ASSISTANCE

Adapted situation awareneSS tools and tailored training curricula for increaSing capabiliTies and enhANcing the proteCtion of first respondErs

European Commission

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Deliverable D7.1

Validation Plan Report

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[1] PU: Public; PP: Restricted to other programme participants (including the EC services); RE: Restricted to a group specified by the Consortium (including the EC services); CO: Confidential, only for members of the Consortium (including the EC services).

ASSISTANCE

Nowadays different first responder (FR) organizations cooperate together to face large and complex disasters that in some cases can be amplified due to new threats such as climate change in case of natural disasters (e.g. larger and more frequent floods and wildfires, etc.) or the increase of radicalization in case of man-made disasters (e.g. arsonists that burn European forests, terrorist attacks coordinated across multiple European cities).

The impact of large disasters like these could have disastrous consequences for the European Member States and affect social well-being on a global level. Each type of FR organization (e.g. medical emergency services, fire and rescue services, law enforcement teams, civil protection professionals, etc.) that mitigate these kinds of events are exposed to unexpected dangers and new threats that can severely affect their personal safety.

ASSISTANCE proposes a holistic solution that will adapt a well-tested situation awareness (SA) application as the core of a wider SA platform. The new ASSISTANCE platform is capable of offering different configuration modes for providing the tailored information needed by each FR organization while they work together to mitigate the disaster (e.g. real-time video and resources location for firefighters, evacuation route status for emergency health services and so on).

With this solution, ASSISTANCE will enhance the SA of the responding organizations during their mitigation activities through the integration of new paradigms, tools and technologies (e.g. drones/robots equipped with a range of sensors, robust communications capabilities, etc.) with the main objective of increasing both their protection and their efficiency.

ASSISTANCE will also improve the skills and capabilities of the FRs through the establishment of a European advanced training network that will provide tailored training based on new learning approaches (e.g. virtual, mixed and/or augmented reality) adapted to each type of FR organizational need and the possibility of sharing virtual training environments, exchanging experiences and actuation procedures.

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Disclaimer

Executive Summary

This document is devoted to the work carried out in the task T7.1: Validation Plan. This deliverable provides a description of the System Engineering approach followed to manage risk and ensure that the functionalities are achieved through a specifically designed validation plan.

This validation plan will be particularized for each component of the overall ASSISTANCE system, following the system architecture of D2.4. It will ensure that all the user requirements captured in D2.2 are validated. Furthermore, along the deliverable the components of the peer-reviewed plan will comprise the following two principal branches:

- Test plans to validate that the system requirements have been met.
- Test plans for the user trials that validate the effectiveness and efficacy of ASSISTANCE in meeting the user requirements.

Apart from that, this document will be the basis for the consecutive Task 7.2, where the results from the execution of these tests designed during this task will be carried out.

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Acronyms

AI	Artificial Intelligent
API	Application Programming Interface
ASET	Available Safe Egress Time
CBRN	Chemical Biological Radiological Nuclear
CCTV	Closed-circuit television
C-GCS	Central Ground Control Station
DALR	Damaged Assets Location & Routing
EM	Evaluation Management
FR	First Responders
GCS	Ground Control Station
GIS	Geography Information System
GPS	Global Positioning System
GUI	Graphical User Interface
HMI	Human Machine Interface
IMU	Inertial Measurements Units
JSON	JavaScript Object Notation
KPI	Key Performance Indicator
MPM	Mission Planner Management
MQTT	Message Queuing Telemetry Transport
RC	Radio Control
RSET	Required Safe Egress Time
SAS	Sensor Abstraction Service
SAP	Situation Awareness Platform
SoEL	Societal, Ethical and Legal
UAV	Unmanned Aircraft Vehicle
UGV	Unmanned Ground Vehicle
URL	Uniform Resource Locator
UWB	Ultra Wide Band
VPN	Virtual Private Network

1 Introduction

This document is devoted to the task T7.1: Validation Plan, adopted during the System Engineering Approach that the project has performed to manage risk and to ensure that the required functionalities and features of the system are achieved. The approach proposed and followed is derived from the requirements capture, the reference scenarios and the KPI definition, as well as from the System and Network Architecture i.e., the exercise developed here is highly related with D2.2, D2.3 and D2.4 of the project.

Following the architecture developed in D2.4, each component and sub-system of the overall ASSISTANCE project has been identified. For each component, in D2.2 it can be found the requirements capture. Then, in D2.3, taking the reference scenarios, the specifications for the pilot operations were set. The objectives of each of those pilot operations were defined together with related KPIs for their assessment. These objectives were traced with the requirements, covering most of them and making easy the identification of the objectives per components.

The approach set out here starts from the objectives developed in D2.3. It has been identified the objectives that concerns each of the components of ASSISTANCE. Then, these objectives have been grouped encompassing a single functionality of the subsystem to finally design specific tests for each of them.

1.1 Purpose of the document

The main purpose of this deliverable is to describe the design of the validation plan followed in T7.1. During the task, the components of a peer-reviewed validation plan were compiled, comprising two principal parts:

- Test plans to validate that the system requirements have been met.
- Test plans for the user trials that validate the effectiveness and efficacy of ASSISTANCE in meeting the user requirements.

The different tests exposed during the document will be the base for T7.2, which will extract the results and analysis of the performance of the tests. Particularly, a total of nine components or subsystems to be tested by themselves have been identified. They are (together with the responsible partner in parenthesis):

- UAVs (FADA-CATEC),
- Robots (PIAP),
- CBRN (TNO),
- Communications (VIASAT),
- SAS (ETRA),
- Mission planner (VIASAT),
- Damaged assets location and routing and (ETRA),
- Adapted situation awareness (UPVLC)

Different phases for the validation plan can be established, which can be applied or not to the different modules. The main phases would be:

- Laboratory environment

- Outdoor controlled environment
- Realistic environment

The validation tests will be performed by the partner responsible for the development of each component.

1.2 Scope

This deliverable is the first one within the WP7 of the ASSISTANCE project, which aims to validate the ASSISTANCE end products. The main objective of the WP concerning this deliverable is: *"To describe the tests that will be used for validating the whole ASSISTANCE system implementation against the requirements and pilot scenarios specified in WP2".* Therefore, this document describes all the work to be carried out by the whole consortium to validate the individual systems before reaching the final pilot demonstrations.

1.3 Relationship with other work packages

This deliverable gets information from the following tasks:

- Task 2.2 User requirements gathering analysis and tracking
- Task 2.3 Reference scenarios, pilot operations specifications and KPIs.
- Task 2.4 System and Network Architecture Design
- Task 4.2 UAV Management and sensors integration
- Task 5.2 SA advanced modules development

The output from the task 7.1 and consequently this deliverable D7.1 contributes to the following tasks:

- Task 7.2 Integrated system test bed
- Task 7.3 Pilot Demonstration
- Task 7.4 Data Analysis, Economical and Usability Evaluation

2 Validation plan methodology

As previously stated, this document aims to present the System Engineering approach followed to determine the validation plan for the components of the ASSISTANCE system. This methodology, called V model, is widely known, and it follows two branches: the validation process first, and afterwards the verification process. This model is illustrated in Figure 1, and it shows the role of the validation plan in this process, linking the two branches of the V model.

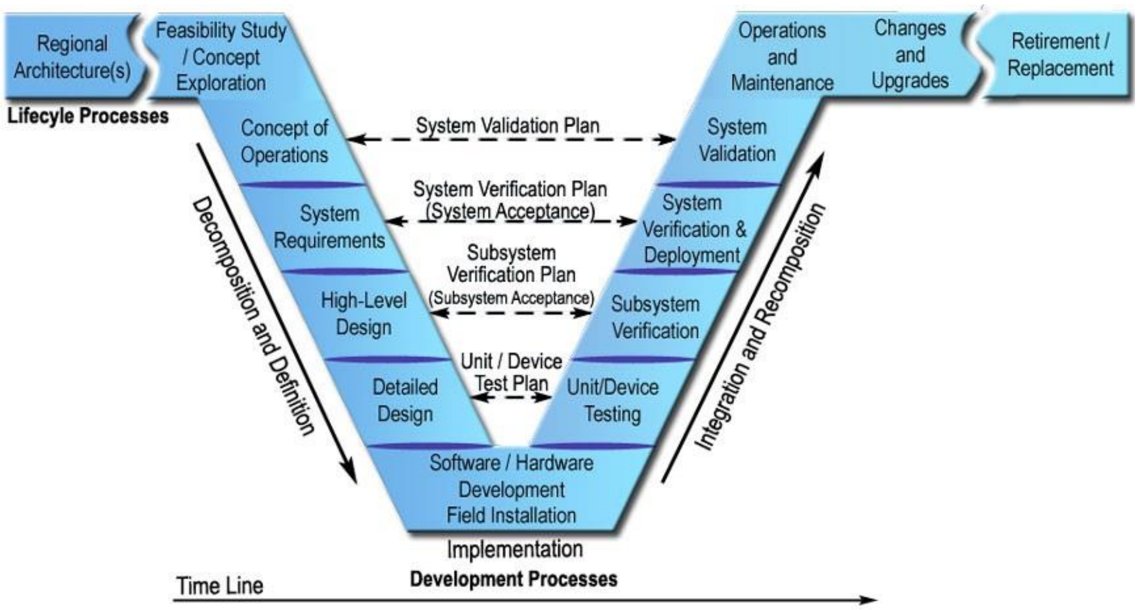

Figure 1: V model for an Engineering System Approach[2]

Top-level design procedures were performed in previous deliverables. Thus, in D2.2 – User Requirements Specifications, User Requirements were captured, following a rigorous procedure, the Volere Methodology. Then, following the overall ASSISTANCE architecture set in D2.4 – ASSISTANCE System and Network, in D2.3 the use cases to support each of the scenarios were defined, and a list of KPIs and objectives were associated to each use case.

The present document will consider all the previous steps to define the validation plan per component/subsystem of the ASSISTANCE system. The methodology has been divided into the following steps:

1. Split the ASSISTANCE system into components or subsystems according to the architecture of D2.4
2. Compile the objectives set in D2.3 per components or subsystems, which were traced with the user's requirements of D2.2. A double check to ensure that all the requirements are traced with at least an objective has been performed. If a

[2] https://ops.fhwa.dot.gov/publications/seitsguide/section3.htm

requirement was missed in D2.3, it has been justified the motivation of it or it has been assigned to an objective.

3. Define the test that composed the validation plan for each component or subsystem. Once all the tests have been defined, they have been traced with the objectives named above. Since the objectives are traced with the requirements, and the test with the objectives, finally the tests ensure that the requirements are validated.

Figure 2 shows an overview of all the validation and evaluation activities planned for the ASSISTANCE project; the block of activities documented in this report is highlighted in orange. There are several types of requirements that do not suit any specific component/subsystem or simply cannot be validated through a test. These requirements are shown in Figure 2 as blocks with no colour and are discussed briefly in section 0. Please consult the corresponding deliverable reports for more detailed discussion.

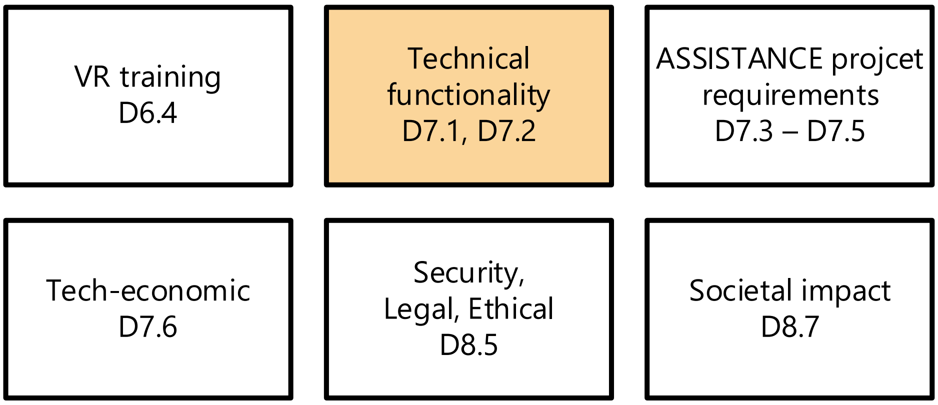

Figure 2: Validation and evaluation activities with their corresponding deliverables. The colored cell indicates the block of activities documented in this report.

2.1 Requirements to be validated by other means

Although the majority of the user's requirements are going to be validated through the validation plan presented in the current document, there are some of them that cannot be validated by mean of a regular test. These types of requirements, following the nomenclature stablished in D2.2, are:

- ASSISTANCE project requirements,
- Legal and ethical requirements,
- Communications Security requirements,
- Societal impacts,
- Technology-economic cost benefit evaluation, and
- Training and Virtual Reality platforms requirements.

All the ASSISTANCE project requirements mainly refer to non-functional requirement and, moreover, they refer to features of the overall system performance, which shall be validated once the system has been integrated and the pilot demonstrations performed.

They will be validated, for example, by mean of questionnaires handed to the end-users participating in the pilot demonstrations.

The legal and ethical requirements refer to restrictions to be complied with due to norms, standards or regulations that may affect the systems to be developed within the project. In addition, ethical requirements will be checked through SoEL developed in WP8. Security requirements will be assessed also to the overall ASSISTANCE project since they cannot be assigned to a unique subsystem.

Societal impacts, such as human factor impact and the gender dimension, will be assessed primarily through surveys and focus groups as ongoing activities throughout the course of the project.

An assessment of the balance between the costs of developing the ASSISTANCE technology and the costs of the damage caused by large disasters will be conducted using the results of the pilot demonstrations, interviews/surveys of the participating first responders and the literature.

Finally, the requirements related to training and virtual reality platforms are not requirements to be tested within the scope of T7.1. This set of requirements, that concerns data and training methods, will be ensured for quality, effectiveness, and equal access in D6.4.

3 UAVs validation plan

Once the methodology has been described, it is time to apply it to each component and subsystem within ASSISTANCE. The current section will deal with the validation plan regarding the UAVs. At least one UAV, if not a swarm, will be used in each scenario. Hence, the designed validation plan has covered a wide range of possibilities and situations, engaging the system to properly work during the pilots and demonstration.

3.1 Objectives and requirements traceability

In the deliverable D2.3 - ASSISTANCE Reference Scenarios and Pilot Experiments Specifications, the objectives that meet the UAV_XXX requirements were set. Table 2 lists all the objectives related to the UAVs. As can be seen, there are objectives regarding the three scenarios to be carried out in the ASSISTANCE project. Moreover, there were a total of 24 requirements captured in D2.2 (although the IDs are up to 26, there was a typing error with 2 requirements IDs, UAV_009 and UAV_016, omitted). Some of these requirements were not linked, and they have been linked with the correct objective, see Table 1.

Table 1: Relation of UAV requirements not correlated in D2.3

Requirement ID	Description	Link
UAV_018	The ASSISTANCE captor drone has to carry a capture device	SC3-UC7-OBJ2-KPI2-SC1 SC3-UC7-OBJ4-KPI1-SC1
UAV_019	The captor drone must be able to capture multi-copter drones	SC3-UC7-OBJ1-KPI1-SC1
UAV_020	The captor drone should be able to load the intruder drone when it is caught, and carry it to a safe place	SC3-UC7-OBJ5-KPI1-SC1
UAV_021	The Control Station that will manage the swarm of drones must be centralized in order to be able of controlling all the vehicles from a single computer	SC1-UC7-OBJ4-KPI1-SC1
UAV_025	The captor drone must be able to calculate an efficient trajectory to get close to the intruder drone.	SC3-UC7-OBJ3-KPI1-SC1
UAV_026	The captor drone must be able to follow the intruder drone in an autonomous way	SC3-UC7-OBJ3-KPI1-SC1

Table 2: KPIs related with UAV and their traceability with the requirements.

KPI ID	Description	Req ID link	Req. Description
SC1-UC1-OBJ1-KPI1-SC1	Video cameras are installed and working properly on the drones/UGVs.	UAV_001	UAVs must be able to transmit visual images in RTSP 264 to the SAS platform in real-time.
SC1-UC1-OBJ1-KPI2-SC1	Drones/UGVs are able to transmit live-video and the ASSISTANCE framework receives this information in the correct format.	UAV_001	UAVs must be able to transmit visual images in RTSP 264 to the SAS platform in real-time.
SC1-UC1-OBJ2-KPI1-SC1	The mobile platform is able to load its mission and start its operation in a time below 15 minutes.	UAV_011	Setup time of UAV must be less than 10 minutes.
SC1-UC7-OBJ1-KPI1-SC1	Three points are calculated based on the setup characteristics.	UAV_007	The flight envelope of the aerial vehicle has to be provided in the user interfaces of the UAVs for flying and landing
		UAV_023	Swarm drones must be able to integrate or transport the Wi-Fi access points provided by the communication specialists for creating an Ad Hoc Network
SC1-UC7-OBJ2-KPI1-SC1	4 drones available for the operation	UAV_022	The swarm of drones should be composed by at least 4 vehicles
		UAV_023	Swarm drones must be able to integrate or transport the Wi-Fi access points provided by the communication specialists for creating an Ad Hoc Network
		UAV_022	The swarm of drones should be composed by at least 4 vehicles

KPI ID	Description	Req ID link	Req. Description
SC1-UC7-OBJ2-KPI3-SC1	Three drones flying continuously in the calculated locations.	UAV_023	Swarm drones must be able to integrate or transport the Wi-Fi access points provided by the communication specialists for creating an Ad Hoc Network
SC1-UC7-OBJ3-KPI1-SC1	New configuration of swarm calculated based on setup options.	UAV_024	Drone swarm should be reconfigured in case one drone stops its activities
SC1-UC7-OBJ4-KPI1-SC1	4 drones can be controlled from the C-GCS	UAV_021	The Control Station that will manage the swarm of drones must be centralized in order to be able of controlling all the vehicles from a single computer
		UAV_024	Drone swarm should be configured in case one drone stops its activities
SC2-UC1-OBJ1-KPI1-SC1	Market gas sensors are installed and working properly in the mobile platform. Reading of measurements are correct.	UAV_003	UAV must be capable to be equipped with a gas/smoke sensor
SC3-UC1-OBJ1-KPI1-SC1			
SC2-UC1-OBJ1-KPI2-SC1	Mobile platform is able to transmit the gas measurements and the ASSISTANCE framework receives this information in the specific format.	UAV_003	UAV must be capable to be equipped with a gas/smoke sensor
SC3-UC1-OBJ1-KPI2-SC1			
SC2- UC8-OBJ1-KPI5-SC1	User can decide on correct actions regarding the current and predicted position of the cloud.	UAV_003	UAV must be capable to be equipped with a gas/smoke sensor

KPI ID	Description	Req ID link	Req. Description
SC2- UC8-OBJ4-KPI1-SC1	The system can give advice on the position on which measurements are needed.	UAV_003	UAV must be capable to be equipped with a gas/smoke sensor
		UAV_005	UAV must have the possibility of being controlled by both pilot RC commands and unmanned way-point navigation capabilities.
SC3-UC7-OBJ1-KPI1-SC1	The captor drone receives activation signal from the system and starts flying towards the intruder drone.	UAV_001	UAVs must be able to transmit visual images in RTSP 264 to the SAS platform in real-time.
		UAV_004	UAV ground control station al-lows tracking the UAV during the whole operation
		UAV_005	UAV must have the possibility of being controlled by both pilot RC commands and unmanned way-point navigation capabilities.
		UAV_008	UAV used must fulfil with the current regulation in order to obtain the flight permits.
		UAV_010	UAV operation time must be at least 20 minutes
		UAV_011	Setup time of UAV must be less than 10 minutes.
		UAV_012	UAV must provide real-time video streaming and distribution
		UAV_014	UAV must be equipped with command interface to control UAV according to simulation purposes
		UAV_015	UAV must be equipped with telemetry data link connected to ASSISTANCE to provide telemetry data
		UAV_017	UAV can be equipped with 3D mapping capabilities depending on the type of planned mission
		UAV_019	The captor drone must be able to capture multi-copter drones
		UAV_006	UAV System small enough to be transported by van or pallet, preferably with an MTOW less than 15 kg.

KPI ID	Description	Req ID link	Req. Description
SC3-UC7-OBJ2-KPI2-SC1	The capture mechanism is activated and deployed onboard the captor drone.	UAV_018	The ASSISTANCE captor drone has to carry a capture device
SC3-UC7-OBJ3-KPI1-SC1	The captor drone maintains constant relative distance to the intruder drone during the tracking phase.	UAV_005	UAV must have the possibility of being controlled by both pilot RC commands and unmanned way-point navigation capabilities.
		UAV_007	The flight envelope of the aerial vehicle has to be provided in the user interfaces of the UAVs for flying and landing
		UAV_010	UAV operation time must be at least 20 minutes
		UAV_013	UAV must follow geofencing rules
		UAV_025	The captor drone must be able to calculate an efficient trajectory to get close to the intruder drone.
		UAV_026	The captor drone must be able to follow the intruder drone in an autonomous way
SC3-UC7-OBJ4-KPI1-SC1	The intruder drone is captured by the mechanism launched from the captor drone.	UAV_007	The flight envelope of the aerial vehicle has to be provided in the user interfaces of the UAVs for flying and landing
		UAV_010	UAV operation time must be at least 20 minutes
		UAV_012	UAV must provide real-time video streaming and distribution
		UAV_018	The ASSISTANCE captor drone has to carry a capture device
SC3-UC7-OBJ5-KPI1-SC1	The caught drone is brought to land for FR analysis.	UAV_020	The captor drone should be able to load the intruder drone when it is caught, and carry it to a safe place

3.2 Validation environments

This section presents the procedures to perform the test of the UAV validation plan. A test has not been designed for each objective, but the strategy followed has been to combine objectives related to the same functionality in a single test. The validation plan will be divided in three different phases: laboratory environment, outdoor controlled environment and finally the realistic environment. Each of these phases will be performed in the following sites:

1) CATEC´s testbed:

The laboratory tests for the UAVs platform will be performed in CATEC´s facilities, where there is a 15 m × 15 m testbed. This testbed is also equipped with Vicon System for indoor positioning purposes, which can be used as ground truth for highly precise positioning. The scenario will recreate a tank inspection, as it can be seen in Figure 3.

Figure 3: CATEC´s testbed

2) CATEC outdoor premises:

CATEC has two premises near its facilities in La Rinconada (Seville), in which they can perform experiments and test. These sites allow recreating more realistic scenarios. Therefore, the inspections can be carried out simulating real conditions such as wind and temperature, as well as the installation of infrastructures that can more closely resemble those that the UAVs will eventually have during the real demonstrations. These premises are shown in Figure 4, and they both are located half an hour driving from CATEC´s facilities in Seville (Spain). The one on the left, with dimensions of approximately 100x60m, is in a karting track. It has installed a mock-up that allows the installation of several infrastructures. The other one (on the right) is a rural runway located also half an hour driving from CATEC´s facilities. The extension of this flight runway is bigger than the previous one, and hence, it is the suitable location to test all the advance functionalities of the UAVs, since its wide extension allows the UAV to be pushed to the limit of their capabilities, such as Autonomous Navigation Systems, communications, swarming, etc.

Figure 4: UAV outside controlled environments. Karting track on left and rural runway on right.

3) Pilots and demonstrator location:

Finally, the realistic test will be evaluated during the final demonstrations of the project.

3.3 UAV validation tests

In the following sections, the validation plan for each of the functionalities identified regarding the UAVs is presented.

3.3.1 UAV Video cameras installation and transmission

This set of tests will validate the following KPIs:

- SC1-UC1-OBJ1-KPI1-SC1: Video cameras are installed and working properly on the drones/UGVs.
- SC1-UC1-OBJ1-KPI2-SC1: drones/UGVs can transmit live-video and the ASSISTANCE framework receives this information in the correct format.
- SC1-UC1-OBJ2-KPI1-SC1: The mobile sensor can load its mission and start its operation in a time below 15 minutes.

The aim of the tests to be performed here is, first, to validate that the installation of the cameras in the UAVs is correct and is working properly; then, to check that the transmission of the live-video and the reception of information within the ASSISTANCE framework is in the proper format. Finally, the time of initialization of the system, which must be lower than 15 minutes, will be also tested.

In three different levels, the test will be in the same following manner: the UAV will be placed in a determined safe take-off/landing area. At this area, the prior-to-flying checklist will be checked and ticked. Once the checklist has been approved, or even while it is being performed, the mission will be loaded to the UAV core. No more than 15 minutes should pass before the UAV starts the mission after it is loaded (SC1-UC1-

OBJ2-KPI1-SC1). After that, the UAV will perform the mission, transmitting live-video during the whole operation. The transmission should be stable and robust, especially in those waypoints where the UAV will be placed to monitor an area (SC1-UC1-OBJ1-KPI1-SC1). During the test, the transmission between the UAV and the ASSISTANCE framework will be checked, paying special attention to the format in which the information is sent (SC1-UC1-OBJ1-KPI2-SC1). Regarding the different phases and environments, the following plan is proposed:

Table 3: Validation plan for UAV video camera installation and transmission

Environment	Goal	Output
Laboratory	Prior to the flight of the UAV, the installation of the cameras will be checked in different manners: - Robustness - Proper integration for the purpose of the scenario - No interference between the field of view of the cameras and the airframe of the UAV Once the integration has been checked, a mission will be carried out inside an indoor testbed	Approved checklist Real-time video transmission Transmitted pictures Report of the set of camera integration
Outdoor controlled	To probe UAV with the set of cameras integrated in conditions of wind, temperature, and light like the ones in the real scenario.	Real-time video transmission Transmitted pictures
Real	The UAV performs an autonomous mission, as designed by the user. The video transmission is stable and in real-time during the whole operation. Moreover, the user could modify the mission during its execution. The UAV must	Real-time video transmission Transmitted pictures

3.3.2 Swarming capabilities

This set of tests will validate the following objectives:

- SC1-UC7-OBJ1-KPI1-SC1: Three points are calculated based on the setup characteristics.

- SC1-UC7-OBJ2-KPI2-SC1: 4 drones available for the operation
- SC1-UC7-OBJ2-KPI2-SC2: Three drones flying continuously in the calculated locations.
- SC1-UC7-OBJ3-KPI1-SC1: New configuration of swarm calculated based on setup options.
- SC1-UC7-OBJ4-KPI1-SC1: 4 drones can be controlled from the C-GCS

The aim of these tests is to validate the swarming capabilities of the system needed to provide ad-hoc network coverage. The objective is to achieve four drones flying cooperatively. However, the validation plan will increase progressively the number of UAVs in the swarm. Hence, the test will start with two UAVs, and it will be repeated adding one new drone each time until the number of four drones is achieved.

Once the swarm is composed of four drones, and given a specific zone, three locations points will be calculated to provide the network with the best coverage area (SC1-UC7-OBJ1-KPI1-SC1). To do that, features such as the available equipment and the characteristics of the UAV will be considered. These points will determine the positions in which one UAV should be placed and stay flying during the operation (SC1-UC7-OBJ2-KPI3-SC1). Only three drones will be flying at the same time, whereas the fourth UAV will be available to be deployed at any time (SC1-UC7-OBJ2-KPI1-SC1).

The test should prove whether the swarm of UAVs can be reconfigured in case one of the drones stops working (SC1-UC7-OBJ3-KPI1-SC1). Finally, it will be shown that the four UAVs can be all controlled from the same C-GCS (SC1-UC7-OBJ4-KPI1-SC1).

Table 4: Validation plan for the swarming capabilities

Environment	Goal	Output
Laboratory	To strengthen the swarming capabilities. Evaluate the most suitable architecture. System robust enough to be probed outdoor. Progressively increase the number of UAVs involved in the swarm.	Robust and reliable algorithm to control the swarming in real-time.
Outdoor controlled	The swarm operates all the time, exchanging positions between the reserve drones and the ones flying.	Telemetry of the UAVs involved Ground station requests, to match it with the

	Selection of interest points can be calculated based on the setup characteristics.	performance of the swarm afterwards
Real	A real mission is performed onsite by the swarm, responding to the FR inputs	Telemetry of the UAVs involved FR requests, to match it with the performance of the swarm afterwards

3.3.3 Gas sensor integration

The following objectives will be validated through the current set of tests:

- SC2-UC1-OBJ1-KPI1-SC1: Market gas sensors are installed and working properly in the mobile platform. Reading of measurements are correct.
- SC3-UC1-OBJ1-KPI1-SC1: Market gas sensors are installed and working properly on the UAVs/UGVs. Reading of measurements is correct.
- SC2-UC1-OBJ1-KPI2-SC1: Mobile platform is able to transmit the gas measurements and the ASSISTANCE framework receives this information in the specific format.
- SC3-UC1-OBJ1-KPI2-SC1: UAVs/UGVs are able to transmit the gas measurements and the ASSISTANCE framework receives this information in the expected format.
- SC2- UC8-OBJ1-KPI5-SC1: Based on the calculations and available measurements, the uncertainty of the cloud's position is presented.
- SC2- UC8-OBJ4-KPI1-SC1: The system can give advice on the position on which measurements are needed

The aim of these tests is to validate the integration of the gas sensor onboard the UAVs. One of the pilots, particularly the one related with the industrial accident, requires the UAV to transmit gas measurements to the user, to facilitate them to identify where efforts are needed. Since this set of tests concerns an external system to be integrated onboard the UAV, the gas sensor, the validation plan will first focus on it. Once its function and performance are checked, and it is proved that the selected sensor meets the requirements, the whole system, i.e. both the UAV and the gas sensor will be validated together.

Hence, the gas sensor will be briefly tested independently before its integration in the UAV. A simple test will be carried out, ensuring that the readings coming from the sensor are correct and as expected. After that, the gas sensor will be integrated in the UAV, and this integration will be check by a technical manager as well (SC2-UC1-OBJ1-KPI1-SC1 and SC3-UC1-OBJ1-KPI1-SC1). An active gas generator will be needed for the test. A mission will be loaded to the UAV, which will fly following it. During the flight, the FR must receive gas measurements coming from the UAV, which should be provided in the specific format expected by the ASSISTANCE framework (SC2-UC1-OBJ1-KPI2-SC1 and SC3-UC1-OBJ1-KPI2-SC1).

At any given time, the gas generator will be activated, and then the FR must receive the information coming from the mobile platform. Then, the FR will decide which actions should be taken by the UAV. They will design a new mission that will be directly command to the UAV (SC2- UC8-OBJ1-KPI5-SC1). The UAV carrying the gas sensor will perform the new mission, taking new measurements in those areas in which the FR has decided it is needed. Moreover, the system could advice the user about those positions in which further measurements are needed (SC2- UC8-OBJ4-KPI1-SC1). All these features will be tested along the different scenarios' levels proposed in Table 5.

Table 5: Gas sensor integration validation tests

Environment	Goal	Output
Laboratory	Test the performance of the gas sensor by itself by carrying out simulations. Check the integration of the sensor onboard the UAV.	Data gather by the sensor during the simulations. Report and acceptance of the integration by a technical manager.
Outdoor controlled	Validation of the overall system (UAV + gas sensor) in real gas conditions. Transmission and reception of the data gathered by the sensor. Command the UAV to return to a certain location in which extra measurements shall be collected	Data gather by the sensor. Telemetry of the UAV GCS requests to be matched afterwards with the UAV telemetry
Real	Correct performance of the system during a real scenario. The FR receives the expected information.	Data gather by the sensor. Telemetry of the UAV FR requests to be matched afterwards with the UAV telemetry

3.3.4 Captor drone

The last set of tests will validate the following objectives:

- SC3-UC7-OBJ1-KPI1-SC1: The captor drone receives an activation signal from the system and starts flying towards the intruder drone.
- SC3-UC7-OBJ2-KPI2-SC1: The capture mechanism is activated and deployed onboard the captor drone.
- SC3-UC7-OBJ3-KPI1-SC1: The captor drone maintains constant relative distance to the intruder drone during the tracking phase.
- SC3-UC7-OBJ4-KPI1-SC1: The intruder drone is captured by the mechanism launched from the captor drone
- SC3-UC7-OBJ5-KPI1-SC1: The caught drone is brought to land for FR analysis

Regarding the last pilot scenario of the ASSISTANCE project, which will simulate a terrorist attack, a captor drone is required. This drone will give chase to a potential intruder drone. The validation plan presented for this feature will be iterative since the capture functionalities are a novel and cutting-edge technology which will require several validation iterations before reaching the final real environments. Another drone apart for the one carrying the catching mechanism will be needed to simulate the intruder drone.

The simulated intruder drone will be flying on site, and a time, the captor drone will receive the activation signal from the system and then, it will start flying towards the intruder drone (SC3-UC7-OBJ1-KPI1-SC1). It will approach the intruder drone, but it will not directly catch the intruder. The captor UAV must track the other and maintain a constant relative distance with it during the tracking phase (SC3-UC7-OBJ3-KPI1-SC1). The FR will command to the captor the time in which it will have to proceed with the capture. Then, the captor UAV will activate and deploy its capture mechanism onboard and it will proceed with the capture manoeuvre (SC3-UC7-OBJ2-KPI2-SC1 and SC3-UC7-OBJ4-KPI1-). Once the intruder is captured, the UAV will bring it to a safe area, landing, and it will give the FR the possibility to perform further analysis of the intruder (SC3-UC7-OBJ5-KPI1-SC1). This scenario will be completed in the different phases of the validation plan depending on the environment, as explained in Table 6.

Table 6: Captor drone validation plan

Environment	Goal	Output
Laboratory	Check the effectiveness of the capture mechanism. Validate the integration of the capture mechanism with the UAV.	Report of acceptance of the capture mechanism by a technical manager and its integration in the UAV.

Outdoor controlled	Catch an intruder drone Maintain a constant distance with the intruder drone during the tracking phase Bring the intruder safe to a landing area	Telemetry of the captor UAV Videos to be analysis of the caption operation
Real	Catch an intruder drone once the FR requires it Maintain a constant distance with the intruder drone during the tracking phase Bring the intruder safe to a landing area	Telemetry of the captor UAV Videos to be analysis of the caption operation

3.4 Tests vs objectives traceability

Table 7: Tests vs. objective traceability matrix for UAV component

Validation plan / Objectives	UAV video cameras installation and transmission	Swarming capabilities	Gas sense integration	Captor drone
SC1-UC1-OBJ1-KPI1-SC1	X			
SC1-UC1-OBJ1-KPI2-SC1	X			
SC1-UC1-OBJ2-KPI1-SC1	X			
SC1-UC7-OBJ1-KPI1-SC1		X		
SC1-UC7-OBJ2-KPI1-SC1		X		

SC1-UC7-OBJ2-KPI3-SC1		X		
SC1-UC7-OBJ3-KPI1-SC1		X		
SC1-UC7-OBJ4-KPI1-SC1		X		
SC2-UC1-OBJ1-KPI1-SC1			X	
SC3-UC1-OBJ1-KPI1-SC1			X	
SC2-UC1-OBJ1-KPI2-SC1			X	
SC3-UC1-OBJ1-KPI2-SC1			X	
SC2- UC8-OBJ1-KPI5-SC1			X	
SC2- UC8-OBJ4-KPI1-SC1			X	
SC3-UC7-OBJ1-KPI1-SC1				X
SC3-UC7-OBJ2-KPI2-SC1				X
SC3-UC7-OBJ3-KPI1-SC1				X
SC3-UC7-OBJ4-KPI1-				X
SC3-UC7-OBJ5-KPI1-SC1				X

4 Robots validation plan

The current section will deal with the validation plan regarding ground robots. As described in previous deliverables (notably D4.1) PIAP GRYF robot will be used for scenario 2&3. The motivation for exclusion of UGV in scenario 1 is based on risk mitigation for customs procedures related to sending military equipment outside EU. Therefore, this validation plan is prepared to cover the system to properly work during all pilots and demonstrations.

4.1 Objectives and requirements traceability

In the deliverable D2.3 – "ASSISTANCE Reference Scenarios and Pilot Experiments Specifications" links between certain use-cases and requirements have been made. In Table 8 all the objectives related with the UGVs are listed. A total of 25 requirements have been defined and had their priorities evaluated by end-users during task T2.2. Most of the requirements have not been linked to objectives in D2.3 document. Therefore, these links list had to be revised and extended to directly refer to specific KPIs. Table 8 below includes the corrected requirement-objective/KPI links. Some requirements have been left without any link due to being a physical property rather than a functionality that can be added. Requirements without links to KPIs are listed in this chapter in

Table 9.

Table 8: KPIs related with UGV and their traceability with requirements

KPI ID	Description	Requirement ID link	Req. Description
SC1-UC1-OBJ1-KPI1-SC1	Video cameras are installed and working properly on the drones/UGVs.	ROB_023	Robot has to be equipped with multiple cameras
SC2-UC1-OBJ2-KPI2-SC1	Base ground platform has video cameras installed and working properly		
SC3-UC1-OBJ2-KPI1-SC1	Video cameras are installed and working properly in the UAVs/UGVs.		
SC1-UC1-OBJ1-KPI2-SC1	Drones/UGVs are able to transmit live-video and the ASSISTANCE framework receives this information in the correct format	ROB_019 ROB_022	Robot data link has to be secured Robot can transfer sensor results to the operator using its datalink.
SC2-UC3-OBJ1-KPI2-SC1	Video streaming can be inserted in the SAS and accessed through the infrastructure		

SC3-UC1-OBJ2-KPI2-SC1	UAVs/UGVs are able to transmit live-video and the ASSISTANCE framework receives this information in the specific format.	ROB_025 ROB_009	Sensor can connect to the robot using a specified open standard. Robot control should be protected by an authentication system.
SC1-UC1-OBJ2-KPI1-SC1	The mobile sensor is able to load its mission and start its operation in a time below 15 minutes	ROB_011 ROB_012	Robot should be operated by one person. Robot setup time should be lower than 10 minutes
SC3-UC1-OBJ1-KPI1-SC1	Mobile sensor is able to load its mission and start its operation in a time below 15 minutes		
SC1-UC3-OBJ1-KPI1-SC1	The SAS has an API REST service that allows the insertion of the information of the UAVS, UGVs and FRs wearable sensors, which is sent in different formats and standards	ROB_022	Robot can transfer sensor results to the operator using its datalink
SC3-UC2-OBJ1-KPI1-SC1	The SAS has an API REST service that allows the insertion of the information of the UAVS, UGVs and FRs wearable sensors, which is sent in different formats and standards		
SC1-UC3-OBJ1-KPI2-SC1	Video streaming can be inserted in the SAS and accessed through the infrastructure	ROB_022	Robot can transfer sensor results to the operator using its datalink
SC2-UC1-OBJ1-KPI1-SC1	Market gas sensors are installed and working properly in the mobile platform. Reading of measurements are correct	ROB_020	Robot has to have the capability to carry multiple sensors
SC3-UC1-OBJ1-KPI1-SC1	Market gas sensors are installed and working properly on the UAVs/UGVs. Reading of measurements is correct.		

SC2-UC1-OBJ1-KPI2-SC1	Mobile platform is able to transmit the gas measurements and the ASSISTANCE framework receives this information in the specific format	ROB_022	Robot can transfer sensor results to the operator using its datalink
SC3-UC1-OBJ1-KPI2-SC1	UAVs/UGVs are able to transmit the gas measurements and the ASSISTANCE framework receives this information in the expected format.		
SC3-UC3-OBJ1-KPI1-SC1	The real time video flows from the available portable cameras have to be visualized in a proper way with enough quality in the SA application main HMI.		
SC2-UC1-OBJ2-KPI1-SC1	Base ground platform has weather station sensor installed and working properly	ROB_020	Robot has to have the capability to carry multiple sensors
SC2-UC1-OBJ2-KPI3-SC1	Mobile platform has a thermal camera mounted, installed and working properly	ROB_023	Robot has to be equipped with multiple cameras
SC2-UC1-OBJ2-KPI4-SC1	UGV is able to transmit sensor readings and the ASSISTANCE framework receives this information in the specific format.	ROB_022	Robot can transfer sensor results to the operator using its datalink
SC2-UC6-OBJ1-KPI1-SC1	When mission is deployed in SA application, it should be sent to and received by UGV operator	ROB_024	Robot can be teleoperated / telemanipulated by remote operator or work in automatic mode.
SC2-UC6-OBJ2-KPI1-SC1	Video is captured, sent and displayed for UGV operator on HMI console	ROB_022	Robot can transfer sensor results to the operator using its datalink
SC2-UC6-OBJ2-KPI1-SC2	Video is captured, sent and displayed for OC/FC in SA application		

SC2-UC6-OBJ1-KPI2-SC1	Thermal video is captured, sent and displayed in SA application		
SC2-UC6-OBJ1-KPI3-SC1	All sensor data is being captured and sent to SA application		

Table 9: Relation of UGV requirements not correlated in D2.3

Requirement ID	Description	Reason for no correlation
ROB_001	Robot should be capable to operate in a temperature range from -40C to 60C.	It applies to the scope of the product, so it applies to all the KPI.
ROB_002	Robot should be protected from the environment (dust and water) according to IP67.	It applies to the scope of the product, so it applies to all the KPI.
ROB_003	Robot shall have a maximum speed of at least 4 m/s.	It applies to the scope of the product, so it applies to all the KPI.
ROB_004	Robot shall have minimum work time of 4h.	It applies to the scope of the product, so it applies to all the KPI.
ROB_005	Robot should have the capability of changing batteries without tools and understanding of the technical part of the robot	It applies to the scope of the product, so it applies to all the KPI.
ROB_006	Robot should be equipped with manipulator maximum load of 5 kg.	It applies to the scope of the product, so it applies to all the KPI.
ROB_007	Robot should have the mobility to traverse terrain, like debris, stairs, etc.	It applies to the scope of the product, so it applies to all the KPI.
ROB_008	Minimal operation range 400m.	It applies to the scope of the product, so it applies to all the KPI.
ROB_010	Robot should be equipped with a monitoring system for: battery level, radio link quality, robot orientation.	It applies to the scope of the product, so it applies to all the KPI.

ROB_013	Control system should be operated in multiple languages.	It applies to a usability requirement, so it applies to all the KPI. Currently UGV is operated in English, with manuals available in more languages.
ROB_015	Robot should have a maximum weight of 25kg.	It applies to the scope of the product, so it applies to all the KPI.
ROB_016	Maximum Size 60x60x80cm (width x length x height).	It applies to the scope of the product, so it applies to all the KPI
ROB_017	Control system should be user-friendly.	Explanation below the table.
ROB_018	Control system should have low latency.	It applies to the scope of the product, so it applies to all the KPI
ROB_021	Sensors can be mounted quickly without any tools.	No KPI is associated with this requirement, since this is a core design principle that is applied to chosen particular UGV.

4.2 Validation environments

This section presents procedures to perform the test of the UGV validation plan. Some objectives do not have specifically designed tests for each one but are rather grouped in relation to functionalities that those objectives cover. Validation will be performed in three phases: controlled laboratory, controlled outside and realistic. Tests will be performed in following several locations:

- ŁUKASIEWICZ-PIAP Hall 4A:

ŁUKASIEWICZ-PIAP's one of several halls used for manufacturing and testing robots and other devices. Hall 4A is main area for development and testing UGVs for Security and Defence Systems Division. Space is over 100m2 with complete coverage of UWB radio system Pozyx for internal positioning.

- ŁUKASIEWICZ-PIAP outside area:

ŁUKASIEWICZ-PIAP is located on the edge of Poland's capital Warsaw and the outdoor areas within the Institute premises are used for testing and demonstrations of research results and commercial products. Small testing fields are prepared in the available areas, to include various terrain conditions, obstacles and proximity of the necessary infrastructure. This eliminates all delays related to UGV logistics and ensures having experts from all fields related to robotics, from mechanics through all levels of electronics and software as well as AI experts at hand.

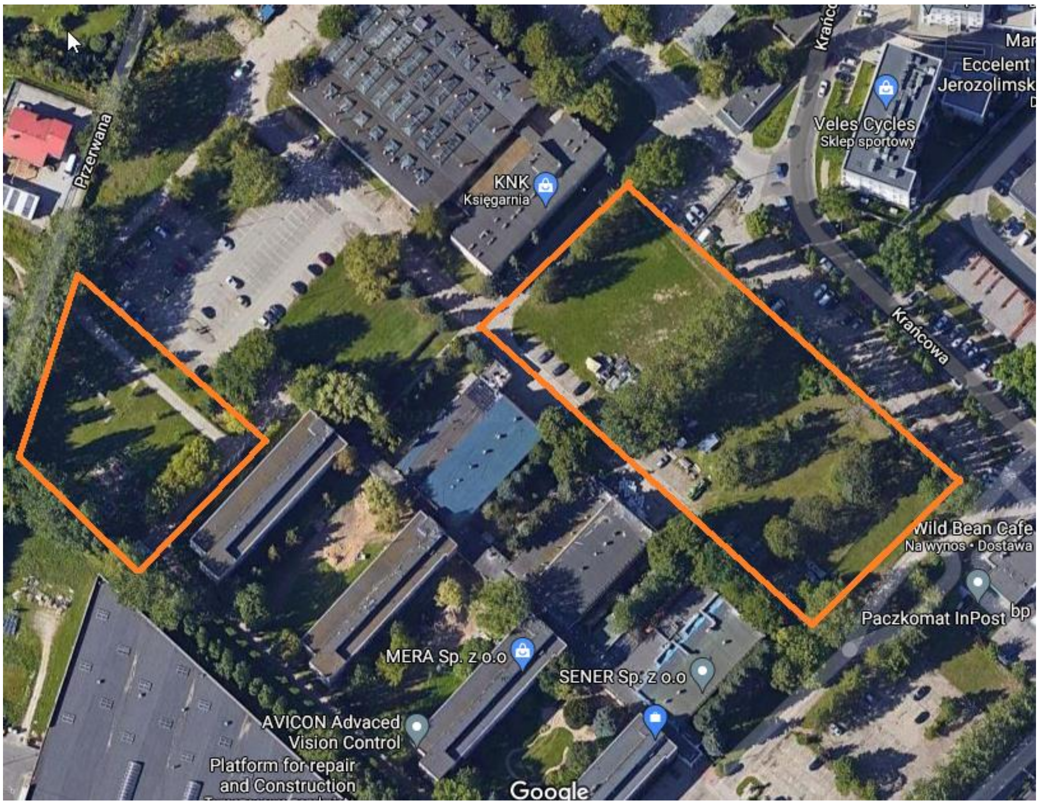

Figure 5: UGV validation outside environment

- Demonstration locations:

For descriptions of pilots locations please refer to document D2.3.

4.3 Robots validation scenarios

4.3.1 UGV resource data integration test

This test will validate following KPIs:

- SC1-UC3-OBJ1-KPI1-SC1: The SAS has an API REST service that allows the insertion of the information of the UAVs, UGVs and FRs wearable sensors, which is sent in different formats and standards
- SC2-UC3-OBJ1-KPI1-SC1: The SAS has an API REST service that allows the insertion of the information of the UAVs, UGVs and FRs wearable sensors, which is sent in different formats and standards
- SC3-UC3-OBJ1-KPI1-SC1: The real time video flows from the available portable cameras have to be visualized in a proper way with enough quality in the SA application main HMI.
- SC2-UC6-OBJ1-KPI3-SC1: All sensor data is being captured and sent to the SA application
- SC3-UC2-OBJ1-KPI1-SC1: The SAS has an API REST service that allows the insertion of the information of the UAVs, UGVs and FRs wearable sensors, which is sent in different formats and standards

This is a basic test that will establish basic integration of robot platform with the rest of the ASSISTANCE system. Connection to the SAS and proper data model implementation is critical for every other functionality. The test mainly consists on data and video flows sent to the SAS and check that they are received correctly.

Tests performed for this scenario are described in Table 10. Each of parameters that is being transferred from an asset to SAS via utilization of data model should be individually tested in both controlled environments. During the test all this data should be both validated and verified with regards to the following criteria: *Is the data being sent? Is the data correctly formatted? Is the data correct? Does the data relate to changes to physical object?*

Table 10: Validation plan for the UGV integration

Environment	Goal	Output
Laboratory	Test proper adapter data model implementation and connection in controlled environment. No GPS data.	Telemetry data from UGV. Other asset related data.
Outdoor controlled	UGV will move around both manually and autonomously within designated area. Test global positioning transformations. Test bandwidth stress limits and range capabilities.	Telemetry data from UGV. Other asset related data.

Real	UGV is connected to SA system at all times. UGV position is continuously updated during demonstrators.	Telemetry data from UGV. Other asset related data.

4.3.2 UGV camera test

This test will validate following KPIs:

- SC2-UC1-OBJ2-KPI2-SC1: Base ground platform has video cameras installed and working properly.
- SC2-UC6-OBJ1-KPI1-SC1: Video is captured, sent and displayed for UGV operator on HMI console.
- SC3-UC1-OBJ2-KPI1-SC1: Video cameras are installed and working properly in the UAVs/UGVs.

This basic test will check the integration of previously existing cameras – all added functionalities will have to be tested. Previously, the only functionality was the video transfer between robot and GCS, the new functionalities cover the video server forwarding, VPN integration and dynamic mux camera settings.

Table 11: Validation plan for the UGV camera

Environment	Goal	Output
Laboratory	Test cameras integration, video server implementation, video format compatibility, bandwidth stress on multiple cameras, dynamic mux camera settings, VPN integration.	Video transmission.
Outdoor controlled	Tests will include driving UGV in both manual and autonomous operation with one or multiple cameras with different mux settings. Stress test controller bandwidth utilization with multiple cameras, dependency between dynamic mux changes and controller range. Test stress on computing power and battery life for simultaneous video server stream	Video transmission. Report on range, computation power and battery life depending on settings.

	forwarding, calculating 3d terrain map, costmaps and position fusion.	
Real	Video streams will be available during demonstrators whenever UGV is deployed. Cameras will be used for the UGV/SAP operator, autonomous surveillance and damaged asset and routing module. Part of this test will be initial UGV deployment during demonstrations.	Video transmission.

4.3.3 UGV thermal camera test

This test will validate the following KPIs:

- SC2-UC1-OBJ2-KPI3-SC1: Mobile platform has a thermal camera mounted, installed and working properly
- SC2-UC6-OBJ1-KPI2-SC1: Thermal video is captured, sent and displayed in the SA application

This test will validate all components and functionalities of the thermal camera. Thermal camera has been fully developed for the ASSISTANCE robot configuration; therefore all components will be thoroughly checked.

Table 12: Validation plan for the UGV thermal camera

Environment	Goal	Output
Laboratory	Test the thermal camera interface and format integration, test mechanical compatibility, test power consumption, test mounting & unmounting, test robustness, test reaction time, test overheating, test thermal stream integration with video server	Thermal video transmission. Report of component final effective parameters.
Outdoor controlled	Test hot swapping camera in field, test connection and reaction to broken stream pipe, test robustness during mission.	Thermal video transmission.
Real	Thermal video streams will be available during demonstrations whenever UGV is deployed with thermal camera. Thermal camera will specifically be used for SC2-UC6 investigation mission.	Thermal video transmission.

4.3.4 UGV gas sensor test

This test will validate the following KPIs:

- SC2-UC1-OBJ1-KPI1-SC1: Market gas sensors are installed and working properly in the mobile platform. Readings of measurements are correct.
- SC2-UC1-OBJ1-KPI2-SC1: Mobile platform is able to transmit the gas measurements and the ASSISTANCE framework receives this information in the specific format.
- SC3-UC1-OBJ1-KPI1-SC1: Market gas sensors are installed and working properly on the UAVs/UGVs. Reading of measurements is correct.
- SC3-UC1-OBJ1-KPI2-SC1: UAVs/UGVs are able to transmit the gas measurements and the ASSISTANCE framework receives this information in the expected format.

This test will validate the basic gas sensor MG811. During the test mechanical and electronic integration, as well as connectivity, data accuracy and correctness of the gathered data transfer will be tested. This sensor detects only CO2; therefore it will be possible to test data correctness without specialized equipment.

Table 13: Validation plan for UGV gas sensor

Environment	Goal	Output
Laboratory	Test the integration of gas sensor data, test electronic circuit, test mechanical integration, test data correctness, test measurement conversion to physical units.	Gas sensor data. Report on data correctness and conversion.
Outdoor controlled	Test gas sensor robustness and data collection capabilities on moving platform. Test data transmission to the SAS in field. Test turning the sensor on/off.	Gas sensor data.
Real	Gas sensor will be tested by collecting data during the missions and exercises performed by the robot.	Gas sensor data.

4.3.5 UGV gas analyser test

This test will validate the following KPIs:

- SC2-UC1-OBJ1-KPI1-SC1: Market gas sensors are installed and working properly in the mobile platform. Reading of measurements are correct.
- SC2-UC1-OBJ1-KPI2-SC1: Mobile platform is able to transmit the gas measurements and the ASSISTANCE framework receives this information in the specific format.
- SC2-UC1-OBJ2-KPI4-SC1: UGV is able to transmit sensor readings and the ASSISTANCE framework receives this information in the specific format.
- SC2-UC6-OBJ1-KPI3-SC1: All sensor data is being captured and sent to the SA application
- SC3-UC1-OBJ1-KPI1-SC1: Market gas sensors are installed and working properly on the UAVs/UGVs. Reading of measurements is correct.
- SC3-UC1-OBJ1-KPI2-SC1: UAVs/UGVs are able to transmit the gas measurements and the ASSISTANCE framework receives this information in the expected fomat.

This test will be performed similarly to MG811 gas sensor but utilizing the ATMON FL gas analyzer laboratory sensor.

Due to the complexity of the sensor data correctness will only be validated partially. The sensor must be calibrated periodically and comes with a certificate that attests the correctness of measurements. The data validation will be related only to the proper internal data handling and type conversions.

Table 14: Validation plan for the UGV gas analyzer

Environment	Goal	Output
Laboratory	Test the integration of gas sensor data, test electronic circuit, test mechanical integration, test data correctness, test swappable components, test power consumption.	Gas sensor data.
Outdoor controlled	Test gas sensor robustness and data collection capabilities on moving platform. Test data transmission to the SAS in field. Test turning the sensor on/off. Test swapping between internal measurement components.	Gas sensor data.
Real	Gas sensor will be tested by collecting data during the missions and exercises performed by the robot.	Gas sensor data.

4.3.6 UGV radioactivity detector test

This test will validate the following KPIs:

- SC2-UC1-OBJ2-KPI4-SC1: UGV is able to transmit sensor readings and the ASSISTANCE framework receives this information in the specific format.
- SC2-UC6-OBJ1-KPI3-SC1: All sensor data is being captured and sent to the SA application
- SC3-UC1-OBJ2-KPI2-SC1: UAVs/UGVs are able to transmit live-video and the ASSISTANCE framework receives this information in the specific format.

This test will be performed similarly to other sensors, but with use of the ZR-2 radioactivity sensor. No radioactivity data correctness tests will be performed in any phase of the validation, due to the specific CBRN environment testing requirements. The data correctness of this sensor has been tested according to other protocols that are out of the scope of the ASSISTANCE project. ŁUKASIEWICZ-PIAP takes responsibility for proper calibration of ZR-2 sensor before ASSISTANCE demonstrations.

Table 15: Validation plan for UGV radioactivity detector

Environment	Goal	Output
Laboratory	Test integration of radioactivity sensor data, test electronic circuit, test mechanical integration, test power consumption.	Radioactivity sensor data.
Outdoor controlled	Test radioactivity sensor robustness and data collection capabilities on moving platform. Test data transmission to SAS in field. Test turning sensor on/off.	Radioactivity sensor data.
Real	Radioactivity sensor will be tested by collecting data during robot performing missions and exercises. This data is not specifically used for any use-case, but it will showcase SA capability to visualize CBRN related data for operators.	Radioactivity sensor data.

4.3.7 UGV weather station test

This test will validate following KPIs:

- SC2-UC1-OBJ2-KPI1-SC1: Base ground platform has weather station sensor installed and working properly.
- SC2-UC1-OBJ2-KPI4-SC1: UGV is able to transmit sensor readings and the ASSISTANCE framework receives this information in the specific format.
- SC2-UC6-OBJ1-KPI3-SC1: All sensor data is being captured and sent to the SA application
- SC3-UC1-OBJ2-KPI2-SC1: UAVs/UGVs can transmit live-video and the ASSISTANCE framework receives this information in the specific format.

This test will be performed similarly to the MG811 gas sensor but utilizing Viasala WXT530 sensor. This test also has a broader scope due to the amount of data that a weather sensor can capture.

Due to the nature of the weather sensor, we will not be able to test data correctness thoroughly. Capture of many parameters is reliant heavily on uncontrollable elements. Therefore, for most aspects of the data correctness we will rely on the underlying sensor. Most data correctness validation will be centered around proper orientation and position transformations as well as type conversions for several parameters.

Table 16: Validation plan for UGV weather station

Environment	Goal	Output
Laboratory	Test the integration of weather sensor data including wind data/air data/precipitation data, test electronic circuit, test mechanical integration, test data correctness, test power consumption.	Weather sensor data.
Outdoor controlled	Test sensor robustness and data collection capabilities on moving platform. Test data transmission to the SAS in field. Test turning the sensor on/off.	Weather sensor data.
Real	Weather sensor will be tested by collecting data during the missions and exercises performed by the robot. This sensor data can be used for the SAP operator reference as well as optional local weather data for CBRN prediction module.	Weather sensor data.

4.3.8 UGV EMF detector test

This test will validate the following KPIs:

- SC2-UC1-OBJ2-KPI4-SC1: UGV is able to transmit sensor readings and the ASSISTANCE framework receives this information in the specific format.
- SC2-UC6-OBJ1-KPI3-SC1: All sensor data is being captured and sent to SA application
- SC3-UC1-OBJ2-KPI2-SC1: UAVs/UGVs are able to transmit live-video and the ASSISTANCE framework receives this information in the specific format.

This test will validate the requirements for the EMF detector sensor. There are no specific KPIs set for this specific sensor, but when it will be deployed (SC2-UC6) integration of this sensor will be connected to KPIs that require success criteria for all connected sensors and their data to be captured and transmitted.

Table 17: Validation plan for the UGV EMF detector

Environment	Goal	Output
Laboratory	Test the integration of EMF sensor data, test electronic circuit, test mechanical integration, test data correctness, test physical unit conversion, test power consumption.	EMF sensor data. Report on data correctness and physical unit conversions. Manuals for building and use.
Outdoor controlled	Test EMF sensor robustness and data collection capabilities on moving platform. Test data transmission to the SAS in field. Test turning the sensor on/off. Test robot interference.	EMF sensor data
Real	EMF detector will be used in SC2-UC6 for transformer building investigation.	EMF sensor data

4.3.9 UGV mission execution

This test will validate the following KPIs:

- SC1-UC1-OBJ2-KPI1-SC1: The mobile platform is able to load its mission and start its operation in a time below 15 minutes.
- SC2-UC6-OBJ1-KPI1-SC1: When mission is deployed in the SA application, it should be sent to and received by the UGV operator.
- SC3-UC1-OBJ1-KPI1-SC1: Mobile platform is able to load its mission and start its operation in a time below 15 minutes.

This will be the most complex test. It comprises the implementation test and validation of correctness of many individual implementation details regarding autonomous navigation, handling of mission execution and the ability to follow and interact with mission in progress as well as the second part, which is the actual practical UGV deployment on field.

It is important to note that most of the exercises involving UGV in demonstrations will have to be performed manually – investigation inside of the building on fire is not an action that should be performed autonomously.

While all communication that will be tested in previous tests is dependent on proper OpenJAUS protocol implementation, mission execution is the most critical part for compatibility with the NATO standard, due to the complexity of mission management defined in that architecture.

Table 18: Validation plan for UGV mission execution

Environment	Goal	Output
Laboratory	Test two-way communication connected to mission management, test context replication, test proper position transformation and reporting, test internal functionalities with OpenJAUS compatibility, test multiple waypoints missions, test mission actions, test simulators. Test implementation details such as lidar/IMU/UWB/GPS/odometry fusion, positioning transform, costmap creation, obstacle detection and avoidance, path generation.	Mission execution data.
Outdoor controlled	Test mission execution without simulators – one and multiple waypoints, test action execution, test mission start/stop/error, test reloading missions, test	Mission execution data.

	connection breaking behaviour, test global positioning correction mechanisms, test range. Test autonomous capabilities such as pathfinding and obstacle detection and avoidance. Perform example missions.	
Real	Autonomous travel will mostly be used during the demonstrations for transit from one point of interest to another, but all functionalities tested in the controlled environment will be utilized by the operator even during manual execution of the tasks.	Mission execution data.

4.4 Tests vs objectives traceability

Table 19: Tests vs. objective traceability matrix for UGV component

Validation plan / Objectives	4.3.1	4.3.2	4.3.3	4.3.4	4.3.5	4.3.6	4.3.7	4.3.8	4.3.9
SC1-UC1-OBJ2-KPI1-SC1									X
SC1-UC3-OBJ1-KPI1-SC1	X								
SC1-UC3-OBJ1-KPI2-SC1		x							
SC2-UC1-OBJ1-KPI1-SC1				X	X				
SC2-UC1-OBJ1-KPI2-SC1				X	X				
SC2-UC1-OBJ2-KPI1-SC1							X		
SC2-UC1-OBJ2-KPI2-SC1		X							
SC2-UC1-OBJ2-KPI3-SC1			X						
SC2-UC1-OBJ2-KPI4-SC1					X	X	X	X	
SC2-UC3-OBJ1-KPI1-SC1	X								
SC2-UC6-OBJ1-KPI1-SC1		X							X

SC2-UC6-OBJ1-KPI2-SC1			X						
SC2-UC6-OBJ1-KPI3-SC1					X	X	X	X	
SC2-UC6-OBJ1-KPI3-SC1									
SC3-UC1-OBJ1-KPI1-SC1				X	X				X
SC3-UC1-OBJ1-KPI2-SC1				X	X				
SC3-UC1-OBJ2-KPI1-SC1		X							
SC3-UC1-OBJ2-KPI2-SC1					X	X	X	X	
SC3-UC2-OBJ1-KPI1-SC1	X								
SC3-UC3-OBJ1-KPI1-SC1	X								

5 CBRN validation plan

5.1 Objectives and requirements traceability

During the deliverable D2.3 - ASSISTANCE Reference Scenarios and Pilot Experiments Specifications the objectives regarding the CBR_XXX requirements were set. In Table 21 all the objectives related to the module are listed. As can be seen, there are objectives regarding pilot scenario 2 to be carried out in ASSISTANCE project.

Some of these requirements were not linked, and they have been linked with the correct objective, see Table 20.

Table 20: Relation of CBRN requirements not correlated in D2.3

Requirement ID	Description	Link
CBR_007	The CBRN module should be suitable for training.	Related to training (D6.4)
CBR_013	The CBRN module can calculate the fall-out area.	As described in D5.2, this is not implemented. The module calculates the hazards of toxic gases. Gases have no fallout (dry deposition is not significant).

Table 21: KPIs related to the CBRN module and their traceability with the requirements.

KPI ID	Description	Req ID link	Req. Description
SC2-UC6-OBJ1-KPI1	The CBRN model calculates the proper current position of the cloud based on the available data.	CBR_006	The CBRN module dynamically calculates the current position of the hazard footprint based on real-time meteorological information, a realistic landscape, and real-time sensor information.
		CBR_001	The CBRN hazard system should listen to a central data bus (the SAS).
SC2-UC6-OBJ1-KPI2	The CBRN model has access to the current and predicted meteorological information.	CBR_004	The CBRN module dynamically predicts the position of the hazard footprint based on real-time meteorological information, a realistic landscape, and real-time sensor information.

KPI ID	Description	Req ID link	Req. Description
		CBR_006	The CBRN module dynamically calculates the current position of the hazard footprint based on real-time meteorological information, a realistic landscape, and real-time sensor information.
SC2-UC6-OBJ1-KPI3	The CBRN model has access to the relevant landscape information.	CBR_004	The CBRN module dynamically predicts the position of the hazard footprint based on real-time meteorological information, a realistic landscape, and real-time sensor information.
		CBR_006	The CBRN module dynamically calculates the current position of the hazard footprint based on real-time meteorological information, a realistic landscape, and real-time sensor information.
SC2-UC6-OBJ1-KPI4	The CBRN model calculates the proper predicted position of the cloud based on the available data.	CBR_006	The CBRN module dynamically calculates the current position of the hazard footprint based on real-time meteorological information, a realistic landscape, and real-time sensor information.
		CBR_004	The CBRN module dynamically predicts the position of the hazard footprint based on real-time meteorological information, a realistic landscape, and real-time sensor information.
		CBR_001	The CBRN hazard system should listen to a central data bus (the SAS).
SC2-UC6-OBJ1-KPI5	Based on the calculations and available measurements, the uncertainty of the cloud's position is presented.	CBR_011	The CBRN module can calculate the uncertainty of the gas cloud position.

KPI ID	Description	Req ID link	Req. Description
SC2-UC6-OBJ1-KPI5 [3]	User can decide on correct actions regarding the current and predicted position of the cloud.	CBR_005	The user should easily understand the visualization of the gas measurements on the map.
SC2-UC6-OBJ2-KPI1	The danger zone is calculated and presented on the map that is available for the officer and the infield rescuer.	CBR_008	The CBRN module can determine a danger zone, including highlighting vulnerable places such as hospitals.
		CBR_009	The CBRN module can warn the first responders about approaching the danger zone, in all phases of the emergency.
SC2-UC6-OBJ2-KPI2	The system can send a warning to the infield rescuer based on the current position of the rescuer with regards to the danger zone.	CBR_010	The CBRN module can localize and position all people and critical assets close to/in the danger zone.
		CBR_009	The CBRN module can warn the first responders about approaching the danger zone, in all phases of the emergency.
SC2-UC6-OBJ3-KPI1	Understandability by ambulance and police first responders.	CBR_005	The user should easily understand the visualization of the gas measurements on the map.
		CBR_002	Positions of gas measurements can be placed on the map of the Situational Awareness (SA_017) tool and also integrated into the Damaged Assets Location and Routing tool.
		CBR_003	The end-user shall be able to locate new gas measurements on the map of the Situational Awareness (SA_017) tool and also integrated into the Damaged Assets Location and Routing tool (ALR_002)

[3] The KPI ID has been allocated twice in D2.3 (for this KPI and the one in the row above).

KPI ID	Description	Req ID link	Req. Description
SC2-UC6-OBJ3-KPI2	The visualization can be generated and sent (via e.g., email).	CBR_014	The system shall generate a static visualization of the situation with the following information: Title mentioning the name of the gas Subtitle mentioning the time of visualization generation Map with current/predicted levels of danger.
SC2-UC6-OBJ4-KPI1	The system can give advice on the position on which measurements are needed.	CBR_011	The CBRN module can calculate the uncertainty of the gas cloud position.
		CBR_012	The CBRN module can calculate the optimal sensor position based on current prediction and measurements to gain more certainty about the position of the gas cloud.

5.2 Validation environments

This section presents the procedures to perform the test of the CBRN module validation plan. A test has not been designed for each objective, but the strategy followed has been to combine objectives related to the same group of functionalities in a single test. We distinguish three groups of functionalities:

- Calculation of current and predicted gas distribution
- Danger for FRs and for the public.
- Human-system interaction

The validation plan will be divided in three different phases/environments: the controlled modular environment, the controlled integrated environment, and the realistic, real-time and dynamic environment. At the moment of writing this plan, it is uncertain whether there will be an actual exercise ‘in the field’ in which the system can be tested. In that case, a ‘virtual’, ‘realistic’ exercise will have to be organized in which the integrated testing can be performed.

Another distinction between the two phases is that in the first and second phase, the tests may be run by the developers / designers, while in the third phase it should be operated by (trained) FR/HazMat personnel.

1) Controlled modular environment. This environment tests the performance of the functional module by itself by carrying out simulations. The data that is used as input is simulated data. The tests are standalone and mostly determine whether the basic functionalities are present.

2) Controlled integrated environment. This environment tests the performance of the functional module integrated int the ASSISTANCE infrastructure, receiving real sensor measurements and GPS positions from other modules. Integration into the ASSISTANCE infrastructure and receiving real measurement adds dynamical aspects, such as flow of sensor input, duration, and timing of calculations to the tests.
3) Realistic, real-time, dynamic environment. Finally, the realistic test will be evaluated during the final demonstrations of the project.

5.3 CBRN validation scenarios

In the following sections we present the validation plan for each of the functionalities identified regarding the CBRN module.

5.3.1 Calculation of current and predicted gas distribution

The following objectives are tested:

- SC2- UC6-OBJ1-KPI1: The CBRN model calculates the proper current position of the cloud based on the available data.
- SC2- UC6-OBJ1-KPI2: The CBRN model has access to the current and predicted meteorological information.
- SC2- UC6-OBJ1-KPI3: The CBRN model has access to the relevant landscape information.
- SC2- UC6-OBJ1-KPI4: The CBRN model calculates the proper predicted position of the cloud based on the available data.

The aim of the tests to be performed here is to show that the CBRN model calculates the proper position of the plume as a function of time and properly uses the meteorological input and relevant landscape information in its calculations.

In this set of tests, different variations of inputs with respect to the location, amount, kind of chemical and weather will be used to perform plume calculations and the output will be shown on the map as well as published via the SAS. The output will be compared to calculations done with another dispersion model (the EFFECTS model, which is well validated but not practical for real-time applications) and if there are differences, they must be small or be logically explainable by differences between the models.

Specific variations of input that the tests will be done with are:

- First a realistic 'base scenario' will be chosen.
- For each input variable of the base scenario, 3 different values will be used (one from the base scenario and, if applicable, a significantly higher and a significantly lower value (e.g., multiplied / divided by a factor of 2)
- Source locations on places with different wind speeds and wind directions
- Source locations on places with different roughness lengths

- Source location on a place where the wind speed and/or direction are predicted to change significantly within the hour.

Table 22: Validation plan for the calculation of current and predicted gas distribution

Environment	Goal	Output
Controlled modular environment	Test the calculation of the current and predicted gas distribution based on simulated data.	Data displayed on map: cloud positions (and updates of it when the meteorology changes); sensor data. Data sent into the SAS: plumes.
Controlled integrated environment	Tests the performance of the functional module integrated into the ASSISTANCE infrastructure, receiving 'real' measurements of sensors on UAVs and UGVs. Handle incoming data stream.	Data displayed on map: cloud positions (and updates of it when the meteorology changes); sensor data. Data sent into the SAS: plumes.
Realistic, real-time, dynamic environment	Correct performance of the system during a real, complex, and dynamic scenario. Evaluation of achieving operational goals (improved situational awareness)	(Same outputs as above, but:) Data is received more irregularly and with other frequency.

5.3.2 Danger for FRs and for the public

The following objectives are tested:

- SC2- UC6-OBJ2-KPI1: The danger zone is calculated and presented on the map that is available for the officer and the infield rescuer.
- SC2-UC6-OBJ2-KPI2: The system can send a warning to the infield rescuer based on the current position of the rescuer with regards to the danger zone.

The aim of these tests is to show the integration of the calculation of the danger zone and current position of FRs and of the messaging functionality if the FRs are in the danger zone.

The test consists of several steps: first, for this test, we assume that the current position of the gas distribution is calculated and put on the map (as tested previously, see Section 5.3.1). The following aspects are tested:

- Integration of the FRs' position. Via an external module, the GPS position is sent. The module receives the GPS positions; the positions are also published via SAS. The FRs can see the positions plotted on the map. Updates of the positions are received by the module and updated on the map and in the system.
- Vulnerable places. The module receives the data regarding vulnerable places from an external system. The vulnerable places are published in SAS and plotted on the map. The FRs can set a filter to show particular vulnerable places (e.g., hospitals).
- Danger zone. The GPS position of FRs is shown on the map. If a FR moves into the current position of the gas cloud, a message is sent to the FR to warn about the danger.

Table 23: Validation plan for danger for FRs.

Environment	Goal	Output
Controlled modular environment	Test whether the GPS positions and vulnerable places can be received and shown on the map. Validate determination of danger according to GPS position and danger zone and warning FRs.	Data displayed on map: cloud position (with danger levels); positions of own personnel. Data sent into the SAS: plumes, warnings. Message sent to smart phone of FRs in danger zone.
Controlled integrated environment	n/a	n/a

Realistic, real-time, dynamic environment	Correct performance of the system during a real scenario. The FR not only receives the expected information, understands it and is able to make right decisions.	Data displayed on map: cloud position (with danger levels); positions of own personnel. Data sent into the SAS: plumes, warnings. Message sent to smart phone of FRs in danger zone or when entering the danger zone.

5.3.3 Human-system interaction

The following objectives are tested:

- SC2- UC6-OBJ1-KPI5 – v1: Based on the calculations and available measurements, the uncertainty of the cloud's position is presented.
- SC2- UC6-OBJ1-KPI5 – v2: User can decide on correct actions regarding the current and predicted position of the cloud.
- SC2- UC6-OBJ3-KPI1: Understandability by ambulance and police first responders.
- SC2- UC6-OBJ3-KPI2: The visualization can be generated and sent (via e.g., email).
- SC2- UC6-OBJ4-KPI1: The system can give advice on the position on which measurements are needed.

The aim of these tests is to validate whether the module is understandable and usable and to validate different ways of interaction with the end user.

The test consists of different steps: first, the end user can select different visualizations of the predicted position of the gas cloud, with one visualization showing the uncertainty of the cloud's position (SC2- UC6-OBJ1-KPI5). The different visualizations support different FRs' roles in their decision-making process (depending on their expertise, different visualizations are more applicable; SC2- UC6-OBJ3-KPI1; SC2- UC6-OBJ1-KPI5). After generation of a visualization, an end user can send the information/visualization (via mail) to another person (SC2- UC6-OBJ3-KPI2). In addition, the system gives advice on the position on which measurements are needed (SC2- UC6-OBJ4-KPI1).

To validate the above objectives, a usability test with end users (hazard experts) has been executed, asking about understandability of the uncertainty information.

Table 24: Validation plan for human-system interaction.

Environment	Goal	Output
Controlled modular environment	Validate general understandability of uncertainty presentation and general functions.	Usability test. Experiment on visualization of uncertainty: output preferred visualization to support understanding and interpretation of uncertainty. On map: visualization of uncertainty of predicted cloud; advice on the position on which measurements are needed to lessen uncertainty. Email sent with visualization.
Controlled integrated environment	n/a	n/a
Realistic, real-time, dynamic environment	Correct performance of the system during a real scenario. The FR not only receives the expected information, understands it and is able to make right decisions.	On map: visualization of uncertainty of predicted cloud; advice on the position on which measurements are needed to lessen uncertainty. Email sent with visualization. Evaluation of correct decisions taken during scenario. Evaluation of situation awareness during scenario.

5.4 Tests vs objectives traceability

Table 25: Tests vs. objective traceability for CBRN component

Validation plan / Objectives	Calculation of current and predicted gas distribution	Danger for FRs	Human-system interaction
SC2- UC6-OBJ1-KPI1	x		
SC2- UC6-OBJ1-KPI2	x		
SC2- UC6-OBJ1-KPI3	x		
SC2- UC6-OBJ1-KPI4	x		
SC2- UC6-OBJ1-KPI5 – v1			x
SC2- UC6-OBJ1-KPI5 -v2			x
SC2- UC6-OBJ2-KPI1		x	
SC2-UC6-OBJ2-KPI2		x	
SC2- UC6-OBJ3-KPI1			x
SC2- UC6-OBJ3-KPI2			x
SC2- UC6-OBJ4-KPI1			x

6 Communications validation plan

This section will show how the telecommunication infrastructure set in place for the emergency scenarios have performed and matched all proposed requirements.

6.1 Objectives and requirements traceability

Table 26: KPIs related with communications and their traceability with requirements

KPI ID	Description	Requirement ID	Description
SC1-UC2-OBJ1-KPI1 SC2-UC2-OBJ1-KPI1-SC1 SC3-UC4-OBJ1-KPI1-SC1	User devices will connect to the WiFi network and video flows will be transmitted to the destination.	COM_001	Maximum Global Capacity = 2Mbps
		COM_002	Video Streaming Quality Supported (indicative) = H.264 UDP
		COM_003	Maximum Delay = 850ms
		COM_004	Availability High Availability (4G - LTE)
		COM_005	Physical Interfaces for End Users (units on the field) = Wi-Fi and Ethernet
		COM_006	Physical Interfaces for C2 Users = Ethernet
		COM_007	Communication Field Node - C2 = TCP/IP L3
		COM_008	Remote User to Nomadic Centre communication protocol = Wi-Fi or other radio
		COM_009	UAV to ground communication = Ethernet cable or Wi-Fi
		COM_010	Security protocol to encrypt IP communication = IPSec

6.2 Validation environments

Criteria have been validated during testing campaigns run in Switzerland with the use of an ad hoc vehicle built for mobile satcom + 4G backbone connectivity and offering wireless last mile to the users with the use of digital tactical meshed radios belonging to the Viasat/Trellisware family. A radio working as local repeater have been attached to a flying device to extend the requested range of communication away from the main communication hub. Please verify in D2.2 the details about the test performed.

6.3 Communications validation scenarios

In the following sections we present the validation plan for each of the functionalities identified regarding the communication module. Field test have been conducted in order to simulate the conditions reported in all the three emergency scenarios:

- Earthquake
- Industrial disaster
- Terrorist Attack

The long range and local telecommunication requirements for all these three scenarios coincided, so the test has been performed in the same way during all the scenario simulations.

6.4 Tests vs objectives traceability

Table 27: Tests vs. objective traceability for communications component

Validation Scenario / Objectives	Earthquake	Industrial Disaster	Terrorist Attack
SC1-UC2-OBJ1-KPI1	X	X	X
SC2-UC2-OBJ1-KPI1-SC1	X	X	X
SC3-UC4-OBJ1-KPI1-SC1	X	X	X

7 SAS validation plan

7.1 Objectives and requirements traceability

This section is aimed at listing every KPI related to the Sensors abstraction Service. Based on the D2.3 ASSISTANCE Reference Scenarios and Pilot Experiments specifications, it was identified that there are some requirements that belong to the architectural definition of the SAS and cannot be linked to its main functionalities. Even though these requirements have been successfully implemented, as depicted in D3.2, they cannot be validated by the means of operational testing, as it is the scope of this validation plan. These requirements are:

- SAS_004: The SAS is mission oriented. The mission begins from the moment the incident is declared until it resolves.
- SAS_010: The most relevant indicators will be shown on the map. This will allow calculating the routes of access or evacuation.
- SAS_013: The messages communicated via the data bus should be defined as schemas (e.g., Apache AVRO).
- SAS_014: The services of the modules that are developed should be available via Docker images.

In the first case, SAS_004 cannot be validated through operational testing. It should be updated based on the current stage of development in ASSISTANCE. During the development phase, it was decided that the data model for all messages handled by the SAS should include a mandatory field “context” that links every message with the corresponding incident (it was not called "mission" because the concept of mission is used to designate the path and actions that a UAV/UGV performs autonomously). Therefore, it cannot be stated that “the SAS is mission oriented” since it is composed by several microservices for its correct operation, enabling the different interfaces to inject and consume data, etc. that are totally independent of the concept of “mission” or “context”. This is a substantially better approach to allowing efficient data exchanges.

Regarding SAS_010: It states that indicators should be “shown on the map”. However, the SAS definition did not foresee a GUI with a map and there are many ASSISTANCE tools whose interface has a map (DALR, EM, SAP, CHT, MMM...). Moreover, the calculation of access and evacuation routes belongs to the DALR module, and there are specific requirements for this tool such as ALR_004 (The tool will be able to calculate possible safe evacuation routes and safe access routes for emergency services to critical areas) or ALR_009 (The tool will calculate in real-time routes status and access times to the emergency points). For this reason, this requirement is not applicable to the SAS. In the case of SAS_013 and SAS_014, they are implemented (SAS_013 using JSON Schema specification) but it is not possible to define a validation plan for these requirements within the scope of this deliverable.

On the other hand, requirements SAS_007 and SAS_008, that refer to video-related functionalities are also not included in this section but in the Damaged Assets Location and Routing module validation plan as these features were finally extracted from the SAS itself. The appropriate explanation can be found in section 9.1.1.

Finally, it has been found that the requirement SAS_002 was not linked to SC2-UC1-OBJ1 in D2.3 but it is considered that it should be linked to SC2-UC1-OBJ1-KPI2-SC1. Furthermore, the requirement states that the SAS will provide an API REST for the sensors to insert data but the SAS also provides other interfaces and it has been agreed that is more appropriate to do this via MQTT. **¡Error! No se encuentra el origen de la referencia.** shows the KPIs and requirements that will be part of the SAS validation plan:

Table 28: KPIs related with SAS and their traceability with the requirements

KPI ID	Description	Req ID link	Req. Description
SC1-UC3-OBJ1-KPI1-SC1	The SAS has an API REST service that allows the insertion of the information of the UAVS, UGVs and FRs wearable sensors, which is sent in different formats and standards	SAS_002	The SAS will provide an API REST service to insert data from the sensors and telemetry from Unmanned Ground Vehicle/ Unmanned Aerial Vehicle (UGV/UAV)
SC2-UC3-OBJ1-KPI1-SC1		SAS_006	Metric definition must be provided in the cases that are required
SC3-UC2-OBJ1-KPI1-SC1		SAS_011	The sensors should publish their data to a central data bus (the SAS)
SC1-UC3-OBJ1-KPI3-SC1	The SAS structure is flexible and agnostic, so it can provide interoperability to different types of sensors and different data formats	SAS_005	The structure will be agnostic and flexible
SC2-UC3-OBJ1-KPI3-SC1			
SC3-UC2-OBJ1-KPI3-SC1			
SC1-UC3-OBJ2-KPI1-SC1	The SAS stores the information of the UAVS, UGVs and FRs wearable sensors, allowing the ASSISTANCE tools to consult status and historical data	SAS_001	The platform, Sensor Abstraction Service (SAS), will store information from sensors and display it in a useful way
SC2-UC3-OBJ2-KPI1-SC1			
SC3-UC2-OBJ2-KPI1-SC1		SAS_003	The SAS will provide an API REST service to consult status and historical data

KPI ID	Description	Req ID link	Req. Description
SC2-UC1-OBJ1-KPI2-SC1	Mobile platform is able to transmit the gas measurements and the ASSISTANCE framework receives this information in the specific format	SAS_002	The SAS will provide an API REST service to insert data from the sensors and telemetry from Unmanned Ground Vehicle/ Unmanned Aerial Vehicle (UGV/UAV)
SC2-UC1-OBJ2-KPI4-SC1	UGV is able to transmit sensor readings and the ASSISTANCE framework receives this information in the specific format	SAS_002	The SAS will provide an API REST service to insert data from the sensors and telemetry from Unmanned Ground Vehicle/ Unmanned Aerial Vehicle (UGV/UAV)
SC3-UC1-OBJ1-KPI2-SC1	UAVs/UGVs are able to transmit the gas measurements and the ASSISTANCE framework receives this information in the expected format	SAS_002	The SAS will provide an API REST service to insert data from the sensors and telemetry from Unmanned Ground Vehicle/ Unmanned Aerial Vehicle (UGV/UAV)

7.2 Validation environments

From the SAS perspective, there is no need to define several validation environments as it is available 24/7 and its operation does not depend on any external situation. The tests to be carried out are independent of whether the interaction with the SAS is performed in the laboratory, with controlled conditions or during actual demonstrations.

7.3 SAS validation scenarios

7.3.1 Data injection interfaces

Testing this feature will validate the following KPIs:

- SC1-UC3-OBJ1-KPI1-SC1, SC2-UC3-OBJ1-KPI1-SC1, SC3-UC2-OBJ1-KPI1-SC1: The SAS has an API REST service that allows the insertion of the information of the UAVS, UGVs and FRs wearable sensors, which is sent in different formats and standards.
- SC2-UC1-OBJ1-KPI2-SC1: Mobile platform is able to transmit the gas measurements and the ASSISTANCE framework receives this information in the specific format.
- SC2-UC1-OBJ2-KPI4-SC1: UGV is able to transmit sensor readings and the ASSISTANCE framework receives this information in the specific format.

- SC3-UC1-OBJ1-KPI2-SC1: UAVs/UGVs are able to transmit the gas measurements and the ASSISTANCE framework receives this information in the expected format.

Although the first linked requirements mention the API, it was agreed to use MQTT as the main interface for data injection, especially for devices that require lightweight communications such as UAVs, UGVs and wearable sensors. During this test, sensor measurements from any of these devices shall be sent to the SAS so the message will be processed and stored. A dedicated software can be used to inspect the database such as NoSQLBooster (https://nosqlbooster.com/) to check that the SAS successfully processes the information.

Table 29: Validation plan for SAS data injection interfaces

Goal	Output
Successfully process data received through the SAS dedicated interfaces	SAS processes the received measurements

7.3.2 Agnostic data storage

This set of tests will validate the following KPIs:

- SC1-UC3-OBJ1-KPI3-SC1, SC2-UC3-OBJ1-KPI3-SC1, SC3-UC2-OBJ1-KPI3-SC1: The SAS structure is flexible and agnostic, so it can provide interoperability to different types of sensors and different data formats.

The test shall consist of the successful transmission of heterogeneous data from a UAV and a UGV, such as telemetry (that will have specific fields depending on the type of resource) and any other sensor data (gas, temperature…). The same software mentioned above can be used to check that the data is successfully stored by the SAS.

Table 30: Validation plan for SAS agnostic data storage

Goal	Output
Store data coming from different types of sensors	Successful data storage

7.3.3 Status and historical data of resources and sensors

This set of tests will validate the following KPIs:

- SC1-UC3-OBJ2-KPI1-SC1, SC2-UC3-OBJ2-KPI1-SC1, SC3-UC2-OBJ2-KPI1-SC1: The SAS stores the information of the UAVS, UGVs and FRs wearable sensors, allowing the ASSISTANCE tools to consult status and historical data.

For this test, only one UAV/UGV needs to send its telemetry data and measurements from a sensor. Inspecting the database will allow to verify that each time a message is received, the last status of the resource or the sensor is updated but also a new document is inserted in the corresponding historical data collection.

Table 31: Validation plan for SAS status and historical data of resources and sensors

Goal	Output
Store (and be able to read) current status and historical data of resources and sensors	Status and historical data are stored

7.4 Tests vs objectives traceability

Table 32: Tests vs. objective traceability for SAS component

Validation plan / Objectives	Data injection interfaces	Agnostic data storage	Status and historical data of resources and sensors
SC1-UC3-OBJ1-KPI1-SC1	X		
SC1-UC3-OBJ1-KPI3-SC1		X	
SC1-UC3-OBJ2-KPI1-SC1			X
SC2-UC3-OBJ1-KPI1-SC1	X		
SC2-UC3-OBJ1-KPI3-SC1		X	
SC2-UC3-OBJ2-KPI1-SC1			X
SC3-UC2-OBJ1-KPI1-SC1	X		

SC3-UC2-OBJ1-KPI3-SC1		X	
SC3-UC2-OBJ2-KPI1-SC1			X
SC2-UC1-OBJ1-KPI2-SC1	X		
SC2-UC1-OBJ2-KPI4-SC1	X		
SC3-UC1-OBJ1-KPI2-SC1	X		

8 Mission Planner and Management validation plan

This section explains the validation plan regarding Mission Planner and Management Module. Hence, the designed validation plan covers a wide range of possibilities and situations, engaging the system to work according to requirements during demonstrations.

8.1 Objectives and requirements traceability

The deliverable D2.3 - ASSISTANCE Reference Scenarios and Pilot Experiments Specifications set the objectives that met the MIS_XXX requirements. Table 34 lists all the objectives related to the MPM module. Moreover, there were a total of 7 requirements captured in D2.2. Some of these requirements were not linked, and so they have been linked with the correct objective, see Table 33.

Table 33: Relation of MPM requirements not correlated in D2.3

Requirement ID	Description	Link
MIS_001	The ASSISTANCE system will enable the user to manually select the shooting points requested for each object of interest by first selecting the positions of the shooting points and then linking it to the object of interests (for instance a burning gas station)	SC2-UC6-OBJ1
MIS_002	ASSISTANCE MIS managing the user profile: End-user, UAV operator	SC2-UC6-OBJ1
MIS_006	MIS is creating a detailed mission request (including the flight plan for the UAV).	SC2-UC6-OBJ1

Table 34: KPIs related with MPM and their traceability with the requirements.

KPI ID	Description	Req ID link	Req. Description
SC2-UC6-OBJ1-KPI1-SC1	When mission is deployed in SA application, it should be sent to and received by UGV operator.	MIS_001	The ASSISTANCE system will enable the user to manually select the shooting points requested for each object of interest by first selecting the positions of the shooting points and then linking it to the object of interests (for instance a burning gas station)
		MIS_002	ASSISTANCE MIS managing the user profile: End-user, UAV operator
		MIS_003	MIS enables the user to create a Mission request and to assign a UAV or a land assistance reconnaissance vehicle

KPI ID	Description	Req ID link	Req. Description
		MIS_004	MIS shall be able to manage UAVs and land assistance vehicles missions for reconnaissance purpose.
		MIS_006	MIS is creating a detailed mission request (including the flight plan for the UAV).
		MIS_007	Once the mission request is validated by the end-user, it is sent to either the UAV ground station or the land vehicle. MIS shall also handle the acknowledgement validation to be sent by the platform.
SC2-UC6-OBJ2-KPI1-SC1	Video is captured, sent and displayed for UGV operator on HMI console	MIS_005	Automatic and / or manual mode allocation of a UAV or land vehicle with shooting points

8.2 Validation environments

This section presents the procedures to perform the test of the MPM. This module is a software environment. The validation plan is organized regarding the type of drone (UAV or UGV). Validation plan is divided in two phases: virtual environment and real environment.

1) Virtual environment:

All piece of software provided by THALES and Viasat are installed on the cloud. These sub-modules can communicate together and with SAS.

2) Pilots and demonstrator location:

Finally, the real test will be evaluated during the final demonstrations of the project.

8.3 Mission Planner and management validation scenarios

In this section, the validation plan for both types of drones identified is presented.

8.3.1 UAV Mission Plan Computation

This test will validate the following KPIs:

- SC2-UC6-OBJ1-KPI1-SC1: When mission is deployed in SA application, it should be sent to and received by UGV operator.
- SC2-UC6-OBJ2-KPI1-SC1: Video is captured, sent, and displayed for UGV operator on HMI console.

The objective of the test is to validate the capability to build a specific mission for UAVs. Once the context of the mission is defined (UAV initial location, Targets, Forbidden areas), the module will compute the path of each UAV to perform the mission. As soon as the mission is computed, this mission is sent to each Ground Station through the SAS.

During the test, special attention is paid to the format of the messages that are exchanged with SAS to make sure that the module is compliant with the definition.

Table 35: Validation plan for MPM UAV mission plan computation

Environment	Goal	Output
Virtual	Define the context of the mission. Check the computed mission plan for a list of UAV (waypoints and trigger points) Send mission to the Ground Station	Message Mission
Real	UAV will perform the mission computed by MPM	Message Mission

8.3.2 UGV Mission Plan Computation

This test will validate the following KPIs:

- SC2-UC6-OBJ1-KPI1-SC1: When mission is deployed in SA application, it should be sent to and received by UGV operator.
- SC2-UC6-OBJ2-KPI1-SC1: Video is captured, sent, and displayed for UGV operator on HMI console.

The objective of the test is to validate the capability to build a specific mission for UGV. Once the context of the mission is defined (UGV initial location, Targets, Forbidden areas), the module will compute the path of each UGV to perform the mission. As soon as the mission is computed, this mission is sent to each Ground Station through the SAS.

During the test, a special attention is paid on the format of the message that are exchanged with SAS to be sure that the module is compliant with the definition.

Table 36: Validation plan for MPM UGV mission plan computation

Environment	Goal	Output
Virtual	Define the context of the mission. Check the computed mission plan for a list of UGV (waypoints and trigger points) Send mission to the Ground Station	Message Mission

Real	UGV will perform the mission computed by MPM	Message Mission

8.4 Tests vs objectives traceability

This section gives an overview of the traceability matrix.

Table 37: Tests vs. objective traceability matrix for MPM component

Validation plan / Objectives	UAV Mission Plan Computation	UGV Mission Plan Computation
SC2-UC6-OBJ1-KPI1-SC1	X	X
SC2-UC6-OBJ2-KPI1-SC1	X	X

9 Damaged Assets Location and Routing validation plan

The Damaged Assets Location and Routing module has two main components: Damaged Assets Location and Evacuation Management. Therefore, a dedicated subsection is included in the next sections to describe the specific validation plan defined for each of the two modules.

9.1 Objectives and requirements traceability

9.1.1 Damaged Assets Location and Routing

This module also includes the Video Manager as an auxiliary service, responsible for processing and storing video streaming from UGVs and UAVs as well as serving the corresponding files to the applications that request them. During the requirements definition phase, this functionality was included as part of SAS but, during development and implementation, it was agreed to extract it to a separate microservice. The main reason is that SAS is an agnostic platform that receives messages through the possible interfaces and stores the information in database; on the contrary, this functionality requires a specific service (Shinobi Open Source CCTV) to consume the video streaming and store the physical video files on disk. For this reason, the Table 38 includes requirements with the prefix "SAS_".

Moreover, after analysing the description of the Success Criteria, we have found that SC1-UC3-OBJ2-KPI2-SC1 (The SAS provides a video record of the different visual sensors, which can be accessed in real-time and also replayed later for forensic and training purposes), although it includes a few more words in its description, shares exactly the same objective with SC2-UC3-OBJ2-KPI2-SC1 and SC3-UC2-OBJ2-KPI2-SC1 (The SAS provides a video record of the different visual sensors, which can be accessed in real-time and also replayed later). For this reason, in the following sections the 3 Success Criteria are unified with the same description where appropriate.

Table 38: KPIs related with DALR and their traceability with the requirements.

KPI ID	Description	Req ID link	Req. Description
SC1-UC3-OBJ1-KPI2-SC1	Video streaming can be inserted in the SAS and accessed through the infrastructure	SAS_002	The SAS will provide an API REST service to insert data from the sensors and telemetry from Unmanned Ground Vehicle/ Unmanned Aerial Vehicle (UGV/UAV)
SC2-UC3-OBJ1-KPI2-SC1			
SC3-UC2-OBJ1-KPI2-SC1			
SC1-UC3-OBJ2-KPI2-SC1	The SAS provides a video record of the different visual sensors, which can be	SAS_007	The SAS will provide a video record of the different visual sensors

KPI ID	Description	Req ID link	Req. Description
SC2-UC3-OBJ2-KPI2-SC1	accessed in real-time and also replayed later	SAS_008	Video streaming could be accessed through the infrastructure. The videos can also be accessed later
SC3-UC2-OBJ2-KPI2-SC1			
SC1-UC5-OBJ2-KPI1-SC1	Damaged assets and infrastructures can be marked on the GIS map	ALR_001	The tool will have a user-friendly, intuitive Graphical User Interface
SC2-UC5-OBJ2-KPI1-SC1		ALR_002	The tool will allow users to input emergency parameters (type and location), evacuation areas and shelters (location and capacity), damaged infrastructures (location, damage type and risks) and areas with new gas measurements
SC3-UC6-OBJ2-KPI1-SC1		ALR_003	The tool will have a GIS-based system
SC2-UC5-OBJ3-KPI1-SC1	Toxic areas can be marked on the GIS map	ALR_001	The tool will have a user-friendly, intuitive Graphical User Interface
		ALR_002	The tool will allow users to input emergency parameters (type and location), evacuation areas and shelters (location and capacity), damaged infrastructures (location, damage type and risks) and areas with new gas measurements
		ALR_003	The tool will have a GIS-based system
SC3-UC1-OBJ2-KPI2-SC1	UAVs/UGVs are able to transmit live-video and the ASSISTANCE framework receives this information in the specific format	SAS_002	The SAS will provide an API REST service to insert data from the sensors and telemetry from Unmanned Ground Vehicle/ Unmanned Aerial Vehicle (UGV/UAV)

9.1.2 Evacuation Management

Table 39: KPIs related with EM and their traceability with the requirements.

KPI ID	Description	Req ID link	Req. Description
SC1-UC5-OBJ1-KPI1-SC1	The ALR tool receives and integrates the request of accessing/evacuating route, which contains the status of the First Responders and potential risks.	ALR_002	The tool will allow users to input emergency parameters (type and location), evacuation areas and shelters (location and capacity), damaged infrastructures (location, damage type and risks) and areas with new gas measurements.
		ALR_005	The tool requires FRs status information (location, available units and type) to calculate dynamically safe routes.
		ALR_007	The tool will allow users to explore fictitious emergencies to develop previous plans.
SC1-UC5-OBJ2-KPI2-SC1	Damaged assets and infrastructures are considered for the calculation of optimum routes by the ALR tool.	ALR_001	The tool will have a user-friendly, intuitive Graphical User Interface.
		ALR_002	The tool will allow users to input emergency parameters (type and location), evacuation areas and shelters (location and capacity), damaged infrastructures (location, damage type and risks) and areas with new gas measurements.
		ALR_003	The tool will have a GIS-based system.
SC1-UC5-OBJ3-KPI1-SC1	The First Responders are able to reach the desired location and evacuate people using a safe route, minimizing risks, and avoiding damaged infrastructures, which optimizes the operation time and the FRs safety.	ALR_003	The tool will have a GIS-based system.
		ALR_004	The tool will be able to calculate possible safe evacuation routes and safe access routes for emergency services to critical areas.
		ALR_006	The tool provides real-time results.

KPI ID	Description	Req ID link	Req. Description
		ALR_009	The tool will calculate in real-time routes status and access times to the emergency points.
SC2-UC5-OBJ1-KPI1-SC1	The ALR tool receives and integrates the request of accessing/exit route, which contains status of the First Responders and potential risks.	ALR_002	The tool will allow users to input emergency parameters (type and location), evacuation areas and shelters (location and capacity), damaged infrastructures (location, damage type and risks) and areas with new gas measurements.
		ALR_005	The tool requires FRs status information (location, available units and type) to calculate dynamically safe routes.
		ALR_007	The tool will allow users to explore fictitious emergencies to develop previous plans.
SC2-UC5-OBJ2-KPI2-SC1	Damaged assets and infrastructures are considered for the calculation of optimum routes by the ALR tool.	ALR_001	The tool will have a user-friendly, intuitive Graphical User Interface.
		ALR_002	The tool will allow users to input emergency parameters (type and location), evacuation areas and shelters (location and capacity), damaged infrastructures (location, damage type and risks) and areas with new gas measurements.
		ALR_003	The tool will have a GIS-based system.
SC2-UC5-OBJ3-KPI2-SC1	Toxic areas are considered for the calculation of optimum routes by the ALR tool.	ALR_001	The tool will have a user-friendly, intuitive Graphical User Interface.
		ALR_002	The tool will allow users to input emergency parameters (type and location), evacuation areas and shelters (location and capacity), damaged infrastructures (location, damage type and risks) and areas with new gas measurements.

KPI ID	Description	Req ID link	Req. Description
		ALR_003	The tool will have a GIS-based system.
SC2-UC5-OBJ4-KPI1-SC1	The First Responders are able to reach the desired location (in or out of the incident area) using a safe route, minimizing risks, and avoiding damaged infrastructures and toxic gases, which optimizes the evacuation time and the FRs safety.	ALR_003	The tool will have a GIS-based system.
		ALR_004	The tool will be able to calculate possible safe evacuation routes and safe access routes for emergency services to critical areas.
		ALR_006	The tool provides real-time results.
		ALR_009	The tool will calculate in real-time routes status and access times to the emergency points.
		SAS_010	The most relevant indicators will be shown on the map. This will allow calculating the routes of access or evacuation.
SC3-UC6-OBJ1-KPI1-SC1	The ALR tool receives and integrates the request of evacuation route, which contains status of the people to be evacuated and potential risks.	ALR_002	The tool will allow users to input emergency parameters (type and location), evacuation areas and shelters (location and capacity), damaged infrastructures (location, damage type and risks) and areas with new gas measurements.
		ALR_005	The tool requires FRs status information (location, available units and type) to calculate dynamically safe routes.
		ALR_007	The tool will allow users to explore fictitious emergencies to develop previous plans.
SC3-UC6-OBJ2-KPI2-SC1	Damaged assets and infrastructures and toxic areas are considered for the	ALR_001	The tool will have a user-friendly, intuitive Graphical User Interface.

KPI ID	Description	Req ID link	Req. Description
	calculation of optimum evacuation routes by the ALR tool	ALR_002	The tool will allow users to input emergency parameters (type and location), evacuation areas and shelters (location and capacity), damaged infrastructures (location, damage type and risks) and areas with new gas measurements.
		ALR_003	The tool will have a GIS-based system.
SC3-UC6-OBJ3-KPI1-SC1	The medical emergency services are able to reach the hospital using a safe route, minimizing risks, and avoiding damaged infrastructures, which optimize the evacuation time.	ALR_003	The tool will have a GIS-based system.
		ALR_004	The tool will be able to calculate possible safe evacuation routes and safe access routes for emergency services to critical areas.
		ALR_006	The tool provides real-time results.
		ALR_009	The tool will calculate in real-time routes status and access times to the emergency points.
SC3-UC8-OBJ1-KPI1-SC1	Request of evacuation under particular scenario conditions defined by the type of attack in real time is properly integrated in the ALR tool.	ALR_002	The tool will allow users to input emergency parameters (type and location), evacuation areas and shelters (location and capacity), damaged infrastructures (location, damage type and risks) and areas with new gas measurements.
		ALR_005	The tool requires FRs status information (location, available units and type) to calculate dynamically safe routes.
		ALR_011	The tool should allow changes in the scenario depending on the emergency time evolution.
SC3-UC8-OBJ2-KPI2-SC1	Damaged assets and infrastructures are considered for the	ALR_001	The tool will have a user-friendly, intuitive Graphical User Interface.

KPI ID	Description	Req ID link	Req. Description
	calculation of optimum evacuation routes by the ALR tool.	ALR_002	The tool will allow users to input emergency parameters (type and location), evacuation areas and shelters (location and capacity), damaged infrastructures (location, damage type and risks) and areas with new gas measurements.
		ALR_003	The tool will have a GIS-based system.
SC3-UC8-OBJ3-KPI1-SC1	The Available Safe Egress Time (ASET) does not exceed the Required Safe Egress Time (RSET).	ALR_003	The tool will have a GIS-based system.
		ALR_004	The tool will be able to calculate possible safe evacuation routes and safe access routes for emergency services to critical areas.
		ALR_006	The tool provides real-time results.
		ALR_008	The tool will calculate approximate evacuation times using emergency particular parameters and historical demographic data.
		ALR_009	The tool will calculate in real-time routes status and access times to the emergency points.

9.2 Validation environments

9.2.1 Damaged Assets Location and Routing

After defining the different functionalities of the DALR that will allow to validate all the related KPIs and objectives, it has been decided that it will not be necessary to specify different test environments except for the first functionality related with video streaming processing, for which the validation plan is divided in two different environments:

1) Controlled tests:

In this phase, the Video Manager will be manually controlled to process the video streaming sent by the UAVs/UGVs both from the laboratory and during their controlled tests.

2) Real demonstrations:

During the final demonstrations of the project, the Video Manager will run in an automated manner and UAVs/UGVs will start and stop the video processing through the dedicated API when appropriate.

9.2.2 Evacuation Management

Two validation environments are considered to test the EM functionalities:

1) Laboratory environment:

The laboratory tests for the DALR-EM module will be performed by UC, using a set of historical events. This historical use cases of previous disasters allows to test through simulations, the proper operation of all the models which compose the comprehensive system. The selected disasters are strongly related with the practical demonstrations and are used to validate in a theoretical way all the functionalities provided by the module.

2) Realistic environment:

Realistic test will be evaluated during the final stage of the project in the different scheduled practical demonstrations.

9.3 Damaged Assets Location and Routing validation scenarios

9.3.1 Damaged Assets Location and Routing

In the following sections the validation plan for each of the functionalities identified regarding the DALR module is presented.

9.3.1.1 Video streaming processing

This set of tests will validate the following KPIs:

- SC1-UC3-OBJ1-KPI2-SC1, SC2-UC3-OBJ1-KPI2-SC1, SC3-UC2-OBJ1-KPI2-SC1: Video streaming can be inserted in the SAS and accessed through the infrastructure.
- SC3-UC1-OBJ2-KPI2-SC1: UAVs/UGVs can transmit live-video and the ASSISTANCE framework receives this information in the specific format.

These tests will validate the correct processing of the video streaming. As previously explained, during the controlled tests, the Video Manager service will be manually controlled to process the video sent by UAVs/UGVs, and during the real demonstrations it will be the UAVs/UGVs themselves who will start and stop remotely the processing of the video streaming through the dedicated API when appropriate.

In both cases, the GUI of Shinobi Open Source CCTV must be used, where each resource (UAV/UGV) camera must be preconfigured as a “monitor”. From there, it is possible to start and stop manually the corresponding monitor during the controlled tests and check that it receives the video streaming. During the demonstrations, the monitors will also reflect the current status and a notification will be shown each time a monitor starts or stops via the API.

Table 40: Validation plan for DALR video streaming processing

Environment	Goal	Output
Controlled tests	Process the streaming sent by UAVs/UGVs during controlled tests	Real-time video processing
Demonstrations	Process the streaming sent by UAVs/UGVs during demonstrations Start and stop the video processing through the API	Real-time video processing On-demand start and stop Video Manager

9.3.1.2 Video storage and access to recorded files

The validation of the following KPIs will be done through the tests described below:

- SC1-UC3-OBJ2-KPI2-SC1, SC2-UC3-OBJ2-KPI2-SC1, SC3-UC2-OBJ2-KPI2-SC1: The SAS provides a video record of the different visual sensors, which can be accessed in real-time and also replayed later for forensic and training purposes.

In this case, it is considered unnecessary to define tests environments because no difference in operation, input or output is expected.

After a UAV/UGV starts streaming, it will be possible to watch the corresponding video in real-time either at the above-mentioned GUI of Shinobi Open Source CCTV or opening the corresponding URL in a web browser or a specific software such as VLC media player.

Once the Video Manager is storing the streaming, the video files can also be played at any time. This can be done directly from the DALR GUI, where the operator can select the context, resource, dates and camera to watch the stored videos that match these parameters.

Table 41: Validation plan for DALR video storage

Goal	Output
Watch the streaming sent by UAVs/UGVs in real-time Reproduce stored video files on demand	Video streaming can be watched in real-time and played later

9.3.1.3 GIS-based GUI for damaged areas management

This test will validate the following KPIs:

- SC1-UC5-OBJ2-KPI1-SC1, SC2-UC5-OBJ2-KPI1-SC1, SC3-UC6-OBJ2-KPI1-SC1: Damaged assets and infrastructures can be marked on the GIS map.
- SC2-UC5-OBJ3-KPI1-SC1: Toxic areas can be marked on the GIS map.

Once again, there will be no different tests environments. The DALR GUI allows the operator to insert, modify and delete damaged assets and toxic zones, supported by the playback of recorded videos in which to detect such areas.

Table 42: Validation plan for DALR GIS based GUI

Goal	Output
Insert, update and delete damaged assets and toxic areas	Successful damaged areas management

9.3.2 Evacuation Management

9.3.2.1 Evacuation/Intervention Routing

The following objectives will be validated through the current set of tests:

- **SC1(2)-UC5-OBJ1-KPI1-SC1:** The ALR tool receives and integrates the request of accessing/evacuating route, which contains the status of the First Responders and potential risks.
- **SC1(2,3)-UC5-OBJ2-KPI2-SC1:** Damaged assets and infrastructures are considered for the calculation of optimum routes by the ALR tool.
- **SC1-UC5-OBJ3-KPI1-SC1:** The First Responders are able to reach the desired location and evacuate people using a safe route, minimizing risks, and avoiding damaged infrastructures, which optimizes the operation time and the FRs safety.
- **SC2-UC5-OBJ3-KPI2-SC1:** Toxic areas are considered for the calculation of optimum routes by the ALR tool.
- **SC2-UC5-OBJ4-KPI1-SC1:** The First Responders are able to reach the desired location (in or out of the incident area) using a safe route, minimizing risks, and

avoiding damaged infrastructures and toxic gases, which optimizes the evacuation time and the FRs safety.

- **SC3-UC6-OBJ1-KPI1-SC1:** The ALR tool receives and integrates the request of evacuation route, which contains status of the people to be evacuated and potential risks.
- **SC3-UC6-OBJ2-KPI2-SC1:** Damaged assets and infrastructures and toxic areas are considered for the calculation of optimum evacuation routes by the ALR tool.
- **SC3-UC6-OBJ3-KPI1-SC1:** The medical emergency services are able to reach the hospital using a safe route, minimizing risks, and avoiding damaged infrastructures, which optimize the evacuation time.
- **SC3-UC8-OBJ2-KPI2-SC1:** Damaged assets and infrastructures are considered for the calculation of optimum evacuation routes by the ALR tool.

The aim of these tests is to validate the proper operation of routing system avoiding damaged assets or impassable areas. Also, the integration capabilities with other modules will be tested, particularly with the CBRN module in the industrial accident pilot and the SAP and SAS platforms to test the reception of requests and storage data respectively.

These tests involve a first stage of planning where some of the KPIs are validated in terms of graphical user interface and operational functionalities. After this in a second stage a set of requests are received. These requests are generated by first responders in order to obtain the optimal routes based on the context parameters (damaged assets, routes, etc.). With these stages are the functionalities of routing will be validated and also the integration capabilities since all data produced by other modules which is used is obtained through the SAS and also the received requests.

Table 43: Validation plan for EM routing

Environment	Goal	Output
Laboratory	Test the proper operation of routing model. Test integration with other modules.	Report and acceptance of the proposed routes and the proper reception of requests.
Real	Test the proper operation of routing model under real time conditions. Test the real time data reception from other modules and the proper reception of requests.	Report and acceptance of the proposed routes and the proper reception of requests under real conditions.

9.3.2.2 Evacuation Management

The following objectives will be validated through the current set of tests:

- **SC1(2)-UC5-OBJ1-KPI1-SC1:** The ALR tool receives and integrates the request of accessing/evacuating route, which contains the status of the First Responders and potential risks.
- **SC1(2,3)-UC5-OBJ2-KPI2-SC1:** Damaged assets and infrastructures are considered for the calculation of optimum routes by the ALR tool.
- **SC1-UC5-OBJ3-KPI1-SC1:** The First Responders are able to reach the desired location and evacuate the population through safer routes, minimizing risks, and avoiding damaged infrastructures thus optimizing the operation time and the FRs safety.
- **SC2-UC5-OBJ3-KPI2-SC1:** Toxic areas are considered for the calculation of optimal routes by the ALR tool.
- **SC3-UC6-OBJ1-KPI1-SC1:** The ALR tool receives and integrates the request of evacuation route, which contains status of the people to be evacuated and potential risks.
- **SC3-UC6-OBJ2-KPI2-SC1:** Damaged assets and infrastructures and toxic areas are considered for the calculation of optimum evacuation routes by the ALR tool.
- **SC3-UC6-OBJ3-KPI1-SC1:** The medical emergency services can reach the hospital using a safe route, minimizing risks, and avoiding damaged infrastructures, which optimize the evacuation time.
- **SC3-UC8-OBJ1-KPI1-SC1:** Request of evacuation under particular scenario conditions defined by the type of attack is properly integrated in the ALR tool in real time.
- **SC3-UC8-OBJ2-KPI2-SC1:** Damaged assets and infrastructures are considered for the calculation of optimal evacuation routes by the ALR tool.
- **SC3-UC8-OBJ3-KPI1-SC1:** The Available Safe Egress Time (ASET) does not exceed the Required Safe Egress Time (RSET).

The aim of these tests is to validate the proper operation of evacuation management system providing a comprehensive evacuation plan. Also, as in the previous validated test the integration capabilities will be tested, particularly with the CBRN module in the industrial accident pilot and the SAP and SAS platforms to test the reception of requests and storage data respectively.

To validate the above functionalities, we have a case in which an operator requests the total evacuation of an area due to a specific incident, in our particular case a possible terrorist attack. The system should therefore provide not only the evacuation routes as in the previous case but also the optimal collection of assembly points and shelters as well as a complete simulation of the required evacuation times.

Table 44: Validation plan for EM

Environment	Goal	Output
Laboratory	Test the performance of the system under a complete evacuation management request.	Report and acceptance of the evacuation plan in comparison with information/data from past events.
Real	Planning prior to the event and on demand of complete evacuation plan.	Report and acceptance of the evacuation plan used by first responders under real conditions.

9.4 Tests vs objectives traceability

9.4.1 Damaged Assets Location and Routing

Table 45: Tests vs. objective traceability matrix for DALR

Validation plan / Objectives	Video streaming processing	Video storage and access to recorded files	GIS-based GUI for damaged areas management
SC1-UC3-OBJ1-KPI2-SC1	X		
SC1-UC3-OBJ2-KPI2-SC1		X	
SC1-UC5-OBJ2-KPI1-SC1			X
SC2-UC3-OBJ1-KPI2-SC1	X		
SC2-UC3-OBJ2-KPI2-SC1		X	
SC2-UC5-OBJ2-KPI1-SC1			X

SC2-UC5-OBJ3-KPI1-SC1			X
SC3-UC1-OBJ2-KPI2-SC1	X		
SC3-UC2-OBJ1-KPI2-SC1	X		
SC3-UC2-OBJ2-KPI2-SC1		X	
SC3-UC6-OBJ2-KPI1-SC1			X

9.4.2 Evacuation Management

Table 46: Tests vs. objective traceability matrix for EM

Validation plan / Objectives	Evacuation/Intervention Routing	Evacuation Management
SC1-UC5-OBJ1-KPI1-SC1	X	X
SC1-UC5-OBJ2-KPI2-SC1	X	X
SC1-UC5-OBJ3-KPI1-SC1	X	X
SC2-UC5-OBJ1-KPI1-SC1	X	X
SC2-UC5-OBJ2-KPI2-SC1	X	X
SC2-UC5-OBJ3-KPI2-SC1	X	X
SC2-UC5-OBJ4-KPI1-SC1	X	
SC3-UC5-OBJ2-KPI2-SC1		X

SC3-UC6-OBJ1-KPI1-SC1	X	X
SC3-UC6-OBJ2-KPI2-SC1	X	X
SC3-UC6-OBJ3-KPI1-SC1	X	X
SC3-UC8-OBJ1-KPI1-SC1		X
SC3-UC8-OBJ2-KPI2-SC1	X	X
SC3-UC8-OBJ3-KPI1-SC1		X

10 Adapted Situational Awareness Tools validation plan

10.1 Objectives and requirements traceability

Next table shows the requirements not traced to KPIS from this component.

Table 47: List of requirements not traced to KPIs in D2.3

Requirement ID	Description	Link
SA_019	No SA application HMI action should require more than 4 clicks.	SC1-UC4-OBJ5-KPI1-SC1 SC2-UC4-OBJ5-KPI1-SC1 SC3-UC5-OBJ5-KPI1-SC1
SA_021	System must be equipped with an online (real-time) simulation scenario editor	SC3-UC5-OBJ7-KPI2-SC1
SA_022	System must provide an interface to exchange data with UTM systems form UAVs flight planning purposes.	SC3-UC7-OBJ2-KPI2-SC1 SC3-UC7-OBJ4-KPI1-SC1
SA_023	ASSISTANCE should interface HEMS location system to visualize HEMS location and support HEMS call decisions	External interface
SA_026	ASSISTANCE should provide post-simulation/training analysis.	Related to training (D6.4)

Table 48 shows the traceability matrix between the KPI identified in D2.3 and their related requirements, defined in D2.2, for this component.

Table 48: KPIs related to Adapted Situational Awareness Tools and their traceability with requirements

KPI SC ID	SC Description	Req ID	Req Description
SC1-UC4-OBJ1-KPI1-SC1	Three HMIs adapted to the user category information needs will be shown once different FRs members access to the SAP	SA_002	ASSISTANCE should have different users' profiles stated with different kind of information assigned.
SC2-UC4-OBJ1-KPI1-SC1		SA_003	ASSISTANCE SAP HMI should provide discriminate information access depending on the FRs profile connected to the system
SC3-UC5-OBJ1-KPI1-SC1			

KPI SC ID	SC Description	Req ID	Req Description
SC1-UC4-OBJ1-KPI2-SC1	Different end users can access to the SAP using the secure access control module	SA_015	Only authorized SAP users should have access to the SA stored data
SC2-UC4-OBJ1-KPI2-SC1		SA_028	ASSISTANCE access must be secured with user authentication and authorization
SC3-UC5-OBJ1-KPI2-SC1			
SC1-UC4-OBJ3-KPI1-SC1	All Drones/Robots/vehicles/FRs icons will be shown on the SAP HMI and through these icons the commanders will be able to open the camera video flows from those assets equipped with cameras	SA_005	ASSISTANCE SAP should show real-time video flows from the connected cameras (including the ones mounted on mobile platforms) depending on the needs and restrictions, for instance bandwidth.
SC2-UC4-OBJ3-KPI1-SC1		SA_006	ASSISTANCE SAP should integrate IR cameras video flows (including IR cameras mounted on mobile platforms, if any) depending on the needs and restrictions, for instance bandwidth.
SC3-UC5-OBJ3-KPI1-SC1		SA_007	SAP should integrate the following wearable sensors for being installed on-demand in some FRs uniforms depending on their protection needs. (GPS Sensors, Personal **Video Cameras** and vital signs (including temperature sensors)
SC1-UC4-OBJ3-KPI2-SC1	Different windows will be open and different real-time video flows will be visualized in the SAP HMI.	SA_005	ASSISTANCE SAP should show real-time video flows from the connected cameras (including the ones mounted on mobile platforms) depending on the needs and restrictions, for instance bandwidth.
		SA_007	SAP should integrate the following wearable sensors for being installed on-demand in some FRs uniforms depending on their protection needs. (GPS Sensors, Personal **Video Cameras** and vital signs (including Temperature sensors)
SC1-UC4-OBJ4-KPI2-SC1	Different measurements from sensors and external information data sources	SA_004	ASSISTANCE SAP should be executed on mobile devices (e.g. tablets) and adapt its performance to these devices.

KPI SC ID	SC Description	Req ID	Req Description
SC2-UC4-OBJ4-KPI2-SC1 SC3-UC5-OBJ4-KPI2-SC1	will be visualized in the SAP HMI when commanders click on the corresponding information button.	SA_017	ASSISTANCE mounted and wearable sensors data (e.g. temperature, toxicity measurements, etc) should be visible on the main SA application HMI and in each ASSISTANCE SAP node (including mobile devices e.g. tablets)
SC1-UC4-OBJ5-KPI1-SC1	Different FRs categories will be able to access to different information through the SAP HMI according to their category.	SA_002	ASSISTANCE should have different users' profiles stated with different kind of information assigned.
SC2-UC4-OBJ5-KPI1-SC1 SC3-UC5-OBJ5-KPI1-SC1		SA_003	ASSISTANCE SAP HMI should provide discriminate information access depending on the FRs profile connected to the system
SC1-UC4-OBJ6-KPI1 SC1	FRs will send text messages to the command post and will receive a response message	SA_009	ASSISTANCE SAP should allow messaging capabilities from/to any SAP node
SC2-UC4-OBJ6-KPI1-SC1 SC3-UC5-OBJ6-KPI1-SC1		SA_004	ASSISTANCE SAP should be executed on mobile devices (e.g. tablets) and adapt its performance to these devices.
SC1-UC4-OBJ6-KPI2 SC1	Commanders will send text messages to the FRs and will receive a response message	SA_009	ASSISTANCE SAP should allow messaging capabilities from/to any SAP node
SC2-UC4-OBJ6-KPI2-SC1		SA_004	ASSISTANCE SAP should be executed on mobile devices (e.g. tablets) and adapt its performance to these devices.

KPI SC ID	SC Description	Req ID	Req Description
SC3-UC5-OBJ6-KPI2 SC1			
SC1-UC4-OBJ7-KPI1-SC1	End users will check all available SAP Geo tools during the scenario	SA_013	ASSISTANCE should provide layers management of information capabilities on a GIS to foster the possibility to turn off or on information according to specific needs stated by the FRs.
		SA_018	SAP HMI should allow map selection, distance measurements, zooming and scrolling
SC2-UC4-OBJ7-KPI1-SC1		SA_024	ASSISTANCE should be equipped with 3D mapping functions to provide terrain model information
SC3-UC5-OBJ8-KPI1-SC1		SA_025	ASSISTANCE should be equipped with a real-time map 'tap and fly' function
SC1-UC6-OBJ1-KPI1-SC1	The real time video flows from the available portable cameras have to be visualized in a proper way with enough quality in the SAP main HMI.	SA_007	SAP should integrate the following wearable sensors for being installed on-demand in some FRs uniforms depending on their protection needs. (GPS Sensors, Personal **Video Cameras** and vital signs (including Temperature sensors)
SC2-UC7-OBJ1-KPI1-SC1		SA_017	ASSISTANCE mounted and wearable sensors data (e.g. temperature, toxicity measurements, etc) should be visible on the main SAP HMI and in each ASSISTANCE SAP node (including mobile devices e.g. tablets)
SC3-UC3-OBJ1-KPI1-SC1		WEA_003	Personal cameras wearable sensors must provide connectivity interfaces (e.g. Bluetooth or Wi-Fi) in order to allow the sensor sharing information with the SAS platform
SC1-UC6-OBJ2-KPI1-SC1	FRs GPS locations have to be visualized in the SAP main HMI properly and with enough accuracy.	SA_007	SAP should integrate the following wearable sensors for being installed on-demand in some FRs uniforms depending on their protection needs. (**GPS Sensors**, Personal Video Cameras and vital signs (including Temperature sensors)

KPI SC ID	SC Description	Req ID	Req Description
		SA_010	ASSISTANCE SAP should give in real-time and with high precision location of own resources including mobile platforms location (if available).
SC2-UC7-OBJ2-KPI1-SC1 SC3-UC3-OBJ2-KPI1-SC1		SA_017	ASSISTANCE mounted and wearable sensors data (e.g. temperature, GPS location, etc) should be visible on the main SAP HMI and in each ASSISTANCE SAP node (including mobile devices e.g. tablets)
		WEA_004	GPS wearable sensors must provide connectivity interfaces (e.g. Bluetooth or Wi-Fi) in order to allow the sensor sharing information with the SAS platform.
SC1-UC6-OBJ3-KPI1-SC1	The vital signs measurements from the available portable vital signs' sensors have to be visualized in the SAP main HMI.	SA_007	SAP should integrate the following wearable sensors for being installed on-demand in some FRs uniforms depending on their protection needs. (GPS Sensors, Personal Video Cameras and **Vital signs** (including Temperature sensors)
SC2-UC7-OBJ3-KPI1-SC1		SA_017	ASSISTANCE mounted and wearable sensors data (e.g. temperature, wearable cameras video flows, vital signs, etc.) should be visible on the main SAP HMI and in each ASSISTANCE SAP node (including mobile devices e.g. tablets)
SC3-UC3-OBJ3-KPI1-SC1		WEA_002	Temperature wearable sensors must provide connectivity interfaces (e.g. Bluetooth or Wi-Fi) in order to allow the sensor sharing information with the SAS platform.
		WEA_005	The vital signs sensors must provide connectivity interfaces (e.g. Bluetooth or Wi-Fi) in order to allow the sensor sharing information with the SAS.
SC2-UC4-OBJ3-KPI2-SC1	Different windows will be open and different real time video flows will be visualized in the SAP HMI.	SA_005	ASSISTANCE SAP should show real-time video flows from the connected cameras (including the ones mounted on mobile platforms) depending on the needs and restrictions, for instance bandwidth.

KPI SC ID	SC Description	Req ID	Req Description
SC3-UC5-OBJ3-KPI2-SC1		SA_007	SAP should integrate the following wearable sensors for being installed on-demand in some FRs uniforms depending on their protection needs. (GPS Sensors, Personal **Video Cameras** and vital signs (including Temperature sensors)
SC2-UC4-OBJ4-KPI1-SC1	All Drones/Robots/vehicles/FRs icons will be shown on the SAP HMI and through these icons the commanders will be able to visualize the sensors measurements from those assets equipped with sensors.	SA_007	SAP should integrate the following wearable sensors for being installed on-demand in some FRs uniforms depending on their protection needs. (GPS Sensors, Personal Video Cameras and vital signs (including Temperature sensors)
		SA_008	ASSISTANCE SAP should raise warnings when IP sensors are not available.
		SA_017	ASSISTANCE mounted and wearable sensors data (e.g. temperature, toxicity measurements, etc) should be visible on the main SAP HMI and in each ASSISTANCE SAP node (including mobile devices e.g. tablets)
SC3-UC5-OBJ4-KPI1-SC1		WEA_002	Temperature wearable sensors must provide connectivity interfaces (e.g. Bluetooth or Wi-Fi) in order to allow the sensor sharing information with the SAS platform.
		MET_001	Meteorological information can be shown on the map.
SC2-UC4-OBJ8-KPI1-SC1	All data stored during the scenario has been successfully checked after the exercise.	SA_001	ASSISTANCE SAP should log all the actions done by users and storing all data received from sensors and personnel.
		SA_011	ASSISTANCE SAP should properly store all data received by the system from sensors and external sources in order to ensure the availability of all information stored in the database for being shown to the FRs where necessary.
SC3-UC5-OBJ9-KPI1-SC1		SA_014	SAP should store relevant data gathered during the day and store it properly for 7 days for being used for forensic purposes (If re-quired)

KPI SC ID	SC Description	Req ID	Req Description
		SA_016	SAP should use existing and known standards for data stor-age and management.
SC2-UC5-OBJ1-KPI1-SC1	The ALR tool receives and integrates the request of accessing/exit route, which contains status of the First Responders and potential risks.	SA_012	ASSISTANCE SAP should show near real-time evacuation routes (based on ALR_004) for helping the FRs for moving the victims in a secure and quick way and for FRs evacuation of the area quickly in case of a major incident.
SC2- UC6-OBJ2-KPI1-SC1	The danger zone is calculated and presented on the map that is available for the officer and the infield rescuer.	SA_011	ASSISTANCE SAP should properly store all data received by the system from sensors and external modules in order to ensure the availability of all information stored in the database for being shown to the FRs where necessary.
SC2-UC6-OBJ1-KPI2-SC1	Thermal video is captured, sent and displayed in SAP	SA_006	ASSISTANCE SAP should integrate IR cameras video flows (including **IR cameras mounted on mobile platforms**, if any) depending on the needs and restrictions, for instance bandwidth.
SC2-UC6-OBJ1-KPI3-SC1	All sensor data is being captured and sent to SAP	SA_010	ASSISTANCE SAP should give in real-time and with high pre-cision location of own resources (personnel and vehicles) including mo-bile platforms location (if available).
		SA_007	SAP should integrate the following wearable sensors for being installed on-demand in some FRs uniforms depending on their protection needs. (GPS Sensors, Personal Video Cameras and vital signs (including Temperature sensors)
		SA_017	ASSISTANCE mounted and wearable sensors data (e.g. temperature, wearable cameras video flows, vital signs, etc.) should be visible on the main SAP HMI and in each ASSISTANCE SAP node (including mobile devices e.g. tablets)

KPI SC ID	SC Description	Req ID	Req Description
SC2-UC7-OBJ4-KPI1-SC1	The CO measurements from the available CO sensors have to be visualized in the SAP main HMI.	SA_007	SAP should integrate the following wearable sensors for being installed on-demand in some FRs uniforms depending on their protection needs. (GPS Sensors, Personal Video Cameras and vital signs (including Temperature sensors)
		SA_017	ASSISTANCE mounted and wearable sensors data (e.g. temperature, toxicity measurements, etc) should be visible on the main SAP HMI and in each ASSISTANCE SAP node (including mobile devices e.g. tablets)
		WEA_001	Monoxide detectors (CO) wearable sensors must provide connectivity interfaces (e.g. Bluetooth or Wi-Fi) in order to allow the sensor sharing information with the SAS platform.
SC3-UC5-OBJ7-KPI1-SC1	Correct overlapping of the real video flows on the GIS shown in the SAP HMI.	SA_020	ASSISTANCE SAP should provide augmented video fusion capabilities for overlap real-time video flows from cameras mounted in drones on the emergency area GIS displayed in the SAP HMI.
SC3-UC5-OBJ7-KPI2-SC1	Correct acquisition of a real time event from the video flow and show it on the GIS.	SA_020	ASSISTANCE SAP should provide augmented video fusion capabilities for overlap real-time video flows from cameras mounted in drones on the emergency area GIS displayed in the SAP HMI.

10.2 Validation environments

This section presents the procedures to perform the test of the SAP and Wearable sensors validation plan. A test has not been designed for each objective, but the strategy followed has been to combine objectives related to the same functionality in a single test. The validation plan will be divided in two different phases: laboratory environment and finally the realistic environment during the project pilots. Each of these phases will be performed in the following sites:

1) UPV´s testbed:

The laboratory tests for the SAP and Wearable sensors functionalities will be performed in the UPV lab at Telecommunications School. All the test will be performed with real data sent by the other modules, tools and mobile platforms integrated in the SAP

2) Pilots and demonstrator location:

Finally, the realistic test will be evaluated during the final demonstrations of the project.

10.3 Adapted Situational Awareness Tools validation scenarios

In the following sections it is presented the validation plan for each SAP and Wearable sensors functionalities success criteria identified in the objectives and requirements traceability table.

10.3.1 SAP&WS-Test-01: HMI adapted to the user category information needs test

This test will not show three different HMIs, since the FRs agreed to use the same information and tailor it to their need in each moment through an information filter. On the other hand, the FRs also agreed that all FRs could access to the same information without any distinction due the FRs category.

This test will validate the following KPIs:

- SC1-UC4-OBJ1-KPI1-SC1
- SC2-UC4-OBJ1-KPI1-SC1
- SC3-UC5-OBJ1-KPI1-SC1
- SC1-UC4-OBJ5-KPI1-SC1
- SC2-UC4-OBJ5-KPI1-SC1
- SC3-UC5-OBJ5-KPI1-SC1

The test will show different types of information in the SAP HMI and this information will be filtered using the tailoring information capability developed by UPV. The aim of this test is to validate the visualized information filtering.

Table 49: Validation plan for SAP&WS HMI

Environment	Goal	Output
Laboratory	To check that different visualized information is managed through the SAP tailoring information capability.	Information is visualized according to the inputs included in the tailoring information filter.
Real	As part of each pilot demonstration exercise the information filtering capability will be used by the different FRs organizations for tailoring the visualized information.	Information is visualized according to the inputs included in the tailoring information filter.

10.3.2 SAP&WS-Test-02: Secure access control module test

This test will validate the following KPIs:

- SC1-UC4-OBJ1-KPI2-SC1
- SC2-UC4-OBJ1-KPI2-SC1
- SC3-UC5-OBJ1-KPI2-SC1

The test will show how the end users must introduce their security credentials (login and password) information in the SAP access front end in order to be able to access the SAP. If the credentials included are valid the SAP will be opened and the FRs will be able to access and use all its capabilities, but if the credentials included are not valid, an error message will appears describing the error and giving the possibility of reentering the security credentials.

Table 50: Validation plan for SAP&WS Secure access control

Environment	Goal	Output
Laboratory	To check that valid credentials allow to access to the SAP. To check that invalid credentials trigger the error interface	To access to the SAP if the credentials are valid. To access to the error front end if the credentials are not valid.
Real	At the beginning of each exercise different FRs will access to the SAP using their security credentials.	To access to the SAP if the credentials are valid. To access to the error front end if the credentials are not valid.

10.3.3 SAP&WS-Test-03: Drones/Robots/FRs icons exact location and video flows visualization

This test will validate the following KPIs:

- SC1-UC4-OBJ3-KPI1-SC1
- SC2-UC4-OBJ3-KPI1-SC1
- SC3-UC5-OBJ3-KPI1-SC1
- SC1-UC4-OBJ3-KPI2-SC1
- SC2-UC4-OBJ3-KPI2-SC1
- SC3-UC5-OBJ3-KPI2-SC1
- SC1-UC6-OBJ1-KPI1-SC1

- SC2-UC7-OBJ1-KPI1-SC1
- SC3-UC3-OBJ1-KPI1-SC1
- SC1-UC6-OBJ2-KPI1-SC1
- SC2-UC7-OBJ2-KPI1-SC1
- SC3-UC3-OBJ2-KPI1-SC1

The test will show in the SAP HMI different icons representing FRs units, drones and robots. By clicking in these icons, the individual units' interfaces will be opened showing the sensors available for each unit. By clicking on the "Access Video" button a window will appear showing the real time video flows of the camera attached to this unit.

During the test different video windows from different units (FRs -wearable cameras-, UAV and Robots) will be opened at the same time. During the lab test information shown in the SAP HMI will be fake units' locations and video flows from the real sensors stored in the SAS. In the real project pilots' real units' locations and real time video flows from these units will be shown in the SAP HMI.

Table 51: Validation plan for SAP&WS icons exact location

Environment	Goal	Output
Laboratory	To check that units' locations are correctly shown on the SAP HMI. To check that video flows are shown correctly when the individual unit interface Access Video button is clicked	Correct visualization of the fake units' locations. Correct visualization of the stored video flows
Real	During each pilot exercise different video flows will be opened by the FRs as part of the demonstration	Correct visualization of the real units' locations. Correct visualization of the real time video flows

10.3.4 SAP&WS-Test-04: Measurements from sensors and external information data sources visualization

This test will validate the following KPIs:

- SC1-UC4-OBJ4-KPI2-SC1
- SC2-UC4-OBJ4-KPI2-SC1
- SC3-UC5-OBJ4-KPI2-SC1
- SC2-UC4-OBJ4-KPI1-SC1

- SC2-UC6-OBJ1-KPI3-SC1
- SC2-UC7-OBJ4-KPI1-SC1
- SC3-UC5-OBJ4-KPI1-SC1

The test will show in the SAP HMI different icons representing FRs units', drones and robots available. By clicking in these icons, the individual units' interfaces will be opened showing the sensors available for each unit. In case of drones and robots, by clicking on the "Gas Sensors" button a window will appear showing the information from the gas sensors integrated in the mobile platforms according to the format agreed with the FRs.

In case of FRs units, by clicking on the button "Vital Sensors", the vital signs sensors information will be shown in the format agreed with the end-users.

During the test different sensors information from different units will be opened at the same time. During the lab test information shown in the SAP HMI will be fake units' locations and real sensors data stored in the SAS.

In the real project pilots' real FRs units' locations and real sensors information (GPS, vital signs, gas measurements form mobile platforms) from real units participating in the exercises will be shown in the SAP HMI as part of the pilot's demonstration.

Table 52: Validation plan for SAP&WS sensors integration

Environment	Goal	Output
Laboratory	To check that sensors information are shown correctly when the individual unit interface "Gas Sensor" button is clicked To check that sensors information are shown correctly when the individual unit interface "Vital Sensor" button is clicked	Correct visualization of the different sensors stored information
Real	During each pilot exercise different sensors information will be visualized by the FRs as part of the different pilots' demonstrations	Correct visualization of the different sensors' information in real-time

10.3.5 SAP&WS-Test-05: Messaging Capabilities test

This test will validate the following KPIs:

- SC1-UC4-OBJ6-KPI1 SC1
- SC2-UC4-OBJ6-KPI1-SC1
- SC3-UC5-OBJ6-KPI1-SC1

- SC1-UC4-OBJ6-KPI2 SC1
- SC2-UC4-OBJ6-KPI2-SC1
- SC3-UC5-OBJ6-KPI2 SC1

The lab test will be performed using a laptop simulation the control room and a rugged tablet simulating the unit on field.

A message will be sent from the laptop to the id unit of the rugged tablet. The message will be received in the rugged laptop opened and answered. The answer will be received in the laptop opened and read.

During the project pilots as part of the exercise a message will be send from the real control room to a FRs who is participating in the exercise. This FRs will receive the message and open it. After reading the message the FR will send his/her answer from the rugged tablet and this message will be received in the control room and read by the commanders.

Table 53: Validation plan for SAP&WS messaging capability

Environment	Goal	Output
Laboratory	To check that a message is sent correctly from the laptop in lab. To check that the message is received and answered correctly from the rugged tablet in lab. To check that the answer is received correctly in the laptop in lab.	Correct visualization and transmission of the message. Correct visualization and transmission of the answer.
Real	To check that a message is sent correctly from the laptop in the pilots' control room. To check that the message is received and answered correctly from the rugged tablet. To check that the answer is received correctly in the laptop in the pilots' control room.	Correct visualization and transmission of the message. Correct visualization and transmission of the answer.

10.3.6 SAP&WS-Test-06: SAP Geo tools test

This test will validate the following KPIs:

- SC1-UC4-OBJ7-KPI1-SC1
- SC2-UC4-OBJ7-KPI1-SC1
- SC3-UC5-OBJ8-KPI1-SC1

The lab test will consist in testing one by one all SAP Geo tools capabilities and verify that the results obtained are correct. The capabilities that will be tested are as follows:

Distance measurement between two points: two points will be selected on the map and the distance between them will be measured. The results will be compared with the result of similar tools like google earth. If the measured distance is correct the test will be successful.

Different kind of GIS will be changed on the fly without stopping the operation activities: Different maps will be changed during a simulated operation to use the different capabilities of each map. If no interruptions or malfunctions are detected during the maps changed the capability will be considered correct.

Different GIS capabilities such as zooming in/out, 3D terrain visualization, scrolling, etc will be tested: During a simulated operation all mentioned GIS capabilities will be tested in order to check whether they work properly. If no interruptions or malfunctions are detected during the use of the above-mentioned capabilities the test will be consider successful.

Different layers of GIS information such us show roads, shows map grid, gas stations in the area, banks in the area, etc. During a simulated operation different layer of information will be shown and remove in order to check that this capability works properly. If no interruptions or malfunctions are detected during the use of the different information layers available, the test will be considered successful.

Table 54: Validation plan for SAP&WS Geo tool

Environment	Goal	Output
Laboratory	To check that the distance measured in lab is correct. To check that the maps are changed without interruptions in the lab test. To check that the GIS capabilities work properly during the lab test. To check that the GIS information layers are available and can be shown correctly in lab.	Correct visualization of the measured distance. Correct visualization of the different maps used during the test. Correct visualization of the GIS capabilities during the simulated operation in lab.

		Correct visualization of the information of the different GIS layers available.
Real	To check that the distances measured in the different pilots' exercises are correct. To check that the maps are changed without interruptions by the FRs during the pilots' exercises. To check that the GIS capabilities work properly during the pilots' exercises. To check that the GIS information layers are available and can be shown correctly during the pilots' exercises.	Correct visualization of the measured distance. Correct visualization of the different maps used during the test. Correct visualization of the GIS capabilities during the simulated operation in lab. Correct visualization of the information of the different GIS layers available.

10.3.7 SAP&WS-Test-07: Pilots' data correct storage test

This test will validate the following KPIs:

- SC2-UC4-OBJ8-KPI1-SC1
- SC3-UC5-OBJ9-KPI1-SC1

The lab test will check all the logs and data gathered (videos, measurements, locations, etc.) taken during a short fake scenario to check whether all information/data used during the scenario have been properly stored and can be consulted after the exercise.

For performing this test information already sent to the SAS by different modules and platforms will be used and stored as if the test was a real-time exercise. After that the stored information will be reviewed in order to check whether it has been properly stored.

During the real pilots' demonstrations after each pilot, all data used for the different modules, units and platforms will be checked after the exercise to review its integrity and correct storage.

Table 55: Validation plan for SAP&WS pilot correct data storage

Environment	Goal	Output
Laboratory	To check that GPS locations have been correctly stored during the lab test To check that video files from platforms have been correctly stored during the lab test To check that information from wearable sensors (cameras and vital signs) have been correctly stored during the lab test To check that sensors measurements (CO) have been correctly stored during the lab test. To check that SAP logs have been correctly stored during the lab test	Correct visualization of the GPS location stored. Correct visualization of stored video files Correct visualization of the stored wearable sensors measurements (Video files and vital signs) Correct visualization of the stored sensors information. Correct visualization of the system logs.
Real	To check that GPS locations have been correctly stored during the real pilots To check that video files from platforms have been correctly stored during the real pilots To check that information from wearable sensors (cameras and vital signs) have been correctly stored during the real pilots To check that sensors measurements (CO) have been correctly stored during the real pilots To check that SAP logs have been correctly stored during the real pilots	Correct visualization of the GPS location stored. Correct visualization of stored video files Correct visualization of the stored wearable sensors measurements (Video files and vital signs) Correct visualization of the stored sensors information. Correct visualization of the system logs.

10.3.8 SAP&WS-Test-08: Routes and Plumes visualization test

This test will validate the following KPIs:

- SC2-UC5-OBJ1-KPI1-SC1
- SC2-UC6-OBJ2-KPI1-SC1

The lab test will ask to the SAS for already stored routes and toxic plumes and will show them on the SAP main HMI. On the other hand, secondary integration test will ask for real time information on routes and plumes to the DAL&R and CHT modules and will show them on the SAP main HMI.

During the project pilots' demonstrations real time information on evacuation routed and potential toxic plumes evolution will be asked to the DAL&R and CHT modules and will show them on the SAP main HMI.

Table 56: Validation plan for SAP&WS routes and plumes visualization test

Environment	Goal	Output
Laboratory	To check that the routes visualization in the lab test is correct. To check that the toxic plumes can be shown correctly in the SAP main HMI during the lab test.	Correct visualization of the evacuation routes during the lab test. Correct visualization of the toxic plumes during the lab test.
Real	To check that the routes visualization is correct during the pilots' exercises. To check that the toxic plumes can be shown correctly in the SAP main HMI during the pilots' exercises.	Correct visualization of the evacuation routes during the pilots' exercises. Correct visualization of the toxic plumes during the pilots' exercises.

10.3.9 SAP&WS-Test-09: Thermal camera test

This test will validate the following KPIs:

- SC2-UC6-OBJ1-KPI2-SC1

During this lab test several thermal video flows stored in the SAS will be used for being displayed in the main SAP HMI. This feature will be tested displaying the thermal video flows in both a laptop simulating the command room and a rugged tablet.

Once all video flows had been displayed correctly in both devices the test will be taken as successful.

During the project pilot 2 the thermal video flows will be displayed in real time during the drone missions in the exercise control room and the rugged tablets of the FRs units.

Table 57: Validation plan for SAP&WS thermal camera

Environment	Goal	Output
Laboratory	To check that the thermal video flows visualization in different devices during the lab test is correct.	Correct visualization of the stored thermal video flows during the lab test.
Real	To check that the thermal video flows visualization in different devices during the real pilot exercise 2 is correct.	Correct visualization of the stored thermal video flows during the real exercise 2.

10.3.10 SAP&WS-Test-10: Advanced video fusion test

This test will validate the following KPIs:

- SC3-UC5-OBJ7-KPI1-SC1
- SC3-UC5-OBJ7-KPI2-SC1

This lab test will show the correct performance of the advanced video fusion capability. During the lab test the icon of a fake drone will be clicked and, once its unit's interface appears, the "Access Video" button from the Video fusion part of the interface will be clicked for launching the advanced video fusion capability.

This test will use stored information from real drones' flights and the video flows will be projected into the GIS and displayed. On the other hand, a fake incident detected through the visualization of the projected video flow will be marked in its exact location using a threat icon.

After checking the correct projection of the video flows on the map the test will be taken as successful.

During the real scenarios where this capability will be tests, real time video flows from the drones operating in the exercises will be projected on the GIS and visualized by the FRs for detecting the exact location of an event (small fire).

Once the small fire was visualized on the projected video on the map the FR will mark the location with a threat icon indicating the exact location of the fire which will be extinguished by the FRs.

Table 58: Validation plan for SAP&WS advanced video fusion

Environment	Goal	Output
Laboratory	To check that the video fusion capability allows the correct visualization of the stored video projected on the GIS To mark the exact location of a fake incident visualized on the projected video with a threat icon.	Correct visualization of the stored video projected on the map during the lab test. Correct location and visualization of the threat icon indicating the detected event.
Real	To check that the video fusion capability allows the correct visualization of the real-time video projected on the GIS To mark the exact location of a real incident (e.g. small fire) visualized on the projected video with a threat icon.	Correct visualization of the stored video projected on the map during the real exercise. Correct location and visualization of the threat icon indicating the detected event.

10.4 Tests vs objectives traceability

Table 59: Test vs. objective traceability matrix for SAP&WS component

	SAP&WS-Test-01	SAP&WS-Test-02	SAP&WS-Test-03	SAP&WS-Test-04	SAP&WS-Test-05	SAP&WS-Test-06	SAP&WS-Test-07	SAP&WS-Test-08	SAP&WS-Test-09	SAP&WS-Test-10
SC1-UC4-OBJ1-KPI1-SC1	X									
SC2-UC4-OBJ1-KPI1-SC1	X									
SC3-UC5-OBJ1-KPI1-SC1	X									
SC1-UC4-OBJ5-KPI1-SC1	X									
SC2-UC4-OBJ5-KPI1-SC1	X									
SC3-UC5-OBJ5-KPI1-SC1	X									
SC1-UC4-OBJ1-KPI2-SC1		X								

SC2-UC4-OBJ1-KPI2-SC1		X								
SC3-UC5-OBJ1-KPI2-SC1		X								
SC2-UC4-OBJ3-KPI1-SC1			X							
SC3-UC5-OBJ3-KPI1-SC1			X							
SC1-UC4-OBJ3-KPI2-SC1			X							
SC2-UC4-OBJ3-KPI2-SC1			X							
SC3-UC5-OBJ3-KPI2-SC1			X							
SC1-UC6-OBJ1-KPI1-SC1			X							
SC2-UC7-OBJ1-KPI1-SC1			X							
SC3-UC3-OBJ1-KPI1-SC1			X							
SC1-UC6-OBJ2-KPI1-SC1			X							
SC2-UC7-OBJ2-KPI1-SC1			X							
SC3-UC3-OBJ2-KPI1-SC1			X							
SC1-UC4-OBJ4-KPI2-SC1				X						
SC2-UC4-OBJ4-KPI2-SC1				X						
SC3-UC5-OBJ4-KPI2-SC1				X						
SC2-UC4-OBJ4-KPI1-SC1				X						
SC2-UC6-OBJ1-KPI3-SC1				X						
SC2-UC7-OBJ4-KPI1-SC1				X						
SC3-UC5-OBJ4-KPI1-SC1				X						
SC1-UC4-OBJ6-KPI1 SC1					X					
SC2-UC4-OBJ6-KPI1-SC1					X					
SC3-UC5-OBJ6-KPI1-SC1					X					
SC1-UC4-OBJ6-KPI2 SC1					X					
SC2-UC4-OBJ6-KPI2-SC1					X					

SC3-UC5-OBJ6-KPI2 SC1					X					
SC1-UC4-OBJ7-KPI1-SC1						X				
SC2-UC4-OBJ7-KPI1-SC1						X				
SC3-UC5-OBJ8-KPI1-SC1						X				
SC2-UC4-OBJ8-KPI1-SC1							X			
SC3-UC5-OBJ9-KPI1-SC1							X			
SC2-UC5-OBJ1-KPI1-SC1								X		
SC2-UC6-OBJ2-KPI1-SC1								X		
SC2-UC6-OBJ1-KPI2-SC1									X	
SC3-UC5-OBJ7-KPI1-SC1										X
SC3-UC5-OBJ7-KPI2-SC1										X

11 Conclusions

After this whole dissertation about the validation plan developed for each of the systems and components within the ASSISTANCE system, it is time to recap the work reported in this document.

This dissertation has been performed following a System Engineering approach, which was explained in Section 2. This approach was already started in the project throughout deliverables D2.2, D2.3 and D2.4. Hence, this document has been structured following the architecture set up in D2.4. For each system that made up that architecture, a KPI associated with a use case objective has been selected from D2.3. The objectives were developed in the same deliverable in which the concerned system is involved. These KPIs were already linked with the requirements captured in D2.2. Then, the current document has followed the System Engineering approach already started, linking both branches, the Validation and Verification one (see Figure 1).

This exercise performed for each system has been explained though the different sections of the document, each one devoted to each system. The success criteria have been grouped considering the functionality of the system that they are related to. Then, a validation plan has been designed for each functionality, in most cases in three different levels or environments, explaining which is the expected output after each test. Finally, to ensure that the process was completed, every test has been linked with the success criteria that they validate and considering that the success criteria were linked with the requirements, thus, the validation plan also validates the requirements indirectly.

The results of these tests are the baseline of Task 7.2, in which all the tests will be performed, and the results will be shown in D7.2. Hence, the validation plan of each system conforming the overall ASSISTANCE system have been set following a System Engineering approach, finalizing the process started in WP2.