be the first constellation to provide a globally available high-precision precise point positioning service via the signal in space.

The project's objective is to integrate commercial receivers that are both HAS-enabled and OSNMA-enabled into the drone's positioning modules and other assets. While commercial OSNMA-enabled receivers are already available for purchase for consumer and professional applications, Galileo HA receivers are not yet available. EGNOS is traditionally used to enhance the performance of standalone positioning by applying broad area corrections, and the received data calculates Protection Levels using standard algorithms. If Galileo HAS modules are not yet available on the market during system development, the team will explore the possibility of using a COTS receiver that can process the E6 signal and output the raw data bit stream of the navigation message. Custom algorithms will then process it on programmable SDR platforms, aiming to assess the advantages of the new signals compared to state-of-the-art, particularly regarding positioning accuracy and service availability.

4. Methodology and baseline for collecting use cases and requirements

4.1. Methodology

This chapter outlines a comprehensive methodology, adapted from (SAFERS, 2020), for developing and validating a new technology solution addressing a specific user need. The methodology consists of several key activities designed to gather user requirements, validate them with experts and stakeholders, and iterate on the solution based on end-user feedback. Figure 3 depicts the methodology used in the OVERWATCH project for collecting use cases and end-user requirements.

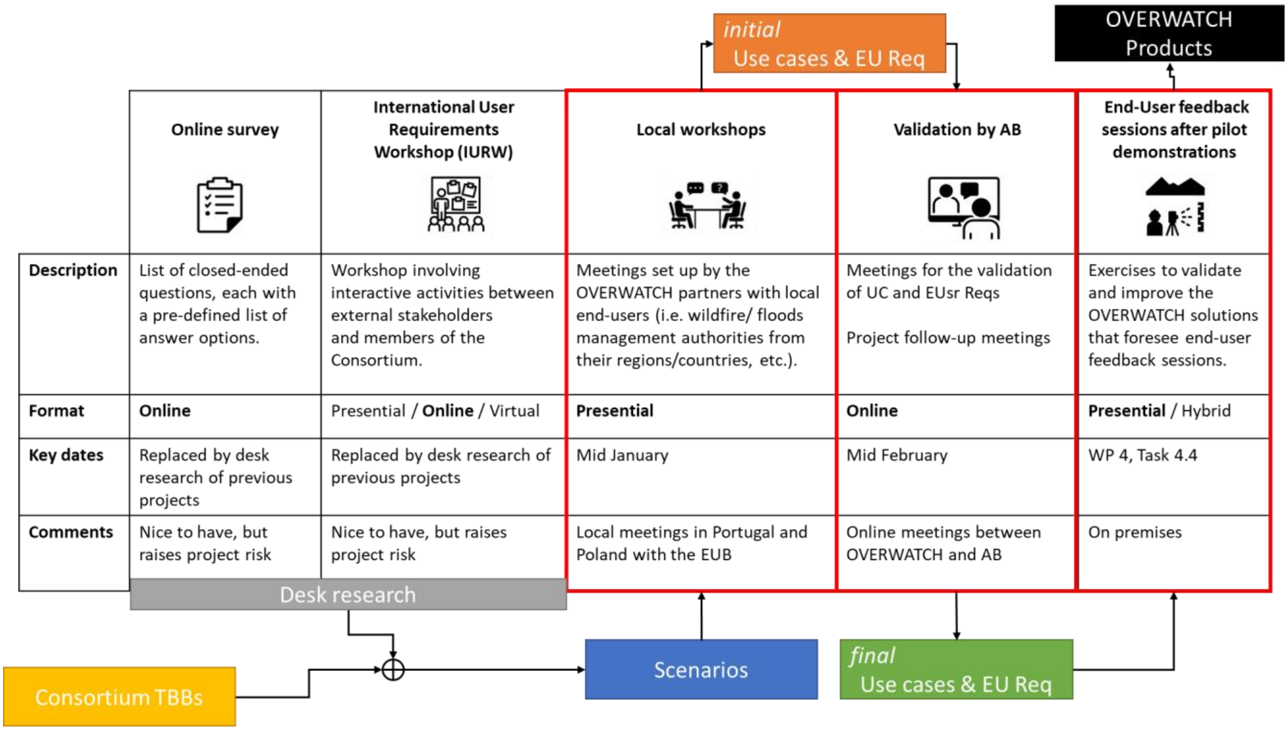

Figure 3 – Methodology for capturing use cases and requirements.

The methodology starts by initially analysing and taking stock of the results from online surveys developed by other EU-funded projects to gather initial insights and identify potential users.

Then, the use cases and end-user requirements will result from dedicated workshops organised with Portuguese and Polish experts to gather detailed information about needs and preferences.

The validation of use cases and end-user requirements by an advisory board will ensure the solution aligns with industry standards and best practices, end-user feedback sessions to identify areas for improvement, and pilot demonstrations to test the solution in real-world scenarios.

This methodology provides a structured approach to technology development that prioritises user needs and ensures that the solution is practical and effective in addressing real-world challenges.

4.2. Objectives

Focusing early on the users' requirements is crucial to building more usable, targeted and innovative solutions, allowing the end-users to achieve their vision or objectives.

The primary purpose behind the users' requirements collection and definition is to get an agreement of all the involved entities based on the end user's point of view. The requirements will be at the foundation of the project. They will shape all the technical and functional needs for the developed technologies, thus defining the solution that addresses the demands and trends expressed by the end users while also focusing on their implementation priorities.

All the decisions will be analysed in the context of users' requirements, intensifying the collaboration between technical partners, domain experts and end users. At the same time, it is ensured adequate traceability regarding where the user requirement originated. Traceability can be very valuable when conflicting user requirements arise by helping to better understand and decipher the user requirements according to their differing standpoints.

4.3. Goals for the use cases

Use case goals provide the context to measure the effectiveness of the OVERWATCH technologies in addressing and improving one or more of the following:

- Leverage situational awareness (SA), i.e., the ability to perceive, understand and anticipate potential disruptive elements and events, concerning time or space, in an emergency environment.
- Improve decision-making (DM) through leveraging multisource data analytics and predictive modelling to identify emerging threats and guide response efforts.
- Enhance command and control (C2) by promoting seamless coordination among emergency responders, including firefighters, medical support, police and security forces, engineering teams, etc.
- Strengthen the resilience of the emergency communication system (ECS).
- Enhance the operational capacity (OC) to deliver critical relief assistance and protection to populations affected by disasters or crises, including improving the allocation of resources (e.g., personnel, equipment and supplies) to areas with the greatest need.
- Support search and rescue (SAR), i.e. the process of searching for and providing assistance to populations in distress or imminent danger, typically in a natural disaster or other emergencies.

These goals set specific objectives in an emergency context and aim to improve the effectiveness and efficiency of emergency response efforts while ensuring the safety of emergency responders and the population. By achieving these goals, the OVERWATCH technologies can help improve the overall effectiveness of emergency response efforts while reducing the risk to first responders and people.

4.4. OVERWATCH stakeholders

In any emergency response scenario, the involvement and support of stakeholders are crucial for effective and efficient operations. Stakeholders can include various individuals, groups, and organisations, each with their priorities, objectives, and needs. From first responders and emergency management agencies to community members and volunteers, each stakeholder has a unique role in supporting emergency response efforts. Therefore, understanding and engaging with stakeholders is essential to ensuring the successful coordination and delivery of emergency support.

4.4.1. Identification

Various stakeholders are involved in wildfire management and contention, including government agencies, firefighters and emergency responders, population and property owners, environmental groups, business owners and industry groups, and insurance companies.

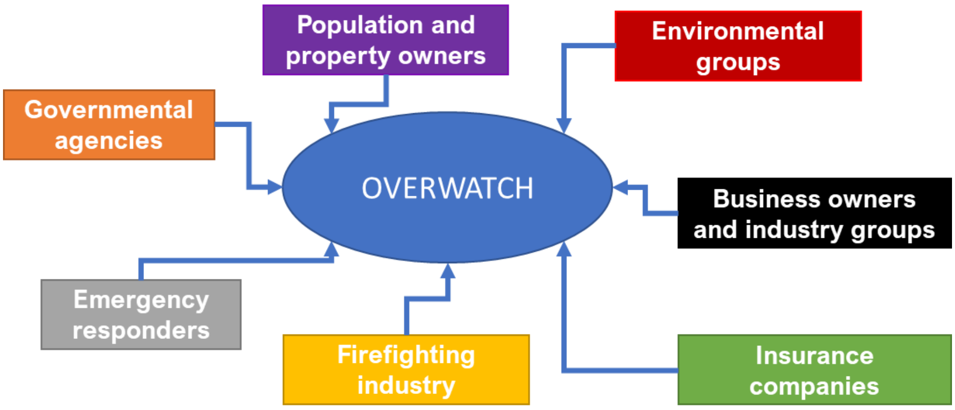

Figure 4 – Stakeholders of the OVERWATCH project.

Government agencies

These include federal, state, and local agencies responsible for managing natural resources and public lands, such as the Emergency Response Coordination Centre (ERCC), the EU National Authorities for Emergency and Civil Protection, the EUSPA - EU Agency for the Space Programme (EUSPA), etc. These agencies are often the coordinators (at the EU level or regionally) for emergency response and are responsible for managing and containing emergency events.

Firefighters and emergency responders

These are the groups on the front lines of emergency management and contention. They are responsible for responding to wildfires, floods and other catastrophes, containing them, and protecting people and property from harm. They also have expertise in fire behaviour, fire suppression techniques, and fire management strategies, which can inform and influence decision-making by other stakeholders.

The firefighting industry

These companies participate in the wildfire contention, e.g. as contractors of means and capacities for firefighting, playing a crucial role in supporting, preventing, containing, and extinguishing wildfires. Their actions can make a significant difference in the outcome of the event.

Population and property owners

People who live in areas prone to wildfires are stakeholders in wildfire management and contention. They have a vested interest in preventing and minimising damage to their homes and communities.

Environmental groups

These groups are interested in protecting natural habitats and wildlife that emergencies may impact. They may also advocate for policies and practices that reduce the risk of wildfires.

Business owners and industry groups

Businesses and industries that rely on natural resources, such as timber and agriculture, are also stakeholders in wildfire management and contention. Wildfires can have significant economic impacts on these industries.

Insurance companies

These companies are interested in reducing their exposure to risk and minimising financial losses from wildfires. They may promote policies and practices that reduce the risk of wildfires.

4.4.2. Analysis of the Power-Interest map

All these stakeholders need to be managed from the OVERWATCH project's perspective. To map these stakeholders into the power-interest map, we need to assess their level of power and interest in the emergency support context. Figure 5 presents an analysis of the Power/Interest map for the project.

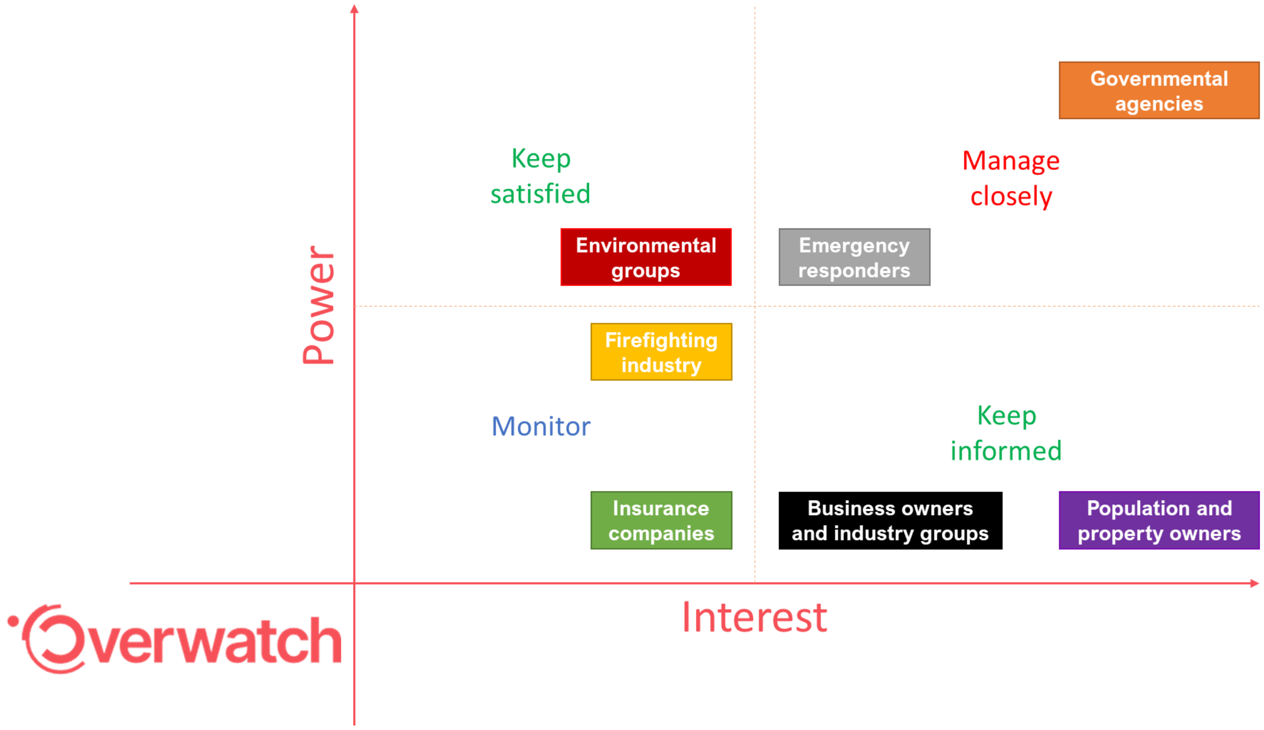

Figure 5 – Stakeholders Power-Interest map for the OVERWATCH project.

Government agencies have high power and interest in emergency support, as they are responsible for coordinating and providing resources for emergency response efforts.

Firefighters and emergency responders have high power and interest in emergency support, as they are on the frontlines of responding to emergencies.

Population and property owners have high interest but lower power in emergency support, as they rely on emergency responders to protect their property and ensure their safety.

Environmental groups may have varying levels of power and interest in emergency support, depending on the nature of the emergency and its impact on the environment.

Insurance companies have a moderate interest in emergency support, as they may have to pay out claims for damages caused by the hazards. However, their power may be limited to providing financial support rather than directly influencing emergency response efforts.

The firefighting industry seeks to influence policies and regulations that can impact the use and procurement of equipment and technologies. They may have varying levels of power and interest since their success depends on external factors, such as budget constraints, government regulations or even public perception.

4.4.3. Communication strategy

The communication strategy to approach and gather use cases and end-user requirements must consider the stakeholders identified in Section 4.4. Therefore, in the initial phase of Task 1.2, the first approaches should target the political/strategic decision-makers levels from governmental and management agencies, namely the national/regional emergency and civil protection authorities, to gather their support for the project. These meetings should also aim to identify the key challenges and requirements of the regional emergency and civil protection management system. The political decision-makers can provide valuable insights into the national/region's political, social, and economic landscape, which can help develop practical use cases for the project. Additionally, their inputs can help the project team to identify any regulatory constraints that might affect the development of the technologies.

After the initial meetings, the next step would be to engage with the command and control (C2) management levels responsible for the national/regional plan, coordination and control for civil protection and emergency response/mitigation. These meetings should focus on identifying the requirements and constraints for the national/regional coordination and control levels responsible for managing emergency response activities across the nation/region. These stakeholders can provide valuable insights into the technologies and systems currently in use and the strengths and weaknesses of the current emergency and civil protection management systems. This information can help the project team to identify opportunities for innovation and to develop use cases that address critical gaps in the current system.

Finally, the project team should engage with the tactical and operational levels who use technologies in the field. This meeting should focus on gathering specific use cases and scenarios that operational personnel encounter during emergency response activities. This information can help the project team to identify the requirements for technologies that can improve operational efficiency, enhance situational awareness, and support decision-making in the field. Additionally, the feedback from operational personnel can help the project team to develop solutions with a usability focus, easy to adopt and tailored to the needs of emergency responders (firefighters, medical support, police and security forces, and engineering teams, etc.).

Gathering use cases for a project to develop emergency response supporting technologies requires a multi-level approach involving engagement with political and top-level decision-makers, command and control, and operational personnel. By engaging with stakeholders across the emergency management ecosystem, the project team can develop practical solutions that address the needs and requirements of the entire system.

4.5. Operational constraints

Several constraints can limit the actuation of emergency responders in the operational theatre, including:

Capacity constraints – emergency responders may be limited in their ability to respond to emergencies due to a lack of personnel, equipment, or training. For example, the response may be delayed or ineffective if there are insufficiently trained firefighters to combat a wildfire.

Resources constraints – emergency responders may also be constrained by limited resources such as water, fuel, or medical supplies. Such constraints are more stringent in remote or hard-to-reach areas, where it may be difficult to transport these resources to an emergency site.

Terrain constraints – the terrain can also present challenges for emergency responders, particularly in the case of wildfires or floods. Rough or mountainous terrain can make it difficult to access the affected area, while floodwaters can make roads impassable.

Communications constraints – effective communication is essential for coordinating response efforts, but it can be challenging in emergencies. Poor or non-existent communication networks can hinder the ability of first responders to coordinate with each other and other stakeholders.

Legal and regulatory constraints – legal or regulatory constraints that limit the actions of emergency responders, such as restrictions on the use of specific firefighting techniques or limitations on the deployment of drones or other aerial technologies due to, e.g., the priority of aerial combat systems.

All these constraints can significantly impact the ability of first responders to act quickly and effectively in emergencies. It is essential to develop effective emergency management strategies considering each situation's challenges and leveraging available resources and technologies to mitigate their impact and overcome constraints.

4.6. Meetings and local workshops

Section 4.4 identified groups of stakeholders relevant to the OVERWATCH project. The Power-Interest map analysis emphasised two stakeholder groups to manage closely, therefore of particular relevance for the OVERWATCH activities of use cases and user requirements elicitation: governmental agencies and emergency responders.

The methodology in Section 4.1 proposes realising local workshops with prospective end users from both groups. The local workshops with prospective users of proposed innovations aimed to obtain a targeted needs analysis and a broad overview of requirements towards the go-to solutions. The method used the moderated discussion to identify the needs or systemic gaps (or vulnerabilities) originating them. This approach allows for determining the actual shortfall (or area of improvement) rather than directly asking respondents for a solution which they thought would work best.

The local workshops were designed with a structured approach, utilizing focus groups of carefully selected experts in emergency response, particularly wildfires and floods, since these are the hazards proposed for the OVERWATCH project. These groups provided a collaborative environment for in-depth discussions and analysis of specific topics and to generate innovative ideas and solutions to address emergency response-specific challenges. The moderation by a facilitator asking open-ended questions encouraged discussion among the participants.

The OVERWATCH technologies will be tested in two field validation demonstrators/exercises (FSX) to be held at the end of the project, in Portugal for wildfires and in Poland for floods. These activities will require support from emergency responders from both countries; therefore, to engage these communities early in the project, and because Task 1.1 has a short duration, the project's end users board consisted of experts from Portugal and Poland. The criteria for selecting the groups of experts were: recognised expertise in emergency response, inclusive representation across different command tiers and open aptitude towards innovative technologies (e.g. communications technologies, earth observation, geographic information systems (GIS), drones, etc.).

An initial inquiry suggested that potential workshop experts from these countries would feel more comfortable attending meetings conducted in their native language, so the local workshops were held in Portuguese and Polish.

Thirty-six experts attended the meetings and local workshops with the end users board (19 PL and 17 PT), Table 1 below. There were also meetings with the Directors of governmental agencies.

Date	Activity	No. of experts	Stakeholder description
06.01. 2023	Meeting	1	**COA – Governmental agency, the Azorean Operational Command** (https://www.emgfa.pt/emgfa/estrutura): meeting with the Commander, Lieutenant-general Luís Baptista
09.01. 2023	Meeting	1	**ANEPC – Governmental agency, National Emergency and Civil Protection Authority** (http://www.prociv.pt/en-us/)**:** meeting with the Director, Brigadier-general Duarte Costa
10.01. 2023	Meeting	1	**CIGEOE – Geographic information provider of the Portuguese state** (https://www.igeoe.pt/)**:** meeting with the Director, Colonel Silva Teodoro
10.01. 2023	Meeting	3	**CIGEOE – Geographic information provider of the Portuguese state** (https://www.igeoe.pt/)**:** geographic information, the fusion of GIS and EO

24.01. 2023	Meeting	1	**SIRESP – Governmental agency, manager of the Portuguese Emergency Communications System** (https://www.siresp.pt/)**:** meeting with the Director, Brigadier-general Viegas Nunes[3]
24.01. 2023	Meeting	8	**SIRESP – Governmental agency, manager of the Portuguese Emergency Communications System** (https://www.siresp.pt/)**:** add-on communications networks for emergency response
27.01. 2023	Meeting	1	**Wielkopolska Komenda Główna PSP w Poznaniu (Greater Poland SFS HeadQuarter in Poznań):** responsible for logistics and informational needs of on-site staff of ground forest fire fighting (with vehicles) module, forest fire fighting, onsite incident command.
01.02. 2023	Workshop	7	**Regionalny Zarząd Gospodarki Wodnej w Rzeszowie (Regional Water Management Authority in Rzeszów)**: an institution responsible for infrastructure and preventive investments, overall assessment and modelling of the regional flood risk and providing the Disaster Management Authorities with actionable interpretations of collected data related to the development of the flood situation. **Komenda Powiatowa PSP w Przeworsku (State Fire Service in Przeworsk County)**: an early adopter of drones, the only one in PL with live experience from Flash Floods **Podkarpacki Urząd Wojewódzki w Rzeszowie, Wydział Bezpieczeństwa i Zarządzania Kryzysowego (Podkarpackie Voivodship Crisis Management Department)**: drones and deriving processed EO information during flash floods; flood response and recovery in mountainous areas; management of medical services, political-level disaster management
03.02. 2023	Interview	1	**Regionalny Zarząd Gospodarki Wodnej w Krakowie - Wydział Koordynacji Inwestycji (Regional Water Management Board in Kraków - Investment Coordination Department):** an infrastructure maintenance and preventive investments, levee conservation and inspections.
08.02. 2023	Meeting	2	**ANEPC – Governmental agency, National Emergency and Civil Protection Authority** (http://www.prociv.pt/en-us/)**:** debate about the emergency management process at the **National Command of Emergency Operations** level, functionalities and potential enhancements of the information system for management of civil protection.
15.02. 2023	Workshop	4	**Wydział Operacyjny Komendy Wojewódzkiej Państwowej Straży Pożarnej w Poznaniu (Operations Department of Regional State Fire Service Headquarters in Poznań):** early adopter of various GIS and EO systems, GIS implementation to

[3] The Director of SIRESP invited OVERWATCH to pitch the project in the 2nd SIRESP Bootcamp Madeira (https://www.siresp.pt/eventos-siresp/bootcamp/) as a consequence of the meeting with the project. The SIRESP Bootcamps provide forums to bring together end-users, academia and industry to debate emergency communications. The Bootcamps are events for Industry and Academia aimed at providing the context to pitch new products, concepts and projects, providing also the stage for the demonstration and practical application/testing technologies and their operational validation with the SIRESP network.

			Polish SFS, drone utilisation, operational requirements of analytic section of on-site incident command, regional-level response, utilisation of aircraft during wildfires.
08.02. 2023	Online Meeting	1	**Civil Protection Department from the Municipality of Setubal** (https://www.mun-setubal.pt/protecao-civil-municipal/)**:** debate about the emergency management process at the **Regional Command of Emergency Operations** level, technological capacities and needs.
21.02. 2023	Workshop	6	**Regionalny Zarząd Gospodarki Wodnej w Krakowie (Regional Water Management Board in Kraków)** **Centrum Operacyjne Ochrony Przeciwpowodziowej (Flood Protection Operations Centre):** flood development forecasting, the recommendation for preventive flooding and emergency sandbag dikes, setting response priorities for other Disaster Management actors. **Wydział Koordynacji Ochrony Przed Powodzią i Suszą (Flood and Drought Protection Coordination Division):** flood modelling; flood risk assesment.
08.02. 2023	Meeting	1	**Associação Humanitária de Bombeiros Voluntários de Alcochete** (https://www.bombeirosalcochete.pt/)**:** debate about the **operational unit** level, in particular the roles and duties of the **Situation Assessment and Reconnaissance Teams**, technological capacities and needs.
06.03. 2023	Workshop	3	**Zespół Śmigłowcowy, Biuro Planowania Operacyjnego Komendy Głównej Państwowej Straży Pożarnej (Helicopter Team of Operational Planning Department of National State Fire Service Headquarters)**: utilisation of manned and unmanned aircraft.
13.03. 2023	Workshop	5	**1st meeting with the Advisory Board.** Presentation of the use cases previously collected from the End-User Board. Discussion and feedback from the AB concerning the use cases and requirements. The AB also provided written comments on each use case.

Table 1 – List of the meetings and local workshops organised for the end-users board.

5. Relevant projects sponsored by the European Comission programmes

This chapter revises selected research and development (R&D) projects cofinanced by EU funding programmes, notably FP7 and Horizon 2020, in the same scope as the OVERWATCH project. Some partners participating in OVERWATCH already participated in some of these projects. The projects are presented by order of starting date.

5.1. TEMA – Trusted Extremely Precise Mapping and Prediction for Emergency Management

Title	TEMA – Trusted Extremely Precise Mapping and Prediction for Emergency Management (TEMA, 2022)
Consortium	20 participants from the EU
Funding Programme	Horizon Europe - Global Challenges and European Industrial Competitiveness - Digital, Industry and Space
Duration	48 months
Start date	1 December 2022
Website	https://tema-project.eu/
DOI	10.3030/101093003
Description	TEMA will greatly improve Natural Disaster Management (NDM, e.g. for wildfires, floods) by automating precise semantic 3D mapping and disaster evolution prediction to achieve NDM goals in near-real-time. It will analyze and fuse many heterogeneous extreme data sources: smart drone and in-situ sensors, remote sensing data, topographical data, meteorological data/predictions and geosocial media data (text, image and videos). TEMA will focus on the extreme nature of the data, due to their varying resolution and quality, very large volume and update rate, different spatiotemporal resolutions and acquisition frequencies, real-time needs and multilingualism. It will develop an integrated, ground-breaking NDM platform, focusing on real-time semantic extraction from multiple heterogeneous data modalities and sources, on-the-fly construction of a meaningful semantically annotated 3D disaster area map, prediction of disaster evolution and improved communication between service providers and end-users, through automated process triggering and response recommendations. Semantic analysis computations will be distributed across the edge-to-cloud continuum, in a federated manner, to minimize latency. Extreme data analytics will be performed in a trustworthy and transparent way, by greatly advancing state-of-the-art AI and XAI approaches. The constantly updated 3D map and the disaster evolution predictions will form the basis for an advanced, interactive, Extended Reality (XR) interface, where the current situation will be visualized and different response strategies will be dynamically evaluated through simulation by NDM personnel. The innovative, scalable and efficient TEMA platform will provide precise NDM support, based on extreme data analytics. It will be validated on two critical

	disaster use-cases (wildfires and floods), in four EU countries, and will form the basis for the TEMA NDM-Analytics-as-a Service (NDM-AaaS) model.
Work performed	No results are available yet, as the project started in December 2022.
Relevance for OVERWATCH	Integration of many heterogeneous data sources: drone, remote sensing data, in-situ sensors, topographical data, meteorological data/predictions and geosocial media data. Automating precise semantic 3D mapping and disaster evolution prediction in near-real-time. Interactive, Extended Reality (XR) interface, where the current situation will be visualized.

Table 2 – Synthesis of the TEMA project.

5.2. SAFERS – Structured Approaches for Forest fire Emergencies in Resilient Societies

SAFERS	
Title	SAFERS – Structured Approaches for Forest fire Emergencies in Resilient Societies (SAFERS, 2020)
Consortium	14 participants from the EU and the United Kingdom
Funding Programme	H2020 Societal Challenges - Climate action, Environment, Resource Efficiency and Raw Materials
Duration	36 months
Start date	1 October 2020
Website	https://safers-project.eu/
DOI	10.3030/869353
Description	Changing climate is increasing the risk of wildfires. As temperatures continue to soar in the future, scientists warn that extreme fires will become more common. Meaningful early warning forecasts, early identification and tracking, and effective response are paramount to saving lives and containing environmental damage. The EU-funded SAFERS project developed a complex emergency management system capable of acting along the whole emergency management cycle, thanks to the coupled use of heterogeneous Big Data, advanced models, and AI. Earth Observation data from Copernicus and GEOSS was the primary data source, combined with data from social media, smoke detectors, and mobile applications. Such an approach allowed first responders, citizens and decision-makers to generate new and more accurate information, enhancing our society's resilience against wildfires.
Work performed	• The project developed "Innovation Co-Design". • An International User Requirement Workshop (IURW) fully virtualised and adopted new digital tools to conduct co-design exercises. • Ninety people from 65 organizations in 18 different countries attended the IURW. • The project produced a list of all end-user requirements to identify a common set of technical requirements and the functional requirements of all "Intelligent services from EO and in-field data." • A "Web-based platform for decision support" solution was developed. • A set of local workshops have been performed (one in each pilot site), generating specific requirements at the local level for implementing the beta release.

	• The project developed an analysis and design, as reported in the deliverables. • "Field Validation with end-users and citizens" started with defining the pilot methodology, including the execution of the training, the in-field demo & feedback workshops. • "Impact Maximization" has been executed as planned, delivering all outputs and important KPIs concerning the social media metrics.
Relevance for OVERWATCH	• Intelligent services from the fusion of EO and data collected in the theatre of operations (TO). • Key findings relating to wildfire management requirements identified from the online survey. • Outcomes of the scenario analysis, especially for wildfire-related response activities. • The user requirements concerning data and information.

Table 3 – Synthesis of the SAFERS project.

5.3. INGENIOUS – Next Generation Integrated Toolkit for Collaborative Response

Title	INGENIOUS – The First Responders (FR) of the Future: a Next Generation Integrated Toolkit (NGIT) for Collaborative Response, increasing protection and augmenting operational capacity (INGENIOUS, 2019)
Consortium	24 participants from the EU, Norway, South Korea, Switzerland and the United Kingdom
Funding Programme	H2020 Secure societies - Protecting freedom and security of Europe and its citizens
Duration	48 months
Start date	1 September 2019
Website	https://ingenious-first-responders.eu/
DOI	10.3030/833435
Description	First responders are the first to arrive at an emergency. They include firefighters, police officers and paramedics who take significant risks to save people, property or the environment. New technologies can give them an edge during a crisis, whether a small-scale emergency or a devastating disaster. The EU-funded

	INGENIOUS project developed and tested a next-generation integrated toolkit (NGIT) for a collaborative response. The toolkit included tools to keep first responders protected, connected and fully aware of risks and threats during a crisis. The outcomes boosted their operational capacities, ensuring safety and efficiency in rescue operations.
Work performed	• The project supported and improved various response activities such as situational awareness, communication, command, control, coordination, health and safety, logistics, resource management, casualty management, and training. • The NGIT platform included novel applications for detecting, monitoring, and analyzing threats, upgrading responders' uniforms and body gear, tracking and tracing their assets, and using advanced triaging and victim classification techniques. • The NGIT equipped first responders with affordable and reliable tools, including wearables, communication, and localisation components, to protect and assist them in responding. • The NGIT also comprised smart devices in the air and on the ground, external response modules operated by first responders to monitor, map, analyse and assess the incident scene, and supports first responders with multi-fusion and expert reasoning modules for improving situational awareness, a C3 and a COP platform with augmented reality capabilities, and mobile applications to improve response activities. • The project implemented Integration testing and validation activities in a rich programme (led by First Responders), with several Laboratory Integration Tests, Small Scale Field Tests and 2 Large Scale Exercises. • The project brand and communication strategy were defined while all the necessary steps to meet the ethical, legal and security requirements were taken.
Relevance for OVERWATCH	• User requirements concerning selected project products, such as drones, communication systems and the operational picture platform.

Table 4 – Synthesis of the INGENIOUS project.

5.4. SHELTER – Sustainable Historic Environments hoListic reconstruction through Technological Enhancement and community based Resilience

Shelter	
Title	SHELTER – Sustainable Historic Environments hoListic reconstruction through Technological Enhancement and community based Resilience (SHELTER, 2019)
Consortium	25 participants from the EU, Turkey and the United Kingdom
Funding Programme	H2020 Societal Challenges - Climate action, Environment, Resource Efficiency and Raw Materials
Duration	48 months
Start date	1 June 2019
Website	https://shelter-project.com/
DOI	10.3030/821282
Description	SHELTER implements a framework in multiscale and multisource data driven platform able to provide the necessary information for planning and adaptive governance related to cultural heritage. The project adopts a case studies based approach with two objectives: to generate the required knowledge regarding the different impacts in diverse typologies of Natural and Cultural Heritage and to co-validate the suitability, adaptability and replicability of the SHELTER framework, methodologies and ICT tools to different contexts. All the developments of the project were validated in 5 open-labs, representative of main climatic and environmental challenges in Europe and different heritage's typologies.
Work performed	• Definition of a multiscale data model. • Classification and evaluation of data sources according to their compatibility with standards and the use of metadata (INSPIRE). • Establishment of a Big Data storage solution with a data catalog, the definition of data model based on international standards. • Establishment of a cross-scale, multidimensional assessment methodology based on indicators. • Development of a method for rapid damage assessment in general and flood delineation using the satellite imagery based on a Machine Learning algorithm (Random Forest) and an adapted Deep Learning model (U-Net). • Adaptation of a subset of deep neural networks - convolutional neural networks (CNNs) - to find burned regions. • Establishment of an innovative Open Labs approach that allows the co-identification of problems and priorities, co-creation, test and pilot of solutions, co-monitoring and awareness-raising.
Relevance for OVERWATCH	Identification of user requirements and user needs (structured as: general, data, analysis, visualization, crowd (communication with people), models, equipment, report) using i.a. Use Case Scenarios. Methods for flood delineation with supervised machine learning and burned areas finding with convolutional neural networks.

Table 5 – Synthesis of the SHELTER project.

5.5. FASTER - First responder Advanced technologies for Safe and efficienT Emergency Response

Title & Reference	FASTER – First responder Advanced technologies for Safe and efficienT Emergency Response (FASTER, 2019)
Consortium	27 participants from the EU and Japan
Funding Programme	H2020 RIA - Research and Innovation action
Duration	36 months
Start date	1 May 2019
Website	https://www.faster-project.eu/
DOI	10.3030/833507
Description	During natural catastrophes, technological disasters or terrorist attacks, first responders – police, bomb squads, firefighters, anti-terrorism units and emergency medical workers – play a crucial role. Their effectiveness depends on several factors. The project examined first responders' impact and role in disasters. It considered the entire emergency preparedness and response lifecycle, including the planning, logistical support, maintenance and diagnostics, training and management. The project aimed to further the European Union's ability to respond to emergencies.
Work performed	• The project aimed to address the challenges faced by First Responders while enhancing their capabilities. The solutions' societal, ethical, legal, and privacy implications were assessed by conducting a SELP Impact Assessment. • The project collected requirements and specifications following a plan of the continuous interaction of technical partners with the users, fine-tuning the design in short iterations. • A Secure IoT Computing and Communication framework was developed featuring: a Smart Textiles Framework with sensors for physiological measurements, a harness for K9 activity recognition, and a Social Media Analysis tool. • The project developed two ground vehicles with sensors, autonomous navigation, and drones that perform mapping, monitoring, and equipment transfer tasks. An AI-based analysis tool provided disaster scene analysis.

	• The project tested 5G infrastructure with ML-powered QoS Monitoring. Relay network capabilities, emergency communication devices, haptic communication, and DLT-based trusted communication were developed. • The project developed Augmented Reality technologies, including Extended Vision, gesture-based UxV navigation, and intuitive UI for providing information and localization to first responders (FR). • The project developed an Information Model to allow the fusion of data. A COP dashboard for indoor and outdoor environments was developed, integrating mission management functionalities. • The project held 13 pilot events for FR, impact assessment and evaluation. • The project communication and dissemination strategy included the launch of multiple websites, social media campaigns, newsletters, publications and project videos. • 16 FASTER's Key Exploitable Results (including joint) have been selected and analysed with the support of the Horizon Results Booster service. An MoU has been signed.
Relevance for OVERWATCH	• A method developed by the project to continuously engages stakeholders as part of the process. • The application of the LEAN methodology as a process in introducing new technologies to improve the SAR procedure. • The SotA for the AR and user interface.

Table 6 – Synthesis of the FASTER project.

5.6. FLOOD-serv – Public FLOOD Emergency and Awareness SERVice

Title	FLOOD-serv – Public FLOOD Emergency and Awareness SERVice (FLOOD-serv, 2016)
Consortium	12 participants from the EU
Funding Programme	H2020 Societal Challenges - Europe In A Changing World - Inclusive, Innovative And Reflective Societies
Duration	36 months
Start date	1 August 2016
Website	https://www.floodserv-project.eu/
DOI	10.3030/693599
Description	The overall objective of FLOOD-serv was to develop and to provide a pro-active and personalised citizen-centric public service application that will enhance the involvement of the citizen and will harness the collaborative power of ICT networks

	(networks of people, of knowledge, of sensors) to raise awareness on flood risks and to enable collective risk mitigation solutions and response actions. Other general objectives were: 1. Empowering local communities to directly participate in the design of emergency services dealing with floods mitigation actions. 2. Harness the power of new technologies, such as social media, and mobile technologies to increase the efficiency of public administrations in raising public awareness and education regarding floods risks, effects and impact. 3. Encourage the development and implementation of long-term, cost-effective and environmentally sound mitigation actions related to floods though an ICT-enabled cooperation and collaboration of all stakeholders: government, private sector, NGOs and other civil society organizations as well as citizens.
Work performed	• Three studies were carried out in selected regions to investigate comparatively the European, national and regional legal framework of public services related to the flood risk management and evaluate their characteristics including existing ICT instruments. • User and technical requirements related to the FLOOD-serv System were elicited and the architecture of the overall solution and its components were defined. • FLOOD-serv System components were tested in five Pilot Cities, with three different types of participants (citizens, stakeholders and employees of Pilot Cities).
Relevance for OVERWATCH	The Emergency Mangement Console (EMC) developed under the project makes use of data from the other components and outside the project to produce analyses, decision suggestions and simulations, and monitoring of actions. The Territory Monitoring Component (TMS) analyses satellite and aerial images to produce automated detection of flood related events using novel and intelligent algorithms.

Table 7 – Synthesis of the FLOOD-serv project.

5.7. iREACT – Improving Resilience to Emergencies through Advanced Cyber Technologies

Title	iREACT – Improving Resilience to Emergencies through Advanced Cyber Technologies (iREACT, 2016)
Consortium	20 participants from the EU, Norway and the United Kingdom
Funding Programme	H2020 Secure societies - Protecting freedom and security of Europe and its citizens

Duration	36 months
Start date	1 June 2016
Website	http://project.i-react.eu/ (*link currently not working*)
DOI	10.3030/700256
Description	I-REACT proposed a system to improve the resilience of European citizens and assets to natural disasters. It integrated existing services into a platform supporting the emergency management cycle, using innovative cyber technologies and ICT systems to enable early planning, effective preparedness, and efficient emergency response. I-REACT integrated multiple systems and European assets, structured as a user-driven project. It also presented new business development opportunities to reduce the number of affected people and loss of life, lowering environmental and economic costs due to damaged assets.
Project objectives	• The design phase was based on a user-centred design and included the requirements definition. Within this activity, an international workshop was organised at UNESCO Headquarters, which brought together policy-makers, emergency service providers, scientists and technology experts from different European countries. The workshop aimed to define the project requirements, the data architecture, the privacy and security requirements and the gamification strategy to engage the communities. • The project developed “External Services and Data Integration”, which integrated open data and existing services such as Copernicus EMS, EFAS, and EFFIS. • The project realised an automatic data chain for producing flood delineation maps from Sentinel-1, and algorithms to enhance the positioning using European assets (i.e. Galileo and EGNOS). • The project developed “Modelling and Engines” focused on realising all the core models of I-REACT, including weather, extremes weather and climate forecasting, flood and fire nowcast and forecast, risk forecasts, and a social media data engine. • The “Service Oriented Architecture” project realized the I-REACT centralized platform and the data collection, analysis, and visualization technologies. The core elements were: a mobile application to enable real-time reporting from both citizens and in-field agents, a wearable device and smart glasses application for in-field agents, drones capable of gathering images and videos, big-data analytics and a web front-end capable of monitoring and exploring in real-time data and analysis coming from all I-REACT elements. • The outcome of the communication and dissemination actions in I-REACT achieved the desired impact and KPI compliance.
Relevance for OVERWATCH	• End-user requirement collection activities, including online surveying and workshops • Use of crowdsourcing & social media for early warning in emergency • Synthesis of social media contents; automatic rapid mapping (satellite/drones/ manned aerial); needs towards information visualisation: importance of

	recsuers positioning and activity, number of affected people, water extent area for floods; dynamic risk mapping. • Gap Analysis of abovementioned areas.

Table 8 – Synthesis of the iREACT project.

5.8. ANYWHERE – EnhANcing emergencY management and response to extreme WeatHER and climate Events

Title	ANYWHERE – EnhANcing emergencY management and response to extreme WeatHER and climate Events (ANYWHERE, 2016)
Consortium	35 participants from the EU, Norway, Switzerland and the United Kingdom
Funding Programme	H2020 Secure societies - Protecting freedom and security of Europe and its citizens
Duration	42 months
Start date	1 June 2016
Website	http://anywhere-h2020.eu/
DOI	10.3030/700099
Description	ANYWHERE has developed a pan-European platform (A4EU) for decision support concerning extreme climate risks. The platform identifies beforehand critical situations that could lead to fatalities and economic losses. AI is used to integrate the hazard forecastings served by the MH-EWS with high resolution local impact models (like PROPAGATOR in wildfire propagation, the FF-EWS flash-flood impact indicator, the EFAS flood awareness products or the snow impact on roads, among many others) automatically combining them with the regional layers of exposure and vulnerability in the emergency command centres (EMCs). The ANYWHERE tools have been implemented operationally to trigger automatic warnings to activate self-protection plans. They include the A4Campsites, A4Snow, A4Schools and A4Grids as well as the municipal version of the platform, A4Cities.
Work performed	• Development of a flood-oriented Early Warning System (A4 Campsite) specifically targeted at raising self-protection in campsites located in the flood-prone areas of Catalonia. The system shows real-time meteorological information, local data from river gauges and forecasts of rainfall and flash flood hazards that can affect campsites located in flood-prone areas. In case of warnings it shows specific self-protection actions to be done, allowing the campsite operators to better manage such events. • Development of a Decision Support Tool (A4Snow) able to translate flood and snow forecasts into road network performance impact specifically targeted at enabling self-response of the logistic platforms of the food distribution companies during severe weather events. The tool shows a real-time estimation of the extent of the affected area and the impact on the circulation

	conditions, which are then translated into the impact on the network capacity, by cross-correlating the weather forecasts (such as level of snow, precipitation, etc.). Afterwards it simulates and evaluates different transport network scenarios. • Development of a service (A4School) specifically specifically targeted at increasing self-awareness and self-protection in front of flooding risk in schools all over the the Municipality of Genoa city. The service standarizes and improves the communication protocols between schools and emergency managers, but is also able to provide customized information to the parents about the impact of the weather conditions on the schools by suggesting them the safer behaviour to protect thier children and themselves. • Development of a tool (A4Grids) to deal with the problem of predicting power outages in an electrical power grid due to convective storms. This tool supports the decision-making and improves the planning of placing the resources of the electricity companies over severe weather events that can have a negative impact on operational performance. It provides the forecasted route and severity of the convective cells, an impact of the storm in euros, kWh and households without electricity, an amount of the teams needed on the field to repair the faults and the estimate of the power outage's duration. • Development of platform for municipalities (A4Cities). The platform provides the capacity of early-warning detection and proactive decision-making when facing extreme weather-related emergencies. This allows the municipal Public Protection and Disaster Relief staff to better manage such events, minimizing losses and saving lives. • The The A4EU prototypes have been tested and operationally demonstrated in 7 EMCs covering all the climatic range in EU during more than one year.
Relevance for OVERWATCH	Integration of hazard forecastings with impact models, e.g. PROPAGATOR in wildfire propagation, the FF-EWS flash-flood impact indicator, the EFAS flood awareness products, using AI.

Table 9 – Synthesis of the ANYWHERE project.

5.9. SAFEDAM - Advanced technologies in the prevention of flood hazard

SAFEDAM	
Title	SAFEDAM - Advanced technologies in the prevention of flood hazards. (SAFEDAM, s.d.)
Consortium	5 consortium members
Funding Programme	Poland: National Centre for Research and Development; Defense and Security Programme
Duration	53 months

Start date	22 December 2015
Website	https://www.safedam.gik.pw.edu.pl/safedam_eng
Cordis	N/A
Description	The aim of the SAFEDAM project is the creation of system for levees monitoring using unmanned aerial vehicles (equipped with light LiDAR unit, multispectral and/or thermal camera), optical and radar satellite imagery and archival aerial imagery. Multi-sourced and multi-temporal data allow to evalute the levees condition. A comprehensive IT system enables the collection, automatic data analysis and visualization for hydrological services and crisis management professionals. Its implementation will ensure effective management of flood risk. SAFADAM complements the already implemented projects of flood protection in Poland such as ISOK.
Project objectives	• The aim of the SAFEDAM project is the creation of a system for levees monitoring using a non-invasive, unmanned aerial platform, which scans from low-altitude, optical, radar satellite and aerial imagery. For this purpose, innovative photogrammetry and remote sensing technologies will be used. Endangered areas, detected preliminarily by images, will be measured by non-invasive, flying measuring platform with centimetre accuracy using a 3D measurement technique. The methodology of system application, training program and proposals of procedures related to the management of flood risk will also be prepared. • A comprehensive system will enable the collection, automatic data analysis and 3D visualization for hydrological services and crisis management professionals. The system will also allow society to geoparticipation in monitoring the levees. Its implementation will ensure effective management of flood risk. The system will complement the already implemented projects of flood protection.
Relevance for OVERWATCH	• Levee imagery for digital surface model (DSM) - Low-altitude photogrammetry geo-datasets collection over two test areas with a fixed-wing platform in real colours (RGB), near-infrared (CIR) and airborne laser scanning (LIDAR) • Trends in non-invasive monitoring of flood levees using a variety of photogrammetry and remote sensing technologies (Kurczyński Z., 2016)

Table 10 – Synthesis of the SAFEDAM project.

5.10. DRIVER+ – DRiving InnoVation in crisis management for European Resilience

driver+	
Title	DRIVER+ – DRiving InnoVation in crisis management for European Resilience (DRIVER+, 2014)

<table>
<tr><td>Consortium</td><td>42 participants from the EU, Norway and Israel</td></tr>
<tr><td>Funding Programme</td><td>FP7-SECURITY</td></tr>
<tr><td>Duration</td><td>72 months</td></tr>
<tr><td>Start date</td><td>1 May 2014</td></tr>
<tr><td>Website</td><td>https://www.driver-project.eu/</td></tr>
<tr><td>Cordis</td><td>https://cordis.europa.eu/project/id/607798</td></tr>
<tr><td>Description</td><td> The project focused on developing the sustainability of the European test bed, exploiting the DRIVER Portfolio of Solutions, and promoting a European crisis management community. Due to the high cost and destabilisation of existing systems, DRIVER+ aimed to augment existing crisis management capabilities rather than replace them. The project had three main objectives: developing a pan-European test-bed for crisis management capability development; creating a comprehensive portfolio of crisis management solutions; facilitating a shared understanding of crisis management across Europe. The project conducted trials and produced results in a Portfolio of Solutions (PoS), including information on experiences, needs to be addressed, and regulatory conditions. </td></tr>
<tr><td>Project objectives</td><td>To develop a pan-European Test-bed for Crisis Management capability development enabling practitioners to create a space where stakeholders can collaborate to test and evaluate new products, tools, processes or organisational solutions.
The development of a scientifically based Trial Guidance Methodology (TGM) for conducting Trials of Crisis Management solutions and the Test-bed Technical Infrastructure (TTI) that underpins it
Implementation of large-scale Trials using TGM and TTI conducted in Poland, France, the Netherlands and Austria, set up to assess technological and other Crisis Management solutions in realistic scenarios.
To develop a portfolio of solutions (PoS) in the form of a database-driven website that documents all DRIVER+ solutions.
The project tested the solutions via trials during the project's lifetime. It opened the PoS to external organisations willing to share data and experiences of solutions to foster a shared understanding of crisis management across Europe through an enhanced cooperation framework.
The establishment of an open, cooperative information-sharing community of practice, the Crisis Management Innovation Network Europe (CMINE).
The establishment of a network of DRIVER+ Centres of Expertise to ensure the sustainability of project outputs.</td></tr>
</table>

Relevance for OVERWATCH	• The trial guidance methodology (TGM) proved to be a robust method for testing the implementation of innovative technologies for crisis and emergency management practitioners. • The OVERWATCH might use the TGM as a valuable reference to plan and execute the FSX and respective actions preceding the pilots.

Table 11 – Synthesis of the DRIVER+ project.

5.11. INDIGO – Innovative Training & Decision Support for Emergency operations

Title	INDIGO – Innovative Training & Decision Support for Emergency operations (INDIGO, 2010)
Consortium	8 participants from the EU
Funding Programme	FP7-SECURITY - Specific Programme "Cooperation": Security
Duration	36 months
Start date	1 May 2010
Website	http://indigo.diginext.fr/
DOI	https://cordis.europa.eu/project/id/242341
Description	The INDIGO project aimed to research, develop and validate an innovative system integrating the latest advances in Virtual Reality, Simulation and Artificial Intelligence in order to homogenise and enhance both the operational preparedness and the management of an actual complex crisis. It enables: - the 3D interactive and realistic visualisation of the complete crisis environment, including data coming from the field, simulation results, and building interiors, - the simulation of different evolving scenarios for planning, training, and anticipating future states and impending developments during operations, and analyse events after the crisis - the simultaneous training of decision makers, crisis managers as well as first responders and emergency field units that will be influenced by the simulated scenario and that will reciprocally influence its evolution, - the simultaneous involvement of multiple participants, thanks to its distributed architecture, while offering a unique pictorial way of sharing and communicating complex knowledge across organisation boundaries. In addition, INDIGO will propose a European emergency symbology reference for 2D/3D maps.
Work performed	• Development of a system based on state-of-the-art virtual reality, simulation and artificial intelligence that improved the operational preparedness and management of complex crisis situations. • Development of the Emergency Symbology Set, following a detailed analysis of the needs of crisis managers.

	• Tests on the operational and training capability of the system in two real-life situations.
Relevance for OVERWATCH	Assessment of existing symbology standards and the results from the European Emergency Symbology reference for 2D/3D maps.

Table 12 – Synthesis of the INDIGO project.

6. Scenarios

Scenarios are pre-planned storyline that drives an exercise and the stimuli used to achieve exercise project performance objectives. (ISO22300:2021, n.d.)

Crisis and emergency management are essential to disaster response to mitigate the effects of disasters and natural hazards. Wildfires and floods are among the most significant natural hazards, causing substantial damage and loss of life yearly. This chapter aims to identify and present crisis and emergency management scenarios, specifically wildfires and floods.

The chapter will explore various scenarios and use cases related to wildfire and flood response, providing valuable insights into the challenges faced by disaster management agencies and stakeholders. It will examine case studies of successful crisis and emergency management initiatives, highlighting the latest tools and technologies for disaster risk reduction, early warning systems, and post-disaster recovery.

The chapter will also identify end-user requirements for crisis and emergency management related to wildfires and floods, providing a comprehensive understanding of the needs and expectations of stakeholders involved in disaster response. It will explore the different phases of crisis and emergency management, including pre-disaster planning, response, and recovery, and how these phases can be leveraged to improve the overall effectiveness of disaster response. The scenarios described in this chapter follow the WHO (2020) classification of hazards.

Generic group	1. Natural	1. Natural
Group	1.2 Hydro-meteorological	1.2 Hydro-meteorological
Subgroup	1.2.1 Hydrological	1.2.3 Climatological
Main type	Flood	Wildfire
Subtypes	- riverine flood - flash flood	- land fire [e.g. brush, bush, pasture] - forest fire

Table 13 – Classification of hazards used for the OVERWATCH scenarios (WHO, 2020)

This chapter provides a comprehensive overview of two scenarios related to natural hazards, aiming to enhance the OVERWATCH understanding of the project scenarios, helping to improve the overall effectiveness of disaster response and reduce the impact of natural hazards.

6.1. Scenario I – wildfires

Wildfires can be one of the most dangerous and unpredictable types of fires to combat. Every year, wildfires cause millions of euros in damage, threaten the lives of residents, and destroy natural habitats. As climate change exacerbates the frequency and intensity of these fires, relevant players (firefighters, first responders and emergency managers and coordinators) must be prepared to respond effectively to this type of emergency.

Figure 6 –Classification of Scenario I according to the WHO (2020).

In this scenario, relevant players will respond to a wildfire that has broken out in a densely wooded area on the outskirts of town. The wildfire is spreading rapidly, and there are reports of nearby homes that may be in danger. Your team must assess the situation quickly, determine the best course of action, and work together to contain and extinguish the fire before it causes further damage. Training and expertise will be put to the test as relevant players work to protect both lives and property in the face of this dangerous and unpredictable natural disaster.

6.1.1. Risks and trends

The European Union (EU) is heavily forested, with nearly 160 million hectares of forest cover, representing 36% of the EU's territory. These forests provide numerous benefits to society and the environment but are also vulnerable to wildfires that cause significant damage to the social, economic, and environmental landscape. Over the past decade, wildfires have burned more than 4 million hectares of forest and other wooded lands, causing the loss of over 400 lives and significant economic damage. The number and size of wildfires vary yearly, but recent trends show an increase in frequency, severity, and duration. The risk of wildfires is not only limited to the Mediterranean region but is a cause of concern in other parts of the EU, including northern Europe and the Arctic.

6.1.2. Key risk drivers

Natural phenomena or human activity are key risk drivers for wildfires in Europe, and their impact depends on the amount of fuel available, weather conditions, and proximity to human infrastructure. Human behaviour and actions cause 95% of wildfires in Europe due to socioeconomic developments, changes in land use, and unsustainable forest management practices.

Wildfires can also affect hazardous infrastructure or industrial zones, leading to significant accidents with toxic releases, fires, or explosions, known as Natech accidents. Weaknesses in forest and fire risk management practices have contributed to fire risks, and climate change is projected to increase wildfire risks due to warmer temperatures and changes in precipitation. Wildfires also contribute to climate change due to greenhouse gas emissions from burning forests and forest degradation.

The level of wildfire risk varies across Europe, and mapping fire risk zones is an established practice in European countries. Policies on spatial planning, national forestry strategies, and others have not sufficiently integrated considerations on fire prevention. Firefighting strategies have contributed to fuel accumulation and landscapes being more prone to significant and intense fires.

6.1.3. Wildfires in the EU risk assessment

The European Union (EU) is heavily forested, with nearly 160 million hectares of forest cover, representing 36% of the EU's territory. These forests provide numerous benefits to society and the environment but are also vulnerable to wildfires that cause significant damage to the social, economic, and environmental landscape.

Over the past decade, wildfires have burned more than 4 million hectares of forest and other wooded lands, causing the loss of over 400 lives and significant economic damage. The number and size of wildfires vary yearly, but recent trends show an increase in frequency, severity, and duration.

6.1.4. Main constraints

Wildfires can spread to residential/industrial areas, severely threatening populations and assets. The damage caused by these fires can be catastrophic, with devastating effects on heritage and historical landmarks, property and wildlife. The severity of the situation requires an immediate and effective response to manage the outbreak of fires in large rural or forestry areas that may impact residential areas.

In such situations, FR play a crucial role in managing the fire and ensuring the safety of the people and property at risk. They are activated to respond quickly to the outbreak of fires, and their timely intervention is critical in controlling and containing the spread of the fire.

Several factors, such as capacities and available resources, impact the actuation of FR in the operational theatre. Coordination of resources is also critical, since the coordinated efforts of FR, along with the support of the community and other relevant authorities, are crucial in effectively managing the situation and minimising the damage caused by wildfires.

6.1.5. Scenario I

Soaring temperatures and drought conditions often characterise the dry season, especially in southern Europe, making the environment prone to the outbreak of wildfires. An ignition, whether naturally generated or due to human carelessness, can be sufficient to start rural or forest fires.

Wildfires are known to expand quickly, fueled by dry vegetation and high temperatures, and can spread to large forest areas. The situation can worsen when weather conditions, such as strong winds or high temperatures, do not favour controlling the fire, leading to uncontrollable conditions.

Such severe types of fires can extend to populated or industrial regions, significantly extending their impact and reach. Therefore, they require containment tactics supported by technologies of fire combat that may support mitigating effects and consequences, e.g., material, financial, human, etc.

Completing the scenario implies completely extinguishing the wildfire, re-establishing basic services to the population, and completely restoring capacity to ensure the business continuity of emergency responders.

6.2. Scenario II – floods

While downpours and following inundation play an essential role in replenishing water resources, fertilizing farmland, increasing biodiversity or shaping the cultural landscape, they must be considered one of the most dangerous natural disasters. Climate changes, dense/unplanned urbanization and demographic growth considerably make them even more extreme and fatal.

Figure 7 –Classification of Scenario II according to the WHO (2020).

6.2.1. The risk and trends

Extreme meteorological events caused EU Member States losses totalling an average of over 5.000 million €/year from 1980 to 2020 (EEA, 2022). More recently, in July 2021, Western and Central Europe faced severe flooding, leading to 230 fatalities and 36.000 million € economic losses (Cornwall, 2021).

Floods can cause significant loss of life and property damage, both in direct losses and in the context of impacting the economy by disrupting transportation, damaging businesses, and causing losses in agriculture and other industries.

All European countries have implemented flood management strategies to mitigate these risks, such as early warning systems, floodplain mapping, and infrastructure improvements such as dams and levees. However, despite these efforts, floods remain a significant hazard.

6.2.2. Key risk drivers

Floods can affect residential/industrial areas, severely threatening populations and assets. The damage caused by this water can be catastrophic, with devastating effects on property and wildlife. The seriousness of the phenomena requires pre-emptive preparation followed by an immediate, effective and purposeful response to address vulnerable areas appropriately.

In such situations, FR play a crucial role in ensuring the safety of the people and property at risk, primarily by reinforcing infrastructure and leading preventive evacuation. Their timely response applied at points requiring the most urgent attention is critical in controlling and containing the floodwaters.

Various factors, including the availability of useful information, resources, and capacities, influence the implementation of response actions in the field. Coordinating resources effectively to manage the situation and reduce the consequences is essential. Situational awareness facilitated among FR, community, and relevant authorities are necessary.

6.2.3. Scenario II

The scenario proposes an emergency response context to test the OVERWATCH technologies.

- Increase the situational awareness of flood development and allow informed decision-making.
- Support detecting signs of wear or damage over levees, recommendations for constructing emergency sandbag flood walls, and advice for evacuation.
- Support for safe and coordinated missions accomplished by multiple manned and unmanned aircraft in shared emergency area air volume, according to the boundaries defined by the EU and National legislation/regulation.
- Provide safety of rescue vehicles while travelling through the deluged territory.
- Support detection of people and real-time remote data acquisition (e.g. water current, water extent, water depth, etc.).

Rainfall or snowmelt can trigger these events, although the effects exercised during project trials may involve a wider range of phenomena identified by the interviewed experts: levee bursts, flash floods or floodwater pollution and any other relevant ones. Specific topics for individual sessions may also relate to the developing effects of typical flood scenarios, such as SAR activities, policing access restrictions or pre-flood data acquisition for modelling purposes. The completion of the scenario implies the restoration of basic services to the population.

7. Use cases

Use case collection activities are essential to the system development process, enabling designers and developers to gather critical stakeholder requirements while addressing operational constraints. Regarding emergency management, it is crucial to involve first responders and other civil protection stakeholders in the use case elicitation process to ensure that the system meets the needs of those using it in real-life scenarios. In this context, use case elicitation activities can help identify how technology can improve disaster response and management efficiency and effectiveness.

Wildfires and floods are two of the most common and dangerous natural disasters that pose significant challenges to first responders and other civil protection stakeholders. Collecting use cases for these hazards requires interactions with proper stakeholders.

The collection of wildfire use cases can involve the collaboration of firefighters, forestry services, and other emergency management authorities. The use cases can focus on improving situational awareness, such as real-time fire mapping, detection, and prediction systems, and coordinating communication between emergency teams. The use cases can also consider pre-disaster planning and mitigation strategies, including the development of evacuation plans, risk assessment, and environmental monitoring to prevent the outbreak of wildfires.

Similarly, to elicit use cases related to floods, the activities can involve collaborating with rescue teams, water management authorities, and other stakeholders in flood response and recovery. The use cases can focus on improving early warning systems, enhancing the ability to forecast the potential impact of floods, and developing more efficient evacuation plans. The use cases can also consider post-disaster recovery strategies, such as monitoring and assessing water and soil quality and developing infrastructure to prevent future flooding.

7.1. Template for the use cases

Each use case in this chapter addresses one of the two scenarios of Chapter 0, while more than one use case may address the same scenario. Each use case involves a set of stakeholders and has specific goals to accomplish facilitated by the OVERWATCH technologies. The technologies developed in the project will be tested and validated through extensive testing in two pilots (FSX) in Portugal and Polland. The following table provides a template for defining the use cases.

The codename of the use case
Scenario This section identifies the scenario contextualising the use case: wildfires or floods.
Description Brief description of the use case.
Rationale Provide the rationale supporting the use case.
Stakeholders (actors) List relevant stakeholders (actors) for the use case and their roles in the FSX. The basis is the list in Section 4.4.

<table>
<tr><td>Preconditions
List the relevant environmental state required to start the use case.</td><td>Postconditions
List the expected state after the execution of the use case.</td></tr>
<tr><td>Basic flow
The flow of the response to the disaster event involving all actors.</td><td>Alternate flow
An alternate flow of the response considering a different evolution of the case.</td></tr>
<tr><td colspan="2">Non-functional requirements
End user non-functional requirements.</td></tr>
<tr><td colspan="2">Precedent use cases
Cross-references to other use cases.</td></tr>
<tr><td>Frequency
Low / Medium / High</td><td>Impact
Low / Medium / High</td></tr>
<tr><td colspan="2">Constraints
List constraints the use case addresses, i.e., capacity, resources, terrain, communications, legal and regulatory.</td></tr>
<tr><td colspan="2">Story
A description of the events in time as a story.</td></tr>
<tr><td colspan="2">OVERWATCH supporting technologies
OVERWATCH components/systems that will be tested and validated in the correspondent pilot to facilitate reaching the goals set. One or more of the following components/systems will be listed: earth observation (EO), drones (DR), fallback communication (FC), artificial intelligence-based backend management system (AIMS), and augmented reality (AR).</td></tr>
<tr><td colspan="2">Goals
The use case contributes towards improving one or more of the following goals in an emergency context: situational awareness (SA); decision-making (DM); command and control (C2); emergency communication system (ECS); operational capacity (OC); search and rescue (SAR).</td></tr>
</table>

Table 14 – Template for the use cases.

7.2. Wildfires

This section presents the natural disaster scenario of wildfires covering large rural/forestry areas and includes three use cases. The first use case is "Support situation assessment and reconnaissance teams". Earth observation (**EO**), drones (**DR**), and artificial intelligence-based backend management system (**AIMS**) technologies will be used.

The second use case is "Deploy a resilient emergency communication network", and it will use drones (**DR**), fallback communication (**FC**), and artificial intelligence-based backend management system (**AIMS**) technologies.

The last use case is "Manage response to a forest fire", which will use drones (**DR**), fallback communication (**FC**), artificial intelligence-based backend management system (**AIMS**) technologies, and augmented reality (**AR**).

The diagram below of Figure 8 presents the relations between the wildfires scenario, the three use cases, respective goals and interdependencies, and the OVERWTACH technologies tested therein.

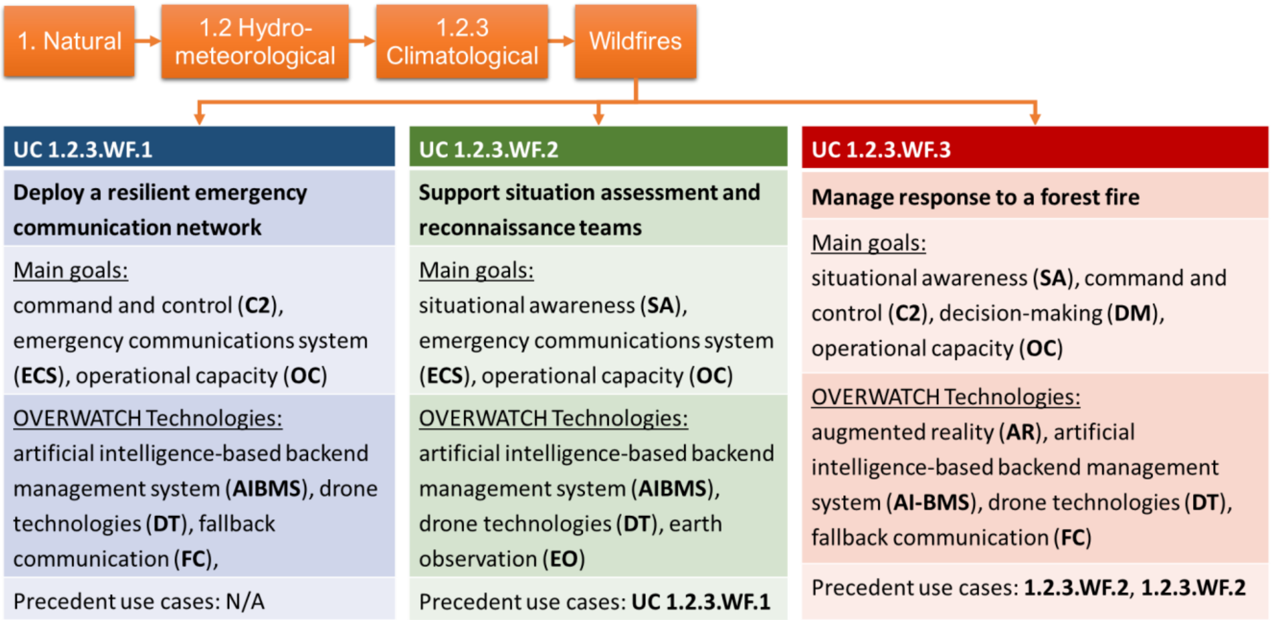

Figure 8 – Summary of use cases for Scenario I – Wildfires.

The FSX for the wildfires scenario will dedicate two working days for the teams to integrate technologies before the scenario and the event logistics and one working day per use case. The total will be five working days for the first FSX. The following three sections provide additional details for the use cases of Scenario I – Wildfires.

7.2.1. Deploy a resilient emergency communication network

Table 15 below describes the first use case for the wildfires scenario.

UC 1.2.3.WF.1 – Deploy a resilient emergency communication network
Scenario Scenario I – Wildfires.
Description • A large forest fire is burning out of control in a mountainous region with dry vegetation. • Due to uneven terrain, communication blackouts in some areas disturb communications between emergency teams and the command centre. • Tethered drones provide a stable platform for communication equipment and increase the resilience of emergency response communication networks. • Tethered drones have other payloads to detect emergent risks and provide real-time situational awareness. • Tethered drones provide fallback communication systems to improve response efforts, leveraging safety and effectiveness in challenging environments.

Rationale

Deploying a resilient emergency communication network in remote locations ensures that emergency responders can access reliable emergency communication. The terrain can be rugged and unpredictable, generating shadow/blackout regions and making it difficult for traditional communication networks to provide complete coverage. By deploying a resilient emergency communication network, emergency personnel can access communication even in areas with weak signal strength or no coverage, which is critical for making timely decisions and coordinating response efforts.

In addition to voice communication, data communication is becoming essential in emergencies. The ability to share information such as maps, photos, and other critical data can significantly enhance the effectiveness of emergency response efforts.

A resilient emergency communication network can provide voice communication and high-speed data transfer capabilities, allowing emergency personnel to quickly and securely share critical information.

Stakeholders (actors)

Emergency responders, namely the local emergency management authority, the communication engineers and operational personnel. OVERWATCH team.

Preconditions

- SIRESP will provide operational conditions for executing the FSX.
- The ERs are responsible for the overall FSX safety.
- The OVERWATCH team provides, operates and safeguards all technologies under test in UC 1.2.3.WF.1.
- The OVERWATCH team ensures the interface and compatibility with the ERs' technologies and NECS.
- All stakeholders taking part in the FSX are briefed on their role, the basic flow/script exercise, the safety conditions, and the technologies to test in UC 1.2.3.WF.1.

Postconditions

- Assess the overall performance of technologies used in the UC 1.2.3.WF.1.
- Assess the quality of the OVERWTACH network in complementing the NECS.
- Assess the overall satisfaction of all personnel using the OVERWATCH network.
- All results must be measurable, quantifiable, and verifiable according to technical (functional/non-functional) requirements.
- Provide post-action reports to all stakeholders taking part in the UC 1.2.3.WF.1.

Basic flow

1. The OVERWATCH team launches the FC using a tethered drone.
2. The FC joins the ECS as a new network node/hotspot.
3. The FC accesses the AIMS over the ECS structure.
4. ERs access the ECS through the FC to exchange voice, image and metadata.
5. The AIMS broadcasts services, e.g. SA, to the network through the ECS.

Alternate flow

N/A.

Non-functional requirements

Check UC 1.2.3.WF.3.

Precedent use cases	
N/A.	
Frequency Low / Medium	**Impact** High
Constraints • Capacity: drones and specific ICT. • Terrain: mountainous region and abundant dry vegetation. • Communications: resilience of voice communications; multiple data links, including satellite; data streaming consuming large bandwidth. • Legal and regulatory, e.g., EASA or ANAC drone regulations, the DON directives or specific laws and regulations for the communications emergency systems, such as the Portuguese SIRESP[4,5,6].	
Story A large forest fire consumes large amounts of forest, fuelled by dry vegetation and burning out of control in a mountainous region. Several areas in the mountainous region are in a communications blackout due to the uneven terrain, causing emergency teams to have no communication between themselves and the command centre. A tethered drone network provides fallback communication hotspots to increase the resilience of emergency response communication networks. Tethered drones are connected to a ground control station (GCS) through a tether, allowing them to remain airborne for extended periods and providing a stable platform for communication equipment. In a network outage or damage to existing communication infrastructure, tethered drones will temporarily provide reliable voice and data communications to first responders and other emergency personnel. Such functionalities can be especially critical in remote or rugged terrain where traditional communication methods may not be effective. By providing real-time situational awareness, these systems can help responders make more informed decisions and allocate resources more effectively. Using tethered drones as fallback communication antennas can significantly enhance emergency response networks' resilience and improve response efforts' safety and effectiveness in challenging environments.	
OVERWATCH supporting technologies Drones (**DR**), fallback communications system (**FCS**), and artificial intelligence-based backend management systems (**AIMS**).	
Goals Command and control (**C2**), Emergency communication system (**ECS**), and operational capacity (**OC**).	

Table 15 – UC 1.2.3.WF.2 – Deploy a resilient emergency communication network.

[4] https://www.siresp.pt/legislacao/
[5] https://dre.pt/dre/detalhe/resolucao-conselho-ministros/88-1999-423040
[6] https://dre.pt/dre/detalhe/decreto-lei/81-a-2019-122592101

7.2.2. Support situation assessment and reconnaissance teams

Table 16 below describes the second use case for the wildfires scenario.

UC 1.2.3.WF.2 – Support situation assessment and reconnaissance teams	
Scenario Scenario I – Wildfires.	
Description • A large wildfire spreads across a diverse mainland area with forests, agricultural fields, and small villages. • The fire is expected to spread to neighbouring areas, putting small villages at risk. • The regional tactical command sends Situation Assessment and Reconnaissance Teams[7] (SATR) to assess the local risk and availability of resources for emergency response. • These teams use all-terrain vehicles, pickups, drones, advanced sensors and cameras to gather near real-time data on the fire's status and surrounding terrain. • The collected data supports AI-powered decision-making to plan effective firefighting strategies and allocate resources more efficiently, enhancing the resilience of emergency response efforts in the face of wildfires.	
Rationale Using drones and AI-powered fusion of earth observation and GIS data can benefit situation assessment and reconnaissance teams in detecting and spotting areas for wildfire progression and identifying local resources. These technologies can provide an efficient and effective way of collecting data over large areas, allowing teams to quickly and accurately assess the situation and make informed decisions. Drones can be equipped with specific payloads, e.g., high-resolution cameras and sensors that can detect changes in temperature and moisture levels, allowing them to identify areas where fires are likely to spread or intensify. Additionally, drones can fly over difficult or dangerous locations for humans to access, providing situational awareness and reconnaissance data that would not be possible otherwise. Using AI-powered fusion of earth observation, drones and existing GIS data, these technologies can also identify patterns and trends that may not be visible to the human eye. These technologies can help teams predict where fires will likely spread and develop strategies to contain them. Moreover, AI can identify resources such as water, fuel, roads, or alternative routes to escape danger and fire progression, providing valuable information to emergency responders.	
Stakeholders (actors) Emergency responders: tactical command, operational experts. OVERWATCH team.	
Preconditions	**Postconditions**

[7] The portuguese regulation for Situation Assessment and Reconnaissance teams is available from: http://www.prociv.pt/bk/PROTECAOCIVIL/LEGISLACAONORMATIVOS/OUTROSNORMATIVOSDIRETIVAS/Documents/DON_2_DECIR_2022.pdf

• The ER will provide operational conditions for executing the FSX. • The ERs are responsible for the overall FSX safety. • The OVERWATCH team is responsible for operating and safeguarding the technologies under test in UC 1.2.3.WF.2. • OVERWATCH Technologies will interface with the ER technologies, supporting and complementing the existing capacities. • All stakeholders taking part in the FSX are briefed on their role, the basic flow/script exercise, the safety conditions, and the technologies to test in UC 1.2.3.WF.2.	• Assess the overall performance of technologies used in UC 1.2.3.WF.2. • Assess the quality of the information provided by the SART supported by the drones and AIMS to the C2. • Assess the overall satisfaction of all personnel using the OVERWATCH technologies. • All results must be measurable, quantifiable, and verifiable according to technical (functional/non-functional) requirements. • Provide post-action reports to all stakeholders in UC 1.2.3.WF.2.
Basic flow 1. Notification of wildfire 2. Assessment of the theatre of operations (TO) regarding location and perimeter. 3. AIMS supports identifying critical areas for observation/reconnaissance by the SART. 4. The SART move into target areas. 5. SART launches drones swarm. 6. Drones swarm starts data streaming to a GCS. 7. The GCS streams data to the AIMS over the ECS infrastructure. 8. The GCS streams data to the AIMS over a satellite link. 9. AI-powered data analytics produces actionable information (estimation of vegetable fuel and weather conditions, the population for relocation, water points, roads, etc.) for C2. 10. The SART receives relevant data and C2 orientation using a ruggedised phone/tablet.	**Alternate flow** If the data links between the drones and the GCS (step 6) or between the GCS and the AIMS (7) are faulty, then launch UC 1.2.3.WF.1 and return to step 6/7.
Non-functional requirements Check UC 1.2.3.WF.3	
Precedent use cases UC 1.2.3.WF.1	
Frequency High	**Impact** High
Constraints • Capacity: swarms of drones, GCS, specific information and communication technologies (ICT), AIMS powered with DM and fusion of EO and GIS data subsystems. • Terrain: remote uneven terrain with forests, agricultural fields, and small villages),	

• Communications: multiple data links, including satellite; streaming of voice, data and image consuming large bandwidth. • Legal and regulatory: data protection and privacy regulation for collecting live footage or personally identifiable data (e.g., compliance with the GDPR[8]); drone regulations set by the European Union Aviation Safety Agency[9] (EASA) or the national authorities, e.g. the National Civil Aviation Authority[10] (ANAC) in Portugal; regulation for the emergency systems, e.g. the Portuguese National Operational Directives[11,12] (DON).
Story A large wildfire spreads across a mainland area with a diverse, scattered landscape of forested and agricultural fields and numerous small villages throughout the region. Due to the expected weather conditions, the fire will likely spread to neighbouring areas, possibly putting the small villages in the surrounding area at risk. The regional tactical command, which is in charge of managing the emergency response operation, sends situation assessments and reconnaissance teams to those regions still outside the operations theatre to assess the local risk for the populations and the availability of resources. The Situation Assessment and Reconnaissance will assess the risk locally and especially the existence of residents in places that might need evacuation. The teams will also check existing information on water points and their status to provide aerial systems, fuel service stations, roads, or alternative routes to escape danger and fire progression. The Situation Assessment and Reconnaissance teams travel to the marked locations using all-terrain vehicles or pickups with some carrying capacity, such as basic firefighting capabilities, medical support and drones. Once arriving at the locations, the teams start direct observation processes complemented by deploying swarms of drones to feed data into the SA and AIMS to support the C2 action. These drones can be equipped with advanced sensors and cameras to gather real-time data on the status of the fire and the surrounding terrain. AI-powered algorithms analyse this data and provide valuable insights to C2 and tactical commanders. These swarms of drones monitor wind direction and speed, humidity levels, and other environmental factors that can affect the spread of the fire. This information can determine the direction of fire progression and identify areas where the fire is most likely to spread. By warning of potential fire outbreaks early, these drones help emergency responders take proactive measures to contain the fire before it spreads too far. Furthermore, the data collected by these drones can be used to create 3D models of the fire and the surrounding area. These models can be used to plan the most effective firefighting strategies and to allocate resources more efficiently. The AIMS algorithms simulate the behaviour of the fire under different conditions and identify the most effective routes for emergency responders to access/leave the area.

[8] https://commission.europa.eu/law/law-topic/data-protection/data-protection-eu_en
[9] https://www.easa.europa.eu/en
[10] https://www.anac.pt/vPT/Generico/drones/Paginas/AeronavesCivisPilotadasRemotamente.aspx
[11] http://www.prociv.pt/bk/PROTECAOCIVIL/LEGISLACAONORMATIVOS/Directivas/ANPC_DON-1_DIOPS.pdf
[12] http://www.prociv.pt/bk/PROTECAOCIVIL/LEGISLACAONORMATIVOS/OUTROSNORMATIVOSDIRETIVAS/Documents/DON_2_DECIR_2022.pdf

Collected data will support the decision-making process of the regional C2 to deploy capabilities in the terrain and optimise the emergency response. Using AI-powered decision-making, swarms of drones and payloads of environmental sensors can significantly enhance the resilience of emergency response efforts in the face of wildfires. These technologies can help emergency responders stay ahead of the fire and take proactive measures to contain it before its impact and effects grow uncontrolled.
OVERWATCH supporting technologies Earth observation (**EO**), drones (**DRS**), artificial intelligence-based backend management systems (**AIMS**) and augmented reality (**AR**).
Goals Situational awareness (**SA**), Emergency communication system (**ECS**), and operational capacity (**OC**).

Table 16 – UC 1.2.3.WF.1 – Support situation assessment and reconnaissance teams.

7.2.3. Manage the response to a forest fire

Table 17 below describes the third use case for the wildfires scenario.

UC 1.2.3.WF.3 – Manage the response to a forest fire
Scenario Scenario I – Wildfires.
Brief Description (This use case is the successor of the two previous use cases, **UC 1.2.3.WF.1** and **UC 1.2.3.WF.2**; therefore, it includes their stories and activities as subsets to be tested again, now jointly as an integrated system) • Using an AI-powered decision-making tool, the OVERWATCH **AIMS**, allows commanders to allocate resources efficiently and coordinate emergency response in real-time, ensuring the use of force continuum. • The **AIMS** uses the fire's location, severity, terrain, and weather conditions to manage risk, adjust resource allocation, and determine effective firefighting strategies. Swarms of drones monitor potential fire progression and gather real-time data on the fire's status and the surrounding terrain, creating 3D models to plan firefighting strategies and identify effective routes for responders. • **AR** provide an immersive sandbox to support the **C2** management of the emergency response. • Tethered drones provide fallback communication hotspots to increase the resilience of emergency response communication networks, ensuring reliable voice and data communications for first responders in the event of a network outage or infrastructure damage. • These technologies, working together, provide real-time situational awareness to help responders make informed decisions and allocate resources more effectively.
Rationale

Forest fires can be unpredictable and fast-moving, making it difficult for the C2 and tactical levels to allocate resources and coordinate their efforts effectively in emergency response. By implementing AI-powered decision-making for resource allocation and planning, C2 and tactical management can quickly and efficiently deploy personnel and equipment to areas of greatest need. Such circumstance allows for a more effective and coordinated response to the wildfire, potentially reducing the time it takes to contain the fire and minimising damage to property and natural resources.

In addition to resource allocation and planning, AI-powered fusion of earth observation and GIS data can help emergency responders better understand the fire's behaviour and progression. C2 and tactical management can then adjust response strategies and allocate resources accordingly. For example, if the fire spreads rapidly in a particular direction, resources can be redirected to that area to contain it more effectively.

By leveraging AI-powered technologies, emergency responders can improve the speed and effectiveness of their response to forest fires, potentially saving lives and minimising damage. This approach also allows for a more data-driven response, which can be especially helpful when conditions are rapidly changing and challenging to predict.

Stakeholders (actors)

Political/strategic decision-makers.

Emergency responders: C2, tactical management, operational experts.

OVERWATCH team.

Preconditions

- The ER will provide operational conditions for executing the FSX.
- The ER is responsible for the overall FSX safety.
- The OVERWATCH team is responsible for operating and safeguarding the technologies under test in UC 1.2.3.WF.3.
- OVERWATCH technologies will interface with the ERs and ECS technologies, supporting and complementing the existing capacities.
- All stakeholders taking part in the FSX are briefed on their role, the basic flow/script exercise, the safety conditions, and the technologies to test in this UC 1.2.3.WF.3.

Postconditions

- Assess the overall performance of technologies used in the UC 1.2.3.WF.3.
- Assess the quality of the OVERWATCH technologies in complementing the existing emergency response system.
- Assess the overall satisfaction of all personnel using the OVERWATCH technologies.
- All results must be measurable, quantifiable, and verifiable according to technical (functional/non-functional) requirements.
- Provide post-action reports to all stakeholders taking part in the UC 1.2.3.WF.3.

Basic flow

1. Notification of wildfire.
2. Activation of first responders.
3. The AIMS supports the initial assessment of the operations theatre (e.g., location and external perimeter, type (forest, rural, urban), vegetation and other fuel, weather, risk assessment, etc.) and neighbouring potentially high-risk areas.
4. AR enhance the C2 action by providing a broad perspective of the TO.

Alternate flow

In step 10, the situation escalates severely, requiring aerial support in the TO. The AIMS must support the C2 in de-conflicting the airspace to ensure a clear and safe flying envelope for all aircraft (e.g., aerial firefighting resources, reconnaissance/surveillance drones, etc. This process should be semi-automated, allowing for supervision and control by an engineer. The goal is quickly identifying and

<table>
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<td>
5. C2 activates the SART.
6. Communications fail in remote areas.
7. C2 allocates the FC to the blackout areas.
8. The SART data identify high-risk areas.
9. The weather conditions deteriorate.
10. The AIMS supports the DM of the C2 by continuously assessing the TO and updating the SA.
11. Ensure the use of force continuum by escalation/de-escalation of response.
12. The fire escalates in intensity.
13. The AIMS supports the C2 in assessing the situation and activating further ER and relevant resources.
14. The fire gets controlled.
15. The AIMS supports the C2 in monitoring the situation.
16. The situation evolves into mop-up and monitoring
17. The AIMS supports the C2 in progressively demobilising the ERs.
</td>
<td>resolving potential conflicts, minimizing the risk of accidents or delays.</td>
</tr>
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<td colspan="2">
Non-functional requirements

<u>Reliability</u>: the OVERWATCH response system must be highly reliable and available during the wildfire duration, accommodating for minimising system failures or their impacts.

<u>Security</u>: the OVERWATCH system must ensure that all communications and data are secure and protected against unauthorised access, hacking, and cyber threats.

<u>Scalability</u>: the OVERWATCH must be scalable to accommodate many users and devices during peak usage, such as during a wildfire outbreak.

<u>Interoperability</u>: the OVERWATCH system should integrate with various emergency response systems used by different agencies and organisations.

<u>Usability</u>: the OVERWATCH must be user-friendly and easy to use by emergency responders with varying technical expertise.

<u>Performance</u>: the OVERWATCH must perform efficiently and quickly, providing real-time information and communication to emergency responders in the field.

<u>Availability</u>: the OVERWATCH should be available for extended times, even during network disruptions or natural disasters.

<u>Compatibility</u>: the OVERWATCH system could be compatible with various devices and operating systems, allowing emergency responders to use their preferred tools and platforms.

<u>Accessibility</u>: the OVERWATCH system could be accessible to all emergency responders, regardless of physical or sensory abilities.

<u>Maintainability</u>: the OVERWATCH system should be easy to maintain and upgrade, allowing quick and seamless updates to improve its functionality and performance.
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Precedent use cases

1.2.3.WF.2, 1.2.3.WF.2.
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<td>Frequency</td>
<td>Impact</td>
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</table>

High	Medium / High
Constraints Capacity (swarms of drones, GCS, specific information and communication technologies (ICT), fusion of EO and GIS data, and the AIMS system), resources (human, vehicles and logistic support), terrain (remote uneven terrain with forests, agricultural fields, and small villages), communications (multiple data links, including satellite; streaming of voice, data and image consuming large bandwidth), legal and regulatory (data protection and privacy regulation for collecting live footage[13]; drone regulations set by the European Union Aviation Safety Agency[14] (EASA) or the National authorities, such as the National Civil Aviation Authority[15] (ANAC) in Portugal).	
Story A forest fire has broken out in a remote area and rapidly spreads due to high winds and dry vegetation. The C2 and tactical commanders use an AI-powered decision-making tool to determine the optimal allocation of resources, including firefighters, equipment, and supplies, to combat the fire effectively. The OVERWATCH AIMS tool considers the fire's location, severity, terrain, and weather conditions to ensure that resources are deployed most efficiently and effectively. The tool also allows the emergency managers to coordinate emergency response, including establishing a command post and coordinating communication among the various responding agencies. The AI-powered fusion of earth observation and GIS data provides real-time information on the fire's progress and the location of local resources, such as water sources, fuel, or roads, that could be used as escape routes. This information allows for reallocating resources and determining the most effective firefighting strategies. As the firefighting efforts continue, the AIMS tool provides decision support, enabling the incident commander to adjust the allocation of resources and coordinate the response as needed. The tool also provides situational awareness to all responding agencies, allowing them to make informed decisions and react to changing conditions in real-time.	
OVERWATCH supporting technologies Drones (**DR**), fallback communications system (**FCS**), artificial intelligence-based backend management systems (**AIMS**), and augmented reality (**AR**).	
Goals Situational awareness (**SA**), command and control (**C2**), decision-making (**DM**), and operational capacity (**OC**).	

Table 17 – UC 1.2.3.WF.3 – Manage the response to a forest fire.

7.3. Floods

This section presents the natural disaster scenario of floods threatening large rural areas and includes three use cases. The first use case is a pre-flood analysis of the state of infrastructure". It will use earth observation (**EO**), drones (**DR**), augmented reality (**AR**) and artificial intelligence-based backend management system (**AIMS**) technologies.

[13] https://commission.europa.eu/law/law-topic/data-protection/data-protection-eu_en
[14] https://www.easa.europa.eu/en
[15] https://www.anac.pt/vPT/Generico/drones/Paginas/AeronavesCivisPilotadasRemotamente.aspx

The second use case, "Post-flood impact documentation", will use earth observation (**EO**), drones (**DR**), artificial intelligence-based backend management system (**AIMS**), and augmented reality (**AR**) technologies.

The last use case, "Flood-time rapid data collection and actionable intelligence", will use drones (**DR**), the fallback communication (**FC**)[16] system, augmented reality (**AR**) and artificial intelligence-based backend management system (**AIMS**) technologies.

The diagram below of Figure 8 presents the relations between the flood scenario, the three use cases, respective goals and interdependencies, and the OVERWTACH technologies tested therein.

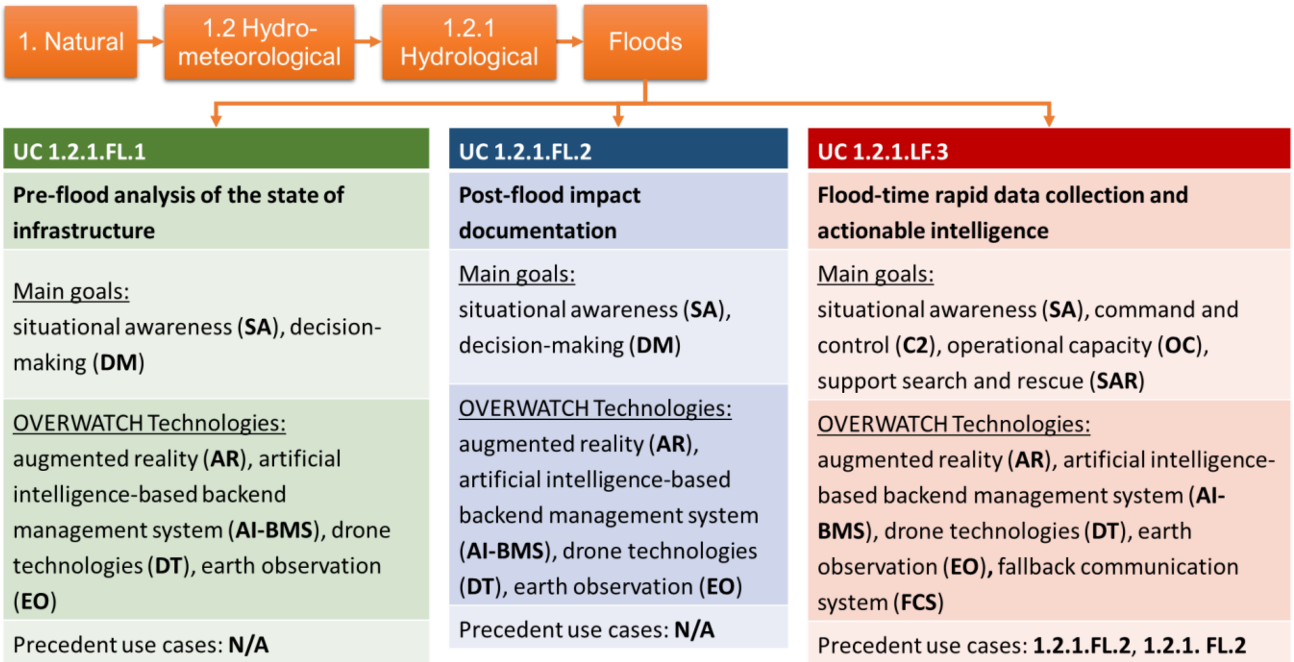

Figure 9 – Summary of use cases for Scenario II – Floods.

FSX for the floods scenario will take place after the FSX for wildfires as soon as suitable environmental and atmospheric conditions are met. The following three sections provide additional details for the use cases of Scenario II – Floods.

[16] Static system demonstration only, no real usage planned.

7.3.1. Pre-flood analysis of the state of infrastructure & flood risk modelling

Table 16 below describes the first use case for the wildfires scenario.

UC 1.2.1.FL.1 – Pre-flood analysis of the state of infrastructure
Scenario Scenario II – Floods.
Description This scenario focuses on issues related to the control of the technical condition of the infrastructure, change detection, and comparison of different types of data to accelerate and integrate currently dispersed processes resulting in achieving the complete overview of the flood protection system. • Infrastructure inspection is laborious, and the assessment often exceeds the biennial target. The regional water management authority lists critical areas at risk, which should be prioritised and gradually addressed. • A large flood threatens a mainland area with forests, agricultural fields, and small villages. • Weather forecasts project high water levels could damage levees, especially those of a weakened condition. • Based on a report from the regional water management authority (RWMB), the crisis management team activated the DT to conduct several reconnaissance actions and map the infrastructure to its current state in high-risk areas not yet inspected. • The state fire service requests the designation of an airspace reservation zone to enable unrestricted drone flights. • AIMS supports identifying weak spots for reinforcing known weak spots with secondary sandbag flood walls. AR display of existing DSM and DTM models with actual layered ortho-photomosaic supports this activity. • The collected data supports AI-powered decision-making to plan the reinforcing of levees and allocate resources more efficiently, enhancing the resilience of emergency response efforts.
Rationale The infrastructure is under constant review by on-the-ground means; however, the costs of the process reduce its frequency. Authorities conduct regular inspections for the major watercourses, which is impossible for smaller ones. Farmers, recreational polder users (walkers, bikers), wild animals or illegal structures can unintentionally damage levees. To prevent floods, authorities should assess all infrastructures detecting changes, spotting landform changes (levees and inter-levee area), damage to the levee (cuts, slips, burrows, removed turf), ongoing or uncompleted earthworks and assess the general technical condition[17].

[17] Key parameters of levee condition: stability calculations, filtration, condition of leveestructures, condition of the inter-levee area, levee body dimensions, safe elevation of the levee crest, importance class of structures in the light of the latest applicable regulations. The technical condition and safety of levees are rated by with assigning one of 4 categories: 0 - no assessment due to lack of data, 1 - safety-threatening condition, 2 - condition that may threaten safety, 3 - good technical condition, not threatening safety. Assessor subjectively evaluates levee by following a set of standardisation criteria – qualitative assessments of the condition of key elements: the body of the levee; the subsoil directly under the levee and in the area adjacent to the levee up

Low-level aircraft data acquisition and AI-powered fusion of earth observation and GIS data can enable rapid pre-flood infrastructure analysis through remote inspection and automation. These technologies can provide actionable intelligence allowing pre-emptive measures to close potential weak-spots and prevent events escalation. Drones can be equipped with LIDAR, high-resolution cameras and sensors that can detect temperature and moisture level changes, allowing them to identify soaked levees more prone to critical failure. Additionally, drones can fly over difficult or dangerous locations for humans to access and provide SA and reconnaissance data that would not be possible otherwise. AR systems can support planning defensive structures for screening endangered areas in places with a high risk of overflows or levee damage. Assessing those structures on a virtualised model for the terrain while displaying photogrammetric data will enhance safety and efficiency. The AI-powered fusion of EO and GIS data will support comparing and analysing data in near real-time to identify problems invisible to the human eye, e.g., illegal earthworks or constructions in areas adjacent to the levee. These technologies can help C2 by providing actionable recommendations for targeted preparatory activities.	
Stakeholders (actors) Regional water management board, emergency responders/management agencies, weather forecasting providers, water management institutions, and users of emergency aircraft. OVERWATCH team.	
Preconditions The ER will provide real/simulated conditions for executing the FSX. The ER is responsible for the overall FSX safety. The OVERWATCH team is responsible for operating and safeguarding the technologies under test. OVERWATCH Technologies will interface with the ER technologies, supporting and complementing the existing capacities. All stakeholders in the FSX are briefed on their role, the exercise's basic flow/script, the safety conditions, and the technologies to test.	**Postconditions** Assess the overall performance of technologies in the current FSX under real/simulated conditions. Assess the quality of the information provided by the RWMB supported by the drones and AIMS to the C2. Assess the overall satisfaction of all personnel using the OVERWATCH technologies. All results must be measurable, quantifiable, and verifiable according to technical (functional/non-functional) requirements. Provide post-action reports to all stakeholders.
Basic flow 1. Alert (forecast) 2. Data collection with aircraft (LIDAR/visual/ thermal imagery) [FSX or simulated]	**Alternate flow** N/A.

to 50m from the foot of the levee both on the both sides, including especially the area where filtering occurs during floods; structures accompanying the levee, such as: pumping stations, culverts, sluices, drains, drainage facilities, drainage outlets, levee ditches, levee crossings; flood and access roads to the levee; control and measurement facilities and other elements related to the protective line formed by the levee; the inter-levee; protected area on the protected side of the levee.

3. The ground station streams data to the AIMS using the EMS 4. AI-powered data analytics produces actionable information (levee weak points, irregularities) for RWMB 5. RWMB produces recommendations for C2 and presents them during crisis management team meetings.	
Non-functional requirements Check UC 1.2.3.WF.3	
Precedent use cases N/A	
Frequency High	**Impact** High
Constraints • Capacity: drones, ground stations, specific information and communication technologies (ICT), AIMS powered with DM and fusion of EO and GIS data subsystems. • Terrain: riverbank and levee of condition 1, 2 or eventually 0. • Communications: data links, including satellite data and images, consume large bandwidth. • Legal and regulatory: data protection and privacy regulation for collecting live footage or personally identifiable data (e.g., compliance with the GDPR[18]); drone regulations set by the Polish air navigation services agency (PANSA) and civil aviation authority (ULC).	
Story A large flood threatens a diverse mainland area with forests, agricultural fields, and small villages. Weather forecasts indicate a flood risk. A flood wave is expected to come in a few days. High water levels could damage levees, especially those in weakened conditions. At a meeting of the crisis management team, representatives of the crisis centre of the regional water management board advise several measures to prepare for the upcoming threat. Forces and resources are on standby, and the central and regional reserves are mobilised. State fire service requests the designation of an airspace reservation zone (R) with a ceiling of 500m above the emergency area to effectively utilise drones. Municipal authorities are asked to carry out inspections of levees' technical condition and document areas with irregularities. Simultaneously, authorities assess large watercourses using foot patrols and aircraft. The regional water management board maps the infrastructure using aircraft from different providers (e.g., own resources, police, territorial defence forces, etc.) and available EO data. Based on previous experiences, key infrastructure and known weak spots are being reinforced with secondary sandbag flood walls. AR display of existing DSM and DTM models with up-to-date high-resolution orthophoto mosaic layered on it supports this activity.	

[18] https://commission.europa.eu/law/law-topic/data-protection/data-protection-eu_en

The collected data further supports AI-powered decision-making to plan effective levee reinforcing and allocate resources more efficiently, enhancing the resilience of emergency response efforts Collected data will support the decision-making process of the regional C2 to deploy capabilities in the terrain and optimise the emergency response. Using AI-powered decision-making, drones and payloads of environmental sensors can significantly enhance the resilience of emergency response efforts in the face of floods. These technologies can help emergency responders stay ahead and take proactive measures to stop processes that, unaddressed, could lead to further event escalation.
OVERWATCH supporting technologies Earth observation (**EO**), drones (**DRS**), artificial intelligence-based backend management system (**AIMS**) and augmented reality (**AR**).
Goals Situational awareness (**SA**), decision-making (**DM**).

Table 18 – UC 1.2.1.WF.1 – Pre-flood analysis of the state of infrastructure.

7.3.2. Post-flood impact documentation

Table 15 below describes the second use case for the flood scenario.

UC 1.2.1.FL.2 – Post-flood impact documentation
Scenario Scenario II – Floods.
Description This scenario focuses on issues related to observing water flows and water extent, detecting and marking flood damage, and sharing the results. • One of the effects of a flood event is the changes caused to the environment, with particular reference to the alteration of the river channel. • Floodwaters are expected to leave debris and sediments that need further mapping. • Documentation of water extent pays a key role in the risk modelling and updating process of existing planning documents. • Observation resources can source information collected for documenting and further comparative analysis of the events' consequences and dynamics.
Rationale Information on the extent of flooding allows fraud detection and subsequent adjustments of the flood hazard and risk models. Currently, such data is collected by surveying municipalities that have experienced flooding. This process, done weeks, months or even years after floods, is prone to errors caused by a lack of thematic knowledge, imprecise allocation of events to an area, inaccurate testimonials or deliberate misstatement to claim funds. EO and drone capacities assisted by AIMS can significantly collect more precise data, resulting in more robust and evidence-based flood dynamics and hazard analytics.

The videos published by private drone owners are another yet undeveloped data source. The images of the course of the floods that can be seen on them can also be reprocessed and used as testimonials. After a flood, especially for mountainous watercourses, there is a significant chance of changing the watercourse corridor. Additionally, floodwater might alter the riverbed. Awareness of these changes is crucial for the flood (risk) modelling adjustment process.	
Stakeholders (actors) Regional water management board, emergency responders/management agencies, weather forecasting providers, water management institutions, and users of emergency aircraft. OVERWATCH team.	
Preconditions The ER will provide real/simulated conditions for executing the FSX. The ER is responsible for the overall FSX safety. The OVERWATCH team is responsible for operating and safeguarding the technologies under test. OVERWATCH Technologies will interface with the ER technologies, supporting and complementing the existing capacities. All stakeholders taking part in the FSX are briefed on their role, the exercise basic flow/script, the safety conditions, and the technologies to test.	**Postconditions** Assess the overall performance of technologies in the current FSX under real/simulated conditions. Assess the quality of the information provided by the RWMB supported by the EO, drones and AIMS. Assess the overall satisfaction of all personnel using the OVERWATCH technologies. All results must be measurable, quantifiable, and verifiable according to technical (functional/non-functional) requirements. Provide post-action reports to all stakeholders.
Basic flow 1. Data collection from satellite EO sources. 2. Data collection with aircraft (LIDAR/visual/ thermal imagery) [FSX or simulated] 3. The ground station streams data to AIMS using the Emergency Communication System 4. AI-powered data analytics for RWMB – modelling department, crisis centre unit, infrastructure department.	**Alternate flow** N/A.
Non-functional requirements Check UC 1.2.3.WF.3.	
Precedent use cases N/A.	
Frequency N/A	**Impact** N/A

Constraints • Capacity: drones, ground stations, specific ICT, AIMS powered with DM and fusion of EO and GIS data subsystems. • Terrain: simulated debris and sediments or access to data collected during emergencies. • Communications: data links, including satellite, data and images, consume large bandwidth. • Legal and regulatory: data protection and privacy regulation for collecting live footage or personally identifiable data (e.g., compliance with the GDPR[19]); drone regulations set by ULC and PANSA.
Story Mountainous flood leaves the watercourse corridor changed. Riverbed alteration should be measured and provided to modelling department of responsible agency. Additionally, the sediments and other debris should be measured and evidenced, so clean-up priorities and recommendations can be issued. Finally, all possible sources of evidence of the dynamics of the flood are subject to further documentation and analysis. All data collected during flash flood response, and videos provided by private drone owners, can be further analysed. The key research goal are: backtracking the maximum water extent (and depth); reconstruction of the flood dynamics; identification of the actual source of flooding at a given point (e.g. rainfall slope runoff, river overflow). This analysis should end with secondary outcomes - maximum water extent and maximum water depth.
OVERWATCH supporting technologies Drones (**DR**), earth observation **(EO)** and artificial intelligence-based backend management system (**AIMS**).
Goals Situational awareness (**SA**), decision-making (**DM**).

Table 19 – UC 1.2.1.FL.2 – Post-flood impact documentation.

7.3.3. Flood-time rapid data collection and actionable intelligence for response management

Table 17 below describes the third use case for the flood scenario.

UC 1.2.1.FL.3 – Flood-time rapid data collection and actionable intelligence
Scenario Scenario II – Floods.
Brief Description This use case is the successor of the two previous use cases, UC 1.2.1.FL.1 and UC 1.2.1.FL.2; therefore, while assimilating their outputs, it shifts towards C2 and DM tools for Operational Level

[19] https://commission.europa.eu/law/law-topic/data-protection/data-protection-eu_en

resource management. As such allows for the joint presentation of a whole set of project technical solutions as an integrated system.

- Floodwaters filled the inter-levee area and will persist on a similar level for an extended time
- It is necessary to have an overview of the status of dispersed resources: capacity and filling level of reservoirs, sandbag stores, municipal capacity to transport and receive evacuees, number and status of hospital beds
- Levees are under the highest stress due to water pressure and are prone to failures. Regular monitoring should be introduced for early detection of stress signs
- Debris and sediments can mount up, especially in prone infrastructure, e.g. bridges or canals, therefore reducing water flow locally, raising the water table and causing backdrafts
- Over time, levee failure can occur, resulting in flooding of nearby rural areas. When this takes place, it is necessary to initiate SAR measures (detection of people in the flooded area), prioritisation of areas to be searched, plan for the evacuation of further areas
- Using an AI-powered decision-making tool, the AIMS, allows commanders to allocate resources efficiently and coordinate emergency response in real-time.
- The AIMS uses collected data: levee condition classification, water levels measurements, water currents, and weather forecast to manage risk, adjust resource allocation, manage stock inventories of sandbags in different locations and determine effective levee reinforcing strategies
- DR monitor levees to gather real-time data on their status, create 3D models, detect changes and signs of wear, detect water pools on the outer side of levees, and when breakage occurs - mapping water extent and measure their depth, conduct SAR, communicate via onboard speakers and identify routes for responders
- AR provide an immersive sandbox and, by using user-defined colour scales zeroed at the indicated point, allows a better understanding of terrain topography to support the C2 management of the emergency response
- These technologies, working together, provide real-time situational awareness to help responders make informed decisions and allocate resources more effectively

Rationale

Gathering key information on the state of the watercourse at the time of the flood allows not only for forecasting. Additionally, it provides a better understanding of its dynamics, provides a basis for correcting existing models and develops evidence-based recommendations for future protective infrastructure investments. The current system's data collection is based on telemetric sensors and manual measuring points that record water surface elevation and flow.

The information available to rescuers is in dispersed databases, and the maps are not digitised into a single geographical information system. Rescuers are provided with a list of planned investments, an assessment of the technical condition of the levees, information on the expected height of the water table, information on the size of the crown of the levees and a weather forecast. These data are not consolidated nor depicted graphically. Their interpretation requires knowledge of the phenomena and an awareness of the existence of documentation that contains the key information - this element appears to be prone to omission. For this reason, decisions to make elevations and reinforcements out of sandbags are taken without complete situational awareness.

One important phenomenon, the early detection of which can significantly reduce the severity of floods, is the blockage of water flow by waterborne debris. This can cause noticeable increases in water levels or stronger localised erosion. Bridges and channels are particularly susceptible to such blockages. The effect may be an increase in the water table progressing upstream of the watercourse and flooding areas not included in the risk analysis.

The occurrence of flooding causes an increased need for continuous monitoring of levees. Ground-based methods of looking for signs of damage and levee wear rely on reports from rescuers and bystanders. Verbal reports do not always allow for a meaningful comparative

assessment of the actual damage and, therefore, the optimal deployment of forces and resources. The current approach reduces the likelihood of timely detection in areas with no emergency operations. In addition, monitoring the levees on foot creates significant risk, and the principle of allowing as few people as possible to walk on them is applied. There is a set of phenomena, the early detection of which could theoretically allow the effects to be adequately counteracted: water pooling on the protected side, levee waterlogging, hydraulic breakdowns – piping and seepage (under the pressure of elevated water, even occurring at some distance from the levee – (depending on the geological structure of the soil) seepage is less intense, creates visible geysers / craterlike structure of eroded sand, and is followed by more intense piping that unaddressed can lead to levee failure). Examples include pointing out places where the depth of the water can cause a danger to life but also identifying impassable roads or those that can only be crossed by fording. At the same time, it is important to understand how many people have been affected by an event and how many resources need to be prepared to mitigate its effects. In cases where the flood water cannot be contained (levee breakage, overflow, etc.), it is very difficult to determine the actual extent of the disaster - the flooded area. An accurate awareness of the extent of flooding is essential from the point of view of conducting an effective rescue operation. This applies to searches for areas where the depth of the water can cause a danger to life but also to the identification of impassable roads or those that can be passed only by fording. Currently, maps of the flooded area are only made by manually plotting the effects of aerial observation or by noting radio messages transmitted by units working in the field or testimonies provided by other people still present in the affected area. Although GIS systems are nothing new, the complexity of the technical and legal issues around their implementation results in insufficient sharing between flood response actors in many countries. Currently, in the working environment of the experts interviewed, there is no cross-institutional system that integrates flood data. Moreover, forecasts and other reports on the development of the event are predominantly provided in verbal and textual form (during meetings of the Crisis Management Board), less frequently in the form of non-interactive maps. There is no habit of sharing information layers or working on an integrated map environment. Incident Commander coordinates the usage of drones during operations. He can delegate this to the coordinator of flight operations, an officer with advanced competencies in drone utilisation. Communicating expected ceiling while designating safe air volume involves converting values understood by many drone pilots (relative height to the takeoff point expressed in meters) flying from multiple takeoff points and manned aircraft pilots using AGL values in feet). Large-scale operations could include drones and several manned aircraft coming and leaving the area of responsibility (SAR, medical evacuation, water-bombing). Those aircraft may have an ADS-B transponder (or similar device). For the coordination of flights, knowledge of the current position, AGL height and velocity vector for each manned aircraft would make it possible to reduce time and space buffers
Stakeholders (actors) State fire services, governmental crisis management, emergency responders/management agencies, weather forecasting providers, water management institutions, and users of emergency aircraft. OVERWATCH team.

Preconditions	**Postconditions**

The ER will provide real/simulated conditions for executing the FSX. The ER is responsible for the overall FSX safety. The OVERWATCH team is responsible for operating and safeguarding the technologies under test. OVERWATCH Technologies will interface with the ER technologies, supporting and complementing the existing capacities. All stakeholders taking part in the FSX are briefed on their role, the exercise basic flow/script, the safety conditions, and the technologies to test	Assess the overall performance of technologies in the current FSX under real/simulated conditions. Assess the quality of the information provided by the RWMB supported by the EO, drone and AIMS. Assess the overall satisfaction of all personnel using the OVERWATCH technologies. All results must be measurable, quantifiable, and verifiable according to technical (functional/non-functional) requirements. Provide post-action reports to all stakeholders.
Basic flow Complex emergency with general steps as follows: 1. High water in the inter-levee area; the flood is contained. 2. Areas are being preventively monitored, and outer-levee water extent is being measured 2 Series of injected sub-episodes dedicated to one use-case: seeping/seeping craters, breakage risk, debris-driven water flow obstruction. 3. Escalation - flooding of large rural area: SAR, calculation of evacuees, water extent detection and communication, prioritising - dangerously deep areas, analysis of fordable roads, search for signal flags	**Alternate flow** N/A.
Non-functional requirements <u>Reliability</u>: the OVERWATCH response system must be highly reliable and available during the wildfire duration, accommodating for minimising system failures or their impacts. <u>Security</u>: the OVERWATCH system must ensure that all communications and data are secure and protected against unauthorised access, hacking, and cyber threats. <u>Scalability</u>: the OVERWATCH must be scalable to accommodate many users and devices during peak usage, such as during a wildfire outbreak. <u>Interoperability</u>: the OVERWATCH system should integrate with various emergency response systems used by different agencies and organisations. <u>Usability</u>: the OVERWATCH must be user-friendly and easy to use by emergency responders with varying technical expertise. <u>Performance</u>: the OVERWATCH must perform efficiently and quickly, providing real-time information and communication to emergency responders in the field.	

Availability: the OVERWATCH should be available for extended times, even during network disruptions or natural disasters. Compatibility: the OVERWATCH system could be compatible with various devices and operating systems, allowing emergency responders to use their preferred tools and platforms. Accessibility: the OVERWATCH system could be accessible to all emergency responders, regardless of physical or sensory abilities. Maintainability: the OVERWATCH system should be easy to maintain and upgrade, allowing quick and seamless updates to improve its functionality and performance.

Precedent use cases 1.2.3.WF.2, 1.2.3.WF.2.	
Frequency Low	**Impact** High
Constraints Capacity: drone, ground stations, specific information and communication technologies (ICT), AIMS powered with DM and fusion of EO and GIS data subsystems. Terrain: simulated debris and sediments or access to data collected during a real emergency. Communications: data links, including satellite, data and images, consume large bandwidth. Legal and regulatory: data protection and privacy regulation for collecting live footage or personally identifiable data, e.g., GDPR; drone regulations set by the ULC and PANSA.	
Story The C2 and tactical commanders use an AI-powered decision-making tool to determine the optimal allocation of resources, including firefighters, equipment, and supplies and decide upon reinforcement actions number and extent. Aircraft and drones patrol the area for water pooling, seeping craters, debris and other pre-failure indicators. The AIMS tool considers the levee height, condition and effects of monitoring activities and location, severity, terrain, and weather conditions to ensure that resources are deployed most efficiently and effectively. Crowdsourced data is processed and inputted as an additional information source for an AR tool that enhances situational awareness of experts and commanders working from a remote location to support the C2 management of the emergency response. The tool also allows the emergency managers to coordinate emergency response, including establishing a command post and coordinating communication among the various responding agencies. The AI-powered fusion of earth observation and SIG data provides real-time information on breakage combined with safe areas extracted from risk modelling and the location of local resources (vehicles, teams, stockpiles, evacuation means and shelters) roads that could be used as escape routes. This information is used to adjust the allocation of resources and to determine the most effective coping strategies. The air rescue operations coordinator uses the tools to display traceable aircraft in the location and to translate and communicate airspace zoning geographical borders together with floor and ceiling elevation to drone teams. As the disaster mitigation efforts continue, the AIMS provides DM, enabling the incident commander to adjust the allocation of resources and coordinate the response as needed. The tool also provides SA to all responding agencies, allowing real-time and informed decisions.	

OVERWATCH supporting technologies
Drones (**DR**), fallback communications system (**FCS**) *(only as a demonstration)*, artificial intelligence-based backend management system (**AIMS**), and augmented reality (**AR**).
Goals
Situational awareness (**SA**), command and control (**C2**), decision-making (**DM**), and operational capacity (**OC**).

Table 20 – UC 1.2.1.FL.3 – Flood-time rapid data collection and actionable intelligence

8. User requirements

The present chapter details the functional and non-functional requirements that will guide the implementation phase of OVERWATCH. These requirements were derived from the various meetings and workshops held with the stakeholders between January and March 2023.

In some situations, the user requirements captured by end users are somewhat high-level. The OVERWATCH team will assess their feasibility and, whenever achievable, refine them into low-level engineering requirements in the project's design phase.

8.1. Convention for requirement identification

8.1.1. Convention for the functional requirements

Each functional requirement will be unequivocally identifiable by a unique identification of the form:

FFF – T – SSS

According to the following construction rules:

FFF corresponds to the category of the requirement.

T corresponds to the requirement's type.

SSS corresponds to a sequential number identifying the requirement within the requirement set in a given category.

The category can assume one of the following values:

Augmented reality (**AR**).

Artificial intelligence-based backend management system (**AIMS**).

Drones (**DRS**).

Earth observation (**EO**).

Fallback communication system (**FCS**).

The type for the functional requirements follows the MoSCoW prioritisation:

Must-have (**M**) means a mandatory requirement.

Should-have (**S**) represents a requirement of high priority but not critical.

Could-have (**C**) represents an optional requirement of lower priority.

Won't-have (**W**) serves to clarify the project's scope without being implemented in the current timeframe.

The sequential numbering in **SSS** increments in multiples of 10 allows adding new requirements at later project stages without reordering the existing ones.

8.1.2. Convention for the non-functional requirements

Each non-functional requirement will be unequivocally identifiable by a unique identification of the form:

FFF – SPEC

According to the following construction rules:

FFF corresponds to the category of the requirement.

SPEC corresponds to predefined non-functional specifications.

The category can assume one of the following values: augmented reality (**AR**); artificial intelligence-based backend management system (**AIMS**); drone (**DRS**) technologies; earth observation (**EO**); fallback communication system (**FCS**).

The non-functional specifications are: availability (**AVT**); accessibility (**ACC**); compatibility (**COMP**); compliance (**CPL**); interoperability (**INT**); maintainability (**MNT**); performance (**PERF**); safety (**SAF**); resilience (**RES**); reliability (**REL**); security (**SEC**); scalability (**SCA**); usability (**USBT**).

8.2. Requirements for the augmented reality technologies

8.2.1. Functional requirements

These requirements specify the desired functional and non-functional requirements to develop the augmented reality (AR) in the OVERWATCH project, as collected from stakeholder interactions.

IDENTIFIER	DESCRIPTION
AR-M-000	The OVERWATCH must support augmented reality (AR) for the AIMS to enhance command and control (C2) emergency management during the response in the real world
AR-M-005	The OVERWATCH must ensure a 'real-time' experience for users interactions and visualisation of 3D data in the AR space, therefore responding with minimal latency
AR-M-010	The AR must provide the ability to render and overlay digital objects, e.g., the virtual sandbox generated by the AIMS, geotagged images and other data layers, on the users’ physical surroundings
AR-M-020	The AR must deliver high-quality and realistic rendering of virtual objects
AR-M-030	The AR must support interaction with the physical environment allowing input data through gestures, voice commands, or other input methods to, e.g., select functions/features, define 2D areas or 3D volumes, etc.
AR-M-040	The AR must support extracting data (distances, volumes, inclination or other spatial/features data) from the virtualised environment
AR-M-050	The AR must support multiple platforms, including smartphones, tablets, and headsets
AR-M-060	The AR must provide accurate tracking of the user's position and orientation to ensure a precise overlay of AR content
AR-M-070	The AR must have reliable object recognition and tracking for AR applications that require object identification
AR-M-080	The AR must have multi-user support to enable collaborative experiences
AR-M-090	The AR must have a real-time rendering of 3D graphics and animations for a smooth experience
AR-M-100	The AR must integrate with computer vision technologies for advanced features like gesture recognition
AR-M-110	The OVERWATCH must provide an AR training module on the technology for the intended emergency managers

IDENTIFIER	DESCRIPTION
AR-M-120	The OVERWATCH must provide the ability to share the AR experience on screen, in real-time, with local/remote participants
AR-M-130	The AR must display all data and layers from AIMS
AR-S-000	The AR should support integration with external sensors and data sources, such as GPS and weather data
AR-S-010	The OVERWATCH should provide a scenario and use cases simulation module to deliver exercises aimed at different C2 levels
AR-S-020	The OVERWATCH should provide voice assistants for hands-free AR interaction
AR-S-030	The OVERWATCH should integrate with machine learning algorithms to improve AR object recognition accuracy over time
AR-S-040	The OVERWATCH should store, restore and retrieve AR content for offline access, e.g., allowing audits and forensics, post-action reviews or lessons learned
AR-S-050	The AR should support the spatial localisation of users within a shared space
AR-S-060	The OVERWATCH should support 3D scanning and modelling technologies for creating custom AR content
AR-C-000	The OVERWATCH could have integration with real-time language translation technologies for AR experiences in multilingual environments
AR-C-010	The OVERWATCH could support integration with haptic feedback technologies for more immersive AR experiences
AR-C-020	The OVERWATCH could provide easy-to-use AR authoring tools for creating and deploying AR content
AR-C-030	The OVERWATCH could provide seamless integration with existing apps and services, including social media and e-commerce platforms
AR-C-040	The OVERWATCH could support augmented audio technologies for an enhanced AR experience
AR-C-050	The OVERWATCH could provide the ability to create and share AR content within a community of emergency management users
AR-C-060	The OVERWATCH could have integration with biometric sensors for personalized AR experiences based on physiological data
AR-W-000	The OVERWATCH won't have integrations with other AR technologies beyond those developed for this project directly
AR-W-010	The OVERWATCH won't integrate with virtual reality technologies, and instead will only use AR technologies.
AR-W-010	The OVERWATCH won't provide hybrid AR/VR technologies.

Table 21 – Functional requirements for augmented reality technologies.

8.2.2. Non-functional requirements

IDENTIFIER	DESCRIPTION
AR-ACC	The system should comply with users with disabilities, including visual, auditory, and physical impairments

IDENTIFIER	DESCRIPTION
AR-COMP	The system should be compatible with a variety of hardware and software systems, as well as comply with relevant industry standards and regulations, including data privacy laws and security guidelines
AR-CPL	The system must comply with relevant laws and regulations, such as those concerning privacy, intellectual property, safety or cybersecurity
AR-INT	The system should be interoperable with other systems and devices, allowing for seamless integration and data exchange
AR-MNT	The system should be easy to maintain and update, with minimal disruption to operations, and be robust enough to tolerate rough handling
AR-PERF	The system should have high-performance capabilities, ensuring that it can operate without delays or significant lags
	The AR must project real-time experiences and performance with minimal latency to ensure a seamless user experience
AR-REL	The system should be reliable and stable, with minimal downtime and maximum uptime
AR-RES	The system should be deployable, e.g., to the on-site command centre (vehicles, tents, etc.), with high tolerances for impacts, dusting, liquid spills, moisture accumulation or extreme temperatures
AR-SCA	The system should be scalable, capable of handling an increasing number of users and larger data sets
AR-SEC	The system should be secure, with appropriate controls in place to protect against unauthorized access or data breaches
AR-USBT	The interface should be user-friendly and easy to use, even for users with limited technical knowledge

Table 22 – Non-functional requirements for the augmented reality technologies.

8.3. Requirements for the artificial intelligence-based backend management system

8.3.1. Functional requirements

These requirements specify the functional and non-functional requirements to develop the artificial intelligence-based backend management system (**AIMS**) in the OVERWATCH project, as collected from stakeholder interactions.

IDENTIFIER	DESCRIPTION
AIMS-M-000	The AIMS must manage the OVERWATCH system using artificial intelligence algorithms, e.g., to analyse historical/current data, identify patterns and trends relevant to improve risk assessment and decision-making
AIMS-M-010	The AIMS must support the C2 in managing emergencies along the response and recovery phases by providing information related to wildfires and floods
AIMS-M-020	The AIMS must have the ability to continuously assess the TO and update the SA of the C2 decision-makers and other emergency responders

IDENTIFIER	DESCRIPTION
AIMS-M-030	The AIMS must facilitate and support C2 in allocating resources (personnel, equipment, supplies, etc.) based on, e.g., severity, the potential spread of the natural hazard and the impact on human life and property
AIMS-M-040	The AIMS must support managing/coordinating the operation and use of autonomous vehicles in the environment, e.g. the missions and airspace used by drones
AIMS-M-050	The AIMS must collect and analyse real-time data from internal OVERWATCH sensors and sources, such as drone payloads, other sensors, cameras, and other devices
AIMS-M-060	The AIMS must access and ingest satellite imagery and other remote sensing data to supplement on-the-ground data collection efforts
AIMS-M-070	The AIMS must collect and analyse data from the Copernicus EMS
AIMS-M-080	The AIMS must collect and analyse existing GIS data
AIMS-M-090	The AIMS must be able to support identifying critical areas, e.g., for observation and reconnaissance by the SART
AIMS-M-100	The AIMS must be able to process and provide information to support risk assessment, e.g. by identifying potentials risks, their location, severity, and potential impact on responders, population and the environment
AIMS-M-110	The AIMS must process and analyse large amounts of data quickly and accurately, e.g., generating maps and 3D models of the emergency and the surrounding area to support decision-making and resource allocation
AIMS-M-120	The AIMS must be able to identify resources such as water, fuel, roads, or alternative routes to escape danger and emergency progression, providing valuable information to emergency responders
AIMS-M-130	The AIMS must support integration with existing emergency management systems
AIMS-M-140	The AIMS must support communications with existing emergency communication networks
AIMS-M-150	The AIMS must be able to provide real-time situational awareness to emergency responders
AIMS-M-160	The AIMS must be able to generate reports and visualisations that help emergency responders make informed decisions quickly
AIMS-M-170	The AIMS must be able to generate reports and visualisations for post-action review and lessons learned
AIMS-M-180	The AIMS must provide situational awareness to all emergency responders, enabling them to make informed decisions in real-time and coordinated responses
AIMS-M-190	The AIMS must incorporate advanced drawing, marking and measuring functions through the AR interface
AIMS-M-200	The AIMS must have the capability to share data and information with other emergency response agencies and organisations

IDENTIFIER	DESCRIPTION
AIMS-M-210	The OVERWATCH must provide a playback module to deliver exercises aimed at different C2 levels, e.g., providing the ability to run and stream to the AR a scenario that offers simulated inputs from relevant sensors, other technical modules, and the positioning of dynamic forces in the TO
AIMS-M-220	The AIMS must be able to provide multi-language support, e.g., English, Portuguese or Polish, for ER from different member states
AIMS-S-000	The AIMS should be able to integrate with multiple external sensors and data sources to enhance data collection and analysis
AIMS-S-010	The AIMS should be able to provide real-time updates and alerts to emergency responders based on changing conditions
AIMS-S-020	The AIMS should be able to generate heat maps and other visualisations that support ER in understanding the spread of emergencies and critical areas
AIMS-S-030	The AIMS should provide a chatbot to help emergency responders quickly find the necessary information
AIMS-S-040	The AIMS should be able to support prioritising response efforts based on the potential impact on human life, property, and the environment
AIMS-S-050	The AIMS should provide remote access to emergency responders to allow them to access the system from their own devices, e.g., providing lightweight UI for inputting data, dashboards or chat boards
AIMS-S-060	The AIMS should be able to provide early warning alerts to emergency responders based on detected risks
AIMS-S-070	The AIMS should provide situational awareness to residents in the TO or possible emergency evolution areas, allowing them to make informed decisions about evacuation
AIMS-C-000	The AIMS could have the capability to predict the direction of a wildfire based on wind and weather conditions
AIMS-C-010	The AIMS could provide predictive analysis to help emergency responders plan and prepare for potential risks and hazards
AIMS-C-020	The AIMS could have the capability to provide real-time air quality monitoring for responders and the public
AIMS-C-030	The AIMS could be able to estimate the population for relocation in case of danger or emergency progression
AIMS-C-040	The AIMS could have the ability to incorporate natural language processing to facilitate communication between emergency responders
AIMS-C-050	The AIMS could support visualising the modelling results of the behaviour of development of the emergency provided by third-party services
AIMS-C-060	The AIMS could model the development of the emergency under different conditions to provide SA support in identifying effective routes for emergency responders to access/leave the affected area
AIMS-C-070	The OVERWATCH could provide automation and mechanisms to address errors or malfunctions, leading to their resolution under human control

IDENTIFIER	DESCRIPTION
AIMS-C-080	The AIMS could be able to provide recommendations to emergency responders on the most effective response strategies
AIMS-C-090	The AIMS could be able to provide situational awareness for multiple incidents in different locations
AIMS-C-100	The AIMS could provide the optimal route for waterline laying in unfamiliar TO, namely the water supply line set along a road and composed of hoses, fire engines and transfer tanks, according to the DSM
AIMS-C-110	The AIMS could provide advanced functionalities, such as inferring water depth/volume based on known water extent and DSM, e.g., for assessing the gravity of floods or the availability of water reservoirs for supplying fire combat aircraft
AIMS-C-120	The AIMS could have the capacity for modelling the consequences of emergency events, e.g., levee breakages or burnet areas
AIMS-W-000	The AIMS won't command any emergency response operation in any possible way
AIMS-W-010	The AIMS won't override the commander in charge of operations in any possible way
AIMS-W-020	The AIMS won't override the personnel in the C2 chain in any possible way
AIMS-W-030	The AIMS won't override the operational staff in any possible way
AIMS-W-040	The AIMS won't violate any ethical principle and must be used responsibly and effectively
AIMS-W-050	The AIMS won't be used in the OVERWATCH project without explicit knowledge of all stakeholders taking part in the FSX
AIMS-W-060	The AIMS won't have the ability to predict human behaviour during an evacuation

Table 23 – Functional requirements for the artificial intelligence-based backend management system.

8.3.2. Non-functional requirements

IDENTIFIER	DESCRIPTION
AIMS-AVT	The system must be available at all times, even during peak usage or unexpected events, to ensure that emergency responders can rely on it when needed
AIMS-COMP	The system should be compatible with intended devices and platforms, ensuring that emergency responders can access them from predefined locations and devices
AR-CPL	The system must comply with relevant laws and regulations, such as those concerning privacy, intellectual property, safety or cybersecurity
	The OVERWATCH must ensure that the AI system is trained on a diverse set of data and is regularly audited to identify and mitigate any biases or errors
	The OVERWATCH must ensure that the privacy of individuals is protected and that the data is only used for its intended purposes.

IDENTIFIER	DESCRIPTION
AIMS-INT	The system should integrate seamlessly with other emergency response systems, ensuring data exchange with different tools and platforms
	The AIMS should provide a user-friendly interface for emergency responders to access and use the system efficiently
AIMS-MNT	The system should be easy to maintain, with minimal downtime required for maintenance and updates
	The AIMS must incorporate a backup and restore for all its contents
AIMS-PERF	The system must be able to process and analyse large amounts of data in real-time, providing timely insights to emergency responders
	The system must be able to stream scalable volumes of data to accommodate on-site commanders operating from satellite terminals
AIMS-REL	The AIMS system must be highly reliable, with minimal downtime and a low probability of failure, to ensure it can provide the necessary information to emergency responders in critical situations
AIMS-SCA	The system should scale up or down based on the size of the emergency response, e.g., ensuring that it can handle any volume of incoming data and traffic or users accessing the system
AIMS-SEC	The system should have robust security measures to protect sensitive data and ensure that only authorised personnel can access it
AIMS-USBT	The system should be easy to use and intuitive, requiring minimal training for emergency responders to understand how to use it effectively

Table 24 – Non-functional requirements for the artificial intelligence-based backend management system.

8.4. Requirements for the drone technologies

8.4.1. Functional requirements

These requirements specify the desired functional and non-functional requirements to develop the drone technologies (**DT**) in the OVERWATCH project, as collected from stakeholder interactions.

IDENTIFIER	DESCRIPTION
DT-M-000	The drone technologies must support the operation of emergency responders providing functional support capabilities
DT-M-010	The drones must operate in a diverse range of visibility conditions, e.g., day, low-light/low-visibility, fog or smog, at night, or beyond the visual line of sight
DT-M-020	The drones must be able to fly autonomously or remotely piloted, with the ability to take off, hover, and land safely
DT-M-030	The drones must use flight control and stabilization systems to provide accurate flight missions
DT-M-040	The drones must use algorithms and instrumentation to perform safe flight missions according to the mission plans

IDENTIFIER	DESCRIPTION
DT-M-050	The drones must use signals from GNSS to navigate in the airspace
DT-M-060	The drones should be able to navigate safely, avoiding obstacles, such as trees, buildings or high-voltage cables, and respond to changes in the environment
DT-M-070	The drones must have the ability to return to base or land safely in case of a malfunction or loss of communication
DT-M-080	The drones must be able to relay/stream data to the GCS/AIMS
DT-M-090	The drones should be able to communicate with other drones or the respective GCS to coordinate sharing the same airspace to convey information or coordinate operations
DT-M-100	The drones must support switching between piloted and autonomous modes of operation whenever necessary
DT-M-110	The drones must have on-board real-time processing of data from sensors
DT-M-120	The drones must detect adverse weather, e.g., strong wind, and inform the GCS
DT-S-000	The drones should be able to operate in secure and encrypted communication networks
DT-S-010	The drones should be able to adjust their flight mission in real-time based on changing environmental conditions via GCS
DT-S-020	The drones should carry advanced payloads, e.g., LIDAR, thermal imaging technology or multispectral sensors adequate for wildfires or floods
DT-S-030	The drones should be able to follow topography while maintaining the same flight height or safety-required ceiling in piloted and autonomous missions.
DT-C-000	The drones could use automatic calibration and self-diagnosis to support condition-based maintenance
DT-C-010	The drones could have onboard real-time processing of data from sensors
DT-C-020	The drones could recharge or swap batteries quickly
DT-C-030	The drones could carry modular payloads, e.g., capable of measuring temperature, humidity, and other environmental factors
DT-C-040	The drones could provide modular fixings and interfaces
DT-C-050	The drone could be able to communicate its flight height using universally recognised systems, e.g. QNE, QNH or QFE, and real-time translation to AGL
DT-C-060	The drone operators could be aware of surrounding airspace, e.g., using the AIMS
DT-W-000	The drones won't operate without explicit clearance from the commander in charge of operations, which overrides any automation or regulation
DT-W-010	The drones won't fly without meeting all safety regulations set by the regional/national authorities
DT-W-020	The drones won't fly unless the pre-flight checklist has been completed and verified
DT-W-030	The drones won't be able to operate in controlled airspace without explicit clearance; e.g., they won't fly in shared airspace with aerial firefighting aircraft

IDENTIFIER	DESCRIPTION
	unless there is explicit clearance, regulation and coordination for such operation
DT-W-040	The drones won't be able to fly in severe weather conditions, such as high winds or heavy rain

Table 25 – Functional requirements for drone technologies.

8.4.2. Non-functional requirements

IDENTIFIER	
FCS-AVT	The drones should have high-capacity batteries and be able to fly for extended periods without recharging
FCS-COMP	The operation of drone technologies must comply with sectorial, regional, and national laws and regulations
FCS-CPL	The system should comply with all relevant laws, regulations, and standards for drone operations, data processing, and appropriate certification
FCS-INT	The system should be able to integrate with other existing systems and tools used by emergency responders and first responders, e.g., by following a modular design for easy maintenance and upgrades
FCS-MNT	The system should be easy to maintain and update, with well-documented code and modular design
FCS-PERF	The system should be able to handle several drones without compromising the overall system's performance
FCS-REL	The system should be reliable and operate without interruptions for extended periods
FCS-RES	The system should have built-in redundancy by design for improved reliability
	The drones could be able to operate in various weather conditions
	The GCS could be able to operate in various weather conditions
FCS-SAF	The system should be designed with safety in mind, ensuring that the drones do not pose a risk to people or property
FCS-SCA	The system should be scalable, allowing for the addition of more drones and data processing resources as needed
FCS-SEC	The system should be designed with security by design principles, protecting against unauthorized access and potential cyber-attacks
FCS-USBT	The system should be easy to use for operators, with a clear and intuitive user interface

Table 26 – Non-functional requirements for drone technologies.

8.5. Requirements for the earth observation technologies

8.5.1. Functional requirements

These requirements specify the desired functional and non-functional requirements to develop the earth observation (**EO**) technologies in the OVERWATCH project, as collected from stakeholders' interactions.

IDENTIFIER	DESCRIPTION
EO-M-000	The Overwatch must collect, process, and integrate real-time data from earth observation (EO), e.g., the Copernicus EMS, GIS data to produce, e.g., updated thematic layers with the map of fire hazards or flood vulnerable areas
EO-M-010	The EO must integrate data from multiple sources to provide actionable information and SA for emergency responders and the population
EO-M-020	The EO must generate maps and visualizations to feed the SA of ER, allowing it to comprehend the COP and recommend the allocation of resources, e.g. firefighting aircraft
EO-S-000	The Overwatch should support recommendations for evacuations and other emergency measures based on the use of EO
EO-S-010	EO should support risk assessment, e.g. water level forecasting or burned areas
EO-S-020	The Overwatch should support detecting environmental changes using EO, e.g., temperature, humidity, and other factors relevant to emergencies
EO-S-030	The Overwatch should provide alerts when the situation escalates or the weather conditions deteriorate using EO, therefore increasing the potential severity and spread of the natural hazard
EO-S-040	The Overwatch should detect changes in landcover and landuse between two time periods using EO, e.g., for debris/sediments detection or forest planning
EO-S-050	The Overwatch should compare detected changes with landuse plans using EO
EO-C-000	The Overwatch could provide historical data on past natural hazards behaviour to support future planning
EO-C-010	The Overwatch could be able to identify areas where natural hazards have the potential to cause significant damage or loss of life
EO-C-020	The Overwatch could provide information on the long-term effects of natural hazards, such as soil erosion or the changes to riverbeds
EO-C-030	The Overwatch could provide accurate and reliable information on the current location, status, and behaviour of natural hazards over time
EO-C-040	The Overwatch could be able to provide information using EO on the potential impact of emergencies on nearby communities and critical infrastructure
EO-C-050	The Overwatch could provide information on the affected infrastructure/assets
EO-W-000	The Overwatch won't be able to provide predictions of the behaviour of natural hazards with 100% accuracy
EO-W-010	The Overwatch won't be able to provide real-time data from areas without existing earth observation or GIS infrastructure

IDENTIFIER	DESCRIPTION
EO-W-020	The Overwatch won't be able to replace emergency responders' judgment and decision-making skills

Table 27 – Functional requirements for the earth observation technologies.

8.5.2. Non-functional requirements

IDENTIFIER	DESCRIPTION
FCS-AVT	The OVERWATCH should be highly available, ensuring that emergency responders have access to the data they need when they need it
FCS-ACC	The OVERWATCH should be accessible to users with disabilities, including those who rely on assistive technologies such as screen readers
FCS-COMP	The OVERWATCH be compatible with various devices, operating systems, and web browsers
FCS-CPL	The OVERWATCH must comply with relevant legal and regulatory requirements, such as data privacy laws and industry standards
FCS-INT	The OVERWATCH should be interoperable with other systems and technologies commonly used in the fire industry, such as remote sensing tools and geospatial software, and able to integrate with external systems and data sources
FCS-MNT	The OVERWATCH should be easy to maintain and update over time, with clear documentation of its architecture and components and minimal downtime or impact on users
FCS-PERF	The OVERWATCH must be designed to deliver fast response times, handle large data volumes, and support real-time data processing The OVERWATCH should include performance monitoring and logging features to track system performance and identify potential issues in real-time
FCS-REL	The OVERWATCH should be highly reliable, with a low risk of failure or downtime, therefore minimising disruptions to service
FCS-RES	The OVERWATCH must be able to handle unexpected events or errors and recover quickly from failures or disruptions
FCS-SCA	The OVERWATCH must be designed to accommodate a growing amount of data and users while maintaining performance and responsiveness
FCS-SEC	The OVERWATCH should have robust security controls, e.g., secure data/ information management and access control mechanisms, to protect sensitive data from unauthorized access, disclosure, or modification
FCS-USBT	The OVERWATCH should be user-friendly and easy to navigate, with clear interfaces and support for multiple languages, e.g., English, Portuguese and Polish, and accessibility features

Table 28 – Non-functional requirements for the earth observation technologies.

8.6. Requirements for the fallback communication system

These requirements specify the functional and non-functional requirements to develop the fallback communication system (FCS) in the OVERWATCH project, as collected from stakeholder interactions.

8.6.1. Functional requirements

IDENTIFIER	DESCRIPTION
FCS-FM-000	The OVERWATCH must support C2 in coordinating emergency response efforts by providing redundant communication channels using a fallback communications system with a tethered drone
FCS-FM-010	The fallback communications system must integrate with the emergency communication system to facilitate communication between C2 and all other emergency responders in blackout regions[20]
FCS-FM-020	The drone must maintain a stable and reliable connection to the GCS to ensure uninterrupted communication with emergency responders
FCS-FM-030	The drone must carry a payload to support Wi-Fi communications and make use of a satellite broadband communication link for providing fallback communication hotspots in case of infrastructure damage or network outages
FCS-FM-040	The ground control station system must be able to receive and process data transmissions from the tethered drone in real-time
FCS-FM-050	The tethered drone must be able to remain airborne for an extended period, providing continuous communications coverage for emergency responders, provided that they are within the communications range capabilities of the wireless technologies used
FCS-FM-060	The ground station control system must have a user-friendly interface that is easy to use and navigate by emergency responders
FCS-FM-070	The system must provide high-speed data transfer capabilities for sharing critical information such as maps, photos, and other data
FCS-FM-080	The tethered drone must land safely whenever it loses connection to the GCS
FCS-FS-000	The AIMS should be able to identify communication blackouts and automatically deploy tethered drones to maintain communication coverage
FCS-FS-010	The ground station control system should have the ability to provide remote access for authorised personnel to monitor the GCS.
FCS-FS-020	The ground station control system should be able to log all activity for post-incident analysis and reporting

[20] **Note:** this requirement assumes the utilization of two pre-existing components from TETRA-based networks, not developed in the scope of OVERWATCH: 1) a VoIP-TETRA gateway, that allows two-way realtime translation between voice-over-internet protocol (VoIP) data streams and legacy TETRA voice communications; and 2) a VoIP push-to-talk application runing on mobile phones and connected to the VoIP-TETRA gateway to send/receive VoIP data streams. The FCS provides the IP interconnection between these two components – the mobile phone being on-site, and the VoIP-TETRA gateway anywhere on the internet.

IDENTIFIER	DESCRIPTION
FCS-C-000	The FCS could have the ability to integrate with other communication networks, such as cellular networks, e.g., 5G, to provide redundant communication coverage[21]
FCS-C-010	The system could have the ability to provide encrypted communication for the secure transmission of sensitive information
FCS-W-000	The system won't have the ability to operate without the tethered connection to the GCS
FCS-W-010	The system won't be able to provide communications coverage beyond a certain distance from the GCS[22]
FCS-W-020	The tethered drone won't be able to operate in extreme weather conditions, such as heavy rain or strong winds
FCS-W-030	The system won't be able to operate and provide communication coverage in areas where drones are prohibited by law or regulation

Table 29 – Functional requirements for the fallback communication system.

8.6.2. Non-functional requirements

IDENTIFIER	DESCRIPTION
FCS-AVT	The system should be highly available, with minimal downtime and quick recovery in case of failure
FCS-COMP	The system should be compatible with a range of communication equipment (Wi-Fi), allowing for flexibility in deployment and use
FCS-INT	The system should integrate with other communication systems used by emergency responders, allowing for seamless communication between teams
FCS-MNT	The system should be easy to maintain and update, with clear documentation and a straightforward maintenance process
FCS-PERF	The system should have high performance, with minimal latency and fast data transfer rates
FCS-REL	The system should have a high level of reliability, ensuring that it can function in harsh environments and under extreme weather conditions without failure
FCS-RES	The system should be designed to withstand disruptions and failures, ensuring that it can continue to function in the event of an emergency
FCS-SCA	The system should be scalable, allowing for easy expansion as the emergency response network grows
FCS-SEC	The system should be secure, with measures in place to protect data and prevent unauthorised access to the network

[21] **Note:** this requirement depends on aspects such as the radio spectrum availability in the area of operations.
[22] **Note:** the distance is directly tied to the operating radio frequency and maximum transmission power allowed by the regulation, but also to other physical properties of the area of operations such as the topography and the existence of trees, buildings or other obstacles.

IDENTIFIER	DESCRIPTION
FCS-USBT	The system should be easy to use, with intuitive interfaces that require minimal training

Table 30 – Non-functional requirements for the fallback communication system.

9. Conclusions and closing remarks

The present report is the deliverable "D1.1 – End user requirements", which focuses on providing the ground basis for the OVERWATCH project's technical tasks and work packages. The deliverable began by establishing the project context, providing a comprehensive glossary of emergency response terms, introducing the methodology, and analyzing the various stakeholders involved in emergency response systems. The SotA of technologies relevant to OVERWATCH was reviewed, and previous R&D projects undertaken in the EU context and the Member States were examined.

To ensure the project's objectives were well-informed, two realistic scenarios, one relating to wildfires and the other to floods, were created to guide the interactions with emergency management and response end-users. This approach allowed the project team to understand the challenges and complexities that emergency management/response teams face in these scenarios and to ensure alignment of the requirements for the OVERWATCH technologies with end-users' needs.

The project's next stage involved developing detailed use cases and requirements for the OVERWATCH technologies in collaboration with the end-users. The insights from the scenario-based interactions with emergency management and response teams informed these use cases and requirements. They will support meeting the specific needs of end-users.

The project recognized that developing the OVERWATCH technologies was a two-way process. The approach started from the bottom up, leveraging the consortium's existing capabilities and expertise, and then from the top down, considering the prioritised user needs and requirements.

Through rigorous research and analysis, the project team identified that use cases and end-user requirements for emergency response were complex and multifaceted. However, by carefully identifying and prioritizing these requirements, the project has established a solid foundation for developing practical and effective technologies that will (expectedly) meet the diverse needs of those who rely on emergency response services and systems.

By prioritising end-user needs and requirements, the project team can ensure that the technologies they develop will be practical and effective in real-world emergency response scenarios. The approach of starting from the bottom up, considering the consortium's capabilities and skills, also provides a strong foundation for the project team to leverage their expertise and develop innovative solutions grounded in reality.

In synthesis, deliverable D1.1 provided the following products:

- Updated terminology and respective definitions in chapter 2.
- A SotA for the OVERWATCH technologies in chapter 3.
- The identification and analysis of stakeholders in chapter 4.
- Two scenarios, one for wildfires and the other for floods, in chapter 5.
- Six use cases, three related to wildfires for testing the technologies in FSX to be developed in Portugal, and three related to floods for testing the technologies in FSX to be developed in Poland, are in chapter 6.
- One hundred forty-six functional requirements and fifty non-functional requirements covering the technologies to be developed in the scope of OVERWATCH.

By prioritising end-user needs and requirements and leveraging advanced technologies, the OVERWATCH can create emergency response systems that are more effective, efficient, and inclusive, ultimately saving lives and protecting communities.

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