ASSISTANCE

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

European Commission

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

ASSISTANCE

Nowadays different FRs organizations cooperate together facing large and complex disasters, that in some cases can be amplified due to new threats such as, the climate change in case of natural disasters (e.g. big floods, large wild fires, etc) or the increase of radicalization in case of man-made disasters (e.g. arsonist that burn European forest, big combined terrorist attacks in European cities).

The impact of these kinds of large disasters could have disastrous consequences for the European Member States' regions and social wellbeing in general. On the other hand, each type of FRs organizations (e.g. medical emergency services, firefighters' departments, law enforcement teams, civil protection professionals, etc.) that work mitigating these kinds of events are exposed to unexpected dangers or new threats that can severely affect their personal integrity.

Taking into account these facts, ASSISTANCE proposes a holistic solution that will adapt a well-tested SA application as a core of a wider SA platform, capable of offering different configuration modes for providing the tailored information outcome needed by each FR organization, while they work together mitigating the disaster (e.g. real time video and resources location for firefighters, evacuation routes status for emergency health services and so on).

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

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

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Disclaimer

Executive Summary

This document is summary of the state of the art study done to support the ongoing work in the ASSISTANCE project. The content consists of a desk research performed by the project consortium partners experienced in specific areas focusing on technologies that are improved or developed in ASSISTANCE. The desk research is combined with the results of the questionnaire response provided by the end users.

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Acronyms

ASSISTANCE	Adapted situation awareneSS tools and tallored training curricula for increaSing capabiliTie and enhANcing the proteCtion of first respondErs
PC	Project Coordinator
D#.#	Deliverable number #.# (D1.1 deliverable 1 of work package 1)
DoA	Description of Action of the project
EC	European Commission
EU	European Union
GA	Grant Agreement
H2020	Horizon 2020 Programme for Research and Innovation
IPR	Intellectual Property Rights
M#	#th month of the project (M1=May 2017)
WP	Work Package
IPR	Intellectual Property Rights
PSC	Project Steering Committee
PIC	Project Implementation Committee
PSB	Project Security Board
AB	Advisory Board
TL	Task Leader
WPL	Work Package Leader
VR	Virtual Reality
VTE	Virtual Training Environment
SA	Situation Awareness
TGM	Trail Guidance Methodology
FR	First Responder
EOD	Explosive Ordinance Disposal
CEOD	Counter Explosive Ordinance Disposal
CBRNE	Chemical Biological Radiological Nuclear Explosive
UGV	Unmanned Ground Vehicle
USV	Unmanned Surface Vehicle
UUV	Unmanned Underwater Vehicle
UAV	Unmanned Aerial Vehicle
ISO	International Organization for Standardization
HDR	High Dynamic Range
EV	Exposure Value
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
RTK	Real-Time Kinematic
PPK	Post Processing Kinematic
RGB	Red Green Blue
FoV/FOV	Field of View

IoT	Internet of Things
C2	Command and Control
GIS	Geographic Information System
UWB	Ultra Wide Band

1. Introduction

This document is a summary of the state of the art study done to support the ongoing work in the ASSISTANCE project. It describes work performed in Task 2.1. The content consists of a desk research performed by the project consortium partners experienced in specific areas focusing on technologies that are improved or developed in ASSISTANCE. The desk research is combined with the results of the questionnaire response provided by the end users.

1.1. Methodology

This study was performed using the following steps:

1. The project proposal was analysed, focusing on proposed scenarios, technologies, key performance indicators and initial questionnaire that was used to formulate the proposal itself. This step produced a list of technologies/problems that ASSISTANCE project is trying to improve/solve.
2. Based on the list from step 1, a list of chapters was constructed, which was consulted with the entire consortium (including technical partners involved in this study and the end users). This way a refined chapters list has been produced. Those chapters were assigned to partners specialised in the given area.
3. A questionnaire's draft was prepared based on previous steps. The focus was put on two questions:
   a. Which type of technology do you use currently in your operations?
   b. Which type of available technology you know about and would like to test/use in your operations?

   The questions came with the lists of technologies that are interesting for the scope of the ASSISTANCE project, and some suggestions on the format of answers that can be used for analysis.
4. The questionnaire draft was consulted within the consortium. Some changes were made based on that consultations.
   It was also decided that this will be a standalone questionnaire (not directly connected to the similar one prepared in WP6), as the questionnaire used in this study was much more complex, focusing on details of specific technology.
   At this stage it was also decided that there will be two variants of the questionnaire: document based and web based, to enable more end users to fill it as convenient for them. The web based version was done using limesurvey[2], as it allowed to create a complex questionnaire and had good terms of service (mostly connected to data retention).
   At this stage it was also confirmed that questionnaire will not collect any personal data and the results will be gathered as anonymous.
   The questionnaire was send to end users via the end-user partner organisations.

[2] https://www.limesurvey.org/

5. The chapters were gathered from project partners and integrated in two integration/review cycles.
6. The questionnaire results were gathered and analysed.
7. The conclusions to this document were written and discussed with all partners of the consortium.

2. General overview of current trends in research on technologies supporting situational awareness

Awareness of the situation prevailing during the rescue operations is of an extraordinary significance in terms of both protecting the life of rescuers as well as efficiency and effectiveness of the operation. In order to increase it, one can use technical means, through developed and constantly improved procedures. Projects concerning the methods of increasing situational awareness are presented in chapter 6 of this study. The technical elements that raise situational awareness include the following:

- robots and drones,
- all kinds of wearable sensors,
- cameras,
- thermal imaging cameras,
- portable devices for communication and / or displaying video.

Each of the above can be used in a variety of ways. A good example of this could be the EU EASeR [3]project. Its focus is on limiting the impact of the "barrier effect" on the rescue operation being carried out. The barrier effect results from poor recognition of the affected area and causes difficulties in getting to the place of action. The barrier effect usually lasts about one day. As part of the EASeR project, it was proposed to use drones for the initial recognition of the car's route, in order to locate the elements of damaged and impassable roads.

Because the commanding officer of the rescue action is responsible for the decisions made and the people who take part in the operation, he needs a wide range of information on the disposed rescuers. Communication through the radio stations does not give full information and is extremely time-consuming, especially with a significant number of rescuers. At this point, it seems that wearable sensors can greatly help to coordinate the rescue operations in making informed and adequate decisions. Wearable devices can provide information such as:

- location of the rescuer,
- registration of the body temperature of the rescuer and the environment,
- detection of toxic substances,
- registration of sweating,
- measurement of the heart rate.

Such devices can give the emergency coordinators information about:

- level of fatigue in individual rescuers,
- entry of a rescuer into a hazardous area / threatened by harmful substances,

[3] https://www.easerproject.eu/

- the position of an unsafe rescuer.

Information from sensors is very important for commanding rescuers, as it allows to better organise the rescue operation. The main problem in this solution is to provide communication between individual sensors / rescuers and the main command point. This problem can be solved by the group of drones working in the swarm. A group of identical devices with appropriate transmitters and receivers cooperating together would allow the creation of a network and live preview of the vital functions of the rescuers. An example of using a drone swarm to provide communication during a rescue operation was presented in a project called "UAV swarms for emergency response"[4,5]. The authors of the project emphasise that in a crisis situation, there is often no access to a stable and reliable network. Project authors aim to provide the following functionalities using a drone swarm:

- Short-range high-bandwidth network,
- Long-range low-bandwidth network,
- Network coverage optimisation algorithm,
- Collision avoidance and GPS navigation,
- Point-cloud sensors (stereo or laser),
- HD cameras on gimbal.

The test structure of the above system is shown in the Figure 1 and consists of 5 drones (DJI Matrice100 and 4 3DR Solos), which have Buzz software for managing the swarm of drones.

[4] https://mistlab.ca/projects/
[5] https://github.com/MISTLab

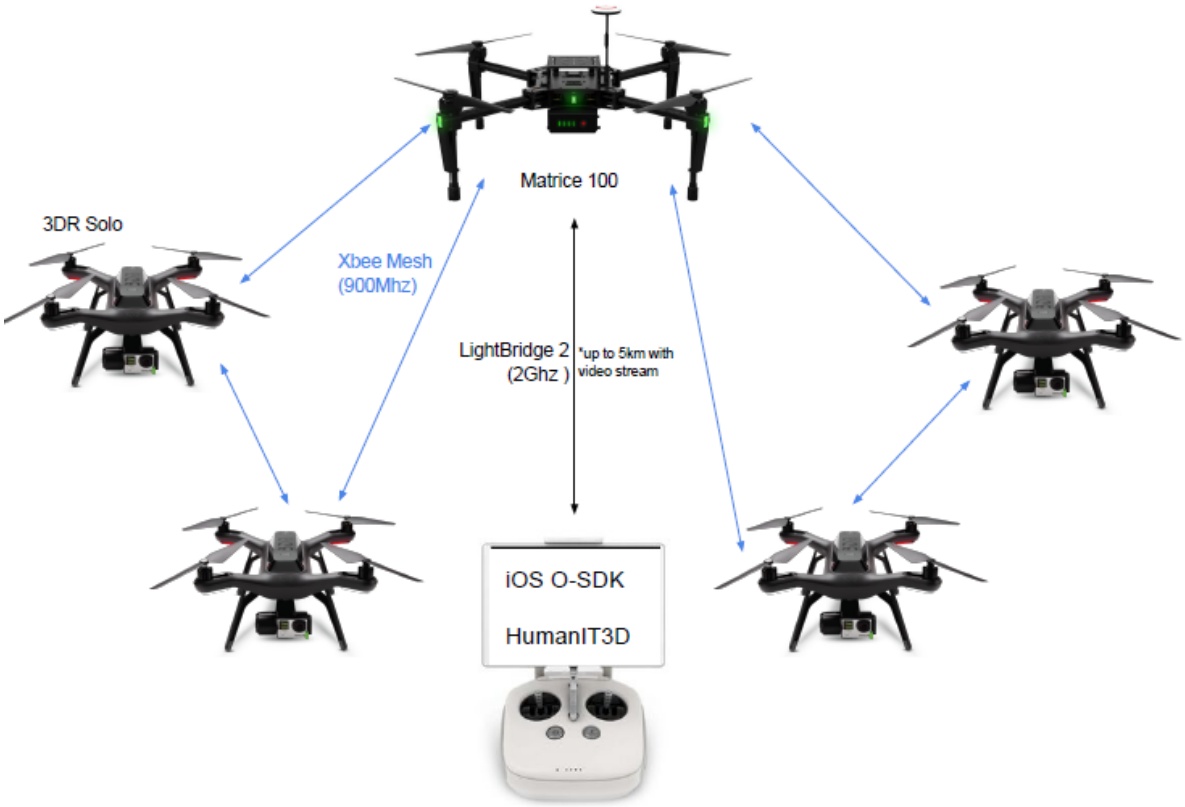

Figure 1 Hardware system swarm of drone[6].

Another system that raises awareness of the situation is the system proposed and introduced by the Data-Smart City Solutions[7,8]. The Situational Awareness Tool built for the City's Office of Emergency Management merges many disparate pieces of information into a single dashboard, enhancing OEM's decision-making abilities. The system allows City's Office of Emergency Management to quickly and effectively assess the current and potential impacts of an emergency or special event on the community and the day-to-day operations of the city. The system integrates and visualises various data combined of all these data sources into a one single view, providing OEM with the ability to turn various data points into actionable information.

Data sets offered by the system:

- Computer-Aided Dispatch (911 calls),
- 311 calls (non-emergency citizen reports),
- Xcel power outages (Denver's energy utility provider),
- Special Event Data,
- Stream Gauge Levels,

[6] https://www.researchgate.net/profile/David_St-Onge/publication/311204206/inline/jsViewer/583f0bc308ae8e63e618237a
[7] https://datasmart.ash.harvard.edu/solutions/situational-awareness-tool
[8] https://datasmart.ash.harvard.edu/news/article/data-driven-emergency-response-learning-from-hurricanes-harvey-and-irma-113?fbclid=IwAR30SYdkS2NOQnjDxJnApR1qqifsF7LeYK0SXahoYfWtvjv-5zrBDJUucCQ

- Rain Levels Gauge,
- Traffic Weather Critical Facilities,
- Basemap Data.

In the case of such a large amount of data, there may be a "data overload" that can be overwhelming for commanders and it seems necessary to use special algorithms to filter the information. A description of such information filtering is described in Johnson, D., Zagorecki, A., Gelman, J.M. and Comfort, L. K. "Improved Situational Awareness in Crisis Management through Automatic Data Analysis and Modeling"[9].

Another interesting solution to the problem of data collection is the use of social media for this purpose, such as Twitter. The use of social media can help in informing and collecting information from the civilian population about safe places, drinking water quality, gathering places for evacuation, places with active access to electricity, water, etc. Such use is described in Mark A. Cameron, Robert Power, Bella Robinson, Jie Yin "Emergency Situation Awareness from Twitter for Crisis Management"[10]. The system described has been configured to search for relevant Tweets from Australia and New Zealand, sorted them for usability and sent them to the checking officer. The authors of the publication pointed to the fact that information can't replace the existing procedures and sources of information, but can be a new source of data that has many potential applications in crisis management and crisis coordination.

In addition to the technical possibilities of raising the awareness of rescuers' situation, attention should also be paid to the procedural aspect. Development and handling of specific procedures and guidelines can greatly improve the rescue action, preventing chaos and disorganisation. However, in order to naturally introduce the proper procedures by the rescuers during the operation, it is necessary for them to carry out numerous field exercises. The organisation of field exercises, especially for a large number of participants, is logistically complex and expensive. To address these problems the training methods offered by virtual reality (VR) can be applied. They allow to carry out many training scenarios allowing to modelling of:

- various atmospheric conditions (rain, snow, etc.),
- various terrain (mountains, river valleys, etc.),
- use of various equipment (e.g. to learn different methods of application).

Currently, there is a lot of interest in VR technologies by emergency services. The main application of VR can be observed especially in medicine[11,12], but there are also platforms

[9] Johnson, D., Zagorecki, A., Gelman, J. M., & Comfort, L. K. (2011). Improved Situational Awareness in Emergency Management through Automated Data Analysis and Modeling. Journal of Homeland Security and Emergency Management, 8(1). doi:10.2202/1547-7355.1873

[10] Mark A. Cameron, Robert Power, Bella Robinson, Jie Yin "Emergency Situation Awareness from Twitter for Crisis Management" WWW 2012 – SWDM'12 Workshop April 16 p.695-698

[11] George Koutitas, Kenneth Scott, Smith Grayson, Lawrence Vangelis, Metsis Clayton, Stamper Mark Trahan, Ted Lehr "A virtual and augmented reality platform for the training of first responders of the ambulance bus" PETRA '19 Proceedings of the 12th ACM International Conference on PErvasive Technologies Related to Assistive Environments Pages 299-302

[12] Jillian L. McGrath, Jeffrey M. Taekman, Parvati Dev PhD, Douglas R. Danforth, Deepika Mohan, Nicholas Kman, Amanda Crichlow, William F. Bond "Using Virtual Reality Simulation Environments to Assess Competence for Emergency Medicine Learners"

dedicated to other emergency services[13,14]. In addition to the virtual reality adapted to the training of rescuers, there are also augmented reality (AR) technologies that can be used not only in training, but also during the real life operation. Augmented reality, consisting of combining virtual elements with the reality seen by the rescuer, can be helpful by displaying various types of information and messages concerning possible threats. In addition, it can allow to combine several views (eg. from a thermal imaging camera) allowing for easier and faster searching for people. An example of a similar application is presented below by Qwake Tech corporation as C-THRU [15]. It presents a system supporting the firefighter's awareness in a highly smoky environment through the use of displays mounted in the helmet, and a thermal camera. Figure below shows schematic view of the system (Figure 2) and example of it performance (Figure 3) :

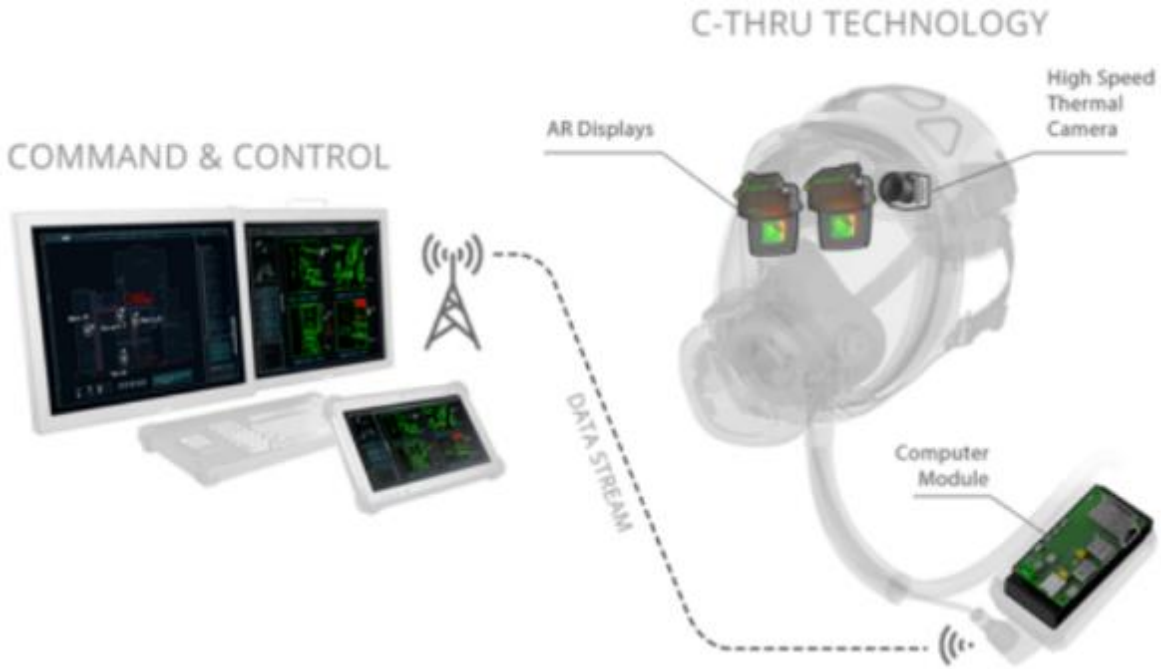

Figure 2 Schematic view of C-Thru technology

[13] Michael N. Louka, Claudio Balducelli „ Virtual reality tools for emergency operation support and training"

[14] Li Yang, Yu Liang, Dalei Wu, Jim Gault „Train and Equip Firefighters with Cognitive Virtual and Augmented Reality", 2018 IEEE 4th International Conference on Collaboration and Internet Computing (CIC)

[15] https://www.qwake.tech/#about

Figure 3 Comparison of views without C-Thru (left), with C-Thru (right)[15]

As seen in Figure 3 this system can be of siginificant help for Firefighters as an awareness tool in a smoky environment.

3. Available training platforms

This chapter describes state of the art in training platforms that are available or in use currently.

3.1. VR platforms

3.1.1. UPVLC Virtual, Mixed and Augmented reality platform

UPVLC Virtual Training Environment

A Virtual Training Environment (VTE) is a computer-based simulated environment where users interact through avatars and intelligent agents. The current applications go beyond merely entertaining purposes as they have become a powerful tool to enhance the capabilities of real world applications and have been widely used for training and learning in different areas, including military units; vehicle driving and flight simulators. Trainees can learn and practice how to perform tasks while working toward animated agents that can collaborate with human trainees in the virtual worlds. Furthermore, the capabilities of traditional virtual systems can be enhanced and extended if a hybrid system is implemented including data from real sources. In the case of crisis management, the use of virtual reality to create immersive training exercises for human beings allows personnel to operate with modern computer equipment; respond rapidly to unforeseen events in situations under stress, and to perform joint exercises with a significant reduction on costs and complexity. However, the interaction of real and virtual worlds with new standards (i.e., MPEG-V), allowing data streaming between both worlds and using commercial off-the shelf (COTS) equipment, has not yet been exploited and means going a step further in the state of the art.

Types of training offered by the UPVLC VTE

This platform currently is used for training the Valencia fire department members for managing virtual scenarios based on potential real situations suggested by this FRs. The system has also been used by the Centre of Excellence (COE) Counter Improvised Explosive Device (CIED) for training on IED detection and deactivation. This platform allows to train different units and commanders in lab (virtual training), but it also offers the possibility of training real units deployed in field along with virtual units managed from the lab.

The UPVLC VTE is a composed by a situation awareness tool integrated with a virtual environment. Through this tool the decision makers could be trained in complex virtual scenarios in which the coordination of large number of units, the decision-making process, along with a quick response to events/changes in the situation are critical. This tool will be potentially capable of using multiple simulation engines to simulate various technical, physical or social phenomena. The decisions taken by trainees will have impact on the dynamics of events simulated by simulation engines, but these engines will be also capable to run in no-wait mode, where results of lack of decision or late decision can be also simulated. This tool is capable to offer mixed reality training and virtual training depending on the FRs needs.

Mixed-reality training

Many times training a large number of FR units deployed in the field in large-scale exercises or threat management simulations is very expensive in terms of economy and logistics. These kinds of exercises involve several agencies consisting mainly of first responders (e.g. fire brigades and police units), including a large deployment of vehicles and equipment. For this reason, these large and complex training exercises can be performed only once or twice a year as a maximum.

For covering this clear training gap stated by some of the end users participant in the consortium, ASSISTANCE proposes a mixed-reality training tool. Through this tool a large number of units (including brigade members and decision makers for agencies from different countries) will be able to train virtually with a reduced number of real units deployed on the field playing the same scenario.

Figure 4 Mixed reality training environment

Figure 4 shows a representation of this mixed-reality environment where a large number of units in lab manages their own avatars and virtual vehicles and/or devices to train together with a reduced number of real units deployed in the field using their real sensors and devices. In addition, decision makers will be able to train operation coordination in the same scenario.

On-field units will be seen as avatars by in-lab training units and the avatars managed by the units in the lab will be represented through augmented reality techniques in the on-field deployed units Head Mounted Displays (HMD). This way all units will be able to train large scale disaster scenario(s), coordinated manoeuvres of large number of units and so on several times over, with a significant reduction of costs.

Virtual training

Some of the parts of the training performed during ASSISTANCE will be done in an in-lab virtual training environment (VTE), where either individuals or cooperative teams will be able to face the specific game-based assessment and learning scenario(s) generated within this VTE, depending largely on the specific skill (set) that needs to be trained. An example of in-lab VTE can be seen in Figure 4, where first responder team along with an aircraft pilot held a joint virtual training session

This VTE will be based on a single virtual environment composed by different training tools, which could be used as a stand-alone solution or in an integrated way depending on the training performed. Its purpose is to train first responder commanders, fire brigades, police units and sanitary teams members and even aircraft pilots on operational and tactical levels.

UPVLC VTE description

The UPVLC VTE is based on an architecture designed for an interoperable system that allows the interconnection of real situation awareness systems, operating in the real world, with virtual world systems. Particularly, the inclusion of real sensors on the virtual side of the system and the access to virtual sensors from real command posts deployed in the operating field. Thus, users will be able to train in virtual environments with the same tools they would use during the real crisis mitigation.

An important consideration is the deployment of equipment on the field in the training area:

- Units act as mobile sensors and actuators in the mitigation of the simulated crisis, feeding the system with real data and responding to the orders of the crisis managers.
- In the real world these units are connected to the operative command centre through some communications system, such as a MESH network, 4G or a satellite terminal.
- Sensors deployed in the real world will be accessible from the virtual world and vice versa: the position and identifier of the units created and spread in the real world will be accessible from terminals of the command and control system unfolded in the virtual world.

The proposed architecture has three main components (see Fig. 3):

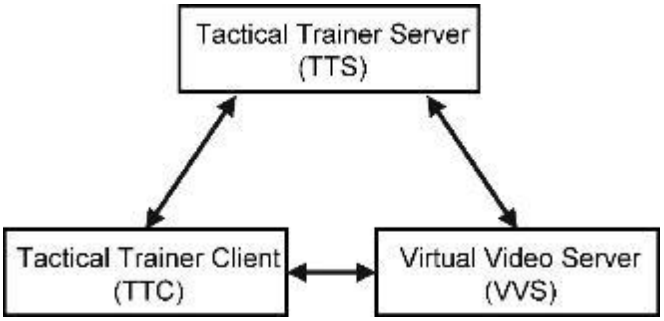

Figure 5 VTE architecture schema

- Tactical Trainer Server (TTS), where the global configuration of the system is set. It includes the virtual world server and the interconnection gateway, the key element to achieve interoperability between real and virtual worlds.

- Tactical Trainer Client (TTC), client subsystem used by the training nodes; includes both a command and control system of the real world and a virtual world client.
- Virtual Video Server (VVS), an innovative system for management, distribution and playback of video generated by the sensors involved in the operations field, from both real and virtual sources.

To achieve interoperability between real and virtual worlds, an interconnection gateway based in the MPEG-V standard has been developed. The main functionality of this gateway is to interconnect two systems (whether they are virtual worlds, command and control systems from the real world, or a combination of both), translate and adapt the relevant information following MPEG-V guidelines and map the adapted data between them. The gateway must be able to take the information from the source system, translate it into MPEG-V and then represent it properly in the target system. Communication is bidirectional. The location of the interconnection gateway in the C4ISR system for emergency training is shown in Fig. 4.

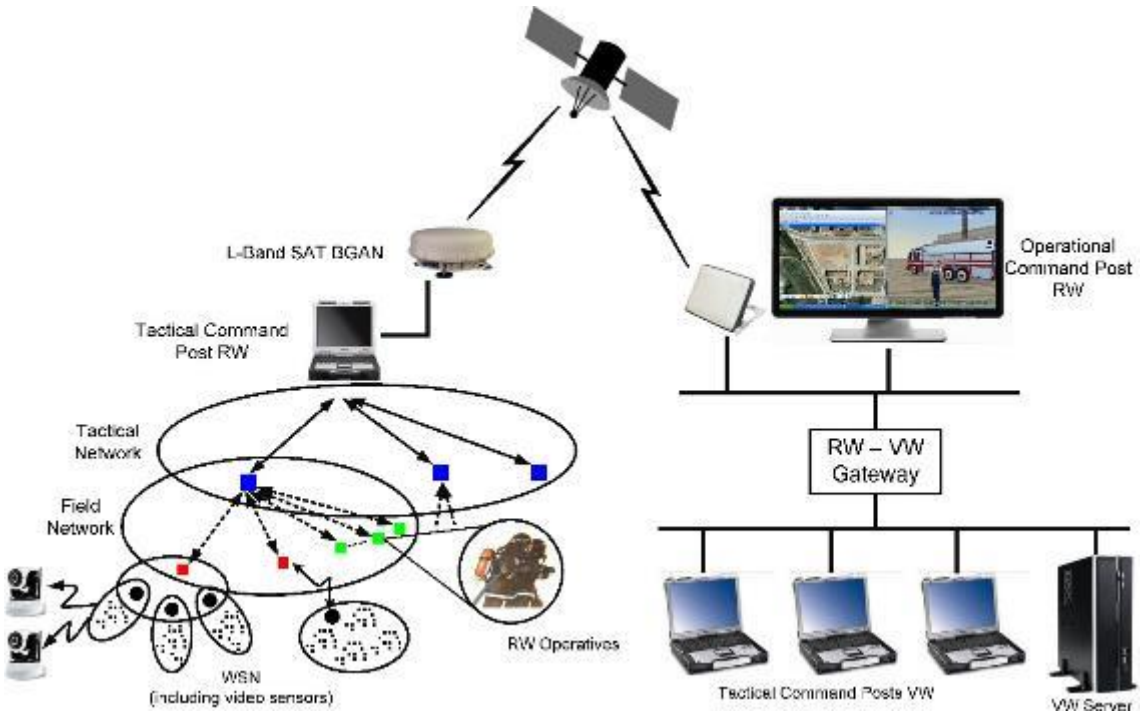

Figure 6 Location of the interconnection gateway.

The final result is a complete virtual/mixed training environment where different kind of FR can train together either using only virtual scenarios or adding real units deployed on field working with synthetic units managed by FR in the lab.

In the following figures different screenshots of the UPVLC VTE are shown:

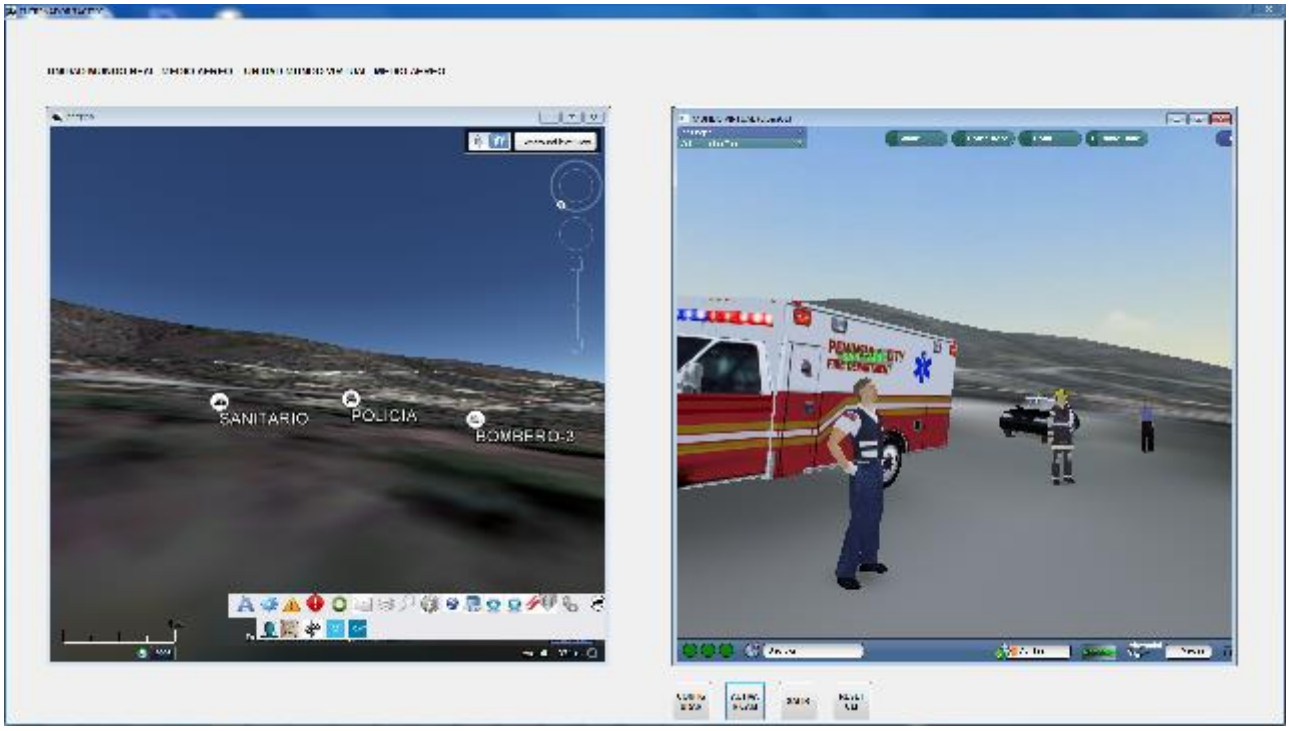

Figure 7 UPVLC Virtual reality training system

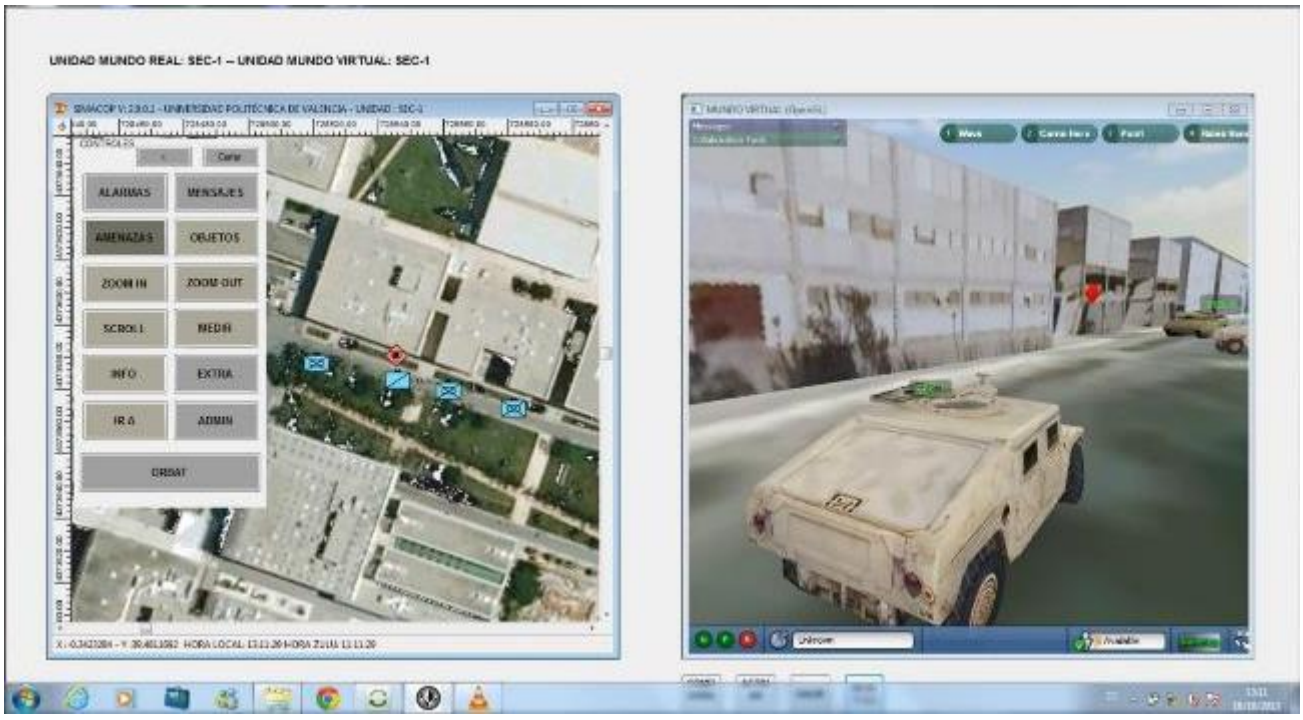

Figure 8 UPVLC Virtual reality training system

3.1.2. CNBOP Virtual reality courses for drones' pilots

CNBOP uses a subcontractor's platform, coming from the "Young scientists" programme. The platform allows to train different FR unit including their commanders. Scenarios can also include the usage of unmanned vehicles UV showing FRs' possible capabilities and threats of using this device in the field.

The "Young scientists" project concerned development of a virtual simulation system supporting training for leadership in the use of unmanned aerial vehicles. The project was placed in VBS3 application. After its development the system was tested by the CNBOP-PIB team composed of the fire-fighting as well as civilian specialists in the field of rescue operations, UAV's, Virtual Reality and research. The system testing proved that the basic components have been integrated with the actual requirements for the training of task groups that participate in the actions of the National Rescue and Firefighting System and showed a great potential for its further development. The system features are discussed below.

Simulation scenarios

The scenarios are created in the VBS3 software which has a built-in mission editor OME (Offline Mission Editor) and they consisted of the following elements:

a) Virtual map of the real area of Poland;

b) Virtual character models;

c) Virtual vehicle models;

a) Virtual model of unmanned aircraft;

b) Virtual models of road infrastructure elements;

d) Virtual models of nature elements;

e) Virtual models of building objects (including those specific);

f) Virtual models of other objects;

g) Atmospheric conditions (which during the course of the scenario can be changed using the editor).

Scenario building involves inserting into the virtual map selected elements available through the object library and assigning simulated events (tasks) to them. Objects are placed on the map by selecting the appropriate object from the object insertion menu, and then selecting the appropriate place on the map. The editor allows creating scenarios in 2D and 3D views. The preview of elements placed in the scenario and the management of objects is possible through the menu of scenario objects. Objects placed in the scenario can be combined into groups, which allows them to automate their behaviour during simulation. The editor allows additional configuration of the scenario by setting the parameters of the atmospheric conditions (eg. cloudiness level, rainfall intensity level, wind speed, wind direction) and the current date and time of the simulated scenario. The next stage of building the scenario is assigning particular objects (or groups of objects) specific tasks related to the planned course of the scenario. Examples of task types that are possible to simulate in VBS3 are, among others:

I. MOVE - displacement;
II. DESTROY - destruction (indicated object);
III. GETIN NEAREST - occupying a position in the vehicle;
IV. GETOUT - getting out of the vehicle;

The editor allows setting detailed task parameters, including how to respond to an opponent, how to behave while moving, formations, how to act during the task, the speed of the task.

An additional element used to build the scenarios are so-called triggers - invisible objects placed in the scenario that allow control of the simulation eg: a person in shock after arrival FR begins to panic, run away, her condition worsens etc.

The system was tested in a simulation system on 7 out of 18 developed training scenarios - one training scenario for firefighters (S12), three training scenarios for the army (WP/R/ 1, WP/R/2, WP/R/3), two training scenarios for border guards (SG/1, SG/2) and one training scenario for the police (P01). The system has been proven very flexible and, depending on the needs, allowing to specify any scenario and train it in any required configuration of station.

The scenario tested by the CNBOP-PIB team consisted of, among others, training stages such as: access to the place of the event (analysis of the most optimal route), its evaluation, disposing of appropriate measures. The system contained few training positions: UAV's operator station, operator of UAV's camera, a position for a function person, a position of fire truck driver, a position of an administrator / training instructor. In the scenario UAV plane was used.

HID (Human Interface Devices) Dedicated panel

The panel controlling the BSP operator simulation is shown in Figure 9. The technology allows for the development and construction of any panel dedicated to the BSP operator and panel for the radio communication simulator depending on the needs.

Figure 9 The panel at the UAV operator station

Radio simulator

The radio communication simulator is a fully functional prototype enabling the implementation of basic activities necessary to simulate communication during the implementation of training using a simulation system.

Functionality of the radio communication simulator:

- continuous communication of the VAV simulation system with a radio communication simulator,
- mutual communication between the UAV simulation system and the radio communication simulator,
- possibility of sending messages with the help of a dedicated button,
- controlling the volume of the simulator with the help of a dedicated button,
- selection of the transmission channel with the help of a dedicated button.

Individual stations of the simulation system

A fully functional prototype of the virtual simulation system is shown in **¡Error! No se encuentra el origen de la referencia.**, **¡Error! No se encuentra el origen de la referencia.**. It supports the training of commands from the use of unmanned aerial vehicles.

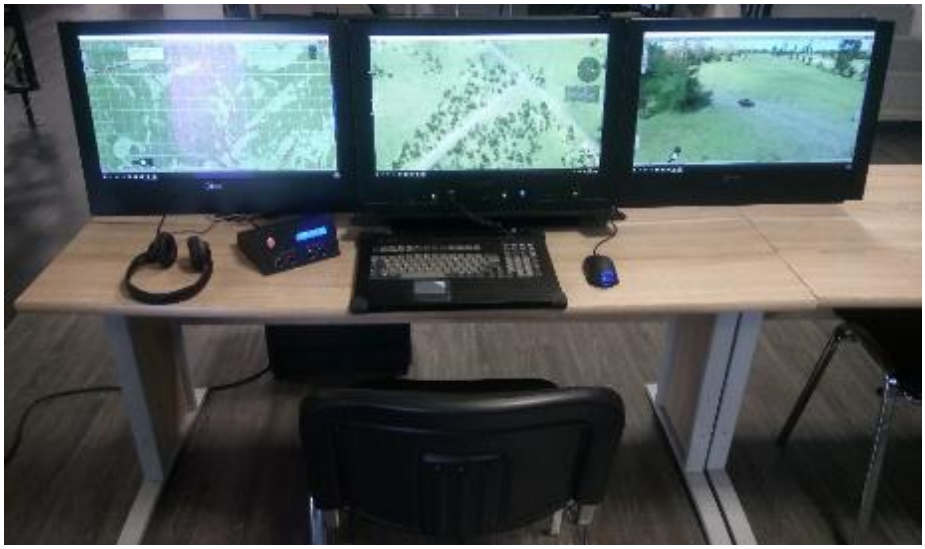

Figure 10 Simulation system instructor / system manager station (1)[16]

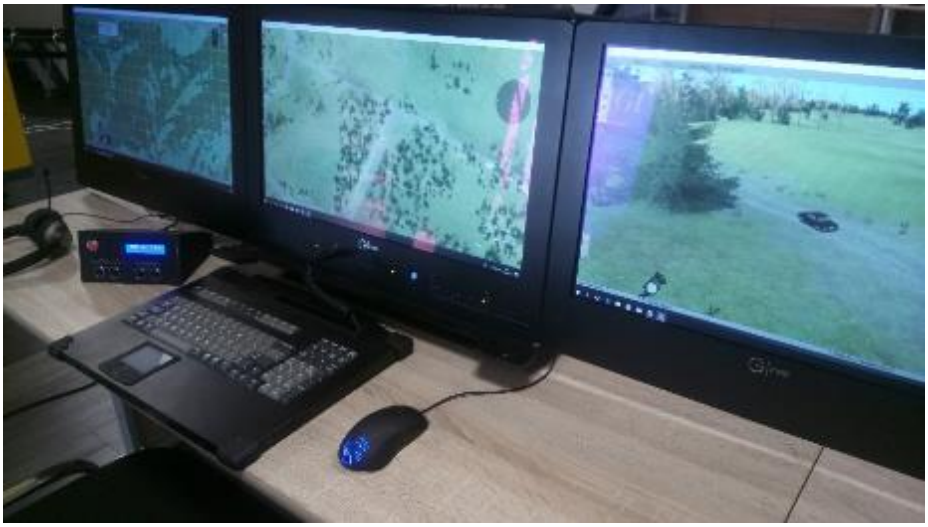

Figure 11 Simulation system instructor / system manager station (2)[¡Error! Marcador no definido.]

[16] CMGI Ltd

The instructor / administrator station in the simulation system consists of the following components:

a. High performance workstation - ELMATIC suitcase computer, model: FlexPACIII-BTO (MS Windows 10 Professional 64-bit PL OEM).
b. A simulation system based on a virtual VBS3 environment programmed on a mobile computer unit that enables the user to perform actions related to:
    - Scenario Editor (OME – offline mission editor), a tool available for use as an instructor / training administrator. The functionalities available for use in the editor are mainly:
        - construction of training missions / scenarios, inserting individual objects selected from the library onto the map, assigning them categories, pages, which should be assigned and places on the virtual map, as well as their limited modification,
        - launching training missions / scenarios,
        - possibility of viewing a virtual map in 2D and 3D,
        - setting the following parameters such as: cloud level, haze level, the level of rain and snowfall intensity, wind speed and direction, current date and time, time of the mission / simulation scenario execution, changing the initially indicated parameters after a specified time
        - modifying the following options:
            - Simulation display configuration options,
            - Voice configuration options,
            - Keyboard and controller configuration options,
            - Configuration options for the simulation run.
        - creating groups - for individual simulation scenarios, individual virtual objects or groups (eg. several virtual objects of characters or vehicles),
        - placing tactical signs on the map (three types: tactical signs compliant with the NATO standard, icons, area signs),
        - setting tasks – eg. assigning tasks to specific units with setting their detailed parameters and assigning them a suitable graphic character,
        - setting "triggers" so-called sensors - these are the elements of the scenario or areas that allow to control the course of the simulations by activating or deactivating them, their task is to trigger certain reactions when the selected object is in their area, will come with them in interaction.
    - Real-time editor (RTE) / Admin Panel that allows interaction during the course of the scenario; the editor's functions allow observation of the course of the exercise, introducing changes and corrections, and triggering the required events. The functionalities available for use in the editor are mainly:
        - editing the mission / training scenario in real time, directly during the activities undertaken in the simulation system,
        - launching a mission / training scenario in local mode - allows simulation for one practitioner,

- launching a mission / training scenario in network mode - allows simulation with the participation of many practitioners,
- starting registration, recording of the exercise course for AAR (After Action Review),

- A database of scenarios, developed and implemented to the simulation system, dedicated to all target entities, which can be used in two basic ways:
  - Scenarios training - scenarios can be used to independently familiarise oneself with system properties, navigation methods and options for use in the system, as well as the functionalities of individual training stations,
  - Networking - it is possible to run scenarios in the network mode, enabling simultaneous training on the same map for many people exercising (the option recommended for use in the developed simulation system).
- An After Action Review (AAR) module that allows the administrator / instructor to recreate the course of the exercise after its completion (during the implementation of the mission in RTE mode, the administrator has the option of registration and recording of the entire exercise and its selected fragments, the status of individual facilities or units for later analysis).
- A virtual map;
- Virtual objects necessary to create and implement the developed training scenarios.

c. Radio simulator.

UAV operator station

The unmanned aerial vehicle operator station in the simulation system is shown in Figure 12 and it consists of the following components:

a. High-performance workstation - ELMATIC suitcase computer, model: MegaPACL2-BTO (MS Windows 10 Professional 64-bit PL OEM)

Figure 12 UAV operator station Source: CMGI Ltd.

b. A simulation system based on a virtual VBS3 environment programmed on a mobile computer unit that allows the user to perform actions related to playing training scenarios (run on the instructor / administrator position), including primarily manual and automatic virtual UAV control. The UAV operator station is devoid of exercise controls, so that the participant does not have the ability to interrupt, change or stop the exercise. The position is dedicated to moving within the virtual map and allows the use of actions and interactions provided by the instructor / administrator of the exercise.
c. Radio simulator.
d. HID control panel.

Commander / function person station

The commander station in the simulation system is shown in Figure 13 and consists of the following components:

a. High-performance workstation - (MS Windows 10 Professional 64-bit PL OEM)

Figure 13 Commander / function person Source: CMGI Ltd.

b. A simulation system based on a virtual VBS3 environment programmed on a mobile computer unit that enables the user to perform actions related to playing training scenarios (run on the instructor / administrator position), primarily providing the commander with a picture of the actions performed by the practicing unmanned aerial vehicle operator. The commander station is devoid of exercise controls, so that the exerciser does not have the ability to disturb, change or stop the training. The station is dedicated to moving within the virtual map and allows the use of actions and interactions provided by the instructor / administrator of the exercise.
c. Radio simulator

Additional training station

The visualisation system can be used interchangeably with one additional station provided for the commander / function person on a high-performance workstation. It means it is either run

as a station which elements are a visualisation system, a high-performance workstation and a radio simulator, or as a stand with only a high-performance workstation and a radio.

The station consists of:

- A high-performance workstation (one of the four workstations envisaged for functional persons, is to be interchangeably used for training at a designated station),
- Radio simulator module (one of 4 modules dedicated to a functional person, to be interchangeably used for training at a designated station),
- "Optoma" multimedia projector (the projector displays the element of the simulation scenario in the form of a route to the event (in the case of scenarios dedicated to fire brigade, police and border guards) and in the form of passage to a specific point in the case of scenarios dedicated to military units,
- A specially designed projection surface (a special screen made to order, allowing use during training in a form resembling the use of the sphere),
- Specially designed screen frame with truss handles.

For the purpose of carrying out internal tests on a bench with a visualisation system, a vehicle cabin as shown in Figure 14 and Figure 15 (not a simulator element) is provided, imitating any police vehicle, fire truck, etc. In the case of training, individual positions imitating vehicles can be developed in a different, less complicated way (e.g. by placing a workstation in front of the sphere at an ordinary table), however, the possible development of the system in the future with such an imitation of the vehicle's cabin adds realism to the training carried out using the simulation system.

Figure 14 Visualisation system - view of the vehicle's cabin Source: CMGI Ltd.

Figure 15 Visualisation system - view of the inside of vehicle's cabin, Source: CMGI Ltd.

3.1.3. IFV BA-ADMS virtual training system

This system makes possible to practice interactively, dynamically and time realistically with different disciplines, incident types and vehicles. Using a joystick, participants walk through the virtual practice area and deploy virtual relief workers by issuing commands and assignments. The actions of the participants determine the course of the incident and thus they constantly practice the process of image forming and decision making. BA-ADMS can be used for both individual and team exercises. IFV has around 15 Virtual Reality systems spread over the country. IFV has a broad experience in conducting large scale incident training with up to 12 VR systems connected within one network.

3.2. AR platforms

Currently there are no existing AR platforms available for training within the consortium partners developments.

At TNO, an open source AR application is available, called WorldExplorer, which runs on the Microsoft HoloLens, and which allows to display a 3D map of the environment, optionally with additional overlays, e.g. to display a gas cloud. Current ongoing modifications include support for 3D terrain, and a connection to the EU-project DRIVER+ technical infrastructure. Although this is not a training platform by itself, it can, however, be used as part of a training, as it provides a multi-user 3D overview of the incident situation.

4. Security and safety related best practices

This chapter focuses on operational guidelines and best practices in defined first response scenarios.

4.1. Risk management standards

Standards provide a consistent, transparent, and systematic basis for establishing a minimum level of performance. In the context of first responder operations and technology the required performance could be related to preparedness, such as specifying a framework for risk management procedures. For technology, the performance could also be related to technical issues, such as equipment robustness, for example its ability to operate satisfactorily in adverse conditions. Standards can also play an important role in ensuring that interoperability is possible, both with respect to communication and interaction between different FR organisations and by specifying compatible interfaces between SA technologies.

A summary of the most widely used existing standards relevant to the ASSISTANCE project is given in the following sections. It is possible that other standards exist that could also useful but are not readily available to the general public.

4.1.1. General risk management

ISO 31000:2018 Risk management – Guidelines[17]

This is a very general standard that can be used by organisations of all types and sizes to help them meet their internal and/or external objectives. This document defines a list of principles and provides a framework for fitting them together in a coherent manner so that risk management can be integrated into activities and functions within the organisation. The essential components of a risk management plan and its implementation process, including regular reviews to continually update and improve the plan are described in brief terms. The details of how each piece of the plan applies to an organisation are not included in the standard and are left for the organisation to determine.

ISO/IEC 31010:2019 Risk management - Risk assessment techniques[18]

This standard provides guidance on the selection and application of techniques for assessing risk in a wide range of situations; in this sense it provides more detail for a subset of the ISO 31000:2018 standard. The risk assessment techniques are used to assist in making decisions where there is uncertainty, to provide information about particular risks and as part of a process for managing risk. Summaries are given of a range of risk assessment techniques.

COSO 2017 - Enterprise Risk Management - Integrated Framework[19]

[17] https://www.iso.org/standard/65694.html
[18] https://www.iso.org/standard/72140.html
[19] https://www.coso.org/Documents/2017-COSO-ERM-Integrating-with-Strategy-and-Performance-Executive-Summary.pdf

This standard was created by the Committee of Sponsoring Organizations of the Treadway Commission (COSO) and uses a business-oriented approach to managing risk. The basic components of the framework are: aligning risk appetite and strategy, enhancing risk response decisions, reducing operational surprises and losses, identifying and managing multiple and cross-enterprise risks, seizing opportunities, and improving deployment of capital.

A Risk Management Standard – IRM/Alarm/AIRMIC 2002[20]

This standard was produced by the Institute of Risk Management (IRM) and appears to follow an approach similar to ISO 31000. It presents information on internal and external risk factors and the risk management process: assessment, analysis, evaluation, reporting and communication. It also includes information on the treatment of risk and maintaining the risk management process.

OCEG "Red Book" 2.0: 2009 - a Governance, Risk and Compliance Capability Model[21]

This is an extensive document that provides a model, used in practice as a standard, for businesses to follow "principled performance" objectives for integrating risk management into their organisational structure. The model includes information on these steps: establish context, organise, assess, pro-act, detect, respond, measure, and interact. There is a large amount of supporting material available.

4.1.2. Risk management for emergency response

NFPA 1600:2019 - Standard on Continuity, Emergency, and Crisis Management[22]

This standard establishes a common set of criteria for all hazards disaster/emergency management and business continuity programs. It is focussed on the United States of America (USA) governmental authority structure at distinct levels (e.g., federal, state/provincial, territorial, tribal, indigenous, and local levels). Other entities, including those outside the USA, such as commercial business and industry, not-for-profit and nongovernmental organisations, and individual citizens may also find this standard useful. Detailed protocols for program management, planning, implementation, execution, training and education, exercises and tests, and maintenance and improvements are provided, along with additional supplementary material. The U.S. Department of Homeland Security adopted this standard as a voluntary consensus standard for emergency preparedness.

National Occupational Standards (NOS) for Civil Protection in England and Wales[23]

The NOS for civil contingencies comprises multiple standards related to activities surrounding integrated emergency management (including risk management) for events or situations that may threaten human welfare, the environment or national security in England and Wales. These

[20] https://www.theirm.org/media/886059/ARMS_2002_IRM.pdf
[21] https://thegrcbluebook.com/wp-content/uploads/2013/03/uploads_Red-Book.2.1.optimized_0.pdf
[22] https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=1600
[23]https://webarchive.nationalarchives.gov.uk/20090412234542/http://www.skillsforjustice.com/websitefiles/SFJ%20Civil%20Leaflet%20Nov%2008%20Stage%201(1).pdf

standards are designed to be used by FRs such as police, fire and rescue services, health bodies, and local authorities, as well as other stakeholders in disaster management.

EU Civil Protection Mechanism

Although it doesn't exist in a formal standard format, the EU Civil Protection Mechanism[24] offers a central hub for member states to share and develop their risk management activities and receive guidance for and peer reviews of their plans.

4.1.3. Triage Standards

There are many standards and guidelines for emergency medical care during disasters, some of which are used on a national or regional level and some that have been developed to correspond to specific cultural and demographic conditions. A recent analysis of 20 of these standards for triage systems used in disasters concludes that there is no "best" system and recommends that triage models should continue to be developed according to native conditions, resources and relief forces[25].

Most of the triage standards use variations of colour coding to classify casualties in terms of their need for medical attention, where red = immediate, yellow = urgent, green = non-urgent and black or blue = dead. A principal difference between approaches is whether the most or least critically injured people are treated first. There are also specialised triage standards, for example, for use in wars, for burn victims, chemical, biological, radiological and nuclear (CBRN) victims, elderly people and children.

4.1.4. Technology Standards

ISO Standards

The ISO technical committee TC 292[26] covers "Security and resilience" and includes standards and guidance documents for the use of situational awareness technology as well as managing the incident, communication, and dealing with the public during an incident. Some of the most relevant standards are listed below:

- ISO 22311:2012 Societal security -- Video-surveillance -- Export interoperability[27] Specifies a common output file format that can be extracted from the video-surveillance contents collection systems (stand-alone machines or large-scale systems) by an exchangeable data storage media or through a network to allow end-users to access digital video-surveillance contents and perform their necessary processing.
- ISO 22315:2014 Societal security -- Mass evacuation -- Guidelines for planning[28] provides guidelines for mass evacuation planning in terms of establishing, implementing,

[24] https://ec.europa.eu/echo/what/civil-protection/mechanism_en
[25] Bazyar J, Farrokhi M, Khankeh HR. Triage Systems in Mass Casualty Incidents and Disasters: A Review Study with A Worldwide Approach. Open Access Maced J Med Sci. 2019 Feb 15; 7(3):482-494. https://doi.org/10.3889/oamjms.2019.119
[26] https://www.iso.org/committee/5259148.html
[27] https://www.iso.org/standard/53467.html?browse=tc
[28] https://www.iso.org/standard/50052.html?browse=tc

monitoring, evaluating, reviewing, and improving preparedness. It establishes a framework for each activity in mass evacuation planning for all identified hazards. It will help organisations to develop plans that are evidence-based and that can be evaluated for effectiveness.

- ISO 22322:2015 Societal security -- Emergency management -- Guidelines for public warning[29] provides guidelines for developing, managing, and implementing public warning before, during, and after incidents.
- ISO 22395:2018 Security and resilience -- Community resilience -- Guidelines for supporting vulnerable persons in an emergency[30] gives guidelines for organisations to identify, involve, communicate with and support individuals who are the most vulnerable to natural and human-induced (both intentional and unintentional) emergencies. It also includes guidelines for continually improving the provision of support to vulnerable persons in an emergency.

The ISO technical committees TC 21[31] and TC 94[32] cover "Equipment for fire protection and fire fighting" and "Personal safety -- Personal protective equipment", respectively. These two technical committees produce many standards that affect the safety and well-being of first responders but do not apply directly to situational awareness.

NFPA Standards

NFPA has minimum performance standards for thermal imaging cameras[33] (NFPA 1801), radios[34] (NFPA 1802, proposed), and personal alert safety systems[35] (NFPA 1982). These standards focus on fire fighting equipment and address issues such as electromagnetic compatibility, intrinsic safety, and quality of performance in harsh enviornments.

4.1.5. Police Standards

The goal of the Minimum Standards for Maximal Security Project[36], commissioned by the EU, is to establish minimum standards for European police offices with regard to their uniforms, equipment and training. This project found a very large discrepancy between EU countries in all areas. Recommendations were given for a minimum kit of equipment, including two-way radios for the officers and SA equipment (communication station, camera, global positioning system (GPS), mobile phone, computor) for the vehicles.

[29] https://www.iso.org/standard/53335.html?browse=tc
[30] https://www.iso.org/standard/50291.html?browse=tc
[31] https://www.iso.org/committee/46628.html
[32] https://www.iso.org/committee/50580.html
[33] https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=1801
[34] https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=1802
[35] https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=1982
[36] http://www.eurofedop.org/spip.php?article925

The National Institute of Justice[37] (NIJ) in the USA supports development of equipment standards to address the needs of law enforcement offices, among others. Among the NIJ standards there are several that deal with situational awareness technology, for example bomb detection, handheld metal detectors, and vehicle tracking systems.

4.1.6. ASTM Medical Standards

ASTM International[38] provides a range of standards for emergency medical professionals. Among them are five communication standards: Emergency Medical Services System (EMSS) Telecommunications, Interagency Information Exchange, Emergency Medical Dispatch, Emergency Medical Dispatch Management, and Communicating an EMS Patient Report to Receiving Medical Facilities. Other related ASTM standards deal with emergency medical health care equipment, organisational management, and personnel, training and education.

4.2. Methodologies

This chapter looks into generic methodologies that are useful in developing first responders situational awareness tools.

4.2.1. Situated Cognitive Engineering Method

At TNO and Delft University of Technology, researchers have been working on a human-centred design methodology for complex, intelligent, and interactive technology. This methodology evolved over the years (a) to address the challenges that technological progress brings forward (e.g., to establish trustworthy human-AI collaboration, responsible data processing in cloud computing and explanatory system behaviours; Neerincx et al., 2018) and (b) to incorporate the lessons learned of its application (e.g. tools to create and re-use the design rationale; Looije et al., 2017[39]). The methodology focuses on the development of joint (human-machine) cognitive systems, like robot-assisted disaster response teams (Mioch et al., 2012; De Greef et al., 2009[40][41][42]), train traffic control systems (Harbers and Neerincx, 2014[43]) or “blended” health-care

[37] https://www.nij.gov/topics/technology/standards-testing/pages/active.aspx
[38] https://www.astm.org/Standards/medical-service-standards.html
[39] Looije, R., Neerincx, M. A., & Hindriks, K. V. (2017). Specifying and testing the design rationale of social robots for behavior change in children.Cognitive Systems Research,43, 250-265.
[40] Neerincx, M. A., van der Waa, J., Kaptein, F., & van Diggelen, J. (2018, July). Using perceptual and cognitive explanations for enhanced human-agent team performance. InInternational Conference on Engineering Psychology and Cognitive Ergonomics(pp. 204-214). Springer, Cham.
[41] Mioch, Tina, N. J. J. M. Smets, and Mark A. Neerincx. "Predicting performance and situation awareness of robot operators in complex situations by unit task tests." *the fifth international conference on advances in computer-human interactions*. 2012.
[42] de Greef, Tjerk, Augustinus HJ Oomes, and Mark A. Neerincx. "Distilling support opportunities to improve urban search and rescue missions." *International Conference on Human-Computer Interaction*. Springer, Berlin, Heidelberg, 2009.
[43] Harbers, M., & Neerincx, M. A. (2014, June). Value sensitive design of automated workload distribution support for traffic control teams. InInternational Conference on Engineering Psychology and Cognitive Ergonomics(pp. 12-21). Springer, Cham.

support systems (Neerincx et al[44]). To stress the "situatedness" of cognition, the methodology was first called 'situated Cognitive Engineering'(sCE; e.g., Lindenberg and Neerincx, 2018, Neerincx, 2011[45][46]). However, more and more, connectivity and interdependencies needed attention, leading to the naming "Socio-Cognitive Engineering (see https://scetool.ewi.tudelft.nl/). The Socio-Cognitive Engineering (SCE) methodology structures and guides the (1) derivation of human needs and analyses of the technological design space, (2) the specification of the requirements with their design rationale (i.e., the "claims"), and (3) the systematic validation and refinement of the first two components (i.e. the "derivation" and "specification"). As an incremental and iterative process, the social, cognitive, and affective support functions are implemented in the evolving systems. The methodology combines different design approaches and techniques in order to establish a sound, theoretically and empirically grounded design solution. The Socio-Cognitive Engineering Tool (SCET) provides guidance and structure for capturing, maintaining and refining functional (user) requirements with the design rationale (including the design patterns). SCET is built and maintained in Atlassian Confluence, a wiki content tool for teams to collaborate and share knowledge efficiently.

Human-Machine Work Harmonisation

To establish the desired human-machine work harmonisation, the SCE methodology supports the construction and implementation of formal models of human factors concepts like shared situation awareness, workload and work agreements.

Shared situation awareness.

Situation Awareness (SA) is the perception of elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future (Endsley, 1995). Inadequate SA can be a factor in accidents ("human error"). It is important in domains with high information load (volume, dynamics, uncertainty) and high costs of errors (e.g., disaster response, aerospace, defence and health care). Team SA is the degree to which every team member possesses the SA required for his or her responsibilities, whereas Shared SA is the degree to which team members possess the same SA on shared SA requirements (Endsley & Jones, 1997, 2001). Team and Shared Situation Awareness are used to describe, explain and predict team performance based on activated knowledge about the current situation, focusing on perception, cognition and action in time and space. In socio-cognitive engineering, human factors concepts, like SA, are formalised into ontological models that both humans and machines can use to reason about (cf. Kokar et al., 2009 2012; Smets et al., 2017). It should be noted that such models should include the awareness of own capabilities,

[44] Neerincx, M.A., van Vught, W., Blanson Henkemans, O. Oleari, E. Broekens, J., Peters, R., Kaptein, F. Demiris, Y., Kiefer, B,. Fumagalli, M. and Bierman, B. (to appear). Socio-Cognitive Engineering of a Robotic Partner for Child's Diabetes Self-Management.

[45] Neerincx, M.A. & Lindenberg, J. (2008). Situated cognitive engineering for complex task environments. In: Schraagen, J.M.C., Militello, L., Ormerod, T., & Lipshitz, R. (Eds).Naturalistic Decision Making and Macrocognition(pp. 373-390). Aldershot, UK: Ashgate Publishing Limited

[46] Neerincx, M.A. (2011). Situated Cognitive Engineering for Crew Support in Space.Personal and Ubiquitous Computing. Volume 15, Issue 5, pp. 445-456

the ability to monitor own progress, and activities of teammates. Concerning mates in a good team: They behave in a predictable way (there is interpredictability), their (cognitive) behaviour is observable (to establish common ground) and they are directable (e.g., to correct) (Johnson et al. 2014[47]).

Workload

In SCE, workload is defined by three concepts (e.g., Harbers and Neerincx, 2018). First, cognitive task load distinguishes the time occupied of the tasks-to-do, the level of information processing and the number of task-set switches (Neerincx, 2003). Second, affective load distinguishes the expected cognitive load ("what has to be done") and the severity level of the current task ("potential consequences of the performance"). Third, the emotional state of the task performer distinguishes arousal and valence.

Adjustable work agreements

Human-machine teams for disaster response have to attune their task allocation to the dynamic operational context, addressing specific performance, safety and health objectives and standards. So-called work agreements help to establish strategies for adequate considerations of the dynamic trade-offs (e.g. the balancing of safety and performance). Work agreements distinguish: Creditor, debtor, antecedent, consequent, lifespan, and acceptance. Recent research (in the TRADR-project on robot-assisted disaster response) showed that these work agreements can bring forward the desired adaptive team behaviour of the robots in the team (Mioch et al., 2018 [48]).

4.2.2. Driver+ Trial Guidance Methodology Handbook

The Trail Guidance Methodology (TGM) is designed for crisis management practitioners who have identified one or more gaps or have in mind solutions that can address these gaps. Before adopting those solutions and investing time and money to figure out what fits best, the TGM provides step-by-step guidelines on how to assess them in non-operational contexts (such as a Trial) through a structured approach. The TGM directly addresses the context of crisis management and deals with investigating and assessing innovation through a broad set of tools available within Driver+ Test-bed (for the handbook, see [49]).

4.3. Scenario specific guidelines

This chapter provides a look into existing guidelines and manuals describing operations of first responders in specific situations that may influence training platforms and situation awareness technologies to be developed in project.

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[47] Johnson, M., Bradshaw, J. M., Feltovich, P. J., Jonker, C. M., Van Riemsdijk, M. B., & Sierhuis, M. (2014). Coactive design: Designing support for interdependence in joint activity. Journal of Human-Robot Interaction,3(1), 43-69.

[48] Mioch, T., Peeters, M. M., & Neerincx, M. A. (2018, August). Improving Adaptive Human-Robot Cooperation through Work Agreements. In2018 27th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN)(pp. 1105-1110). IEEE.

[49] www.driver-project.eu/trial-guidance-methodology

4.3.1. Specific guidelines for safe use of UAVs

Safety is a state in which risks associated with aviation activities, related to, or in direct support of the operation of aircraft, are reduced and controlled to an acceptable level [50]. In the case of using aircraft and its associated elements which are operated with no pilot on board, operated remotely or autonomously, the elimination of accidents (or serious accidents), full safety is not achievable. Failures and errors will continue to occur, despite all efforts to prevent them. It cannot be guaranteed that any action taken by man or a system created by man will be completely safe, i.e. risk-free. Only way is to mitigate and minimise predicted probability and severity of the consequences or outcomes of a hazard through comprehensive approach to every aspects of UAS flights. Based on many studies about UAS operations and flight, analysis of literature, experience gained during real missions, tests, exercises, experiments and training, we propose an approach called 5xM, which are acronym based on words: men, machine, medium, mission, management.

Machine (unmanned aircraft and equipment)

UAS of FR must be reliable, with improved operational parameters, with parameters confirmed by independent units or even certified. It's also significant IP rating (resistance to weather conditions) and Electromagnetic Compatibility (immunity to interference emitted by other devices). Nevertheless, operator must compliance with operational restrictions of UA and adapt to the manufacturer's recommendations.

Readiness for take-off is also important. The time counted from unloading the UA from the vehicle to its take-off can be up to 12 minutes. The preparation includes, among others: UA dispatch, propeller mounting, technical check, equipment switching, including platforms and cameras, calibration, connection between the apparatus / controller and the platform, GPS signal acquisition. It is important to choose the right place of calibration (accelerometer, gyroscope, compass). The proximity of metal objects or electronic devices disturbing the magnetic field may spoil calibration, and next - spoil control over UA and whole flight.

Moreover, the UA must undergo periodic technical inspections, batteries stored in a safe, fire-resistant room. The owner of the UA should have several additional batteries and a set of spare parts for the most vulnerable components for failure or damage (propellers, engines, arms). UA should be equipped with a failsafe system, propeller protection, additional emergency systems (obstacle detection, transponders, parachute, air cushion, independent tracker) - especially during BVLOS (Beyond Visual Line of Sight) operation.

The display should provide the minimum necessary information/parameters and provide comfort of work (have a built-in sunshade or have high contrast).

Pay attention to the communication between UA and GCS (ground control stations) - what is the range of the apparatus, whether there are natural and artificial obstacles nearby, whether there

[50] Annex 19 to the Convention on International Civil Aviation, Safety Management, 1st edition, ICAO, Montreal 2013, p. 1-2.

are communication masts and antennas directed to the UA flight route (if so, they may cause temporary loss of communication and transmission of view).

Therefore, the UA should be immune to signal interference caused by command and communication vehicles.

Advantages of some UAS is that are folding or easy to transport.

In the case of precision of the UA position, it is reasonable to use Global Navigation Satellite Systems receivers acquiring signals from the satellites of the systems such as: EGNOS (European Geostationary Navigation Overlay Service) and Galileo, and only then in the sequential order of GPS or GLONASS.

Man (Human Factor)

The analysis of the causes of aviation accidents indicates that 80% of those responsible for them are Human Factors (HF). It is a kind of topic which contain principles about design, certification, training, operations and maintenance and which seek safe interface between the human and other unmanned system components by proper consideration to human performance51. Human performances are capabilities and limitations which have an impact on the safety and efficiency of UAV operations. In a brief, HF is anything that affects a person's performance, and are related to such sub-topic as:

- Ergonomics – for instance ground control station should be designed to be comfortable to use, provide comfort of work, does not burden the hands and torso
- Human Factors - for instance displays and the number of information on the screen should be adapted to the human perceptive abilities.
- Aviation Psychology – for instance members of UAV team, leadership, orders, procedures, methods of communication or training must be adequate to the level of knowledge, personality,
- Human error - for instance knowledge of the sources of errors allows to develop preventive measures

There are a various and huge amount of classifications, models and methods to analyse human factor and human errors (Fatigue Risk Management System , Generic Error-Modelling System, Human Factors Analysis and Classification System, model SHELL, Swiss Cheese Model, PEAR Model, The Dirty Dozen, Crew resource management). We recommend a "The Dirty Dozen", which are 12 areas of potential problems in human factors divide on two groups[52]: „lack of factors" and „overflow of factors", which are listed in the table below.

[51] Annex 14 to the Convention on International Civil Aviation, Aerodromes, Volume 1, 8th edition, ICAO, Montreal 2018, p. 1-5.

[52] CAP 715: An Introduction to Aircraft Maintenance Engineering Human Factors for JAR 66, Civil Aviation Authority, ISBN 0 86039 834 X, 2002, s. 67.

Table 1 Examples of Human Factors Problems from the "Dirty Dozen" and solutions

„Lack of factors"		**Potential Solutions**
1.	Communication	Use logbooks, worksheets, etc. to communicate and remove doubt. Discuss work to be done or what has been completed. Never assume anything.
2.	Knowledge	Get training on type. Use up-to-date manuals. Ask a technical representative or someone who knows.
3.	Teamwork	Discuss what, who and how a job is to be done. Be sure that everyone understands and agrees
4.	Parts	Check suspect areas at the beginning of the inspection and AOG the required parts. Order and stock anticipated parts before they are required. Know all available parts sources and arrange for pooling or loaning. Maintain a standard and if in doubt ground the aircraft.
5.	Assertiveness	If it's not critical, record it in the journey log book and only sign for what is serviceable. Refuse to compromise your standards
6.	Awareness	Think of what may occur in the event of an accident. Check to see if your work will conflict with an existing modification or repair. Ask others if they can see any problem with the work done
„Overflow of factors"		**Potential Solutions**
7.	Complacency	Train yourself to expect to find a fault. Never sign for anything you didn't do
8.	Distraction	Always finish the job or unfasten the connection. Mark the uncompleted work. Lockwire where possible or use torqueseal. Double inspect by another or self. When you return to the job, always go back three steps. Use a detailed check sheet.
9.	Fatigue	Be aware of the symptoms and look for them in yourself and others. Plan to avoid complex tasks at the bottom of your circadian rhythm. Sleep and exercise regularly. Ask others to check your work
10.	Pressure	Be sure the pressure isn't self-induced. Communicate your concerns. Ask for extra help. Just say 'No'

11.	Stress	Be aware of how stress can affect your work. Stop and look rationally at the problem. Determine a rational course of action and follow it. Take time off or at least have a short break. Discuss it with someone. Ask fellow workers to monitor your work. Exercise your body.
12.	Norms	Always work as per the instructions or have the instruction changed. Be aware the “norms” don’t make it right

First step is to appropriate selection of candidates for operators (including predispositions, personality, character - knowledge, experience, professional skills, ability to cooperate). The better the level of training (using innovative methods e.g. smartphone apps, e-learning, case studies, podcasts, video blogs) and the preparation of the operators for the task, the greater the chance of success of the mission. For example, violent movements of the grips and rods during UA control increase battery consumption. That is why it is important to do regular exercises, improve skills, analyse and evaluate the work of the operator (by himself, by supervisors and even team mates).

The training should be conducted at training centres, in accordance with approved training programs, at the UA with appropriate weight category and the appropriate type (aeroplane, multirotor, hybrid, helicopter) dedicated to future activities, and end with obtaining a license.

Regardless of the nature of the mission, it is important to organise the work and appropriate division of roles in the team using UAS. The experiences indicate that at least two people should create a team - UAS pilot/operator and camera operator. This is due to the fact that simultaneous piloting the drone and observing the terrain would be too much of a burden for one man's perceptual abilities. Separating the functions of the remote control and camera operator allows you to maximise the efficiency of operations. The pilot is then only responsible for the preparation and safe execution of the flight (control, adjustment of altitude, speed, separation, operation in an emergency), while the camera operator focuses on camera movements, area observation, recording / recording material for later processing. It would be optimal if the above-mentioned duo would be complemented by a technician / service technician.

Media (natural and artificial environment)

Before proceeding to the action, it is necessary to recognise the situation, and therefore the place of flights (places for take-off, flight along the route, landing), landform, weather conditions, proximity to the building that hinders flights and communication with the UA, availability of airspace, restrictions on flights, information about nearby air traffic, and last but not least - bird activity/migration (especially in the vicinity of lakes, seas, rivers).

When it comes to weather conditions, it is worth paying attention on air temperature, wind, Kp index (Kp Index above 3 may cause unstable flight caused by GPS disturbance), weather forecast and information (METAR, GAMET, TAF).

The weather, apart from the fact that it can hinder flying and decrease the comfort of piloting, also affects the speed of discharging the battery (what is related to the “Machine” aspect). In the low temperature of the air, the batteries discharge more quickly - here the slowing tool can be special insulating stickers.

Low temperature, as well as flying with the wind, and then returning to against the wind may lead to faster battery discharge despite indications of the expected level of charge / discharge of the battery.

Task (Mission)

Operators must know their scope of responsibility, tactics, the aim of mission, rules of communications, chain of command, procedures and steps. Superiors and commanders should clearly specify mission goal, complexity and difficulty level. Important is also previous segregation of duties between FR (who is UA operator, who is camera operator who is a technician or commander).

Depending on national regulations, it may be necessary to report flights or to reserve a zone, marking the place of take-off and landing, putting on a reflective vest.

Management

Management means supervision on preparation to flights, flights, and evaluation after flights, as well as rest of the crew and keeping documentation (insurances, operational procedures, operational instructions, orders, checklist), includes updates in air law and regulations.

Checklists are a good way to keep procedures and properly prepare the operator and equipment for flights.

5. SA capabilities and new technologies in FRs environments

5.1. Chemical accidents: CBRN Footprint

There are many tools on the market that support SA for First Responders in the EM context. In paragraph (5.4) a number of those tools are presented. Also, in the EU project SAYSO[53], a list of state of the art tools for crisis management is described.

In the context of chemical accidents, an important function of those tools is to provide information on the location and the impact of the CBRN hazard. This section mentions two tools and discusses how the location and impact of the hazard can be tracked and presented.

The methodology of the CBRN footprint (i.e. RESPONSE module) is focused on the Emergency Response phase.

5.1.1. SAFER One

"SAFER One® integrates with multiple chemical gas and meteorological sensors as well as other data sources to create single monitoring platform with an intuitive graphic user interface for the facility (Figure 16). The facility layout is superimposed on Google Map® with live-traffic and internet weather integrated to provide a real-time situational snapshot of the facility. In case of a chemical release the patented dispersion model is rendered on the map screen allowing for easier coordination of evacuation or shelter in place tactics for the surrounding community." [54].

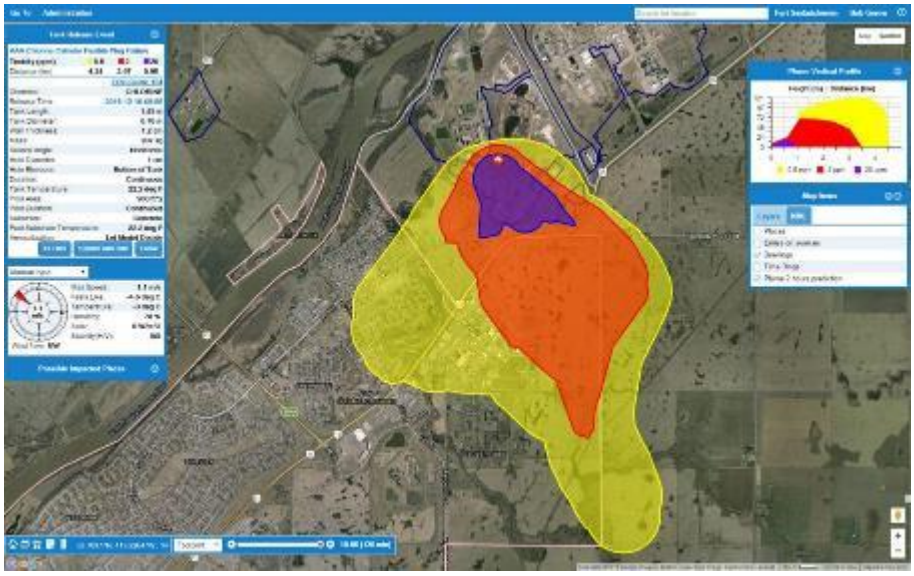


Figure 16: SAFER One® [https://www.safersystem.com].

[53] https://www.sayso-project.eu/
[54] https://www.safersystem.com

5.1.2. EFFECTS

The EFFECTS model of Gexcon efficiently calculate the effects and consequences of accidental release of hazardous material using sophisticated, but easy-to-use software. It combines transparent, traceable and internationally recognised scientific simulations with a user-friendly and flexible interface. With more than 70 models, EFFECTS (Figure 17) simulates a wide variety of scenarios: from leaks and ruptures in pipelines, pressure valves, vessels and storage tanks, to confined gas explosions, BLEVEs, drifting toxic clouds and jet-, pool-, rim-, bund-, or rooftop fires, just to name a few. You can examine models individually, or link them together for a complete picture of a loss-of-containment scenario.

The model calculates the effects of accidental releases based on static input.

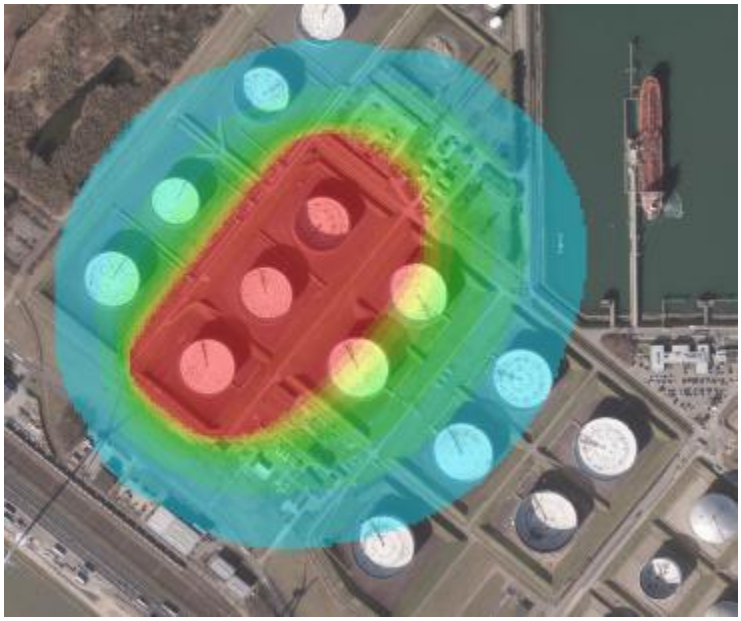


Figure 17: EFFECTS [Gexcon AS]

5.1.3. Gas plume tracking

Several frameworks for gas plume tracking and models for gas dispersion prediction have been developed.

Tochon et al. (2014)[55] developed a framework that first estimates the position of the plume using temporal redundancy of two consecutive frames, then building a binary partition tree and prune according to the previous estimate, in order to retrieve the real location and extent of the plume in the frame. This framework gives satisfactory visual results for the presented video sequence. However, the quality of the solution has not yet been quantitatively assessed and not been evaluated in different real life situations, only on given data sets.

[55] G. Tochon, J. Chanussot, J. Gilles, M. Dalla Mura, J. -. Chang and A. L. Bertozzi, "Gas plume detection and tracking in hyperspectral video sequences using Binary Partition Trees," 2014 6th Workshop on Hyperspectral Image and Signal Processing: Evolution in Remote Sensing (WHISPERS), Lausanne, 2014, pp. 1-4.)

Hyperspectral or infrared video cameras can identify the material in each image pixel using the recorded spectral signature. This can be used for the real-time detection of gases that are invisible to the human eye (Figure 18).

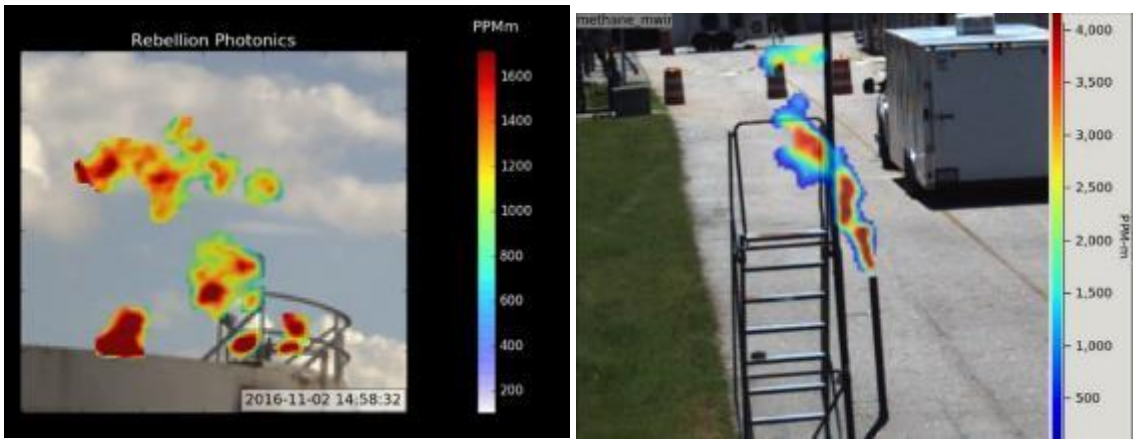


Figure 18. Example videos of methane leak detection and the resulting video images (Source: Rebellion Photonics).

Hyperspetral video cameras are used for gas detection at various distances: in satellites for the remote sensing of atmospheric concentration of gases or fire detection (Veraverbeke et al. 2018[56]), using airborne hyperspectral cameras in planes (Hulley et al. 2016, Agassi et al. 2016[57], Figure 19) and more recently also in UAV (Boubanga et al. 2019[58]), to mobile cameras for early warning of leaks (Chamberland et al. 2005[59], Hagen et al. 2013[60], Watremez et al 2018[61]) and even handheld cameras (

Figure 20).

Such imaging devices are commercial options available from parties such as Rebellion Photonics, Telops, Bruker, Opgal and Flir Industrial.

[56] Veraverbeke, Sander, et al. "Hyperspectral remote sensing of fire: State-of-the-art and future perspectives." *Remote sensing of environment* 216 (2018): 105-121.

[57] Agassi, Eyal, et al. "Detection of gaseous plumes in airborne hyperspectral imagery." *Chemical, Biological, Radiological, Nuclear, and Explosives (CBRNE) Sensing XVII*. Vol. 9824. International Society for Optics and Photonics, 2016.

[58] Tombet, Stephane Boubanga, et al. "Toward UAV based compact thermal infrared hyperspectral imaging solution for real-time gas detection identification and quantification (Conference Presentation)." *Chemical, Biological, Radiological, Nuclear, and Explosives (CBRNE) Sensing XX*. Vol. 11010. International Society for Optics and Photonics, 2019.

[59] Chamberland, Martin, et al. "High-performance field-portable imaging radiometric spectrometer technology for hyperspectral imaging applications." *Chemical and Biological Sensors for Industrial and Environmental Security*. Vol. 5994. International Society for Optics and Photonics, 2005.

[60] Hagen, Nathan, et al. "Video-rate spectral imaging of gas leaks in the longwave infrared." *Chemical, Biological, Radiological, Nuclear, and Explosives (CBRNE) Sensing XIV*. Vol. 8710. International Society for Optics and Photonics, 2013.

[61] Watremez, Xavier, et al. "Remote Sensing Technologies for Detecting, Visualizing and Quantifying Gas Leaks." *SPE International Conference and Exhibition on Health, Safety, Security, Environment, and Social Responsibility*. Society of Petroleum Engineers, 2018.

Figure 19 Methane plume detected from an airborne hyperspectral camera. Source: Hulley et al. 2016.

As Veraverbeke et al. (2018) highlights, airborne hyperspectral sensing is extremely relevant in all phases of fire disturbances. It allows for a detailed assessment of the fuel type and condition, the fire temperatures and gaseous emissions. In this regard, spaceborne hyperspectral missions will be of great importance for explaining the linkage between ecosystem properties and fire disturbances.

In what concerns UAV Thermal Infrared (TIR) Hyperspectral remote sensing, research is still on early stage but is expected to open many doors for a wide variety of applications. This UAV sensing technology offers many benefits over traditional gas detection systems, as it allows safely monitoring and imaging of large areas. Boubanga et al. (2019) reports on the new Thermal Infrared (TIR) Hyperspectral module from Teleops, which can be fully integrated on a UAV due to its reduced size and high-level performance.

Literature also shows the possibility of real-time gas detection using these types of sensors. For instance, in Agassi et al. (2016) a novel detection algorithm using an airborne thermal hyperspectral sensor is presented for detecting plumes, without the need for clear background estimation.

Figure 20 Handheld Optical Gas Imaging Camera (FLIR GF620). Source: FLIR Industrial.

Hulley et al. (2016) presents a Clutter Matched Filter (CMF) algorithm applied to airborne Hyperspectral Thermal Emission Spectrometer (HyTES) observations, to efficiently detect and characterise individual plumes from different gas emitters. The quantitative study demonstrates successful detection and characterisation with high spatial resolution over large areas (100 km^2). This measurement system complements the sparse coverage offered by satellite observations with high measurement accuracy. Sensors can be mounted on unmanned platforms.

5.1.4. Video Cameras, IR Cameras, CBRN Sensors, Temperature Sensors

Most of the work on UAV platforms is covered by video cameras (RGB and thermal) with connection of vision systems and mounted sensors. Typical components include the following: a frame, a driving system, a power system, and a pilot system. To remotely control it and to obtain real-time video, a controller, camera gimbal and a monitor are also required. The full list[62]:

1. Control & Communication
   - Antennas: Receives commands from the ground station (receiver antenna) and sends telemetry and other data (e.g. video) from the on-board system (transmitter antenna
   - Ground Station: Sends operator commands to the UAV and receives real-time flight data
2. Autopilot
   - Flight Controller (computer): Controls the power of each motor and other systems depending on the data received from the sensors, as well as the commands from the ground station; can be a commercial standard device with open software or something developed for a specific solution
   - GPS Establishes the geographic position of the RPAS
   - Barometer Determines the distance from the sea level
   - Inertial measurement unit (IMU): Integrated accelerometers, gyroscopes, and magnetometers. Determines the current rate of acceleration, changes in rotational attributes and orientation drift
   - Airspeed sensors: Determines the relative speed between the air and the RPAS
   - Positioning Camera: Points towards the ground to keep its position over a specific area over the ground; also records images
   - Ultrasonic Sensors: Determines the distance from ground and various obstacles
   - Infrared Sensors: Ranges and detects static/moving obstacles
   - FPV Camera: Gives a first person view of the flight and can be used to take pictures or record video
3. Payloads
   - HD Camera: Produces photographs; usually stabilised with gimbal device
   - Thermography Camera: Produces thermal images
   - Laser Sensors: Generates a point cloud of the build and natural geometry

62 https://www.researchgate.net/publication/305453238_State_of_Technology_Review_of_Civilian_UAVs

- Gas Sensors: Determines environmental temperature
- Radioactivity Sensors: Measures radioactivity
- Other: Many other systems (physical and electronic) and sensors can be easily integrated

5.1.5. Solutions on the market

This chapter describes some solution that can be found parameters and some parameters as examples and starting point for later work in project.

DroneFly matrice 210 RTK[63]

Although, in special missions where mapping a terrain is crucial photogrammetry cameras are used[64]. Some of the mapping drones are fully autonomous and provide high-resolution aerial photos that can be transformed into orthomosaics, e.g. SenseFly eBee X.

- Cameras:
  - Thermal Imager: Uncooled VOx Microbolometer
  - FPA/Digital Video Display Formats:
  - 640 × 512
  - 336 × 256
  - Analog Video Display Formats:
  - 720 × 480 (NTSC);
  - 720 × 576 (PAL)
  - Pixel Pitch: 17 µm
  - Spectral Band: 7.5 - 13.5 µm
  - Full Frame Rates:
  - 640 × 512 : 30 Hz (NTSC) 25 Hz (PAL)
  - 336 × 256 : 30 Hz (NTSC) 25 Hz (PAL)
  - Exportable Frame Rates: 7.5 Hz NTSC; 8.3 Hz PAL
  - Sensitivity (NEdT): <50 mK at f/1.0
  - Scene Range (High Gain):
  - 640 × 512 : -13° to 275°F (-25° to 135°C)
  - 336 × 256 : -13° to 212°F (-25° to 100°C)
  - Scene Range (Low Gain): -40° to 1022°F (-40° to 550°C)
  - Spot Meter: Temperatures measured in central 4×4
  - File Storage Micro SD Card:
  - Photo Format: JPEG, TIFF
  - Video Format: MP4
- Infrared sensors:
  - Obstacle Sensing Range: 0-16.4 feet (0-5 m)
  - FOV: ±5°

[63] https://www.dronefly.com/police-drone-infographic/
[64] https://www.sensefly.com/drone/ebee-mapping-drone/

  - Operating Environment: Large, diffuse and reflective obstacles (reflectivity >10%)
  - Gimbal
  - Angular Vibration Range: ±0.03°
  - Mount Detachable:
  - Controllable Range: Tilt +35° to -90°; Pan：±320°; Roll：±15°
  - Mechanical Range: Tilt：+45° to -135° Pan：±320° Roll：±45°
  - Max Controllable Speed: 120°/s
- S.O.D.A. 3D photogrammetry camera.
  - RGB lens F/2.8-11, 10.6 mm (35 mm equivalent: 29 mm)
  - RGB resolution 5,472 x 3,648 px (3:2)
  - Exposure compensation ±2.0 (1/3 increments)
  - RGB shutter Global Shutter 1/30 – 1/2000s
  - White balance Auto, sunny, cloudy, shady
  - ISO range 125-6400
  - RGB FOV Total FOV: 154°, 64° optical, 90° mechanical
  - Support RTK/PPK

Parrot Anafi-Thermal[65]

Fire department often have to assess risk and danger e.g. when dealing with wildfires or large buildings. Drones help firefighters understand, how fire is spreading and where it might go next. In these cases drones are using thermal and RGB cameras to analyse the environment, e.g.. Parrot Anafi-Thermal:

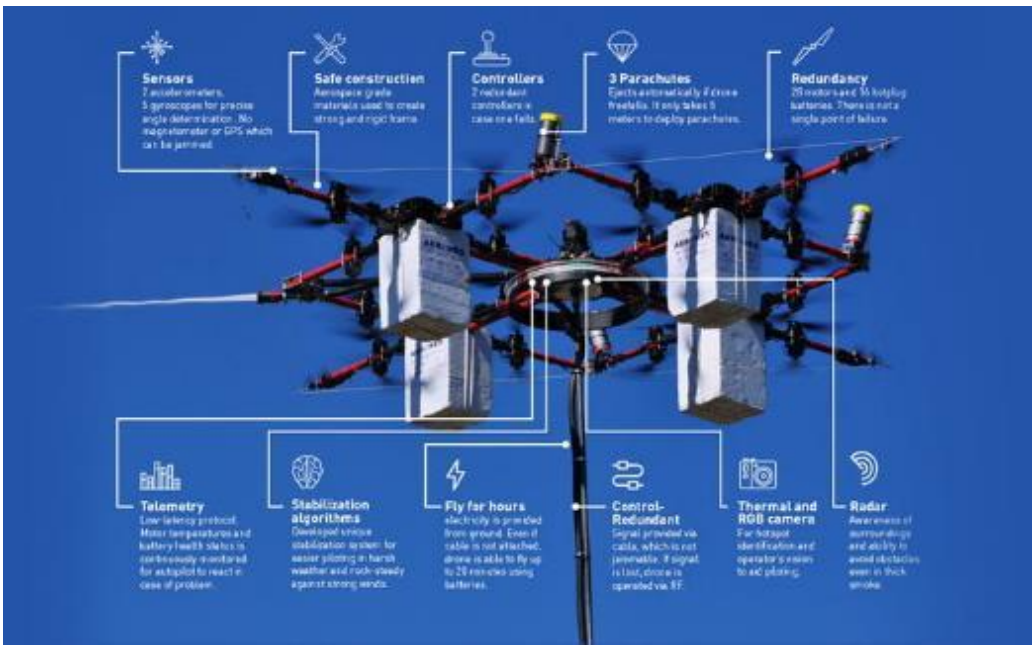
- Sensors:
  - GNSS: GPS + GLONASS
  - Barometer and magnetometer
  - Vertical camera and ultrasound sensor
  - 2x6-axis IMU
  - 2x3-axes accelerometer
  - 2x3-axes gyroscope
- Cameras:
  - Sensor: CMOS 1/2.4", 21MP
  - Video format: MP4 (H264)
  - HDR: 4K UHD, 2.7K et 1080p videos, JPEG photos
  - Photo formats: JPEG, DNG(RAW)
  - Photo modes: single, burst, bracketing, timer and panorama
  - Shutter speed: from 1 to 1/10000s
  - ISO: from 100 to 3200
  - EV compensation: [-3, +3]
  - Maximum video sampling rate: 100Mbps

[65] https://www.parrot.com/global/drones/anafi-thermal/

- LD-ASPH LENS :
  - f/2.4 aperture
  - Depth of focus: 26mm (35mm equivalent)
  - Depth of field: 1.5m to infinity
- DIGITAL ZOOM :
  - Lossless: up to x2.8 (FHD), up to x1.9 (2.7K), up to x1.4 (4K UHD)
  - Standard: up to x3 (all resolutions)
- THERMAL-IMAGING CAMERA :
  - Sensor: FLIR Lepton 3.5 microbolometer (radiometric)
  - Sensor resolution: 160x120
  - HFOV: 57°
  - Pixel pitch: 12µm
  - Spectral band: 8-14µm
  - Thermal sensitivity: <50mK (0.050°C)
  - Photo format: JPEG
  - Photo resolution: 3264x2448 (4/3)
  - Photo modes: Single / Time-lapse / GPS Lapse
  - Video format: MP4 (H264)
  - Video recording resolution: 1440x1080, 9fps
  - Precision: ±5% max.(High-gain) or ±10% max.(Low-gain)
  - Scene Dynamic Range: -10° to +140°C (High-gain) or -10° to +400°C (Low-gain)
  - Video: MP4

Aerones

Solutions for firefighting in the city[66].



[66] https://www.aerones.com/eng/firefighting_drone/

Figure 21 Photo: Aerones [67]

Rescue UAVs

Ambulance drones are helpful in case of cardiac arrest. "The first minutes after an accident are critical and essential to provide the right care to prevent escalation. Speeding up emergency response can prevent deaths and accelerate recovery dramatically. This is notably true for heart failure, drowning, traumas and respiratory issues. Lifesaving technologies such as an Automated External Defibrillator (AED), medication, Cardiopulmonary Resuscitation (CPR) aids can be designed compact enough to be carried by a drone" - (concept)[68].

Another good example of a rescue drone is The Little Ripper[69], an Australian drone that already saved a life. It uses:

- Payload delivery system
- Hi-definition zoom camera
- Siren and speaker system with multiple languages
- Pod deployment
- Shark shield deployment (software)
- Sea marker deployment

Underwater vehicles (UUV)

Rov Pegaso[70] is a good example of Light Work, Visual and Instrumental inspection, Observation, Search and Survey robot. Sensors:

- Cameras:
    - 3 Video channels, feat. Zoom, focus and still camera controls provided as standard, ROS high resolution Colour & B/W cameras standard mounted on Pan&Tilt.
- Other:
    - Optional Cathodic protection(CP) Probe
    - Inertial navigation System
    - Multi-beam Echosounders
    - Panoramic sonar
    - Dual head profiler system
    - Bathymetric system
    - Altimeter
    - Pipe tracker
    - Current-meter or underwater metal detector
    - In addition underwater tools/manipulators

[67] https://www.aerones.com/
[68] https://www.tudelft.nl/en/ide/research/research-labs/applied-labs/ambulance-drone/
[69] https://thelittleripper.com.au/
[70] http://it.calzoni.com/products-services/rov-2/

Ground vehicles (UGV)

In case of unmanned ground vehicles there are several companies that produce well-packed machines. Robots have various tasks – from defence to first responder missions. Originally used for counter explosives operations (CEOD), now gain new markets in counter CBRNE operation and for general situation awareness (Figure 22).

Figure 22 IBIS® and PIAP Gryf® with sets of CBRNE accesories. Source: PIAP.

5.1.6. Sensors used by first responders possible to integration with unmanned platforms

LEADER SEARCH Life Detectors (USAR)

USAR is used in rescue operations to detect and then locate the position of victims entombed in collapsed structures. It will pinpoint and detect the slightest of vibrations by effectively turning the entire structure into a giant microphone (Figure 23).

Figure 23 LEADER SEARCH Life Detectors (USAR)[71]

LEADER Search detects the presence of buried victims under rubble and identifies their exact location using Wireless and/or Wired ultra-sensitive seismic sensors.

Furthermore it allows two-way communication with the victim once they are found thanks to its communication probe waterproof up to 2 meters.

LEADER SCAN Life Search Equipment (USAR)

The LEADER Scan has been designed to detect and locate live victims trapped, buried or entombed, usually following disasters such as: collapse structures, landslides, avalanches and so on, LEADER Scan allows to locate victims by detecting movements at a distance of 30m.

Using UWB technology (Ultra Wide Band technology), it interrogates the sub-surface that allows identifying the victim's location by detecting movements. Its sensitivity and stability of signal allows movements' detection as precise as the chest movement produced from breathing or a finger movement (Figure 24).

Figure 24 LEADER SCAN Life Search Equipment (USAR)[72]

Delsar LifeDetector LD3

It is A Seismic and Acoustic Listening Device for Extensive Search. Used by FEMA, USAR, SUSAR and rescue teams from around the world (Figure 25). The Delsar Life Detector LD3 is seismic/acoustic listening device to detect and locate live victims trapped in:

- Collapsed structures caused by earthquakes
- Explosions
- Landslides
- Mine disasters or cave-ins

[71] https://www.leader-group.company/en/usar-victim-search-equipment/usar-life-detectors-search-cameras/life-victim-detector
[72] https://www.fireproductsearch.com/leader-scan-life-search-equipment-usar/

Figure 25 Delsar LifeDetector LD3[73]

LEADER Sentry Stability Controller

It detect a 5mm movement at a distance of 30m (100 ft). A telescope on the unit, allows the LEADER-Sentry to precisely focus on the targeted building or unstable structure. LEADER-Sentry continuously detects and warns of any movement.

Various maximum movement thresholds (stepped from 5mm to 100mm) can be selected. When any movement monitored exceeds the selected threshold, the audible alarm is activated (Figure 26).

Figure 26 LEADER Sentry Stability Controller[74]

Warning Alarm Stability Protection device - Leader WASP

Leader WASP detects movement (0 to 2.6 degrees) and vibration (0 to 100 Hz) simultaneously or not. Alarm is triggered due to rotational failure of the sructure that it has been attached to.

[73] https://www.fireproductsearch.com/delsar-lifedetector-ld3/
[74] https://www.fireproductsearch.com/leader-sentry-stability-controller/

It was purely designed for risk reduction to personnel working in close proximity to a risk that had the potential of further movement/collapse of USAR operations (Figure 27).

Figure 27 Warning Alarm Stability Protection device - Leader WASP[75]

FirstLook 360 – The First Live Streaming 360° Technical Rescue Camera

A rescuer can simply probe the camera in any space, hang by a carabiner or locate at a high point and view the 360 live by swiping a finger across the screen or by using FL360's virtual joystick feature to zero in a particular area of interest (Figure 28).

Figure 28 FirstLook 360 – The First Live Streaming 360° Technical Rescue Camera[76]

Thermal camera head for search camera TIC head

TIC head (Thermal Imaging Camera) uses infrared sensor to detect and display hottest points of a confined space. Compared to classic search camera with LED light, TIC head instantly pintpoints the victim's body heat (Figure 29).

[75] https://www.leader-group.company/en/firefighting-equipment/rescue-stability-monitor/warning-alarm-stability-protection-device-leader
[76] https://www.fireproductsearch.com/firstlook-360/

Figure 29 Thermal camera head for search camera TIC head[77]

Con-Space Rescue Kit 1 with Power Talk Box

It enables simultaneous, two-way voice communications between the rescuers and the victim. Rescuers use it where traditional radios fail or when hands-free, secured communications are required.

Figure 30 Con-Space Rescue Kit 1 with Power Talk Box[78]

Dräger X-am® 8000

The 1 to 7 gas detector detects toxic and flammable gases as well as vapours and oxygen all at once – either in pump or diffusion mode (Figure 31).

[77] https://www.leader-group.company/en/usar-victim-search-equipment/usar-life-detectors-search-cameras/victim-detector-accessories/thermal-camera-head-search-camera-tic-head

Figure 31 Dräger X-am® 8000[79]

OxygenTest 100

Determines the oxygen content of breathing air and oxygen mixtures (Figure 32).

Figure 32 OxygenTest 100[80]

Rados RAD60

Digital Pocket Alarm Stand Alone Dosimeter designed for use emergency responders who may be exposed to gamma and X-ray radiation (Figure 33).

[78] https://www.fireproductsearch.com/con-space-rescue-kit-1-with-power-talk-box/
[79] https://www.draeger.com/en_uk/Fire-Services/Products/Mobile-Gas-Detection/Multi-Gas-Detection-Devices/X-am-8000
[80] https://www.draeger.com/en_uk/Fire-Services/Products/Diving-Equipment-and-Systems/Test-Equipment-for-Diving/OxygenTest-100

Figure 33 Rados RAD60[81]

5.2. FRs Wearable Sensors

In recent years, the technology of wearable sensors has developed, partly as personal gadgets, but also in the form of technology that can be used in other environments. Handy technology can also be very useful for responding to emergency situations, helping in gathering information, organising and managing rescue operations. Obtained in this way, information can be very valuable for the managers of rescue operations. It should also be noted that in the era of miniaturisation of all sensors, the package of sensors used by the rescuer does not have to be large or heavy. In order to build such sensors, MEMS systems (microelectromechanical system) are usually used. The advantages of using MEMS sensors include:

- Very small size, mass, volume,
- very low power consumption,
- cheap in cost,
- easy to integrate into systems or modify,
- small thermal constant.

As everything, MEMS technology heave some disadvantages such as:

- designing them is a tough task because it includes very much complex procedures,
- materials for making the sensors are very fragile (e.g. polysilicon).

Applications of electromechanical micro-devices:

- sensors:
  - acceleration,
  - pressure,

[81] https://seintl.com/radiation-alert/first-response-kit/

  - vibration,
  - gyros,
  - magnetic field,
  - microphones,
  - temperature,
- electrodes for brain examination,
- endoscopy,
- chemical microreactors (also known as “lab-on-a-chip”).

Very important for wearable sensors are labs-on-a-chip (LOC), which are a devices that integrates one or several laboratory functions on a single integrated circuit (commonly called a "chip") of only millimeters to a few square centimeters to achieve automation and high-throughput screening.

The information that can be obtained from wearable sensors may include, for example:

- carbon monoxide sensors,
- position sensors,
- heart rate
- sweat sensors,
- body and ambient temperature sensors,
- sensors of dangerous substances.

This information, obtained from the sensors, can provide coordinating rescue operations with information on the location of individual units, threatened areas, health of the rescuer. The information from the lifeguard's garment equipment is transferred to the coordinator without the need for communication between them, which significantly facilitates and speeds up the work, at the same time increasing the safety of rescuers.

An interesting example of the use of wearable equipment to protect health and life was presented in the publication "A Self-test to Detect a Heart Attack Using a Mobile Phone and Wearable Sensors[82]". The authors propose the use different sensors such as accelerometer, blood pressure monitor, Electrocardiogram Sensor (ECG) and cell phone applications for the detection of pre-infants. The proposed application in the event of detection of such a state would give information about the location of the person at risk and inform other people and the medical service. A simplified scheme of the discussed system is presented in the figure below (Figure 34).

[82] Peter Leijdekkers, Valérie Gay „A Self-test to Detect a Heart Attack Using a Mobile Phone and Wearable Sensors”, 21st IEEE International Symposium on Computer-Based Medical Systems.

Figure 34. Personal Health Monitor System [82]

Other use of carrying devices is described in the article "Wearable Sensing Application- Carbon Dioxide Monitoring for Emergency Personnel Using Wearable Sensors"[83]. Such use of wearable device is of particular importance to firefighters. The information about smoke is especially important for this formation, informing the user about entering the danger zone, and the coordinator about the occurrence of such a zone. **¡Error! No se encuentra el origen de la referencia.** show possible location of wearable device.

Figure 35 Firefighter's boot with built-in pocket used for enclosing the CO_2 sensor and wireless sensing module (on right)[83]

[83] Tanja Radu, Cormac Fay, King Tong Lau, Rhys Waite, Dermot Diamond "Wearable Sensing Application- Carbon Dioxide Monitoring for Emergency Personnel Using Wearable Sensors", Proceedings of World Academy of Science, Engineering and Technology. 58. World Academy of Science, Engineering and Technology.

In the article, the authors drew attention to the impact of the construction of the pocket, and more specifically to its waterproof membrane. Its application caused a slower activation of the sensor, but it did not cause its repeatability. However, to be able to fully use the device, generating correct indications in all conditions, there is a need to provide the same type of membrane in different protective outfits.

As can be seen from the previous example, wearable devices can be located in different clothes. The most obvious choices for placing wearable devices include shoes[83], vests[84] and helmets[85]. A very interesting application of fire-fighting equipment is the integration of a thermal imaging camera in helmets. There is lots of difficulties using thermal camera, cause there are many factors influencing the proper operation of a thermal camera [86,87]. In order to assess the overall quality of a particular device, several parameters must be determined and measured, including sensitivity, non-uniformity of an FPA and noise equivalent temperature difference NETD. Thermal camera forms an image from infrared radiation originating from observed, visualised objects. In addition to protecting the firefighter's head, use of set of sensors effectively increases the effectiveness of fire and rescue actions, for example by providing better vision in smoky or poorly lit areas thanks to infrared images. Besides that, system measure vital signs using sensor module is a complementary element of the helmet-mounted system. To achieve this functionality there is additional wrist part added with ability to measure heart rate and temperature shown on the Figure 36. Device also transmit data to the main unit inside a helmet structure via wireless data link.

[84] Richard Silberglitt, Andrew Lauland, Michael Watson, Christopher A. Eusebi, Jesse Lastunen, "Wearable Technologies for Law Enforcement", RR-2012-NIJ, 2017 RAND Corporation

[85] Tomasz SOSNOWSKI, Henryk MADURA, Grzegorz BIESZCZAD, Mariusz KASTEK „Thermal camera system integrated into firefighter helmet", Measurement Automation Monitoring, Feb. 2017, no. 02, vol. 63

[86] Perry D. L., Dereniak E. L.: Linear theory of nonuniformity correction in infrared staring sensors, Opt. Eng. 32(8), 1854-1859 (Aug 01,1993).

[87] Krupiński M., Bieszczad G., Sosnowski T., Madura H., Gogler S.: Non-uniformity correction in microbolometer array with temperature influence compensation. Metrol. Meas. Syst., Vol. XXI (2014), No. 4, pp. 709–718.

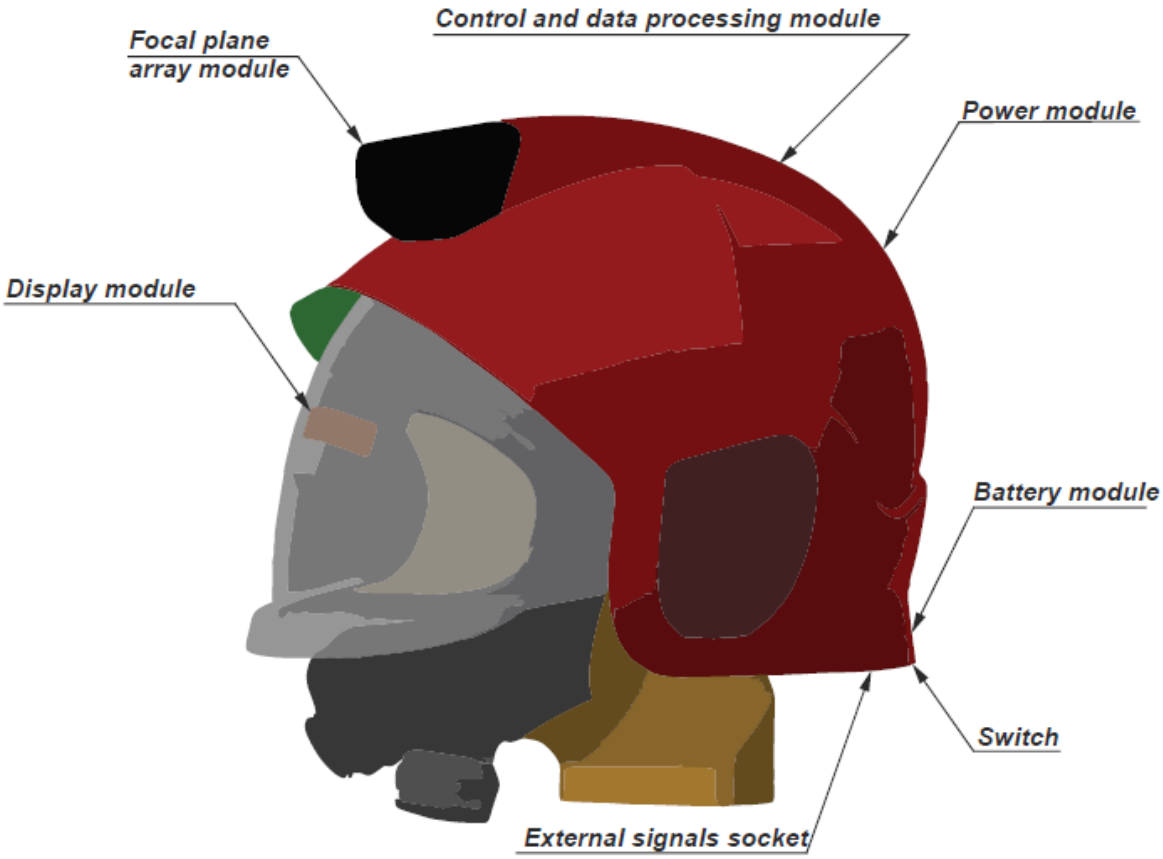


Figure 36. Conceptual drawing of a fireman's helmet with an integrated infrared camera[85]

The project developed a working prototype helmet with integrated electronic modules, including:

- an observation thermal imager,
- life sensor monitoring (Figure 37),
- near-eye OLED display.

Figure 37 Wrist-wearable vital signs sensor module[85]

Matching the data link slot to the helmet will provide a connection between the firefighter and the officer coordinating the fire and rescue operations adding another very important securing functionality. Prototype helmet model with an integrated infrared camera, vital signs sensors and near-eye OLED display has been tested both in the laboratory and in simulated scenarios of the rescue mission. The test results proved that the expected technical specifications of both the design of the helmet and the integrated electronic components were achieved, and the correct operation of the entire system in terms of the rescue mission was confirmed.

Another natural place to put on the sensors to wear is a rescuers vest. A set of possible solutions is described in detail in Richard Silberglitt, Andrew Lauland, Michael Watson, Christopher A. Eusebi, and Jesse Lastunen "Wearable Technologies for Law Enforcement Multifunctional Vest System Options ".

One of the basic elements of the rescuer's vest is the power module. Currently, the most developed and most commonly used method is the use of lithium-ion batteries, but in this case we see a significant development of technology. Zinc Polymer Batteries (Imprint Energy) and a flexible lithium-ceramic battery that is resistant to mechanical damage and retains its functionality (ProLogium, 2015) seem to be the future in powering rescurers vests. Despite the fact that wearable sensors do not consume much energy, it is sensible to introduce self-discharge systems, at the expense of smaller and lighter batteries. This would reduce the weight of the vest itself, without affecting the system's operating time. Self-reloading could take place by collecting the kinetic energy of the rescuer's movement, thermal exchange with the body or the environment or using cells of flexible solar cells. There are many significant research and development efforts on energy generation technologies, including for example in the field of energy acquisition and storage using nanotechnology (Assist, 2012; North Carolina State University, 2016) and on the transformation of mechanical energy from the movement of human feet into electricity (Sensitile Systems; Instep Nanopower, 2016).

Another widely used solution that could be used in such a system is wireless charging. Examples of the benefits of using this solution are as follows:

- no wear and tear to connectors
- no connector port providing entry for contaminants
- no small connectors to attach
- capability to charge devices continuously by building power transmitters into common objects.

Wireless charging in small devices currently uses inductive or resonant magnetic coupling. The main standards in the area are Qi (short-range magnetic induction charging) and Alliance for Wireless Power (A4WP) (longer-range magnetic resonancecharging). Qi-standard technology is currently used by most leading mobile device manufacturers (e.g., BlackBerry,Samsung, HTC, and Nokia) and is widely in use. The biggest disadvantage of described system is the need for permanent placement of sensors. The A4WP system, used in dry companies as Intel, Qualcomm, and WiTricity, is characterised by greater flexibility, which makes it better suited for use in a rescuers vest.

Another important functionality that vests should provide is communication. It may be implemented by various means and methods, such as:

- WiFi
- Bluetooth
- Nonwireless connectivity

In improved and advanced systems they can be WiFi networks that can connect mobile nodes used to provide coordinating officers with information about their comrades (ie location) and streaming video and audio from a camera mounted on a vest to nearby officers and emergency vehicles. The network itself could be based on home WiFi networks that are already used in commercial applications, or could use the 5.92 Ghz spectrum as defined by the Federal Communications Commission (FCC) for vehicle-vehicle and vehicle-to-pedestrian safety systems. Another possibility is to use Bluetooth standard for communication, but it have less working radius. Besides wireless connectivity there could be also a need to use other methods to ensure constant information flow and wide-enough bandwidth for any situation. In addition to wireless connectivity, it may also be necessary to use other methods to ensure a constant flow of information and a wide bandwidth for each situation. For this purpose, well-known and developed wired standards can be used. In addition to wireless connectivity, it may also be necessary to use other methods to ensure a constant flow of information and a wide bandwidth for each situation. For this purpose, well-known and developed wired standards can be used.

Like the helmet, as well as in the rescuers vest, portable camera can be placed (Figure 38). This solution is already known and available by, for example, the police. Currently used camera systems do not weigh much and take up very little space while maintaining high resolution..

Figure 38 Example of small camera which can be mounted in rescuers vest[88]

Although microphones are not so often implemented in wearable rescue devices, they can still give the coordinator a view of the situation of the rescuer. This is due to the fact that the devices carried by the rescuer are usually passive (telephone, radio, etc.). Microphones and accompanying software may enable sound detection and triangulation, source identification and event sound monitoring by the officer.

It is very important for every wearable device to use it, and thus to disassemble the elements and sensors. An example of the distribution of individual elements and sensors in the rescuer's vest is shown in Figure 39.

[88] https://it.dhgate.com/product/hd-1080p-mini-wifi-camera-p2p-camera-diy/411195348.html

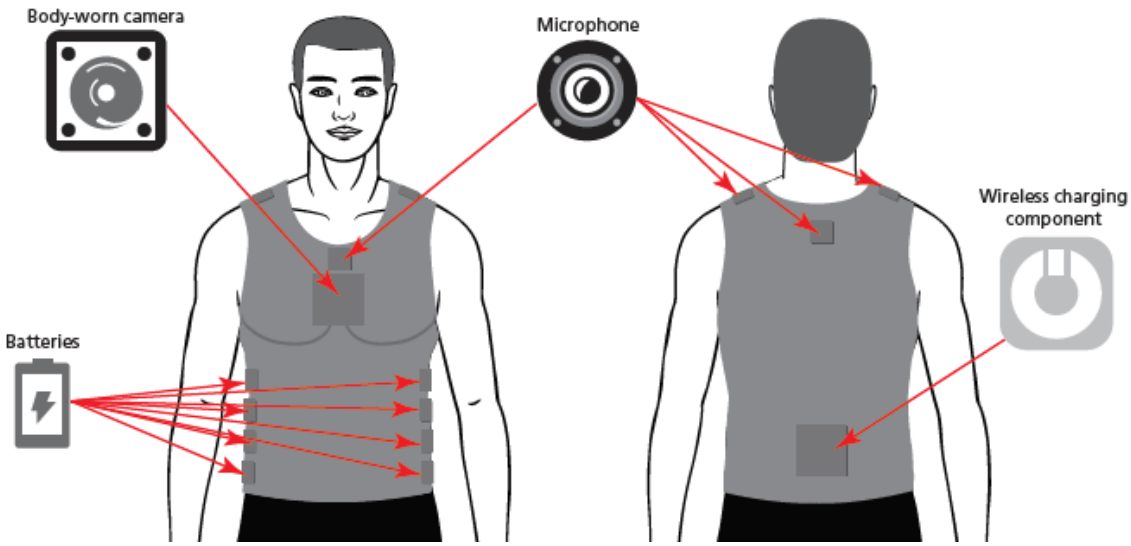


Figure 39 An example of the distribution of elements and sensors in rescuers vest

5.2.1. Cameras

In recent years, wearable devices have been improved, offering new approaches to capturing a scene, offering the command center a first view of the event.

BodyWorn Smart Scene 360

BodyWorn is and advanced police body camera, with a built-in accelerometer, being able to detect when an officer is running and start recording. User can capture evidences using a 360º view option, which can be later used in court. [89]

REAL WEAR HMT1

The HMT-1 has a completely hands-free voice-controlled user interface allowing workers to operate the tools and equipment needed for the job, even while climbing a scaffold or tower. Allowing the worker to maintain full situational awareness and maximum productivity, HMT-1 is faster, safer and smarter than either a tablet or smart glasses.[90] Geotools can be used for delimiting areas in a map giving a response and start recording when the officer enters that pre-defined geographical area. All recorded data goes to a secure cloud storage, which can be reached at any moment, even in real-time situations.

Vimpex CompactPRO

CompactPRO[91] is an advanced thermal imaging camera designed for smartphones. Made for iPhone® and Android™ top models, this highly-portable thermal imaging camera features a large, 320x240 thermal sensor with high sensitivity and a wide, 32-degree field of view. Offering adjustable thermal span, level, and emissivity settings, the CompactPRO delivers unprecedented high-resolution thermal imaging and software capabilities at an affordable price:

[89] https://www.bodyworn.com/bodyworn/police-camera/
[90] https://www.realwear.com/products/hmt-1/
[91] http://www.rescuetools.co.uk/ppe-seek-ti.html

- 320 x 240 High-Resolution thermal sensor
- Adjustable emissivity and radiometric files
- Wide, 32-degree field of view - Easily scan a large area to identify potential hazards in seconds
- Focusable lens for quick identification
- Utilises the power and display of your smartphone
- Intuitive, free mobile app available on Google Play and iTunes App Store
- Waterproof Case

Figure 40 CompactPRO - advanced thermal imaging camera designed for smartphone

5.2.2. Other Detectors

EVIRONICS EnviScreen Operix

Environics Monitoring System[92] incorporates sensor integrations, data communications, databases, system services and user interfaces. In the Monitoring System, sensor measurement and event data is collected by a data processing unit called Master Module. Master Module filters and harmonises protocol specific sensor data in real-time for the EnviScreen Operix 2016 user interface running in the Control Station.

The Enviscreen Operix 2016 is complete software solutions for continuous real time operative CBRN and Environmental situation awareness and guidance. Its technology reaches from single site to full nation-covering monitoring networks. EnviScreen Operix 2016 system software is the solution when people safety and system reliability are number one issues.

The EnviScreen Operix offers also emergency instructions and tools for reporting and hazard area plotting to enable appropriate countermeasures at the time of a suspected threat event. EnviScreen Operix includes software modules for integration to 3rd party systems and system training and simulation.

92 https://www.environics.fi/product/enviscreen-operix/

AreaRAE

AreaRAE Pro is a wireless multi-gas, multi-threat detector equipped with more sensors, more versatility, and more insight into threats happening in real-time—arming FR with the information they need when seconds count (Figure 41).

Figure 41 RAE Systems AreaRAE Pro

Key Features:

- Monitors up to seven threats, including Gamma radiation , VOCs, combustibles, Toxics and Oxygen,
- Ppb performance level on VOCs measurement,
- Dedicated gamma sensor slot,
- Local weather station,
- Part of ConneXt Safety Solutions with ISM and Wi-Fi wireless configurations,
- Wireless technology sends real-time data to command station up to two miles (3km) away
- Secondary radio module (Mesh) act as an communication Hub for other wireless devices,
- Ruggedized, portable, and weather-resistant design for harsh environments.

MX908

MX908 is a handheld mass spectrometry™ (HPMS) is a multi-mission tool utilised by first responders conducting chemical, explosive, priority drug and HazMat in situ. (Figure 42, Figure 43) Trace-level threat detection and discriminating selectivity deliver real-time actionable intelligence in seconds. Weights 2 kg. MX908 detects compounds at sensitivity levels comparable to ion mobility spectrometry (IMS).[93]

[93] https://908devices.com/products/mx908/

Figure 42 MX908 device

Figure 43 MX908 control

Smiths Detection's LCD 3.3

Based on leading IMS technology, the LCD 3.3 is a light and versatile chemical warfare agent (CWA) and toxic industrial chemical (TIC) detector (Figure 44). LCD 3.3 alarms to gas and vapour threats detected and identified at or below immediately dangerous to life and health (IDLH) levels, by determining the agent or type, class, concentration and dosage of chemical exposure. It can also be used as a screening and survey device.[94]

[94] https://smithsdetection-scio.com/AssetDownload.aspx?client=1&task=sbPmY%2bDLheyDTviGR7NZDg%3d%3d

Figure 44 LCD 3.3 from Smiths Detection's

Weighing 0,65kg including batteries, it is a light detector which allows multiple flexible mounting options that can be handheld or clipped to a belt, harness or shoulder trap. It features audible, visual alarms and liquid crystal display. It can be integrated into vehicle systems or onto robots, with the Auto Inlet Module (AIM) accessory to provide remote and automatic operation. The unit can be fitted with a survey nozzle to aid in the detection of residual persistent contamination while in survey mode. Data logging records up to 72 hours of mission data for future analysis. Built-in RS232 connectivity for data downloads and post-mission analysis. Data logging records up to 72 hours of mission data for future analysis. Integrates with Smiths Detection's Sensa-LINX wireless communications network.

US DHS POINTER

Precision Outdoor and Indoor Navigation and Tracking for Emergency Responders (POINTER) has been developed by the Department of Homeland Security Science and Technology of the United States. As is described in the Project Responder Report[95] utilises low frequency magnetic fields that can transmit though materials and obstructions; the POINTER sensor system enables accurate track positioning in the most diverse and complex environments. The electrically small magnetic field that is generated by POINTER does not lose energy as it passes through obstructions, enabling location to the exact floor in a building. First responders wear a small tracking device that relays a signal to receivers at a command unit. Functionally, POINTER administers 3D location and motion tracking and works indoors, outdoors, below ground and underwater. It can also be applied to long-range situations or where line of sight is severely blocked, such as when individuals are located in mines or bunkers.

iTrack First Responder Tracking System

The First Responder Tracking System can provide accurate tracking and accountability of a team of firefighters into indoor environments without GPS input needs. The system continuously

[95] https://www.dhs.gov/sites/default/files/publications/Project-Responder-5-Report_170814-508.pdf

tracks the first responder's motion behaviour, whether it be walking, running, or crawling. It maintains its accuracy by periodically referencing the distance to the fire trucks, first response vehicles and other ad-hoc beacons. The system consists in a portable vest-worn network radio module, and a small strap-down foot-mounted module, that increments in 300 g in weight.[96] The Fire trucks and other first response vehicles will be deployed with reference beacons Figure 45. The system stores a trace of the first responder's movement. The trace is useful to find the injured firefighter.

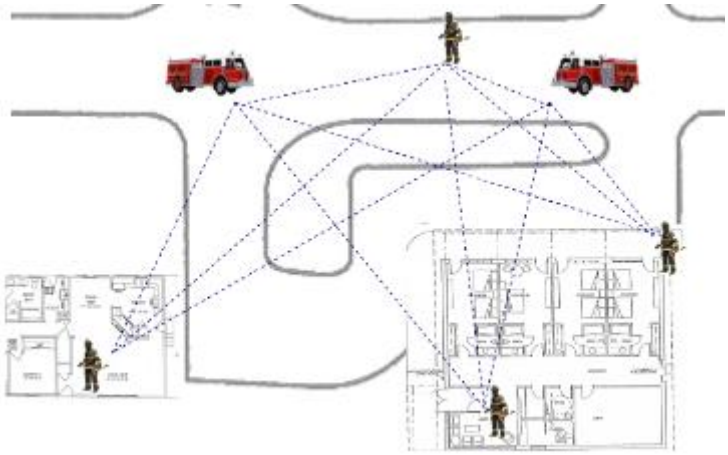


Figure 45 First Responder Tracking System hypothetical scenario.

iREACT

I-REACT is a current innovation project funded by the European Commission. It is a wrist-device as shown on Figure 46 applied to disasters with both positioning and sensing capabilities. The advanced navigation technology provides accurate positions as is using a multi-constellation receiver which combines raw satellite navigation data from American GPS, European Galileo/EGNOS and Russian GLONASS, as well as and Inertial Sensors (INS) providing a reliable positioning system. The functionality of environmental sensing will be used for the detection of risky scenarios for first responders. [97]

[96] http://www.itrack-llc.com/download/pts.pdf
[97] http://project.i-react.eu/tag/wearables/

Figure 46 3D representation of the I-REACT wearable

Chameleon® Chemical Detection Armband Morphix Technologies

Chameleon Chemical Detection Armband is a rugged hand-free device integrating colour-change chemical detection system for hazardous chemicals[98] The Chameleon does not require a liquid sample; it detects toxic chemicals in air. The armband has room for up to 10 cassettes that can detect a variety of threats Figure 47. Chameleon chemical detector can be used in arctic, tropical and desert conditions and it is up to one-hour waterproof. [99]

Figure 47 Chameleon® Chemical Detection Armband, Morphix Technologies without cassettes.

5.3. Portable SA Platforms

Having a portable SA Platform as mobile terminals, smartphones and tablet apps will help to enhance situational awareness, coordinating staff in real-time and being able to have bidirectional communication. New portable SA Platforms incorporate Geographic Information

[98] https://www.morphtec.com/chameleon/
[99] https://youtu.be/BPC4ppKKPmo

Systems an essential complement to see the whole picture situation. In this section will analyse some examples.

5.3.1. GINA First Response Intervention Systems

GINA (Geographic Information Assistant) is a map software technology for computes, tablets and mobile devices developed in the Czech Republic co-founded by EU. [100] It provides useful features as dynamic mapping, tactical coordination, communication and information and data exchange. The system integrates GINA Central, GINA Tablet, GINA Smart and GINA Hems. [101] Consisting of sturdy mobile terminals, smartphone and table apps, GSM or Satellite trackers, mission control software and the possibility of including sensors or drones to the system. GINA is used in several countries during emergency and security situations.

GINA software features local maps worldwide, which makes it easy to find and update directly the status of the emergency in an actualised interactive map. From the sensors data, crisis managers can see direction of personnel and vehicles in the field, their direction and speed; being able to draw over the map on tablets, mobile handhelds or PC the terrain situation and update the personnel about priorities and information.

GINA Central[102] is designed to provide modern dispatch and command & control tool. The platform is based on collaborative map with instant updates. GINA Central allows interactions with other unit in the terrain and enables operation dispatcher to collect all the mission critical datasets (Figure 48). Units in the field can use GINA Smart application for communication, navigation, and incident reporting (Figure 49). It is available for iOS and Android. [103]

[100] https://www.ginasystem.com/index-en.php
[101] https://www.ginasystem.com/first-response-intervention-systems.php
[102] https://www.ginasystem.com/gina-central.php
[103] https://www.ginasystem.com/gina-smart.php

Figure 48 GINA Central

Figure 49 GINA Smart application

GINA Tablet is designed to help first emergency responders in the terrain (**¡Error! No se encuentra el origen de la referencia.**). Linking all parts of public security forces together for faster arrival time to the scene, providing current traffic situation, real time tracking for all cooperating units, status dispatching with confirmation, communication, possibility to take, edit and transmit photos, access to external applications (RESCAR, HAZMAT) among other features.

Figure 50 GINA Tablet

5.3.2. DragonForce

DragonForce, from DRAKONTAS[104] is a mobile team collaboration platform that delivers mission-critical command and control and incident management capabilities in real time. (Figure 51) Integrate real-time personnel tracking, instant text messaging among individuals and groups, online storage and data sharing capabilities, digital forms and situation reports, and a unique team white boarding capability (Figure 52) that turns any map, picture or floorplan into a shared whiteboard. DragonForce operates on Android, iPhone, iPad and several standard web browsers without the need to install any software.

Figure 51 DragonForce Command Center Application

Figure 52 DragonForce Collaborative Whiteboarding tool

5.3.3. FiRST

First Responder Support Tools (FiRST)[105] application is a bomb tool that puts key decision making data, such as safe standoff distances, damage and injury contours, nearby areas of concern, and suggested roadblocks, directly at responders' fingertips. FiRST is available to first responders for a nominal fee, available for iPhones and iPads, Androids, and Windows personal computers. (Figure 53) Specifically defined DHS bomb standoff data is considered sensitive and is automatically made available to those that register the application with a .gov, .mil, or .us email address. The app will be of interest and applicable to anyone who might need to address a

104 https://www.drakontas.com/index.php/dragonforce/
105 https://www.dhs.gov/publication/first-responder-support-tools-first-application

potential bomb or HAZMAT spill response, such as industry, HAZMAT transport, or security personnel. HAZMAT information is available to all users. It is based on the Emergency Response Guidebook (ERG) which includes information on over 3,000 hazardous materials. The FiRST app uses services readily available with current smartphones: email, phone, Google Maps, Google Search, and weather and road network data. FiRST app relays clear, contextual incident information on a user-friendly digital map that users can annotate with their own data.[106]

Figure 53 FiRST Application

5.3.4. IMPACT

Incident management Preparedness and Coordination Toolkit is a free GIS tool easy to use by non-GIS professionals as first responders, designed to enhance SA, communication, preparedness and coordination during and for security events. [107][108] IMPACT combines simulation, visualisation, and mapping into an integrated user interface similar to a smart phone or tablet. First responders can use it for planning, situation awareness, and response to natural and man-made disasters[109] for instance: wildfire monitoring (Figure 54), plume model (Figure 55), evacuation plans, shooter line-of-sight, evacuation simulation among others. IMPACT collected data uses common open data formats including Google Earth's KML, ESRI's shapefile, a comma separated value (CSV) text file, or the native OGV archive format in order to easily exchange data with other map-based tools.

106 https://www.dhs.gov/sites/default/files/publications/FiRST%20Operational%20Field%20Assessment%20Final%20Report.pdf
107 https://geo.ornl.gov/impact/index.html
108 To request a free copy of IMPACT, use the link: https://geo.ornl.gov/impact/downloads.html
109 https://geo.ornl.gov/impact/docs/IMPACT_Examples.pdf

Figure 54 Wild fire monitoring visualisation

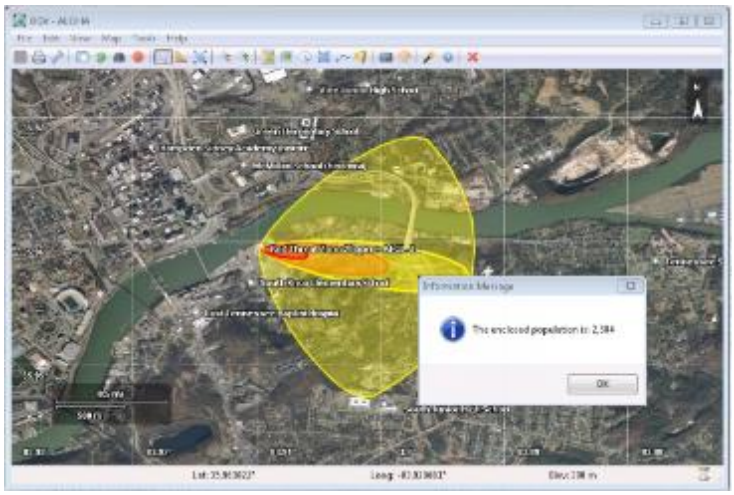


Figure 55 Plume model with ALOHA program (NOAA) visualisation

IMPACT enables simulation for table-top exercises and operates with a desktop or laptop (tablets via remote desktop) and is operational with or without a network connection in the field. Was developed by Oak Ridge National Laboratory[110], a Department of Energy facility[111], under sponsorship of the Department of Homeland Security Science and Technology Directorate (S&T)[112] and the Centres for Disease Control and Prevention[113]. It is in use by over 650 federal, state, and local government agencies and their partners.

5.3.5. GeoFES

GoeFES is an operational command system for government agencies and organisations with public safety tasks. Developed in Germany by Eurocommand[114], build over ERI ArcGIS software, which supports unit leaders in standard operations, as well as in large-scale and extensive

[110] https://www.ornl.gov/
[111] https://www.energy.gov/
[112] https://www.dhs.gov/science-and-technology
[113] https://www.cdc.gov/
[114] http://www.eurocommand.com/en/

damage situations due to man-made (Figure 56) or natural disasters. GeoFES has a comprehensive integration notable also for its use of geographic information in order to generate spatial analyses. It can be specifically configured for unit leaders, technical command centres, and crisis staff roles. By importing all operational data from the command centre, several layers can be managed and administrated at the same time. The situational overview is completed with the geographical integration of tactical symbols (DV 102). Based on geo-information, ad hoc identification of endangered areas is possible, including areas to be searched, warned, and evacuated according to a fast analysis of the affected population and protected goods. Statistical or analysis-based checklists support processing according to standardised operational.[115]

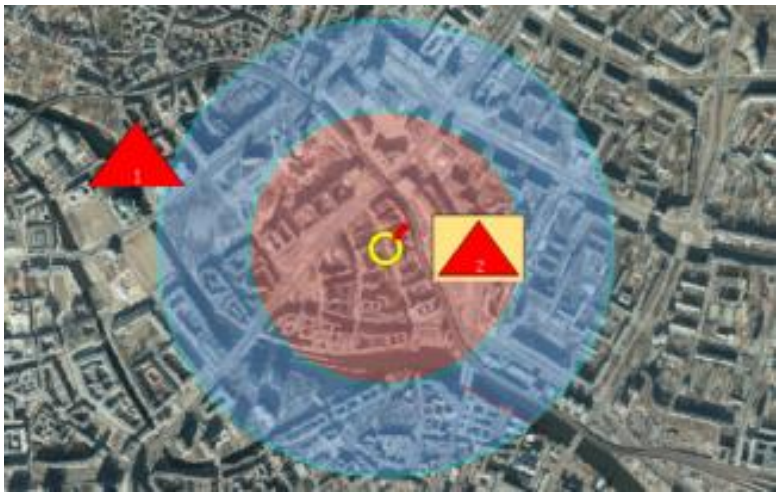


Figure 56 CBRNe events

5.3.6. RAIDO

RAIDE application from AnsuR[116] suite target scenarios where rapid remote access to observations, through photos or videos, can make a difference in unforeseen emergency situations in which fast response and communication is critical. RAIDO's mission is to facilitate interactive visual communication between field personnel and command centre staff so that they can get their jobs executed in the fastest and smartest possible way. The RAIDO applications (Figure 57) can be used for a wide range of mission-critical scenarios in which situational awareness is imperative. The deployment of an interactive communication system ensures images and video can be shared with disaster recovery teams even in the event of terrestrial communications failure following a disaster. RAIDO provides rapidly available in-situ geo-tagged images. These field observations are mapped with GIS, aerial and satellite data, providing emergency management and relief teams with accurate situational awareness for faster and more precise assessment, decision making and action. With RAIDO interactive communication, UAVs send minimum data initially. Observations are pushed by preview photos,

115 http://www.eurocommand.com/en/comprehensive-solutions/professional-tools-for-operational-command.php
116 https://www.ansur.no/

video storyboards or live streaming. Actual data transferred may be reduced by 100X for photos, and HD video by 1000X/minute.

Figure 57 RAIDO emergency software

5.3.7. CommandX

CommandX is an easy to operate support system for emergency communications in cases of an incident, available for smartphones and computers. Users do not need to install software on their clients.[117] Additionally, one workplace can communicate with multiple instances locally or via a network connection. The CommandX user interface is so clearly arranged that no user can get lost. Situation map is running on the communication server, making possible that multiple users can access it simultaneously. ArcGIS by Esri is the geodata infrastructure used with access to municipal geodata and geoanalysis tools. CommandX has the complete palette of DV102 tactical symbols on board. It can be integrated with telematics, GPS and UAVs, providing CM with direct access to field information (Figure 58), including current weather data and live videos. With CommandX, this information can be imported immediately, and the sensor data, photos, and videos quickly give a complete and informative overview of the situation. [118]

Figure 58 Interactive situation display with CommandX

5.3.8. ESRI ArcGIS for Emergency Management

ArcGIS Solution for Emergency Management includes a series of focused maps and apps designed to help emergency management and public safety personnel maintain situational awareness during an incident or event.[119] This solution includes a harmonised suite providing

[117] http://www.eurocommand.com/en/comprehensive-solutions/commandx-all-inclusive.php
[118] http://www.eurocommand.com/en/comprehensive-solutions/telematics-and-gps.php
[119] http://solutions.arcgis.com/emergency-management/situational-awareness-overview/

key applications to support CM activities. Maps help visualising physical geography, social demography, and operations information in a unified view of incident information. The common operational picture (Figure 59) provides emergency operations centres, incident commanders, and response personnel accurate and timely information when responding to, and managing, an incident or event. Situational Awareness Viewer (Figure 60) as well as Operations Response applications assist in understanding the current status of emergency facilities and response teams. They are configurations of Web AppBuilder for ArcGIS that can be deployed on desktop computers, smartphones, and tablet devices.

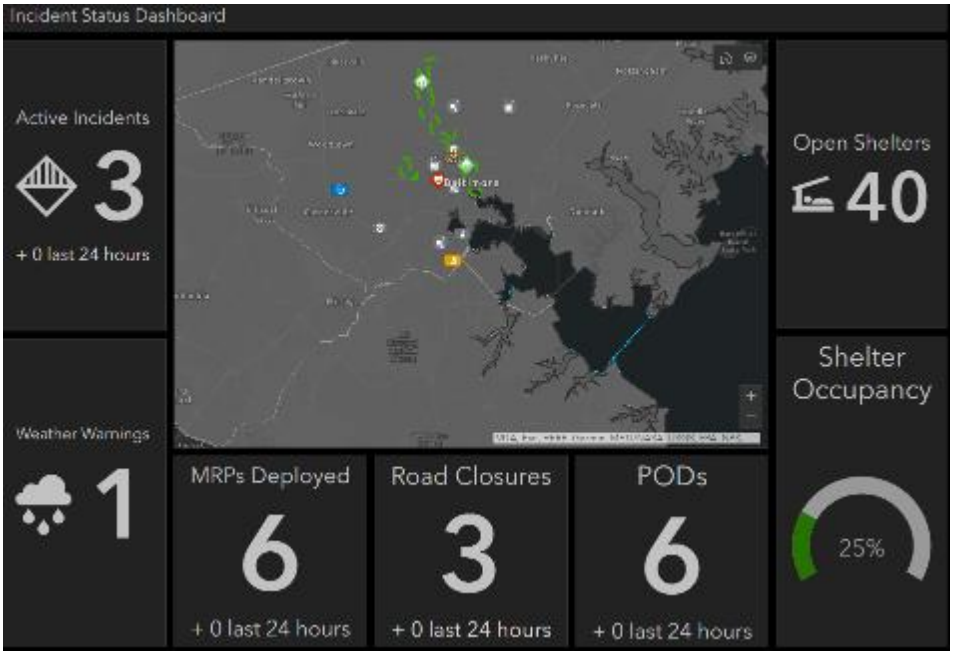


Figure 59 Incident Status Dashboard

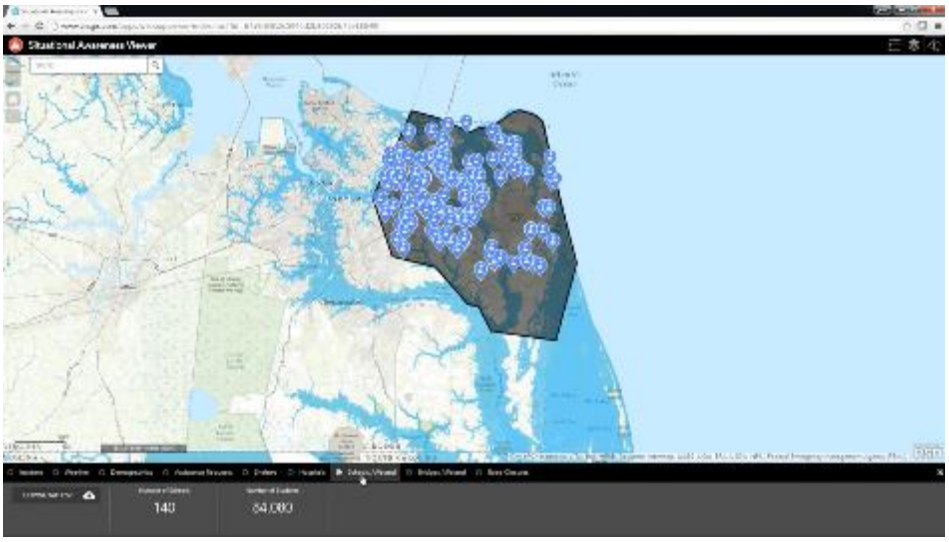


Figure 60 Situational Awareness Viewer application

5.3.9. MOSAIC

Airbox designed MOSAIC[120] for planning, execution and after action review for Law Enforcement, Search & Rescue, Fire and Medical emergency Services. Data overlays visualise mission enhancing data, weather and environmental data and CCTV & sensor feeds. All kind of maps are available including all types like ICAO, maritime, military, satellite, street level, and topographical. Has been designed for optimal performance using minimum bandwidth. Eighty five percent of MOSAIC's features are available when operating offline. MOSAIC is available for tablets, smartphones and wearable technology. (Figure 61)

[120] https://airboxsystems.com/mosaic/

Figure 61 MOSAIC shared situational awareness apps

5.4. Sensor Abstraction Service (SAS)

The SAS is a middleware that provides interoperability of data coming from the different heterogeneous sensing elements of ASSISTANCE, integrating it with the Situational Awareness platform in an asynchronous, by-subscription and efficient way. It is a platform that serves as integration layer for the multi-source information being monitored, so it can be later analysed, correlated and visualised effectively.

Standards, architectural models and existing solutions for integrated platforms have been collected and analysed. Solutions are mostly focused on IoT ecosystems and smart cities applications and how deploying interoperable platforms can uncover the maximum potential of smart sensors and systems.

5.4.1. IBM – Intelligent Operations Centre (IOC) Platform

This Intelligent Operations Centre (IOC)[121] platform offers cities integrated visualisation, almost real-time collaboration and exhaustive analytics to improve operations and planning. The solution has integrated maps, online dashboards, customisable reports, multiple analytics algorithms, interactive standard operating procedures, and other tools to improve cities operations and response to emergencies or incidents. The solution allows:

- To supervise operations and respond to events and incidents received through agents.
- To involve citizens in the notification and resolution of incidents.
- To group and analyse feedback from citizens through social networks.

[121] https://www.ibm.com/uk-en/marketplace/city-insights

- Manage a wide range of operations in the city.
- Deploy quickly with minimal IT resources.

IBM Intelligent Operations Centre uses the power of data generated in the real world to:

- Collect and manage the correct data.
- Integrate and analyse the data.
- Provide easy and timely access to information.
- Adjust systems to achieve results based on acquired perceptions.

The architecture of the IOC Platform is summarised in Figure 62

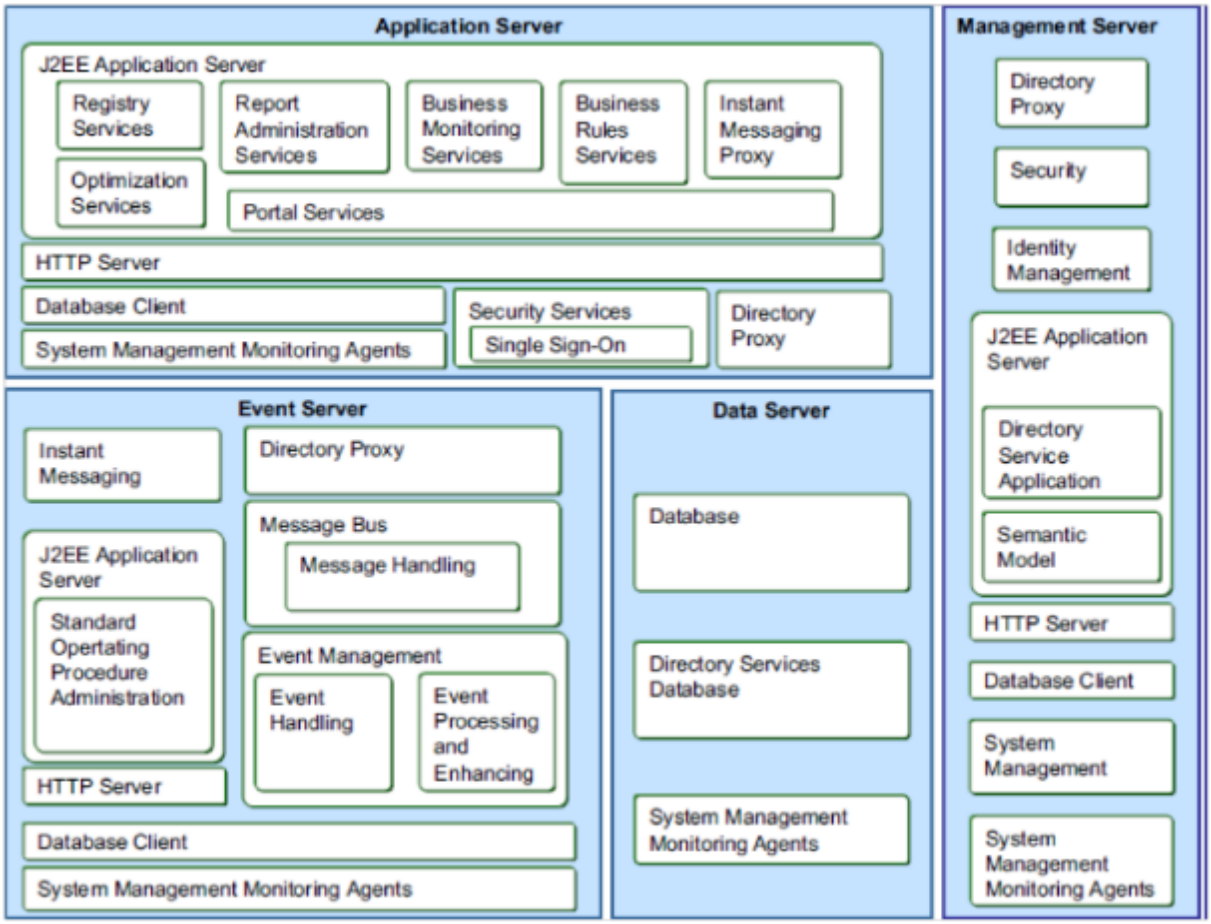


Figure 62 IBM Intelligent Operations Center (IOC) Platform architecture

5.4.2. Minsait – Onesait

This platform, previously known as Sofia2 (Smart Objects For Intelligent Applications) is a middleware that allows the interoperability of multiple systems and devices, offering a semantic platform that allows real-world information to be available to be used in intelligent applications (Internet of Things).

Onesait is multilanguage and multiprotocol, thus allowing the interconnection of heterogeneous devices. It provides publication and subscription mechanisms, facilitating the orchestration of sensors and actuators to monitor and act on the environment (Figure 63). Onesait is:

- Open-source.
- Multiplatform: available for Windows, Android, Linux, iOS...
- Multilanguage: portings to Java, Javascript, C ++, Arduino.
- Agnostic of communications: with implementations TCP, MQTT, HTTP (REST and WebServices), Ajax Push...
- Multi-device, through its SDK, API's and extension mechanisms that allows its integration with any type of device.

It is based on the following standards:

- JSON (JavaScript Object Notation): Text format for information exchange between systems, very light and suitable for devices (Arduino, mobile, etc.), used by many Open DATA platforms.
- REST and RESTful services. APIS Web as an evolution of SOA Services.
- Hadoop.

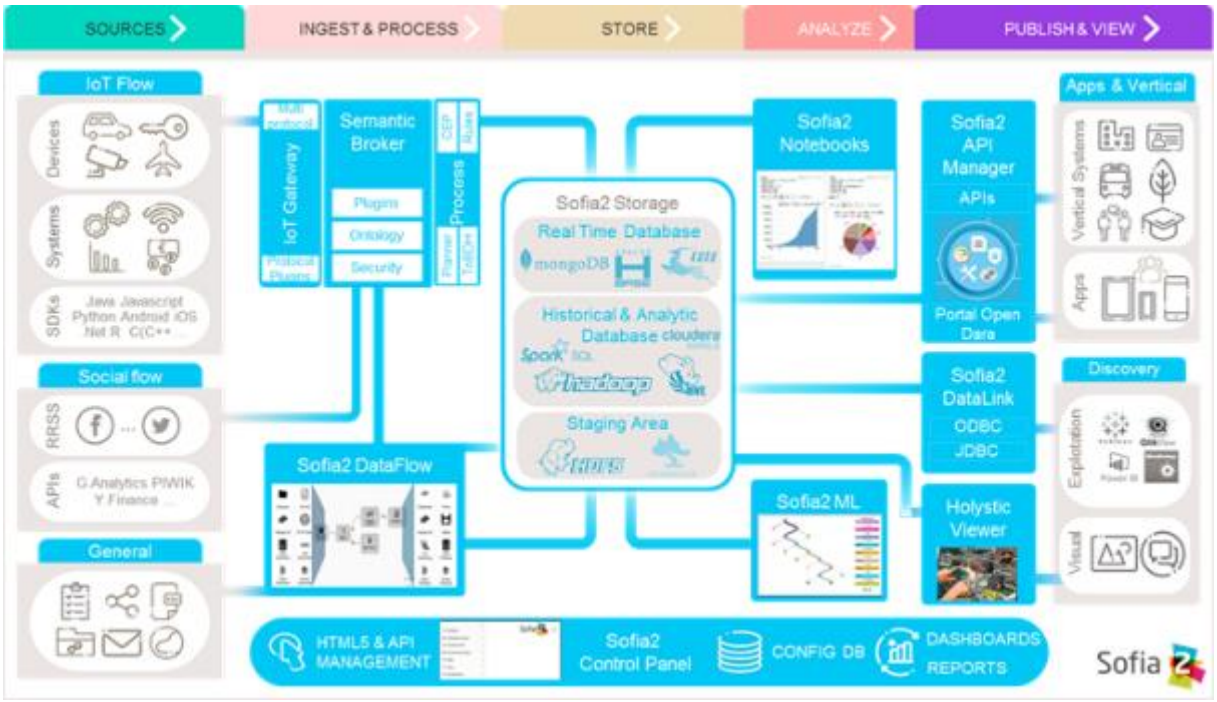


Figure 63 Minsait Onsait platform architecture [122]

5.4.3. TELEFÓNICA – Thinking City

Thinking City is Telefónica's Smart Cities solution, based on their IoT platform. It is compatible with FIWARE and is characterised by being a horizontal and open platform, based on standards[123]. The solution incorporates:

- APIs that provide NGSI open interfaces through which access to the service layer is given to the data and capabilities of the knowledge layer.

[122] https://www.minsait.com/en/products/platform
[123] https://iot.telefonica.com/en/

- Development Kit: Eclipse, TALEND, JBOSS Developer Studio.
- Open Data Portal: for access to open data of the city.
- Dashboard in Microstrategy for the variety of services that the city can deploy on the platform: transport (panels, parking, municipal bicycles...), infrastructure management (irrigation, lighting...), security and emergencies, etc.

5.4.4. oneM2M architecture

The architecture standardised by oneM2M defines an IoT Service Layer, i.e. a software Middleware, sitting between processing and communication hardware and IoT applications providing a rich set of functions needed by many IoT applications. It provides functions that IoT applications across different industry segments commonly need (eg. data transport, security/encryption, scheduling, event notifications, remote software update, etc.). In addition, it supports cooperative intelligence in distributed applications i.e. in devices, gateways and back-end/cloud applications. Besides, oneM2M Service Layer supports a selection of underlying transport protocols and serialisation formats, being like an Operating System for the Internet of Things, sitting on field devices and sensors, gateways and in servers. Finally, it is a standard, so it is not controlled by a single private company [124].

5.4.5. Alliance for Internet of Things Innovation (AIOTI)

The AIOTI has developed a High Level Architecture (HLA) for IoT, which follows the ISO/IEC/IEEE 42010 standard, and whose functional model is composed by three layers:

- The Application layer: contains the communications and interface methods used in process-to-process communications.
- The IoT layer: groups IoT specific functions, such as data storage and sharing, and exposes those to the application layer via interfaces commonly referred to as Application Programming Interfaces (APIs). The IoT layer makes use of the Network layer's services.
- The Network layer: the services of the Network layer can be grouped into data plane services, providing short and long range connectivity and data forwarding between entities, and control plane services such as location, device triggering, QoS or determinism.

Besides presenting the Domain Model and Functional Model of an IoT architecture in order to allow interoperability and maximum integration of intelligent sensors and systems, the AIOTI HLA also provides deployments considerations related to relevant IoT architectural matters such as cloud and edge computing, Big Data and virtualisation[125].

Software Defined Network-based control system for an efficient traffic management for emergency situations in smart cities

[124] https://www.etsi.org/deliver/etsi_ts/118100_118199/118101/02.10.00_60/ts_118101v021000p.pdf
[125] https://aioti.eu/wp-content/uploads/2018/06/AIOTI-HLA-R4.0.7.1-Final.pdf

This solution, developed by a team of researchers from the University of Granada and the Polytechnic University of Valencia (UPV), aims at improving the rapid action of police, firemen or ambulances in an emergency. It helps to redirect traffic through alternative routes to give priority to emergency services. This platform, oriented to reorder traffic, uses a Software Defined Network (SDN) that articulates different sensor networks (IoT) and controls traffic elements such as traffic lights or information panels[126].

5.5. Methods for malevolent/hostile drones neutralisation

At the time of constantly growing usage of UAVs, the threat of their hostile use also increases. Still small amount of events does not guarantee that future will not bring a change. To limit further incidents counter-drone technology were introduced into civil sphere of life. Counter-drone technology also known as counter-UAS, C-UAS, or counter-UAV technology, refers to systems that are used to detect and/or neutralise unmanned aircraft. This document is focused on the neutralisation part.

Drone neutralisation topic is in a scope of governmental, academic and private entities interest. By its crucial role in defensive against hostile UAV actions publicly accessible information about the state of the art is highly limited. Actual level of knowledge and conducted tests is unknown due to companies and governmental policy, so that this document presents data gathered by searching over the Internet and talks with people engaged in antidrone projects, wanted to share their knowledge.

Drones neutralisation has many aspects. Firstly in terms of platform and therefore a range and a power because some methods have better efficiency as airborne than as ground placed. Secondly damage certainty and its strength in terms of UAV neutralisation. Some methods guarantee none or minimal damages whereas the other lead to total destruction of the target. Neutralisation approach also determines whether the landing is controllable or not and therefore may cause collateral damages. Some solutions for drone neutralisation are automatic in means that they require target position but the device itself do not need to be held by the operator and manually targeted. Legal issues also play important role because for some methods authorisation is not required whereas for instance omnidirectional jamming is almost impossible event to test officially. Last issue and most critical one is efficiency of the approach and event more important - under what circumstances it can fail. Unfortunately, there is no accessible studies over this topic nowadays, therefore is very hard to present reliable information.

Nevertheless neutralisation method shall be adjusted to the level of threat it causes. There is a clear division between threats given to city or a state and those to public or private space. Military and civil forces are not equal and therefore their methods are different.

[126] https://www.researchgate.net/publication/325584067_Software_Defined_Network-based_control_system_for_an_efficient_traffic_management_for_emergency_situations_in_smart_cities

Approaches of drone neutralisation can be divided into two main groups, so called hard and soft kill. Hard kill concerns physical destruction or instant stoppage of the target whereas soft kill covers methods mostly related to hacking and jamming. Both groups are usually related to ground platforms therefore one more group of intercepting methods is sometimes mentioned. This group concerns a use of an airborne platform however utilise methods from soft and hard kill (Figure 64).

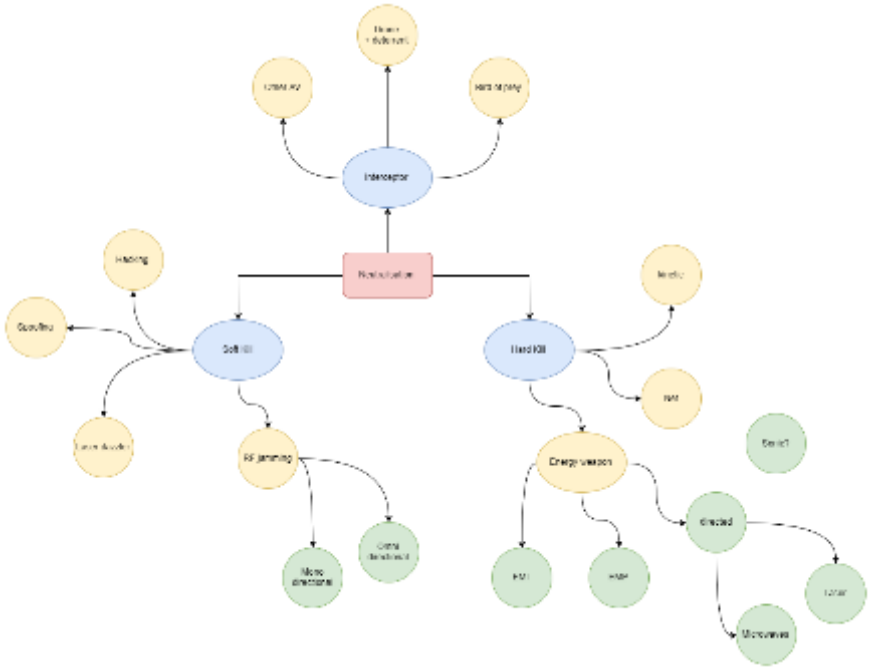


Figure 64 Diagram of UAV neutralisation methods

5.5.1. Soft kill

Spoofing

Spoofing is about sending fake data to the drone. Spoofing nowadays is limited to GNSS system and is based on sending fake position with a signal stronger from the one gained from satellites. Method is limited due to the fact some customised drones in autonomous mode may not use information from GNSS but visual- or lidar-based SLAM to navigate.

Jamming

Jamming is the most popular and most accessible method in drone neutralisation nowadays. Number of companies manufactured handheld or automatic ground-based products[127]. French company **Cerbair** offers **Medusa** product to neutralise hostile drones[128], however very small amount of information is available. **DroneShield** is a company based in Australia, USA and UK and provides many antidrones solution. Among other products DroneShiled offers handheld

[127] https://zala-aero.com/en/production/means-of-ew/rex-1/
[128] https://www.cerbair.com/solutions/electronic-countermeasure/

jammers **DroneGun Tactical**[129] and **DroneGun MKIII**[130]. It is said that DroneGun Tactical provides a safe countermeasure against a wide range of drone models, with effective coverage of 2km and operating tome of 2hrs. The DroneGun MkIII is a compact, lightweight drone countermeasure designed for one hand operation with effective coverage of 500m. Israeli company **IAI** offers **ELI-4030 Drone Guard** system which combines detection, tracking, classification and neutralisation with a jammer. Whole system is stationary and neutralisation is up to 2km[131]. British **DroneDefence** manufactured **SkyFence** which is also a fixed installation[132] but no further data is available.

Hacking

Only a few companies deals with drones hacking. Hacking concerns intervention into communication protocol and for instance encoding data in pilot-drone communication link. The outputs of hacking might be disconnection of the drone and a pilot, shutdown of a drone by stoppage its engines so that drone may fail down or just be unable to start, drone might be also made to land in safe area. In some cases taking total control of the drone might be possible but there is no reliable information about it. Another solution is hacking video signal so that operator will not have information from the cameras. It is believed that hacking was relatively easy and possible a few years ago but with a development of the UAV technology drones security was greatly upgraded as well and is much more robust for external tries of interference.

There are research over possibility of controlling drones using 4G and 5G network, what will enable for instance control a swarm of the drones from another part of the world. This approach might lead to some new possibilities in drones hacking as well.

In terms of DJI products, the manufacturer developed and sells aeroscope – drone identification platform that can track all DJI drones in a range of 50 km and gain key information from them in 2 seconds[133]. Unfortunately the platform does not enable any neutralisation method and needs to be integrated with users' existing security systems. Nevertheless backdoor system for drone hacking is also very interesting and straightforward approach, that could be introduced to the manufactures by governmental authorities.

5.5.2. Hard kill

Ground net launcher

Net launcher is actually most popular civil way of dealing with the drones by their immediate stoppage. **Openworks Engineering** - British company manufactured ground based net launcher offered in manual version **SkyWall 100** (Figure *65*)[134] and automatic version **SkyWall 300** (Figure *66*)[135]. Both approaches concern shooting to the target with a missile that before reaching the

[129] https://www.droneshield.com/dronegun-tactical
[130] https://www.droneshield.com/dronegun-mkiii
[131] https://www.iai.co.il/p/eli-4030-drone-guard
[132] https://www.dronedefence.co.uk/products/skyfence/
[133] https://www.dji.com/pt/aeroscope
[134] https://openworksengineering.com/skywall-100/
[135] https://openworksengineering.com/skywall-300/

target falls apart and project a net that cover the target. The net unable rotary motors to operate, destabilise the target and cause its fall. To prevent uncontrolled fall each net is provided with a parachute, therefore captured drone is steady and without damages landing on the ground. This approach also shall not lead to collateral damages. According to the manufacturer, the range of SkyWall 100 is up to 100m.

Figure 65 Skywall 100, counter drone device by OpenWorks Engineering

Figure 66 Skywall 300, counter drone device by OpenWorks Engineering

Other solutions

Besides net based solutions there are a few other methods for a hard kill from ground, however their usage in civil space is doubtful. First of them is a usage of a high-power microwave electromagnetic pulse which is highly effective against electronic equipment. Second is about using high power laser beam as a directional weapon that is able to melt or burn the target. Third is based on the opposite element, which is water. Water projector would be able to destabilise the target or to pump water inside it to damage its electronics. It is believed that this idea is proposed by Chenega International in a product called DroneSoaker[136]. Last solution is based on projecting bullets or missiles to the drones. Good example is military system called

[136] https://www.chenegainternational.com/media/1195/counteruav_cic.pdf

Phalanx air defence system manufactured by Raytheon which uses 20-mm cannon and is often mounted on the navy ships[137].

5.5.3. Interception

In interception main role plays an interceptor which is usually a drone with a mounted deterrent. Main idea of using interceptive drones is a to shorten the distance to the target and therefore use the deterrent with a major power and efficiency. The deterrent in that case might be a net launcher, net gripper, bullet/missile launcher, electromagnetic pulse emitter or RF jammer.

Net launcher and net gripper

Both approaches where already presented by academic societies[138,139]. Net launcher was used by **MTU**, which prepared a flying robot (Figure 67) able to capture other malicious drone by chasing the suspect drone to a distance of less than 12 meters, then launching a net, capturing the drone and carrying it through the air to a safe area. **KAIST, the** Korean Research Institute has developed a prototype of a drone with a net gripper, that can be seen in Figure *68*. The drone with a net has to catch up with and place over the target to capture it in the net. After that it carries the cargo to the selected location.

Figure 67 MTU drone prototype launches the net toward the target

137 https://web.archive.org/web/20060628002308/http://www.raytheon.com/products/stellent/groups/public/documents/content/cms01_055720.pdf

138 https://www.mtu.edu/news/stories/2016/january/drone-catcher-robotic-falcon-can-capture-retrieve-renegade-drones.html

139 https://www.youtube.com/watch?v=tioWbDS5Zm8 / http://unmanned.kaist.ac.kr/

Figure 68 KAIST drone prototype with a net gripper, with already cached drone

Commercial use of net launcher mounted on the drone was introduced by i.a. Dutch company Delft Dynamics[140] and American – Fortem Technologies[141], SCI[142], Theiss UAV Solutions[143].

Delft Dynamics has developed a capture system called **DroneCatcher** (Figure *69*) integrated in a drone as a platform. The company have performed several tests with a capture of Phantom 4 through the launch of a net. Once the intruder drone is inside the range of action, the pilot, taking references from the images provided by its camera, activates the firing of the net by means of special cannon, reaching the drone. Then the DroneCatcher carries captured drone held through a cable, to a safe place.

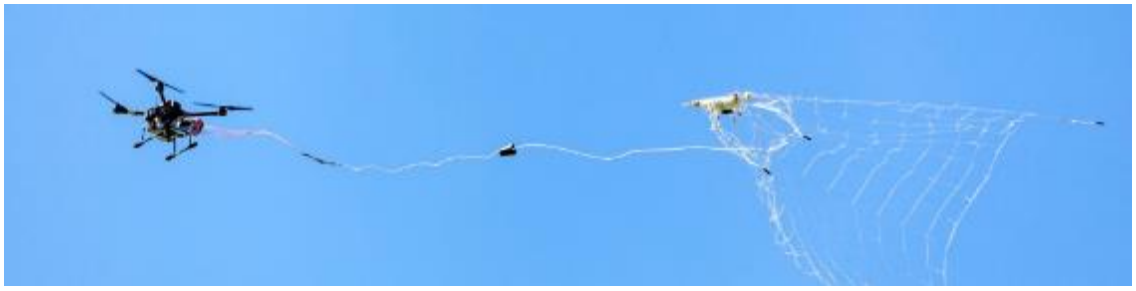


Figure 69 Drone Catcher (Delft Dynamics product) launches net towards the target

Fortem Technologies have provided a solution called **Fortem DroneHunter** that works both at day and night, based on the same solution of net launcher and cargo carriage. It uses radar for the final approach to the target (Figure *70*).

[140] https://dronecatcher.nl/
[141] https://fortemtech.com/products/dronehunter/
[142] https://www.sci.com/aeroguard/
[143] http://www.theissuav.com/counter-uas

Figure 70 Fortem DroneHunter in action (left); radar mounted on the drone (right)

SCI have proposed **AeroGuard** which is an autonomous system to capture malicious drones using net launcher and carry them to the safe area (Figure *71*).

Figure 71 AeroGuard (SCI) in action

Theiss UAV Solutions have launched the **EXCIPIO Aerial Netting System**, which allows the capture of the rogue drone. Among its novelties, is the possibility of launching several nets during the same flight (Figure *72*).

Figure 72 Drone form the EXCIPIO Aerial Netting System launching the net

Interesting solution proposed Swiss company **Skysec**, which developed two products called **Sentinel Catch** and **Sentinel Catch&Carry** (Figure *73*). Sentinel Catch is a small UAV which carries a hanging net and moves towards the target, capturing it (Figure *74*). When the target is captured, the small UAV falls to the ground together with the target, using a parachute to decrease the impact energy. Sentinel Catch&Carry is bigger and instead of falling together with a caught target it carries the cargo towards selected area. Maximal weight of the carried objected is 6 kg.

Figure 73 Sentinel Catch (left) and Sentinel Catch&Carry (right) manufactured by Skysec

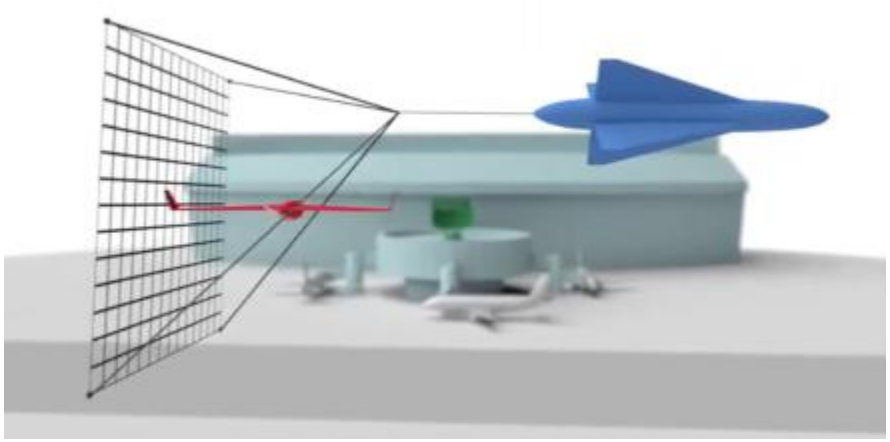


Figure 74 Skysec product captures the target using the net

Other solutions and important notes

Three others methods used in interception (bullet/missile launcher, electromagnetic pulse emitter, RF jammer) are in a phase of tests by private and government organisations but

knowledge about them is limited. There are ideas of mounting water cannon that could reach and damage motor or motors of the UAV.

Crucial for interception methods is efficiency of reaching and following the target in automatic mode. It means that interceptive drones shall have quick and efficient algorithms for other drones detection (usually visual) and prediction of their movement. Those features shall enable constant and stable tracing of the target and therefore use of a deterrent in an effective way. The other point is a weight and size of a deterrent because the drone has to be able to lift it and preserve own agility and pace. Deterrent shall be free from recoil effect to not destabilise the platform and additionally be repeatable.

Some companies like **Lockheed**, **MBDA**, **WB Electronics, IAI** produce suicide drones (loitering munition)[144,145,146], however they are focused on military antipersonnel, antiradar and antivehicle usage. In drone neutralisation, suicide drones shall reach the target and hit it with some kinetical power, what would lead to a destabilisation of the target and its fall down. High risk of collateral damage is here inevitable.

Animal participation

Guard From Above, company from Netherlands, proposed a bird of prey instead of another drone as an interceptor[147]. In that case a bird predator usually a falcon or an eagle attacks the drone and tries to destabilise it or capture. This approach might be effective in terms of small, rotary, non-customised drones, however legal and humanitarian (possibility of birds injuries) aspects shall be taken under consideration. Figure *75* shows a predatory bird approaching flying drone.

Figure 75 Predatory bird intercept a drone

5.6. Ad Hoc network coverage using drones' swarm equipped with Wi-Fi access points

[144] https://dronecenter.bard.edu/files/2017/02/CSD-Loitering-Munitions.pdf
[145] https://www.wbgroup.pl/en/produkt/warmate-loitering-munnitions/
[146] https://www.iai.co.il/p/harpy
[147] https://guardfromabove.com/

A ground transmitter send signal to a particular drone and then to drones' swarm which provide signal in disaster areas. The main problem is power consumption and the number of drones used for the mission. Here we can see an interesting research in which we can find solutions for the previously mentioned problems[148]. Quoted calculations show how to minimise the number of drones deployed to provide service to ground users and, among the solutions with the same number of drones, minimise the NICs average power consumption attributable to VoWiFi (Figure 76).

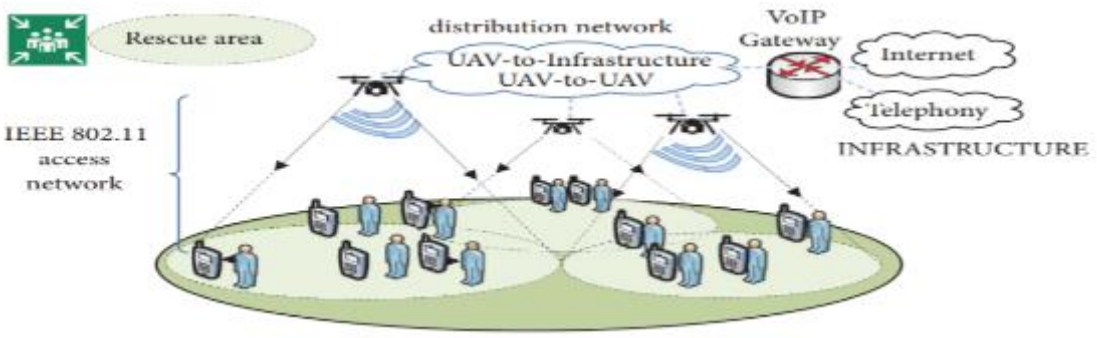


Figure 76 Reliable communication service scenario[149]

Similar systems are also used for communicating with beyond line of sight devices, with require continuous contact with ground control station, like drones and UAVs. One of examples is project[150] designed to extend range interrupted by distance and complicated environment, based on Mother-Son UAVs which one of them was autonomous controlled and programmed to keeping the optimal distance to signal receiving and forwarding. Second one was normally used as guided drone.

Alike idea is offered for military use by Sky-Watch[151] with radio communication relaying system. Also there is many similar ideas and solutions[152,153] which are based on similar solutions and ideas.

5.7. Damaged Assets Location and Routing

Taking advantage of the UAV video streaming, the purpose of this module will be twofold: (i) firstly to easily locate and take into account damaged assets and/or infrastructure given an area, and on the other hand (ii) to provide rerouting mechanisms based on damaged assets or infrastructure in order to better plan intervention or evacuation routes.

[148] https://www.researchgate.net/publication/332286131_Deploying_a_Reliable_UAV-Aided_Communication_Service_in_Disaster_Areas
[149] Mayor, Vicente & Estepa, Rafael & Estepa, Antonio & Madinabeitia, Germán. (2019) Deploying a Reliable UAV-Aided Communication Service in Disaster Areas. Wireless Communications and Mobile Computing. 201
[150] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5087484/#B1-sensors-16-01696
[151] https://sky-watch.com/defense-security/radio-relaying/
[152] http://www.eurecom.fr/en/publication/5492/download/comsys-publi-5492.pdf
[153] https://ieeexplore.ieee.org/document/7562472

Furthermore, evacuation and intervention times will be provided based on appropriate optimisation and decision algorithms and real-time computer simulation models (for those areas or facilities where relevant information is available). These models will be essentially stochastic, with a high degree of sophistication and with the capabilities of generating and processing results of thousand simulations, providing additional information to make timely decisions.

Currently, no similar tool or software that provides this complete service has been found in the market. Because of that, several solutions have been analysed, each one of them covering one of the individual aspects that the Damaged Assets Location and Routing module of ASSISTANCE will offer.

5.7.1. Real-time video editing

Open Broadcast Studio

OBS Studio is an open source central control room for live, real time video editing. It features instant encoding using x264 (an open source h.264 encoder) and AAC. It captures and mixes high quality real-time sound and video, with unlimited scenes between which you can easily switch through custom transitions (Figure 77).

Figure 77 Open Broadcast Studio

Besides, OBS Studio is equipped with a powerful API that allows the development of add-ons to provide greater customisation and functionality specific to your needs. Work with developers in the streaming community to get the features you need[154].

Anvato and Hexaglobe

These two different tools offer real-time editing and clipping functionalities, in this case mainly targeted to sports events and live news. They both offer a hybrid approach that combines the ease-of-use of cloud editing with the HD quality of on-premise capture. Moreover, AD insertion

[154] https://opensource.com/life/15/12/real-time-linux-video-editing-with-obs-studio

functionalities allow to dynamically insert interactive ads targeted for each user. Using sophisticated video analysis technology, the tools can identify mismatches between ads and target device capabilities in real-time. Ads are transcoded (converted to the correct video format) on-the-fly, and seamlessly inserted into the video stream[155,156].

5.7.2. Rerouting service based on real-time information

Sygic Professional Navigation

Sygic offers advanced route calculation algorithms tailored to different kinds of vehicles – e.g. trucks, vans, buses – and different use cases – e.g. deliveries, emergencies, smart cities. Their Sygic Professional Navigation offers pro level traffic rerouting to make fleet operations more efficient. By combining real-time and historical traffic data in the route calculation, Sygic can predict congestion more effectively. Sygic Professional Navigation uses historical data about traffic to estimate that, if the traffic is further than 2 hours from the driver's current position, the traffic will be gone before you get there and does not include this delay in the route. If the driver is only 15 minutes away from traffic, all calculations are based on real-time data instead of historical data[157].

Waze

Waze is a popular mobile app that provides routing services to users, based on real-time information on traffic, police, accidents, construction works, etc. Waze (Figure 78) uses live information reported and located by other users, such as car crashes, traffic jams, hazards or road closures, and offers it in real-time to the users' community. This information is used by the software to automatically redefine the fastest and easiest route in each case.

Figure 78 Waze mobile App

Waze checks real-time speeds for updates on traffic situation every few minutes and sets the most efficient routes for drivers based on that constantly updated data[158].

[155] https://www.anvato.com/
[156] https://www.hexaglobe.com/
[157] https://www.sygic.com/es/blog/2018/no-more-irrelevant-routes-with-rerouting-in-sygic-professional-navigation
[158] https://www.waze.com/es/

5.8. Mission Management

Mission management is very important and complicated task required in every major crisis handling action. Base goal of mission management is to organise first responders actions and maximise efficiency. To achieve these goals, good situation awareness, information synthesis and inter crew communication is necessary. Current methods of situation awareness acquisition are:

- Crew – Leader and inter crew radio communication and data exchange, e.g. goTenna PRO[159]
- Video and audio streams from local sensors e.g. monitoring cameras
- Personal first responders and in action distributed specialised sensors
- Area topology and vital information from local community and pre-made maps.

In many cases, the leader is responsible for information synthesis. Sometimes a separate person may be assigned for this purpose. In making this task easier and less time consuming, proper data visualisation may be helpful. Current data visualisations methods:

- Applications that puts all of vital information like emergency plans, evacuation routes or floor plans provided by facility owners on cloud and make it easy accessible with devices like tablet. Good example may be ARC Mobile Facilities Dashboard[160].
- Applications with digital map of terrain. It may track deployed first responders, casualty or critical emergency positions. It also provide critical information like member tasks or status. Good example Mission Manager[161].
- Monitors with augmented streams from on location cameras or other data from local sensors[162].
- Pen and paper with most critical information on it.

Last part of in action mission management is communication and order distribution . Popular ways are:

- Leader – crew radio communication
- Apps that provide on map first responders selections and order distribution interfaces

Last aspect of a problem is response time. To minimise the response time, many management task are necessary, like first responders availability tracking, fastest routes to emergency area planning or administration tasks. Many of those tasks are made by hand, or on specialised platforms like Mission Management.

[159] https://gotennapro.com/
[160] https://www.e-arc.com/services/emergency-life-safety/
[161] https://www.missionmanager.com/
[162] https://edgybees.com/

6. Security and safety related projects in the topic

6.1. ALADDIN

H2020 ALADDIN Advanced hoListic Adverse Drone Detection, Identification Neutralization From 2017-09-01 to 2020-08-31, ongoing project. ALADDIN will study, design, develop, and evaluate, in series of complementary pilots, a counter UAV system as a complete solution to the growing UAV threat problem, building upon a state-of-the-art system and enhancing it by researching on various technologies and functionalities.

6.2. AUGGMED

H2020 AUGGMED Automated Serious Game Scenario Generator for Mixed Reality Training From 2015-06-01 to 2018-05-31, closed project The aim of AUGGMED is to develop a serious game platform to enable single- and team-based training of end-users with different level of expertise from different organisations responding to terrorist and organised crime threats. The game scenarios will include advanced simulations of operational environments, agents, telecommunications and threats, and will be delivered through VR and MR environments with multimodal interfaces.

6.3. TARGET

H2020 TARGET Training Augmented Reality Generalised Environment Toolkit. From 2015-05-01 to 2018-10-31, ongoing project. TARGET will deliver a Pan-European serious gaming platform featuring new tools, techniques and content for training and assessing skills and competencies of SCA (Security Critical Agents - counterterrorism units, border guards, first responders (police, firefighters, ambulance services civil security agencies, critical infrastructure operators). Mixed-reality experiences will immerse trainees at task, tactical and strategic command levels with scenarios such as tactical firearms events, asset protection, mass demonstrations, cyber-attacks and CBRN incidents.

6.4. FIREMIND

Erasmus+ programme FIREMIND Tool for assessing and training Fireground Situation Awareness and decision-making

FIREMIND project main aim is to develop an innovative online training tool – the FireMind- that will support and enhance the decision making of firefighters and fire incident commanders. The tool will employ digital training scenarios and incidents to enable assessment of knowledge about a situation (Situation Awareness or SA) and also decision-making “bias” (whether the available information available is used conservatively or more liberally). Bias can produce errors of judgment, with too conservative a bias leading to “miss” errors and too liberal to “false alarm” errors. Self-awareness and monitoring of SA and bias may improve the safety of decision-making in fire and rescue operations.

6.5. CRISIS

FP7 CRISIS CRitical Incident management training System using an Interactive Simulation environment. From 2010-05-01 to 2013-10-31. CRISIS was conceived as a 3D immersive virtual world in which major incidents occur. Trainees are presented with a real-time evolving situation such as a train crash resulting in fires, explosions, increasing casualties and resources distributed around in a 3D virtual world. The trainee is required to view and assess the situation, formulate a plan, and organise a response by instructing his team while coordinating with other teams and higher command. Delays or incorrect actions would result in consequences such as higher death rates or greater damage.

6.6. ICARUS

FP7 ICARUS Integrated Components for Assisted Rescue and Unmanned Search operations. From 2012-02-01 to 2016-01-31, closed project. The goal of ICARUS is to decrease the total cost (both in human lives and in €) of a major crisis. In order to realise this goal, the ICARUS project proposes to equip first responders with a comprehensive and integrated set of unmanned search and rescue tools, to increase the situational awareness of human crisis managers and to assist search and rescue teams for dealing with the difficult and dangerous, but life-saving task of finding human survivors. As every crisis is different, it is impossible to provide one solution which fits all needs.

6.7. EDEN

The accidental or deliberate release of CBRNE materials are low probability events that can have a significant impact on citizens and society. Whenever and wherever they occur, they usually require a gradual and multi-facetted response as they tend to provoke severe and unexpected physical, psychological, societal, economic and political effects that cross EU-borders. Successful CBRNE resilience requires a global System-of-Systems approach. The EDEN project will leverage the added-value of tools and systems from previous R&D efforts and improve CBRNE resilience through their adaptation and integration. The concept of the EDEN project is to provide a “toolbox of toolboxes” EDEN Store to give stakeholders access to interoperable capabilities they deem important, or affordable, from a certified set of applications. It will share the burden of development and allows for lessons to be learned and applications to be enhanced. The benefit of the EDEN concept is that integration will be applied at the application level. This means that all countries and stakeholders, irrespective of their existing capability levels, will gain immediate advantages through improved interoperability. EDEN Store will allow capabilities to be shared among multi-national CBRNE stakeholders, which is paramount in cross-border incident management, and through time allow for a build-up of common capability across European boundaries. EDEN will be validated by three themed end-user demonstrations (Food Industry, Multi Chemical, Radiological) covering multiple hazards (CBRNE), phases of the security cycle, response tiers, and stakeholders. The EDEN consortium includes CBRNE domain end-users, major stakeholders, large system integration and solution providers, including SMEs with innovative solutions, and RTOs. The impact of EDEN is to provide affordable CBRNE resilience and market sustainability through the better integration of systems in real operations and thus enhancing the safety of citizens.

6.8. ENCIRCLE

To improve its resilience to new CBRN attacks and threats, the EU needs a specialised, efficient and sustainable industry, competitive on a less fragmented EU market and globally. Capitalising on its experience in the EDEN Demonstration Project, in other CBRN relevant projects, and in the CBRN market and supply chain, the ENCIRCLE consortium proposes an innovative approach to reach this goal in a short to long term perspective so that SMEs and large industries can propose and invest in the best innovations on the market.

This approach results in 5 objectives aimed at prompting the innovation and business development, and filling market gaps in the project timeframe:

1. Create an open and neutral EU CBRN cluster,
2. Provide a sustainable and flexible vision and roadmap for the development of the European CBRN market and innovations,
3. Provide integration with platforms (systems, tools, services, products) by proposing standardised interfaces and future EU standards to integrate CBRN technologies and innovations developed from the Part b projects,
4. Support CBRN safety, security and defence commercial and market services,
5. Improve and facilitate European CBRN dissemination and exploitation.

6.9. FIRE-IN

Among 16th countries in Europe there is CNBOP-PIB as a partner. Such a net can spread products of project and knowledge throughout the UE.

FIRE-IN has been designed to raise the security level of EU citizens by improving the national and European Fire & Rescue (F&R) capability development process. FIRE-IN addresses the concern that capability-driven research and innovation in this area needs much stronger guidance from practitioners and better exploitation of the technology potentially available for the discipline. We argue that this is to be achieved by practitioners more effectively coordinating on operational needs, on available research and innovation, on standardisation, and on test & demonstration and training. Further, we claim the need for the development of a common research culture that is to be achieved by better cooperation between practitioner and research/industry organisations. Main objective of project was to improve national and European fire and rescue capability development process by activities as they are described below:

FIRE-IN addresses these objectives through four main areas of activity: (i) the identification and harmonisation of operational capability gaps based on the contribution provided by a significant and heterogeneous practitioner network, (ii) the identification of promising solutions to address those gaps through monitoring and screening of research outcomes and the continuous involvement of research and industry representatives, (iii) the definition of a F&R Strategic Research and Standardisation Agenda (SRSA) based on the previous elements as well as (iv) the development of a concept for more efficient use of test & demonstration and training facilities to support innovation and joint skill development. Project assemble over 500 Experts in 5

thematic group which is covering fields of: Search and Rescue (SAR) and emergency Medical Response, Structure Fires, Vegetation Fires, Natural Disasters and CBRN's.

The overarching result of the project will be a proven process for organising F&R capability-driven research based on a wide practitioner and research and innovation network. The network will be linked at cross-domain and cross-border level and will feed harmonised operational requirements (or challenges) into national and EU capability development, i.e. research, innovation, procurement and standardisation programmes.

Benefits of project are moving boldly in directions of saving costs and optimising R&D investments, reducing implementation time, simplified access to state of the art technologies, simplifying collaboration between practitioners (EU and worldwide). Main goal to achieve is to maintain faster and cheaper access to the state-of-the-art fire and rescue technology for the whole Europe.

Knowledge obtained in the Fire-In and net of expert and practitioners made through the project could be reliable source of information in the matter of first response behaviour and in other information needed in the course of project.

6.10. DRIVER+

DRIVER+ starts from the experience that neither successful R&D nor strong end-user demand always lead to innovation in the Crisis Management (CM) domain. This is a problem since as societies become more complex, increasing scope and unpredictability of potential crises and faster dynamics of major incidents put increasingly stringent demands on CM. European CM capabilities already constitute a mature System of Systems; hence wholesale redesign would often be too costly and might critically destabilise existing CM capabilities. Therefore DRIVER+ focuses on augmenting rather than replacing existing capabilities. DRIVER+ has three main objectives: 1) Develop a pan-European Test-bed for crisis management capability development; 2) Develop a well-balanced comprehensive portfolio of crisis management solutions, and 3) Facilitate a shared understanding of crisis management across Europe.

The DRIVER+ Test-bed will provide the technological infrastructure, the necessary supporting methodology and adequate support tools. The Portfolio of Solutions (PoS) is a database driven web site that documents all the available DRIVER+ solutions. The PoS includes information on the experiences with a solution (i.e. results and outcomes of trials), the needs it addresses, the type of practitioner organisations that have used it, the regulatory conditions that apply, societal impact consideration, a glossary, and the design of the trials. Initially, the PoS will contain information about the solutions that are already available within the consortium; the PoS will be extended with third-party solutions when required by the trials, and ultimately opened up for any external organisation to share data and experiences on solutions.

A series of trials will be conducted during which solutions will be operationalised and tested. All results of the trials will be stored and made available in the PoS. Several I4CM events will be organised as well as a final conference. In addition to this, a firm link is established and will be maintained with DG HOME's "Community of Users on Secure, Safe and Resilient Societies" and other European stakeholder groups and relevant initiatives, for instance on standardisation.

The FP7 project DRIVER+'s (Driving Innovation in Crisis Management for European Resilience, 2014 – 2020) main aim is to cope with current and future challenges due to increasingly severe consequences of natural disasters and terrorist threats, by the development and uptake of innovative solutions that are addressing the operational needs of practitioners dealing with Crisis Management.

For ASSISTANCE, it provides the following useful features:

- An open source technical infrastructure for supporting trials, life or table-top exercises and trainings (available from GitHub at https://github.com/DRIVER-EU). It includes tools such as a scenario editor, after-action review and observer support tools (animation). In addition, it provides a Trial Guidance Methodology and handbook for helping you setup a new trial or exercise, and online e-learning training modules.
  As this technical infrastructure is build upon Apache Kafka, is it also suitable for supporting life experiments or during operations.
- A community of CM practitioners, CMIME (https://www.cmine.eu), where practitioners and researchers in the field of crisis management can share information.
- A database of CM solutions and trials, the so-called Portfolio of Solutions (PoS), where you can find and discuss existing CM solutions, and learn from past experience. Outcomes of the ASSISTANCE project, such as new solutions, outcomes and lessons learned of experiments, should be shared there as well.

6.11. LETSCROWD

LETSCROWD is a project led by ETRA that overcomes challenges preventing the effective implementation of the European Security Model (ESM) with regards to mass gatherings. This is achieved by providing the following to security policy practitioners and in particular, LEAs:

1. A dynamic risk assessment methodology for the protection of crowds during mass gatherings centred on human factors in order to effectively produce policies and deploy adequate solutions.
2. A policy-making toolkit for the long-term and strategic decision making of security policy makers, including a database of empirical data, statistics and an analytical tool for security policies modelling.
3. A set of human-centred tools for Law Enforcement Agencies (LEAs), including real time crowd behaviour forecasting, innovative communication procedures, semantic intelligence applied to social networks and the internet, and novel computer vision techniques.

LETS-CROWD is a security practitioner driven project, fostering the communication and cooperation among LEAs, first responders, civil protection and citizens in the fight against crime and terrorism during mass gatherings by a set of cooperation actions. The project puts citizens at the centre of the research and assesses and evaluates how security measures affect them, and how they perceive them, while respecting EU fundamental rights.

LETS-CROWD impact is measured under practical demonstrations involving seven LEAs and relevant emergency services units. In order to facilitate the assessment of the performance,

transferability, scalability and large-scale deployment of these solutions, the demonstrations are conducted following eleven use cases.

ETRA, as coordinator of the project, system integrator and responsible of exploitation activities, will make use of the lessons learned and the solutions developed in the project for handling multi-source data streams and communication services among LEAs in order to provide them with advanced Situational Awareness. The experience gained through LETSCROWD will be especially useful for the definition and development of the Sensor Abstraction Service (SAS) that will integrate all data and information coming from different sensors, providing interoperability.

6.12. SAURON

SAURON project proposes the holistic situation awareness concept as an integrated, scalable and yet installation-specific solution for protecting EU ports and its surroundings. This solution combines the more advanced physical SA features with the newest techniques in prevention, detection and mitigation of cyber-threats, including the synthetic cyber space understanding through the use of new visualisation techniques (immersive interfaces, cyber 3D models and so on).

SAURON faces the coordinated and every time more complex terrorist attacks that target many critical infrastructures (CI) (e.g. EU ports) and ICT systems. The impact of a coordinated physical attack, a deliberate disruption of critical automation systems or even a combined scenario including both kind of attacks, could have disastrous consequences for the European Member States' regions and social wellbeing in general.

A Hybrid Situation Awareness (HSA) application capable of determine the potential consequences of any threat will show the potential cascading effect of a detected threat in the two different domains (physical and cyber). On the other hand, through SAURON approach the public in the surroundings and the rescue/security teams will be able to be informed on any potential event/situation that could put in risk their integrity.

Several partners of SAURON (ETRA, UPVLC and THALES) will use the experience gained through the project, especially in the development of Situational Awareness services and tools, 3D models and immersive interfaces. Lessons learned and synergies will be exploited in order to maximise the effectiveness of the tools developed in ASSISTANCE.

6.13. CRM4EMS

Erasmus+ programme Key Action 2 CRM4EMS Project "Crew Resource Management for Emergency Medical Services" The principal aim of the CRM4EMS project is to provide Emergency Medical Services with a resource that they can adapt and utilise within their organisations to improve system and operational safety and help mitigate against the causes of errors that result in adverse events for the public who need to use EMS provision and for EMS professionals too.

CRM4EMS Project will enhance to Human Factors perspective of ASSISTANCE Project; because CRM4EMS Project aims to adapt Crew Resource Management Course that in use in Aviation Sector to Emergency Medical Services. Topics are Situational Awareness, Teamwork, Decision Making, Task Management and Communication.

6.14. CASCEFF

The aim of the FP7 CASCEFF project was to improve understanding of the cascading effects in crisis situations and to reduce the consequences of escalating incidents in complex environments. In order to do this, initiators, dependencies and key decision points were identified. These were used to develop an Incident Evolution Tool which enables improved decision support in escalating incidents, contributing to the reduction of collateral damages and other unfortunate consequences associated with large crises.

6.15. IMPROVER

The overall objective of the H2020 IMPROVER project was to improve European critical infrastructure resilience to crises and disasters through the implementation of resilience concepts to real life examples of pan-European significance, including cross-border examples. The improvement arises through the development of a methodology for implementing combinations of societal, organisational and technological resilience concepts to critical infrastructure based on risk evaluation techniques and informed by a review of the positive impact of different resilience concepts on critical infrastructure.

7. End users feedback on state of the art

The questionnaire has been developed in order to enhance the desk research on the state-of the-art with an overview on the actual state-of-play of the technologies and methods used by the end-users in real-life operations or the ones they are mostly interested in. The ned user partners in the consortium have distributed the questionnaire among their networks and 40 responses to the questionnaire have been gathered. The study participants distribution among the organisation type is shown in Figure 79. The results of the survey are discussed in this chapter and gathered in Annex 9.1.

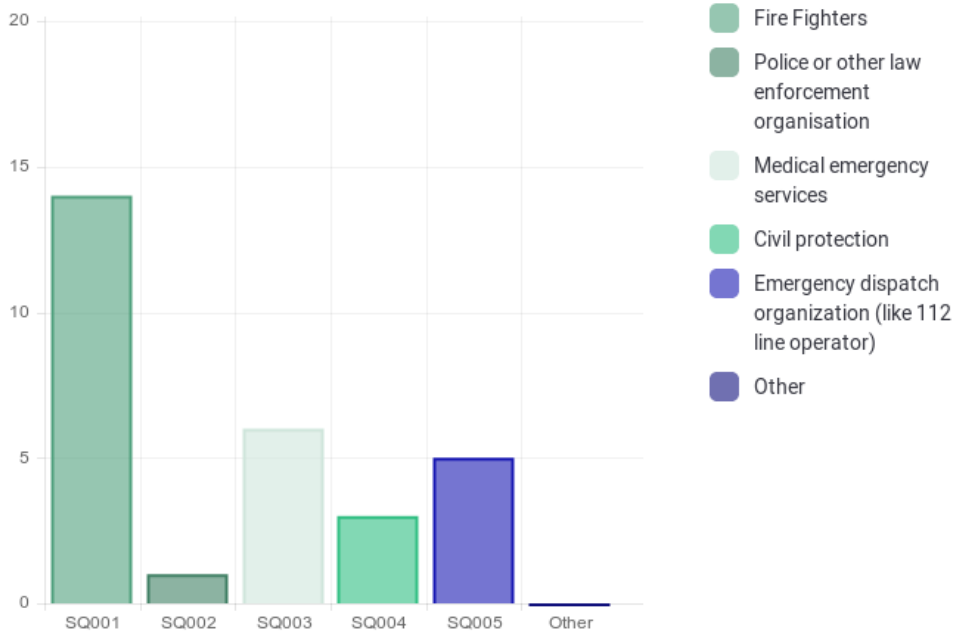


Figure 79 Survey participants by organisation type

Command and Control (C2) technologies used by the first responders are mostly digital maps, emergency vehicles tracking systems and real-time video streaming. Tracking is widely used in all ground ambulances, fire trucks, motorcycles and helicopter ambulances movements.

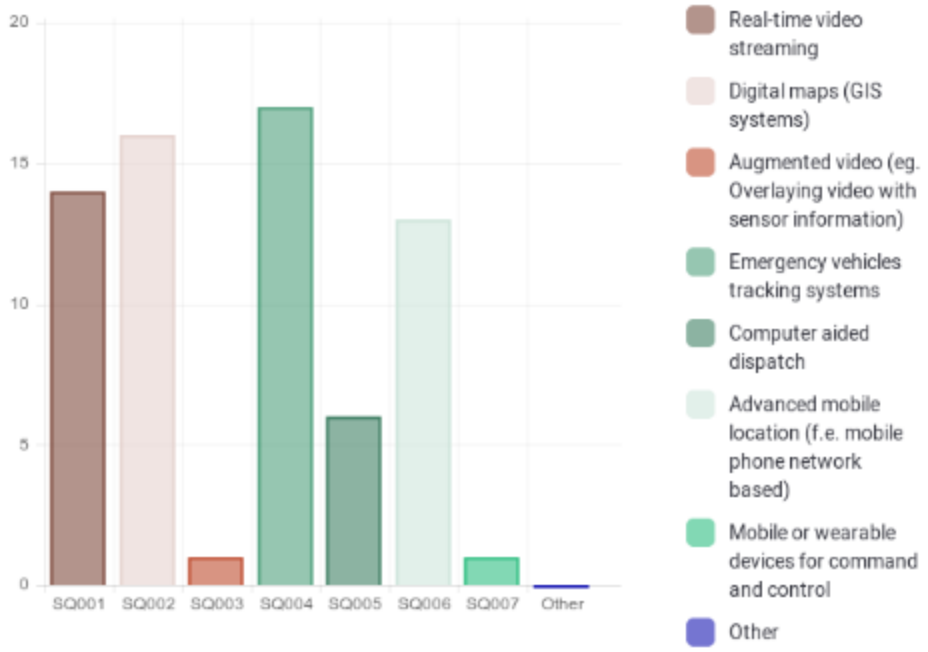


Figure 80 Command and controll technologies used

Communication is covered by radio (mostly APKO and Motorola), GSM/GPRS and satellite (National Medical Rescue Teams – UMKE).

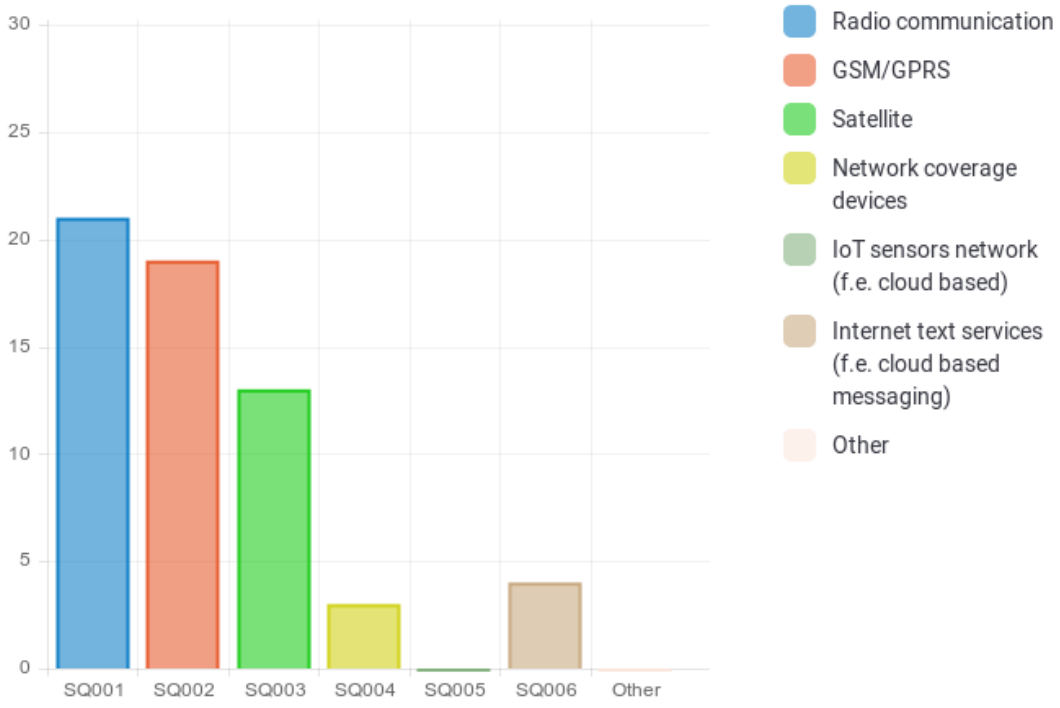


Figure 81 Communication technologies used

In case of unmanned platforms, only drones are used - as a visual assistance during rescue operations and social events. Most of UAVs are light and commercial e.g. Phantom 4, DJI Mavic Pro.

Handheld sensors include CO2 and radioactive detectors, also thermal cameras are a part of equipment.

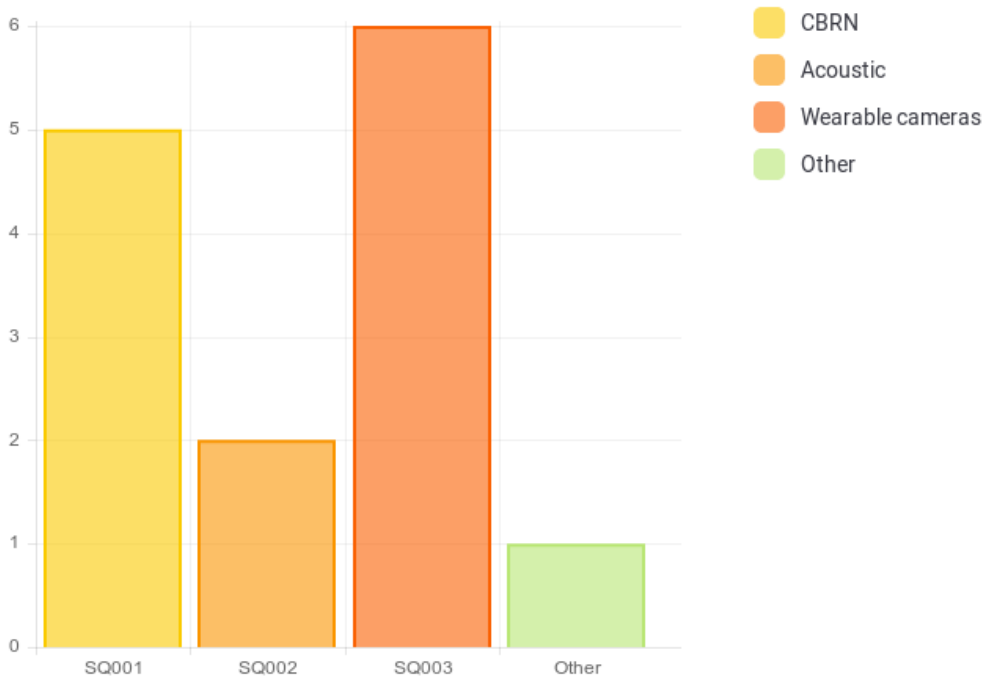


Figure 82 Handheld sensors used

Wearable sensors are as follows: GPS localisation is taken from multiple sources (tablets, phones, radio or a car). Personal video cameras are mainly used by the motorcycle teams. There are also temperature sensors used by firefighters and CBRN detectors.

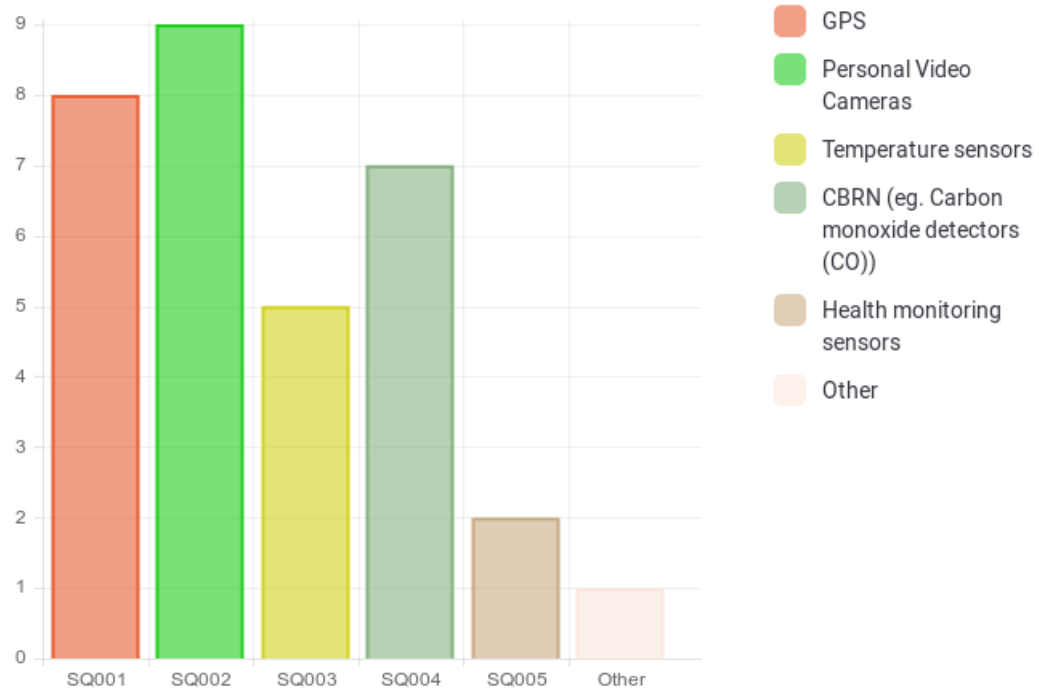


Figure 83 Wearable sensors used

Real live training system is the system that is chosen by the first responders primarily. Sometimes the training is supported by VR technologies and tablet support mannequins.

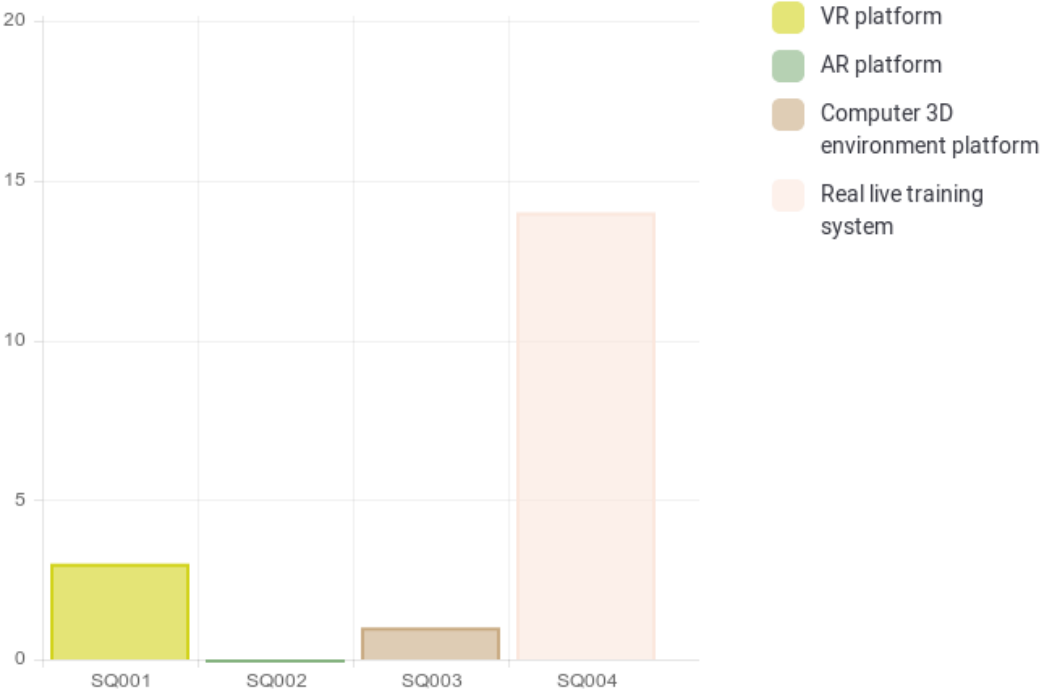


Figure 84 Training.

8. Analysis and conclusions

The results of the questionnaire have provided useful information about the current state-of-play in technologies used by the first responders and also on the needs and interests of end-users in technologies that are either already available or in research. The chart below shows that there is a call to have a more complex Command and Control (C2) technologies to be used in first response operations.

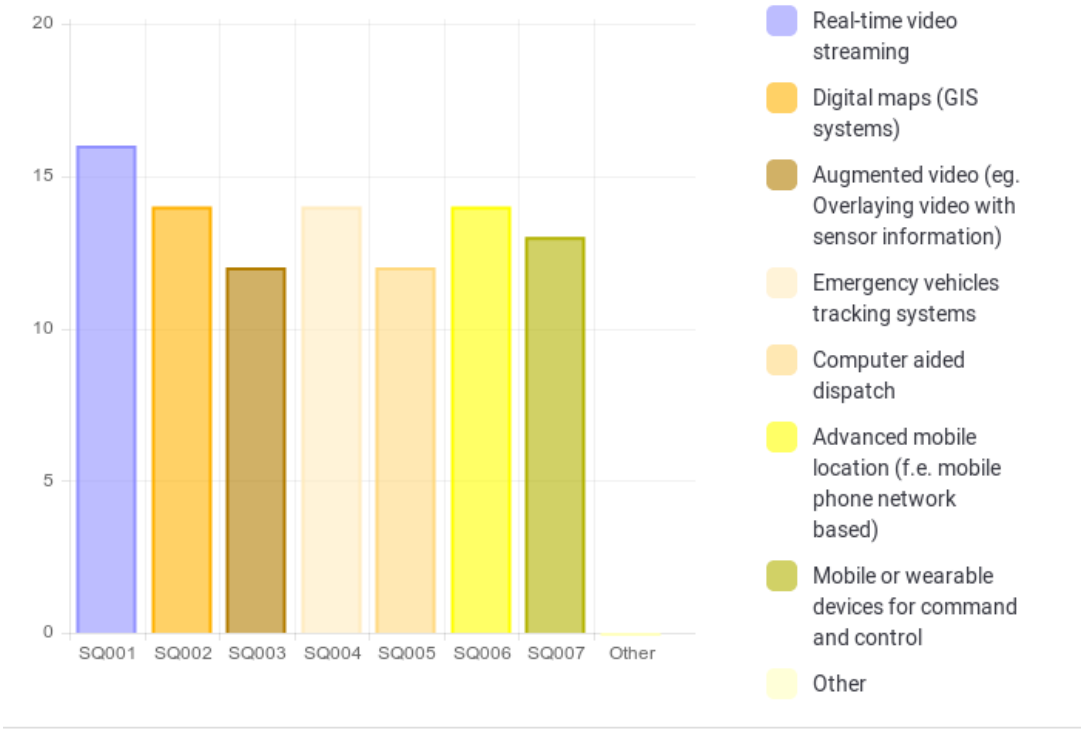


Figure 85 Command and control technologies interesting for end users

There are also gaps to fill in the area of unmanned platforms in case of scanning the dangerous places and searching for people and threats.

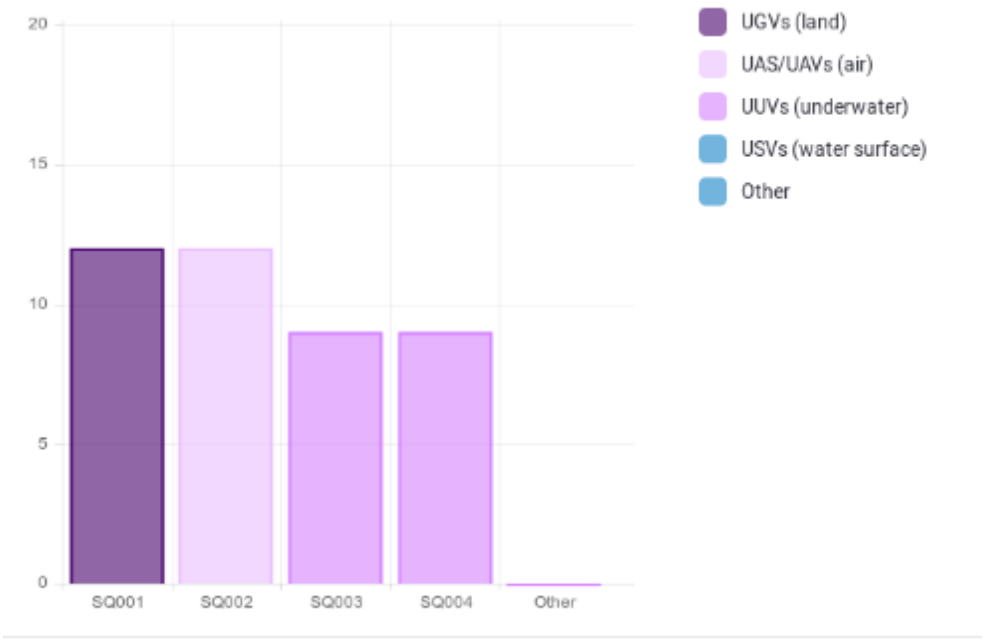


Figure 86 Unmanned platforms that are interesting for end users

With regards to sensors mounted on the platforms:

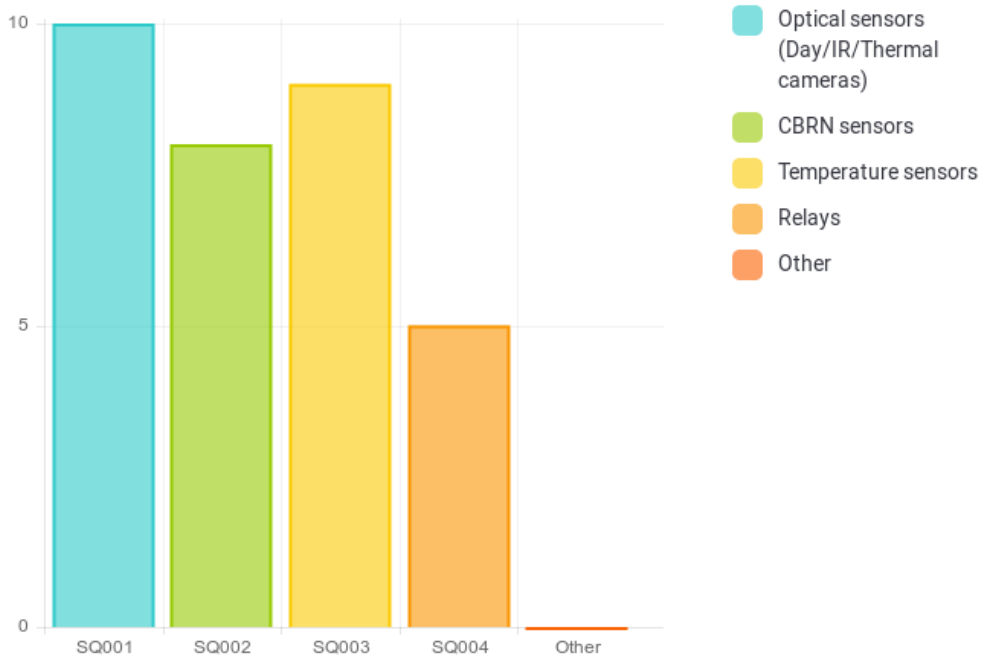


Figure 87 Interesting sensors for unmanned platforms

Providing technologies like VR, AR or computer 3D environment should be useful in training and preparing for operations.

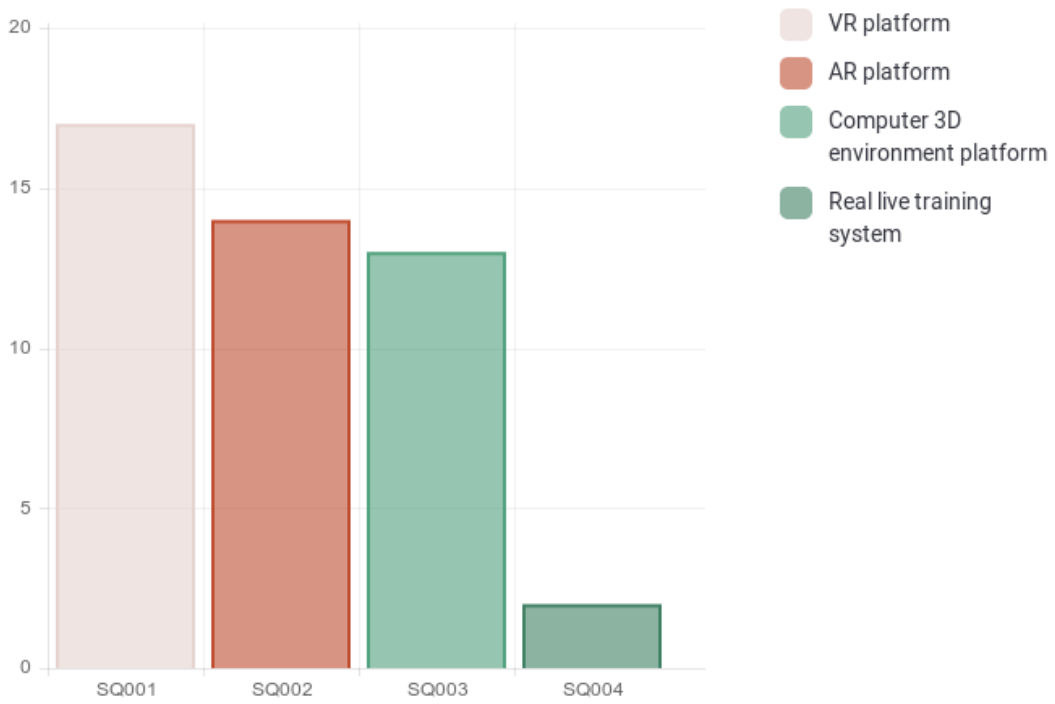


Figure 88 Interesting training tools

9. Annexes

9.1. End user feedback results

Answer	Count	Percentage
Organisation type		
Fire Fighters (SQ001)	14	45.16%
Police or other law enforcement organisation (SQ002)	1	3.23%
Medical emergency services (SQ003)	6	19.35%
Civil protection (SQ004)	3	9.68%
Emergency dispatch organisation (like 112 line operator) (SQ005)	5	16.13%
Other		
Command and Control (C2)	0	0.00%
Real-time video streaming	14	66.67%
Digital maps (GIS systems)	16	76.19%
Augmented video (e.g. Overlaying video with sensor information)	1	4.76%
Emergency vehicles tracking systems	17	80.95%
Computer aided dispatch	6	28.57%
Advanced mobile location (e.g. mobile phone network based)	13	61.90%
Mobile or wearable devices for command and control	1	4.76%
Other		
Communication	0	0.00%
Radio communication	21	100.00%
GSM/GPRS	19	90.48%
Satellite	13	61.90%
Network coverage devices	3	14.29%
IoT sensors network (e.g. cloud based)	0	0.00%
Internet text services (e.g. cloud based messaging)	4	19.05%
Other		
Unmanned platforms	0	0.00%
UGVs (land)	2	14.29%
UAS/UAVs (air)	12	85.71%
UUVs (underwater)	0	0.00%
USVs (water surface)	0	0.00%
Other	0	0.00%
Type		
Ultra-light (< 0.6 kg) (SQ001)	3	25.00%
light (0.6 – 5 kg) (SQ002)	7	58.33%
medium (5 – 25 kg) (SQ003)	2	16.67%
heavy (> 25 kg) (SQ004)	0	0.00%
multi rotor (SQ005)	4	33.33%
single rotor (SQ006)	0	0.00%
fixed wing (SQ007)	0	0.00%
fixed wing hybrid VTOL (SQ008)	0	0.00%
Swarm of drones (SQ009)	0	0.00%

Handheld sensors		
CBRN	5	38.46%
Acoustic	2	15.38%
Wearable cameras	6	46.15%
Other	1	7.69%
Portable situation awareness platform		
Mobile phones	16	80.00%
Tablets	16	80.00%
Other	0	0.00%
Wearable sensors		
GPS	8	47.06%
Personal Video Cameras	9	52.94%
Temperature sensors	5	29.41%
CBRN (e.g. Carbon monoxide detectors (CO))	7	41.18%
Health monitoring sensors	2	11.76%
Other	1	5.88%
Sensors mounted on unmanned platforms		
Optical sensors (Day/IR/Thermal cameras)	4	40.00%
CBRN sensors	0	0.00%
Temperature sensors	1	10.00%
Relays	1	10.00%
Other	1	10.00%
Stand-off sensors		
Radar	0	0.00%
Laser-based (LIDAR, spectroscopy etc.)	1	10.00%
X-Ray	1	10.00%
Acoustic	2	20.00%
Gunshot detection	0	0.00%
Other	0	0.00%
CBRN		
Sensors	3	27.27%
Weather stations	2	18.18%
Computer simulation (e.g.. hazardous cloud dynamics detection)	1	9.09%
Integrated systems	0	0.00%
Other	0	0.00%
Command and Control – willing to use		
Real-time video streaming	16	80.00%
Digital maps (GIS systems)	14	70.00%
Augmented video (e.g.. Overlaying video with sensor information)	12	60.00%
Emergency vehicles tracking systems	14	70.00%
Computer aided dispatch	12	60.00%
Advanced mobile location (e.g. mobile phone network based)	14	70.00%
Mobile or wearable devices for command and control	13	65.00%

Other	0	0.00%
Communication – willing to use		
Radio communication	14	70.00%
GSM/GPRS	15	75.00%
Satellite	14	70.00%
Network coverage devices	8	40.00%
IoT sensors network (e.g.. cloud based)	9	45.00%
Internet text services (e.g. cloud based messaging)	10	50.00%
Other	0	0.00%
Unmanned platforms – willing to use		
UGVs (land)	12	70.59%
UAS/UAVs (air)	12	70.59%
UUVs (underwater)	9	52.94%
USVs (water surface)	9	52.94%
Other	0	0.00%
Handheld sensors – willing to use		
CBRN	11	61.11%
Acoustic	5	27.78%
Wearable cameras	13	72.22%
Other	0	0.00%
Wearable sensors – willing to use		
GPS	11	57.89%
Personal Video Cameras	17	89.47%
Temperature sensors	11	57.89%
CBRN (e.g. Carbon monoxide detectors (CO))	9	47.37%
Health monitoring sensors	13	68.42%
Other	0	0.00%
Sensors mounted on unmanned platforms – willing to use		
Optical sensors (Day/IR/Thermal cameras)	10	66.67%
CBRN sensors	8	53.33%
Temperature sensors	9	60.00%
Relays	5	33.33%
Other	0	0.00%
Stand-off sensors - willing to use		
Radar	2	16.67%
Laser-based (LIDAR, spectroscopy etc.)	3	25.00%
X-Ray	4	33.33%
Acoustic	3	25.00%
Gunshot detection	3	25.00%
Other	0	0.00%
CBRN – willing to use		
Sensors	13	68.42%
Weather stations	10	52.63%
Computer simulation (e.g. hazardous cloud dynamics detection)	12	63.16%
Integrated systems	3	15.79%
Other	0	0.00%

Technology in research – willing to use		
Integrated situation awareness systems	0	0.00%
Command and control	1	9.09%
Communication	0	0.00%
Unmanned platforms	3	27.27%
Sensors and devices	0	0.00%
CBRN hazard evolution assessment	0	0.00%
Other	1	9.09%

Training platform		
VR platform (SQ001)	3	15.00%
AR platform (SQ002)	0	0.00%
Computer 3D environment platform (SQ003)	1	5.00%
Real live training system (SQ004)	14	70.00%

Training platform – willing to use		
VR platform (SQ001)	17	85.00%
AR platform (SQ002)	14	70.00%
Computer 3D environment platform (SQ003)	13	65.00%
Real live training system (SQ004)	2	10.00%

End-users responses:
Summary for G2Q00001

ID	**Response**
10	LiveU (https://www.liveu.tv/)
18	from municipal buildings and our fire management vehicles
24	Only to observe the helicopter ambulance take-off movement
32	Securo (https://stream.securo.eu/), airCCTV 3G/4G (https://aeromind.pl/product-pol-2710-airCCTV-3G-4G.html)
41	Only to observe the helicopter ambulance take-off movement
43	Only to observe the helicopter ambulance take-off movement
44	Mobile Command Control Vehicle
24	All land ambulances movements
32	Securo (https://stream.securo.eu/)
43	All land ambulances movements
18	from municipal buildings
10	GPS in the radiosystem RAKEL (Sweden)
14	e-remiza system.
15	fire - fighting application e remiza in the car
18	In the national 112 system
32	4Hawks, Trackimo
38	Ground ambulances, motocycles and air ambulances
39	Arvento Mobile Systems
41	All ground ambulances, motorcycles and helicopter ambulances movements
44	All fire trucks
48	E remiza
18	In the National 112 system
39	Armakom information technologies
14	localisation fireman's and fire truck
15	fire - fighting application e remiza in the car
18	In the national 112 system
24	100 meters-500 meters
38	100 meters-1km.(Determines the number of base stations

41	100 meters-500 meters
43	100-500 meters
44	10-500 METERS
46	100-500 METERS
47	100 meters-500 meters
45	100-500 meters

Summary for G2Q00002

ID	Response
10	RAKEL (national system of Sweden) and closerange radion for firefighters.
14	motorola system
15	motorola system
18	In the Swedish national safe radio "Rakel" (Tetra)
32	Motorola TLKR T40,
34	Motorola
38	Digital APCO 25/ASELSAN for EMS ; analog system for technical support teams
39	APCO 25
40	ASELSAN APCO 25
41	Digital APCO 25/ASELSAN for EMS ; analog system for technical support teams
48	Motorolla
14	tablet in the car
15	special tablet in the fire truck
18	Public network
34	Garmin
38	TURKCELL
41	TURKCELL
48	E remiza
24	For only National Medical Rescue Teams (UMKE)
32	EGNOS, Galileo, GPS, ASG-EUPOS
34	only during international misssions- Thuraya, B- gan
38	National Medical Rescue Teams (UMKE)
41	For only National Medical Rescue Teams (UMKE)
45	Some special intervention police cars
10	In the cars
18	Public network
10	Ipad and Iphone
14	chat e remiza,
45	Bulk message system over service providers
48	E remiza

Summary for G2Q00003

ID	Response
44	Robotic
10	DJI Mavic pro and DJI Mavic 2 enterprise Dual
14	test, DJI Spark, visual assistance during rescue operations
15	DJI Spark drone tested during rescue operations
18	To some extent, agreements with private companies
32	Yuneeec Typhoon H, Yuneec Typhoon H520, DJI Inspire 1, Phantom 4,
34	DJi
44	Drone
45	Using drones some cases in social events.

Summary for G2Q00006

ID	Response
10	Dräger
18	Find radioactive radiation
44	CO2 dedectors
44	Radio frequency
14	thermovision's camera Flir company
15	three thermovision camera Filr search and rescue
18	Flir systems, Look for glow and fire
34	thermal cameras
48	Kamera termowizyja Flir E5xt
10	FLIR

Summary for G2Q00007

ID	Response
10	Iphone
14	private and aplication e remiza
15	and special application e remiza
18	Under all kinds of assignments
32	Samsung Galaxy J2,
10	Ipad
14	samsung solid in the car
15	and special application e remiza. In the fire truck.
18	Under all kinds of assignments, comand and control
32	Lenovo Tab2, Crystal Sky
48	Samsung tablet

Summary for G2Q00008

ID	Response
10	In the radio
14	in the car and and phone
15	mobile phones and special application e remiza. All firefighters see on the map where I am
18	All vehicles and boats (100 units)
32	Garmin GPSMAP 62
14	camera on the helmet
38	Motocycle teams (GoPro)
39	Motocycle teams (GoPro)
41	GoPro for only motorcycle teams
42	Motocycle Teams (GoPro)
10	FLIR
18	Flir systems, Look for glow and fire
10	Dräger (only during CBRNE event)
14	personal detector, MSA Auer
18	In case of chemical accidents
48	MSA Altair 4x4
15	watch Garmin Fenix 3 HR, heart rhythm monitoring
18	Flir systems, Look for glow and fire
10	On fire fighters to detekt if they stop moning = Sound

Summary for G2Q00009

ID	Response
10	Thermal on our UAV DJI Mavic 2 enterprise dual.
34	3 D cameras

	CGOET (thermal camera for Typhoon H https://aeromind.pl/product-eng-8-Dron-Yuneec-Typhoon-H-with-CGOET-Thermal-camera.html)
32	
10	For longer radio coverage in all cars
15	camera HD Ready in the dron DJI Spark

Summary for G2Q00010

ID	Response
34	geophones

Summary for G2Q00011

ID	Response
10	Dräger
44	Drager sensor
10	RIB (https://rib.msb.se/)

Summary for G3Q00001

ID	Response
15	assisting in the management of the rescue operation
24	1
15	assisting in the management of the rescue operation
24	2
15	assisting in the management of the rescue operation
24	4
18	There are fully automatic systems to find the nearest vehicle faster
24	3
15	assisting in the management of the rescue operation
15	assisting in the management of the rescue operation

Summary for G3Q00002

ID	Response
24	1
15	assisting in the management of the rescue operation
24	2
15	a modern way of organizing a rescue operation
24	3
24	4
15	a quick way of notifying a large number of people
24	5

Summary for G3Q00003

ID	Response
15	irreplaceable in dangerous places
18	We need different types of robots during fires and accidents
32	https://centauro-project.eu/,
34	for CBRN
	a quick way to watch the rescue action, in conjunction with a thermal imaging
15	camera a good search device
34	fixed wings- fuselage
15	searching for people and threats
15	searching for people and threats

Summary for G3Q00004

ID	Response
34	on uniform/ helmet

Summary for G3Q00005

ID	Response
15	programs and applications supporting the rescue operation
15	programs and applications supporting the rescue operation

Summary for G3Q00006

ID	Response
18	Increases the safety of our staff during operations and improves follow-up
32	https://www.rosenbauer.com/en/int/rosenbauer-world/products/equipment/firefighting-helmets/heros-titan https://www.qwake.tech/ , https://www.rosenbauer.com/en/int/rosenbauer-world/products/equipment/thermal-imaging-cameras/helmet-mounted-c1-thermal-imaging-camera
32	
39	National Medical Rescue Team (UMKE)

Summary for G3Q00007

ID	Response
18	Great need during various types of accidents
10	On drones
18	Great need during various types of accidents
18	Great need during various types of accidents
18	Great need during various types of accidents

Summary for G3Q00009

ID	Response
18	Great need during various types of accidents
18	Important to be able to train our staff
34	to allow monitoring current location of rescuer versus CBRN threats source

Summary for G4Q00001

ID	Response
32	https://www.drone-hopper.com/firefighting-drones, https://www.flycontrol.fr/contac , AMSD (Autonomic Modular Scouting Drone), https://abstracts.societyforscience.org/Home/PrintPdf/16903
42	UAV
45	Using drones in all social events, demonstrations, accidents etc.
32	DARIUS (Deployable SAR Integrated Chain with Unmanned Systems), CRISMA (Modeling crisis management for improved action and preparedness), AIRBEAM (AIRborne information for Emergency situation Awareness and Monitoring), AIROBOTS (Innovative aerial service robots for remote inspections by contact), OPARUS (Open Architecture for UAV-based Surveillance System), CLOSE-SEARCH (Accurate and safe EGNOS-SoL Navigation for UAV-based low-cost SAR operations), DITSEF (Digital & innovative technologies for security & efficiency of first responder operations), ICARUS (Integrated Components for Assisted Rescue and Unmanned Search operations), 10-FireSpec (Integrated spectroscopic sensors for the risk assessment of fires), SURVEIRON (Advanced surveillance system for the protection of urban soft targets and urban critical infrastructures),

EC-SAFEMOBIL (Estimation and control for safe wireless high mobility cooperative industrial systems),
TIRAMISU,
BERISUAS (Better Response and Improved Safety through Unmanned Aircraft Systems),
RECONASS (Reconstruction and REcovery Planning: Rapid and Continuously Updated COnstruction Damage, and Related Needs ASSessment),
ROLFER (RObotic Lifeguard For Emergency Rescue),
SafeShore,
MOBNET(MOBile NETwork for people's location in natural and man-made disasters),
SAFEDAM,
EENA-DJI Pilot Project,
ANCHORS UAV-Assisted Ad Hoc Networks for Crisis Management and Hostile Environment Sensing,
FIRE-RS (Wildfire Picosatellite Constellation & UAVs Remote Sensing: Active fire mapping and management),
EffFeu (Efficient Operation of Unmanned)

Summary for G5Q00001

ID	Response
15	first aid training in the e platform
18	Training is done at our training facilities
32	none
42	Tablet support mannequins

Summary for G6Q00002

ID	Response
15	first aid training application
18	There is access to this in Sweden but is under construction
32	VR platform - RealFlight Drone, http://cmgi.eu/pl/produkty/straton-wojsko/straton-bsp/
34	VR based on VBS3 system- developer CMGI polish company - simulator of UAV operator

Summary for G7Q00001

ID	Response
18	We handle a large number of different types of accidents. It can be fires or traffic accidents, cardiac arrest, environmental damage, race and landslides. There are recommended plans that can be changed depending on the type of event. The accidents are led from our alarm center. The staff there ensures that the correct recipe to manage an accident is used. Our officer in our alarm center is the one who has the main responsibility
32	- JARUS guidelines on Specific Operations Risk Assessment (SORA) - Manual on Remotely Piloted Aircraft Systems (RPAS), Doc 10019, ICAO, Montreal 2015 - Safety Management Manual (SMM) (Doc 9859) ICAO - Unmanned Aircraft Systems (UAS), Cir 328, ICAO, Montreal 2011,
38	Directive of Emergency Call Center Services - 112 Single number call center, Regulation on Emergency Health Services - Provincial level organization, Emergency Call Center Services Directive - Standards of ambulances type, stations and personal, Provincial Health Disaster and Emergency Plans Directive - 112

	Single number call center, TS- 1295 standard - VHF Radio, EN-1789 standard - Road Ambulance- medical vehicles and their equipment.
39	Regulation of Emergency Medical Services - EMS operation and organization, Directive of Emergency Call Center Services - 112 Single number call center, Provincial Health Disaster and Emergency Plans Directive - Provincial level organization, Regulation of Ambulances and Emergency Medical Vehicles - Standards of ambulances type, stations and personal, TS- 1295 standard - VHF Radio, EN-1789 standard - Road Ambulance- medical vehicles and their equipment
40	Regulation of Emergency Medical Services - EMS operation and organization, Directive of Emergency Call Center Services - 112 Single number call center, TS-1295 standard - VHF Radio, EN-1789 standard - Road Ambulance- medical vehicles and their equipment

Summary for G7Q00002

ID	Response
18	We have hundreds of different plans and it's hard to list all. The sites are in the national 112 system
32	- wytyczne nr 1 Prezesa Urzędu Lotnictwa Cywilnego z dnia 4 lutego 2019 r. w sprawie prowadzenia szkolenia lotniczego do uzyskania świadectwa kwalifikacji operatora bezzałogowego statku powietrznego używanego w celach innych niż rekreacyjne lub sportowe (UAVO) oraz uprawnień wpisywanych do tego świadectwa, DZ. URZ. 2019.11, http://edziennik.ulc.gov.pl/#/legalact/2019/11/ - JARUS SORA STS-01 for Aerial Work Operations - JARUS guidelines on Specific Operations Risk Assessment (SORA) - Manual on Remotely Piloted Aircraft Systems (RPAS), Doc 10019, ICAO, Montreal 2015 - Safety Management Manual (SMM) (Doc 9859) ICAO - Unmanned Aircraft Systems (UAS), Cir 328, ICAO, Montreal 2011, - internal operational instruction (INOP) and checklists
38	Notification of Paramedik and EMT working procedures and principles, Radio operation manual of EMS staff
39	Notification of Paramedik and EMT working procedures and principles, Radio operation manual of EMS staff

Summary for G8Q00001

ID	Response
15	my organization is comprehensive, we participate in a large number of rescue operations. (about 400 a year)
18	You ask for specific products in this survey, in some cases we could point out what we want It is not possible to respond to the level of detail requested. It would take weeks of investigation to do it.

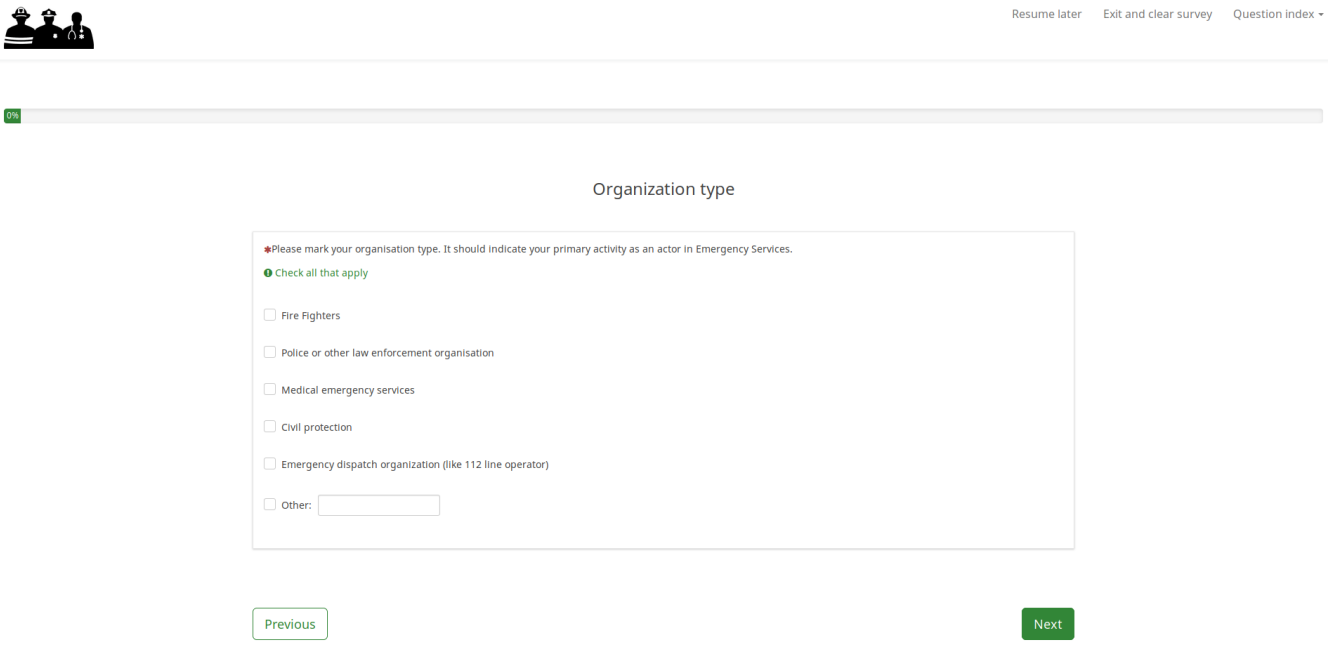
Summary for G2Q00004

Answer	Count	Percentage
Ultra-light (< 5 kg) (SQ001)	1	7.14%
light (5 – 40 kg) (SQ002)	3	21.43%
medium (40 – 500 kg) (SQ003)	0	0.00%
heavy (> 500 kg) (SQ004)	0	0.00%
Tracked (SQ005)	2	14.29%
Wheeled (SQ006)	0	0.00%
“Snake like” (SQ007)	0	0.00%
Walking (legged) (SQ008)	0	0.00%
	Count	Percentage

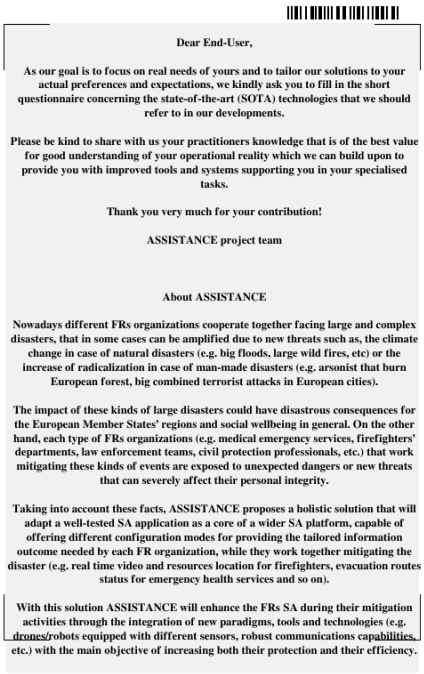
Summary for G2Q00005

Answer		
Ultra-light (< 0.6 kg) (SQ001)	3	25.00%
light (0.6 – 5 kg) (SQ002)	7	58.33%
medium (5 – 25 kg) (SQ003)	2	16.67%
heavy (> 25 kg) (SQ004)	0	0.00%
multi rotor (SQ005)	4	33.33%
single rotor (SQ006)	0	0.00%
fixed wing (SQ007)	0	0.00%
fixed wing hybrid VTOL (SQ008)	0	0.00%
Swarm of drones (SQ009)	0	0.00%

9.2. Questionnaire (web version)



The screenshot above show general look of web version of questionare. Below there is an export of all questions, those while beeing filled online would look similar to screenshot above.



Dear End-User,

As our goal is to focus on real needs of yours and to tailor our solutions to your actual preferences and expectations, we kindly ask you to fill in the short questionnaire concerning the state-of-the-art (SOTA) technologies that we should refer to in our developments.

Please be kind to share with us your practitioners knowledge that is of the best value for good understanding of your operational reality which we can build upon to provide you with improved tools and systems supporting you in your specialised tasks.

Thank you very much for your contribution!

ASSISTANCE project team

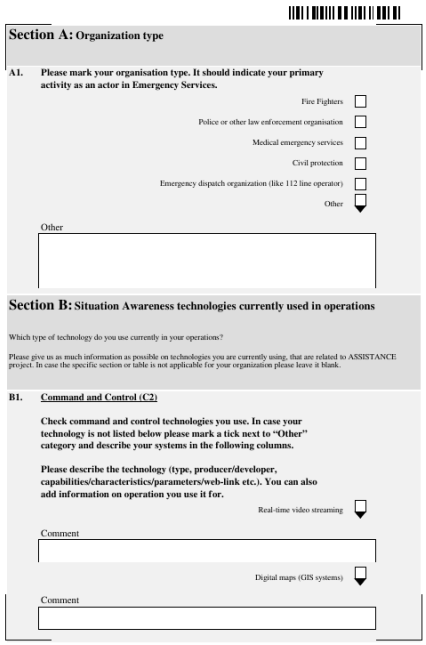
About ASSISTANCE

Nowadays different FRs organizations cooperate together facing large and complex disasters, that in some cases can be amplified due to new threats such as, the climate change in case of natural disasters (e.g. big floods, large wild fires, etc) or the increase of radicalization in case of man-made disasters (e.g. arsonist that burn European forest, big combined terrorist attacks in European cities).

The impact of these kinds of large disasters could have disastrous consequences for the European Member States' regions and social wellbeing in general. On the other hand, each type of FRs organizations (e.g. medical emergency services, firefighters' departments, law enforcement teams, civil protection professionals, etc.) that work mitigating these kinds of events are exposed to unexpected dangers or new threats that can severely affect their personal integrity.

Taking into account these facts, ASSISTANCE proposes a holistic solution that will adapt a well-tested SA application as a core of a wider SA platform, capable of offering different configuration modes for providing the tailored information outcome needed by each FR organization, while they work together mitigating the disaster (e.g. real time video and resources location for firefighters, evacuation routes status for emergency health services and so on).

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



Section A: Organization type

A1. Please mark your organisation type. It should indicate your primary activity as an actor in Emergency Services.

- Fire Fighters ☐
- Police or other law enforcement organisation ☐
- Medical emergency services ☐
- Civil protection ☐
- Emergency dispatch organization (like 112 line operator) ☐
- Other ☐

Other

Section B: Situation Awareness technologies currently used in operations

Which type of technology do you use currently in your operations?

Please give us as much information as possible on technologies you are currently using, that are related to ASSISTANCE project. In case the specific section or table is not applicable for your organization please leave it blank.

B1. Command and Control (C2)

Check command and control technologies you use. In case your technology is not listed below please mark a tick next to "Other" category and describe your systems in the following columns.

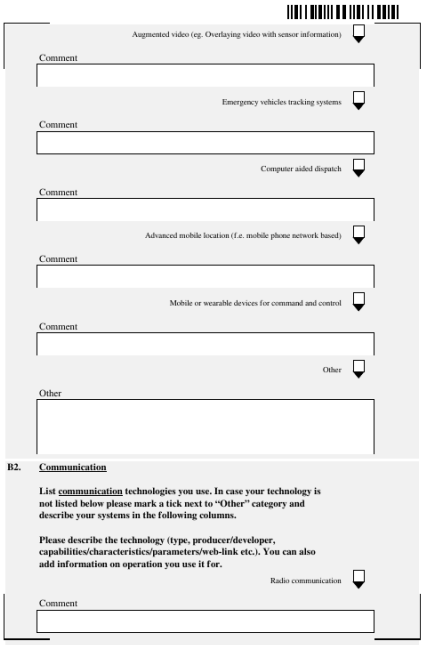
Please describe the technology (type, producer/developer, capabilities/characteristics/parameters/web-link etc.). You can also add information on operation you use it for.

- Real-time video streaming ☐

Comment

- Digital maps (GIS systems) ☐

Comment



- Augmented video (eg. Overlaying video with sensor information) ☐

Comment

- Emergency vehicles tracking systems ☐

Comment

- Computer aided dispatch ☐

Comment

- Advanced mobile location (f.e. mobile phone network based) ☐

Comment

- Mobile or wearable devices for command and control ☐

Comment

- Other ☐

Other

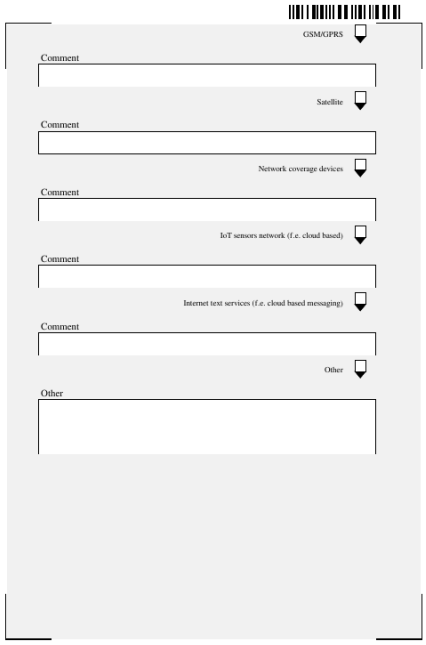
B2. Communication

List communication technologies you use. In case your technology is not listed below please mark a tick next to "Other" category and describe your systems in the following columns.

Please describe the technology (type, producer/developer, capabilities/characteristics/parameters/web-link etc.). You can also add information on operation you use it for.

- Radio communication ☐

Comment



- GSM/GPRS ☐

Comment

- Satellite ☐

Comment

- Network coverage devices ☐

Comment

- IoT sensors network (f.e. cloud based) ☐

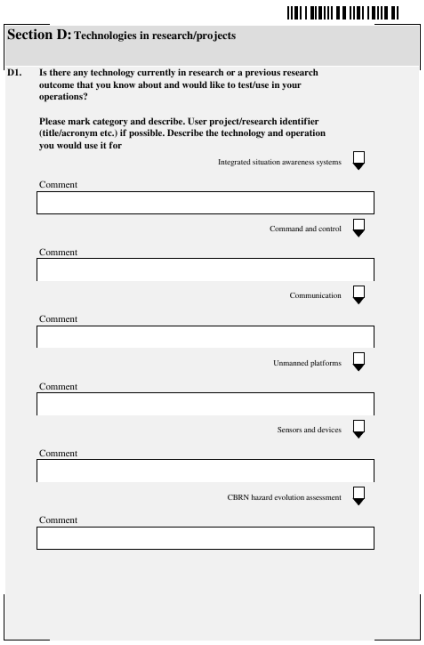
Comment

- Internet text services (f.e. cloud based messaging) ☐

Comment

- Other ☐

Other

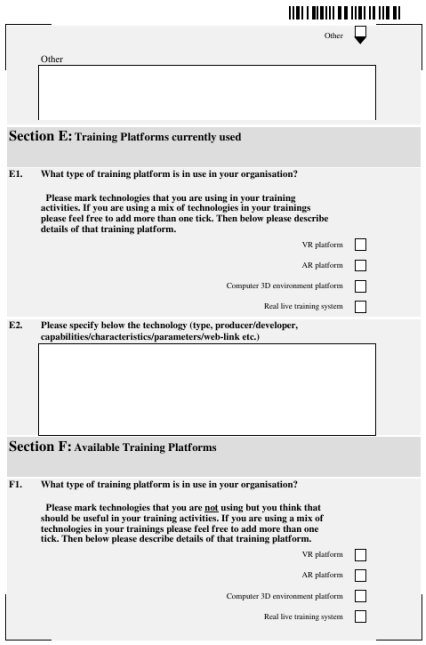


Section D: Technologies in research/projects

D1. Is there any technology currently in research or a previous research outcome that you know about and would like to test/use in your operations?

Please mark category and describe. User project/research identifier (title/acronym etc.) if possible. Describe the technology and operation you would use it for

- Integrated situation awareness systems ☐
  - Comment
- Command and control ☐
  - Comment
- Communication ☐
  - Comment
- Unmanned platforms ☐
  - Comment
- Sensors and devices ☐
  - Comment
- CBRN hazard evolution assessment ☐
  - Comment



- Other ☐

Other

Section E: Training Platforms currently used

E1. What type of training platform is in use in your organisation?

Please mark technologies that you are using in your training activities. If you are using a mix of technologies in your trainings please feel free to add more than one tick. Then below please describe details of that training platform.

- VR platform ☐
- AR platform ☐
- Computer 3D environment platform ☐
- Real live training system ☐

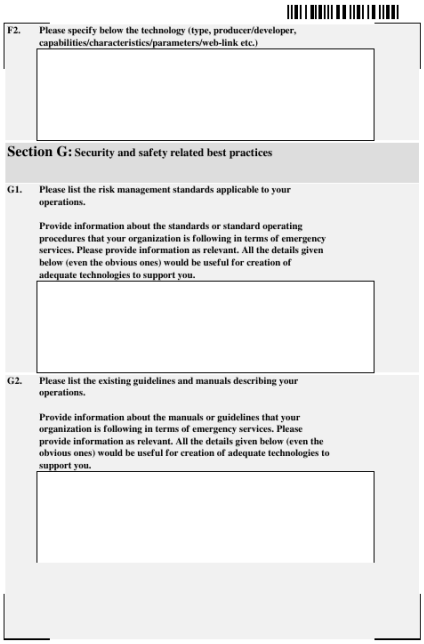
E2. Please specify below the technology (type, producer/developer, capabilities/characteristics/parameters/web-link etc.)

Section F: Available Training Platforms

F1. What type of training platform is in use in your organisation?

Please mark technologies that you are <u>not</u> using but you think that should be useful in your training activities. If you are using a mix of technologies in your trainings please feel free to add more than one tick. Then below please describe details of that training platform.

- VR platform ☐
- AR platform ☐
- Computer 3D environment platform ☐
- Real live training system ☐



F2. Please specify below the technology (type, producer/developer, capabilities/characteristics/parameters/web-link etc.)

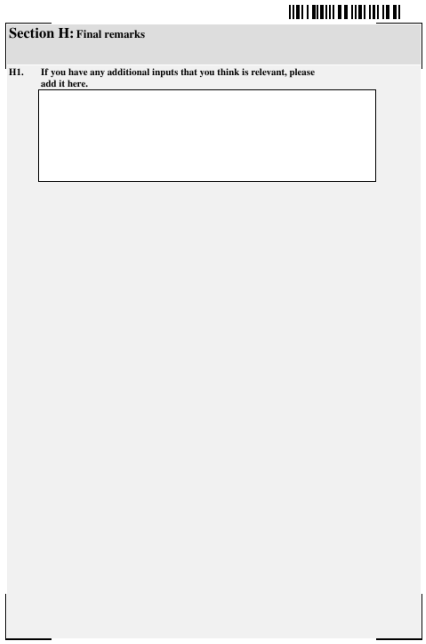
Section G: Security and safety related best practices

G1. Please list the risk management standards applicable to your operations.

Provide information about the standards or standard operating procedures that your organization is following in terms of emergency services. Please provide information as relevant. All the details given below (even the obvious ones) would be useful for creation of adequate technologies to support you.

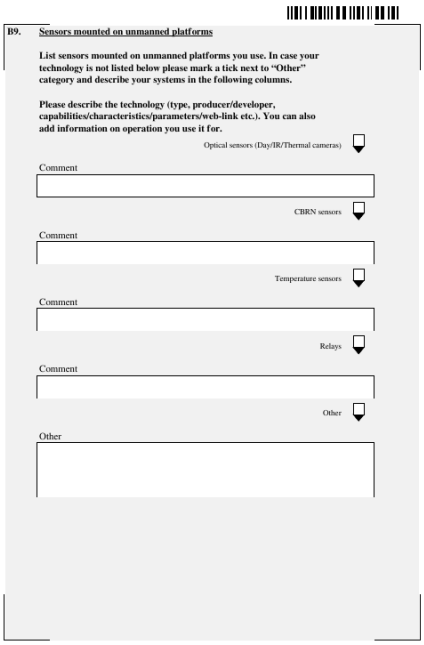
G2. Please list the existing guidelines and manuals describing your operations.

Provide information about the manuals or guidelines that your organization is following in terms of emergency services. Please provide information as relevant. All the details given below (even the obvious ones) would be useful for creation of adequate technologies to support you.



Section H: Final remarks

H1. If you have any additional inputs that you think is relevant, please add it here.



B9. Sensors mounted on unmanned platforms

List sensors mounted on unmanned platforms you use. In case your technology is not listed below please mark a tick next to "Other" category and describe your systems in the following columns.

Please describe the technology (type, producer/developer, capabilities/characteristics/parameters/web-link etc.). You can also add information on operation you use it for.

Optical sensors (Day/IR/Thermal cameras) ☐

Comment

CBRN sensors ☐

Comment

Temperature sensors ☐

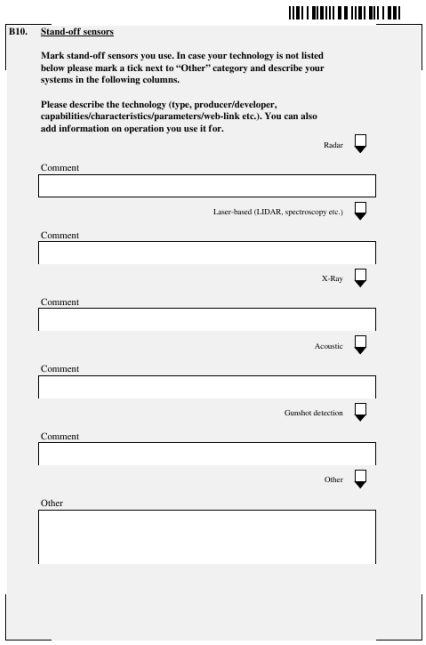
Comment

Relays ☐

Comment

Other ☐

Other



B10. Stand-off sensors

Mark stand-off sensors you use. In case your technology is not listed below please mark a tick next to "Other" category and describe your systems in the following columns.

Please describe the technology (type, producer/developer, capabilities/characteristics/parameters/web-link etc.). You can also add information on operation you use it for.

Radar ☐

Comment

Laser-based (LIDAR, spectroscopy etc.) ☐

Comment

X-Ray ☐

Comment

Acoustic ☐

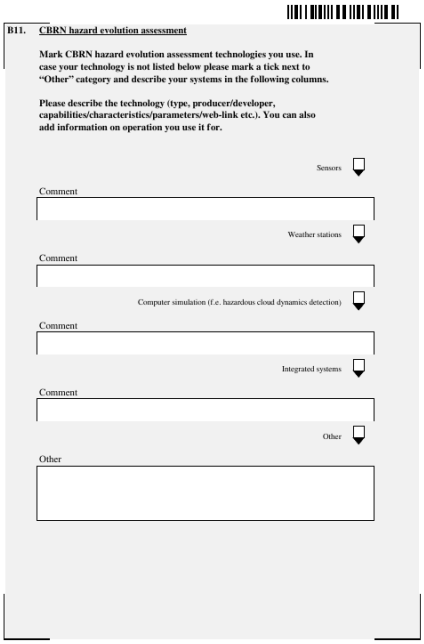
Comment

Gunshot detection ☐

Comment

Other ☐

Other



B11. CBRN hazard evolution assessment

Mark CBRN hazard evolution assessment technologies you use. In case your technology is not listed below please mark a tick next to "Other" category and describe your systems in the following columns.

Please describe the technology (type, producer/developer, capabilities/characteristics/parameters/web-link etc.). You can also add information on operation you use it for.

Sensors ☐

Comment

Weather stations ☐

Comment

Computer simulation (f.e. hazardous cloud dynamics detection) ☐

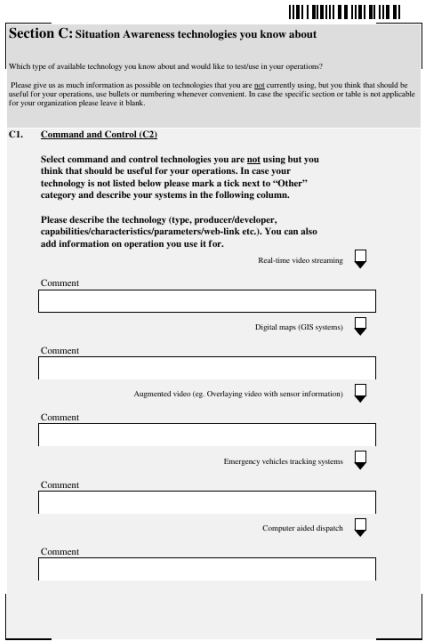
Comment

Integrated systems ☐

Comment

Other ☐

Other



Section C: Situation Awareness technologies you know about

Which type of available technology you know about and would like to test/use in your operations?

Please give us as much information as possible on technologies that you are not currently using, but you think that should be useful for your operations, use bullets or numbering whenever convenient. In case the specific section or table is not applicable for your organization please leave it blank.

C1. Command and Control (C2)

Select command and control technologies you are not using but you think that should be useful for your operations. In case your technology is not listed below please mark a tick next to "Other" category and describe your systems in the following column.

Please describe the technology (type, producer/developer, capabilities/characteristics/parameters/web-link etc.). You can also add information on operation you use it for.

Real-time video streaming ☐

Comment

Digital maps (GIS systems) ☐

Comment

Augmented video (eg. Overlaying video with sensor information) ☐

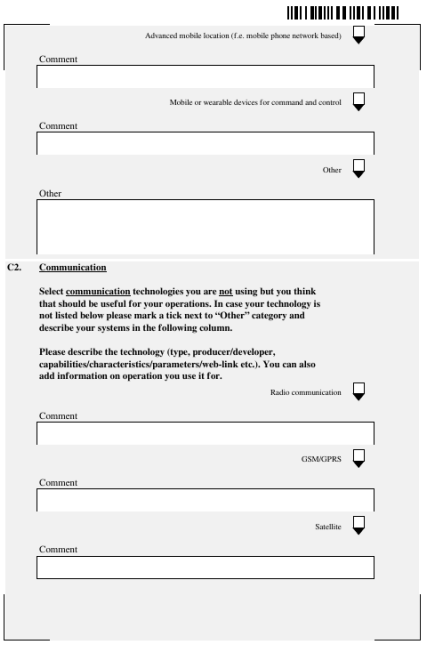
Comment

Emergency vehicles tracking systems ☐

Comment

Computer aided dispatch ☐

Comment



Advanced mobile location (f.e. mobile phone network based)

Comment

Mobile or wearable devices for command and control

Comment

Other

Other

C2. Communication

Select communication technologies you are not using but you think that should be useful for your operations. In case your technology is not listed below please mark a tick next to "Other" category and describe your systems in the following column.

Please describe the technology (type, producer/developer, capabilities/characteristics/parameters/web-link etc.). You can also add information on operation you use it for.

Radio communication

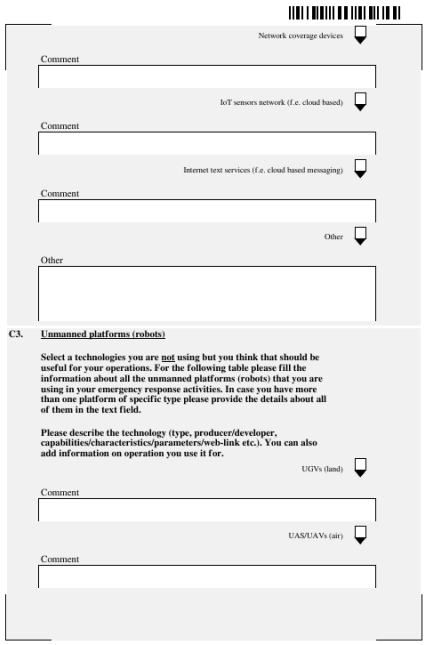
Comment

GSM/GPRS

Comment

Satellite

Comment



Network coverage devices

Comment

IoT sensors network (f.e. cloud based)

Comment

Internet text services (f.e. cloud based messaging)

Comment

Other

Other

C3. Unmanned platforms (robots)

Select a technologies you are not using but you think that should be useful for your operations. For the following table please fill the information about all the unmanned platforms (robots) that you are using in your emergency response activities. In case you have more than one platform of specific type please provide the details about all of them in the text field.

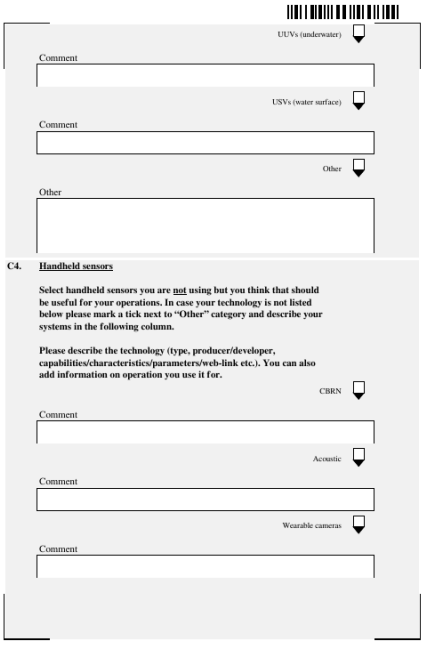
Please describe the technology (type, producer/developer, capabilities/characteristics/parameters/web-link etc.). You can also add information on operation you use it for.

UGVs (land)

Comment

UAS/UAVs (air)

Comment



UUVs (underwater)

Comment

USVs (water surface)

Comment

Other

Other

C4. Handheld sensors

Select handheld sensors you are not using but you think that should be useful for your operations. In case your technology is not listed below please mark a tick next to "Other" category and describe your systems in the following column.

Please describe the technology (type, producer/developer, capabilities/characteristics/parameters/web-link etc.). You can also add information on operation you use it for.

CBRN

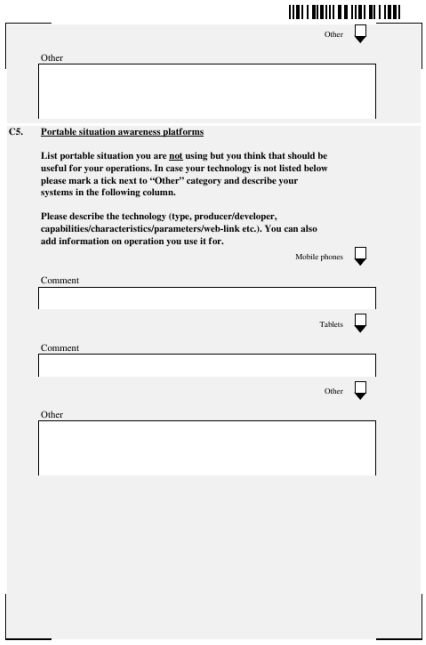
Comment

Acoustic

Comment

Wearable cameras

Comment



Other

Other

C5. Portable situation awareness platforms

List portable situation you are not using but you think that should be useful for your operations. In case your technology is not listed below please mark a tick next to "Other" category and describe your systems in the following column.

Please describe the technology (type, producer/developer, capabilities/characteristics/parameters/web-link etc.). You can also add information on operation you use it for.

Mobile phones

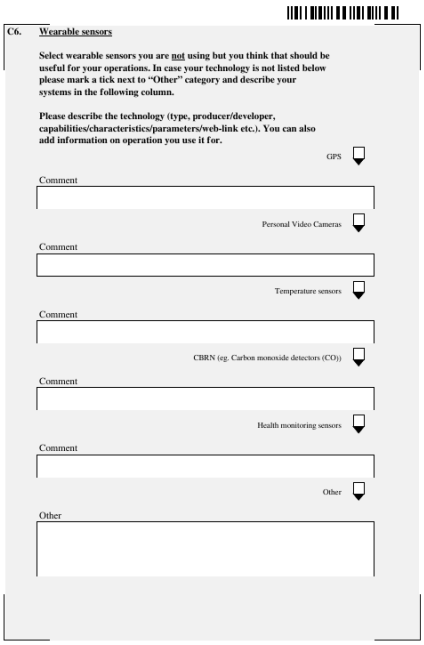
Comment

Tablets

Comment

Other

Other



C6. **Wearable sensors**

Select wearable sensors you are not using but you think that should be useful for your operations. In case your technology is not listed below please mark a tick next to "Other" category and describe your systems in the following column.

Please describe the technology (type, producer/developer, capabilities/characteristics/parameters/web-link etc.). You can also add information on operation you use it for.

GPS ☐

Comment

Personal Video Cameras ☐

Comment

Temperature sensors ☐

Comment

CBRN (eg. Carbon monoxide detectors (CO)) ☐

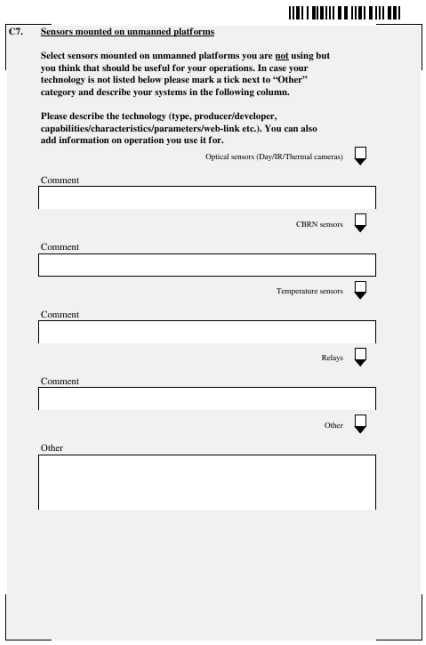
Comment

Health monitoring sensors ☐

Comment

Other ☐

Other



C7. **Sensors mounted on unmanned platforms**

Select sensors mounted on unmanned platforms you are not using but you think that should be useful for your operations. In case your technology is not listed below please mark a tick next to "Other" category and describe your systems in the following column.

Please describe the technology (type, producer/developer, capabilities/characteristics/parameters/web-link etc.). You can also add information on operation you use it for.

Optical sensors (Day/IR/Thermal cameras) ☐

Comment

CBRN sensors ☐

Comment

Temperature sensors ☐

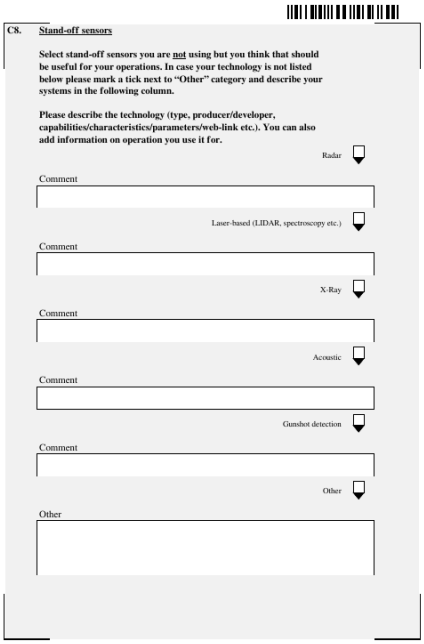
Comment

Relays ☐

Comment

Other ☐

Other



C8. **Stand-off sensors**

Select stand-off sensors you are not using but you think that should be useful for your operations. In case your technology is not listed below please mark a tick next to "Other" category and describe your systems in the following column.

Please describe the technology (type, producer/developer, capabilities/characteristics/parameters/web-link etc.). You can also add information on operation you use it for.

Radar ☐

Comment

Laser-based (LIDAR, spectroscopy etc.) ☐

Comment

X-Ray ☐

Comment

Acoustic ☐

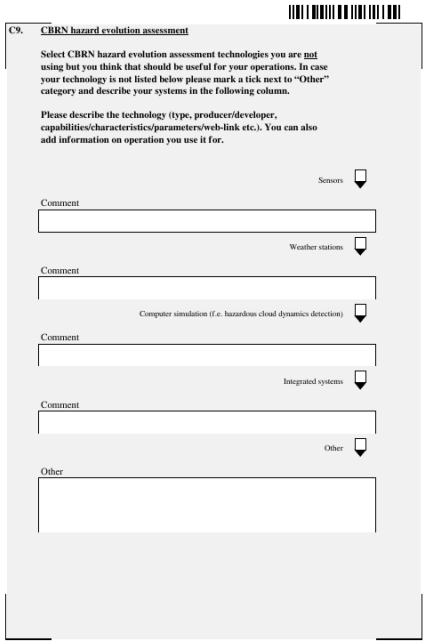
Comment

Gunshot detection ☐

Comment

Other ☐

Other



C9. **CBRN hazard evolution assessment**

Select CBRN hazard evolution assessment technologies you are not using but you think that should be useful for your operations. In case your technology is not listed below please mark a tick next to "Other" category and describe your systems in the following column.

Please describe the technology (type, producer/developer, capabilities/characteristics/parameters/web-link etc.). You can also add information on operation you use it for.

Sensors ☐

Comment

Weather stations ☐

Comment

Computer simulation (f.e. hazardous cloud dynamics detection) ☐

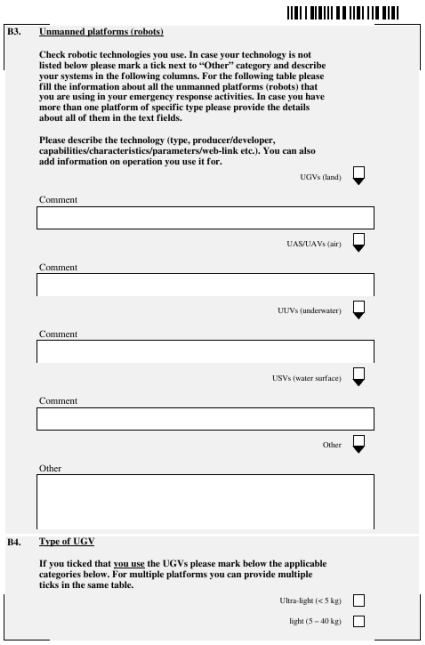
Comment

Integrated systems ☐

Comment

Other ☐

Other



B3. Unmanned platforms (robots)

Check robotic technologies you use. In case your technology is not listed below please mark a tick next to "Other" category and describe your systems in the following columns. For the following table please fill the information about all the unmanned platforms (robots) that you are using in your emergency response activities. In case you have more than one platform of specific type please provide the details about all of them in the text fields.

Please describe the technology (type, producer/developer, capabilities/characteristics/parameters/web-link etc.). You can also add information on operation you use it for.

UGVs (land) ☐

Comment

UAS/UAVs (air) ☐

Comment

UUVs (underwater) ☐

Comment

USVs (water surface) ☐

Comment

Other ☐

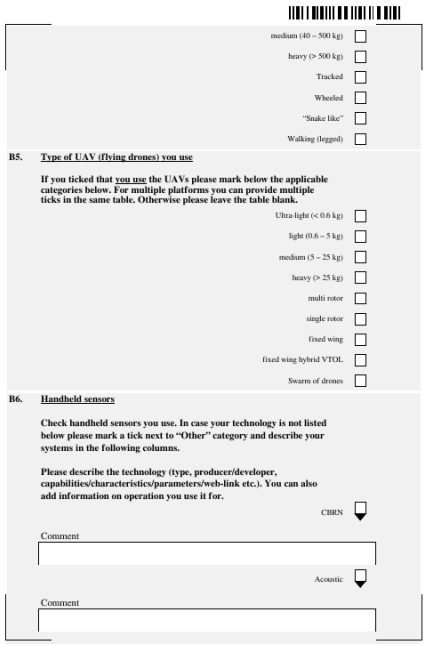
Other

B4. Type of UGV

If you ticked that you use the UGVs please mark below the applicable categories below. For multiple platforms you can provide multiple ticks in the same table.

Ultra-light (< 5 kg) ☐

light (5 – 40 kg) ☐



medium (40 – 500 kg) ☐

heavy (> 500 kg) ☐

Tracked ☐

Wheeled ☐

"Snake like" ☐

Walking (legged) ☐

B5. Type of UAV (flying drones) you use

If you ticked that you use the UAVs please mark below the applicable categories below. For multiple platforms you can provide multiple ticks in the same table. Otherwise please leave the table blank.

Ultra-light (< 0.6 kg) ☐

light (0.6 – 5 kg) ☐

medium (5 – 25 kg) ☐

heavy (> 25 kg) ☐

multi rotor ☐

single rotor ☐

fixed wing ☐

fixed wing hybrid VTOL ☐

Swarm of drones ☐

B6. Handheld sensors

Check handheld sensors you use. In case your technology is not listed below please mark a tick next to "Other" category and describe your systems in the following columns.

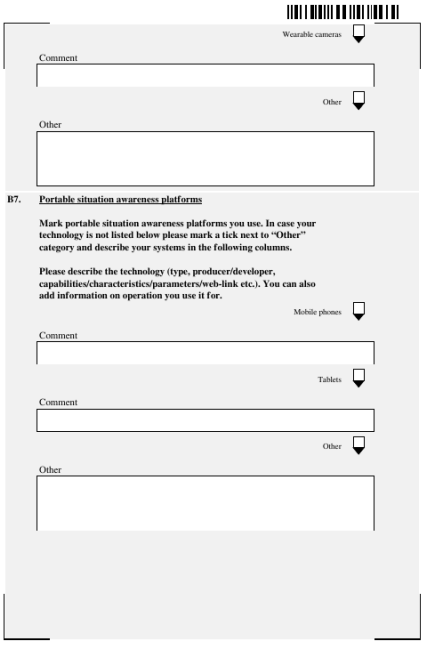
Please describe the technology (type, producer/developer, capabilities/characteristics/parameters/web-link etc.). You can also add information on operation you use it for.

CBRN ☐

Comment

Acoustic ☐

Comment



Wearable cameras ☐

Comment

Other ☐

Other

B7. Portable situation awareness platforms

Mark portable situation awareness platforms you use. In case your technology is not listed below please mark a tick next to "Other" category and describe your systems in the following columns.

Please describe the technology (type, producer/developer, capabilities/characteristics/parameters/web-link etc.). You can also add information on operation you use it for.

Mobile phones ☐

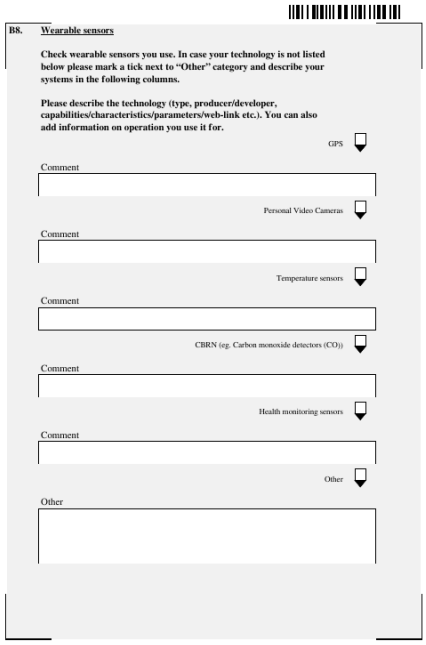
Comment

Tablets ☐

Comment

Other ☐

Other



B8. Wearable sensors

Check wearable sensors you use. In case your technology is not listed below please mark a tick next to "Other" category and describe your systems in the following columns.

Please describe the technology (type, producer/developer, capabilities/characteristics/parameters/web-link etc.). You can also add information on operation you use it for.

GPS ☐

Comment

Personal Video Cameras ☐

Comment

Temperature sensors ☐

Comment

CBRN (eg. Carbon monoxide detectors (CO)) ☐

Comment

Health monitoring sensors ☐

Comment

Other ☐

Other

9.3. Questionnaire (Word document version)

ASSISTANCE

Adapted situation awareneSS tools and tallored training curricula for increaSing capabiliTie and enhANcing the proteCtion of first respondErs

European Commission

Project co-funded by the European Union within the Horizon 2020 Programme

ASSISTANCE SOTA questionnaire for End-Users

About ASSISTANCE

Nowadays different FRs organizations cooperate together facing large and complex disasters, that in some cases can be amplified due to new threats such as, the climate change in case of natural disasters (e.g. big floods, large wild fires, etc) or the increase of radicalization in case of man-made disasters (e.g. arsonist that burn European forest, big combined terrorist attacks in European cities).

The impact of these kinds of large disasters could have disastrous consequences for the European Member States' regions and social wellbeing in general. On the other hand, each type of FRs organizations (e.g. medical emergency services, firefighters' departments, law enforcement teams, civil protection professionals, etc.) that work mitigating these kinds of events are exposed to unexpected dangers or new threats that can severely affect their personal integrity.

Taking into account these facts, ASSISTANCE proposes a holistic solution that will adapt a well-tested SA application as a core of a wider SA platform, capable of offering different configuration modes for providing the tailored information outcome needed by each FR organization, while they work together mitigating the disaster (e.g. real time video and resources location for firefighters, evacuation routes status for emergency health services and so on).

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

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

ASSISTANCE is funded by the Horizon 2020 Programme of the European Commission, in the topic of Critical Infrastructure Protection, contract 832576.

ASSISTANCE SOTA questionnaire for End-Users

Dear End-User,

As our goal is to focus on real needs of yours and to tailor our solutions to your actual preferences and expectations, we kindly ask you to fill in the short questionnaire concerning the state-of-the-art (SOTA) technologies that we should refer to in our developments.

Please be kind to share with us your practitioners knowledge that is of the best value for good understanding of your operational reality which we can build upon to provide you with improved tools and systems supporting you in your specialised tasks.

Thank you very much for your contribution!

ASSISTANCE project team

Acronyms

ASSISTANCE	Adapted situation awareneSS tools and tAllored training curricula for increaSing capabiliTie and enhANcing the proteCtion of first respondErs
AR	Augmented Reality
CBRN	Chemical, Biological, Radiological and Nuclear Defense
COTS	Commercial off-the-shelf
C2	Command and control
GIS	Geographic Information System
GSM	Global System for Mobile communications
GPRS	General Packet Radio Service
IR	Infrared
LEA	Law Enforcement Agency
SA	Situation Awareness
UAS	Unmanned Aerial System
UAV	Unmanned Aerial Vehicle

UGV	Unmanned Ground Vehicle
UUV	Unmanned Underwater Vehicle
USV	Unmanned Surface Vehicle
VR	Virtual Reality

Type of organisation

Please fill mark your organisation type. It should indicate your primary activity as an actor in Emergency Services.

Fire Fighters	Police / LEA	Medical emergency services	Civil protection	Emergency dispatch organisation (like 112 line operator)	Other (Please specify)

Situation Awareness technologies

Which type of technology do you use currently in your operations?

Please give us as much information as possible on technologies you are currently using, that are related to ASSISTANCE project, use bullets or numbering whenever convenient. In case the specific section or table is not applicable for your organisation please leave it blank.

List technologies **you use**. For the following table please fill (add if necessary) an additional row at the bottom in case you use a technology matching "**command and control**" group that is not mentioned in the predefined fields in the table.

Command and control	*Please tick 'X'*	*COTS or custom made*	*Please describe the technology (type, producer/developer, capabilities/characteristics/parameters/web-link etc.)*	*Please describe briefly the kind of operation you use it for*
Real-time video streaming				
Digital maps (GIS systems)				
Augmented video (eg. Overlaying video with sensor information)				
Emergency vehicles tracking systems				
Ccomputer aided dispatch				
Advanced mobile location (f.e. mobile phone network based)				
Mobile or wearable devices for command and control				

List technologies **you use**. For the following table please fill (add if necessary) an additional row at the bottom in case you have a technology matching "**communication**" group that is not mentioned in the predefined fields in the table.

Communication	*Please tick 'X'*	*COTS or custom made*	*Please describe the technology (type, producer/developer, capabilities/characteristics/parameters/web-link etc.)*	*Please describe briefly the kind of operation you use it for*
Radio communication				
GSM/GPRS				
Satellite				
Network coverage devices				
IoT sensors network (f.e. cloud based)				
Internet text services (f.e. cloud based messaging)				

List technologies **you use**. For the following table please fill the information about all the unmanned platforms (robots) that you are using in your emergency response activities. In case you have more than one platform of specific type please provide the details about all of them in the text fields.

Unmanned platforms (robots)	*Please tick 'X'*	*COTS or custom made*	*Please describe the technology (type, producer/developer, capabilities/characteristics/parameters/web-link etc.)*	*Please describe briefly the kind of operation you use it for*

UGVs (land)				
UAS/UAVs (air)				
UUVs (underwater)				
USVs (water surface)				

If you ticked that **you use** the UGVs please mark below the applicable categories below. For multiple platforms you can provide multiple ticks in the same table.

	UGV (land robots) types	***Please tick 'X'***
	Ultra-light (< 5 kg)	
	light (5 – 40 kg)	
	medium (40 – 500 kg)	
	heavy (> 500 kg)	
	Tracked	
	Wheeled	
	"Snake like"	
	Walking (legged)	

If you ticked that **you use** the UAVs please mark below the applicable categories below. For multiple platforms you can provide multiple ticks in the same table. Otherwise please leave the table blank.

	UAV (flying drones) types	*Please tick 'X'*
	Ultra-light (< 0.6 kg)	
	light (0.6 – 5 kg)	
	medium (5 – 25 kg)	
	heavy (> 25 kg)	
	multi rotor	
	single rotor	
	fixed wing	
	fixed wing hybrid VTOL	
	Swarm of drones	

List technologies **you use**. In case your technology (sensors and devices) is not listed below please mark a tick next to "**Other**" category and describe your systems in the following columns.

Sensors and devices	*Please tick 'X'*	*COTS or custom made*	*Please describe the technology (type, producer/developer, capabilities/characteristics/parameters/web-link etc.)*	*Please describe briefly the kind of operation you use it for*
Handheld sensors				
CBRN				
Acoustic				
Wearable cameras				
Other				
Portable SA platforms				
Mobile phones				
Tablets				
Other				
Wearable sensors				
GPS				
Personal Video Cameras				
Temperature sensors				
CBRN (eg. Carbon monoxide detectors (CO))				

	Health monitoring sensors				
	Other				
Mounted on unmanned platforms					
	Optical sensors (Day/IR/Thermal cameras)				
	CBRN sensors				
	Temperature sensors				
	Relays				
	Other				
Stand-off					
	Radar				
	Laser-based (LIDAR, spectroscopy etc.)				
	X-Ray				
	Acoustic				
	Gunshot detection				

	Other				

List technologies **you use**. For the following table please fill (add if necessary) an additional row at the bottom in case you have a technology matching "**CBRN hazard evolution assessment**" group that is not mentioned in the predefined fields in the table.

CBRN hazard evolution assessment	*Please tick*	*COTS or custom made*	*Please describe the technology (type, producer/developer, capabilities/characteristics/parameters/web-link etc.)*	*Please describe briefly the kind of operation you use it for*
Sensors				
Weather stations				
Computer simulation (f.e. hazardous cloud dynamics detection)				
Integrated systems				

Which type of available technology you know about and would like to test/use in your operations?

Please give us as much information as possible on technologies that **you are not currently using**, but you think that **should be useful for your operations**, use bullets or numbering whenever convenient. In case the specific section or table is not applicable for your organisation please leave it blank.

List technologies you **are not using** but you think that **should be useful for your operations**. For the following table please fill (add if necessary) an additional row at the bottom in case you want to mention technology matching "**command and control**" group that is not mentioned in the predefined fields in the table.

Command and control	*Please tick 'X'*	*COTS or custom made*	*Please describe the technology (type, producer/developer, capabilities/characteristics/parameters/web-link etc.)*	*Please describe briefly the kind of operation you use it for*
Real-time video streaming				
Digital maps (GIS systems)				
Augmented video (eg. Overlaying video with sensor information)				
Emergency vehicles tracking systems				
Ccomputer aided dispatch				
Advanced mobile location (f.e. mobile phone network based)				
Mobile or wearable devices for command and control				

List technologies you **are not using** but you think that **should be useful for your operations**. For the following table please fill (add if necessary) an additional row at the bottom in case you want to mention technology matching "**communication**" group that is not mentioned in the predefined fields in the table.

Communication	***Please tick 'X'***	***COTS or custom made***	***Please describe the technology (type, producer/developer, capabilities/characteristics/parameters/web-link etc.)***	***Please describe briefly the kind of operation you use it for***
Radio communication				
GSM/GPRS				
Satellite				
Network coverage devices				
IoT sensors network (f.e. cloud based)				
Internet text services (f.e. cloud based messaging)				

List technologies you **are not using** but you think that **should be useful for your operations**. For the following table please fill the information about all the unmanned platforms (robots) that you find interesting for you in your emergency response activities. In case you have more than one platform of specific type please provide the details about all of them in the text fields.

Unmanned platforms (robots)	***Please tick 'X'***	***COTS or custom made***	***Please describe the technology (type, producer/developer, capabilities/characteristics/parameters/web-link etc.)***	***Please describe briefly the kind of operation you use it for***
UGVs (land)				
UAS/UAVs (air)				
UUVs (underwater)				
USVs (water surface)				

List technologies you **are not using** but you think that **should be useful for your operations**. In case your technology (sensors and devices) is not listed below please mark a tick next to "**Other**" category and describe your systems in the following columns.

Sensors and devices	*Please tick 'X'*	*COTS or custom made*	*Please describe the technology (type, producer/developer, capabilities/characteristics/parameters/web-link etc.)*	*Please describe briefly the kind of operation you use it for*
Handheld sensors				
CBRN				
Acoustic				
Wearable cameras				
Other				
Portable SA platforms				
Mobile phones				
Tablets				
Other				
Wearable sensors				
GPS				
Personal Video Cameras				
Temperature sensors				
CBRN (eg. Carbon monoxide detectors (CO))				

	Health monitoring sensors				
	Other				
Mounted on unmanned platforms					
	Optical sensors (Day/IR/Thermal cameras)				
	CBRN sensors				
	Temperature sensors				
	Relays				
	Other				
Stand-off					
	Radar				
	Laser-based (LIDAR, spectroscopy etc.)				
	X-Ray				
	Acoustic				
	Gunshot detection				

	Other				

List technologies you **are not using** but you think that **should be useful for your operations**. For the following table please fill (add if necessary) an additional row at the bottom in case you want to specify a technology matching "**CBRN hazard evolution assessment**" group that is not mentioned in the predefined fields in the table.

CBRN hazard evolution assessment	*Please tick*	*COTS or custom made*	*Please describe the technology (type, producer/developer, capabilities/characteristics/parameters/web-link etc.)*	*Please describe briefly the kind of operation you use it for*
Sensors				
Weather stations				
Computer simulation (f.e. hazardous cloud dynamics detection)				
Integrated systems				

Is there any technology currently in research or a previous research outcome that you know about and would like to test/use in your operations?

Please fill the table as necessary describing the activities or emerging technologies that match your current or future operational needs. This is an open list you can shape it as relevant. In case it is possible please follow the predefined headings – although it is not obligatory. All experimental stuff that you have tried or you know about and would like to try could be included below.

Please list as many as you know, adding rows, if needed	*Project/research identifier (title/acronym etc.)*	*Please describe the technology (type, developer/project, capabilities/characteristics/parameters/web-link etc.)*	*Please describe briefly the kind of operation you would use it for*
Integrated SA systems			
C2			
Communication			
Unmanned platforms			

Sensors and devices			
CBRN hazard evolution assessment			
Other			

Training Platforms

What type of training platform is in use in your organisation?

In the following table please mark a tick ('X') of a technology that **you are using** in your training activities. If you are using a mix of technologies in your trainings please feel free to add more than one tick. Then below please describe details of that training platform.

VR platform	AR platform	Computer 3D environment platform	Real live training system	Other
Please specify below the technology (type, producer/developer, capabilities/characteristics/parameters/web-link etc.)				

Which type of training platform (available or in research) you know about and would like to test/use in your operations?

In the following table please mark a tick ('X') of a technology **that you are not using** in your training activities but you feel it matches your needs. If you are wishing to use a mix of technologies in your trainings please feel free to add more than one tick. Then below please describe details of that training platform.

VR platform	AR platform	Computer 3D environment platform	Other
Please specify the technology (type, producer/developer/project, capabilities/characteristics/parameters/web-link etc.)			

Security and safety related best practices

Please list the risk management standards applicable to your operations (add rows if necessary)

The following table is aimed at obtaining information about the standards or standard operating procedures that your organisation is following in terms of emergency services. Please provide information as relevant. All the details given below (even the obvious ones) would be useful for creation of adequate technologies to support you.

Nº	*Standard's identifier (name/title etc.)*	*Please describe briefly the scope*

Please list the existing guidelines and manuals describing your operations

The following table is aimed at obtaining information about the manuals or guidelines that your organisation is following in terms of emergency services. Please provide information as relevant. All the details given below (even the obvious ones) would be useful for creation of adequate technologies to support you.

Nº	*Guideline/manual identifier (name/title etc.)*	*Please describe briefly the scope*

Remarks

If you have any additional inputs that you think is relevant, please add it here.