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Emerging technologies for the Early location of Entrapped victims under Collapsed Structures & Advanced Wearables for risk assessment and First Responders Safety in SAR operations

D7.10 SnR platform Test Cases and overall system evaluation results Final version

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Search and Rescue Project Profile

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Table 1: List of Abbreviations

Abbreviation	Explanation
AC or ac	Alternating Current
Cat-6	Category 6
CCTV	Closed Circuit Television
FAT	Factory Acceptance Test
FOC	Fibre Optic Cable
FOV	Field of View
GPS	Global Positioning System
GLONASS	Global Navigation Satellite System
HMI	Human Machine Interface
IEEE	Institute of Electrical & Electronic Engineers
IP	Internet Protocol
IVVQ	Integration, Verification, Validation and Qualification
IT	Information Technology
ITU	International Telecommunication Union
LAN	Local Area Network
LCD	Liquid Crystal Display
LED	Light Emitting Diode
Lipo	Lithium Polymer
Mb/s	Megabits per second
MIMS	Membrane Inlet Mass Spectrometer
ODS	Obstacle Detection System
PoE	Power over Ethernet
RTMP	Real-Time Messaging Protocol
SnR	Search and Rescue
SAT	Site Acceptance Test
SDK	Software Development Kit
SW	Software
TCP/IP	Transmission Control Protocol/Internet Protocol
UC	Use case

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Executive Summary

The Deliverable D7.10, titled "SnR platform Test Cases and overall system evaluation results final version", continue and terminate the work done in the previous D7.9 deliverable related to the testing of the overall platform and each equipment developed within the WP7 in Search & Rescue Project.
The document is divided in two main chapters:

1. The first chapter is related to the components' tests, i.e. the tests done by every partner to test locally the components under its responsibility. For this reason, a recap of all the components is done and then for everyone, it is provided a description of how the component has been tested and which are the main results obtained.
2. The second chapter focus on the S&R use cases and analyze every use case one by one. As several components take part in every use case execution, the analysis is done by following the relations and the communication between the various components within the use case. So the second chapter is more focused on high level relations between the components and the overall result of the tests conducted for the use case execution.

1 Tests on Project Components

In this section a recap of all the components that constitute the overall S&R system is shown; these components are under responsibility of different project partners, that are responsible for the component development, installation and testing.
Partners have in fact performed tests on their components in order to prove the correct working and the meet of the project requirements and expectations.
The section 1.1 show a recap of all the components while the section 1.2 presents the tests done on every single component providing a description and main results obtained.

1.1 Main Components

The following subsections makes a recap of all the components involved in the S&R project architecture.

1.1.1 Smartwatch

- **Provider**: KONNEKT-ABLE
- **Description**: It is the Yamai smart watch used to retrieve heart-rate, average speed, timestamp, latitude and longitude coordinates of the first responders; the output data are provided in JSON representation to be sent to the first responder smart phone through Bluetooth.
- Referred Deliverables: D7.3, D7.4

1.1.2 Rescue MIMS

- Provider: NTUA
- Description: it is a portable device used to find chemical hazardous (benzene, acetone etc); it produces in output a CSV files with data/time masses of elements with increments.
- Referred Deliverables: D5.1, D5.3, D5.4

1.1.3 Wearable GPS Tracker

- Provider: UNICA
- Description: it is the GNSS (Global Navigation Satellite System) module integrated within the smartphone of the first responders; this sensor acquires several data such as latitude and longitude coordinates, and communicates it to a custom Android App developed by UNICA and installed over the smartphone; data are sent in JSON format.
- Referred Deliverables: D5.2, D7.3, D7.5

1.1.4 Wearable Strain Sensors

- Provider: UNICA
- Description: these are wearable sensors applied directly on the first responder’s body which can monitor different body joints such as knees and elbows; these sensors communicate with the first responders’ smartphone through BLE; the output data from the smartphone to the data aggregation unit is a JSON file.
- Referred Deliverables: D5.2, D7.3, D7.5

1.1.5 Wearable ECG, EMG

- Provider: UNICA

- Description: these are organic polymeric electrodes embedded into a technical underwear (composed of t-shirts and pants) of the first responder, which have to be in contact with the skin (ECG on the trunk and EMG on the legs); electrodes are connected with the electronic module through conductive wires sewed on the garment. The electronic module communicates with a custom Android App installed on the first responder smartphone through BLE. Data are sent to the server in JSON format.
- Referred Deliverables: D5.2, D7.3, D7.5

1.1.6 Six Gas Monitor

- Provider: UNICA
- Description: it is a commercial portable device used to detect both toxic or explosive gases; it shows real time values over a display that the first responders can read in real time; it communicates with a custom Android App installed on the first responder smartphone through BLE. The data format sent to the server is JSON.
- Referred Deliverables: D5.2, D7.3, D7.5

1.1.7 Radiation sensors

- Provider: UNICA
- Description: it is a wearable sensor able to detect radiation level; it communicates with the first responder smartphone through BLE; data are sent to the data aggregation unit in a JSON file.
- Referred Deliverables: D5.2, D7.3, D7.5

1.1.8 Emergency Response Health Condition Monitoring Device

- Provider: CERTH
- Description: it is a compact device used to monitor rescuers and victims health status from discovery up to the ambulance; it has internet connectivity and communicates with an android app installed on the first responder smartphone; data communicated are provided in JSON format and the main fields are timestamp, GPS coordinates, heart rate, respiration rate, oxygen saturation, body temperature, blood pressure, body posture, ambient humidity, ambient temperature.
- Referred Deliverables: D5.2

1.1.9 Drones & Collaborative drone platform

- **Provider**: UHASSELT
- **Description**: drones are embedded with camera for video and image recordings; the drones are controlled by a control unit connected with a laptop through 4G where a windows SDK from DJI is installed; the laptop acquires drone position, altitude, battery level, camera gimball, video streams and images. Video streams are acquired by DJI Go 4, and android app installed on the tablet or on the mobile which can communicate with a streaming server using wifi or 4G. The drone collaboration platform is a platform that provides internal communication interfaces for drones to communicate; these interfaces are not provided to the external and are not integrated in the data lake.
- **Referred Deliverables**: D5.1, D5.4

1.1.10 3D Mixed Reality CC

- Provider: CERTH
- Description: The 3D mixed reality command centre visualizes information from various data sources for the decision makers: position and states of rescuers, victims, robots. It communicates using MQTT for textual information; data format is a JSON file with fields timestamp, GPS location, destination location, sex, age, posture, health condition.
- Referred Deliverables: D4.2

1.1.11 Smart Glasses

- **Provider**: SIMAVI
- **Description**: the selected smart glasses model is Oculus Quest 2 headset: it is used to simulate different environment with different scenarios (fire, terrorism etc.) for training purposes. It does not communicate with the rest of the S&R platform: scenarios are run stand alone and it requires a PC to work properly. A client application will run on the VR headset to allow communication with the PC where a dedicated server application is installed.
- **Referred Deliverables**: D6.7

1.1.12 Rescue Robots & autonomous vehicles

- **Provider**: DFKI
- **Description**: robots are used for exploring areas and measure gas with the usage of a rescue MIMS mounted on the robot; they can generate a spatial map during exploration and add to it all gas measures in their real position; map can be visualized on a control machine that will return back specific commands to the robot for manual control; the object detection algorithm is installed on the robot and it is connected to a ethernet hub mounted on the robot that provides access to a remote control system. The robot send data using the robot operating system (ROS): it publishes data on topics. There is a PC with the ROS is installed in the control room to enable the communication with the robot: in fact it can subscribe to specific topics and retrieve the data generated by the robot; also the robot can subscribe to command topics in order to receive commands published by the PC in the control room.
- **Referred Deliverables**: D5.4

1.1.13 COncORDE

- **Provider**: KONNEKT-ABLE
- **Description**: it is a cloud-based platform for crisis management operations and support S&R use cases. It exposes several services through REST and JSON based APIs; the usages of these services is allowed through HTTP. The main services exposed are: LoginService (for operators login in the platform), UserService (for user management), IncidentService (for incident management), OrganizationService (for organization management, such as EMS, Hospitals etc), TriageService (for patients management), NotificationService (for notifications of data during the disaster evolution). All output data from Concorde to the external system are communicated in JSON format.

- **Referred Deliverables**: D6.7

1.1.14 Situation awareness modules

- **Provider**: UBITECH
- **Description**: The situation awareness module aims to provide the appropriate alarms and notifications to first responders (and other actors) so that they can define the decisions that they make during the course of S&R operation. The module exposes REST APIs to be used for communication.
- **Referred Deliverables**: D3.2, D3.8

1.1.15 BIM based services & apps

- **Provider**: UBITECH
- **Description**: this model represents the main spatial topological elements of a building and its information, in combination with the situational awareness model, are used to provide a clear view of the incident itself. The module exposes REST APIs to be used for communication.
- **Referred Deliverables**: D3.3, D3.4

1.1.16 Sensor Web Services

- **Provider**: MAGGIOLI
- **Description**: web services used to extract information produced by the sensors during S&R use cases execution. The format adopted is SOAP over HTTP.
- **Referred Deliverables**: D6.4

1.1.17 SOT DSS

- **Provider**: KONNEKT-ABLE
- **Description**: this system purpose is to support the end user regarding the decision-making process. It provides resource allocation during emergency situation and the prediction of casualties within an incident. SOT DSS provides recommendations of possible decisions to be taken to manage the incident based on the incoming information. SOT DSS services are provided through REST APIs and there are 4 main services: casualty estimation, ems allocation, patient allocation and task allocation. The data format provided by SOT DSS is JSON.
- **Referred Deliverables**: D4.3, D4.5, D4.7, D4.9, D4.11

1.1.18 PHYSIO DSS

- **Provider**: CNR
- **Description**: it is part of the S&R DSS and is responsible to provide functions and algorithms to predict the evolution of the physical status of the victims in order to support victim prioritization and efficient health resource allocation in real time. It provides also information about the deployment of ambulances, treatments and triage. The Physio DSS exposes web services to simulate different crisis scenarios, to describe the evolution of the victims health status, to compute of the estimated time to death. Based on the results of these services, the physio DSS can provide suggestions on which resource assign to a victim and can also return patients prioritization.
- **Referred Deliverables**: D4.4, D4.6, D4.7, D4.10, D4.11

1.1.19 Volunteer app

- **Provider**: CERTH & KONNEKT-ABLE
- **Description**: it is used to know the human resources availability in case of emergency. Any individual or organization can register to the app to provide their help in case of disaster. Civilians may also register in order to receive relocation instructions/guidance from the field Command Operating Center. The application provides the total amount of volunteers available and their skill and equipment in order to take the right decision about their allocation. All requests and responses sent by the Volunteer App's API are provided in JSON format.
- **Referred Deliverables**: D2.5

1.1.20 e-learning based platform

- Provider: CERTH
- Description: it is a standalone platform to enhance participant understanding and knowledge of safety and security operations; the e-learning platform provides content on specific areas of SnR that need further assistance. A provided course may contain content, pictures, videos, sound, and tests-quizzes.
- Referred Deliverables: D2.4

1.1.21 Object detection algorithms on Autonomous Vehicles

- **Provider**: THALIT
- **Description**: these are a set of algorithms that use the information acquired by various sensors equipped on the ODS robot to detect possible collisions; these algorithms are installed on a dedicated module used by the ODS robot to avoid collisions.
- **Referred Deliverables**: D3.6, D5.4

1.1.22 Object detection on UAV imagery

- **Provider**: AIDEAS
- **Description**: algorithm based on deep learning to detect people and objects on images; these are used to enhance drones with AI features based on deep learning detection algorithm. The algorithm returns a new image (or video) identical to the original one with the addition of a boundary box that allow to focus on the detected person/object; moreover, it also returns a text file in JSON or TXT format with the description of what has been detected.
- **Referred Deliverables**: D3.5

1.1.23 Integration Platform

- **Provider**: SIMAVI
- **Description**: the integration platform is composed by several modules such as Apache Kafka, Apache ServiceMix, Apache Camel, Apache CXF, Apache Karaf and Apache ActiveMQ which all together allow to integrate the various sensors/systems providing data exchange, messaging and routing: in practice it allows to realize integration between multiple applications, taking care of data model transformation, handle of connectivity, conversion between specific communication protocols etc.

- **Referred Deliverables**: D7.5, D7.6

1.1.24 SnR Data model

- **Provider**: THALIT
- **Description**: it is the modelling of all the heterogeneous types of data measured by all the sensors and systems within S&R project and comprise also for historical data and similar European initiatives data modelling. The data model is provided in XML Schema and Avro Schema files in order to be adopted by WebServices and/or RestServices/Topics.
- **Referred Deliverables**: D6.2

1.1.25 Data Lake Ecosystem

- **Provider**: KONNEKT-ABLE
- **Description**: the data lake ecosystem consists of several components such as Apache Hadoop, Apache Yarn and Apache Spark which serve the purpose to support S&R operations by implementing an aggregation mechanism adopted to process, filter, aggregate and deliver information to the platform considering also the S&R Data Model.
- **Referred Deliverables**: D4.1, D4.8

1.2 Components Tests

1.2.1 Smartwatch

Smartwatch specifications and details were provided to D7.3 and also to "D7.4 Adapted Systems and Services".
The tests focused on the smooth integration and adaptation of the smartwatch data to the final SnR Platform, COncORDE. The smartwatch data are integrated into the Event Log Service. Moreover, data coming from the field were sent to SA model, in order to provide awareness on measurements and finally include them to COncORDE's notification service.
Last but not least, the smartwatch was tested in UC3 on an operational and technical level.

1.2.2 Rescue MIMS

In D5.1, the design framework of the RESCUE-MIMS device was provided; a new tool for SnR operations, a field device for on-line monitoring of chemical compounds in the disaster scene. A number of lab-scale experiments took place for the testing and validation of the analytical performance of the RESCUE-MIMS prototype with relevant components: (a) chemical hazards for the safety of the first responders (b) components relevant to human presence, based on literature recordings (c) other relevant compounds, as it is described thoroughly in D5.3. In D5.5, as a follow up of D5.1 a number of testing took place focusing on checking the design-configuration of the RESCUE-MIMS prototype for serving the specific needs of the two pilot scenarios that the RESCUE-MIMS will be used inside the SnR project; (a) for measuring on-line components relevant to human presence to possibly support the search and rescue operation of entrapped people in the rubbles (UC5) and (b) for measuring on-line chemical hazards on-board robotic platforms for the safety of the first responders (UC4). The evaluation results of the device in terms of usability and its capability of on-line detection of key compounds in the two pilot scenarios (UC5 and UC4) will be available in D5.7.

1.2.3 Wearable GPS Tracker

The tests performed to evaluate the correct functioning of the GPS tracker were the following:

- verification of autonomous operation of the sensor;
- offline analysis of the tracks after the acquisition;
- verification of the correct integration with the Android App developed by UNICA.

The results of all tests were positive.

1.2.4 Wearable Strain Sensors

The tests performed to evaluate the correct functioning of the wearable strain sensor were the following:

- strain response test with different sensor bending levels;
- test of usability and comfort among people with different gender and size;
- verification of the correct integration with the Android App developed by UNICA;
- offline analysis of the data after the acquisition;
- statistical analysis (bends over 30° per minute knee, bends over 30° per hour knee, maximal bends knee).

The results of all tests were positive.

1.2.5 Wearable ECG, EMG

The tests performed to evaluate the correct functioning of the wearable ECG and EMG sensors were the following:

- test of usability and comfort among people with different gender and size;
- verification of the correct integration with the Android App developed by UNICA;
- offline analysis of the data after the acquisition;

- comparison test of ECG signal quality measured by textile electrodes with commercial biopotential amplifier with respect to commercial disposable gelled electrode;
- comparison test of EMG signal quality measured by textile electrodes with commercial biopotential amplifier with respect to commercial disposable gelled electrode.

The results of all tests were positive.

1.2.6 Six Gas Monitor

The tests performed to evaluate the correct functioning of the HLX3000-P5 gas monitor were the following:

- verification of the correct integration with the Android App developed by UNICA;
- offline analysis of the data after the acquisition.

The results of all tests were positive.

1.2.7 Radiation sensors

The tests performed to evaluate the correct functioning of the wearable radiation sensor were the following:

- X-ray response test with different dose rates using a collimated tube with a molybdenum target;
- test of usability and comfort among people with different gender and size;
- verification of the correct integration with the Android App developed by UNICA;
- offline analysis of the data after the acquisition.

The results of all tests were positive.

1.2.8 Emergency Response Health Condition Monitoring Device

The Emergency Response Health Condition Monitoring Device (EMR) is still under development in task 5.2. The functionality of its individual components has been tested as well as integration with a controller and its communication with a smartphone application. The system will be further concerning its accuracy with a medical grade patient monitor.
The functionality that will be tested concerns the following measurements:

- electrocardiogram
- oxygen saturation
- blood pressure
- heart rate
- temperature

Additionally, during UC2 and UC4 the following functionality will be tested concerning the system usability:

- sensors are easy to fix on patient without moving the patient
- bio sensor data is transmitted wirelessly
- visualization of data on several devices (smart phone, tablet, laptop)
- alert function in case of critical data acoustically
- position of sensor is transmitted wirelessly
- time of alert appears on display of rescue person.
- time of alert appears on display of headquarter.
- monitoring of sensors in real time available.
- device can be used for minimum 120 min
- multiple devices can be used simultaneously

1.2.9 Drones & Collaborative drone platform

UHASSELT's task consists of 2 activities: firstly, a real (hardware) drone has been used to stream the camera view of the drone to the streaming server and to integrate other data related to the flight (streaming the battery level, the pitch of the camera, the GPS position of the drone…etc.) to the coordination center via an MQTT broker. The drone video has also been uploaded to an online repository to be used as input for the victim detection module.
Secondly, the collaborative drone platform (a computer simulation, not hardware) has demonstrated the importance of the collaboration of the drones for search and rescue operations. This platform models the coordination between a swarm of drones to achieve collaborative patrolling missions.
In the two sub-sections below a description of the realized tests of drone components is provided.

1.2.9.1 Drones' integration with central coordination center

A Universal Windows Platform (UWP) application has been developed using the DJI Windows SDK (Software Development Kit). The application communicates with the Remote Control (RC) of the drone to collect the data related to the flight and send control commands to the drone. First, the transfer of text data (in JSON format) to the MQTT broker has been tested using MQTTX client and Mosquitto MQTT Broker. The Figure 1 shows the received JSON data from the MQTTX client. The streamed text data has also been logged in as CSV file locally Figure 2. Second, to stream the video online, Nginx streaming server has been installed in a dedicated virtual machine. A test has been performed to test the streaming of the video by OBS streaming tool. The streamed video could afterward be displayed in other devices using tools such as VLC media player. Figure 3 shows a streamed video received form VLC media player on a phone device.

Figure 1: Received Data from MQTTX Client

datapoints.csv | position.csv

	timestamp	recordtime	speedx	speedy	speedz	latitude	longitude	altitude	gimbalPitch	voltage
1	03:38:13.0444	0	0	0	0	50.933162019117	5.39609213195585	0	-11.9	15365
2	03:38:16.6098	0	0	0	0	50.9331634527482	5.39609245943545	0	-11.9	15335
3	03:38:20.0458	0	0	0	0	50.9331639377713	5.39609566076902	0	-11.9	15361
4	03:38:23.8789	0	0	0	0	50.9331627545305	5.39609511361941	0	-11.9	15365
5	03:38:27.1521	0	0	0	0	50.9331617733111	5.39609536095548	0	-11.9	15361
6	03:38:30.5325	0	0	0	0	50.9331625892723	5.39609643606074	0	-11.9	15363
7	03:38:33.7998	0	0	0	0	50.9331624292134	5.3960963088941	0	-11.9	15347
8	03:38:36.8563	0	0	0	0	50.9331627892607	5.39609903544615	0	-11.9	15358
9	03:38:40.0805	0	0	0	0	50.933162276136	5.3961052466021	0	-11.9	15362
10	03:38:43.9103	0	0	0	0	50.9331612833616	5.39610677461364	0	-11.9	15363
11	03:38:47.6617	0	0	0	0	50.9331595636608	5.3961098325534	0	-11.9	15348
12	03:38:51.5558	0	0	0	0	50.9331579401239	5.39611390146457	0	-11.9	15334
13	03:38:55.4626	0	0	0	0	50.9331555414088	5.39612027589813	0	-11.9	15362
14	03:39:00.3661	0	0	0	0	50.9331533317891	5.39612883687071	0	-11.9	15361
15	03:39:03.4557	0	0	0	0	50.9331529813591	5.39613342210155	0	-11.9	15362
16	03:39:06.9040	0	0	0	0	50.9331523903573	5.39613884863048	0	-11.9	15362
17	03:39:10.0760	0	0	0	0	50.933152464184	5.39614450442638	0	-11.9	15362
18	03:39:14.6895	0	0	0	0	50.9331520996304	5.39615093440275	0	-11.9	15348
19	03:39:19.2389	0	0	0	0	50.93315095402	5.39615219948995	0	-11.9	15337
20	03:39:23.6340	0	0	0	0	50.93315060804	5.39615352658363	0	-11.9	15338
21	03:39:27.8781	0	0	0	0	50.9331492752038	5.39614847391512	0	-11.9	15334
22	03:39:31.9989	0	0	0	0	50.9331478536853	5.39614068020395	0	-11.9	15336
23	03:39:36.0980	0	0	0	0	50.9331463047013	5.39613616074497	0	-11.9	15336
24	03:39:40.0396	0	0	0	0	50.933147202859	5.39613589496601	0	-11.9	15337
25	03:39:44.5929	0	0	0	0	50.933148751041	5.39613612671379	0	-11.9	15340
26	03:39:48.9119	0	0	0	0	50.9331480677085	5.39613024314618	0	-11.9	15336

Figure 2: Logged Data in local csv file

Figure 3: Streamed video received form VLC media player on a phone device.

Figure 5 shows the current view of the UWP application. The UWP application allows the following functionalities:

- Take pictures or video and record it locally on the SD card of the drone.
- Monitor in near real time the variation of speed (x,y,z), altitude, GPS location, Gimbal Pitch value, Battery level as a percentage ,Current voltage of the battery.
- Log flight data in a CSV file locally and stream it remotely to MQTT Broker.
- View the current FOV (Field of View) of the drone.
- Create and upload a waypoint mission to the aircraft.
- Set the current position as HOME.
- Pause and resume the waypoint mission.

The UWP application also allows to plan a waypoint mission and upload it to the drone. In the waypoint mission, the drone travels between geopoints, executes actions at waypoints, and adjusts heading and altitude between waypoints. From the map view, the user can add geo points to create a waypoint of the mission which should be within the communication radius of the drone. After creating the mission, it is uploaded to the drone and started if the current state is valid (the current state is mainly related to the calibration of the sensors of the drone, the level of the battery and the length of the mission, strength of GPS signal...).

Figure 4: Tested Communication between local machine and streaming server (NginX) and local machine and MQTT Broker (Mosquito)

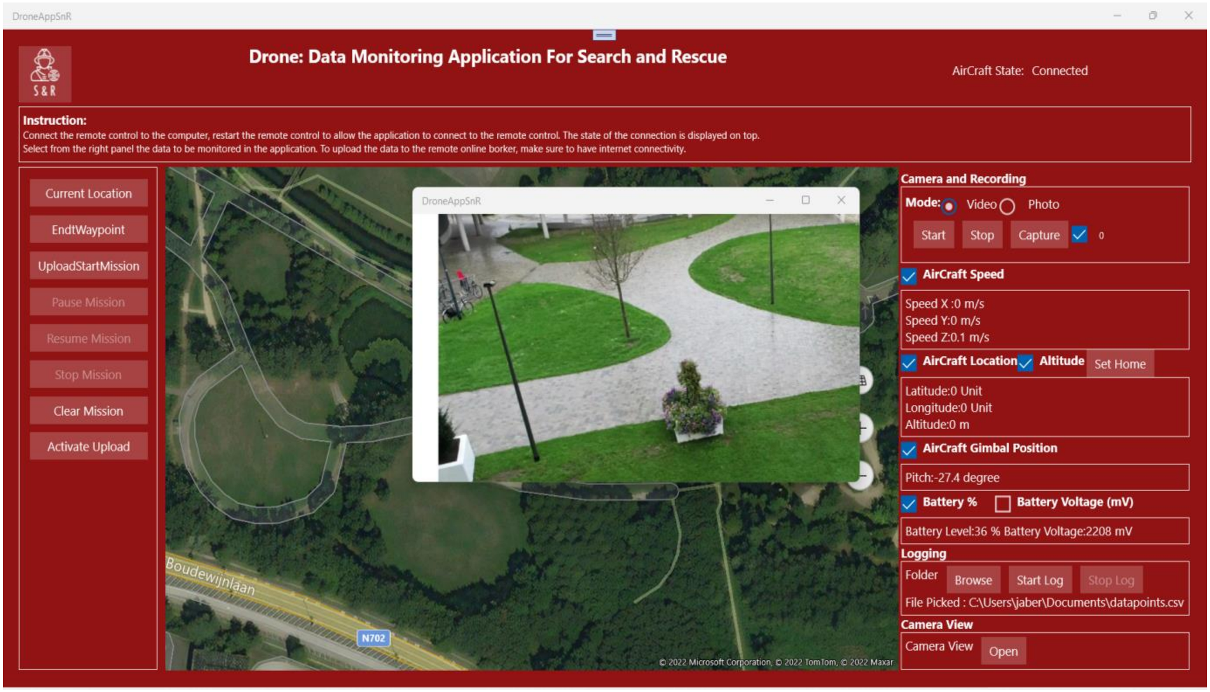


Figure 5: current view of the UWP application

To test the control the waypoints mission execution, two tests have been conducted. The first test shows that some options should be adjusted like: finishedAction, maxFlightSpeed and the altitude of the waypoint of the flight mission. The next table shows the adjusted parameters with the fixed value.

Table 2: Drones parameters

Parameters	Description	Adjusted Value
maxFlightSpeed	While the aircraft is travelling between waypoints, the pilot can offset its speed by using the throttle joystick on the remote controller.	10 m/s

	maxFlightSpeed is this offset when the joystick is pushed to maximum deflection. For example, If maxFlightSpeed is 10 m/s, then pushing the throttle joystick all the way up will add 10 m/s to the aircraft speed, while pushing down will subtract 10 m/s from the aircraft speed. maxFlightSpeed has a range of [2,15] m/s	
finishedAction	Action that the aircraft will take when the waypoint mission is complete.	GO_HOME: The aircraft will go home when the mission is completed. If the aircraft is more than 20m away from the home point it will go home and land. Otherwise, it will land directly at the current location.
gotoFirstWaypointMode	Defines how the aircraft will go to the first waypoint from its current position.	SAFELY: The aircraft will rise to the same altitude of the waypoint if the current altitude is lower than the waypoint altitude. It then goes to the waypoint coordinate from the current altitude, and proceeds to the altitude of the waypoints.
Altitude	-	Fixed to 20m for each waypoint.

After the first test, a few features have been added to the application which are:

- Pause and Resume of the waypoints mission.
- Stop the waypoint mission: Stops the executing or paused mission. After a mission is stopped successfully, the pilot can manually control the aircraft. The new state will become READY_TO_UPLOAD. From the user interface, the pilot can clear the waypoint mission and create a new waypoint mission and upload it to the drone.
- Clear Mission: The waypoint mission will be cleared to allow the pilot to re-create the waypoint mission. If the mission is upload it could not be cleared only if the mission is paused.

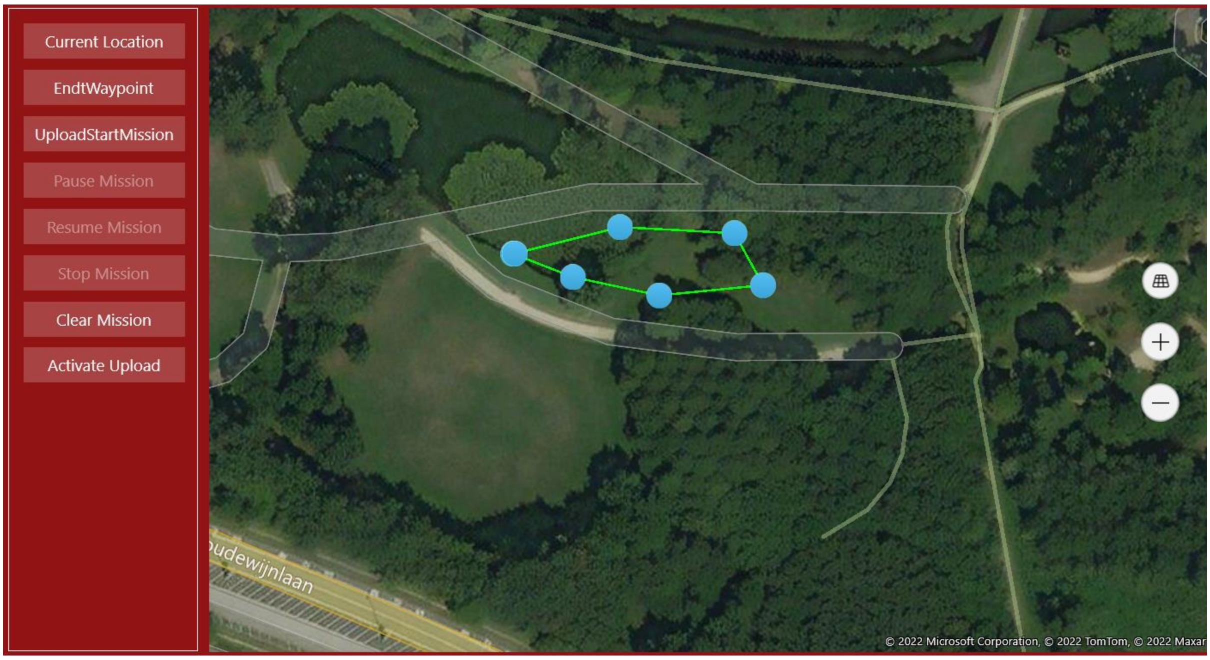


Figure 6: Create waypoints mission from the UWP application.

Finally, a script run locally to transfer the recorded video to the remote repository as shows in Figure 7.

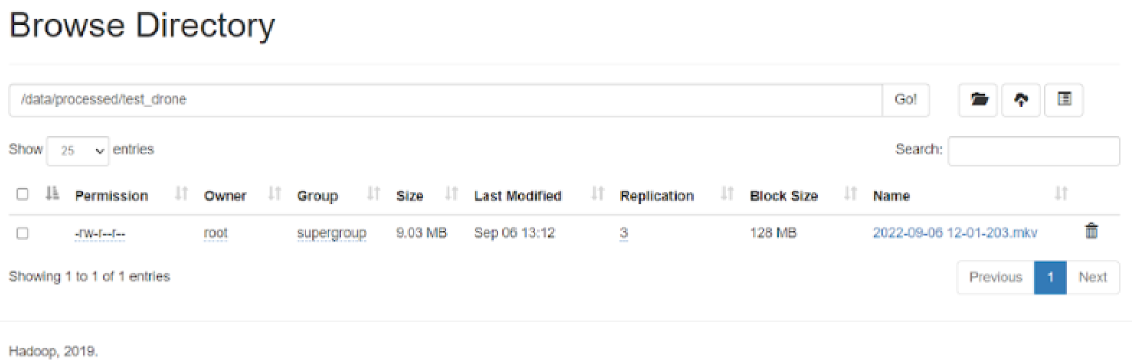


Figure 7: Uploaded video recording to online repository

A last trial is planned to test the added features as well as performance with remote server using 4G communications.

1.2.9.2 Drones' collaboration platform.

The drone collaboration platform allows to create virtual mission of the drones. The main aim of the mission is to patrol a specific area. In the modeled area a number of charging stations and swapping stations is created. The role of swapping stations is to replace the battery of a drone with a charged battery and the role of charging station is to charge drone. While the ground station allows to deployidle drone whenever is needed and possible. The Figure 8 shows the initial view of the simulation.

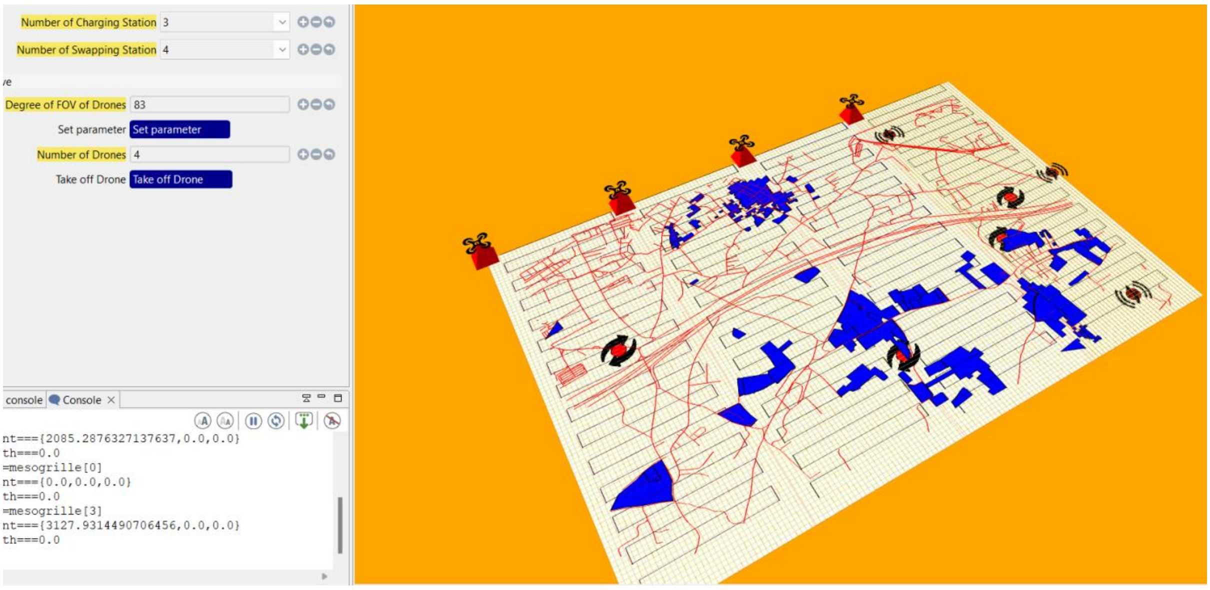


Figure 8: View of the drone collaborative platform

To test the behavior of the drone collaborative platform, the following test are planned:

Table 3: Drone Collaborative Platform Tests

Test	Description
Build of Environment settings and agent's structure.	This test includes the modeling of the structure of the agents in the simulation as well as the simulation environment. The simulation will try to mimic the real situation of the use case. However, a larger surface will be covered to demonstrate the importance of the collaboration.
Agent behavior testing	In this test the Belief Desire Intension (BDI) of the agents in the simulations will be tested to assure that the agents react in a correct way to the events in the environment and to their internal state. For example, if the battery is low, the drone has to execute "battery_charging_plan".
Agent communication testing	In this test communications between agents will be checked including the communication between drone and ground station and communication between charging station / swapping station and the ground station. These communications play a major role in the coordination of the drone actions.

The first test related to the simulation components has been already realized. The behavioral of the agents and the communication modules are under development and the listed tests will be conducted as the development progress.

1.2.10 3D Mixed Reality CC

The 3D Mixed Reality Command Centre (3D MR CC) was developed during the task T4.3 and its function is presented in D4.2. The 3D Mixed Reality CC was tested internally at CERTH after its initial development in August 2021. The test took place without the integration of external components and with dummy data. The following functionality was tested:

- the system can display stereoscopic 3D visualizations

- the system can register images from multiple sources (drones) in specific positions of the 3D visualization
- the system presents data of rescuers/rescue units regarding location and condition
- system reacts to hand gestures of user

The system was presented to the public during the 85th Thessaloniki International Fair, with positive feedback from civil protection and military professionals.
Additional specific functionality will be tested during UC2 with the integration of external components. The functionality concerns the following tasks:

- the functionality of the system with external SnR components
- the user can choose the type of information to be visualized (filter information)
- the system presents position of a distress call in real time
- user can communicate with field units
- the system can be used indoor and outdoor
- device can be used for min. 120min
- system can be used on a local network connection
- multiple people can use the system simultaneously

1.2.11 Smart Glasses

The following tests were performed to ensure the smart glasses were operating properly:

- Verifying the connection drops with the streaming server.
- Analyzing the voice delay between headsets in comparison with the wireless signal.
- Tests to see how the UI reacts to real environment.
- Tests with the end-users to see if the UI is user-friendly.

1.2.12 Rescue Robots & autonomous vehicles

The tests of the robot were split into software and hardware tests, as initially described in D5.4. The hardware components were tested for correct mechanical stability, electrical connection and expected behavior:

Table 4: Robot Hardware Components Tests

Component	Mechanical	Electrical	Behavior
Motors	stable	connected/powered	velocity control accurate
Pan-Tilt-Unit	manually controllable	loses power occasionaly	initialization inaccurate
Cameras	stable on PTU	connected/powered	sending correct data
Velodyne Lidar	stable on PTU	connected/powered	sending correct data
Hokuyo Lidar	mounted on tower	servo had no connection	sending correct data
Battery	stable, hotswapable	1/6 batteries had charging issues	provides power for 2h of operation and motion

Network adapter	detachable from tower	powered by USB, PoE has connection issues	creates correct access point to connect to

For the software, it was visually confirmed that the components yield the expected in- and outputs under any conditions, specifically under extremes:

Table 5: Robot Software Components Tests

Component	Input	Output
Motor driver	velocity command	correct control output
Camera driver		correct image data
Velodyne Lidar		correct pointcloud
Hokuyo Lidar		correct laserscan data
SLAM	pointclouds, camera, IMU	correct localization with loop closure, octomap
Exploration	octomap	velocity command for spatial exploration
ODS (see 1.2.21)	Pointcloud, camera	obstacles

Together with the soft- and hardware components, the robot was tested first in simulation and then in a real environment for the following conditions:

- can carry 30kg payload
- can climb small ramps and steps under reduced velocity
- stops when too close to unidentified obstacles and walls

1.2.13 COncORDE

COncORDE specifications and details were provided to D7.3 and also to "D7.4 Adapted Systems and Services".
The tests focused on:

- The operational level of COncORDE, meaning the Incident, User, Organization Management
- The adaptation/integration of SnR Components to COncORDE's Event Log and Notification Service.

The SnR Systems (hardware) adapted on COncORDE, are:

- GPS Tracker (UNICA)
- Strain Sensor (UNICA)
- ECG Device (UNICA)
- EMG Device (UNICA)
- Six Gas Monitoring (UNICA)
- Rescue MIMS (NTUA)
- Smartwatch (KT)
- Drones (UHASSELT) via Object Detection System (AIDEAS)
- Rescue Robots (DFKI) via Obstacle Detection System (THALIT)

The SnR Software and Services adapted on COncORDE, are:

- Data Lake Ecosystem (KT)
- Apache Kafka (SIMAVI)
- Web Services (MAG)
- Situation Awareness Model (UBITECH)
- SnR Data Model (THALIT)
- Historical Databases (NTUA)
- SOT DSS (KT)
- PHYSIO DSS (CNR)
- Volunteer app (KT & CERTH)
- Object Detection System (AIDEAS)
- Obstacle Detection System (THALIT)
- e-learning Platform (CERTH)

All the above system and technologies were tested by KT (providing unit tests in many of the above), as well as they were tested in an operational level in Use Case 1, 3, 5 and 6.
More information can also be found in the evaluation questionnaires of the above Use Cases, provided in WP8.
In the following months, the rest of the SnR Technologies and Services (e.g 3D Mixed Reality Command Center, etc.) will be integrated and adapted to COncORDE and as a result, they are going to be technically and operationally (in UC4, 2 and 7) tested.

1.2.14 Situation awareness modules

The purpose of the SA model is to provide general situation awareness services by monitoring the biometrics of actors in S&R operations, as well as alerting the first responders and rescue teams about critical events happening in the field.
The SA model was successfully implemented in Use Cases 1, 2, 4 and 6, where its smooth integration within the SnR platform was assessed. Specifically, the tests involved the communication of the SA model with the COnCOrde platform where it successfully received data values from the ConCORDE platform and then forwarded the corresponding alerts about the technologies in the field.
More details about the component specifications can be found in D3.8 "Situation Awareness Model – specification V2", D7.3 "Component Specifications Interface for interoperability within S&R" and "D7.4 Adapted Systems and Services".

1.2.15 BIM based services & apps

The scope of the BIM model web service is to ensure the timely delivery of proper information flow for the building-related and SA-related data that will be retrieved and properly interconnected in the context of the project. The model will be tested as a standalone service in the SnR platform.
More details about the component specifications can be found in D3.3 "BIM based services and applications", D7.3 "Component Specifications Interface for interoperability within S&R" and "D7.4 Adapted Systems and Services".

1.2.16 Sensor Web Services

The pilot tailored Sensor Web Services have been initially tested and validated on MAG soapUI platform. Afterwards, they have been integrated into ConCorde platform from KT and have been tested in the recent Use Cases. All the results and indications were operating as intended. A detailed test description has been included in the deliverable D6.8.

1.2.17 SOT DSS

SOT DSS specifications and details were provided to D7.3 and also to "D7.4 Adapted Systems and Services", as well as an updated version in D4.9 and D4.11.
The tests focused on the smooth integration and adaptation of SOT DSS Services to the final SnR Platform, COncORDE. SOT DSS was integrated as a standalone service in the COncORDE Platform, in

order to give to the end-user an overall picture of recommendations coming from the field. SOT DSS was operationally tested in UC1, UC5 and UC6 by the High and Field Commanders (COncORDE Users).

1.2.18 PHYSIO DSS

The validation and verification processes of the PHYSIO DSS component have been thoroughly described in Deliverables D4.7 – DSS Validation, V1 and D4.13 – DSS Validation, V2. Briefly, each function of the PHYSIO DSS component has been tested and the test design has been decided before the implementation phase was started. The development and test of the PHYSIO DSS Component made use of different programming languages, including MATLAB®, C++, XML and PHP (requirement R5). The use of more than one programming language and the involvement of different programmers allowed the semantic and syntactic check of the implemented functions. MATLAB®, being a mathematical interpreted language and a numerical simulation toolbox, was mainly used for prototyping functions and algorithms for an easier and more immediate semantic debugging, allowing to verify, by means of graphs and simulations, if the system responses were compliant with what expected. C++ is a middle-level compiled language employed for fast code execution. All the algorithms prototyped in MATLAB were translated to C++ and consistency of the outputs of the two implementations was verified for different sets of inputs. PHP is a scripting language operating on a Web Server. It was used to build a module, invoked on the web server, to call the compiled C++ executable files. XML Extensible Markup Language, is a markup language adopted for the construction of the Web Service Description, the public interface of the web service, and for a simplified data sharing and exchange according to the SOAP protocol. For each function or algorithm, the design and test foresaw the implementation of 6 items. They are reported and described in the following table:

Table 6: Physio DSS Functions

item	environment	desription
א aleph	MATLAB	A Matlab function, that is a series of statements which take the inputs and return the outputs
ג gimel	MATLAB	a sample function in MATLAB which calls the corresponding aleph function locally and shows the results
ד dalet	MATLAB	a client function in MATLAB which calls remotely the webservice (which uses the server-located vav function) and returns the output
ו vav	c++	a function implemented in C++ which translates the corresponding aleph function into compiled executable code
ח chet	MATLAB	A MATLAB function calling both the function vav remotely (compiled in C++) and the MATLAB function aleph present in the local environment for a comparison of the results
PhysioService	PHP	A PHP module which calls the functions (vav items) located on the server

Since most of the functions are not deterministic but contain different elements of randomness (see deliverables D4.4, D4.6, D4.10 and D4.12), the comparison between the output of two different programming languages had to employ the same sequence of pseudo-random numbers in each simulation. To this end, we reimplemented a simple Linear Congruential Generator (LCG), defined by the following iteration

$$x_{n+1} = (ax_n + c) \bmod m$$

where a, c, m are given parameters. Starting from an integer seed $x_0 \geq 0$, such a sequence returns natural numbers bounded by m-1. We normalized the sequence by dividing each element by m-1, so that we obtained a pseudo-random generator in the interval [0,1].
In the following, we report, as an example, a figure showing the results obtained after a call to the ETD service in Matlab e C++ (on the server, in remote execution).

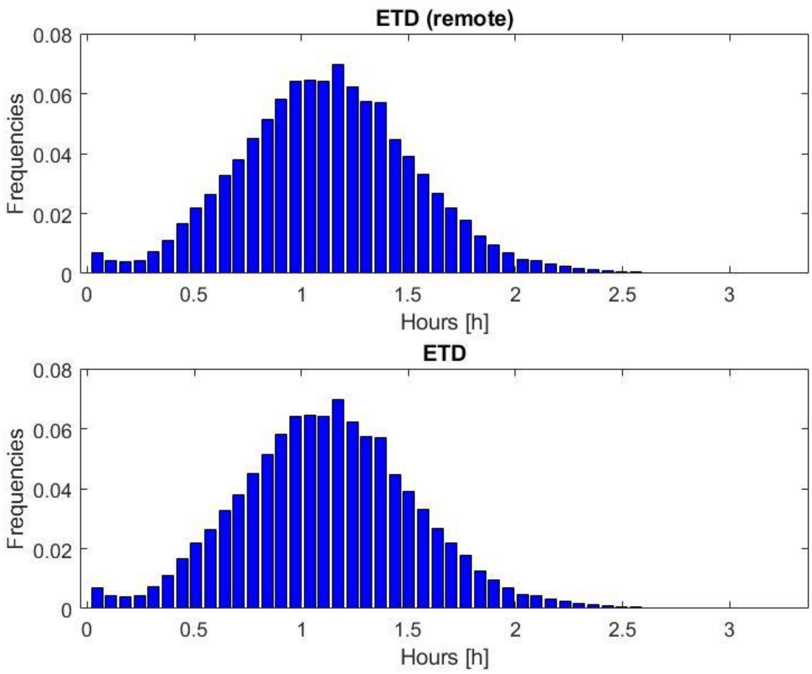


Figure 9: Remote and Local "Expected Time to Death" (ETD) distribution computation comparison

Moreover, two table-tops demonstrations were organized with the members of the Evaluation Committee which was constituted with the aim of evaluate the S&R DSS. During the two meetings all the functionalities of the PHYSIO DSS were showed and comments and suggestions were collected for future improvements.

1.2.19 Volunteer app

The volunteer app has been developed by CERTH and KT which took care of the frontend and backend part of the app, respectively. Tests have been done by both the partners.

1.2.19.1 CERTH

The first complete test of the Volunteer App took place in early 2022. The testing group for the evaluation consisted of 6 persons from CERTH with a background in software development.
During this testing process issues were found in relation to the communication between the front-end and the back-end as some information used by the front-end was not sent as expected from the back-end. In addition, an error message appeared in the front end during the password verification process in case the user typed a wrong password. Minor issues regarding the visualization of the equipment and skills in the user profile were also identified.

A second testing was undertaken by the same group after correcting the aforementioned issues to ensure that the Volunteer App was working as it was meant to. The testing group also verified that the flow of information was fast and consistent and that all information regarding the user was properly displayed. An important issue was to ascertain that when someone pressed the RED BUTTON, a crucial functionality of the application, the other testers were informed within seconds. The testing group verified and reported that the overall application was easy to handle and that no issues were found neither with the visual representation nor with the functional part. Report D2.5 includes a detailed description of the functionalities of the volunteer application.
Further evaluation will take place during the operationalization of UC2 and UC4 where the Volunteer App is going to be used by volunteers in the field. The evaluation will focus on the functionality and usability of the application. The basic KPIs are:

- The login process to be functional and easy.
- The functionality of the profile information tab.
- The functionality of the emergencies tab (e.g. the volunteers can see new emergencies).
- The functionality of the "RED BUTTON".

It is expected that during this testing the users will be able to handle immediately new incoming emergencies and have better responsiveness in case a fellow volunteer is in danger. D8.9 includes a comprehensive list of the KPIs. The results of the UC testing will be documented in either D8.10 or D8.11.

1.2.19.2 KT

Volunteer app specifications and details were provided to D7.3 and also to "D7.4 Adapted Systems and Services", as well as on D2.5.
The tests focused on the smooth integration and adaptation of COncoRDE Operational information (e.g Incident details, users, etc.) to the volunteer app, as the main feedback. KT created and tested the back-end of the Volunteer App (Django, etc.) and tested POST, GET, PATCH requests between COncORDE back-end and Volunteer back-end. Moreover, in collaboration with CERTH, KT also tested the integration of the back-end data to CERTH's front-end page of the volunteer app.
This component will be tested in the coming months on UC4 and UC2.

1.2.20 e-learning based platform

The eLearning platform was developed in T2.4 and an early testing in relation to its functionality was performed by Month 24 by contributing partners so to reflect the contents of D2.4 submitted then. Following the submission, the eLearning platform became available to consortium partners and was further evaluated in UC6 by selected UC6 participants. As part of the evaluation, a questionnaire was answered by several users. This sample of users has approximately three years of experience and their ages ranged from twenty-five to forty-five years old. Some users were familiar with such eLearning platforms (e.g., Udemy, EntryPointNorth, etc.), while others were completely unfamiliar with them. This evaluation was focused on determining the usability and the responsiveness of the SnR eLearning platform. As the course's content of the platform was developed and reviewed by consortium parnters during T2.4 who are expert in their fields and are end-users, the evaluation prioritized, as aforementioned, the functionality of the platform. Nevertheless, testers of the platform (UC6 participants) were also asked to provide feedback with regard to meeting their learning objectives and improving their preparation, through the online courses, in terms of safety and security management as this relates to their forthcoming participation in the UC.
According to the SnR eLearning platform evaluation, most of the users found the platform well organized and easy to navigate through it. This is a result of the well-defined instructions, as users reported. They also reported that images combined with the text and the sound made the courses more familiar and more understandable providing them with the feeling of being better prepared to deal with the field operation. Moreover, the courses of the platform included some quizzes/questionnaires which enhanced the learning process and helped the participants to understand and learn important topics that were mentioned in the course. Based on users' feedback, the final quizzes/questionnaires were in perfect match with the content of the respective course.

In conclusion, all users that tested the SnR eLearning platform felt better prepared for the upcoming exercises and they fulfilled their final eLearning objectives. The results of the UC testing is documented in either D8.10 or D8.11.

1.2.21 Object detection algorithms on Autonomous Vehicles

The THALIT's Obstacle Detection System (ODS) offers Object Detection and Tracking features that can be employed in the Autonomous Driving context. The system exploits Object Detection on multiple type of sensors (LiDAR, camera) and data fusion to track objects of interest in the 3D environment. This type of information can be either used as an input for a driving logic with the purpose of obstacle avoidance and as a support for operators to enhance the understanding of the operating environment. In the context of Use Case 3 and Use Case 4, the ODS is integrated with DFKI's SeekurJr robot, which will support operators in the exploration of dangerous and critical zones. The system offers the following functionalities:

1. Support obstacle avoidance for autonomous exploration by providing input for the robot's driving logic, by feeding information (location, speed, etc.) about relevant objects in front of the robot. This is accomplished by using Robot Operating System (ROS) for inter-process communication.
2. Support operators by providing a visualization service that displays sensors data, such as video from stereo camera and point cloud from LiDAR, enhanced with the ODS processing data, such as objects detected in video frames and tracked objects in the 3D space. The service is offered as a web application.

The testing procedure for the ODS proposed in section 7.2.3 of "*D5.8 Testing of RESCUE MIMS on-board robotic platforms and drones*" deliverable will be used to perform an evaluation of the previously described functionalities during the Use Cases. Therefore, the tests are grouped in two sets to better understand the strengths and the weaknesses of the system. For each test a description, a list of prerequisites and a list of expected results are provided. The tests are grouped in:

1. **Functional Tests**: these tests are related to the integration of the ODS in the SeekurJr robot and the functional correctness of the ODS processing. These tests aim to perform a series of checks on the systems at different integration levels. First, correct powering and networking will be assessed. Then, ROS messages exchange between ODS and other nodes on the robot (sensors, driving logic) will be checked. Finally, tests to assess the capability of the system to detect and track objects of interest will be performed.
2. **Visual Tests**: these tests are related to the visualization service offered by ODS and they aim to test the usability of such interface. The tests can be performed under the prerequisite that the ODS is able to receive the input from the robot's sensors and that the web service can be accessed by a client. The proposed tests will be used to check if the service can be successfully employed by an operator. Thus, correct visualization of sensor data and ODS processing data will be assessed.

During the development of the ODS and its following integration with the robot platform, the tasks listed in the tests have been used to assess the functional properties of the system. In such a way, during the development phase of the system, correct implementation of the communication protocol via ROS has been ensured and correct processing of the input data (LiDAR's point cloud and camera's streams) has been assessed. These operations have been performed using sensor's prerecorded data acquired in the robot platform (rosbag). During the integration phase on the robot, board powering and networking setup has been performed and assessed to ensure correct communication between the ODS and the platform. Moreover, test runs with the robot have been undertaken to assess the correct behavior of the ODS with respect to the driving logic, while the viewer application has been employed to qualitatively check the system functionalities.

During the Use Cases all the listed tests will be performed to ensure that both functional and visual results are compliant to the expected ones in a real-world experimental setup. The testing will also allow to acknowledge what the most critical tasks for the system are and so, to understand what functionalities can be improved.

1.2.22 Object detection on UAV imagery

The AIDEAS OD algorithms were evaluated in UC1, in UC2 and UC4. In each use case scenario, the purpose of this component was to recognize human objects. All UCs received their input data via drone footage or data feeds. The OD technique was deployed within the KT's Data Lake Ecosystem. The optimum OD network was chosen on the basis of D3.5's thorough experimentation, findings, and conclusions. To validate the component's functionality, the following steps were conducted. Initially, CNR, HRT, and UHasselt were given with a comprehensive list of shooting requirements. AiDEAS suggested recording many videos at varying altitudes in order to test and compare their models' performance. Each end-user recorded numerous videos with human objects at elevations of 10 meters, 20 meters, 30 meters, and 40 meters (>5 minutes at each altitude). This method was essential for identifying the best height range for the most precise model to recognize human things. The drone's camera angle should not be vertical, but rather angled (e.g., 45 degrees). Acceptable was the use of a resolution of 1080p or above to increase the precision of video analysis. Due to the fact that the algorithm worked efficiently with several persons in a single backdrop, a maximum of 10 humans per background were suggested for testing.
The gathered videos were then analyzed and evaluated using the current model. The model successfully recognized human objects in most of the cases. There were some human objects that remained undetected. To handle this, AiDEAS was required to retrain the existing model and upgrade its weights. Consequently, a novel model with enhanced human identification ability in demanding environments was created. In the vast majority of situations, the findings confirmed the effectiveness of the recommended technique. Finally, it successfully recognized the human as an object in the vast majority of scenarios when this is important for end users to quickly identify them. It was established that the algorithm is occasionally incapable of recognizing a human, particularly when the drone is flying at a very high altitude (e.g., >80 meters).

1.2.23 Integration Platform

Tests performed:

- Integration platform KAFKA is running
- Connections to KAFKA topics work
- Apache ServiceMIX is running
- Connection to Apache ServiceMIX work
- Bridge to HDFS (Data Lake) work

1.2.24 SnR Data model

The Data Model has been provided as a set of XML Schema and Avro Schema files that can be easily adopted for the development of web and rest services. In particular the XML Schema files have been imported and used within the Web Services developed by Maggioli while the Avro Schema files have been adopted within the topics provided for sending and filtering the data produced by the various sensors towards the data lake.
Before providing it to the partners it has been tested using test applications such as SOAP-UI and POSTMAN: a dedicated test suite has been created on both the application by generating a mock service and client; the mock service have been setup to import the data model schema files and expose a test api on a dedicated endpoint; the mock client has been setup to import the data model schema files, generate some test data and use the data model to populate specific data structures; finally these data has been sent to the mock service by calling the exposed api. On the server side, we have checked that all the data was received and logged. In practice the data model has been successfully tested as a tool to exchange the modeled data structures.
After this test, the data model has been provided to the partners which have successfully used it to send and filter the data produced by the various sensors towards the data lake, by making use of the exposed web services and topics.
In practice the data model has been used by the various S&R components to exchange data and it has been tested also during the various use cases execution.

1.2.25 Data Lake Ecosystem

Data Lake Ecosystem specifications and details were provided to D4.1, D4.8, D7.3 and D7.4.
Data Lake successfully consumed incoming data from the field from Apache Kafka Topics (SIMAVI) on behalf of the following technologies:

- GPS Tracker (UNICA)
- Strain Sensor (UNICA)
- ECG Device (UNICA)
- EMG Device (UNICA)
- Six Gas Monitoring (UNICA)
- Rescue MIMS (NTUA)
- Smartwatch (KT)

Data Lake was also tested in an operationally level on UC1, UC5, UC6 and UC3, since if Data Lake was not consuming the incoming data from the field technologies, then COncODE would not be able to consume in its turn the field awareness.
Finally, Data Lake also provides the aggregated and transformed field data to the web service (MAG), for further filtering.

2 Use Cases Tests

The previous section has focused specifically on each single component of the S&R ecosystem and has shown how each one of these components has been tested.
This section is at higher level and focuses on the various uses cases: each use case adopt a set of components to perform the expected behavior. The aim of this section is to explain how each use case have been tested by providing a view of the relations between the adopted components, the exchanged data and the result of the use case execution.
This evaluation is reported use case by use case on the next subsections. For every use case a quick description is reported, which is useful to recap the purpose of the use case and the main involved components; then for every use case the test execution and the main results are provided.

2.1 UC1 - The Poggioreale Old Town Demo Victims trapped under rubble

2.1.1 UC1 Summary

The UC1 has been executed in Poggioreale, Sicily. The following situations have been simulated:

- people trapped under the rubble and / or in premises not reachable as a consequence of an earthquake;
- release of gases and / or other toxic substances as a consequence of an earthquake;
- blocked roads preventing traditional vehicles to reach the area.

A detailed description of UC1 is presented in D8.2.
The main components/technologies which have been tested within this use case are:

1. Wearable GPS tracker (UniCA)
2. Situational Awareness Model (UBITECH)
3. Emergency communication App (KT)
4. Decision Support System (KT, CNR, NTUA)
5. Rescue kits for children (UniFI)
6. Smart textile professional uniform (UniFI)
7. Wearable ECG, EMG (UniCA)
8. Wearable strain sensors (UniCA)
9. AI algorithms for recognizing humans from drone images (AIDEAS)

The next table reports a detailed list of the components that have been involved in the use case execution together with their status, dependencies, testing and other specific details.

UC Leader	CNR	Fabio Cibella	DONE!
UC Date	28/04/22	D8.2	

Techologies	Partner	Status	Dependencies	Integrated	Testing	Date to be completed	TUC (Technical Use Cases)	Completed
COncORDE	KT	Ready	SA, PHYSIO, MAG responses, SOT DSS	Yes (with SOT & SA)	Yes	December 2021	TUC.1	
Data Lake	KT	Ready	UNICA Technologies, Kafka	Yes	Yes	June 2021		
Apache Kafka	SIMAVI	Ready	UNICA technologies, adaptation	-	Yes	November 2021	TUC.2	
SnR Data Model	THALIT	Ready	UNICA Technologies	Yes	Yes	November 2021		
GPS Tracker	UNICA	Ready	Adaptation, Apache Kafka	Yes	Yes	December 2021		
Strain Sensors	UNICA	Ready	Adaptation, Apache Kafka, Smart Uniform	Yes	Yes	February 2022	TUC.5	
ECG, EMG	UNICA	Ready	Adaptation, Apache Kafka, Smart Uniform	Yes	Yes	February 2022		
SA model	UBI	Ready	UNICA Techologies, Apache Kafka, DLake	Yes	Yes	Late March 2022	TUC.8	
Field Sensor services	MAG	Ready	UNICA Techologies, Apache Kafka, DLake	Yes	Yes	Late March 2022	TUC.7	
PHYSIO DSS	CNR	Ready	Triage	Yes (The services were provided on 07/03/22)	Yes	mid - April 2022	TUC.9	mid-April 2022
SOT DSS	KT	Ready	COncORDE	Yes	Yes	December 2021	TUC.6	
Detection algorithms applied on UAV	AIDEAS	Ready	Drones, Data Lake	Yes	Yes	March 2022	TUC.3	
Drones	Sicily Civil Protection	Pre-defined data will be used	Depended components: Dlake, Detection algorithms	**Due to the fact that there are no details yet for the drones' server, predefined videos will be used *The videos that Civil Proterction of Sicily provided**	-	-		
Smart Uniforms	UniFI	Ready	-	-	-	-	-	
Rescue System for children	UNIFI	Ready	-	-	-	-	-	

Traning	Training Sessions * 2	Providers	Deadline
11/04/2022	1st Training Session	KT-CNR	mid-March

Figure 10: Use Case 1 recap table

2.1.1.1 Field Technologies

The data flow within the use case is the same for all the field technologies: once generated, the data flow towards the Data Lake Ecosystem following this schema:
<Source technology/system> -> Apache Kafka Topic -> SnR Data Model -> Data Lake Ecosystem.
Then the data are dispatched to the following components:

- COncORDE Event Log Service (All Events)
- Web Services (Further Filtered Data) -> COncORDE Event Log Service (e.g GPS)
- SA model -> COncORDE Notification Service
- COncORDE Interactive Map (pins of GPS tracking on the map)

This procedure applies to all the field technologies such as the GPS tracker, the ECG, the EMG, the Strain Sensors etc.

2.1.1.2 Rest Services

Regarding the rest services the data flow is the following:

- COncORDE Incident, Users Management & Interactive Map -> SOT DSS
- COncORDE Triage -> PHYSIO DSS -> COncORDE Patients Management
- Drone Video from UC1 Partners (not in real-time) -> Data Lake Ecosystem -> Object Detection Algorithm -> COncORDE ODS Page

In an operational level, the end-users navigated to COncORDE screens, in order to orchestrate the emergency and be aware of the incoming information from the field.

2.1.2 UC1 Test

2.1.2.1 Sensors Integration Test

- **Test Prerequisite Condition**: GPS working properly, ECG/EMG sensors, strain sensor, UNICA app, Apache Kafka, Data Lake, COncORDE.
- **Test Input**: GPS, ECG, EMG and strain Data from the field.
- **Test Procedure**: GPS trackers, ECG, EMG and strain sensors generated data to the first responders' smartphones and produced to a dedicated APache Kafka Topic. Then, the Data Lake Ecosystem consumed the data, stored them to a specific directory into HDFS, process and aggregate them and finally produced them to COncODE's Event Log Service. Moreover, the

same data were used for the Notification Service (SA) and the interactive Map (Pins on the map).

- **Expected Results**: The end-user must have the ability to see GPS measurements in COncORDE Event Log Service, notifications in COncORDE Notification Service and pins on the map.
- **Test Result**: Use Case executed, all the components tested according to the identified procedure; overall use case test was positive.

2.1.2.2 COncORDE Integration Test

- **Test Prerequisite Condition**: WiFi Connection, the rest services working in a proper way.
- **Test Input**: Data Lake, SA, SOT data.
- **Test Procedure**: COncORDE consumes incoming data (in a homogeneous format) from the Data Lake Directories via WebHDFS, stores and handles them to the Event Log Service. Then, Event Log produces the same data to Web Services for further filtering and SA model for Notification and Alarms. COncORDE consumes their results. Meanwhile, other software and services such as SOT DSS, produces their response to COncORDE in order for it to consume it and demonstrate it to the end-user.
- **Expected Results**: The end-user must have the ability to see all the incoming data from the field technologies and SnR services.
- **Test Result**: Use Case executed, all the components tested according to the identified procedure; overall use case test was positive.

2.1.2.3 SOT DSS Test

- **Test Prerequisite Condition**: COncORDE Incident, User, Organization, Patient MGT & Map.
- **Test Input**: COncORDE's Incident, User, Organization, Patient (triage) APIs.
- **Test Procedure**: The end-user provides feeds COncORDE with details on Incident, Organization, Users and Patients on the field and each SOT DSS service consumes them, in order to generate via linear programming algorithms its recommendations.
- **Expected Results**: The end-user must have the ability to see the 4 SOT DSS Services responses in SOT DSS screen.
- **Test Result**: Use Case executed, all the components tested according to the identified procedure; overall use case test was positive.

2.1.2.4 PHYSIO DSS Test

- **Test Prerequisite Condition**: COncORDE Patient MGT (Triage).
- **Test Input**: COncORDE's Triage.
- **Test Procedure**: The first responders feed COncORDE Triage with Patient health data from the field. Then, Triage API feeds PHYSIO Web Services with data, in order to train the excepted time of death algorithm and its dedicated pies. Then, COncORDE consumes PHYSIO response via WDSL and provides graphs into the Patient Screen for each patient.
- **Expected Results**: The end-user must have the ability to see the PHYSIO DSS graphs for each registered patient.
- **Test Result**: Use Case executed, all the components tested according to the identified procedure; overall use case test was positive.

2.1.2.5 Object Detection Test

- **Test Prerequisite Condition**: videos captured by drones available for implementation.
- **Test Input**: videos captured by drones adopted for object detection model training.
- **Test Procedure**: videos taken by drones, to be acquired locally by the end users. The model to be trained offline in the Data Lake Ecosystem using the acquired videos as training input. Results of the training to be sent to end users for evaluation.
- **Expected Results**: end users to confirm that the goodness of the model training.
- **Test Result**: Use Case executed, all the components tested according to the identified procedure; overall use case test was positive.
- **Additional notes**: the next picture shows some instances of the videos adopted to train the model.

Figure 11: Frames taken from a video tape produced by CNR.

- **Additional notes**: the next picture shows the results of the model training done using the videos captured by drones.

Figure 12: Examples from the model's results.

2.2 UC2 – Plane crash in a mountainous region around Thessaloniki

2.2.1 UC2 Summary

The UC2 has been executed in mount Chortiatis, a mountainous area near Thessaloniki. The following situation has been simulated:

- Aircraft crash in a remote location.

A detailed description of UC2 is presented in D8.3.
The main components/technologies which have been tested within this use case are:

1. Smartwatch (KT)
2. Emergency Communication App (KT)
3. Situational Awareness (UBITECH)
4. 3D Mixed Reality Command Centre (depending on the required hardware) (CERTH)
5. Volunteer application (CERTH)
6. Emergency Response Health Condition Monitoring Device (Test the device on the simulated victims) (CERTH)
7. e-learning based platform (to be used for training) (CERTH) (UC2 is foreseen to take place in Oct-Nov 2022, so I believe that we will be OK, timewise)
8. Smart Glasses (to be used for training and if possible, to display information through AR on the field) (SIMAVI)* CERTH will provide 2 Smart Glasses and SIMAVI will provide technical assistance
9. AI algorithms for recognizing humans from drone images (AIDEAS)

The next table reports a detailed list of the components that have been involved in the use case execution together with their status, dependencies, testing and other specific details.

UC Leader	**HRT**	Iosif Vourarchis, Lorentzo Nerantzis	**DONE!**
UC Date	**11-13 November 2022**	**D8.3**	

Techologies	Partner	Status	Dependencies	Integrated	Testing	Date to be completed	TUC (Technical Use Cases)	Completed
COncORDE	KT	Ready	SA, PHYSIO, MAG responses, SOT DSS	Yes (with SOT & SA)	Yes	December 2021	TUC 1	October 2022
Data Lake	KT	Ready	UNICA Technologies, Kafka	Yes	Yes	June 2021	TUC 2	
Apache Kafka	SIMAVI	Ready	UNICA technologies, adaptation	-	Yes	November 2021		
SnR Data Model	THALIT	Ready	UNICA Technologies	Yes	Yes	November 2021		
SA model	UBI	Ready	UNICA Techologies, Apache Kafka, DLake	Yes	Yes	Late March 2022	TUC 8	
Field Sensor services	MAG	Ready	UNICA Techologies, Apache Kafka, DLake	Yes	Yes	Late March 2022	TUC 7	
Smartwatch	KT	Ready	Adapation, Apache Kafka, DLake	Yes	Yes	December 2021	TUC 4	
Detection algorithms applied on UAV	AIDEAS	Ready	Drones, Data Lake	Yes	Yes	March 2022	TUC 3	
SOT DSS (Only Service 3)	KT	Ready	COncORDE	Yes	Yes	December 2021	TUC 6	
Drones	HRT	Ready	To be connected to 3D Mixed CC	Yes	Yes		-	
3D Mixed CC	CERTH	Ready	CERTH Techologies, MQTT, COncORDE	No, it will work as a standalone tool	Yes			
Emergency Response Health condition Monitoring Device	CERTH	Ready	CERTH Techologies, MQTT, DLake	Yes	Yes			
e-learning platform	CERTH	Ready	3rd party application	Yes	Yes			
Volunteer Application	CERTH & KT	Ready	COncORDE	Yes	Yes			
Smart Glasses	SIMAVI	Not tested	COncORDE	No	No			

*D8.3 does not include any DSS. However, the KPIs are mentioning DSS. However, the KPIs are not alligned with PHYSIO or SOT DSS. Please see T4.5 and T4.6 on what our DSS do

Traning	Translation	Training Sessions * 3	Deadline
KT	HRT	KT-HRT	September 2022

Figure 13: Use Case 2 recap table

2.2.2 UC2 Test

2.2.2.1 GPS Integration Test

- **Test Prerequisite Condition**: GPS working properly, Smartwatch, Apache Kafka, Data Lake, COncORDE.
- **Test Input**: GPS Data from the the field.
- **Test Procedure**: GPS trackers generated data to the first responders' smartphones and produced to a dedicated Apache Kafka Topic. Then, the Data Lake Ecosystem consumed the data, stored them to a specific directory into HDFS, process and aggregate them and finally produced them to COncORDE's Event Log Service. Moreover, the same data were used for the Notification Service (SA) and the interactive Map (Pins on the map).
- **Expected Results**: The end-user must have the ability to see GPS measurements in COncORDE Event Log Service, notifications in COncORDE Notification Service and pins on the map.
- **Test Result**: Use Case executed, all the components tested according to the identified procedure; overall use case test was positive.

2.2.2.2 COncORDE Integration Test

- **Test Prerequisite Condition**: WiFi Connection, the rest services working in a proper way.
- **Test Input**: Data Lake, SA, SOT data.
- **Test Procedure**: COncORDE consumes incoming data (in a homogeneous format) from the Data Lake Directories via WebHDFS, stores and handles them to the Event Log Service. Then, Event Log produces the same data to Web Services for further filtering and SA model for Notification and Alarms. COncORDE consumes their results. Meanwhile, other software and services such as SOT DSS, produces their response to COncORDE in order for it to consume it and demonstrate it to the end-user.
- **Expected Results**: The end-user must have the ability to see all the incoming data from the field technologies and SnR services.
- **Test Result**: Use Case executed, all the components tested according to the identified procedure; overall use case test was positive.

2.2.2.3 Object Detection Test

- **Test Prerequisite Condition**: For the purpose of detecting humans in live video footage from a drone, it is important to ensure that the necessary hardware and software requirements are met for the deep learning model being used. This may include specific hardware components, such as a graphics processing unit (GPU) for faster model training and inference, and software dependencies, such as specific versions of programming languages and libraries. In addition, it is important to consider any regulatory or safety considerations that may be relevant to the use of the drone, such as laws and regulations governing the use of drones in specific locations and the potential risks to individuals or property. The real-time video feed from the drone will need to be analyzed by a computer with sufficient processing power to run the deep learning model effectively.

- **Test Input**: videos captured by drones adopted for object detection model training.
- **Test Procedure**: videos taken by drones, to be acquired locally by the end users. The model to be analyzed offline in the Data Lake Ecosystem using the acquired videos as input. Results of the detection analysis to be sent to end users for evaluation.
- **Expected Results**: The model is able to detect humans in images and videos with high accuracy, demonstrating the effectiveness of its training and receiving confirmation from end users of its performance.
- **Test Result**: Use Case executed, all the components tested according to the identified procedure; overall use case test was positive.
- **Additional notes**: the next picture shows some instances of the videos adopted to train the model.

Figure 14: Frames taken from a video tape produced by HRT.

- **Additional notes**: the next picture shows the results of the model training done using the videos captured by drones.

Figure 15: Examples from the model's results.

2.3 UC3 - Heavy storms in the region of Kufstein railway station

2.3.1 UC3 Summary

The UC3 has been executed at the NÖ Feuerwehr- und Sicherheitszentrum, Tulln, Austria.

The following situations have been simulated:

- A heavy storm is ongoing, which uproots several trees and causes a blackout;

A detailed description of UC3 is presented in D8.4.
The main components/technologies which have been tested within this use case are:

1. Robot: SeekurJr (weight 80kg, max. payload 50kg, 3-5h operating time) (DFKI)
2. Obstacle avoidance system (THALIT)
3. CONCORDE Communication App (KT)
4. Smartwatches (KT)
5. Six Gas HazMat Monitor (UNICA)

The next table reports a detailed list of the components that have been involved in the use case execution together with their status, dependencies, testing and other specific details.

UC Leader	JOAFG & JUH	Birgit Schilcher, Daniela Weismeier-Sammer, Simon Bittner ~~Pia Ferner, Georg Aumayr, Svenja Bertram~~	DONE!
UC Date	Fri 30.9./Sat 1.10	D8.4	

Techologies	Partner	Status	Dependencies	Integrated	Testing	Date to be completed	TUC (Technical Use Cases)	Completed
COncORDE	KT	Ready	SA, PHYSIO, MAG responses, SOT DSS	Yes (with SOT & SA)	Yes	December 2021	TUC.1	Late August 2022
Data Lake	KT	Ready	UNICA Technologies, Kafka	Yes	Yes	June 2021	TUC.2	
Apache Kafka	SIMAVI	Ready	UNICA technologies, adaptation	-	Yes	November 2021		
SnR Data Model	THALIT	Ready	UNICA Technologies	Yes	Yes	November 2021		
Field Sensor services	MAG	Ready	UNICA Techologies, Apache Kafka, DLake	Yes	Yes	Late March 2022	TUC.7	
SA model	UBI	Ready	UNICA Techologies, Apache Kafka, DLake	Yes	Yes	Late March 2022	TUC.8	
Smartwatches	KT	Ready	Adaptation, Apache Kafka	Yes	Yes	December 2021	TUC4	
Six Gas Hazmat	UNICA	Ready	Adaptation, Apache Kafka	Yes	Yes	June 2022		
Robot	DFKI Integration of Map	Ready	OAS	Yes	Yes			
Obstacle avoidance system	THALIT IFrame	Ready	Robot	Yes	Yes			

* There is no DSS in the UC.

Traning	Translation	Training Sessions * 3	Deadline
KT	JOAFG & JUH	KT-JOAFG & JUH	Early September 2022

Figure 16: Use Case 3 recap table

2.3.1.1 Field Technologies

The data flow within the use case is the same for all the field technologies: once generated, the data flow towards the Data Lake Ecosystem following this schema:
GPS Tracker -> Apache Kafka Topic -> SnR Data Model -> Data Lake Ecosystem. Then the data are dispatched to the following components:

- COncORDE Event Log Service (All Events)
- Web Services (Further Filtered Data) -> COncORDE Event Log Service (e.g GPS)
- SA model -> COncORDE Notification Service
- COncORDE Interactive Map (pins of GPS tracking on the map)

This procedure applies to all the field technologies such as the Six Gas Monitoring.

2.3.1.2 Rest Services

Regarding the rest services the data flow is the following:

- Rescue Robot Video -> Obstacle Detection System -> COncORDE ODS Page via NGINX redirection to THALIT'S ODS Page

In an operational level, the end-users navigated to COncORDE screens, in order to orchestrate the emergency and be aware of the incoming information from the field.

2.3.2 UC3 Test

2.3.2.1 Sensors Integration Test

- **Test Prerequisite Condition**: GPS working properly, Six Gas HazMat working properly, UNICA app, Apache Kafka, Data Lake, COncORDE.
- **Test Input**: GPS and Six Gas HazMat Data from the field.
- **Test Procedure**: GPS trackers generated data to the first responders' smartphones and produced to a dedicated APache Kafka Topic. In the same way, Six Gas HazMat generated data and produced to a dedicated APache Kafka Topic. Then, the Data Lake Ecosystem consumed both the data, stored them to a specific directory into HDFS, process and aggregate them and finally produced them to COncODE's Event Log Service. Moreover, the same data were used for the Notification Service (SA) and the interactive Map (Pins on the map).
- **Expected Results**: The end-user must have the ability to see GPS measurements in COncORDE Event Log Service, notifications in COncORDE Notification Service and pins on the map.

- **Test Result**: Use Case executed, all the components tested according to the identified procedure; overall use case test was positive.

2.3.2.2 COncORDE Integration Test

- **Test Prerequisite Condition**: WiFi Connection, the rest services working in a proper way
- **Test Input**: Data Lake, SA, SOT data
- **Test Procedure**: COncORDE consumes incoming data (in a homogeneous format) from the Data Lake Directories via WebHDFS, stores and handles them to the Event Log Service. Then, Event Log produces the same data to Web Services for further filtering and SA model for Notification and Alarms. COncORDE consumes their results. Meanwhile, other software and services such as SOT DSS, produces their response to COncORDE in order for it to consume it and demonstrate it to the end-user.
- **Expected Results**: The end-user must have the ability to see all the incoming data from the field technologies and SnR services.
- **Test Result**: Use Case executed, all the components tested according to the identified procedure; overall use case test was positive.

2.4 UC4 - Forest fire expanded and threat to industrial zone

2.4.1 UC4 Summary

The UC4 has been executed in the region of Lecheo, near to the city of Korinthos.
The following situations have been simulated:

- Wildfire in a dry forest which expand towards residential areas and critical infrastructure facilities;
- Huge quantity of smoke requires nearby communities to evacuate the area: people trapped inside smoke plumb are not able to reach the safe place;
- Remote sensing technologies used for first responders safety are tested.

A detailed description of UC4 is presented in D8.5.
The main components/technologies which have been tested within this use case are:

1. Smart Glasses (SIMAVI)
2. Smartwatch (KT)
3. Emergency response health condition monitoring device (CERTH/HRT)
4. Radiation sensors (UNICA)
5. Chemical sensors - Rescue MIMS (NTUA)
6. Drones (UHasselt)
7. Collaborative drones' platform (UHasselt)
8. AI algorithms for recognizing objects from drone images (AIDEAS)
9. Rescue Robots & Autonomous vehicles (DFKI)
10. Obstacle Detection and Avoidance System (THALIT)
11. Volunteer application (CERTH)

The next table reports a detailed list of the components that have been involved in the use case execution together with their status, dependencies, testing and other specific details.

UC Leader	**EPAYPS**	Michael Chalaris, Iason Aliferis	**DONE!**
UC Date	**4-6 November 2022**	**D8.5**	

	Techologies	Partner	Status	Dependencies	Integrated	Testing	Date to be completed	TUC (Technical Use Cases)	Completed
*Not included in D8.5	COncORDE	KT	Ready	SA, PHYSIO, MAG responses, SOT DSS	Yes (with SOT & SA)	Yes	December 2021	TUC.1	October 2022
	Data Lake	KT	Ready	UNICA Technologies, Kafka	Yes	Yes	June 2021	TUC.2	
	Apache Kafka	SIMAVI	Ready	UNICA technologies, adaptation	-	Yes	November 2021		
	SnR Data Model	THALIT	Ready	UNICA Technologies	Yes	Yes	November 2021		
	SA model	UBI	Ready	UNICA Techologies, Apache Kafka, DLake	Yes	Yes	Late March 2022	TUC.8	
	Field Sensor services	MAG	Ready	UNICA Techologies, Apache Kafka, DLake	Yes	Yes	Late March 2022	TUC.7	
	Smartwatch	KT	Ready	Adapation, Apache Kafka, DLake	Yes	Yes	December 2021	TUC4	
	Radiation Sensors	UNICA	Ready	Adaptation, Apache Kafka	Yes	Yes	October 2022	TUC4	
	Drones	UHASSELT	Ready	Depended components: SIMAVI script, Dlake, Detection algorithms	Yes	Yes			
	Detection algorithms applied on UAV	AIDEAS	Ready	Drones, Data Lake	Yes	Yes	March 2022	TUC 3	
	Robot	DFKI Integration of Map	To be tested until end of June 2k22	OAS	Yes	Yes		-	
	Obstacle avoidance system	THALIT IFrame	To be tested until end of June 2k22	Robot	Yes	Yes		-	
	Rescue MIMS	NTUA	Ready	Adaptation, Apache Kafka	Yes	Yes			
	Smart Glasses	SIMAVI	We need to see if SIMAVI will bring them in UC						
	Volunteer Application	CERTH & KT	Ready	COncORDE	Yes	Yes			
	eLearning Platformλ	CERTH	REady						

Traning	Translation	Training Sessions * 3	Deadline
KT	EPAYPS	KT-EPAYPS	September 2022

Figure 17: Use Case 4 recap table

2.4.2 UC4 Test

2.4.2.1 Sensors Integration Test

- **Test Prerequisite Condition**: GPS working properly, radiation sensor, UNICA app, Apache Kafka, Data Lake, COncORDE.
- **Test Input**: GPS and radiation Data from the the field.
- **Test Procedure**: GPS trackers (from the smartwatch) and the radiation sensor generated data to the first responders' smartphones and produced to a dedicated APache Kafka Topic. Then, the Data Lake Ecosystem consumed the data, stored them to a specific directory into HDFS, process and aggregate them and finally produced them to COncODE's Event Log Service. Moreover, the same data were used for the Notification Service (SA) and the interactive Map (Pins on the map).
- **Expected Results**: The end-user must have the ability to see GPS measurements in COncORDE Event Log Service, notifications in COncORDE Notification Service and pins on the map.
- **Test Result**: Use Case executed, all the components tested according to the identified procedure; overall use case test was positive.

2.4.2.2 COncORDE Integration Test

- **Test Prerequisite Condition**: WiFi Connection, the rest services working in a proper way.
- **Test Input**: Data Lake, SA, SOT data.
- **Test Procedure**: COncORDE consumes incoming data (in a homogeneous format) from the Data Lake Directories via WebHDFS, stores and handles them to the Event Log Service. Then, Event Log produces the same data to Web Services for further filtering and SA model for Notification and Alarms. COncORDE consumes their results. Meanwhile, other software and services such as SOT DSS, produces their response to COncORDE in order for it to consume it and demonstrate it to the end-user.
- **Expected Results**: The end-user must have the ability to see all the incoming data from the field technologies and SnR services.
- **Test Result**: Use Case executed, all the components tested according to the identified procedure; overall use case test was positive.

2.4.2.3 Drone & Collaborative Drone platform Test

2.4.2.3.1 <u>Drone application</u>

- **Test Prerequisite Condition**: WiFi Connection, the rmtp server running.
- **Test Input**: Data Lake, HDFS repository.
- **Test Procedure**: To test the drone application, we should first setup the wireless and wired connection. Then, we activate the remote and the drone and start the drone application, once the drone takes off, we can activate the monitoring for the drone parameters and the log of the data locally and/or to the data lake. We can start the streaming to the Rmtp server and the recording onboard the drone. The video files will also be stored locally and transferred to HDFS remote repository.
- **Expected Results**: The drone pilot can see the view of the camera of the drone from the application. The camera stream could also be collected using a Rmtp streaming client like VLC.

The video files are also transferred to HDFS. The pilot can monitor the flight data via the application interface. The drone text data could be retrieved and consumed from the data lake (gimbal position, altitude, position of the drone and battery level). The pilot can also create a waypoint drone mission, by setting the altitude, the speed and the waypoint.

- **Test Result**: Use Case executed; the functioning of the drone application has been tested as follows:
  - Transfer of the video recorded files to the HDFS remote directory
  - Stream of the text data to MQTT broker and to Kafka topics.
  - Monitoring of real-time data of the drone data.
  - Logs of the flight data in a local file.
  - Start and stop the video recording and the capture picture onboard the drone.
  - Display of the camera view of the drone.
  - All the features provided by the application are functional. The data communication from the drone to the remote control (wireless: OcuSync 2.0) and from the remote control to the application (wired connection) provided a near real-time data transfer. However, the communication to the remote file storage system and to the streaming server was slow because of the type of data to transfer (videos) and the speed of the connection.

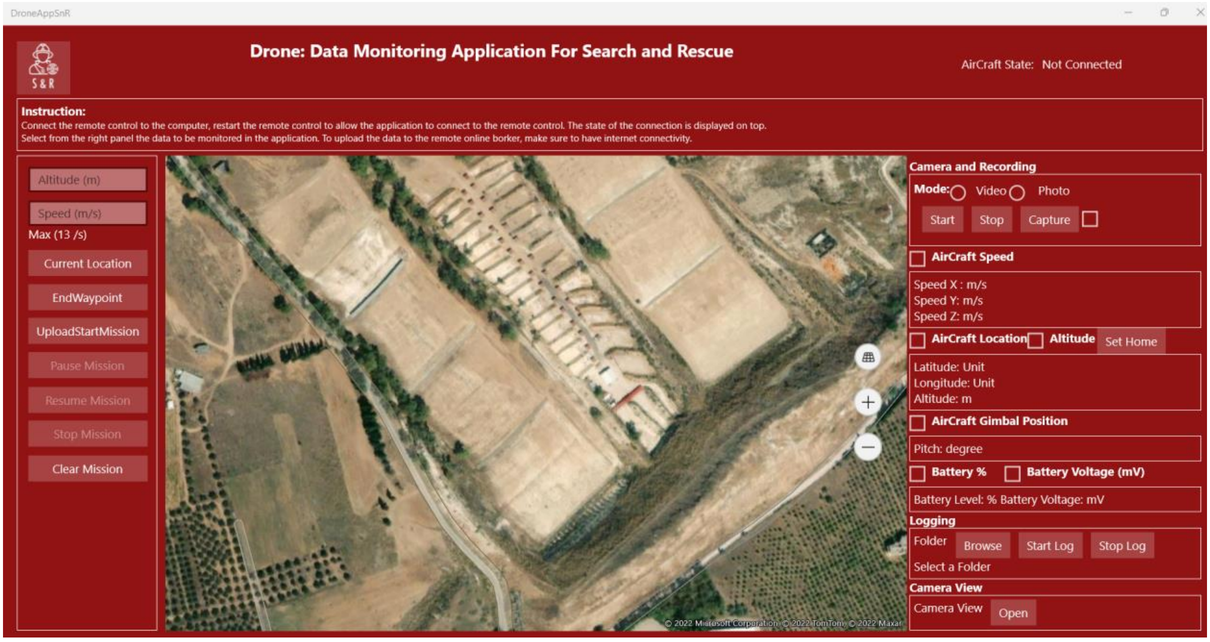


Figure 18: Drone Data Monitoring Application

Overall, the use case test was positive, yet a bottleneck was experienced in the network bandwidth and the capacity of the streaming server.

2.4.2.3.2 <u>Drone collaborative platform</u>

- **Test Procedure**: To test the drone collaborative platform, we need first to open the Gama platform and run the experiment setting interface, the number of the used drones and the number of charging stations need to be inserted and the stations should be initialized and distributed in the environment. Afterward, we can start the simulation.

- **Expected Results**: During the simulation the drones, should be able to switch their plans based on their current state. For example, once the battery level onboard the drone reduced significantly, the drone should autonomously communicate with the coordination centre. The coordination centre has a global view of the charging and swapping station states. If there is any swapping station (to swap the battery of the drone) where we still have charged batteries, the coordination centre will send the coordination of this station to the drone. The drone can start the plan of "battery_swapping". During this plan, the drone goes to the swapping station and swaps his battery and resumes the plan of patrolling. If no swapping stations are available (with charged batteries), the coordination centre checks the availability of any idle drone in the coordination centre, that can take over the mission of the first drone while the first drone charges his battery. If no idle drone is available, the coordination centre sends the drone the coordinates of a free charging station where the drone can charge his battery.
- **Test Result**: The agent simulation has been tested with 4 active drones ,4 idle drones and 4 charging- and swapping stations. The drones are able to switch their plans based on their current stated. They can communicate with the coordination centre and change their execution plans based on the received FIPA ACL messages from the coordination centre.

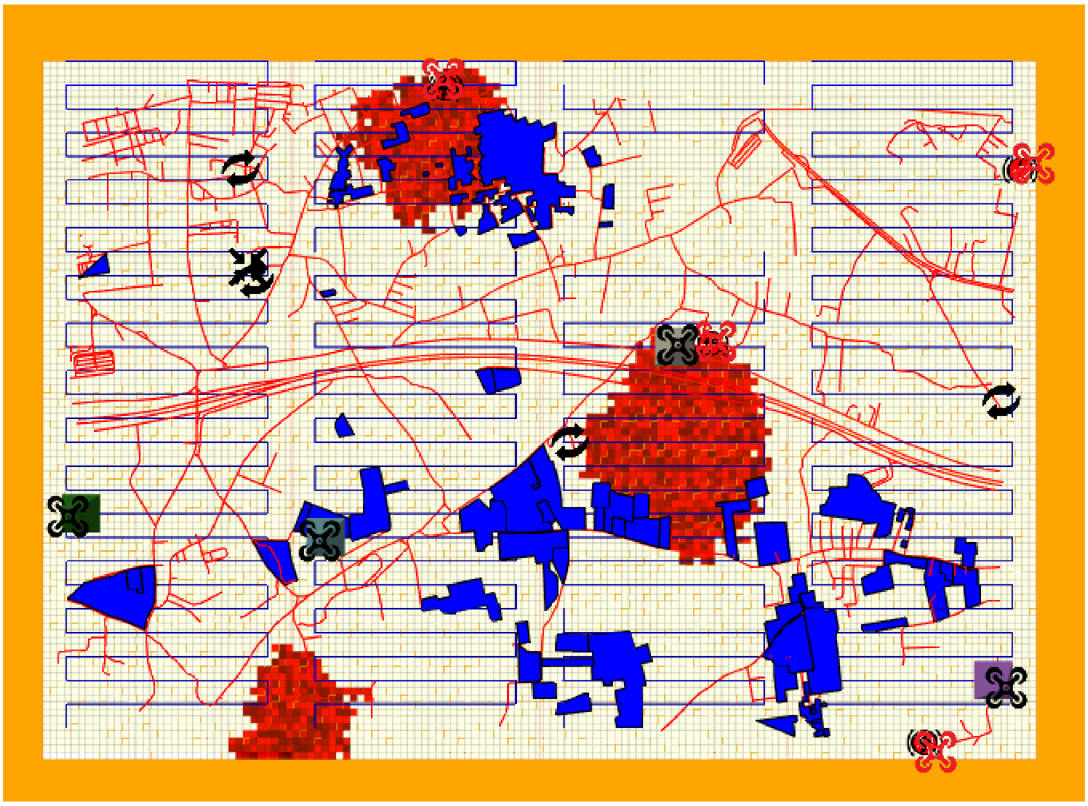


Figure 19: Overview of the simulation environment

In figure 16, the drones which are charging are indicated in red color. The red squares are used to model the fire event distributed in the environment. The blue lines indicate the patrolling path of the drones. The drones executing the patrolling plan are marked in black color. The charging stations are symbols with red circles and the swapping station are the icons with double arrows. Finally, the coordination center is marked with four arrows.

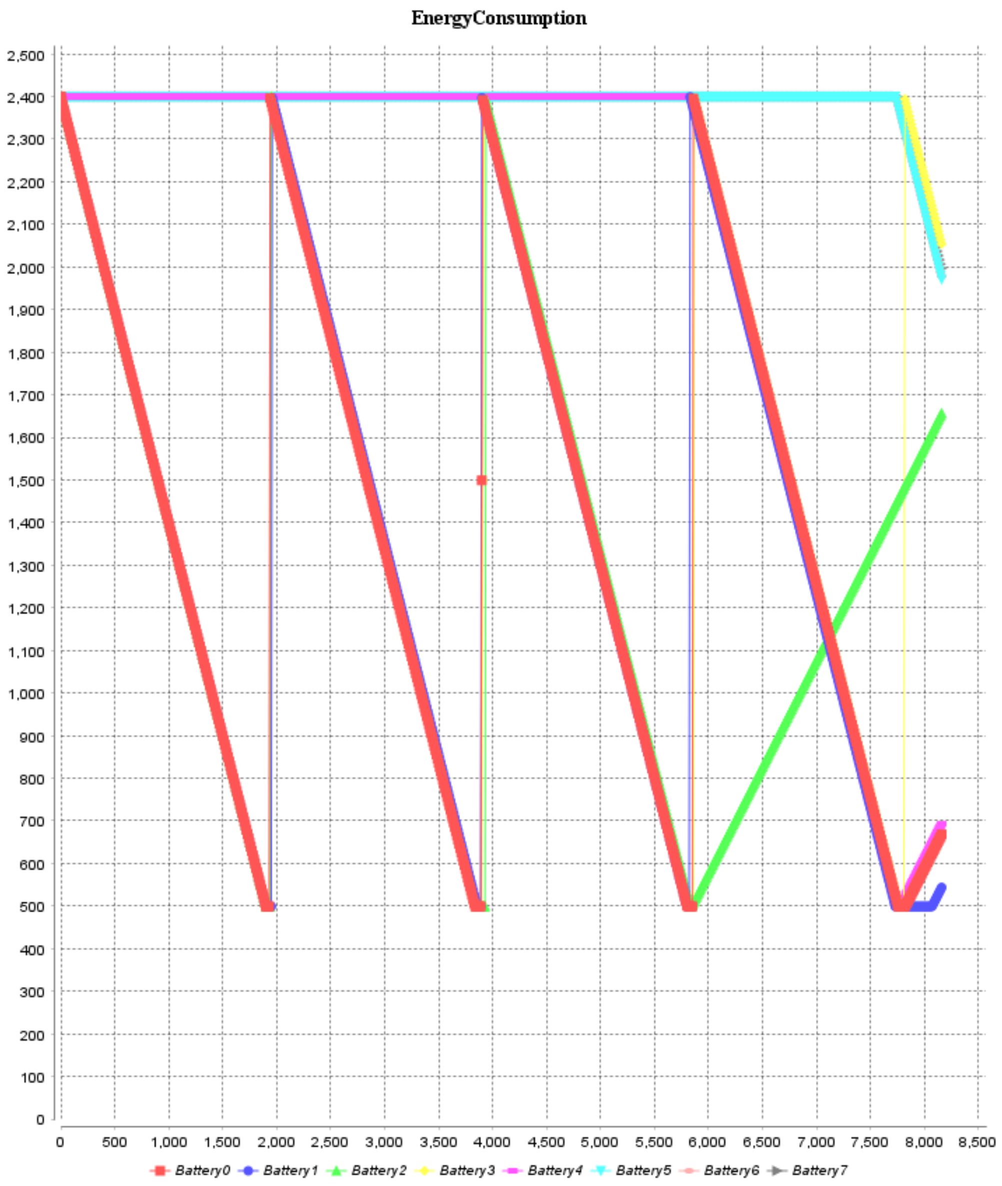


Figure 20: variation of energy level in all collaborative drones

In figure 17, the color on the legend identifies the color used of the battery of each drone (4 active drones and 4 idle drones) the four active drones manage to swap their battery three times. Drone 2 was the first drone to go to a charging station while drone 4 was the first drone to take over the mission of drone 2. After 500 cycles (simulation step) drone 5 also took over the mission of another drone.

Overall, the use case test was positive: the simulation tool simulates how multiple drones can collaborate, and in what capacity, in the context of search and rescue activities in the scenario of an expanding forest fire.

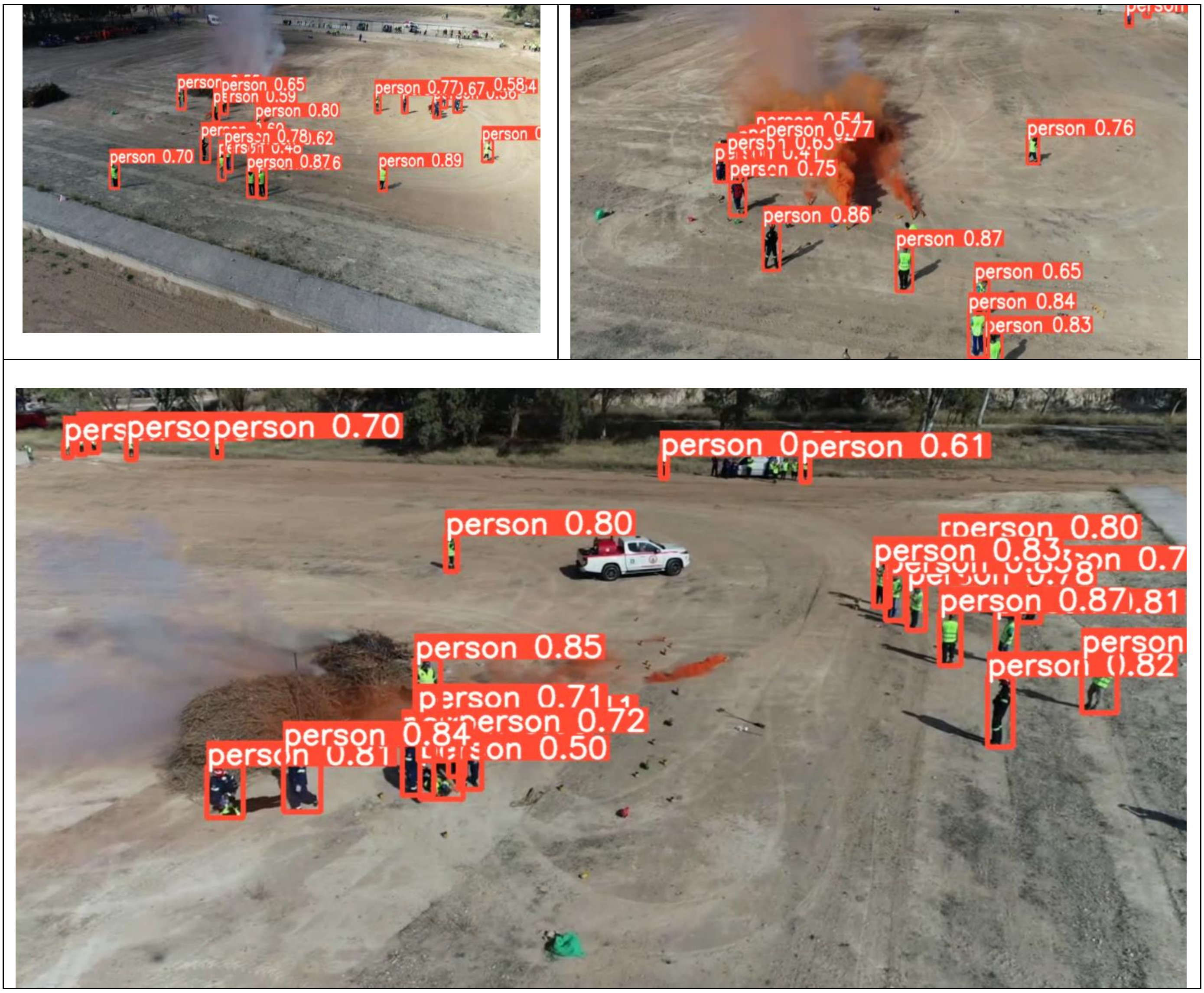
2.4.2.4 Object Detection Test

- **Test Prerequisite Condition**: For the purpose of detecting humans in live video footage from a drone, it is important to ensure that the necessary hardware and software requirements are met for the deep learning model being used. This may include specific hardware components, such as a graphics processing unit (GPU) for faster model training and inference, and software dependencies, such as specific versions of programming languages and libraries. In addition, it is important to consider any regulatory or safety considerations that may be relevant to the use of the drone, such as laws and regulations governing the use of drones in specific locations and the potential risks to individuals or property. The real-time video feed from the drone will need to be analyzed by a computer with sufficient processing power to run the deep learning model effectively.

- **Test Input**: To test the model's ability to detect humans in images and videos, the input provided to the model will be videos captured by drones. These videos have been specifically chosen for their suitability to be used as input for an object detection model, allowing for the effective testing of the model's capabilities. By using videos captured by drones, the model will be able to analyze a wide range of scenarios and environments, providing a comprehensive evaluation of its performance.
- **Test Procedure**: To fully test the model's ability to detect humans in images and videos, end users will need to acquire videos taken by drones from a local source. These videos will be used as input for the model to analyze, with the detection analysis being performed offline in the Data Lake Ecosystem. Once the analysis is complete, the results will be sent to the end users for evaluation. This process will allow for a thorough and comprehensive assessment of the model's performance, providing valuable feedback for further development and optimization.
- **Expected Results**: It is expected that the model will be able to accurately detect humans in the videos provided as input, with a high degree of accuracy. This will demonstrate the effectiveness of the model's training and provide confirmation from end users of its performance. By achieving these results, the model will have successfully passed the testing phase and can be considered for deployment in real-world scenarios.
- **Test Result**: After conducting the test, it was determined that the use case was executed successfully and all components were tested according to the specified procedure. The overall result of the use case test was positive, indicating that the model is able to accurately detect humans in images and videos, demonstrating the effectiveness of its training. This positive result allows for the further consideration of the model for deployment in real-world scenarios.
- **Additional notes**: the next picture shows some instances of the videos adopted to train the model.

Figure 21 Frames taken from a video tape produced by UHasselt.

- **Additional notes**: the next picture shows the results of the model training done using the videos captured by drones.



2.5 UC5 – Victims trapped under rubble (France)

2.5.1 UC5 Summary

The UC5 has been executed in a small town called "La Souterraine" in Creuse department (Nouvelle Acquitaine) in the center of France.
The following situations have been simulated:

- research and localization of the victims from the K9 team and electronic devices;
- control of gaz absence or dangerous or radioactive materials;
- reinforcement of the buildings from the by shoring;
- drilling of collapsed concrete areas and metal structures;
- rescue of the victims in height;
- medicalisation of the victims;
- coordination of operations by a command post integrated into an operations base;
- medical post activated in the operations base.

A detailed description of UC5 is presented in D8.6.
The main components/technologies which have been tested within this use case are:

1. Rescue MIMS (NTUA),
2. Drones (UHASSELT),
3. Situational Awareness Model (UBITECH),
4. PHYSIO DSS (CNR),
5. Wearable GPS tracker, ECG and EMG sensors (UNICA),
6. Protective uniform (UNIFI).

The next table reports a detailed list of the components that have been involved in the use case execution together with their status, dependencies, testing and other specific details.

UC Leader	PUI	Illiana Korma, Philippe Benson	DONE!
UC Date	18/06/22	D8.6	

Techologies	Partner	Status	Dependencies	Integrated	Testing	Date to be completed	TUC (Technical Use Cases)	Completed
COncORDE	KT	Ready	SA, PHYSIO, MAG responses, SOT DSS	Yes (with SOT & SA)	Yes	December 2021	TUC.1	Late May
Data Lake	KT	Ready	UNICA Technologies, Kafka	Yes	Yes	June 2021	TUC.2	
Apache Kafka	SIMAVI	Ready	UNICA technologies, adaptation	-	Yes	November 2021		
SnR Data Model	THALIT	Ready	UNICA Technologies	Yes	Yes	November 2021		
Field Sensor services	MAG	Ready	UNICA Techologies, Apache Kafka, DLake	Yes	Yes	Late March 2022	TUC.7	
GPS Tracker	UNICA	Ready	Adaptation, Apache Kafka	Yes	Yes	December 2021	TUC.5	
ECG, EMG	UNICA	Ready	Adaptation, Apache Kafka	Yes	Yes	February 2022		
SA model	UBI	Ready	UNICA Techologies, Apache Kafka, DLake	Yes	Yes	Late March 2022	TUC.8	
PHYSIO DSS	CNR	Ready	Triage	Yes	Yes	mid - April 2022	TUC.9	
SOT DSS	KT	Ready	COncORDE	Yes	Yes	December 2021	TUC.6	
Rescue MIMS	NTUA	Ready	Adaptation, Apache Kafka	Yes	Yes	mid May 2022	TUC.	
Smart Uniforms	UniFI	Ready	-	-	-	-	-	

Traning	Translation	Training Sessions * 3	Deadline
KT	PUI	KT-PUI	early May 2022

Figure 22 Use Case 5 recap table

2.5.1.1 Field Technologies

The data flow within the use case is the same for all the field technologies: once generated, the data flow towards the Data Lake Ecosystem following this schema:
GPS Tracker/ECG/EMG -> Apache Kafka Topic -> SnR Data Model -> Data Lake Ecosystem. Then the data are dispatched to the following components:

- COncORDE Event Log Service (All Events)
- Web Services (Further Filtered Data) -> COncORDE Event Log Service (e.g GPS)
- SA model -> COncORDE Notification Service

This procedure applies to all the field technologies such as the ECG, EMG, Strain sensors.

2.5.1.2 Sensors Integration Test

- **Test Prerequisite Condition**: GPS working properly, ECG/EMG sensors, UNICA app, Apache Kafka, Data Lake, COncORDE.
- **Test Input**: GPS, ECG, EMG Data from the field.
- **Test Procedure**: GPS trackers, ECG, EMG sensors generated data to the first responders' smartphones and produced to a dedicated APache Kafka Topic. Then, the Data Lake Ecosystem consumed the data, stored them to a specific directory into HDFS, process and aggregate them and finally produced them to COncODE's Event Log Service. Moreover, the same data were used for the Notification Service (SA) and the interactive Map (Pins on the map).
- **Expected Results**: The end-user must have the ability to see GPS measurements in COncORDE Event Log Service, notifications in COncORDE Notification Service and pins on the map.
- **Test Result**: Use Case executed, all the components tested according to the identified procedure; overall use case test was positive.

2.5.1.3 Rescue MIMS

The Rescue MIMS component had an extra requirement to be adapted as shown below:
Rescue MIMS (hardware) -> Rescue MIMS (laptop) -> LogStash & ELK stack (created by KT in collaboration with NTUA) -> Apache Kafka Topic -> SnR Data Model -> Data Lake Ecosystem. Then the data are dispatched to the following components:

- COncORDE Event Log Service (All Events)
- Web Services (Further Filtered Data) -> COncORDE Event Log Service (e.g GPS)
- SA model -> COncORDE Notification Service

2.5.1.4 Rest Services

Regarding the rest services the data flow is the following:

- COncORDE Incident, Users Management & Interactive Map -> SOT DSS
- COncORDE Triage -> PHYSIO DSS -> COncORDE Patients Management

In an operational level, the end-users navigated to COncORDE screens, in order to orchestrate the emergency and be aware of the incoming information from the field.

2.5.2 UC5 Test

2.5.2.1 Rescue MIMS Integration Test

- **Test Prerequisite Condition**: MIMS working properly, Apache Kafka, Data Lake, COncORDE;
- **Test Input**: MIMS Data from the laptop on the field;
- **Test Procedure**: Rescue MIMS generated data from the device to a connected laptop to the device. Then, this data were saved in a specific directory on the laptop, and they were consumed by logstash and produced to a dedicated APache Kafka Topic. Then, the Data Lake Ecosystem consumed the data, stored them to a specific directory into HDFS, process and aggregate them and finally produced them to COncODE's Event Log Service.
- **Expected Results**: The end-user must have the ability to see RESCUE MIMS measurements in COncORDE Event Log Service and notification in COncORDE Notification Service.
- **Test Result**: Use Case executed, all the components tested according to the identified procedure; overall use case test was positive.

2.5.2.2 SOT DSS Test

- **Test Prerequisite Condition**: COncORDE Incident, User, Organization, Patient MGT & Map.
- **Test Input**: COncORDE's Incident, User, Organization, Patient (triage) APIs
- **Test Procedure**: The end-user provides feeds COncORDE with details on Incident, Organization, Users and Patients on the field and each SOT DSS service consumes them, in order to generate via linear programming algorithms its recommendations.
- **Expected Results**: The end-user must have the ability to see the 4 SOT DSS Services responses in SOT DSS screen
- **Test Result**: Use Case executed, all the components tested according to the identified procedure; overall use case test was positive.

2.5.2.3 COncORDE Integration Test

- **Test Prerequisite Condition**: WiFi Connection, the rest services working in a proper way.
- **Test Input**: Data Lake, SA, SOT data.
- **Test Procedure**: COncORDE consumes incoming data (in a homogeneous format) from the Data Lake Directories via WebHDFS, stores and handles them to the Event Log Service. Then, Event Log produces the same data to Web Services for further filtering and SA model for Notification and Alarms. COncORDE consumes their results. Meanwhile, other software and services such as SOT DSS, produces their response to COncORDE in order for it to consume it and demonstrate it to the end-user.
- **Expected Results**: The end-user must have the ability to see all the incoming data from the field technologies and SnR services.
- **Test Result**: Use Case executed, all the components tested according to the identified procedure; overall use case test was positive.

2.6 UC6 – Resilience support for critical infrastructures through standardized training on CBRN

2.6.1 UC6 Summary

The UC6 has been executed in the international airport of Tuzla (Romania).
The following situations have been simulated:

- Testing the technologies, products and services developed for S&R in case of a real intervention situation for a terrorist attack using CBRN;
- Define a standardized training system;

A detailed description of UC6 is presented in D8.7.
The main components/technologies which have been tested within this use case are:

1. Smart glasses (SIMAVI)
2. Communication system for rescue (KT)
3. GPS tracker (UNICA)
4. ECG/EMG sensors (UNICA)
5. Six Gas Hazmat Monitor (UniCa)
6. Wearable strain sensors (UniCa)
7. Rescue system for children (UNIFI)
8. Smart textile professional uniform (UNIFI)
9. E-learning based platform (CERTH)

The next table reports a detailed list of the components that have been involved in the use case execution together with their status, dependencies, testing and other specific details.

UC Leader	PROECO	Nicolae Maruntelu	DONE!
UC Date	06-07/09/2022	D8.7	

	Techologies	Partner	Status	Dependencies	Integrated	Testing	Date to be completed	TUC (Technical Use Cases)	Completed
*Not included in D8.5	COncORDE	KT	Ready	SA, PHYSIO, MAG responses, SOT DSS	Yes (with SOT & SA)	Yes	December 2021	TUC.1	Late August 2022
	Data Lake	KT	Ready	UNICA Technologies, Kafka	Yes	Yes	June 2021	TUC 2	
	Apache Kafka	SIMAVI	Ready	UNICA technologies, adaptation	-	Yes	November 2021		
	SnR Data Model	THALIT	Ready	UNICA Technologies	Yes	Yes	November 2021		
	SA model	UBI	Ready	UNICA Techologies, Apache Kafka, DLake	Yes	Yes	Late March 2022	TUC 8	
	Field Sensor services	MAG	Ready	UNICA Techologies, Apache Kafka, DLake	Yes	Yes	Late March 2022	TUC 7	
	Strain Sensors	UNICA	Ready	Adaptation, Apache Kafka	Yes	Yes	February 2022	TUC 5	
	ECG, EMG	UNICA	Ready	Adaptation, Apache Kafka, Smart Uniform	Yes	Yes	February 2022		
	GPS Tracker	UNICA	Ready	Adaptation, Apache Kafka	Yes	Yes	December 2021		
	Six Gas Hazmat	UNICA	Ready	Adaptation, Apache Kafka	Yes	Yes	June 2022		
	Smart Glasses	SIMAVI	Ready	Not Integrated. Only Used for Training	No	-	August 2022		
	e-learning platform	CERTH	Ready	Redirection from COncORDE to e-learning	Yes	Yes	June 2022		
	SOT DSS	KT	Ready	COncORDE	Yes	Yes	December 2021	TUC 6	
	Rescue System for children	UNIFI	Ready	-	-	-	-	-	
	Smart Uniforms	UniFI	Ready	-	-	-	-	-	

* There is no DSS in the UC.

Traning	Translation	Training Sessions * 3	Deadline
KT	PROECO	KT-PROECO	September 2022

Figure 23 Use Case 6 recap table

2.6.1.1 Field Technologies

The data flow within the use case is the same for all the field technologies: once generated, the data flow towards the Data Lake Ecosystem following this schema:
Six Gas Hazmat Monitoring Device/ECG/EMG/Strain/GPS tracker -> Apache Kafka Topic -> SnR Data Model -> Data Lake Ecosystem. Then the data are dispatched to the following components:

- COncORDE Event Log Service (All Events)
- Web Services (Further Filtered Data) -> COncORDE Event Log Service (e.g GPS)
- SA model -> COncORDE Notification Service

This procedure applies to all the field technologies such as the ECG, EMG, Strain sensors, GPS.

2.6.1.2 Rest Services

Regarding the rest services the data flow is the following:

- COncORDE Incident, Users Management & Interactive Map -> SOT DSS
- e-Learning Platform -> COncORDE e-learning Platform Redirection Page

In an operational level, the end-users navigated to COncORDE screens, in order to orchestrate the emergency and be aware of the incoming information from the field.

2.6.2 UC6 Test

2.6.2.1 Sensors Integration Test

- **Test Prerequisite Condition**: GPS working properly, ECG/EMG, Strain sensor, Six Gas Hazmat Monitor, UNICA app, Apache Kafka, Data Lake, COncORDE
- **Test Input**: GPS, ECG/EMG, Strain and Gas Data from the field
- **Test Procedure**: GPS trackers, EMG, ECG, Strain sensors and Six Gas Hazmat Monitor generated data to the first responders' smartphones and produced to a dedicated APache Kafka Topic. Then, the Data Lake Ecosystem consumed the data, stored them to a specific directory into HDFS, process and aggregate them and finally produced them to COncODE's Event Log Service. Moreover, the same data were used for the Notification Service (SA) and the interactive Map (Pins on the map).
- **Expected Results**: The end-user must have the ability to see all measurements in COncORDE Event Log Service, notifications in COncORDE Notification Service and pins on the map.
- **Test Result**: Use Case executed, all the components tested according to the identified procedure; overall use case test was positive.

2.6.2.2 COncORDE Integration Test

- **Test Prerequisite Condition**: WiFi Connection, the rest services working in a proper way
- **Test Input**: Data Lake, SA, SOT data
- **Test Procedure**: COncORDE consumes incoming data (in a homogeneous format) from the Data Lake Directories via WebHDFS, stores and handles them to the Event Log Service. Then, Event Log produces the same data to Web Services for further filtering and SA model for Notification and Alarms. COncORDE consumes their results. Meanwhile, other software and services such as SOT DSS, produces their response to COncORDE in order for it to consume it and demonstrate it to the end-user.
- **Expected Results**: The end-user must have the ability to see all the incoming data from the field technologies and SnR services.
- **Test Result**: Use Case executed, all the components tested according to the identified procedure; overall use case test was positive.

2.6.2.3 SOT DSS Test

- **Test Prerequisite Condition**: COncORDE Incident, User, Organization, Patient MGT & Map.
- **Test Input**: COncORDE's Incident, User, Organization, Patient (triage) APIs.
- **Test Procedure**: The end-user provides feeds COncORDE with details on Incident, Organization, Users and Patients on the field and each SOT DSS service consumes them, in order to generate via linear programming algorithms its recommendations.

- **Expected Results**: The end-user must have the ability to see the 4 SOT DSS Services responses in SOT DSS screen.
- **Test Result**: Use Case executed, all the components tested according to the identified procedure; overall use case test was positive.

2.7 UC7 – Chemical substances spill

2.7.1 UC7 Summary

The UC7 has been executed in the National School of Civil Protection in Rivas Vaciamadrid, Madrid.
The following situations have been simulated:

- delimit the working zones according to the existing risks and toxicity levels, in order to guarantee the safety of the first responders and rescue dogs, and the victims of the incident:

A detailed description of UC7 is presented in D8.8.
The main components/technologies which have been tested within this use case are:

1. Concorde (KT)
2. Emergency communication app (KT)
3. DSS (KT)
4. Wearable GPS tracker (UniCa)
5. Six Gas Hazmat Monitor (UniCa)
6. ECG/EMG sensors (Unica)
7. Strain Sensors (Unica)
8. Smartwatch (KT)

The next table reports a detailed list of the components that have been involved in the use case execution together with their status, dependencies, testing and other specific details.

UC Leader	SERMAS & ESDP	Anna Maria Cintora, Marta ESDP, Horrillo Garcia Cristina Lorena, Suzana Izquierdo	DONE!
UC Date	13, 14,15 December 2022	D8.8	

Techologies	Partner	Status	Dependencies	Integrated	Testing	Date to be completed	TUC (Technical Use Cases)	Completed
COncORDE	KT	Ready	SA, PHYSIO, MAG responses, SOT DSS	Yes (with SOT & SA)	Yes	December 2021	TUC.1	
Data Lake	KT	Ready	UNICA Technologies, Kafka	Yes	Yes	June 2021		
Apache Kafka	SIMAVI	Ready	UNICA technologies, adaptation	-	Yes	November 2021	TUC 2	
SnR Data Model	THALIT	Ready	UNICA Technologies	Yes	Yes	November 2021		
SA model	UBI	Ready	UNICA Techologies, Apache Kafka, DLake	Yes	Yes	Late March 2022	TUC 8	
Field Sensor services	MAG	Ready	UNICA Techologies, Apache Kafka, DLake	Yes	Yes	Late March 2022	TUC 7	September 2022
Smartwatch	KT	Ready	Adapation, Apache Kafka, DLake	Yes	Yes	December 2021	TUC 4	
ECG, EMG	UNICA	Ready	Adaptation, Apache Kafka	Yes	Yes	December 2021	TUC 5	
GPS Tracker	UNICA	Ready	Adaptation, Apache Kafka	Yes	Yes	December 2021	TUC 5	
Strain Sensor	UNICA	Ready	Adaptation, Apache Kafka	Yes	Yes	December 2021	TUC 5	
Six Gas Hazmat	UNICA	Ready	Adaptation, Apache Kafka	Yes	Yes	June 2022	TUC 6	
SOT DSS	KT	Ready	COncORDE	Yes	Yes	December 2021	TUC 6	
Smart Protective Uniform	UNIFI	Ready	UNICA technologies	yes	yes			
First aid device for kids	UNIFI	Ready	UNICA technologies	yes	yes			
PHYSIO DSS	CNR	Pending	Triage	Yes (The services were provided on 07/03/22)	Yes	mid - April 2022	TUC.9	

Traning	Translation	Training Sessions * 3	Deadline
KT	SERMAS & ESDP	KT-SERMAS & ESDP	September 2022

Figure 24 Use Case 7 recap table

2.7.2 UC7 Test

2.7.2.1 Sensors Integration Test

- **Test Prerequisite Condition**: GPS, ECG/EMG, Strain sensor, Six Gas hazmat Monitor working properly, UNICA app, Apache Kafka, Data Lake, COncORDE.
- **Test Input**: GPS, ECG(EMG, Strain and Gas Data from the field.
- **Test Procedure**: GPS tracker, ECG/EMG, Strain sensor, Six Gas hazmat Monitor generated data to the first responders' smartphones and produced to a dedicated APache Kafka Topic. Then, the Data Lake Ecosystem consumed the data, stored them to a specific directory into HDFS, process and aggregate them and finally produced them to COncODE's Event Log Service. Moreover, the same data were used for the Notification Service (SA) and the interactive Map (Pins on the map).

- **Expected Results**: The end-user must have the ability to see sensors measurements in COncORDE Event Log Service, notifications in COncORDE Notification Service and pins on the map.
- **Test Result**: Use Case executed, all the components tested according to the identified procedure; overall use case test was positive.

2.7.2.2 COncORDE Integration Test

- **Test Prerequisite Condition**: WiFi Connection, the rest services working in a proper way.
- **Test Input**: Data Lake, SA, SOT data.
- **Test Procedure**: COncORDE consumes incoming data (in a homogeneous format) from the Data Lake Directories via WebHDFS, stores and handles them to the Event Log Service. Then, Event Log produces the same data to Web Services for further filtering and SA model for Notification and Alarms. COncORDE consumes their results. Meanwhile, other software and services such as SOT DSS, produces their response to COncORDE in order for it to consume it and demonstrate it to the end-user.
- **Expected Results**: The end-user must have the ability to see all the incoming data from the field technologies and SnR services.
- **Test Result**: Use Case executed, all the components tested according to the identified procedure; overall use case test was positive.

3 Conclusions

This deliverable has presented the tests executed to check the proper working of all the main S&R components. For every component, it has been asked to the relevant project partners to provide a detailed overview of the executed tests and the main obtained results.
Then, in section 2 the seven use cases defined for S&R project have been taken into consideration and for everyone it has been made a summary of the use case, a recap of the main components involved in the use case execution and the main tests performed with the achieved results.
Basically, it has been tested every component individually, as a standalone independent module and it has also been tested all the components together in the context of the use case execution. In particular in this second case, the tests have considered not only the single component working but in particular the relations between two or more components and the data flow between components. In fact, a use case can be executed with success only if all the components work correctly together, i.e. if the relations and connections between components work as expected assuring the right data flow between different components/systems/technologies.
In the end we have found that all the components and use cases test were success: in fact, the use cases have been executed correctly following the defined behavior and assuring the project results.