Overwatch

Integration & validation methodology and plan

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Author(s)	André Carvalho (ISQ) Guilherme Covas (ISQ) Afonso Melo (ISQ)
Co-Author(s)	Nelson Matos (ISQ), Hugo Silva (INESC TEC), Helder Fontes (INESC TEC)
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Deliverable abstract	Overwatch project is comprised of several technological components. This document aims to provide clarity regarding if these modules integrate with each other. Verification tests are performed to validate the proposed solution, a summary table is also included highlighting if each test has passed or not, during both FAT and SAT.
Keywords	Validation, Tests, SAT, FAT

Table of Content

Document revision history 7
Acronyms and abbreviations 8
Executive Summary 9
Use Cases 10
System Arquitecture 11
Verification Plan 12
1.1. Verification Methodology 13
1.2. Verification Matrix 14
1.3. Factory Acceptance Test (FAT) set up 15
1.4. On-site Acceptance Test (SAT) set up 15
1.5. Verification List and Procedures 16
1.5.1. VRF1 - Request Overwatch mapping using the main dashboard 16
1.5.2. VRF2 - Request EO mapping using AR Backend 17
1.5.3. VRF3 - Visualize EO mapping result onto the data repository 18
1.5.4. VRF4 - Visualize EO mapping result onto the dashboard 19
1.5.5. VRF5 - Visualize EO mapping result onto the AR Frontend (AR device) 20
1.5.6. VRF6 - Testing Real-time Drone Mapping Accuracy Against Ground Control Points 21
1.5.7. VRF7 - Verifying Drone Navigation and Mapping Coverage Excluding Wildfire Affected Areas 22
1.5.8. VRF8 - Accurate navigation and localization capabilities 23
1.5.9. VRF9 - Quasi Real-time visualization of AI mapping w.r.t. wildfire/flood conditions 24
1.5.10. Tests to be detailed until FAT completion 25
Overall Test Matrix Results 26
Conclusion 27
ANNEX A 28
Verification Report Template 28

Figures

Figure 1: Overwatch system architecture. 11

Tables

Table 1: Verification Tests for both FAT and SAT, (Verification Methodology, see section 1.4)....... 14
Table 2: FAT and SAT test execution results.......... 26

Document revision history

Version	Date	Description	Editor
V1	20/09/2023	First version	ISQ
V2	23/10/2023	Addresses Reviewers comments	ISQ

Acronyms and abbreviations

AA	Authentication and Authorization
AI	Artificial intelligence
AR	Augmented reality
BPL	Broadband over power lines
C4I	Command, control, communication, computers and information
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 responders
FAT	Factory Acceptance Test
FR	First responder
FSX	Full-scale exercise [an exercise that involves multiple organizations 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
LEO	Low Earth Orbit
LIDAR	Laser imaging, detection, and ranging
HAS	High Accuracy Service
ISAR	Interactive streaming for augmented reality
ML	Machine Learning
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
SAT	Site Acceptance Test
SDK	Software development kit
SotA	State of the art
TO	Theatre of operations
VR	Virtual reality
XR	Extended reality

Executive Summary

This document presents the OVERWATCH "Integration & validation methodology and plan". The project involves Earth Observation (EO), Remote Sensing, and Machine Learning (ML) technologies, enhanced with Augmented Reality (AR) to improve decision-making during crisis management, such as floods and wildfires.

The primary goal of this project is to empower decision-makers across two specific types of crises, with advanced tools that provide real-time insights, enhance situational awareness, and support data-driven decision-making through the fusion of EO data, Remote sensing, AR visualization while also leveraging ML.

This document aims to describe how integration and validation should take place. A set of validation tests are described and two phases are set: (1) Factory Acceptance Tests (FAT) and (2) Site Acceptance Tests (SAT). These tests aim to cover all modules developed during the project and ensure that they correctly communicate with each other.

The current document version (1) lists and describes the procedures, agreed by the consortium, on how to test the OVERWATCH project. Two additional versions of this document are expected, which will also include an integration & validation methodology and plan update and the results of the tests during both FAT and SAT along with their reports.

Use Cases

As per deliverable 1.1-version 1.0 of 30th March 2023, 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. The technologies developed in the project will be tested and validated through extensive testing in two pilots (FSX) in Portugal and Poland.

The OVERWATCH main modules, Earth Observation, Drones, Fallback Communication, Artificial Intelligence-based Backend Management System, and Augmented Reality will be tested in these pilots, contributing to the validation of these applications integrated all together.

The use cases will be mainly focused on Wildfires and Floods scenarios, and will serve as validation of the expected outputs of the OVERWATCH project, like rapid data collection, pre, during and post response management with real-time data to produce updated maps and visualizations, good communication network and support situation assessment by actionable intelligence.

System Arquitecture

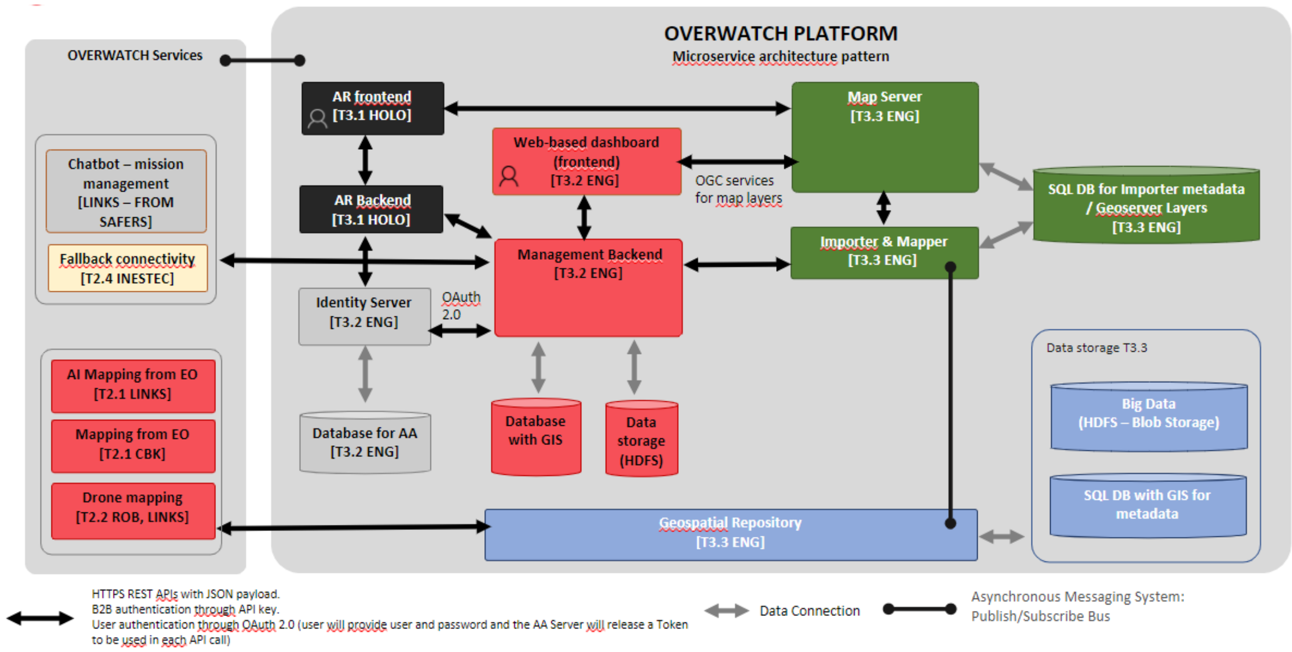

Figure 1: Overwatch system architecture (D1.2 v0.5 02/06/2023)

Overwatch architecture, according to deliverable 1.2 -version 0.5 of 2nd June 2023, is divided in two main components: the first provides useful data based on imagery that comes from satellite Earth observation or from drone acquisition or from legacy systems, the second gathers the information and serves the results to the final user.

GIS layers and images are the primary data source of the architecture, therefore they have specific standardized pipeline. It begins by ingesting data, using a Big Data storage solution to receive and store this data through the Geospatial Repository that, in event-driven way, will share the signalling of the operation using a message broker, maintaining a loose coupling among the components that provide data from other components.

Once images and other GIS-enabled data have been stored, the underlying storage infrastructure triggers the processing phase that performs required operations to import and harmonize the data into map layers.This will provide a mechanism for cataloguing and querying the imported data together with metadata information, exploiting OGC-compliant services such as GeoServer[2].

The delivery of this information is possible since the management system able to query and visualize the content that has been imported, through OGC services that provide the capability to serve and deliver maps to clients or end-users in a format that can be easily rendered and displayed on devices or applications such as AR and web dashboard.

The two parts that comprise the architecture are connected to each other with technologies and mechanisms that also foresee a fallback connectivity. In operational scenarios, the network connectivity is a crucial component to ensure the correct interactions between modules. However disruptions or failures can occur due to various reasons, such as network outages, hardware failures, or environmental factors above all, especially in crisis situations. By considering the possibility of such disruptions, system designers incorporate backup or alternative connectivity options to mitigate the impact on the overall system functionality. The symbol represents the presence of a message bus that will allow to exchange all the metadata between the services and the backend and all the updates that will be forwarded from the services to the geospatial repository. The message bus is a standard component in the architecture and is based on a publish/subscribe mechanism.

Verification Plan

The following sections list and describe the verification tests, how to set up the Factory Acceptance Tests (FAT) and On-Site Acceptance Tests (SAT) for execution, the facilities location and equipment, a definition of the five verification methodologies, and ends with the description of the procedures for each of the tests presented in the following sub-section.

1.1. Verification Methodology

- **Possible Methods**:
  - **Inspection (I)** – Verification by inspection shall consist of visual determination of physical characteristics. Visual inspection of either graphical interface, textual results, user manual, or equipment manufacturer specifications. It will require an analysis of the documentation and/or visual inspection, providing evidence of the correct implementation that satisfy the requirement by means of screenshot, extraction of sections from operational manuals, etc. Therefore, no specific test procedure with detailed operations is envisaged.
  - **Analysis (A)** – Verification by analysis is done when other methods are not appropriate or too cumbersome to perform a verification by test. It is usually done by collecting data like test results related to some part of the system, and then, knowing the system design, an engineering-based judgement is performed to infer whether the verification was successful or not.
  - **Demonstration (D)** – Verification by demonstration is done verifying the behaviour of the system, either once or more than once, without special test equipment or instrumentation. Demonstration can be documented in different ways, such as with pictures or screen captures.
  - **Test (T)** - Verification tests consist of measuring system performance and functions under representative environments. Tests will be executed according to the type (Factory or on-Site) at the designated facility using the target delivered HW/SW with strict testing procedures, than shall be repeatable, and identifying the success/fail criteria (expected output) for each test.
    - Factory testing – test shall be foreseen at prime contractor premises;
    - On-site testing – test shall be foreseen on the target pilot system(s).

1.2. Verification Matrix

Table 1: Verification Tests for both FAT and SAT

ID	Verification Descriptor	Module(s)	Verification Metodology	Stage
VRF-1	Request Overwatch mapping using the main dashboard	Web Based dashboard Mapping from EO Management Backend	D	FAT, SAT
VRF-2	Request EO mapping using A/R Backend	AR Frontend/Backend Management Backend	D	FAT, SAT
VRF-3	Visualize EO mapping result onto the data repository	Web Based dashboard Mapping from EO Management Backend	D	FAT, SAT
VRF-4	Visualize EO mapping result onto the dashboard	Web Based dashboard Mapping from EO Management Backend Drone mapping	D	FAT, SAT
VRF-5	Visualize EO mapping result onto the AR Frontend (AR device)	AR Frontend/Backend Management Backend	D	FAT, SAT
VRF-6	Testing Real-time Drone Mapping Accuracy Against Ground Control Points	Drone navigation Management Backend	I	FAT, SAT
VRF-7	Verifying Drone Navigation and Mapping Coverage Excluding Wildfire Affected Areas	Drone navigation Management Backend	D	FAT, SAT
VRF-8	Accurate navigation and localization capabilities	Drone navigation	T	SAT
VRF-9	Quasi Real-time visualization of AI mapping w.r.t. wildfire/flood conditions	ALL	T	SAT
VRF-10	Monitorization: Performance, Availability, Reliability, Restorability	Management Backend	A	SAT
VRF-11	Fallback Internet connectivity through flying Wi-Fi hotspot linked to LEO backhaul.	Fallback connectivity	A	SAT
VRF-12	Investigate resistance to weather, water, dust, and other field conditions.	Drone mapping, Hardware	A	SAT
VRF-13	Ensure availability and continuity of operation	ALL	D	SAT
VRF-14	Ensure clarity and comprehensibility of the results	Web Based dashboard Mapping from EO Management Backend	A	SAT

1.3. Factory Acceptance Test (FAT) set up

The FAT shall be performed with the purpose to review and validate that the system designed and build meets the system and user requirements, i.e. to verify that the "as-built" system and components against the required "as designed" system and its constituent components.
The necessary acceptance tests for this phase of the system qualification and production are summarized in the Validation Matrix and described in the Verification List and Procedures section of this document. The objective is to test all the design and build system adaptability for future developments and scalability.
For the FAT both a User (i.e. a person who utilizes the system/service to simulate the end-user) and an Operator (i.e. a person who controls and monitors the system software to simulate the service/system support) shall participate in the acceptance tests.
The FAT walkthrough process shall consist of the following activities:

- Preparation of the review items and review meeting for discussion of the test block/test procedure agenda;
- Verification test roll-out;
- Test output results, discussion, a report and an update to this document.

The review process shall start when the WP leader and project manager consider the review items to be stable and complete. At the time of writing, the expected date is 1 month after the FAT, between M25 and M29, during the FAT event this document should be finalized and completed appending a report and an update to this document to the existing tests.

1.4. On-site Acceptance Test (SAT) set up

The SAT shall be performed remotely, i.e. with all partners and End-User premises, by accessing the platform. The SAT purpose is to demonstrate that the proposed service/system can accomplish its intended use in the intended operational environment, i.e. to validate and evaluate if the service/system addresses the needs of the users.
The necessary acceptance tests for this phase are summarized in the Validation Matrix and described in the Verification List and Procedures section of this document. The objective is to test the system adaptability for future developments and scalability.
For the SAT the End-User will access and use the Overwatch project digital platform to simulate the use of the proposed system/service. The use of the system/service by the User shall be accompanied by an Operator (i.e. a person who controls and monitors the system software to simulate the service/system support) together with a test manager appointed to manage and monitor the acceptance tests. These shall be selected from the development team according to their skills and their allocation and roles shall be defined by both the project management and WP leader.

The SAT walkthrough process shall consist of the following activities:

- Preparation of the review items and review meeting for discussion of the test block/test procedure agenda;
- Verification test roll-out;
- Test output, results discussion and report.

Schedule:
An exact date will be pointed during the update performed upon completion of the FAT.
The review process is planned by the end of the project and the review process start when both project manager and End-User consider the review items to be stable and complete.

1.5. Verification List and Procedures

1.5.1. VRF1 - Request Overwatch mapping using the main dashboard

Verification Objective

Visualization of the tool that allow the selection of the area on the field to map using the services.

Verification Methodology

Create a task request on the dashboard to initiate mapping. "Guarantee" that signal messages are shared using a Geospatial Repository message bus.

Verification Set-up and configuration

A testing or production environment has been set up, and every service required for the communication is operational.

Verification Prerequisite

The message bus, data repository, and management backend must be up and running.

Verification Procedure

- Access the Overwatch Platform via web;
- Login to an account;
- Select the area to map and desired output layers
- Submit the request
- Access to the Message Bus and wait for the message with the request info
- The request has been submitted and is on going, the message bus has received the signalling message.

Verification Expected Output

Visualize the creation of the request and status changes.

1.5.2. VRF2 - Request EO mapping using AR Backend

Verification Objective

Requesting of map tiles (EO mapping) to the AR Backend, verify that AR Backend can load the EO map tiles for use.

Verification Methodology

Use the Management Backend (ENG) and confirm a successful request receipt should be sent to AR Backend from Management Backend.

Verification Set-up and configuration

A testing or production environment has been set up, and every service required for the communication is operational.

Verification Prerequisite

There must be a specific location (i.e., specific coordinates) provided. The backend will send a map request through the main Backend, or through the message bus directly. In case of a positive response, the data will be made available through a map server (e.g. Geoserver).

Verification Procedure

- Access the Overwatch Platform via an AR backend with appropiate credentials;
- Select the area to map;
- Submit the request;
- Confirmation about rejection if data is not sent to AR Backend (depending on ENG Backend Management);
- If no rejection, recieve the EO map tiles from the Management Backend;
- Render the EO map tiles in AR Backend and stream application to AR frontend;
- Visualize EO mapping in AR device;

Verification Expected Output

Once the request is accepted by Management Backend, then an error message or EO data will be visualised.

1.5.3. VRF3 - Visualize EO mapping result onto the data repository

Verification Objective

The EO mapping services correctly upload different kinds of data onto the main repository.

Verification Methodology

Files on the data repository will require a thorough inspection in terms of format and accessibility (e.g., INSPIRE-compliant metadata, files can be downloaded).

Verification Set-up and configuration

A testing or production environment has been set up, and every service required for the communication is operational.

Verification Prerequisite

Complete successfully VRF1 and VRF2

Verification Procedure

- Access the Overwatch Platform via web;
- Login to an account;
- Create a map request triggering any kind of EO mapping type;
- The map request is processed by the EO mapping service;
- The outputs of the mapping service are automatically uploaded onto the data repository;
- Check on the data repository confirm the correct upload.

Verification Expected Output

The heterogeneous data generated by the EO mapping service is correctly uploaded and accessible through the data repository for further processing and use.

1.5.4. VRF4 - Visualize EO mapping result onto the dashboard

Verification Objective

Visualization of all relevant information to better understand and handle an emergency.

Verification Methodology

Visualize the EO mapping ouputs and check if they are correctly displayed onto the web dashboard.

Verification Set-up and configuration

A testing or production environment has been set up, and every service required for the communication is operational.

Verification Prerequisite

Pass Verification VRF1 and VRF3.

Verification Procedure

- Access the Overwatch Platform via web;
- Login to an account;
- Select a specific mapping from the list of completed EO mappings;
- Verify and visualize a selected EO mapping.

Verification Expected Output

Ability to visualize and check all details of the EO mapping and generated information. Verify that the new information provided improves interpretability of that scenario.

1.5.5. VRF5 - Visualize EO mapping result onto the AR Frontend (AR device)

Verification Objective

Visualization of all relevant information to better understand and handle an emergency, via the AR Backend and AR Frontend.

Verification Methodology

Via an AR device, visualize the EO mapping ouputs and check if they are correctly displayed.

Verification Set-up and configuration

A testing or production environment has been set up, and every service required for the communication is operational.

Verification Prerequisite

Pass Verification VRF1 .

Verification Procedure

- Access the Overwatch Platform via an AR connection to the AR Backend;
- Select a specific mapping from the list of completed EO mappings;
- Verify and visualize a selected EO mapping outputs
- A UI element confirmation will be used to verify that the AR Backend and AR Frontend have successful connected. A successful connection will confirm that relevant UI elements as well as EO mapping data is capable of being displayed and in the expected quality.

Verification Expected Output

Output from this verification would be (from the AR Backend) the application and rendered content stream, and (from the AR Frontend) sensor data derived from the AR glasses. The former allows the visualization of EO data and improves interpretability of the scenario.

1.5.6. VRF6 - Testing Real-time Drone Mapping Accuracy Against Ground Control Points

Verification Objective

To evaluate the accuracy of the real-time drone mapping against established ground control points, ensuring the reliability and precision of the drone's mapping outputs within the testing environment.

Verification Methodology

- Establish a set of ground control points (GCPs) within the testing environment, ensuring they're clearly marked and visible from the air.
- Fly the drone within the testing environment to capture real-time imagery.
- Compare the drone's real-time mapping against the GCPs to measure any discrepancies.

Verification Set-up and configuration

- A specific testing environment is prepared, ensuring every service for communication is operational.
- Ground control points are strategically placed within the testing environment.

Verification Prerequisite

Ground control points are distinctly marked and identified.

Verification Procedure

- View the real-time feed of the drone's mapping within the testing environment.
- Compare the positions of the GCPs on the drone's real-time map to their predetermined coordinates.
- Measure any discrepancies or deviations from the expected positions.
- Verify the consistency and accuracy of the real-time updates.
- Assess the accuracy of the drone's real-time map based on the established GCPs.

Verification Expected Output

- The drone's real-time mapping within the testing environment aligns closely with the positions of the GCPs.
- Discrepancies between the drone's real-time mapping and GCPs are within acceptable limits (standard deviation of up to 8 meters, although it is expected much higher precision, but in forests with tall trees and large hills, the accuracy might decrease)

1.5.7. VRF7 - Verifying Drone Navigation and Mapping Coverage Excluding Wildfire Affected Areas

Verification Objective

Ensure the drone effectively explores and captures the entire testing area while avoiding regions algorithmically detected as affected by wildfires. The drone should avoid direct flights over detected wildfire regions, navigating around their perimeter to ensure comprehensive mapping of the safe regions.

Verification Methodology

- Using the mapping algorithm, detect and categorize the wildfire affected areas within the testing environment.
- Ensure the drone's flight path avoids the wildfire regions and traces their perimeter.

Verification Set-up and configuration

- The testing environment is scanned with the mapping algorithm to identify and categorize wildfire regions.
- Communication channels are established to ensure real-time data transmission.
- Drone's camera FOV (Field of View) is calibrated to measure the area it captures in real-time.

Verification Prerequisite

- Pass Verification VRF6
- Wildfire areas are algorithmically identified and are excluded from the drone's exploration target.

Verification Procedure

- Launch the drone and initiate the real-time mapping feed.
- The mapping algorithm runs concurrently to identify and mark regions affected by wildfires.
- Monitor the drone's flight path to ensure it avoids regions detected as affected by wildfires.
- As the drone navigates, verify it covers the perimeter of the algorithmically identified wildfire areas without crossing into them.
- Check for any blind spots or regions the drone's camera missed during navigation, excluding the detected wildfire regions after completion of the mission.

Verification Expected Output

- The drone successfully navigates around the algorithmically detected wildfire areas, tracing their perimeter without crossing over (This ensures that the entire perimeter of the wildfire is within the sensor's view, as long as the drone can access that area safely, i.e., without fly directly over the wildfire, thereby compromising its safety)
- No significant blind spots or missed regions, outside of the detected wildfire areas, are observed in the drone's mapping feed.

1.5.8. VRF8 - Accurate navigation and localization capabilities

Verification Objective

Evaluate the performance of the devised navigation board.

Verification Methodology

Measure the observed accuracy of the navigation module, verify that it is within a predefined range from a higher quality post-processed signal, considered as ground truth.

Verification Set-up and configuration

A testing or production environment has been set up, and every service required for the communication is operational.

The receiver is installed on a test drone or mobilized through any other means necessary.

Verification Prerequisite

The module must be able to receive GNSS signals, be powered up and ready to log data.

Verification Procedure

- The module is installed and activated
- A log is extracted from the navigation tests
- The error of the computed positioning solution w.r.t. the ground truth is evaluated.

Verification Expected Output

The error of the computed positioning solution (position, velocity, time) w.r.t. the ground truth falls within a given threshold.

1.5.9. VRF9 - Quasi Real-time visualization of AI mapping w.r.t. wildfire/flood conditions

Verification Objective

Test the overall functionality of the system, in a pratical exercise or demonstration.

Verification Methodology

Operate the drone at the demonstration site, and observe remotely via AR or the web platform. Then verify that information being collected from EO and the drone, plus AI models outputs provide accurate decision making information, in quasi real-time.

Verification Set-up and configuration

A testing or production environment has been set up, and every service required for the communication is operational.

Verification Prerequisite

Pass Verification VRF1, VRF3, VRF6.

Verification Procedure

- Access the Overwatch Platform via an AR device or web platform;
- Login to an account;
- Open the mapping area of the demostration;
- Verify and visualize a selected EO mapping outputs;
- Verify that there are the quasi realtime updates being generated;
- Due to the drone acquired imagery being processed and transformed into decision making information.

Verification Expected Output

Verify the drone acquired imagery being processed and transformed into decision making information, in quasi real-time and it corresponds to what it being observed in the field.

1.5.10. Tests to be detailed until FAT completion

Tests 8-14 are to be included later in the project upon completion of FAT or when more clear and detailed description can be provided.

These include the following tests:

- VRF-8 Visualize EO mapping result onto the AR Frontend (AR device)
- VRF-9 Accurate navigation and localization capabilities
- VRF-10 - Monitorization: Performance, Availability, Reliability, Restorability;
- VRF-11 - Fallback Internet connectivity through flying Wi-Fi hotspot linked to LEO backhaul;
- VRF-12 - Investigate resistance to weather and other field conditions;
- VRF-13 - Ensure availability and continuity of operation;
- VRF-14 - Ensure clarity and comprehensibility of the results.

Overall Test Matrix Results

Table 2: FAT and SAT test execution results.

Test ID	Test Descriptor	FAT Results	SAT Results
VRF-1	Request Overwatch mapping using the main dashboard		
VRF-2	Request EO mapping using A/R Backend		
VRF-3	Visualize EO mapping result onto the data repository		
VRF-4	Visualize EO mapping result onto the dashboard		
VRF-5	Visualize EO mapping result onto the AR Frontend (AR device)		
VRF-6	Testing Real-time Drone Mapping Accuracy Against Ground Control Points		
VRF-7	Verifying Drone Navigation and Mapping Coverage Excluding Wildfire Affected Areas		
VRF-8	Accurate navigation and localization capabilities	N/A	
VRF-9	Quasi Real-time visualization of AI mapping w.r.t. wildfire/flood conditions	N/A	
VRF-10	Monitorization: Performance, Availability, Reliability, Restorability	N/A	
VRF-11	Fallback Internet connectivity through flying Wi-Fi hotspot linked to LEO backhaul.	N/A	
VRF-12	Investigate resistance to weather, water, dust, and other field conditions.	N/A	
VRF-13	Ensure availability and continuity of operation	N/A	
VRF-14	Ensure clarity and comprehensibility of the results	N/A	

Conclusion

Overwatch interlaces several modules and components to be performant. This document is designed to evaluate the way the different components of the system work together and ensure that the system behaves as expected under various conditions. It outlines the anticipated behaviour of the system and validates that it functions correctly. The tests described in this document showcase the various functionalities of Overwatch and should be conducted during both FAT and SAT.

SAT verification procedures are not included, due to current development uncertainties. It is expected the second version of this document to include a detailed description of all test procedures, as well as the results of the FAT execution.

ANNEX A

Verification Report Template

Test Id:	Test Descriptor:	Notes
Requirements Trace (e.g. SR)		
Methodology		
Prerequisite		
Set-up and Configuration		
Procedure		
Expected Output		
Results & Evidences (e.g. xls sheet, data file, log file, pictures, video, screen capture)		
Observation		
Conclusion	Passed/Not Passed	
Responsible	Print Name and Signature	**Place:** **Date:**