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Search & Rescue

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

D1.8 Definition, evaluation and refinement of the SnR CM governance model, V3

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Executive Summary

The specific deliverable D1.8 is the updated and final version of D1.3 (M12) & D17 (M24) and its main purpose is to define and include the SnR Governance model in the seven use cases that have took place in SnR project.

In this final version of the deliverable related to the Definition, evaluation and refinement of the SnR CM governance model, we will try to include the specification of the SnR Governance model to the SnR use cases. All seven use cases are described and analysed below along with their respective evaluation.

The vision of EU will be as well described in details together with the common framework assessing the users' needs and integrating the responses.

Furthermore, the Interoperability framework will be presented between emergency organizations with common, accepted and validated updated Standard Operating Procedures, promoting more efficient, multinational and multi-organisational disaster response actions, and being fully compatible with (i) the actual (updated) existing SOP within the organisations – end users included in the project, EU MS and International Organisations (ii) technological framework and (iii) interoperability concepts.

Nine end – users from various EU countries have come together to describe once again their Standard Operating Procedures that were used in their countries (Italy, France, Greece, Austria-Germany, Spain & Romania) during their pilot phases and the results are well described in the following sections.

The respective questionnaire has been answered for the third time by the partners, helping us compare the procedures of each end-user.

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Table 0-2: List of abbreviations

Abbreviation	Explanation
AR	Augmented reality
BoO	Base of Operation
COTS	Commercial off-the-shelf
CM	Crises management
CRYSIS	Critical Response in Security and Safety emergency
EMS	Emergency Medical Services
EUMODEX	UE Module Exercises
ECPP	European Civil Protection Pool
EUCPM	EU Civil Protection Mechanism
GAP	Hiatus
ICMS	Incident & Crisis Management System
LEMA	Local emergency management authority
MEDEVAC	Medical evacuation
MIMS	Membrane Inlet Mass Spectrometer
OSSOC	On-site Operations Coordination Centre
INSARAG	International Search and Rescue Advisory Group
RDC	Reception/Departure Centre
SOP	Standard Operating Procedures
S&R	Search and Rescue
UC	Use Case
UNDAC	UN Disaster Assessment and Coordination
USAR	Urban Search and Rescue
VOC	Volatile organic compounds
VR	Virtual Reality

1 Introduction

1.1 Purpose & Scope

The SnR crisis governance model will be linked to existing databases to provide functionality for capturing Risk Assessment (e.g., comparable functions for disaster type, location, radius, impact and threats).

The component will be based on a library of terms, business rules and methods to support these types of analysis identified and implemented in WP3 (T3.1 and T3.2).

The content of the library reflects unified community definitions of risk and other parameters utilized to characterize a disaster or crisis event.

The SnR CM allows for increased situational awareness and early warning of major disaster incidents with ad-hoc, innovative and dynamic solutions.

The common operating framework supports also wider training and education activities for emergency responders.

In fact, the majority of emergency responders are not overtly involved in EU response through the Mechanism but may become either direct beneficiaries of EU aid or have to face event consequences that have already been experienced, a 'lessons learnt' programme delivered online.

The SnR CM concept allows for a wider definition which includes the capability to (a) collect static and dynamic data on the basis of standards and protocols and (b) all relevant static and dynamic data suppliers that are relevant to various disaster types.

Nine end users of SnR project have been invited to complete a questionnaire developed for the purposes to identify and register the operational procedures of these end users from 6 EU countries (Greece, Romania, Spain, France, Italy, Austria) that are involved in this project. The specific questionnaire has been designed and developed by PUI and had been distributed to the partners for completion before, during and after their use cases.

It has to be mentioned that 70 questions were prepared related to these procedures that will be analysed in the specific section below.

1.2 Structure of the Document

In this deliverable we intend to give an updated and final version of the deliverable D1.3 definition, evaluation and refinement of the SnR CM governance model as defined in Task 1.4 of SnR project. This deliverable is part of WP1 called First responders Requirements and Governance model which covers the whole period of the project's duration.

We will give a short description of the users' needs in research and technical issues, use case scenarios and user perspectives, additionally with a short gap analysis.

Great emphasis will be given in the specifications of the SnR Governance model regarding its operational model and its emergency management system integrated solutions.

All the above-mentioned will be developed according to the updated existing Standard Operating Procedures (SOP) from EU MS and International organisations and the accountabilities and responsibilities of all the organizations involved the crisis management domain.

One more important task that will be analysed in this document refers to the Interoperability framework between the emergency organisations.

In order to clearly understand the clear concept of this framework, we are going to analyze the updated common, accepted and validated Standard Operating Procedures, that will be used in the use cases promoting more efficient multi-national and multiorganizational disaster response actions, fully compatible with (i) the actual existing SOP within specific organizations, EU MS and International Organizations (ii) technological framework and (iii) interoperability concepts.

The EU common vision will close this document as in the first version.

The end users – partners of SnR project have once again collaborated closely in the development of this deliverable in order to contribute to the SnR Governance Model and the Interoperability framework

between emergency organizations. In this deliverable, all the seven use cases are presented and described in the sections below along with their evaluations.

2 First Responders' Requirements & Gap Analysis

The conclusions and proposals as described in the D1.6 "Report on the Functional specifications of SnR, V2" refer to the current state of the process of defining end-user requirements for chemical sensors (Six Gas HAZMAT monitor with VOC Detection and RESCUE MIMS (wear First Responders uniform, in hand, as backpack or on the platform of a RESCUE ROBOT) as foreseen by the SnR project in WP1 (First responders Requirements and Governance model) at T1.2 (End User Requirements for SAR equipment and tools) and the results obtained so far in the scientific research activity of the prototypes referred to.

This activity, completed in M12, included the study of equipment and technologies already on the market, a multitude of technical meetings and coordination between the partners of the SnR project, the organisation of a workshop ("End-user requirements and Beyond "of April 14, 2021), and a permanent online exchange of ideas and possible technical and operational solutions necessary to achieve the purpose and objectives mentioned in deliverable D1.6, as a continuation of the achievements mentioned in deliverable D1.2 "Report on the Functional specifications of SnR" (M4).

The fundamental conclusion of the gap analysis, complemented by a series of partial conclusions specific to each subchapter, is that the minimum technical and operational characteristics proposed by end users in D1.6, but also the continuation of those proposed in D1.2, constitute a solid working basis. Furthermore, this analysis is completed for scientific research and, in the future, for the testing and validation of the 7 UCs (User Cases) of the SnR project regarding the prototypes of equipment proposed.

A concrete example in favour of this fundamental conclusion is already the future optimization proposals, within the SnR project, mentioned in subchapter 8.2" Proposals for optimization of a future version of RESCUE-MIMS (TRL 7-9)" of the deliverable 5.1" Design & development of the RESCUE MIMS".

In this context, the end-users' proposal is that, together with the partners in the SnR project, they should continue their efforts to achieve the equipment and technologies referred to in T1.2 in deliverables D1.2 and D1.6, in particular due to the fact that there are chances reasonable to obtain a higher added value than initially forecast.

Another conclusion concerns the issue of gap analysis for resilience of the community, the results of which help end users to ensure a managerial act in crisis situations that takes into account the development gaps between local communities of their critical infrastructure, so as to ensure optimal use of equipment and technologies used in rescuing people trapped under the rubble.

This conclusion, discussed and summarized in detail in Chapter 3 "GAP analysis for community resilience" of deliverable D1.6, concludes with the recommendation that SnR project partners use the prioritization resulting from the analysis (see subchapter 3.5 "Conclusions and recommendations", figure 3-14) and GAP processing feedback to identify the most relevant issues for their scope.

It is recommended that the concerned partners use the prioritization that resulted from the GAP analysis and feedback processing in order to identify the most pertinent issues for their scope.

3 Specifications of SnR Governance Model

3.1 SnR Operational Model

The specifications of SnR Operational Model are the core concepts that have started to be developed since the first day of the project's start being one of the main subjects of task 1.4 of SNR project. The definition and deep analysis of CRISYS (Critical Response in Security and Safety emergencies FP7-SEC-2010.4.1-1) operational model as its architectural structure in D1.3 allowed us to easily incorporate next generation R&D and COTS solutions.

The Model supported also a unified vision of the EU role and provided a common framework to assess needs and integrate responses. The framework enabled a pro-active approach using a wider range of decisional support features and monitoring systems and gave to the crisis responders an effective and unified vision of (a) the dynamic changes going on during event's lifetime and (b) the capabilities and resources currently deployed in the field.

The partners managed to define the differences between CRISYS and SnR projects and the **innovation SnR brings** in the Crisis Management sector:

1. **Citizens and local communities will be introduced at the centre of the crisis management process.**

Training and education are utmost importance in crisis management involving both citizens and first responders. The citizens must be aware of the risks of the disasters, act and assist when necessary. Thus, the first responders have to be trained on a regular base in order to be able to respond immediately in every type of disaster.

A two-way process must be ensured whereby citizens also have the opportunity to contribute and integrate their local knowledge into the disaster management cycle. The core idea behind each training module is the simulation of the situation that will present itself and, depending on each scenario that will take place during the project, how it evolves and what decisions need to be made.

The aim of SnR project is the well-trained citizens which is a fundamental requirement for a high-quality disaster response. The closer involvement of citizens in information and preparedness activities could reduce significantly the defect level in cases of emergency and at the same time improve the quality of disaster response measures.

For that reason, volunteering groups will be involved in the pilots, citizens as well as young people. Before the pilots, training courses, joint simulation exercises and an exchange programme will take place, where experts can learn first-hand about similar responsibilities under different national systems. It has to be mentioned that VR first responder training modules will be integrated in SnR. Additionally, special Glasses and Helmets using Advanced Augmented Reality technologies will be developed for training and operational purposes.

There are many advantages for the citizens to integrate into the crisis management:

Develop a risk-awareness culture in order to raise public awareness and invest more for their own safety.

Promote cooperation between the citizens and first responders in order to be more efficient and reduce the delays in emergency response.

Train the citizens in rescue management in order to be involved in their own safety, because during a major disaster, the rescue teams will not be able to face all the requests of the citizens who will have to carry out an initial rescue phase by themselves for their families, their neighbours and other citizens.

Ensure a two-way learning process whereby citizens and local communities also contribute and integrate their local knowledge into the disaster management cycle.

Understand the value of crisis management and then contributing to avoid disaster emergency caused by human errors.

The new AR/VR technologies will allow for the development of interactive and distance training modules; these scenarios are also fun, which allows for an easier diffusion between the citizens.

2. A holistic framework will be promoted, where prevention and preparedness are linked to response, thus moving into a proactive system.

Disaster preparedness consists of a set of measures undertaken by governments, organisations, communities or individuals to better respond and cope with the immediate aftermath of a disaster, whether it be human-made or caused by natural hazards. The objective is to reduce loss of life and livelihoods.

Simple initiatives can go a long way, for instance in training for search and rescue, establishing early warning systems, developing contingency plans, or stockpiling equipment and supplies. In the case of early warning systems, both warning systems present among local communities, for example through repeated experiences in disaster-prone areas, and professional warning systems can be coordinated to ensure higher levels of effectiveness in disaster preparedness. Disaster preparedness plays an important role in building the resilience of communities.

The training activities that will take place within SNR project will raise people' preparedness and their response capacities. Emergency Management is about managing risks to communities and the environment. It is the core business of Emergency Services but every individual and organisation have a part to play.

Emergency Management, as formulated within the United Nations' Yokohama Strategy (1994), includes the following four phases:

- Prevention/Mitigation
- Preparedness
- Response and
- Recovery.

Leaders in organisations need to know their roles and responsibilities in each phase of the emergency management cycle and lead their organisation through them.

Prevention/Mitigation: any action or sustained effort aimed at reducing risk, undertaken in advance. Prevention or mitigation can be structural or non-structural. Examples of structural mitigation include resistant construction, structural modification and creation of barriers among others. Non-structural mitigation includes regulatory measures, design of education programme and non-structural physical modification. Examples can range from back-burning or constructing sea walls to protect from tidal waves, to having alternative sources of electricity or alternative communication systems in place. Prevention activities should be happening all the time.

Preparedness: making arrangements, creating and testing plans, conducting training, educating and sharing information to prepare communities should an emergency eventuate. These are also ACTIONS and they are happening all the time.

Response: the assistance and intervention during or immediately after an emergency. Focus is on saving lives and protecting community assets (buildings, roads, animals, crops, infrastructure). Usually measured in hours, days or weeks.

Recovery: the coordinated process of supporting emergency-affected communities in reconstruction of physical infrastructure and restoration of emotional, social, economic and physical wellbeing. Usually measured in months and/or years.

3. SnR governance model

The investigation regarding the Standard operating procedures of the end-users made us understand the differences and the commons methods that are used within the various teams. The SnR governance model will give (maybe enable or allow) the emergency organisations to work in common structures, use a common equipment and cover the gap which exists especially in the methodology used by the EU end-users. The SnR platform that will be developed during this project, will provide easy integration connectors with other command and control software solutions. The Model is built on the existing SOP investigated and, on the accountabilities, and responsibilities of all the organisations involved in the crisis management domain. Its architectural structure adopted will make it operate more effectively in the future disaster management systems.

Today, the rescue teams do not have all the same standards. Therefore, it is important and necessary to suggest a common doctrine in order to make the work and the interoperability easier for the different teams in the following sectors:

- Engagement procedure (preparedness, mobilization, deployment, e.g.)
- SOP
- Logistics and materials
- Operations management platform
- SnR project will allow for the development and suggestion of operational standards which the rescue teams will manage to adapt. This common basis will allow for a better collaboration and exchange of information in the intervention field.

Additionally, SnR provides:

- New technology tools shared between the teams: by adapting identical tools for the teams, the interoperability has been reinforced, the principle of subsidiarity has been strengthened, allowing the team to share its equipment and communicate it to other stakeholders. The efficiency in finding victims and the safety of rescuers will be more important.
- New operational platform to coordinate the operations: The communication and the share of information are prioritized during the rescue operations. By adopting a common platform, the exchange of information between the teams and on the field will permit to anticipate the evolution of complex situations. The radio communications will be shared in order to assure a direct communication between the teams on site with the structure of the management (EMS).

A deployment procedure will be equally adopted by the teams: the SOP will be able to guide the teams in the use of INSARAG guidelines or European modules on civil protection. These two systems are relatively close and compatible with the deployment of the rescue team.

4. Advanced mixed reality (AR & VR), simulation engines, curricula will be used

As it has already been indicated above, training and education are very important in crisis management. The lack of training and education leads to the loss of human lives.

Education in emergencies provides immediate physical and psychosocial protection, as well as life-saving knowledge and skills (for example, with respect to disease prevention, self-protection and awareness of rights) (Education in emergencies - UNHCR Emergency Handbook). If children and youth receive safe education of good quality during and after an emergency, they will be exposed less frequently to activities that put them at risk.

They will also acquire knowledge and mental resources that increase their resilience and help them to protect themselves. Inclusion in national education systems enhances these protection benefits. VR first responder training modules will be integrated in SnR.

New innovative methods of training will be applied into the project in order to attract the first responders and citizens, offering them an easy and security training curriculum based upon agreed training material and practical exercises built on the five complimentary methodical approaches:

- Modern, didactically refined lectures and seminars, emphasizing interactive learning and including self-tutoring possibilities
- Documented in open-structured, user friendly, based on state-of-the-art software tools in data and knowledge management
- Computer-based interactive models and virtual reality with biofeedback, simulating threat scenarios and the resulting consequences without and with appropriate countermeasures
- Realistic field exercises
- Evaluation of 3D computer-models during the practical field exercises.

The model will be based on the principles of 're-use, before buy, before make' and in this way, seeks a maximal reuse of existing legacy systems and solutions and beyond state-of-science, S&R and COTS tools and technologies.

For the training of the citizens, it is necessary to provide learning tools which will be compatible with people with disabilities (deaf, blind, paralyzed...).

These «fun» learning tools would give the chance to the children to receive more easily the message of training.

5. Access to end-users, certification, harmonization and standardization

The SnR platform contains a wealth of existing mature / near mature technological solutions, which have been developed by partners COTS products or fully demonstrated in FP7 and H2020 projects.

The SnR solutions which will be employed throughout the field demonstrations' will be also tested by the legacy systems of the responders' organisations which will participate in the demonstrations. All technologies, will be fully operational during SnR duration.

- Smart Glasses & AR Helmets
- Emergency communication app
- Six Gas HAZMAT monitor
- Advanced Augmented Reality (AR) technologies
- Wearable GPS Tracker (wearable)
- Wearable ECG, EMG (wearable)
- Wearable Strain sensors (wearable)
- Emergency response health condition monitoring device
- Radiation sensors (wearable)
- Rescue drones
- AI services on top of rescue drones
- Rescue Robots & Autonomous vehicles with Obstacle Detection System
- Chemical sensors
- CONCORDE EMS & Associated module / services
- Decision Support System (DSS)
- Training through AR/VR
- Smart textile professional uniform
- Rescue system for children
- 3D Mixed Reality Command Centre

These different tools of new technology will make easier the work of the rescue teams who have as a priority to save lives. However, we must not forget that this equipment includes field tools and this includes many advantages:

- the equipment tested are robust and resistant, and has no weak points in this area. All the equipment was used in variable climatic conditions, sometimes very high temperatures, such as during use case 5 in France where the temperature was 40°C; this made it possible to observe the good resistance of the MIMS for example and of the sensors connected to the rescuer and thus to obtain results in real conditions. The connected intervention suit was also used in different weather conditions depending on the location of the use case; the outside heat linked to the weather is to be taken into account for the rescuer, so that he adapts his efforts but also the wearing of the outfit during rest periods.

The autonomy of the devices was correct, despite a strong request close to the reality of the interventions, the possibility of recharging the equipment in use was applied and appreciated by the teams of rescuers. The variable climatic conditions had no influence on the autonomy of the equipment, even in unfavourable conditions (rain, cold, heat, etc.). In addition, the equipment tested, equipped with electronic components, was implemented without any particular difficulty, the restrictions of use in rainy weather in particular were respected but had no consequences on their implementation. The batteries show a higher temperature than normal in hot conditions, but this had no influence on the quality of the results obtained.

- The cost of acquiring and maintaining the equipment has been studied and corresponds to an affordable level for the rescue teams. The objective is to allow acquisitions at an appropriate cost, regardless of the financial capacities of the teams.

- the maintenance of the various devices has been evaluated during use, and does not present any specific difficulty: the robustness of the equipment, and the ease of access to the various components allow easy maintenance operations.

6. Test-bed and demonstrations are open to technology providers outside the consortium

Seven use cases had taken place during the SnR project including end-users, first responders, volunteers, training and relevant stakeholders. Seven relevant scenarios have already been developed which gave the opportunity to the relevant parties to test the system under real conditions and provided their feedback for further improvements. The preparation of the use cases has started from month 6 of the project and lasted until December 2022 where the final Use Case took place in Spain. During this time, the use case environments have been identified for each responsible use case partner.

The UC requirements have already been specified by the end-users with the aid of the technical partners who will be involved in the relevant use cases as well. The specific UCs ran from month 13 of the project start until month 33. During this time, SnR platform was developed and the actual execution of the pilots took place under realistic conditions and data through a series of trials. During the trials, the end-users evaluated the demonstrators and apps and assessed the quality and usability of the SnR Platform in collaboration with technical partners who closely monitored throughout the pilot the whole operation.

3.2 Standard Operating Procedures within SnR Use Cases

In this chapter, we are going to introduce the standard operating procedures in EU and International Organisations and the standard operating procedures that have been used within SnR seven use cases.

3.2.1 European Standard Operating Procedures

The **European Civil Protection Pool (ECPP)**[1] forms part of the EUCPM for enhanced European disaster response, with a focus on increased coordination and efficiency. When the EUCPM is activated, member states and participating states offer their assistance to the requesting country. This assistance may be provided in the form of qualified personnel (rescue or medical teams, experts) or equipment, which all represent resources made available through the ECPP. The common pool enables better planned and organised, more predictable, coherent EU operations. Capacities committed to the pool need to meet common high standards, validated through an EC certification and registration process.

Such certification includes participation of registered capacities in disaster simulation exercises to train emergency response jointly with peers and other teams, further preparing the European response capacities to reliably operate during international deployments, in close coordination with authorities of the host nation and other deployed capacities. In case the EUCPM and its related ECPP get activated, the Emergency Response Coordination Centre (ERCC) will coordinate the deployment of relevant capacities. The resources of the ECPP should generally be self-sufficient for several days as well as interoperable in terms of procedures and technical infrastructure.[2] It should be noted, however, that criteria on interoperability are not clearly specified. In the guidelines on the 'Certification and Registration of Response Capacities in the ECPP' interoperability is broadly defined as 'i.e. in how far the response capacity is interoperable with other deployed capacities' (EC, 2019, p.6). Interoperability is referenced as a key criterion in the certification process, further elaborating that *'The capacity should be capable to work efficiently with other mobilised response capacities and contribute smoothly to common operations. This implies a common understanding of basic principles in disaster response operations, flows of communication and communication equipment, technical complementarity of equipment, etc.' (EC, 2019, p.14)*

As briefly mentioned, participation in the ECPP requires prior certification by the European Commission, ensuring compliance with the quality requirements for each of the modules. One of the points in getting certified is for a module to participate in an international field exercise. Among other things, this is supposed to enhance the capability of interoperability between modules from all over Europe, as their only chance to train and work with other modules from all over Europe is during these exercises.

One example for exercises of this scale is **EU MODEX**, a short for European Union Module Exercises, conducted for the European Commission. As the name implies, these are table top exercises as well as full-scale field exercises for all the module types registered in the ECPP. Their goal is to "enhance the coordination of civil protection assistance interventions by ensuring improved compatibility and interoperability between the intervention teams and other intervention support as well as by developing the competence of the experts involved" [3]. During an exercise, modules from all over Europe come together, as they would in a real disaster, and not only have to work as a team themselves, but also with the other modules in order to work as efficient as possible and therefore being able to safe as

[1] https://ec.europa.eu/echo/what/civil-protection/european-civil-protection-pool_en
[2] https://erccportal.jrc.ec.europa.eu/CP-Pool#/
[3] https://etendering.ted.europa.eu/cft/cft-documents.html?cftId=4618 – Tender specifications

many lives as possible. Having this in mind, they are not only useful for working on interoperability, but also they are a good example for a way to strengthen the EUCPM and therefore whole Europe.

3.2.2 International Standard Operating Procedures – International USAR Response Cycle

An international USAR response has the following phases (see Figure 3-1):

Figure 3-1: The International USAR Response Cycle

Based on the INSARAG methodology [22], PUI developed Standard Operating Procedures (SOP) questionnaires which were built according to the "INSARAG GUIDELINES 2020 - INSARAG," [Online]. Available: https://www.insarag.org/methodology/insarag-guidelines/. [Accessed 14 06 2021]. These questionnaires were distributed once again to the nine end-users of SnR project who were committed to complete them according to their experience and expertise that was used during the seven use cases that took place during the project.

3.2.3 Standard Operating Procedures (SOP) within SnR Use Cases

PUI being an INSARAG member since 2010 has prepared a questionnaire according to INSARAG guidelines addressed to the pilot users of SnR project. All the pilot users - partners were asked to complete the specific questionnaire as all the them would take part to SnR pilot tests. Consequently, the nine end users were invited for the third time to complete the SOP questionnaire developed for the purposes to identify and register the operational procedures during the seven pilot cases (Greece, Romania, Spain, France, Italy, Austria) that took part during the development of the project. There were 9 tables collected and their data were analysed by PUI.

It has to be mentioned that 70 questions were prepared related to these procedures that are analysed in the specific section below:

3.2.3.1 Preparedness: planning for major emergencies including training exercises

The preparedness phase is the period between disaster responses. In this phase, USAR Teams undertake preparatory measures to ensure that they are at the highest level of readiness for deployment as possible. Teams will conduct training and exercises, review lessons-learnt from previous experiences, update Standard Operating Procedures (SOPs) as required, and plan future responses.

All the SnR end users who participated in the completion of the SOP **questionnaire prepared by PUI, they all have a training plan for their team**. The only exception is PROECO, whose members are used as trainers for other administrative entities (e.g., the National Institute for Administration).

More specifically, HRT team attends the first level/basic training program and after joining the department of their choice (mountain rescue, water rescue or USAR), they follow a more expertise training, divided in two levels. Additionally, whenever there is an opportunity, members of HRT participate in exercises abroad.

PUI training conform to the INSARAG procedure of deployment. The regular training team working with dogs for ESDP is mandatory in order to make sure that K9 teams are ready to act in case of disaster.

All the end users **organize simulation exercises**. In the RESIST Project (REsilience Support for Critical Infrastructure's through Standardized Training on CBRN), PROECO organizes within 2022, 5 field exercises (Bucharest and Magurele, Tuzla private airport). In the SnR project, PROECO is organizing a field exercise at Tuzla Private Airport, on the use of CBRN means by terrorists. HRT frequently organizes internal simulation exercises for practicing mountain, water and urban search and rescue procedures, which in some cases are joint between our departments. These are not conducted, however, under an existing plan. Each department organizes an average of two or three exercises annually. The organization of simulation exercises for EPAYPS is a frequent procedure which is conducted in properly selected locations in proportion to the existing risk. At least 5 major exercises per year for Natural, Technological and NaTech Disasters. JUH organizes simulation exercises 1–2-year focus on medical and logistics for their own Emergency Medical Team 1 (EMT 1), as well as full-scale field exercises called EU MODEX for USAR capacities (Lot 3) and EMTs (Lot 5), which were already mentioned in 3.2.1. JOAFG organizes approximately 5 exercises of different sizes (internal or with other organisations) - EMS focus, S&R rescue dogs. For PUI, there is 1 simulation every 2 months, management (command-post, ICMS, UCC), medical, search and rescue and logistics. PUI also participates in 1 or 2 international exercises during the year. SUMMA within the Summa112 training program there are: 1.- mandatory practical courses on multi-victim incidents with a final simulation. 2.- Periodical but continuous training (on/off doing PPE practice two hours every 15 days in total, which means each group attends a practice every 2 months, because we are 4 groups) for the professionals that integrate the Biological Risk Transportation Group (which is volunteer). 3.- Periodical training for assembly and disassembly of the SUMMA 112 Sanitary Decontamination Station. 4.- ERICAM (USAR Team) training and reviewing the material monthly. The ESDP organises training exercises twice a week in different search disciplines, as well as theoretical/practical courses throughout the academic year, where knowledge and techniques of search and rescue are updated.

It is worth mentioning that all the end users **organize special sessions – debriefing** in order to analyse the lessons learnt. Most of the end users **use the social network** for their exercises and other public information such as websites, conferences, press releases, newsletters and communication departments inside the teams. HRT's **Operational Manager** is handling and monitoring the whole operational procedure followed by the organization's team members. In that frame, he is strongly collaborating with our telecommunications experts and the head of each department, who initially activate and, then, contact our members in the field.

The operational management of EPAYPS follows every exercise's handbook. The field operational manager, which controls the activities, communicates with the team supervisors for every new progress. The management team members of PUI are members of the fire department and experienced in management of special operation. The operational management of the team members is based on the IMV protocol of the Community of Madrid, which is based on the PLATERCAM protocol. ESDP is under PLATERCAM protocol too. The protocols used in collapsed structures, especially when it comes to international search and rescue work, are those developed by INSARAG, and as dog rescue is often carried out in collapsed structures, the triage and marking system used by the ESDP is the one included in these protocols.

It may be important to note that the INSARAG field manual only refers to work in collapsed structures, although the OSSOC aspect may be applicable to other types of catastrophes.

All the end users are well informed for the safety and security of their teams regarding their pilots. More specifically, their members are intensively and strictly trained in self-protection and properly equipped for each incident that will take place according to every exercise handbook-guidelines. In case they do not have the necessary equipment, they do not participate to all the emergencies. Of course, all their volunteers are insured by the organization for body injuries that may occur during trainings or rescue missions. CNR is conformed to the Decree of Chief of the National Department of Civil Protection of January 12th, 2012 and decree of November 25th, 2013. All the team members of PUI have the training "BSAFE" from UN and during simulation they are working different scenario about the security and safety issues. The information received inside SUMMA is by the coordinating center. The firefighters secure the area and remove the victims from the hot zone. The safety elements used by the team is the individual PPE without being monitored or communicated between us, only through the coordinating centre.

The end users collaborate mainly with their National Authorities (Fire Service, Coastguard, local civil protection offices). JUH is working closely with the German EMT National Focal Point, WHO

Regional Office Europe & EMT Secretariat, EMT classification processes in different countries. PUI collaborates with International Authorities (INSARAG, WHO, International Office for Migration, CARITAS etc). The actions of the regional authorities and SUMMA are contemplated in PLATERCAM (Madrid Civil Protection Plan). More information can be found in https://www.comunidad.madrid/transparencia/sites/default/files/plan/document/acuerdo_de_30_de_abril_de_2019.pdf. They algo belong to ESP USAR Team ERICAM, so they are updated with the circumstances of international catastrophe on behalf of Global Disaster and Coordination System GDACS https://vosocc.unocha.org/. ESDP has a MoU with the National School of Civil Protection and they are members of ERICAM as well working under INSARAG guidelines and PLATERCAM protocol. All the end **users use K9 research activities** and techniques except for JUH and PROECO which is not part of their team. All dogs are trained for searching in open air and debris, using the air scenting technique completed with electronics devices (scanner, sensors). Additionally, the K9 teams **share information with the other members of the team**.

Health certificates and dogs' passports and all the **transport documentations for the dogs** are updated on a regular basis. The teams have **various methods in case of disasters**. In cases of large-scale disasters, HRT organization is aware and invited to support the search and rescue operation by the General Secretariat for Civil Protection or by the local civil protection offices. Their operational manager, in collaboration with the board and the head of the USAR department, examines their operational capacity in accordance with the severity of the disaster, the available rescue equipment and their human resources. At the same time, there is a call for support to all HRT rescue stations in Greece. The respective authorities are relatively informed and the on-field focal points from their side are indicated.

During the operation the volunteers work under the command of the indicated state representative. EPAYPS aims at: 1) Performing rescue (breaching, extrication and transport) in collapsed or failed structures of concrete, heavy wood/reinforced masonry with structural steel (rigging and lifting) and 2) assessing the collapsed structure and local failures to identify void size, location and configuration for potential live victims, and for determining access possibilities. JOAFG uses Manchester and Triage. The rescue efforts are usually executed by the fire brigade. After the assessment phase of the structures, PUI has the process to decide the priorities of search: the K9 team is deploying on the field, always 2 K9 teams for the security. If the result is positive with 1 dog, the second dog confirm or not. The rescue method inside SUMMA is the one established by the IMV protocol of the Community of Madrid. It determines the functions of each resource on a first-come, first-served basis, and also depends of the circumstances of the catastrophe, for example, we have a biological unit for transport patients with this type of risk, and they use PPE adapted to it, also the type of incident influent into the type of rescue. They have available baby safe tool, Fernokit, Pelvic belt, spinal board, blade stretcher, hip aligner for femoral head fractures, stiffness for adults and babies (cervical collars of Laerdal), and immobilizer of head called" dama de elche".

The protocols used in collapsed structures, especially when it comes to international search and rescue work, are those developed by INSARAG, and as dog rescue is often carried out in collapsed structures, the triage and marking system used by the ESDP is the one included in these protocols. It may be important to note that the INSARAG field manual only refers to work in collapsed structures, although the OSSOC aspect may be applicable to other types of catastrophes.

The training of the rescue teams is mostly common with the other members of the teams.

In HRT, the members are initially and basically trained commonly. This training program is held internally; however, they also join external training sessions, held by the Fire Service, the Coastguard, the Hellenic Airforce and the National Emergency Service or by corporations. When joining a specific department, their volunteers follow a more specialized training, though they are all trained commonly in First Aid. Regular exercises with K9 and medical teams take place in JOAFG and also with other organizations. The basic response team training is common and each unit has specialization training (e.g., communications, EMS etc.) except for the rescue dog unit, which is separate. The personnel of SUMMA who belongs to ERICAM make trainings together K9 and firefighters. They also receive the accreditation by UNOCHA together as well. ESDP trains the dogs and the dog handlers twice every week and perform training activities into the ERICAM team, as member of this emergency unit.

Not all of the **end users have a monitoring system for the vaccination of their team**.

All the team members of PUI have a connected card ID1 to register all the information medical or not; they also follow a process for the vaccinations. Regarding SUMMA, there is a control system for the vaccination of ERICAM rescue teams that are candidates for international sorties. The unit for international trips of HIGH-LEVEL Carlos III is in charge of this issue for all the professionals of ERICAM. All team members and dogs in ESDP have vaccination documentation.

There are some differences between staff who work in national or international level. For national teams, hepatitis and tetanus vaccine. For International typhus fever and more diseases in addition. **Only some end users have a medical system.**

Most of them follow their National Health System. All the end users have a **list of the necessary medical equipment for the transportation** and a list of medicines with the signature of the medical team leader except CNR who, during the COVID-19 pandemic they had a close link with the National Health Service. All the end users have **a way of maintenance of their equipment**. There are volunteers in each HRT department appointed for the equipment status, who are responsible for the maintenance and keeping track of it. Their equipment is maintained either by their members or by professionals, who collaborate with HRT. EPAYPS uses the Outsourcing (mainly). They have technicians only for basic support of the systems. JUH uses a software-based quality management system. JOAFG follows the medical product law (Medizinproduktegesetz). PUI disposes a complete list of equipment, limit date of use for medicines, dates of control of the batteries. PROECO uses individual first aid kits. Within SUMMA, the expiry dates and defects in equipment are checked monthly by the ERICAM team and the teams of the mobile uvis carrying the disaster backpack. ESDP has all equipment stored and they do maintenance work. Staff on call checks the equipment, but some kind of equipment needs in depth review. ESDP has two health kits, one for guides and one for dogs, with the necessary equipment to provide first aid assistance to all members of the team, which are checked monthly so that they are ready in case of an intervention.

Equipment used in high interventions as safety harnesses and roped need special maintenance (its use is registered with data as resistance and time of use) in order to determinate the equipment useful life. This is done for security reasons. Veterinary Material is checked with a registration and expiry control too.

All the teams of the **end users are autonomous enough to go for a mission**. JOAFG team is already supporting in transnational actions as support forces. Sometimes under the flag of other organisations. But there are international missions (Mozambique, Nepal, Haiti etc.) The **greatest gap** for HRT is the absence of a logistics software, that could facilitate the whole operational procedure and provide an overview about our equipment. For EPAYPS, the gaps depend on the size of the incident and the number of the units that participate. JOAFG organizes relief convoys for Ukraine, deliveries for Romania, for international organ transport, the team was the dominating organization for decades in Austria. But for shipping K9 or to mobilize large numbers of people, they are relying on international missions from other entities and participate there. They have experts for logistics in different areas. The declaration of IATA, the control of the inventory, the charge of the battery and the control of the date of the medicines are some of the gaps faced by PUI. ESDP, as non-profit organization working with volunteers, faces budget issues in some cases. In the case of a catastrophe, where ESDP is called, volunteers have to take some days off from their own companies, being difficult in some cases. Their team are volunteers and it is not always easy to take some days without previous notice in the case that they have to move to international operations. For SUMMA, it is sometimes difficult get the adequate transport when all the infrastructure has down. The bureaucracy of Governments sometimes is another difficulty. There are possibilities to meet hazard circumstances with special or specific resolution. CNR and JUH do not have any gaps in their teams in relation to the logistics.

The **most usual procedure of transport for an immediate deployment** is vehicles (ambulances, trucks), air transport (airplanes, helicopters) and sea transport. In HRT, mostly is the organization's vehicles and the air transport (via Hellenic Air Force).

3.2.3.2 Mobilization: response and travel, coordination with national and international authorities, transport and logistics

The mobilisation phase is the period immediately following the occurrence of a disaster. International USAR Teams prepare to respond and travel to assist the affected country.

The end users **have a real-time monitoring system for disasters** either national or international. For example, PUI, SUMMA & ESDP as INSARAG members, they use GDACS system to receive alarm

and other applications on smartphone. HRT uses seismographer network of the Greek organization of ant seismic planning and protection. They also use a privately owned meteorology radar. JUH has internal operations centre and collaboration with Johanniter Alert and Information Centre and German Joint Information and Situation Centre (GMLZ).

All the teams **organize a briefing for the team before the deployment**. One is about the disaster situation and the organization of the mobilization, before the medical screening and the loading of the equipment, and the other about the security, safety, the deployment and the presentation of the country (culture, religion etc.) just before the travel to the airport. The end users with K9 have various ways to **ensure that their K9 team is ready for the deployment (health, hygiene) and the whole trip.** HRT volunteers who are responsible for the rescue dogs, take care of such matters. JOAFG K9 is a unit for national actions. PUI has a veterinarian to check the capability of the K9 team for a deployment (veterinarian screening). All the end users follow **procedures to check the documentation concerning the materials to be transported**.

The documentation is prepared by HRT secretariat and checked by the Board and the Operations Manager. JOAFG has inventory lists. The team leaders of PUI & ESDP have all the documents about the material on paper and on a USB stick. All the end users **have official documents related to the practices of the medicine** except for HRT who provide only First Aid. EMAK teams of EPAYPS have the related documents. JOAFG disposes official documentation of education and training of EMTs and paramedics. PUI has all the attestation for the doctor, nurses and veterinarian. PROECO uses instructions regarding the intervention of professional emergency services in search - rescue actions – ISU 02.

HRT team does not **check the medical status of the personnel and dogs participating in the mission**, but it is their family doctors who check it. CNR neither. All the other teams do this check. More specifically, before a deployment, just after the first briefing, PUI's medical team organizes a medical screening to be sure all the members should go on mission (temperature, blood pressure, sticker in case of accident, and COVID test PCR if necessary). In SUMMA, there is an annual checking for all personnel, furthermore, the professionals receive a medical check focus on the medical status, previously to participating in a mission, and after it. The medical team which **follows up on hazardous materials** are JUH, CNR, PROECO, SUMMA & ESDP. PUI team has HAZMAT specialist in the USAR team. All the end users are **able to prepare their own transportation plan** by organizing their equipment to be transported by each one, but is needed to value the type of catastrophe and mission to reply adequately to this question.

There is specific **preparation by the teams regarding the transport of passengers and hazardous materials including the equipment**. Especially when there is air transportation, HRT secretariat makes all the arrangements. With regard to hazardous materials, HRT does not use any. JOAFG uses transport of Power Generator and transport of field kitchen. PUI has to prepare the IATA declaration for the flight, the logistics team leader has is trained in IATA procedure. PROECO follows the instructions related to the intervention of professional emergency services in search - rescue actions – ISU 02. Last month, for example, SUMMA and ESDP did a simulation to work inside a Covid+ environment. Thee organized the preparation of the component, and the movement of the professionals and the work inside the camo with specific PPE against this hazard.

3.2.3.3 Operations: in the country, K9, medical, management, coordination, reporting

The operations phase is the period when international USAR Teams are performing USAR operations in the affected country. It starts with arrival of a USAR Team at the Reception/Departure Centre (RDC) in the affected country, registration with the UCC/OSOCC, reporting to the Local Emergency Management Agency (LEMA) (or National Disaster Management Authority (NDMA)), and performing of USAR operations. The phase ends when the USAR Team is instructed to cease operations.

The management teams coordinate with the local authorities in the disaster area, depending of course on the operational plans. Before a deployment takes place, in PUI, they have to wait the international call for assistance from the country affected, and when PUI is the first team arrived in the disaster area, they have to coordinate with the LEMA (local emergency management authority).

For all the teams, **there is a pace of work in the area**. They work in rotation scheme, depending on the operation, their physical condition and their level of experience and training. The mission duration is normally below h24 for standard duty. In disaster response, 5h-6h shifts with rotation to next 6h shift (role change). Actually, it is mandatory for the maintenance of the team. The **safety and security**

conditions for most of the teams are part of the National Civil Protection Authorities or local emergency management authorities. In PUI, in the Base of operation and on the field, there is a "security officer" to control the Personal Protective Equipment, the security area, covid process, use of equipment in security etc. More specifically, PUI (UC5), SUMMA and ESDP (UC7) used the INSARAG procedures. The teams have to do the ASR 2, which is the Assessment Search and Rescue level 2, victim confirm yes or not, time of work 12 hours or more 12 hours, the site is in category A, B, C or D and after the priorities, the USAR team is deployed on the work site with the priority A, and the K9 team is deployed to search trapped victims; we use 1 dog, and minimum 1 more to confirm. In the case of an assessment of the situation for a SAR operation, HRT uses the ICAR/IMRF/INSARAG guidelines, depending on the situation and the competencies of their volunteers.

The **risk assessment carried out for the teams during the research** is done by the team leader or a security officer. SUMMA nowadays has added a drones' group to Fire fighters of Madrid Community for this issue. Moreover, PUI uses the drones for reconnaissance and evaluation something that was done during Use Case 5 as well (UC5).

Regarding **the evaluation of the situation in order to locate the victims**, most of the teams need only to evaluate whether dogs can take part (division of responsibilities with other rescue organisations). To complete the localization of the victim with K9, the teams can use electronic devices and scanner (extended Wi-Fi). There **is a security perimeter established during the site operation** for all the teams.

The **capacities of the teams are mostly satisfied to cut, pierce and extract a victim** except for medical first responder and K9 units (e.g., JOAFG, JUH e.V.).

Additionally, ESDP may localize the victim but not extract him since the risk assessment is carried out by the most suitable professional, normally they are firefighters. Until the area is not safe, neither the medical teams nor the K9 can intervene in zone 0.

JUH does not have a procedure to follow regarding **the assessment of the work site in order to define priorities**. HRT took into consideration factors like amount of work needed to be carried out, number of volunteers, equipment, building material and structural hazards in the case a rescue takes place in a building, weather conditions (especially in the case of mountain and sea rescue) are that needs to be covered. For EPAPYS the steps to follow were: 1) Determine the scope and magnitude of the incident, 2) Identify scope, location and types of damage. 3) Estimate the urgent resource needs 4) Develop a sectorisation plan 5) Establish priorities, 6) Identify general hazards, 7) Identify infrastructure issues. All steps are usually accomplished by; vehicle, helicopter, waterborne craft, uas, on foot or from reports from others. Teams carrying out this level of assessment must remain mobile, not engage in rescue operations and report the results as quickly as possible. JOAFG identified the safety issues, secure own position, check personal safety, check team safety, move forward, redo. For CNR, this procedure was under the responsibility of the Fire Department. PUI, PROECO, SUMMA and ESDP followed the INSARAG procedures. All the **teams had an evacuation and regrouping point set up for the team safety during the search**.

The medical teams permanently monitored the USAR team at work except for HRT. Regarding the **role of the medical team in taking care of the victims**, HRT provides only first aid treatment. Specialized medical care is provided by the authorities. The medical team of JUH offers basic health care but is not involved in rescue operations. EPAYPS, JOAFG, CNR, PUI, PROECO, SUMMA & ESDP provide triage/assessment and the role of their medical teams is to go into the victim in the confined space to do the first medical assessment and to supervise the extrication and evacuation. The **medical teams of HRT, JUH, PUI and ESDP do not advice the USAR teams in the area of chemical hazards**. All **the teams have a base of operations installed**.

USAR operations are monitored by the logistics teams (equipment, food, water, etc.) in various ways. More specifically, for HRT, the person who is in charge of logistics monitors the operation, in relation to equipment and supplies. Food, water and equipment are listed beforehand, weighted and placed into boxes. Food and water is provided to team members, according to the alimentation plan. EPAYS has set up a base of operations. Logistics team of JUH monitors EMT operation according to SOPs. JOAFG logistics are based on the use of material and equipment. Basic set is laid out for support of 24h operations self-sustainable. Logistic team is always present during operations for CNR. PUI has 1 logistics team is in the BoO to monitor the equipment and the Base of operation and 1 part of the

logistics team on the field, in a "Advance logistics". SUMMA and ESDP by controlling the stock of material, anticipating the needs that may arise.

3.2.3.4 Demobilization: process with local and international authorities, travel, logistics

The demobilisation phase is the period when international USAR Teams have ceased operations, commence withdrawal, coordinating their departure through the UCC/OSOCC, depart from the affected country through the RDC, and travel to their home country.

All **the teams organized a meeting with the local authorities and the teams in charge of the coordination, before leaving the area**. Whenever the teams participate in an operation, they always communicate beforehand with authorities to define their role and level of involvement. For PUI, there is a meeting organized by UCC (Usar Coordination Cell) with the LEMA before the end of the operation, and the LEMA decide to continue or stop the operation.

For the teams which participate **in international missions, there is no donation of equipment made to local teams**. There is also donation of equipment by authorities.

In most of the cases, **there is a communication plan organised with the media before the disengagement**. In case of emergencies there is a plan being the communication with the media. Especially for SUMMA, if the mission is international, the government is informed and is responsible for communicating with the media. If the incident is in the Community of Madrid, SUMMA has a press department that is in charge of informing the media. All the teams **organize a transport operation for the K9 teams and equipment** by the dog unit who is in charge regarding both and search and rescue units. All the medical teams ensure an assessment of the local needs of medical structures before disengaging, except for HRT, JOAFG and ESDP who are not involved in medical activities. For the other teams, it is an ongoing process during the whole mission. Sometimes, during the phase "beyond the rubbles", the medical team could do an assessment of the local needs in hospital or dispensary for a next project or program.

Most of the **teams usually donate medical equipment before the return**, such as medical drags and supplies. Regarding to the COVID risk, all the teams have taken the appropriate measures whenever participating in a mission, use the rapid tests, there are protocols regarding COVID 19, use of mask, collaboration with WHO, EODDY (Greece), German Robert Kock Institute (Germany).

PUI who participated in the explosion in Beirut last August, used FFP2 and hydroalcoholic solution during the transport and all the mission, change every 4 hours, PCR test or vaccination in France before deployment, the results are sent to the country, PCR test in the affected country if necessary at the arrival, PCR test in France for the go back, the medical team continue to monitor the team until the result of the PCR test - on the field, mask FFP2, disinfection of the equipment after using, in the BoO, disinfection of the dog and the team members before entry in the BoO.

Mostly, all of the **teams take into account the transport of hazardous materials for the return**, except for those who do not handle hazardous material, such as HRT and JOAFG. PUI follows IATA procedure and PROECO goes according to the ORDER of the Minister of Interior No. 1184 of February 6, 2006 for the approval of the Norms regarding the organization and assurance of evacuation activities in emergency situations. All the **teams have a transport plan**.

3.2.3.5 Post-missions: actions taken after a disaster to restore services and reconstruct communities, after action, review, lessons to learn

The post-mission phase is the period immediately after a USAR Team has returned home. In this phase the USAR team is required to complete and submit a post-mission report and conduct a lessons-learnt review to improve the overall effectiveness and efficiency for response to future disasters. The post-mission phase continuously merges into the preparedness phase.

The **teams prepare a mission report** except for the Greek teams, HRT and EPAYPS who prepare a debriefing session after the mission. HRT, EPAYPS and ESDP do not **have a «lessons to learn» document prepared** as these lessons are identified during the debriefing. JOAFG neither even though it is considered to be very important. The other teams use a «lessons to learn» document whose synthesis includes:

- conclusions regarding the evolution of the emergency situation, its consequences on the institutions population and assets and their influence on the development of the mission
- the executed actions and the ones being executed, by categories and localities

- planned and unexecuted actions: causes and measures
- other data requested by the upper echelon

Each part of the teams CNR, PUI, PROECO, SUMMA & ESDP prepare a mission report from USAR, management, medical, K9, logistics and drones (PUI). The above-mentioned related to the **«lessons to learn» document prepared in Search are valid for the «lessons to learn» document prepared in Rescue**. HRT, EPAYPS and PROECO do not **have a medical and psychological monitoring system for team members**.

JUH provides psycho-social support and after-care, incl. defusing + debriefing. Expert for psycho-social support is part of the team. JOAFG uses the PEER system. There is debriefing and possibility for psychological follow-up upon request. There is a team particularly dedicated to emergencies (emergency psychologists) in CNR.

The medical team monitor all the team members in PUI during the mission every time, every day, and if necessary, we can have assistance by phone with a psychologist specialist in France during the mission and after. SUMMA has an occupational risk prevention department for the medical follow-up of SUMMA workers. At the psychological level, it also has a department of psychologists who monitor SUMMA workers. In ESDP, SUMMA checks. Regarding psychologist team, it is not mandatory a check, however, team member can decide to ask for an appointment.

The leader **team must complete a mission report** describing the intervention and finally outlining the points for improvement. PUI has to prepare a complete report of the mission and send it to INSARAG secretariat in Geneva. HRT and EPAYPS do not prepare such a report but is it included in the main report.

All the teams have **a plan for restoring equipment and preparing for a new mission**, only for EPAYPS it is not obligatory. But there is a procedure of restoring the equipment through the typical procedures of everyday preparedness for the team at the Base. The logistics team leader of PUI organizes the cleaning, charge of battery, control etc. Each PROECO volunteer is responsible for restoring equipment and preparing for a new mission. On arrival at the base (Las Rozas Fire Station, Madrid) the material used is checked. The material is duplicated in case there is a new departure or mission. There is an Equipment Manifesto and a Vet Manifesto too for ESDP. All **the teams prepare a mission report**.

3.3 Description and Evaluation of SnR Use Cases

By the submission of this deliverable, all the seven use cases were realised within the framework of SnR project. More specifically:

1. UC1: Victims trapped under rubbles, Poggioreale, Italy, April 2022
2. UC2: Plane crash, mountain rescue, non-urban, Thessaloniki, Greece, November 2022
3. UC3: Earthquake / heavy storms between Vienna Rail Station & Kufstein railway station heavy damages in the rail station (Cross-border pilot, Tulln, Austria-Germany), September/October 2022
4. UC4: Forest fire expanded and threat to industrial zone, Korinthos, Greece, November 2022
5. UC5: Victims trapped under rubbles, Limoges, France, June 2022
6. UC6: Resilience Support for Critical Infrastructures through Standardized Training on CBRN, Tuzla, Romania, September 2022
7. UC7: Chemical substances spill, Madrid, Spain, December 2022

Table 3-1 gives an overview of the seven use cases incorporated in this report, providing the specific objectives as well as the intended technologies to be used, as it has been stated in D8.9 (SR Evaluation Framework):

Table 3-1: Use Case-specific objectives and technologies

Use Case (UC)	Main Objectives according to pilot plan	Technologies

UC1: Victims trapped under rubble (April 2022, Italy) CNR, MAG, UniCa, UNIFI, THALIT	The contribution of the tools/equipment developed within the project to a whole series of simulated ad hoc situations will be tested	• Wearable GPS tracker (UniCA) • Situational Awareness Model (UBITECH) • Emergency communication application COncORDE (KT) • Decision Support System (DSS)(KT, CNR, NTUA) • Rescue kits for children (UniFI) • Smart textile professional uniform (UniFI) • Wearable ECG, EMG (UniCA) • Wearable strain sensors (UniCA) • AI algorithms for recognizing objects from drone images (AIDEAS)
UC2: Plane crash, mountain rescue, non-urban (November 2022, Thessaloniki, Greece) HRT, NTUA, CERTH, UBI	Test the capabilities of the S&R platform on risk assessment, crisis management and rescue/volunteer mobilization	• Smartwatch(KT) • 3D Mixed Reality Command Centre (depending on the required hardware) (CERTH) • Smart Glasses (to be used for training and if possible, to display information through AR on the field) (SIMAVI) • Volunteer application (CERTH) • Emergency communication application COncORDE (KT) • Emergency Response Health Condition Monitoring Device (Test the device on the simulated victims) (CERTH) • e-learning based platform (to be used for training) (CERTH) (This depends upon when the actual training material (developed by T2.4 will be available for upload and use in the platform. The

		respective deliverable is due on M24. The e-platform (CERTH's part) will be ready to accommodate the material once the material is ready. Therefore, it also depends on when UC2 will be taking place.) • Artificial intelligence (We understand that this is a technology for image/video analysis. If so, we would like to test it with images from the drones) (AIDEAS) • Situational Awareness (UBITECH)
UC3: Earthquake / heavy storms between Vienna Rail Station & Kufstein railway station heavy damages in the rail station (Cross-border pilot, September/October 2022, Tulln, Austria-Germany) JOAFG, JUH, SYNYO, DFKI, THALIT	• Train patient routing system (tech. supported) • Rebuild communication infrastructure/ad-hoc infrastructure to re-establish basic communication • Train takeover of data management for different ambulance services at the command centre • Manage Common Operational Picture (CONCORDE emergency app) • implement and train triage structures • Conduct informed hazard assessment (using HazMat detection devices) • Test interoperability of search and rescue with dogs and technical equipment *Optional: Covid Tracing via Patient Rounting System*	• Smartwatch(KT) • Obstacle Detection and Avoidance System (ODAS) (THALIT) • Rescue Robots & Autonomous vehicles (DFKI) • Emergency communication application COncORDE (KT) • Six Gas Hazmat Monitor (UniCa)
UC4: Forest fire expanded and threat to industrial zone (November 2022, Korinthos, Greece) EPAYPS, NTUA, CERTH, UBI	Test the remote sensing technologies proposed in the S&R project for the safety of first responders: • alarms for early warning of toxicity and radiation exposure • generally inspection of the hot zone area • use of RPAS/drones, such as rescue robots to facilitate SAR operations	• Smart Glasses (SIMAVI) • Smartwatch (KT) • Emergency response health condition monitoring device(CERTH/HRT) • Radiation sensors (wearable) (UNICA) • Chemical sensors - Rescue MIMS (NTUA) • Drones (UHasselt) • Collaborative drones' platform (UHasselt) • Rescue Robots & Autonomous vehicles (DFKI) • Obstacle Detection and Avoidance System (ODAS) (THALIT)

		• Volunteer application, (Tech 3.1) (CERTH)
UC5: Victims trapped under rubbles (June 2022, France) PUI,KT, THALIT, ATOS	To organise the search and localization of the victims under rubble/in collapsed buildings from the K9 team and electronic devices, the control of gas absence or dangerous radioactive materials, the reinforcement of the buildings by shoring, the drilling of collapsed concrete areas and metal structures, the rescue of victims in height, the medicalisation of the victims, the coordination of operations by a command post integrated into an operations base, and the medical post activated in the operations base.	• COncORDE (KT) • Rescue MIMS (NTUA) • Wearable ECG, EMG (UniCA) • Situational Awareness Model (UBITECH) • Decision Support System (KT, CNR) • Wearable GPS-tracker (UniCA) • Smart Uniforms (UniFI)
UC6: Resilience Support for Critical Infrastructures through Standardised Training on CBRN (September 2022, Tuzla, Romania) PROECO-CBRNE, SIMAVI, KT, ATOS	• Testing the technologies, products and services developed within the SnR project in case of a real intervention situation for a terrorist attack using CBRN • Define a standardized training system	• Smart glasses (SIMAVI) • Emergency communication application COncORDE (KT) • Six Gas Hazmat Monitor (UniCa) • Smart textile professional uniform (UniFI) • Wearable strain sensor (UNICA) • Rescue system for kids (UNIFI) • E learning base platform (to be used for training) CERTH
UC7: Chemical substances spill (December 2022, Madrid, Spain) SERMAS - ESDP, ATOS, KT	• 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 as well, indirectly to the safety of the victims of the incident. • Recognition of changing safety zones by CONCORDE and chemical sensors	• Concorde EMS & Associated module/services (KT) • COncORDE (KT) • DSS (decision support system) (KT, CNR; NTUA) • Wearable strain sensors (UniCa) • Six Gas Hazmat Monitor (UniCa)

In the following sections, the use cases are being described according to their order of execution:

3.3.1 Use Case 1 - ITALY

UC1 stated as an overall objective to test the SnR technologies during an exercise with casualties trapped under rubble after an earthquake or on premises not reachable. Furthermore, the release of gases and/or other toxic substances as well as a blocked road preventing traditional vehicles from reaching the area, was planned.

3.3.1.1 Scenario

The exercise was aimed at demonstrating the technologies developed in the framework of the SnR-project, to expedite the location of victims trapped under rubble, while ensuring the safety of first responders and improving communication skills between the operators. For the search and rescue activities carried out by the rescuers, three sites were used simultaneously. The sites' titles were:

"Nursing home for the elderly", "Collapsed parking lot" (main site) and "Rubbles" (dog training camp). For the research activities carried out by drones, three additional sites were created and used simultaneously: "Rubbles", "Church" and "Hospital".

3.3.1.2 Use case implementation

UC1 was the first pilot implemented in the SnR project in April 2022. UC1-organisers report some infrastructure problems that mainly concerned the internet connection on-site and the GSM network. Wi-Fi was not stable and fast enough. It is concluded that both – stable and fast internet and GSM - are fundamental for proper technology testing. Nonetheless, it is reported that the UC was useful and served its purpose – improving components and technologies for the following use cases.

3.3.1.3 Use case evaluation

The evaluation of UC1 was performed with an ex-post approach in the days following the exercise. Ad-hoc questionnaires have been realized using suggestions from the technology partners (UniFI, UniCA and KT) providing questions for the smart textile uniform, the rescue system for children, COncORDE and SOT DSS. The questionnaires were then circulated among the first responders operating in the field that belonged to different organisations. Finally, the results were presented to the evaluating committee for the evaluation of the Physio DSS in July 2022 (created in the context of T4.6 "DSS Evaluation").

UC1 reports that their main concern was the lack of response to questions regarding COncORDE and SOT DSS.

The evaluation team consisted of three members that were simultaneously experts for the DSS evaluation in WP4 of the project. The panel examined the answers provided to the questionnaires and expressed difficulties in providing an evaluation of the technologies of UC1 due to their complexity.

UC1 lists the following **recommendations**:

Regarding the evaluation of the UC, the organisers recommended that the Wi-Fi environment (stable internet) and GSM networking should be foreseen. Furthermore, questionnaires should be ready to be filled-in by the participants at the end of the exercise and that the evaluation team should be specifically focused on the components and the technologies tested during the exercise. Finally, UC1 states that the post-exercise evaluation was not performed on-site, due to the fact that the questionnaires were not available during the exercise.

3.3.1.4 Self-assessment and evaluation of use case specific objectives and KPIs

All technologies were tested according to plan except for the SA-Model as one of the two components (Physio DSS) was not operational in the COncORDE platform at the time of the exercise. Two additional sites were used for running the algorithms for recognizing objects from the images produced by the drone provided by the fire brigade.

3.3.2 Use Case 5: Limoges/France

3.3.2.1 UC5 objectives

UC5's objective was to test the SnR system and more specifically, to give users the chance of testing the platform, the equipment and uniform in a real setting, focusing on how the first responders interact with the technologies in a real scenario. To assure maximum system operability and to locate possible deficiencies, the close collaboration between end-users and technical partners as well as thorough monitoring during the trial was underlined.

3.3.2.2 Scenario

The French UC-team prepared three work-sites (WS1-3), of which only two (WS1+2) were used for the trial. Those two are described in the following. WS1 was titled "Near the bus". There, victim 1 was trapped under the wreckage of a destroyed bus. Search by foot leads to no answer and therefore, the Rescue MIMS is employed. Furthermore, two K9 are searching for the trapped victim. After locating the victim, first medical support by a rescuer wearing the SnR-uniform and the extraction of the victim from under a concrete plate, the victim is transferred to the collection point for casualties and gets medical treatment.

WS2 was titled "In the tunnel and cars". There, a search for casualties after an earthquake is performed again using the Rescue MIMS and two confirmation K9. One person is located in a car under rubbles. The rescuers (one wearing the SnR-uniform) get access to the trapped person via a tunnel, steel is cut, the casualty gets medical support and finally is extracted and transferred to the collection point for further medical assessment.

3.3.2.3 Use case implementation

UC5-leaders describe their use case to have been interesting and a success, especially as the exchange with technical partners was very satisfying. It seems to have been also quite challenging as participants had to cope with temperatures of more than 40°C on the training day (June 2022).

UC5 concludes that several important points could be extracted from their experience during the execution of the use case. First, it is underlined that first responders participating the trial need to have flexibility and adaptability. Furthermore, security conditions must be respected by all participants (wearing PPE) as the employed site was potentially dangerous. Additionally, they recommend a security briefing prior to the start of the exercises. Finally, UC5 focuses on the length of scenarios during trials as they outline that in their opinion, it is not necessary to conduct long exercises, as the goal of use cases is to test the technologies and not the USAR team of first responders. Hence, it is reasoned that scenarios need to be adapted to technology tests.

Besides that, UC5 recommendations also stress the importance of stable and sufficient Wi-Fi connections for testing technologies. Furthermore, it is recommended that the weather conditions are anticipated for the event. Last but not least, a logistics area for technical partners is suggested for future use cases.

3.3.2.4 Use case evaluation

UC5 reports that the questionnaires that have been prepared for three technologies individually by the UC-team were distributed before the start of the exercise and collected after the end. The goal was to then discuss the answers and comments given during a debriefing session. The debriefing was organised immediately after the exercise in the fire station of La Souterraine region and tape recorded. The minutes of this session were provided for evaluation, too. Introducing a recorded debriefing was a new approach for evaluation and the minutes proved to be an important source of information regarding the execution of the UC and gave further insight into the testing process and the obstacles for evaluation.

UC5 gave the following **recommendations** for further UC:

- The team of first responders must have flexibility and adaptability
- The security conditions must be respected by all the participants (wearing PPE) because sites can be dangerous
- Long exercises are not necessary, as the goal is to test the technologies not the USAR team of first responders
- The scenario must be adapted to the technologies tested during 4-5 hours
- A logistics area (e.g. a tent) must be set-up for the technology partners to give them room for recreation and working
- There needs to be a security briefing at the beginning of the trial. PPE must be worn by all participants working on scene
- The Wi-Fi in the field must be efficient enough to test all the technologies
- Participants need to be informed of accommodation, transportation etc. beforehand
- It is important to anticipate the weather conditions beforehand.

3.3.2.5 Self-assessment and evaluation of use case specific objectives and KPIs

UC5 reports that the pilot was a great success regardless of the bad weather conditions. Seventy individuals were testing the system as end-users, technicians, observers, managers and others. The excellent execution of the UC allowed for feedback from the relevant stakeholders which in turn will help the technicians to proceed to further improvements of the SnR systems.

3.3.3 Use Case 6: Tuzla/Romania

3.3.3.1 UC6 objectives

UC6 stated two main objectives for their exercise: (1) Testing the technologies, products and services developed within the project during a real intervention situation caused by a terrorist attack applying a CBRN-scenario, and (2) defining a standardised training system.

3.3.3.2 Scenario

While passengers of a plane are at the airport terminal heading for customs, there is a degassing of a substance that affects some people in the terminal. They suffer from eye pain, difficulties breathing and vomiting. The airport terminal personnel identify the substance and informs the head of emergency management, who then activates the Crisis Cell of Tuzla Airport. The Crisis Cell intervenes as follows: They notify airport staff by broadcasting the "chemical alarm"-signal through the civil protection notification system, activate the COncORDE-platform to facilitate the information flow, and send the civil protection inspector to the scene to coordinate the intervention and to transmit information on the evolution of the operational situation. The alerted CBRN-team of Tuzla Airport puts on protective equipment and mark the red zone in the contaminated area and the "free access"-zone in the airport. Afterwards, the team prepares stretchers for passengers to be moved to the decontamination tent. Furthermore, they alert the CBRN-team of the County Inspectorate for Emergency Situations Constanta-Tuzla and a team of emergency doctors from the Central Military Hospital located in the area. Additionally, the ONG medical USARS Romania-team is notified to support emergency first aid and the medical ambulance "Samaritanus Romania" for further support.

The Tuzla CBRN-team starts transporting the passengers from the arrival's terminal. The CBRN-team of the County Inspectorate for Emergency Situations Constanta-Tuzla installs the contamination tent and begins with the contamination of the passengers. The team of emergency doctors from the Central Military Hospital, USARS Romania and Samaritanus Romania arrive at the intervention area, where the 3-emergency medical team is handed over the decontaminate passengers and provides them with first medical aid. Affected persons are then transported to the Constanta Emergency Hospital, whereas not affected persons in the evacuation area are taken to the entrance of Tuzla airport. Finally, the CBRN-team of the County Inspectorate for Emergency Situations Constanta-Tuzla begins with the decontamination of the equipment, land and buildings.

3.3.3.3 Use case implementation

UC6 reports several insights from the implementation of their use case especially regarding the planning phase, thus giving important input for following use case-organising teams. Accordingly, it is recommended that the planning processes is started as early as possible and that participation of end-users is mandatory in meetings concerning the technologies (and the necessary equipment) of the UC. Furthermore, UC6 calls for at least three extra meetings between UC and technology partners. An ex-ante visit on-site with first responders on the exercise site is also recommended. Additionally, UC6 strongly recommends that all end-user organisations try to participate in other UCs, regardless if their specific technologies are tested, in order to allow for an exchange of experiences.

Summarizing, UC6 underlines that the process of testing and evaluating the equipment and technologies during the UC should have absolute priority before all other activities. And finally, they recommend the dissemination of the results to all interested parties.

3.3.3.4 Use case evaluation

UC6 reports that the evaluation process ran smoothly and no difficulties arose during the planning phase. Furthermore, no issues regarding the evaluation arose on-site during the execution of the UC.

The evaluation preparation started early on in August of 2021 and the kick-off for the actual evaluation phase was held in August of 2022 with the online meeting. Simultaneously, the UC6 planning team had a meeting on-site with their members to finalise and solve the last technical and logistical aspects.

The evaluation team ensured together with the technology partners the training of the end-users and the completion of evaluation questionnaires including the organisation of a debriefing afterwards, as suggested by UC5. Regarding the evaluation team and the fulfilment of their tasks no issues were reported.

Furthermore, UC6 stated that the evaluation tools (questionnaires and debriefing) had the advantage of being easy to use and flexible, covering all aspects of the evaluation process. They ensured a

comprehensive measurement of the technology tests and data collection. Simultaneously, the evaluation approach was viewed as flexible regarding adaptation to the conditions in the field during the planning process. Altogether, the preparation of the aspects related to the evaluation proved to be sufficient to cover the needs of UC6 and organisers underline that from their point of view they would use the very same evaluation process in the future.

UC6 states the following conclusions and **recommendations**:

- The planning process for the UC needs to start immediately after the approval of the scenario
- The mandatory participation of end-users in all meetings with the SnR-project that address the equipment and technologies used within a UC is recommended.
- It is suggested to hold at least three meetings with first responders and technology partners participating in a UC.
- The organising team should at least once visit the UC-site to get to know the location.
- The results of the evaluation should be disseminated to all interested parties.
- The process of testing and evaluating the equipment and technologies in a UC is the number one priority in all activities.
- It is absolutely necessary for end-users to participate in the UCs that are carried out before their own, regardless of the equipment and technologies used, in order to achieve an exchange of experience.

3.3.3.5 Self-assessment and evaluation of Use Case specific objectives and KPIs

No discrepancies were reported in the fulfilment of the specific objectives proposed in D8.7 SnR Use Case 6: Resilience Support for Critical Infrastructures through Standardized Training on CBRN (Romania) – Pilot plan. UC6 reports that the specific objectives were fully met.

3.3.4 Use Case 3: Tulln/Austria

3.3.4.1 UC3 objectives

UC3 stated a list of objectives for their trial:

- Manage common operational picture
- Train a technologically supported patient routing system (tech. supported)
- Rebuild communication infrastructure *ad hoc*
- Train takeover of data management for different ambulance services at the command centre
- Implement and train triage structures
- Conduct informed hazard assessment
- Test interoperability of SnR with dogs and technical equipment
- Optional: Covid19-tracing via patient routing system

3.3.4.2 Scenario

In the UC3 there were two scenarios on two pilot days.

Scenario 1 contained the emission of gas in a family home after heavy storms. One resident is woken up by a loud noise behind the house and discovers the gas leakage. After leaving the house immediately, the gas provider is informed. The caller informs officials that their spouse and elderly mother are still in the house on the first floor and there is no possibility to communicate with them. The elderly mother is bed-bound. First responders are informed by the gas provider immediately and fire fighters, a team of the gas provider and paramedics arrive on scene. Gas concentrations are measured using the robots with ODS and HLX3000 gas monitor. The two residents of the house are rescued by fire fighters and treated by EMS.

Scenario 2 was scripted as follows. Due to extreme weather conditions in the region, a team of Johanniter Disaster Relief Team is stationed there. Heavy storms lead to the derailing of a passenger train with approx. 40 passengers on board. The train hits a car with an unknown number of passengers. The Disaster Relief Team and the fire brigades are notified of the accident. On arrival, several casualties are laying in front of the train, there are two dead and one heavily injured car passengers next to the car that starts to burn. During the examination of the scene, a total of 24 passengers are discovered, some with the help of Johanniter K9, as they fled the scene in fear after the crash. A total of nine

ambulances with 30 paramedics arrive on scene during the scenario. After triaging and treating the patients in the medical post that has been set up, the patients are transported to hospitals. Three patients were deadly wounded and are pronounced dead on scene.

3.3.4.3 Use case implementation

The Austrian UC was described as a great success with consistently positive feedback from participants. Especially, the realism of the pilot was underlined as it supported testing of the SnR-technologies under circumstances as realistic as possible. The UC-leader recommends to include all partners as early as possible and as detailed as possible in order to facilitate the smooth execution of a use case. Furthermore, it is reported that expertise in trial planning and organization is crucial and should be considered when composing the UC-team. This especially allows for a profound preparation.

Cooperation between JOAFG (Austria) and Johanniter-Unfall-Hilfe EV (Germany) in both planning and implementation of the pilot was very productive and first responders of both organizations were able to benefit from the exchange during and after the exercise.

It is necessary to include extensive consultations with technology partners beforehand. The perspectives of end-user-organisations and technology partners turned out to be extensively different and objectives of the involved parties are different too. Therefore, it can be very helpful to introduce technology partners into the trial, give them detailed information on how the degree of realism will be during the tests and what they can expect from the exercise. A detailed introduction is necessary as technology partners are usually not familiar with first responder situations and might not have sufficient experience with such dynamic and sometimes chaotic situations.

During the planning phase of UC3 this aspect had been somewhat underestimated and resulted in additional efforts for the organisation team right before the start of the trial.

Furthermore, technical requirements (Wi-Fi, end-user equipment etc.) need to be specified in detail in time and cannot be presumed without consultation to avoid last minute stress, misunderstandings and the need for ad hoc adaptations last minute.

3.3.4.4 Use case evaluation

UC3 reports that in general the evaluation process could be performed as planned and that the lessons learned from previous UC were very helpful during the preparation of the evaluation as possible complications could be anticipated and eventually avoided.

The evaluation team consisted of five interdisciplinary researchers of JOAFG with one of them being a trained paramedic. All team members were experienced observers and familiar with field trials. The team-lead was performed by the researcher with medical experience. In the weeks before the UC, tasks on-site were discussed and team-members were given an outlook on the evaluation goals and the main objectives of the project. Folders for every single team member were prepared, containing an overview on tasks, basic information on the technologies in use and other important information (communication, observer instructions etc.). Before the start of the scenarios, an evaluation team-briefing was held with all team members to summarize the upcoming tasks and give room for last questions. During the briefing, observers were given vests (white) to make them easily distinguishable from training staff, which turned out to be very helpful.

During the scenario, the evaluation team-lead kept an overview of the team members and served as a point-of-contact for them. In doing so, it was possible to quickly respond to any spontaneous questions. Team members were able to follow the technology users around. On the second day, a lesson learned from the first day was immediately implemented: technology users were labelled with stickers on their uniforms stating which technology (SmartWatch, COncORDE etc.) they used. This made it a lot easier for observers to find their target person in over 100 participants, most of them wearing the same uniform, FFP2-masks and helmets.

After the scenarios, the questionnaires were distributed. Evaluation team members were asked to wait for the technology users to complete the questionnaire and immediately collect them. Additionally, a feedback meeting was held post exercise on day 2 with the COncORDE users of Johanniter Disaster Relief Team. This was reported to have been a fruitful discussion of the technology, which was audio-taped and transcribed afterwards. Audiotaping allowed for following the discussion undisturbed and for analysing the content later in greater depth.

The evaluation of the evaluation team showed that the composition of the team proofed to be positive and helpful especially regarding the different scientific backgrounds and their experience in observing. As trials for disaster relief can initially be chaotic and very realistic, it was considered important that evaluation team members are somewhat familiar with realistic pilots and SAR situations. A team member with (medical) first responder-experience was viewed being supportive and is recommended to facilitate planning and ensuring realistic expectations (observation possibilities, safety concerns etc.). Furthermore, thorough briefing of the observers, especially that they should not disturb participants and try to avoid unnecessary interruptions of the pilot is reported to be crucial.

UC3 reports the following **recommendations** regarding the evaluation of UC:

- **Organisation/planning:**
  - Include extensive consultations with technology partners beforehand. Perspectives of end-users and technology partners turned out to be different and objectives of the involved parties are differing, too. It can be helpful to introduce the technology partners to the trial, give them detailed information on the degree of realism during the tests and what they can expect from the exercise. It has to be kept in mind, that technology partners usually are not familiar with first responder situations and therefore might not have sufficient experience with the dynamics and the often-chaotic situations they will be confronted with.
  - During planning of the evaluation of UC3 this has somewhat been underestimated and resulted in additional efforts for the organisation team.
  - Technical requirements (Wi-Fi, end-user equipment) needs to be specified in detail beforehand and cannot be presumed without consultation to avoid last minute stress, misunderstandings and the need for ad-hoc adaptations last minute.
- **Evaluation:**
  - If the scenario is of a high realistic degree, it is helpful to employ evaluation team members with first responder-experience, as realistic scenarios can be challenging in terms of dynamics and it therefore can be difficult to focus on observations. Team members familiar with exercises in the field will find it a lot easier to focus on their objectives without getting overwhelmed by the scenario.
  - Mark or label technology users with stickers, vests or some other easily distinguishable marker to make it easier for observers to follow them. In UC3, as all participants wore the same uniform, helmets and masks (due to Covid19-regulations) the stickers used to label the testers turned out to be very helpful.
  - Extensive briefings of the evaluation team on what to expect from the scenario, its sequence and a rough time plan were useful and can strongly be recommended.
- **Documentation:**
  - JOAFG tested video documentation employing six cameras filming throughout the whole trial. Examination of the material is still open (as it is an extensive amount of material) but filming can be a promising approach.
  - Feedback meetings with technology users were tape-recorded, which was very helpful as interviewers did not have to take notes and could focus on the discussion and react immediately on the user's feedback.

3.3.4.5 Self-assessment and evaluation of use case specific objectives and KPIs

UC3 reports that all objectives planned in D8.4, the UC pilot plan, were met except for testing the interoperability of K9 with technical equipment. Nonetheless, search dogs were also part of the train crash-scenario.

- **Train patient routing system:** Objective met. For the first time, a digital PLS (PersonenLeitSystem[4]) was tested with great success. This tool developed by JOAFG enables

[4] PLS can be translated in patient triage system. It contains triage cards that are placed on the patient. In the analogue version currently in use in Vienna, triage categories and other information is written on the card. In the digital version, by scanning a QR-code all information on one patient can be stored digital, which enables the command centre to have a fast and uncomplicated overview of all casualties and their triage categories.

digitalized triage using QR-codes and smartphones for a quick and uncomplicated assessment of casualties and their triage in scenario 2 on 01/10/22.

- **Rebuild communication infrastructure/ad-hoc infrastructure to re-establish basic communication:** Objective met. A data link to our headquarters in Vienna was established over directional radio via relays. Symmetrical 50 MBit/s bandwidth could be achieved and kept stable under load. A mobile VoIP extension was set up and tested by communicating with our operations centre and calls to external phone numbers. Stress testing the connection with VPN-tunneling and 4K video streams was performed. Conception of the system as a stand-alone setup independent of external power supply (Blackout-Concept) deployable by laypersons.
- **Train takeover of data management for different ambulance services at the command centre:** Objective met. COncORDE was tested and evaluated.
- **Manage Common Operational Picture (COncORDE emergency app):** Objective met. COncORDE was used in both scenarios.
- **Implement and train triage structures:** Objective met. In scenario 2, 24 casualties have been successfully triaged and treated.
- **Conduct informed hazard assessment (using HazMat detection devices):** Objective met. In scenario 1, the HLX300 gas detector was successfully tested.
- **Test interoperability of search and rescue with dogs and technical equipment:** Dogs were on-site (JUH K9) but did not test any SnR-technology
- **Optional: Covid19-tracing via PLS:** Covid-tracing was not included in the use case.

3.3.5 Use Case 4: Korinthos/Greece

3.3.5.1 UC4 objectives

UC4's main objective was to create all the necessary conditions for putting the available technologies into operation, to extract and gather all required information under conditions that facilitate the planned actions and ensure the safety of participants and observers.

Referring to D8.5, the UC4-lead refers to the following more detailed objectives:

- General objective: Test and evaluation of the SnR technologies
- Individual objective: Efficient training for the participants of the exercise so that they are well prepared for the technology tests. Observers have to carefully observe all the exhibitions of technologies and the comments of the users in order to describe precisely the true abilities of the tools.

3.3.5.2 Scenario

The simulation of the UC4 took place in the region of Corinthia, Peloponnese, Greece. The exact place of the simulation was nearby the shooting range ΠΒ 698 ΑΒΠ, close to the city of Korinthos.

UC4 prepared four scenarios – referred to as phases – for their exercise that are outlined below.

Scenario 1 – the preparation phase – included training procedures prior to the UC for the incorporated technologies with the goal to make the participants sufficiently familiar with their respective use and handling.

Scenario 2 – the response phase – is described as follows: A pyromaniac deranged person set fire to a Wildland Industrial Interface. Due to the strong winds and the dry forest fuel, which was caused by prolonged heat waves for 10 days before the fire incident, the fire expands rapidly. The area consists of a dense pine forest and the first feedback is that the fire broke to the Wildland side of the Wildland Industrial Interface and it is a matter of time to insert into the industrial interface.

Therefore, assistance is requested from the Fire Services to confront the wildfire and from the Police to control the traffic. A patrol fire vehicle is attempting to approach the incident site from the South. While approaching the closest industrial infrastructures, there are reports to the Fire Service's call centre that there is difficulty in approaching due to the limited visibility and the traffic congestion. There is also a possibility of trapped people in the industrial buildings nearby to Wildland Industrial Interface.

Additional regional help is requested in terms of firefighting personnel, material, aerial support, and special components and technologies from the fire crews. The COncORDE EMS, used to enhance coordination and decision-making between the operational command centre and the field. The fire

protection team of the company's employees reports that the fire has entered the business premises and has reached and burned the cab of the truck with the radioactive cargo.

A team of professional firefighters being supported by a team of volunteer firefighters enters the area where the truck with the radioactive cargo is parked. They wear Smartwatches (KT), Emergency response health condition monitoring devices (CERTH/HRT), and wearables Radiation sensors (TBD) that measure the radiation of the environment and their physical exertion and endurance.

Due to the heavy smoke in the area, the aforementioned teams are trapped inside the industrial with a high danger for their lives. During the search operation, the technologies (KT, CERTH/HRT) provide the management team with critical information about the condition and the health of the entrapped firefighters. With the use of Drones (UHasselt) in addition to the Collaborative drones' platform (UHasselt) the Fire Service managed to find the team's position and try to lead them to an escape route to a safer field environment. For the needs of the scenario, a firefighting aircraft is in flight.

Scenario 3 was executed parallel to scenario 2 as it includes a second team on duty. During the rescue of the first teams, the wind strengthening expands instantaneously the wildfire. The escalation of extreme weather conditions forces the cessation of drone flight and aerial support. Moreover, the previous factors cause the augmentation of the entrapped people. It appeared a possibility that a mixed-construction shed have collapsed in the zone.

Members of the second team are close, but they also wear Smartwatches (KT), Emergency response health condition monitoring devices (CERTH/HRT), and wearables Radiation sensors (TBD). The health condition of two (2) of the members from the first teams begins to change. We observe a reduction of the percentage in their blood and the blood pressure rise. The supportive volunteer team with the communication system provides support to the trapped members and participates in the final operation.

The circumstances of exercise are extremely difficult and the priorities have changed. Therefore, the operation plan has to change. With no more help from the air the RESCUE-MIMS3, a prototype of technology detecting a plethora of chemical masses in the field area is a critical asset. The fire services finally detect a human-sign in the area. Rescue Robots are entering to explore a specific area, inaccessible to fire forces personnel, and create a spatial map of that area. Finally, except for the two members with the health issues that we aforementioned there is one member of the second team under the rubble of the shed.

The health information from KT smartwatch and the Monitoring device (CERTH/HRT) on this occasion is constantly and without reporting particular problems. The operation center detects the firefighter under the debris in good physical condition, but due to extremely low visibility and the dangerous environment, he stays in the spot motionless. A survey operation takes place using professional personnel and equipment to approach the entrapped firefighters. The rescue team provides first aid if necessary, and leads them to a safe environment for recovery and extra help.

It is a direct continuation of the previous scenario. Due to the aggravation of the event, additional technological tools are required to support it. In this phase there are victims and rescue robots are used to find them, but firstly a fire perimeter evaluation of the chemical pollution from the fire smoke is necessary. In accordance with the safety guidelines of the exercise, the victims will not be lying down but walking, so as to avoid any accidents.

Scenario 4 – the mitigation phase – was scheduled as a test of a specific extinguishing material in terms of effectiveness and to be compared with the extinguishing results of the water. In this phase, the technology of Smart Glasses (SIMAVI) was also scheduled to be used and evaluated by professional firefighters and volunteers in virtual conditions, but the equipment was not finally available and is organized to be in trial in a next activity.

3.3.5.3 Use case implementation

UC4 states that throughout the project as a whole the availability of effective technologies was a high priority. Furthermore, EPAYPS highlight the importance of the evaluation process, which is discussed in the next subchapter in detail.

In the UC4 evaluation report is highlighted that there are certain important requirements for the WIFI network during the exercise and it would have been beneficial for the UC-organisers if specific needs had been highlighted earlier in order to make the necessary actions easier. UC4 states that it would

have been preferable to be provided the equipment needed to ensure a stable network on the UC-location.

In general, in UC4 no particular problems arose during the use of the technologies and the procedures were implemented according to the pre-defined schedule.

3.3.5.4 Use case evaluation

UC4 reports that the evaluation process was conducted according to the schedule and in general, the plan was described before the simulation. No particularly difficulties or any problems occurred. The appropriate selection of evaluators, based on specific qualifications, enabled a planned process and ensured the reliability of their observations. The criteria considered for the selection of the observers and evaluators were that they have experience in the specific topic. The effectiveness of the process was enhanced by choosing the specific personnel to actively participate in the process as they were assigned to specific roles. Their active participation in the UC contributed to obtain opinions of the applied technologies very good.

UC4 also mentions the observer sheets as being helpful as observations can bring important insights regarding technology use. The evaluation team members had to observe the handling of two technologies.

The evaluation report also states that it should not be overlooked from the process that in addition to the quantitative approach (using questionnaires) additional methods (qualitative analysis) were applied (observations, video and audio recording) to draw conclusions. Members of the organizing team were participating in the field in order to closely monitor all the actions during the UC, videotaping and recording the evaluation of the debriefing for further analysis.

UC4 concludes that the evaluation process is a key priority in the project and the evaluation of the applied technologies during the simulations is important in order to have a clear picture of their contribution to SAR-activities.

Choosing a quantitative approach by using questionnaires is considered to have been a good choice by UC4. They report that the questionnaires' application did not cause any problems and the method will be capable to bring the expected results. UC4 reports to have chosen the questionnaire part to be done immediately after the end of the activities to introduce them in the "heat of the moment" which can contribute to the best possible results. In any case, it is concluded by UC4 that this a matter of proper planning.

UC4 **recommends**:

- Provide the participants prior to the exercise with a thorough presentation and information on how to use the components that are to be tested.
- This preparation will significantly help the users who come into contact with the technology for the first time to be as familiar as possible and thus lead to better evaluation results.
- Consider the requirements for the Wi-Fi at the location in time.
- Specifications in advance regarding necessities regarding the network would have been beneficial for the UC organisation.
- It could have been preferable if equipment that ensures a network across the location would have been provided.

3.3.6 Use Case 2: Thessaloniki/Greece

3.3.6.1 UC2 objectives

UC2 stated that their pilot aims at testing the capabilities of the SnR platform on risk assessment, crisis management and rescue/volunteer mobilization. The UC's location held some special challenges for the mission, as mountain range environments' search and rescue operations are primarily defined by complexity considering inaccessible terrain and heightened risk.

The specific objectives that UC2 aimed at were:

- To fully operate and test the SnR solution on specific mountainous area.
- To establish a framework for managing data, developed services, and information flow between the various entities participating in emergency management operations.
- Enhance the overall situational picture by acquiring/using tools that make it easier to be geographically and spatially aware, modernizing outdated communication systems, and addressing new demands.

- To validate the SnR Platform from a usability and end-user point of view
- To make the capabilities of the SnR Platform available to policy stakeholders willing to use SnR's technologies.

3.3.6.2 Scenario

The incident begins with a forced landing of a passenger propeller aircraft due to mechanical problems upon approaching the airport of Thessaloniki. The forced landing takes place in a mountainous area, close to the city of Thessaloniki, on Mt Chortiatis.

Civil protection dispatches HRT to support SAR operations. HRT sets up a Command & Control Centre (CCC) close to the area where the plane is expected to have crashed. Three search teams are instructed to search for the aircraft debris and a rescue team is on hold to assist the operations with their specialised equipment, both for victim extrication and first aid support. The first search team, after some time, notifies that they have found the debris and informs the CCC about the location and the needs of resources. The CCC dispatches the rescue team to offer the initial first aid treatment to the victims and recover one passenger trapped under the debris.

The victims are then transported to the nearest location where the EMS vehicles will transport them to the hospital.

3.3.6.3 Use case implementation

UC2 highlights the meticulous and detailed organisation of an exercise which is critical to its success. Preliminary visits on the sites, identification of potential risks and/or needs (e.g. mobile network coverage) where identified in the very early stage of planning. Thus, UC2 organisers had enough time to deal with any potential danger to the pilot execution.

The technical partners' effective collaboration, comprehensive explanations of the requirements (technical and functional), as well as the descriptive and analytical training they offered to the end-users, resulted mostly in the right guidance of the exercise's organisation. Bilateral meetings with the technology partners, as well as physical meetings prior to the pilot on site, highlighted the importance of detailed planning for UC2.

UC2 highlights that several partners (coordinator, evaluation leader, other end-users) offered their own contributions to ensure that all project technologies and tools were tested and evaluated as thoroughly as feasible. The constant communication with the project coordinator regarding the overall planning, the bilateral meetings and the guidance from the evaluation leaders as well as the evaluation material provided was helpful to identify the best ways for effective organisation. Other end-users of the project contributed with their expertise on-site by exchanging their training and methodology with HRT's first responders.

The pilot exercise was meant to put the tested tools in the epicentre. All procedures were designed by incorporating the new technologies into existing action protocols to investigate and assess how first responders' work can become more effective and efficient whilst always ensuring their safety.

3.3.6.4 Use case evaluation

UC2 states that the evaluation process required a lot of preparation from the entire working group to be effective and to ensure that all necessary feedback will be collected. The process went in three phases, starting with the planning and the initial evaluation preparation meeting. After receiving and translating the questionnaires into Greek, the roles were assigned to know who would test the respective tools. Then, lists were created to control who should fill-in which questionnaire. As there were different questionnaires for each tool, there was a carefully planned distribution of the material to ensure that all testers completed the correct questionnaires in the second phase. Additionally, there was an overall debriefing of the pilot with all participants where an extensive discussion followed. In the final phase, the analysis of the collected material was performed which led to the evaluation report, which is the basis for UC2's part in this Deliverable.

UC2's evaluation team consisted of three members. The leader was responsible for the complete implementation of the process as well as to ensure that no questionnaire was omitted. The evaluation team members supported the process by administering the questionnaires to the first responders who tested the tools, which went smoothly without problems.

UC2 reports that the whole process was smooth without problems and that the feedback seems to cover the evaluation's needs.

UC2 gave **recommendations** for specific technologies tested individually. Generally, they recommend:

- Good preparation and "role tracking" are the key to ensuring feedback collection from the corresponding participants.
- The next step could be paperless evaluation materials and activities to add value. An online form could not only reduce the printing costs but the results would be available immediately.

3.3.6.5 Self-assessment and evaluation of use case specific objectives and KPIs

UC2 reports that specific evaluation procedures were used in order to achieve the objectives. More specifically, several tests were carried out throughout the UC process to assess COncORDE from a usability and end-user point of view.

In particular, during the exercise, an alert was triggered, which sent a visual and auditory alarm to the command centre and/or the monitoring centre, indicating where the alert was on a map. The majority of first responders gave the emergency communication application's features positive comments. The only concern that was identified was that there is a significant probability that there will not be any internet connection when there is no signal due to the mountain's geomorphological range. However, satellite internet could be used to tackle this issue.

It is essential to highlight that the mountain of Chortiatis possessed internet access throughout use case 2, therefore evaluating the technologies wasn't an issue.

At the end of the pilot, during the debriefing process, the participants completed questionnaires on SnR technologies while the technical partners engaged in a verbal debriefing procedure with the first responders.

3.3.7 Use Case 7: Madrid/Spain

3.3.7.1 UC7 objectives

UC7 states a list of objectives:

- Main objective: Test the technologies developed in the SnR project and train similar scenarios for the planning and prevention of future events.
- Improve the operational, safety and rescue procedures in this type of incidents.
- Practise the interoperability of the communication system.
- Gather feedback on the SnR tools for evaluation and improvements while still in development.
- Offer SUMMA112 and ESDP support and hands-on opportunities with the tools.
- Extend the stakeholder audience.
- Cluster event with the Rescuer, Med1stMR and INTREPID H2020 European projects.
- Guide future UC by considering the results obtained.

3.3.7.2 Scenario

UC7 was developed in an abandoned oncology hospital located in the Madrid municipality named Villaviciosa de Odon. The scenario was prepared in line with the Urban Search and Rescue (USAR) response cycle, which runs through five different phases: (1) Preparedness, (2) Mobilisation, (3) Operation, (4) Demobilisation and (5) Post-Mobilisation. The incident was divided in two separate scenarios.

Scenario 1 is described as a collapsed structure (residential building) due to an earthquake grad 5,5 on the Richter scale. As the gas monitor does not detect any risk the SnR of eight trapped victims begins. ESDP on the left side of the building rescuing four victims and SUMMA 112 plus GIRECAN (International Disaster Rescue Group) in the central area of the hospital rescuing a baby using the rescue system for children and also the other three trapped victims.

Scenario 2 started 30 minutes later with the gas monitor alerting because of the detection of flammable gas. As a result of the earthquake, a closed factory in the area suffered an ammonia spill due to the rupture of a refrigeration pipe. This ammonia came out in the form of liquefied gas, causing a toxic cloud. SUMMA 112, including CRBN team and GIRECAN worked together in this second scenario.

3.3.7.3 Use case implementation

UC7 concludes that the use of the SnR technologies tested was easy to learn and they could be used independently. UC7 has allowed to improve collaboration between organizations. The tools within the

pilot have been rated in terms of affordability, capability, deploy ability, maintainability and usability, functionality and effectiveness of the SnR tools was a primary objective, along with the ability to reach a wide range of professionals.

As for the scenario in which UC7 has been carried out, it has been a scenario that reproduces real conditions, allowing training in situations that facilitate the planning and prevention of future events. The staging of the incident, as well as the search, rescue, evacuation and medical assistance procedure, has been carried out following the procedure for action in incidents involving multiple victims of SUMMA 112 with the collaboration of GIRECAN, as well as the participation of ESDP. These exercises always help to enrich the implementation of the procedures by reproducing real situations that force the different participants to act as if it were a real case. The subsequent debriefing makes it possible to identify areas for improvement that will enable a more convenient handling of these critical situations.

As final conclusion, the pilot was a big success and a great opportunity for learning.

3.3.7.4 Use case evaluation

The interplay and close collaboration between technology developers, end-users and UC7 participants as well as evaluation leads was crucial to the UC7 evaluation success. The local hosts took a greater role in the evaluation and the on-site partners had intense contact with end-users for feedback in the final debriefing of the pilot. Regarding the preparation of the UC7 evaluation, all necessary steps had been finished prior to the exercise so that no adjustments were necessary on the field during the exercise.

UC7 was content with the evaluation team as it worked together perfectly and carried out the assigned tasks as planned. Nonetheless, some items in the questionnaires could not be quantified due to distance problems in the scenario.

Regarding the evaluation methods employed, UC7 underlines that the observers' notes were crucial and a good addition to the questionnaires. The notes were developed from a compilation of verbal and written feedback obtained during training and test demonstrations.

Concluding, UC7 emphasises that the exercise allowed for improving the collaboration between organisations. The tools within the pilot have been rated in different categories as it was the primary objective and furthermore the UC allowed the technologies to reach a wide range of professionals. Therefore, they rate the pilot a big success and great opportunity for learning.

UC7 **recommends** the following for UC-execution and planning:

- Choose a location depending on meteorological conditions.
- Plan accordingly regarding catering and room for restauration by considering the participation to the UC.
- Tents are convenient and recommended for gathering, as workspaces etc.

3.3.7.5 Self-assessment and evaluation of use case specific objectives and KPIs

UC7 reports that the main objective has been satisfactorily achieved, as the tools were tested as planned during the UC. As for the scenario in which UC7 has been carried out, it has been a scenario reproducing real conditions, allowing training in situations that facilitate the planning and prevention of future events.

Communication is essential for the correct coordination of all the resources involved in the incident. In this exercise, both the COncORDE and TETRA (Terrestrial Trunked Radio) communication platforms have been used, which made it possible to practice the interoperability of communication systems.

Different kinds of tools have been tested, from tools that provide information for incident management such as the smartwatch, the uniform with sensors or the gas detection-device, to the child rescue system that helps transport and evacuation of children. From the use of all of the technologies, both quantitative and qualitative evaluation data have been collected that will allow suggesting improvements for them. All this will result in the possibility of guiding future practical cases considering the results obtained in this exercise. To achieve these objectives, UC 7 was broadcasted with a user-friendly and easily accessible communication platform and social media.

3.4 Conclusion

During the three years of the SnR project, seven use cases were conducted by nine end-user organisations in six participating countries (GR, SP, RO, IT, AU/DE & FR). The organisation, execution under real conditions and evaluation of each use case was a great lesson for the first responders, technical providers and all relevant stakeholders. New innovative technologies were tested by the end-users and interested parties giving the chance for further improvements and finalisation. First responders and experts in the field came together from various countries in order to test SnR system and its technologies giving their valuable feedback addressing SnR goal "to design, implement and test through a series of large scale pilot scenarios a highly interoperable, modular open architecture platform for first responders' capitalising on expertise and technological infrastructure from both CONCORDE(http://www.concorde-project.eu/) and IMPRESS (http://fp7-impress.eu/) FP7 projects as well as the commercial technological insights of CONCORDEs commercial versions v0.1 and v0.2".

During the preparedness phase all USAR Teams **had a training plan for their team**. The only exception is PROECO, whose members are used as trainers for other administrative entities (e.g., the National Institute for Administration). All the end users **organized simulation exercises** within SnR project or other projects they are involved in with **special sessions – debriefing** in order to analyse the lessons learnt. Most of the end users **used the social network** for their exercises and other public information such as websites, conferences, press releases, newsletters and communication departments inside the teams. All the end users were well informed for the safety and security of their teams within their pilots.

The end users collaborated mainly with their National Authorities (Fire Service, Coastguard, local civil protection offices). All the end **users use K9 research activities** and techniques except for JUH and PROECO which was not part of their team. All dogs were trained for searching in open air and debris, using the air scenting technique completed with electronics devices (scanner, sensors). Additionally, the K9 teams **share information with the other members of the team**.

Health certificates and dogs' passports and all the **transport documentations for the dogs** were updated (eg. Travelling to France). The teams have **various methods in case of disasters**.

During the operation the volunteers worked under the command of the indicated state representative. **The training of the rescue teams was mostly common with the other members of the teams**. Not all of the **end users had a monitoring system for the vaccination of their team** and **Only some end users had a medical system.**

Most of them followed their National Health System and all the end users had a **list of the necessary medical equipment for the transportation** and a list of medicines with the signature of the medical team leader except CNR who, during the COVID-19 pandemic they had a close link with the National Health Service. All the end users had **a way of maintenance of their equipment**.

All the teams of the **end users are autonomous enough to go for a mission**. The **most usual procedure of transport for an immediate deployment** is vehicles (ambulances, trucks), air transport (airplanes, helicopters) and sea transport.

During the mobilisation phase International USAR Teams were prepared to respond and travel to assist the "affected" country. The end users **had a real-time monitoring system for disasters** either national or international. All the teams **organized a briefing for the team before the deployment**, one was about the disaster situation and the organization of the mobilization, before the medical screening and the loading of the equipment, and one about the security, safety, the deployment and the presentation of the country (culture, religion etc) just before the travel to the airport. The end users with K9 have various ways to **ensure that their K9 team was ready for the deployment (health, hygiene) and the whole trip.** All the end users follow **procedures to check the documentation concerning the materials to be transported**.

All the end users **have official documents related to the practices of the medicine** except for HRT who provide only First Aid. All the teams with the exception of HRT and CNR **checked the medical status of the personnel and dogs participating in the mission**. The medical team which **follows up on hazardous materials** were JUH, CNR, PROECO, SUMMA & ESDP. PUI team had HAZMAT specialist in the USAR team. All the end users were **able to prepare their own**

transportation plan by organizing their equipment to be transported by each one, but was needed to value the type of catastrophe and mission to reply adequately to this question.

There was specific **preparation by the teams regarding the transport of passengers and hazardous materials including the equipment**.

During the operations phase the **management teams coordinate with the local authorities in the disaster area**, depending of course on the operational plans.

For all the teams, **there was a pace of work in the area** working under the rotation scheme, depending on the operation, their physical condition and their level of experience and training. The **safety and security conditions** for most of the teams are part of the National Civil Protection Authorities or local emergency management authorities.

The **risk assessment carried out for the teams during the research** was done by the team leader or a security officer. Regarding **the evaluation of the situation in order to locate the victims**, most of the teams need only to evaluate whether dogs can take part (division of responsibilities with other rescue organisations). To complete the localization of the victim with K9, the teams could use electronic devices and scanner (extended Wi-Fi). There **was a security perimeter established during the site operation** for all of the teams.

The **capacities of the teams were mostly satisfied to cut, pierce and extract a victim**. JUH did not have a procedure to follow regarding **the assessment of the work site in order to define priorities**. All the **teams have an evacuation and regrouping point set up for the team safety during the search**.

The medical teams permanently monitor the USAR team at work except for HRT. Regarding the **role of the medical team in taking care of the victims**, HRT provides only first aid treatment. The **medical teams of HRT, JUH, PUI and ESDP do not advice the USAR teams in the area of chemical hazards**. All **the teams have a base of operations installed**. **USAR operations are monitored by the logistics teams** (equipment, food, water, etc.) in various ways.

During the demobilisation phase, all **the teams organized a meeting with the local authorities and the teams in charge of the coordination, before leaving the area**. For the teams which participated **in international missions, there is no donation of equipment made to local teams**.

In most of the cases, **there was a communication plan organised with the media before the disengagement**. In case of emergencies there is a plan being the communication with the media. All the teams **organize a transport operation for the K9 teams and equipment** by the dog unit who is in charge regarding both and search and rescue units.

Most of the **teams usually donate medical equipment before the return**, such as medical drags and supplies. Mostly, all of the **teams took into account the transport of hazardous materials for the return**, except for those who do not handle hazardous material, such as HRT and JOAFG. All the **teams have a transport plan**.

During the post-mission phase, the **teams prepared a mission report** except for the Greek teams, HRT and EPAYPS who prepare a debriefing session after the mission. HRT, EPAYPS and ESDP did not **have a «lessons to learn» document prepared** as these lessons are identified during the debriefing. The above-mentioned related to the **«lessons to learn» document prepared in Search are valid for the «lessons to learn» document prepared in Rescue**. HRT, EPAYPS and PROECO do not **have a medical and psychological monitoring system for team members**.

All the teams had **a plan for restoring equipment and preparing for a new mission**, only for EPAYPS it is not obligatory. Last but not least, all **the teams prepared a mission report**.

All the above-mentioned have been used accordingly during the seven use cases (UC1-UC7) that took place in Italy, Greece/2, France, Romania, Austria-Germany and Spain accordingly.

4 Interoperability Framework

4.1 Interoperability Framework within SnR

The definitions of all the tasks related to WP6 and the meetings that took place with the technical partners MAG, KT, SIMAVI and THALIT, have led to the design of SnR interoperability framework (see Figure 4-1). The main database (data lake) contains data from sensors / modules /UAVs and historical data from all sources that participate in SnR. Below, the responsible tasks are explained in details.

Task 6.1 is responsible for the video and data interoperability. All the necessary records can also be transferred to the data lake and from there and from there distributed to SnR modules that need these records (e.g., DSS).

Task 6.2 is responsible for the implementation of the data model in the data lake, so the syntactic interoperability of the data will be maintained.

Also, Task 6.2 will implement the connection to the European civil protection initiatives.

Task 6.3 implemented the Internet services interoperability framework. All web services that need to read or write data to the data lake will first communicate with the T6.3 framework and then T6.3 will forward the corresponding data to or from the data lake.

Task 6.4, in addition to designing the main interoperability framework, is responsible for designing and implementing specific "use case tailored" web services.

Prior to that, MAG distributed a questionnaire to all end users to determine what information is important to them during use cases. All data that will be provided by these services is in the data lake, therefore, this task will communicate with the web services interoperability framework (T6.3) to retrieve these data as described above (see Figure 4-2).

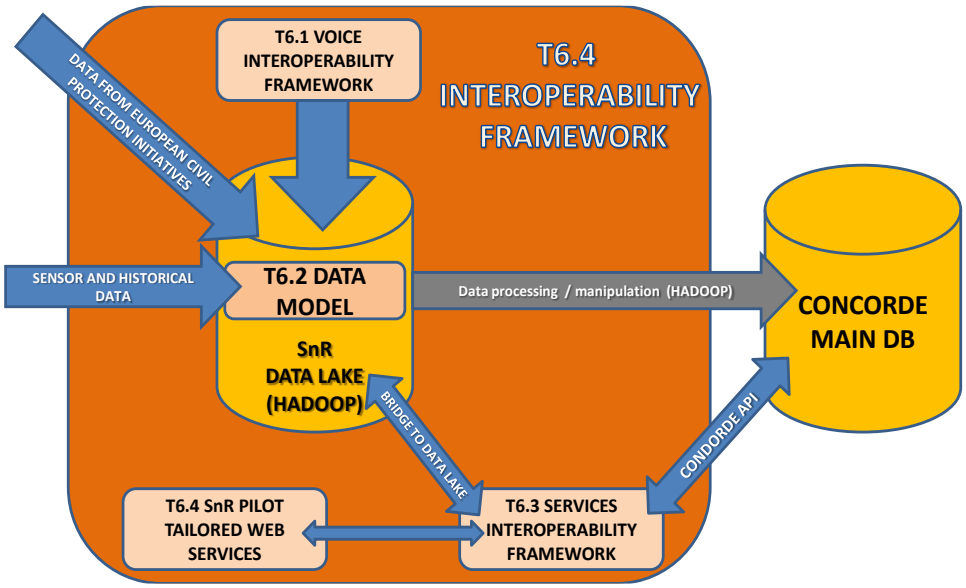

Figure 4-1: SnR Interoperability Framework

Data from the data lake after processing, and filtering by using internal Hadoop tools (Apache Spark) is forwarded to the main CONCORDE database (FP7-SEC-2013-1). COncORDE is a system of systems software platform that supports and enhances the existing coordination and decision processes during small or large-scale crises and medical emergencies, at local, regional and cross-border level.

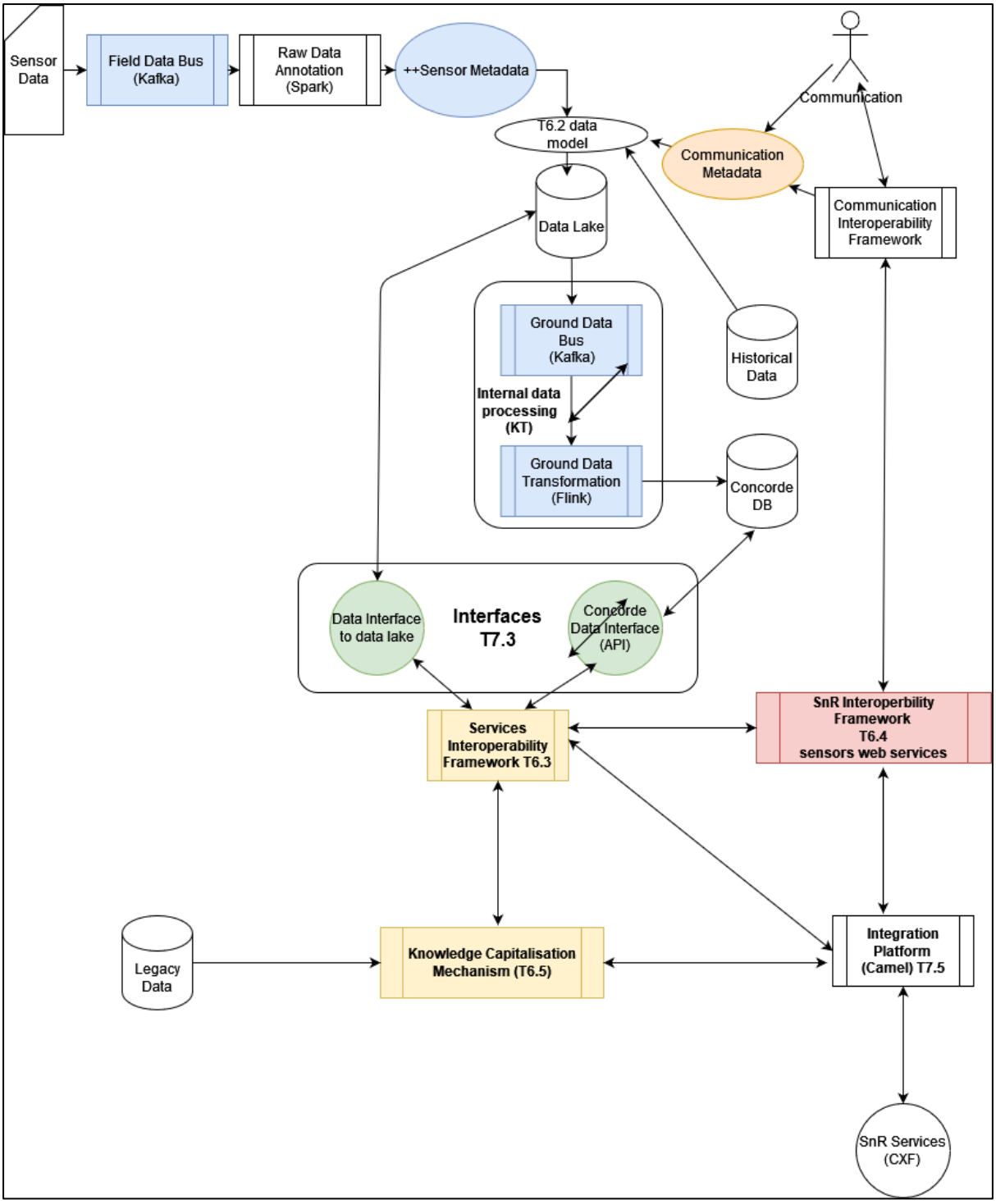

Figure 4-2: SnR Main Architecture (First Draft)

In order to highlight the overall interoperability, the next sub-chapters divide the SnR Technologies to Hardware and Software.

4.2 Hardware Components used within SnR use cases

Within the seven use cases that took place in SnR project, the following technologies have been tested and validated by the end users.

4.2.1 SmartWatch

Partner who provides the hardware component: KT

One technology that will enhance the S&R platform with data coming from the field, is the smartwatch. **YAMAY Smartwatch** [1] was chosen by KT to be tested and provide valid information to the S&R use cases.

Figure 4-3: Smartwatch

YAMAY is a fitness watch with heart rate monitor, timestamp, average speed among other valuable data. This Smartwatch integrates through **Bluetooth** with the first responder's smartphone, in order to get synchronized. It can provide messaging, heart rate monitoring and alerting functions (standalone Android Wear compatible smartwatches can also be used for messaging, heart rate monitoring/alerting and GPS tracking only through the smartphone).

Considering the S&R's needs in every operational level, the aforementioned smartwatch will sustain a wearable device to the Use Cases. More specifically, first responders will wear them, in order to feed the final system with their health data aiming to avoid any danger. Moreover, there is the option to take health measurements from the patients and victims on the field by putting the smartwatch on their wrist too. With this approach the final platform will be fed with first responders', victims' and patients' health data. This will aid operational procedures, such as the situation awareness module and the decision support system, to process more accurate and valid data. As a result, the actors of S&R operation, such as the Command Centre, the Field Commander, the EMS units and the first responders themselves will be more aware and notified for potential grave situations on the field (e.g., Tachycardia that can cause stroke, sudden cardiac arrest or even death).

All the aforementioned can be achieved using the selected smartwatch to generate data from the field, with the aim to send them to the rest platform. YAMAY has also the following characteristics:

Brand	YAMAY
Colour	Black
Connectivity technology	GPS
Compatible devices	Smartphone
Human interface input	Touchscreen
Screen Size	1.3 Inches
Water resistance level	Waterproof
Wireless carrier	Du
GPS	GPS per Smartphone

Figure 4-4: YAMAY Smartwatch Specifications

4.2.2 Rescue MIMS

Partner who provides the hardware component: LPAD/NTUA

The RESCUE-MIMS is a prototype of technology readiness level (TRL) 6 that has been designed and developed aligned with the end-users' requirements of "D1.2 Report on the functional specifications of S&R".

It is provided in a configuration of a robust peli-box luggage meeting specific KPIs, such as portability, robustness, easy operation, sensitivity, low Limit of Detection (LOD), fast response times etc.; more details are provided in "D5.1 Design & development of the RESCUE MIMS" and "D5.3 Testing & validation of the RESCUE MIMS".

In the framework of the SnR project, the RESCUE-MIMS will be tested under specific pilot scenarios relevant to search and rescue. Namely, the aforementioned field technology will be tested for remote sensing on-board robotic platforms under UC4-Forest fire expanded and threat to industrial zone. Moreover, it will be tested under UC5-Victims trapped under rubble; monitoring on-line at simulated debris chemicals that have been correlated in literature with human presence (chemical signs of life e.g., acetone).

Figure 4-5: The RESCUE-MIMS prototype provided by LPAD/NTUA

4.2.3 Wearable GPS Tracker

Partner who provides the hardware component: UNICA

This device will be implemented by using the embedded Global Navigation Satellite System (**GNSS**) module in the smartphone. The smartphone to be used in the pilots will be a rugged version that is currently not available in the lab. Preliminary tests were implemented using a Samsung S10, a mid-to-high-end smartphone with the following connectivity features:

- Enhanced 4x4 MIMO, Up to 7CA, LAA, LTE Cat.20
- Up to 2.0Gbps Download / Up to 150Mbps Upload
- 5G Non-Standalone (NSA), Sub6 / mmWave (Galaxy S10 5G only)
- Wi-Fi 802.11 a/b/g/n/ac/ax (2.4/5GHz),VHT80 MU-MIMO,1024QAM
- Up to 1.2Gbps Download / Up to 1.2Gbps Upload
- Bluetooth® v 5.0 (LE up to 2Mbps), ANT+, USB type-C, NFC
- Location (GPS, Galileo, Glonass, BeiDou)

So, as regards the GNSS the smartphone has a module that allows the reception of the signals of the four main world technologies of USA, Europe, Russia and China.

It is also equipped with assisted GPS (A-GPS), a system that allows to reduce the time required for the first location when using a GPS (fixing) terminal.

Samsung does not provide precise information on the GNSS module used but from various sources it is confirmed that it is the Broadcom BCM47752. One of the features that improves the performance of the device is the possibility of receiving in double frequency; this feature is present in the BCM47755 module, but there is no information on if this BCM4752 chip, which is very close to the BCM47755 chip, supports dual-frequency GPS or not.

However, the accuracy of the **BCM4752** module remains at high levels with an accuracy that stands at 5.3 meters in the open air.

Broadcom, as can be seen on the official website [4], does not provide the specifications for the BCM4752 module but merely gives a list of features:

- Advanced multi-path mitigation techniques provide faster time-to-first-fix performance in challenging environments, as well as a more accurate urban navigation experience
- Multi-constellation capability collects data from four satellite constellations (GPS, GLONASS, QZSS and SBAS) simultaneously and uses the best received signals, resulting in faster signal searches and more accurate real-time navigation
- Integration of key components such as LNA enables lowest bill of materials cost
- Uses 50 percent less power than previous generations, allowing location-aware applications to remain active for longer periods of time
- New applications such as Geofencing™ that provide alerts or services based on location can be completely off-loaded from the smartphone host for ultra-low power operation
- Ground-breaking indoor navigation through integration of Wi-Fi (including 5G WiFi), Bluetooth low energy, NFC and handset inertial sensor data into navigation applications
- Industry-leading urban navigation by applying handset inertial sensor readings into the position computation
- Best in class assisted GNSS (AGNSS) with both GPS and GLONASS assistance data available worldwide from Broadcom's hosted reference network

The features are those that are frequently found in the GNSS modules of mid-to-high-end smartphones. To have a further improvement in performance (accuracy) it is advisable to use smartphones that use the BCM47755 module.

4.2.4 Wearable Strain Sensors

Partner who provides the hardware component: UNICA

The flexible strain sensors developed for S&R project have been fabricated on flexible PET films, with a thickness of 175 um. They are characterized by the presence of interdigitated Organic Field Effect Transistors which acts as the mechanical transducer.

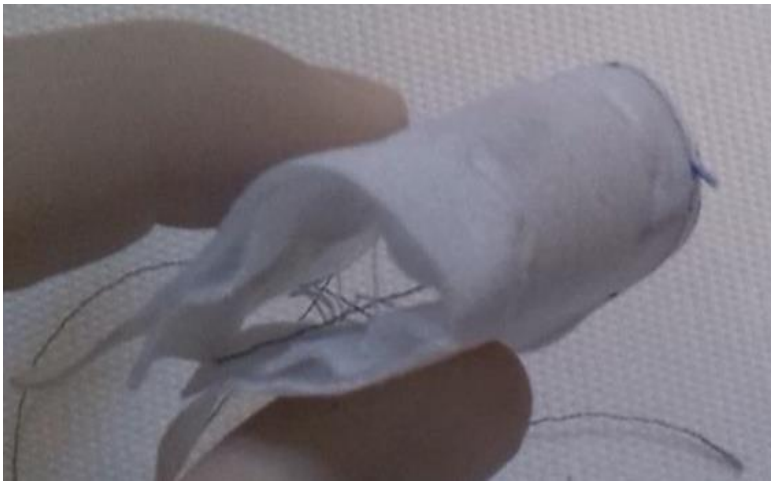

Figure 4-6: Strain Sensors

The device has the capability to detect uni-axial deformations in both directions. In fact, upwards and downwards bending lead to an increase or decrease of the sensor output current, thus allowing the system to discriminate what sort of deformation has been exerted on the sensor. In particular, within the project, such flexible sensors have been inserted into a fabric and can be sewn onto different parts of a clothes to allow the monitoring of different joints.

Considering the detectable strain range of the sensor, such devices can be employed for monitoring knee and elbow motion.

The device comes with three shielded conductive wires, one represents the Source electrode common ground, whereas the other two represents the gate electrode (VGS=-5V), and the Drain electrode (VDS=-5V). The current flowing between the latter electrode and the source one represents the output of the sensor.

Table 4-1: Strain Sensors Specifications

Strain Sensors	Specifications
Device Length	15 cm or less
Device Width	5 cm or less
Device Thickness	< 2 mm – depending of the employed fabrics
Device Weight	< 10 g
Operating Voltage	5 V
Typical Output Current	10 – 50 uA
Strain Range	0 – 2 %
Sensitivity	0.125
Strain Resolution	0.2 %
Detectable current variations	< 50 nA

4.2.5 Wearable ECG, EMG

Partner who provides the hardware component: UNICA

Within the requirements of the project, the first responders will be provided with easy to use, fast-to-wear sensorized garments for the monitoring of biomedical parameters. In order to improve the wearability, a polyesther-based, **stretchable** and **transpirant** t-shirt will be functionalized in order to print on it three textile electrodes integrated directly into the fabric, with which it will be possible to monitor the ECG of the operator during the on-site action. The electrodes are based on a conductive ink based on PEDOT: PSS that will be screen-printed on the garment.

The sensorized t-shirt has the following characteristics:

- Total number of electrodes: 3
- Size of the electrodes: 2 cm in diameter (when stretched)
- Conductivity: 1-20 mS/cm
- Skin-electrode impedance: 10 kOhm-150 kOhm
- Sampling frequency up to 500 Hz
- Resolution up to 16 bit/sample

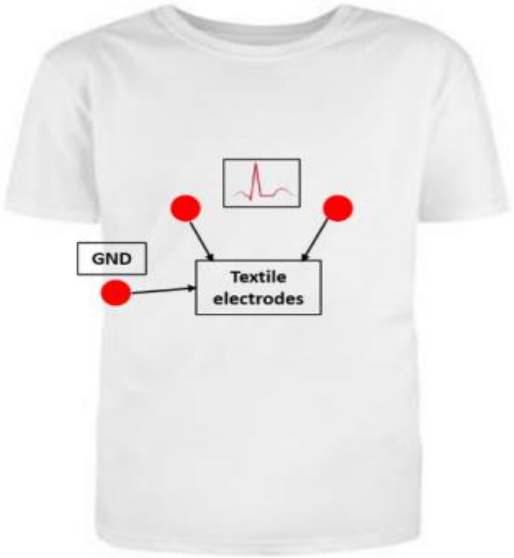

Figure 4-7: ECG, EMG

The first responders will be provided with comfortable polyesther-based, **stretchable** and **transpirant** pants with which it will be possible to monitor the activity of the thigh muscles of the operator during the on-site action. In particular, up to two muscles are targeted. The 5 electrodes (2 for each muscle and one ground electrode) are based on a conductive ink based on PEDOT: PSS that will be screen-printed on the garment.

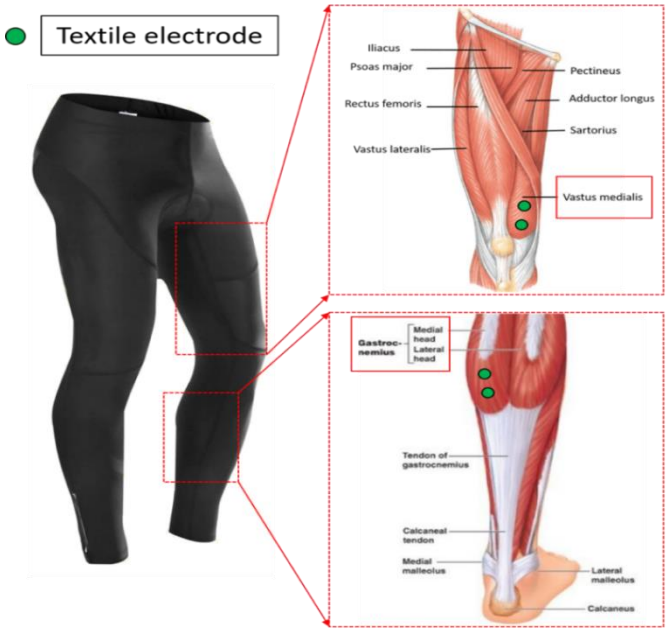

Figure 4-8: Textile Electrode

The short pants have the following characteristics:

- Monitoring of 2 muscles: vastus medialis, gastrocnemius medialis
- Total number of electrodes: 5
- Inter-electrode distance (for each muscle): 2 cm

- Size of the electrodes: 2 cm diameter (when stretched)
- Conductivity: 1-20 mS/cm
- Skin-electrode impedance: 10 kOhm-150 kOhm
- Sampling frequency up to 2 kHz
- Resolution up to 16 bit/sample

4.2.6 Six Gaz Hazmat Monitor

Partner who provides the hardware component: UNICA

In the framework of the SnR project, the equipment of first responders must also protect them from high-risk environmental conditions, such as explosions or the release of toxic gases. For this reason, first responders are equipped with portable single-unit gas monitors capable of detecting at the same time multiple dangerous gases, which can affect the emergency area. These detectors show real-time values in a multiple numerical display, are sensitive, economical, easy to use and safe. Portable monitors can be inserted in a jacket or trouser pocket or tied to the belt, so as to be comfortable and within reach, and not hinder rescue actions.

Figure 4-9: Gas Hazmat Detector

The selected gas hazmat detector is the Digitron's HLX3000 wireless portable monitor (see figures), which is a commercial device and has the following specifications:

- simultaneous measurement of multiple gases (toxic, explosive and VOC gases), multiple numerical display;
- sensors' configuration can be customized according to rescuer needs;
- compact ergonomic design, easy-to-carry device;
- with safety reminder function, sound and light vibration;
- alarm function, man-down alarm function;
- storage through password;
- wireless communication;
- 3.7 V rechargeable lithium battery, battery capacity 2200 mA;
- more than 15 hours in continuous working mode;
- fast response time: << 30 s;
- working temperature: -20 ℃ ~ +50 ℃;
- environmental pressure: 86 ～ 106Kpa;
- size: 157 * 84.5 * 59.5 mm (length * width * height);
- weight: 365 g (including battery, belt clip and filter);
- provided with the main international anti-explosion certifications (ATEX).

Figure 4-30: Gas monitor usage

In accordance with the needs of the project and, specifically, of the demonstration pilots that will show the use of the gas monitor in different emergency situations, the HLX3000 monitor has been customized in order to detect the following gases:

- CO: 0-1000 ppm, resolution 0.1ppm;
- CO_2: 0-2000 ppm, resolution 0.1 ppm;
- O_2: 0-25% Vol, resolution 0.1%Vol;
- EX (all flammable gases calibrated on CH_4) 0-100% LEL;
- H_2S: 0-100 ppm, resolution 0.1 ppm.

4.2.7 Six Gaz Hazmat Monitor

Partner who provides the hardware component: UNICA

In the framework of the SnR project, the equipment of first responders must also protect them from high-risk environmental conditions, such as explosions or the release of toxic gases. For this reason, first responders are equipped with portable single-unit gas monitors capable of detecting at the same time multiple dangerous gases, which can affect the emergency area. These detectors show real-time values in a multiple numerical display, are sensitive, economical, easy to use and safe. Portable monitors can be inserted in a jacket or trouser pocket or tied to the belt, so as to be comfortable and within reach, and not hinder rescue actions.

Figure 4-11: Gas Hazmat Detector

The selected gas hazmat detector is the Digitron's HLX3000 wireless portable monitor (see figures), which is a commercial device and has the following specifications:

- simultaneous measurement of multiple gases (toxic, explosive and VOC gases), multiple numerical display;
- sensors' configuration can be customized according to rescuer needs;
- compact ergonomic design, easy-to-carry device;
- with safety reminder function, sound and light vibration;
- alarm function, man-down alarm function;
- storage through password;
- wireless communication;
- 3.7 V rechargeable lithium battery, battery capacity 2200 mA;
- more than 15 hours in continuous working mode;
- fast response time: << 30 s;
- working temperature: -20 °C ~ +50 °C;
- environmental pressure: 86 ~ 106Kpa;
- size: 157 * 84.5 * 59.5 mm (length * width * height);
- weight: 365 g (including battery, belt clip and filter);
- provided with the main international anti-explosion certifications (ATEX).

Figure 4-42: Gas monitor usage

In accordance with the needs of the project and, specifically, of the demonstration pilots that will show the use of the gas monitor in different emergency situations, the HLX3000 monitor has been customized in order to detect the following gases:

- CO: 0-1000 ppm, resolution 0.1ppm;
- CO_2: 0-2000 ppm, resolution 0.1 ppm;
- O_2: 0-25% Vol, resolution 0.1%Vol;
- EX (all flammable gases calibrated on CH_4) 0-100% LEL;
- H_2S: 0-100 ppm, resolution 0.1 ppm.

4.2.8 Radiation Sensors

Partner who provides the hardware component: UNICA

The X-Rays sensor developed in S&R is an innovative, flexible, two-terminal device. Using a poly-crystalline organic semiconductor film interfaced with gold electrodes, the device can perform a direct conversion of the impinging radiation into an electrical signal, without the need of a scintillating element, with sensitivity values comparable with those of small-area, inorganic crystalline materials. Taking advantage on the peculiar properties of organic electronics, the cost per area unit of sensing pixel is dramatically lower if compared with those of inorganic counterpart. Moreover, as organic materials and plastic substrates are intrinsically flexible and light-weighted, their integration into garments is particularly advantageous.

X-Rays devices are endowed with the following characteristics:

- pixel dimensions: 5x5 mm
- pixel thickness: 0.175 mm
- Sensitivity: 55.3±0.4 nC/Gy
- output signal: voltage;
- nominal resistance: 1 ±0.5 MΩ

4.2.9 Emergency Response Health Condition Monitoring Device

Partner who provides the hardware component: CERTH/HIT

CERTH/HIT is developing an easy to place device equipped with sensors that can measure critical vital signs to be used both in first responders and victims. The device will be able to measure heart rate, respiration rate, blood oxygen levels, and body temperature and provide an approximate estimate of the blood pressure. The device will have communication capabilities. The rescuer will be able to read the victims condition on a smartphone and transmit the position of the victim.

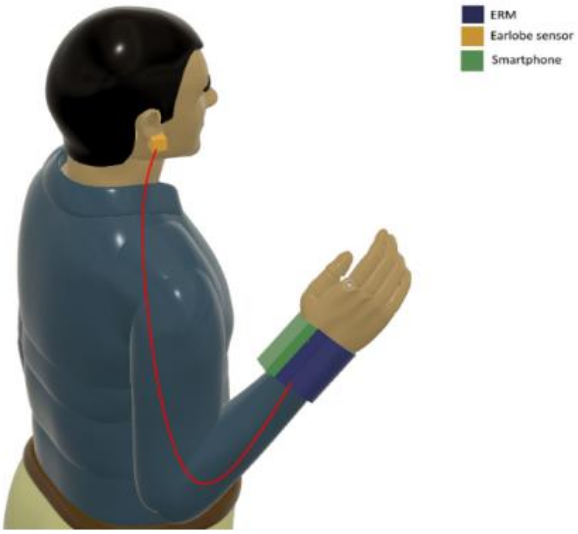

Figure 4-13: A preliminary design of Health Condition Monitoring device

4.2.10 Drones & Collaborative Drone Platform

Partner who provides the hardware component: UHASSELT

During search and rescue operations several hardware resources could be deployed in the field to achieve different type of tasks. Drone technology could be equipped by a variety of sensors that allow each drone to have a generic capabilities like image capturing as well as specific capabilities like sensing special gazes in the environment. Drones are valuable resources that have a limited battery life but have important capabilities that can help to increase the awareness about the operational field and to localize victims. Allowing drone to collaborate to achieve more complex tasks will help to increase the efficiency of search of victims in term of search time and number of localized victims.

In the collaborative drone platform, the drones will be used to coordinate a victim search task using multiple drones. The drones could have a similar or different capabilities but should be able to provide a clear field of view. The flying mission will be attributed to one drone (leader drone). This drone will calculate an estimated required power for the mission. If the mission could not be fully accomplished by one drone. The platform will provide to the user the ability to use collaboration mode.

The collaboration mode will ask for additional settings including the drones that could participate in the mission. Participating drones in the mission could receive communication messages from the leader drone. These messages could include information about the mission and the coordination of the tasks.

For a simple example the participating drone could take over the search mission to allow a long search mission.

Figure 4-14. Dimension of DJI Phantom 4 Pro v2.0

4.2.11 3D Mixed Reality Command Center

Partner who provides the hardware component: CERTH/HIT

A 3D Mixed Reality Command Centre (3D MR CC) was developed at CERTH with the purpose of visualizing contextually relevant and online spatial information from different data sources to the decision makers. The 3D MR CC allows the user to experience the virtual world without losing connection to the real world. This type of experience allows the user to keep the awareness of the real world (what is happening around them) and at the same time use in their benefit the virtual spatially correct representation of the SnR data.

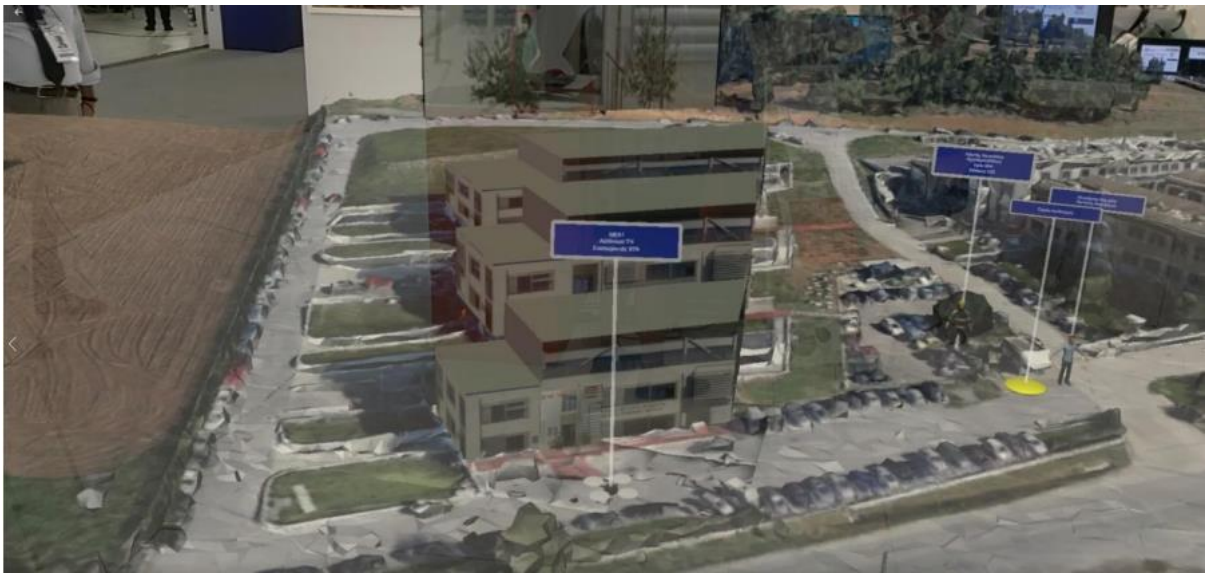

Figure 4-15: The 3D MR CC during a demonstration

4.2.12 Smart Glasses

Partner who provides the hardware component: SIMAVI

One of the newest breakthroughs on the market of wearable devices are the VR headsets and they are already starting to fill different needs into daily lives of people. But before explaining the use of a VR headset, a general explanatory paragraph about Virtual Reality (VR) is necessary.

Any computer-generated environment that allows the user to enter and interact with it by the means of technology can be considered virtual reality. The environment doesn't necessarily need to simulate 100% the reality but it needs to be able to create the illusion of an alternate reality where the user is able to take part. Because of this, VR can involve not only the 3D content but also sound, vibration or various other inputs and effects.

A virtual reality headset is special glass looking device that contains two heads-up displays, one for each eye that allows users to interact with digitally created environments and experience any type of activity in a first-person view. The user's view of the surrounding environment is replaced with virtual reality content containing videos, games or another 360-degree environment that immerse the user by allowing him/her to turn and look around, just as in the physical world. The main problem with older devices is the fact that those were not offering total freedom to the user as they were tethered hardware as well as being weighty and expensive. Today's VR headsets are lighter as they consist of a pair of goggles with smart phone hardware attached to it, which make them not only more portable, but also independent of the connection with other devices, being less expensive and more resistant. If the VR headset succeeds in providing total immersion with an experience that is so real to the user that he/she forgets about the headset, it succeeds its goal as a wearable device that can be used anywhere and under any circumstance.

From simple features like easily accessible screens with different information to more complex ones like fully immersive VR experiences for the user, VR headsets have become the perfect portable companion for any type of activity that will imply immersion or access to simulated environment. Giving users the possibility to experience simulated environment is of high importance to the "Search and Rescue" project where time and gathered information make the difference between life and death.

Figure 4-16: Oculus Quest 2

4.2.13 Rescue Robots & Autonomous Vehicles

Partner who provides the hardware component: DFKI

Robots can assist first responders in search and rescue operations. They can explore an area, reach dangerous locations inaccessible to Humans, create a spatial map of that area, take measurements at crucial locations and overall help first responders finding victims under rubble. They also offer utilities like extending network coverage, transporting items, providing lighting and lifting objects, if they are equipped with a robot arm.

Due to restrictions to the Use-Cases and other components, in the SnR project the robot usage will be limited to exploring an area (semi-)autonomously and measuring gas values with a mounted RESCUE MIMS unit on the **SeekurJr platform**. During the operation, a spatial map will be generated remotely in the control room, and all gas measurements will be inserted into the map. The map needs to be visualized on the control machine, which in return needs to be able to send goal commands to the robot for manual control.

Each component interface is structured around the main components of the S&R platform, which are the integration platform, the data lake ecosystem and COncORDE.

4.3 Software Components used within SnR use cases

4.3.1 COncORDE Platform

Partner who provides the software component: KT

COncORDE is a cloud-based platform, dedicated in Crisis management operations. This platform is assigned to enhance the S&R field operations with its EMS features, starting with the incident management service, the user management, among others.

S&R end-users will organize the Use Cases via the COncORDE platform. More specifically, when an incident occurs, the *High Commander*, a COncORDE role, will be assigned as the head of the operation. As a first step, he/she puts details on the occurring incident in the COncORDE platform and send requests for dispatch to other COncORDE users, such as the Field Commander, the EMS and PSAPs, as well as other first responders on the field. From that point on, the COncORDE users handle the EMS features provided by the platform. More information can be found in COncORDE's documentation [6].

In the section bellow, COncORDE's API specifications, its services and their data format are listed in detail, as D7.3 requests.

4.3.2 Situation awareness Modules

Partner who provides the software component: UBITECH

In the frame of S&R project, specific objectives need to be fulfilled by the SA model. In this context, the model aims to:

- Define the decisions that first responders (and other actors) make during the course of S&R operation.
- Represent the types of critical information required in order to support the various actors with their tasks.
- Represent the important information flows/correlations which potentially exist between involved actors, mediated by a knowledge management system in the form of notifications, alerts and timely information supply.

4.3.3 BIM based services and applications

Partner who provides the software component: UBITECH

The purpose of the BIM Ontology is to represent the main spatial topological elements of a building. This model, in combination with the SA model, acts as the core module within the semantic model web service, where knowledge-based information is manipulated and delivered in order for the first responders to have a clear view of the incident itself. The model is constructed as an extension of the **BOT ontology** that provides the vocabulary to describe the topology of a building as well as the relationships between their main components such as storey, zones, spaces, and building elements.

4.3.4 Sensor web services

Partner who provides the software component: MAG

The purpose of these web services is to extract useful information related to the events (records) produced by the sensors during their operation in SnR use cases. During their design, Maggioli created a questionnaire for end users in task 6.4, asking *what information from the sensors needed for each use case*. The final design of web services was proceeded according to their answers.

Maggioli also created a second questionnaire, this time for sensor providers, asking them to provide the *information each sensor sends to the data lake*. According to their answers and clarifications, in use cases of SnR, five "multiple sensors" will be involved, each containing more than one individual sensor. These multiple sensors are:

- Rescue kit for children

- Smart textile professional uniform
- Emergency response health condition monitoring device
- Six gas monitor
- Rescue MIMS chemical sensor

4.3.5 SOT DSS

Partner who provides the software component: KT

The SOT DSS is intended to support the end users regarding decision-making. For this reason, it provides an efficient resource allocation during an emergency situation as well as, the prediction of the casualties in an incident. The main role of the SOT DSS is to give fast and accurate recommendations of possible decisions to the end user, based on the incoming information. All these have been achieved with the design (D4.3 Design of SOT DSS) and development of four Services (D4.5 Development of SOT DSS) which will be referred to in next section.

4.3.6 Physio DSS

Partner who provides the software component: CNR

The PHYSIO DSS component is part of the S&R DSS and is responsible for providing modules, functions and algorithms, for the prediction of the evolution of the physiological status of the victims with the final goal of supporting an efficient real-time health resource allocation in the field and victim prioritization. The PHYSIO DSS, as part of the S&R DSS, is designed to address part of the objectives defined at the tactical decisional making level, providing information for the deployment of ambulance, treatments, and supporting a better triage and victim prioritization.

4.3.7 Volunteer application

Partners who provide the software component: CERTH/HIT (Front-End), KT (Back-end)

The Volunteer Application has been developed with the purpose of knowing the human resources availability in case of emergency. In the App any individual or organization can register to offer their help in any kind of disaster that may occur. Through the Command Center the App is going to inform the Command Officer with the total amount of volunteers available and use properly according with their skills and equipment.

Moreover, an emergency "RED BUTTON" has been implemented in the home page of the App for the volunteers to use in case they have an accident or they are in grave danger and call for additional aid. More details will be released in the dedicated task of "D2.5 Citizens and volunteer organizations involvement in Crisis Management" at M30.

The volunteer app will also include an option for information and routing of civilians (end-users). This will happen through an independent branch that will be provided in the registration process ("civil/not volunteer" option). Based on this differentiation the volunteer app will be able to direct civilians to respective information and routing recommendations based on guidance provided from the Operations Centre by using simple and clear messages to avoid complexity and confusion.

This app has been developed from CERTH for the front-end needs and KT for the back-end, given the required instructions from EPAYPS (as task leader of T5.2). In D7.3, the back-end specifications will be highlighted, in order to provide the appropriate information on how the volunteer's app functions.

4.3.8 e-learning based platform

Partner who provides the software component: CERTH/HIT

The role of the e-learning platform is to enhance participants' understanding, knowledge and skills in terms of safety and security management at operational and strategic levels. The users will be better

prepared for field operations also act as security advisors within a response team providing them with the knowledge and skills to act appropriately according to the safety regulations.

4.3.9 Object detection algorithms for in-disaster-scene SA

Partner who provides the software component: THALIT

The object detection algorithms applied on autonomous vehicles and rescue robots are a set of algorithms developed for the collision detection. This is done by using and fusing information coming from the sensors equipped on the robot. These algorithms have been integrated in a system (**ODS**) which has the following objectives:

- Detection of obstacles using data coming from different sensors;
- Tracking of obstacles by fusing information obtained in the previous step;
- Notification of potential collisions with detected objects to the robot pilot.
- Thus, in the SnR context, the system will implement the following functionalities:
- Acquire, filter and process Camera and LiDAR raw data;
- Detect obstacles in the front of the robot using detection algorithms on processed data;
- Fuse the detections using a Sensor Fusion Algorithm (SFA) to track the obstacles;
- Provide alarms to notify the pilot of obstacle presence.

Different algorithms have been implemented in order to process data coming from different types of sensors. In particular:

- LiDAR raw data (Cartesian coordinates) is geometrically transformed to be represented in the robot reference system and is aggregated using a clustering algorithm;
- Camera raw data, i.e., video frames, will be processed by a Convolutional Neural Network (CNN). The CNN will detect object on these frames and will output Bounding Boxes (BBs) enclosing detected objects. Moreover, thanks to depth estimation, BBs will be represented on the robot reference system.

These detections are later fused by the **SFA** using Global Nearest Neighbour (**GNN**) and Joint Probabilistic Data Association (**JPDA**) algorithms.

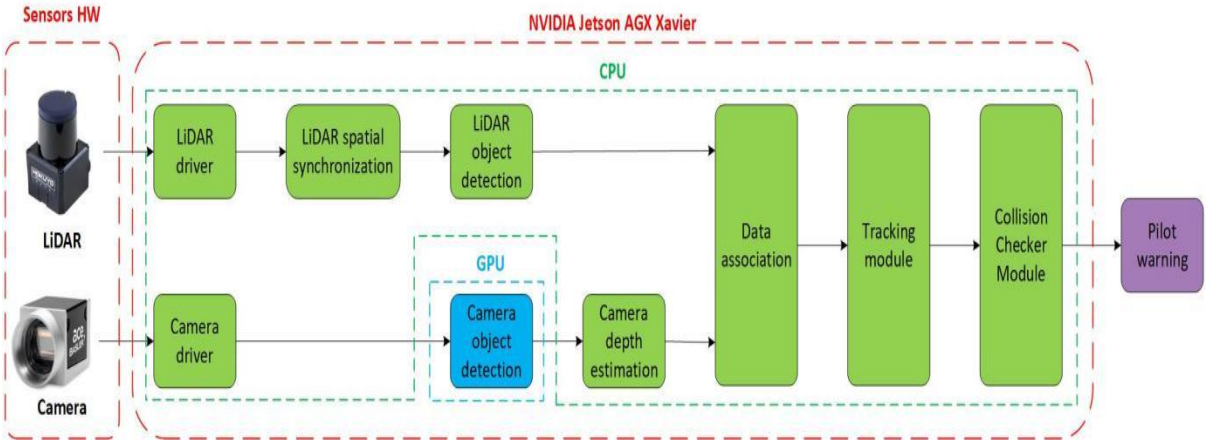

Figure 4-17: ODS block diagram

The Obstacle Detection System is based on the Robot Operating System (**ROS**) framework, which allows an easy inter-process communication. Thanks to ROS, each functional block can be modelled as separate application which can communicate with the other modules using ROS messages.

ODS runs in the NVIDIA Jetson AGX Xavier board with a Linux-based OS installed. This board features:

- CPU: 8-core ARM v8.2 (x64) @2.26 GHz, 8MB L2 + 4MB L3;
- GPU: 512-core Volta GPU @1.37 GHz with Tensor Cores;
- RAM: 32GB 256-Bit LPDDR4x (137 GBps).

4.3.10 Object detection algorithms applied on UAV imagery

Partner who provides the software component: AIDEAS

For search and rescue operations, AiDEAS will enhance drones with AI features based on deep learning detection algorithms. AiDEAS will be in charge of developing AI-powered analytics to increase situational awareness in a disaster scene (e.g., detecting persons, smoke), as well as boost readiness and improve the ability to respond in the event of cascade failures.

4.4 Conclusion

To conclude with, the SnR interoperability framework was designed and implemented by considering the EIY (European Interoperability Framework) principles.

The above hardware technologies generated data from the field operations, this data was consumed by the the Apache Kafka Topics, in order to get stored and aggregated by the Data Lake Ecosystem directories. In addition, the all-incoming data turned into a homogeneous format, in order to extract valuable information to the first responders. This approach allowed the system to be interoperable, in terms that the software components were consuming incoming information from the field in real-time. The approach is illustrated in figure 4.2.

As a result, in case there was a new hardware technology on the field, the SnR System could consume its data to its services. In order to do this, the hardware technology provides must share the specifications of their technology, follow the SnR Data model and integrate to the system.

To sum up, SnR Interoperability framework managed to combine over 12 technologies to a common platform with multiple users and as a result, the SnR operations were richer on field information, as well in better decision making.

*More details on the SnR Interoperability framework can be found in D7.3, D7.4 and D6.4.

5 Common Vision

The new **European Interoperability Framework (EIF)** that was adopted on 23 March 2017, aims to the creation of a single digital market in Europe for public sector, businesses and citizens[5]. Before attempting to provide an analysis on the EU Common Vision on Interoperability and how it can affect Search and Rescue missions, we need to provide a definition of the term "interoperability" and the EIF.

According to EIF, **Interoperability** is "*the ability of organisations to interact towards mutually beneficial goals, involving the sharing of information and knowledge between these organisations, through the business processes they support, by means of the exchange of data between their ICT systems".* Additionally, The **European interoperability framework** is "*a commonly agreed approach to the delivery of European public services in an interoperable manner. It defines basic interoperability guidelines in the form of common principles, models and recommendations*"[6] (see Figure 5-1).

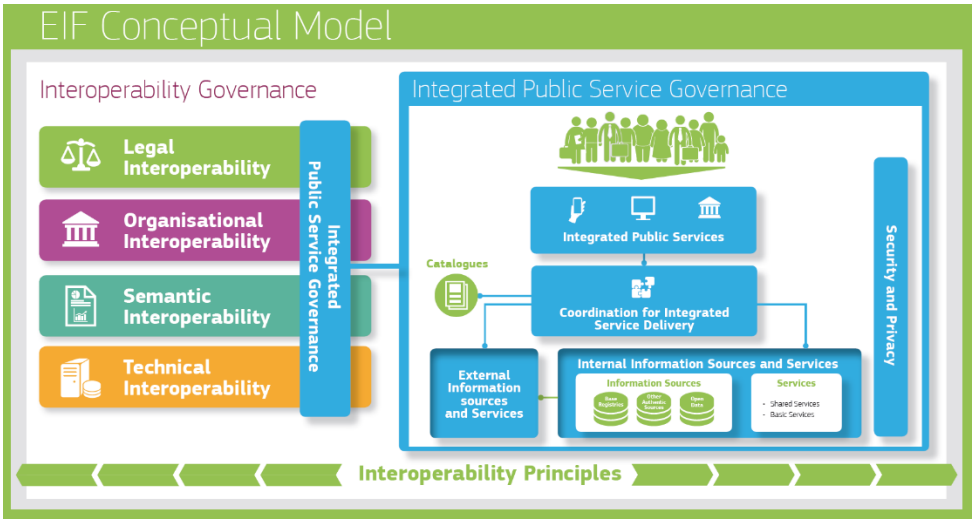

Figure 5-1: EIF Conceptual Model [7]

Moreover, the overall goal of EIF can be summarized as follows:

- To remove barriers between services, IT systems and data
- To support the development of open and commons standards in order to create meaningful connections

Furthermore, the SnR project aims to develop a highly interoperable platform for first responders and to support the unified vision of EU role. In terms of search and rescue operations, the EU role is expressed through the EU Civil Protection Mechanism (EU CPM) and the creation of the RescEU reserve. Thus, the SnR platform will potentially require to be operated in the framework of the EU CPM and the interoperability framework of the platform will be required to support the interconnection across EU and the RescEU mechanism. Therefore, we also need to provide a short presentation of the EU CPM and the RescEU mechanism explaining the importance of the interoperability of the SnR platform in such an environment and how it can function towards a common EU vision.

The European Commission with the EU Civil Protection Mechanism and rescEU provid help and assistance to rescue citizens after a natural disaster (earthquake, forest fires, floods etc...), medical issue or HAZMAT incident. This assistance is deployed with teams of rescuers and specialist, logistics, and coordination. The project SEARCH AND RESCUE and the new technologies could support the effort of the rescEU mechanism through new equipement and tools for the coordination of the

[5] https://ec.europa.eu/isa2/eif_en
[6] https://ec.europa.eu/isa2/sites/default/files/eif_brochure_final.pdf
[7] https://ec.europa.eu/isa2/eif_en

operations. The uniform connected, or sensors and drones, will be a very important support with new technologies for rescuers and can make relief operations easier and more efficient.

According to the EU CPM website, "*the overall objective of the **EU Civil Protection Mechanism (EU CPM)** is to strengthen cooperation between the EU Member States and 6 Participating States in the field of civil protection, with a view to improve prevention, preparedness and response to disasters*"[8]. In simpler terms, it is an EU mechanism that supports a country in need to request for assistance when the scale of an emergency exceeds its response capabilities.

Disaster sees no borders and there are cases where the capabilities of a single country cannot meet the challenges of a crisis. This is the reason behind the importance of EU CPM, which promotes the collective action during a major crisis and allows all members states to have support when managing a major event and have access to expertise from various countries, to provide a more efficient and coherent response.

Furthermore, the mechanism supports the exchange of lessons learned among experts, promoting at the same time a common approach and understanding when managing a major crisis.

In the Figure 5-2, there is a representation of how the EU CPM works.

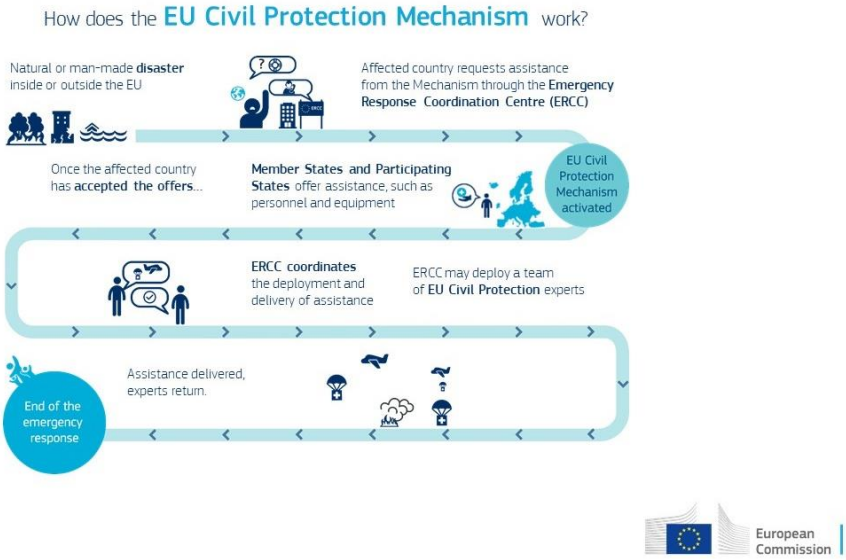

Figure 5-2: How EU CMP works[9]

As shown in the figure, in order for the EU CPM to be activated, the affected country needs to request assistance through the **Emergency Response Coordination Centre (ERCC)**.

Moreover, in March 2019, EU upgraded and enhanced its Civil Protection Mechanism by creating the **RescEU reserve** (DECISION (EU) 2019/420)[10], which initially was a fleet of airplanes and helicopters to support fighting forest fires, but in time it transformed to address other threats as well[11].

It is worth mentioning that in 2018, President of EC at the time, Jean-Claude Juncker said, *"A Europe that protects citizens has to be there in times of need. When there is a dangerous forest fire or a flood overwhelming national response, our citizens want action not words. RescEU will ensure concrete solidarity with our Member States hit by disasters."* [12].

[8] https://ec.europa.eu/echo/what/civil-protection/mechanism_en#
[9] https://ec.europa.eu/echo/what/civil-protection/mechanism_en#
[10] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32019D0420&from=EN
[11] https://ec.europa.eu/echo/what/civil-protection/resceu_en
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It is easily to understand from the above, that the importance of interoperability in Crisis Management systems is very high. Since the view and the intent of EU is for member states to be able to support each other, especially though the EU CPM and RescEU mechanism, for that to be feasible and productive, different organisation from different states that work with different systems need to communicate and to exchange and combine various kinds of information.

The Technical Interoperability, as shown in figure 5-2, is the key to that, since it will allow different systems to interconnect, supporting at the same time different first responder organisations to work together, increasing the level of efficiency when managing a major crisis, promoting at the same time the overall vision of EU for a unified community.

Driven by the EIF, the Project designed and implemented it technical interoperability considering the 12 principles, as follows:

- Subsidiarity and Proportionality: The technical framework was designed based on the Use Leader's requirements, in order to implement platform close to the end-users needs (e.g firefighters, volunteers (citizens))
- Openness: Open data can be found on the final SnR Platform instance, as well as in the lessons learned mechanism (T6.5). These open refer to e.g chemical measurements from the field during the use case scenarios. Taken into consideration the protection of personal data, health information will not be shared to the final open data. Public datasets will be released in the following months, in order to be reused as historical data. Finally, the developed components (e.g. Data Lake Ecosystem) will be available in GIT Repositories, as open-source instances.
- Transparency: The technical interoperability ensured the availability of interfaces to the available SnR Systems (e.g hardware, software), in order to finally be integrated to a common solution, as one, the SnR Platform. Driven by WP2, the platform secured the protection of personal data by following anonymization techniques
- Re-usability: The SnR Interoperability Framework enabled the sharing and reuse of IT solutions (e.g. Data Lake Ecosystem, Object detection Algorithm, among others) in order to be adopted by new search and rescue operations. Since, the project itself have a strong dependence on the hardware technologies (e.g. rescue mims, smartwatch, etc), the interoperability framework has been designed and implemented in a way that the external users could use the IT services with new (but similar) hardware technologies. The same approach was followed for the appliance of the technological neutrality and data portability
- User-Centricity: The framework was designed and implemented driven by the seven Use Case Scenarios, meaning different end-users with different needs depending their nation. For this reason, the project collected the end-user feedback, in order to highlight the common end-users, need during these operations. This approach was followed to improve the existing developed solutions and lead to the final solution as a whole, the SnR Platform
- Inclusion and Accessibility: These principles were addressed by demonstrating to all the project groups (e.g technical partners, end-users, Use Case users) the interoperable framework, divide the Use Case roles to specific Platform roles (e.g High Commander, Field Commander, EMS Rescuers, etc), in order to take advantage all the project's outcome. The Platform has orchestrated more than 400 people on the field, during the use case scenarios
- Security and Privacy: The framework adopted encryption techniques, user authentication mechanisms, as well as dedicated certificates with the aim of securing the whole system and provide trust to the end-users
- Multilingualism: This principle has not officially delivered by the framework, however by adopting specific packages in the front-end development of the platform, the project can easily enable the multilingualism, if asked
- Administrative Simplification: The framework (dedicated IT solutions) is enabled to a common repository and on the cloud, in order to be easily accessible and used as a European Public Service. Moreover, there is a public training material (e.g e-learning platform) which helps the new users to understand how they can use the platform and its services
- Preservation of Information: The Data Lake Ecosystem stored and processed all the available data coming from the UC scenarios. In addition, the component ensure the data protection by

enabling security mechanism, create back-ups, in order to facilitate the long-term accessibility and the security of the framework's outcomes

- Assessment of effectiveness and efficiency: All the technological solutions were evaluated in all the seven use cases, in order to ensure their efficiency during the operation, as well as public services in a real-life scenario. Moreover, evaluation of the technologies was also provided in WP8 (e.g. technologies KPIs), with the aim of inspecting their actual usefulness

As a result, the EIF's principles were adapted into the design and the development of the SnR Interoperability Platform, with the aim of delivering public services to be further used by the European Union, in case of a crisis management operation. In the following months, public instances will be available in the Project's website (e.g. guidelines, IT solutions, demonstrators).

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Annex II: Standard Operating Procedures Questionnaires

Standard Operating Procedures (SOP)	
Column Requested Information	**Explanation/Fill in Guidance**
Organization:	**Please include your organization's name**
Website:	**Please include your organization's web address**
Disaster expertise:	**Please indicate as many as relevant**
Country:	**Please indicate your country of origin**
Current State:	**Please briefly reply if you have standard operating procedures**
Do you have a SOP? If yes, please indicate the start date:	**Please indicate your Standard Operating Procedures and the start date**
Compliance/Condition Status:	**Please indicate the status**
Identified Gaps:	**Please briefly list the major identified gaps**
A. PREPAREDNESS	
A1. Training / Exercices	1) Do you have a training plan for your team?
	2) Do you organise simulation exercices? If yes, how many and under which topics?
	3) Are there any sessions organised in order to analyse the lessons learnt?
	4) Is there any public information from you side?
A2. Management	1) Do you have any particular information about the operational management of the team members?
	2) Do you have any particular information for safety and security of the team?
	3) Is there any collaboration between your team and the National, European or International Authorities?
A3. Search	1) Do you use K9 research activities and/or techniques?
	2) Does the K9 team share information with the other members of the team?
	3) Are all the transport documentations for the dogs updated?
A4. Rescue	1) What is your rescue method in case of a disaster?
	2) Is the training of your rescue team common with the other parts (medical, USAR, K9)?
A5. Medical	1) Do you use a monitoring system for the vaccination of your team?
	2) What is your medical system?

	3) Do you have a list of the necessary medical equipment for the transportation?
A6. Logistics	1) What is the way of maintenance of your equipment?
	2) Is your team autonomous enough to go for a mission?
	3) What are the gaps of your team in relation to the logistics?
	4) What is the usual procedure of transport for an immediate deployment?
B. MOBILISATION	
B1. Management	1) Do you have a real-time monitoring system for disasters?
	2) Do you organise a briefing for the team before the deployment?
B2. Search	1) How can you ensure that your K9 team is ready for the deployment (health, hygiene…) and the whole trip?
B3. Rescue	1) Do you have a procedure to check the documentation concerning the materials to be transported?
B4. Medical	1) Do you have official documents related to the practices of the medicine?
	2) Do you check the medical status of the personnel and dogs participating in the mission?
	3) Does the medical team follow up on hazardous materials?
B5. Logistics	1) Is the team able to prepare its own transportation plan (road, air ...)?
	2) Is there any preparation by the team regarding the transport of passengers and hazardous materials including the equipment?
C. OPERATIONS	
C1. Management	1) Does the management team coordinate with the local authorities in the disaster area?
	2) Is there a pace of work in the area (team rotation)?
	3) How does the team monitor the safety and security conditions?
C2. Search	1) In what procedures does the team assess the situation to locate the victims?
	2) How is the risk assessment carried out for the team during the research?
C3. Rescue	1) What is the procedure followed by the team for the evaluation of the situation in order to locate the victims?
	2) Is there a security perimeter established during the site operation?
	3) What are the capacities of the team to cut, pierce and extract a victim?
	4) How does the team conduct an assessment of the work site to define priorities?
	5) Is there any evacuation and regrouping point set up for the team safety during the search?
C4. Medical	1) Does the medical team permanently monitor the USAR team at work?
	2) What is the role of the medical team in taking care of the victims?
	3) Does the medical team advice the USAR team in the area of chemical hazards?
C5. Logistics	1) Is there a base of operations installed?
	2) How do USAR operations are monitored by the logistics team (equipment, food, water, etc.)?

D. DEMOBILISATION	
D1. Management	1) Is there a meeting organized by the team with the local authorities and the teams in charge of the coordination, before leaving the area?
	2) In international missions, is there a donation of equipment made to local teams?
	3) Is there a communication plan organised with the media before the disengagement?
D2. Search	1) Is there a transport preparation organised for the for K9 teams and equipment?
D3. Rescue	1) Is there a transport preparation organised for the for K9 teams and equipment?
D4. Medical	1) Does the medical team ensure an assessment of the local needs of medical structures before disengaging?
	2) Is there a donation of medical equipment made before the return?
	3) What monitoring has taken place in relation to the COVID risk?
D5. Logistics	1) Does the team take into account the transport of hazardous materials for the return?
	2) Is there a transport plan for the return of the team?
E. POST-MISSION	
E1. Management	1) Does each part of the team prepare a mission report?
	2) Is there a document «lessons to learn» prepared?
E2. Search	1) Does each part of the team prepare a mission report?
	2) Is there a document «lessons to learn» prepared?
E3. Rescue	1) Does each part of the team prepare a mission report?
	2) Is there a document «lessons to learn» prepared?
E4. Medical	1) What medical and psychological monitoring system for team members is being used?
	2) Does the team prepare a mission report?
E5. Logistics	1) Is there a plan for restoring equipment and preparing for a new mission?
	2) Does the team prepare a mission report?