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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Training methodologies and evaluation criteria definition

29/11/2019

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

ASSISTANCE

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

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

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

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

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

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Executive Summary

The aim of T6.1 is to define the training methodology for better practice and knowledge acquisition of each skill proposed by the end users. This document describes the questionnaire by which end-users have provided feedback on training methods that improve the FRs' skills. The document continues with the concise literature review regarding training methodology and evaluation criteria and a description of the literature study on adult learning and learning with virtual tools. Finally, a definition is made of evaluation criteria to measure to what extent the training goals have been accomplished.

The results of the questionnaire are that regarding the preferred FRs learning methods (learning to use information provided by drones, wearables and robots in general). These results state that training with digital simulations Virtual Reality/Augmented Reality (VR/AR), e-learning and participating in workshops are most preferred by end-users. During a real incident FRs proclaim that they, to successfully apply technological tools, need insights about the conditions needed for using the tools, knowledge on how to read feedback of the tools and knowledge on how to make decisions using feedback of the tools.

The methodology defined concentrates on learning with virtual reality for training different FRs' organizations and focusses on what the ideal settings are for adults to learn, and which components of emergency response situations that influence situational awareness need to be considered. Using a variety of activities to train the FRs, and make sure to do that through diverse means is recommended. Due to the nature of the ASSISTANCE project and the VR, AR and Mixed Reality (MR) requirements, high tech training methods are selected like inquiry-based learning, game-based learning, personalized learning and flipped classroom.

The topics of criteria are important when evaluating the ASSISTANCE training method. The topics of evaluation are: adult learning, time pressure, workload and training. In addition, KPI's are proposed that on one hand address the organization and structure of the project and on the other hand address the performance of the training activities. The stated KPI's can be measured by a questionnaire for the FRs and observers.

Based on the training methodology, a training curriculum will be composed in T 6.2.

List of Authors

Organisation	Authors
IFV	Emily Berger, Eric Didderen, Mark Graner, Marloes van ‘t Klooster, Jóhanna Veeneklaas, Suzanne Vet
UPV	Federico Carvajal, Israel Pérez, Débora Robles

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Content

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Acronyms

AR	Augmented Reality
ASSISTANCE	Adapted situation awareneSS tools and taIlored training curricula for increaSing capabiliTies and enhANcing the proteCtion of first respondErs
D#.#	Deliverable number #.# (D1.1 deliverable 1 of work package 1)
EC	European Commission
FR	First Responder
H2020	Horizon 2020 Programme for Research and Innovation
HMI	Human Machine Interface
M#	#th month of the project (M1=May 2017)
MR	Mixed Reality
SA	Situational Awareness
SAP	Situational Awareness Platform
SAS	Sensor Abstraction Service
UAV	Unmanned Aerial Vehicle
VR	Virtual Reality
WP#	Work Package number #

1. Introduction

1.1. Purpose of ASSISTANCE

The ASSISTANCE project aims to protect and help the different organizations of First Responders (FRs) that work together during the mitigation of large-scale disasters, and to improve the FRs' capabilities and skills in facing such disasters. Furthermore, ASSISTANCE will produce a situational awareness platform (SAP) for providing the tailored information needed by each individual FR organization when collaborating on disaster mitigation. This platform integrates innovative modules, UAVs, robots and wearable sensors that will enhance the FRs' SA.

During the proposal preparation phase, the FRs have expressed their needs in terms of useful information for increasing their capabilities and their preferences of type of sensors being mounted on unmanned platforms or integrated in their wearable equipment.

1.2. WP6

The focus of WP6 is to establish the core of an advanced training network based on virtual, augmented or mixed reality. This network includes recognized FRs training institutions that form part of ASSISTANCE consortium along with a set of training curricula. The training curricula are tailored to the needs of the different types of FRs in order to improve their current capabilities.

1.3. T6.1

The aim of T6.1 is to define the training methodology for better practice and knowledge acquisition of each skill proposed by the end users. First a concise literature review regarding training methodology and evaluation criteria will be performed. The methodology to be defined will concentrate on learning with virtual reality for training different FRs' organizations.

Within T6.1, a literature study on adult learning and learning with virtual tools has been conducted. Furthermore, end-users have provided feedback on training methods that improve the FRs' skills. Lastly, a definition is made of evaluation criteria to measure to what extent the training goals have been accomplished.

For more information on T6.1 and the successor task 6.2, see Annex 1 of the Grant Agreement 832576, page 33.

2. Questionnaire

2.1. Target group

The target group of the training that will be developed for ASSISTANCE in WP6 are European First Responders (FRs). Those include, but are not limited to paramedics, police officers, and firefighters. The task that these FRs need to accomplish is to make decisions based on of feedback retrieved from the technology. As no further distinction can be made regarding the exact function or duty, experience, age, nationality, and other characteristics, T6.1 focuses on adult learners in general, and learning in large natural and man-made disasters.

2.2. Prior knowledge

A questionnaire was developed, targeted at FRs regarding the projects end-user partners (see appendix 1 for the full questionnaire). The questionnaire's goal is to gather information on how to teach first responders about using the information extracted from drones, wearables and robots. The FRs were asked about their experience with the tools, their preferred learning method(s) and some demographic features (like their age and gender).

In total, there were 244 responses to the questionnaire. Table 1 shows the distribution of responses by country and gender.

The majority of the respondents (31%) are males between 35 and 44 years old; furthermore, most women that answered are between 25 and 34 years old (7% of all respondents).

The FRs between 45-54 years old are the 23% and 7% is between 55-64 years old.

Most of them do field work as their mission type (146 out of 244 responders), whereas 76 responders (also) work in a command/dispatch function, 45 in training, 37 in a managerial function (office), and 33 in technical support.

Most men (42%) work in the field, where 25% of the women work in the field. Most males have over 20 years of experience as a first responder, most females between 1 and 10 years.

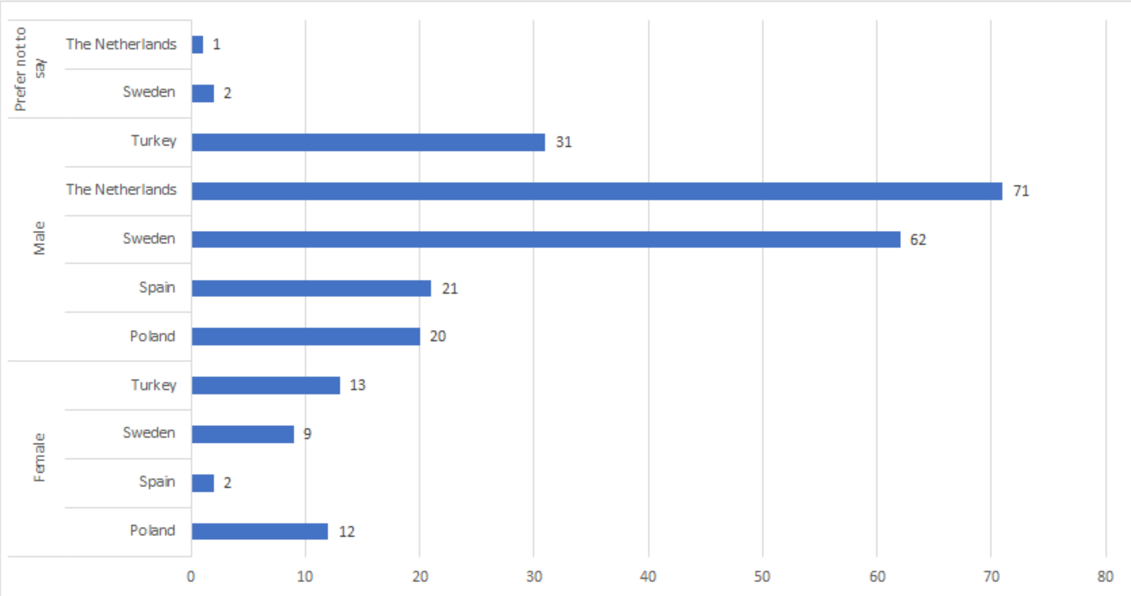


Figure 1. Number of responses per country and gender

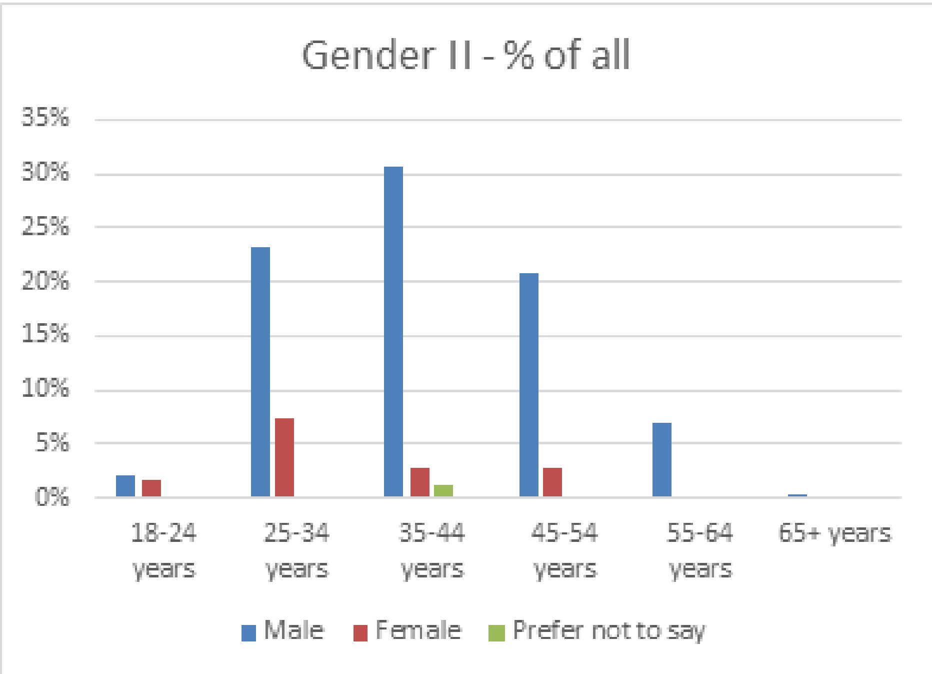


Figure 2. Percentage distribution of gender and age, relative to all respondents

2.2.1. Experience

The majority of the FRs has little experience with using feedback of the proposed technology (see Figure 2Figure 4).

109 respondents (44,5%) do not have **any** professional experience. They answered 'None' when asking “How many times did you professionally use feedback of drones/wearables/robots?”.

Only two responders (0,8%) have used all technologies more than 10 times, which shows the value of the ASSISTANCE project and its goals to European FRs' society. Among the FRs that have used technology before, drones are used the most when compared to wearables and robots.

The most-trained country in terms of the use of drones is Poland (78%). The least trained people among the respondents are Spain (16%) and Sweden (32%). In their free time, 97 FRs (39,7%) do not use the proposed technologies.

FRs have the most experience in gaining knowledge by workshops and handbooks. For working with drones specifically, lectures and seminars are most popular. In general, the FRs are pleased (it was 'fine, good or very good') with the training they have received.

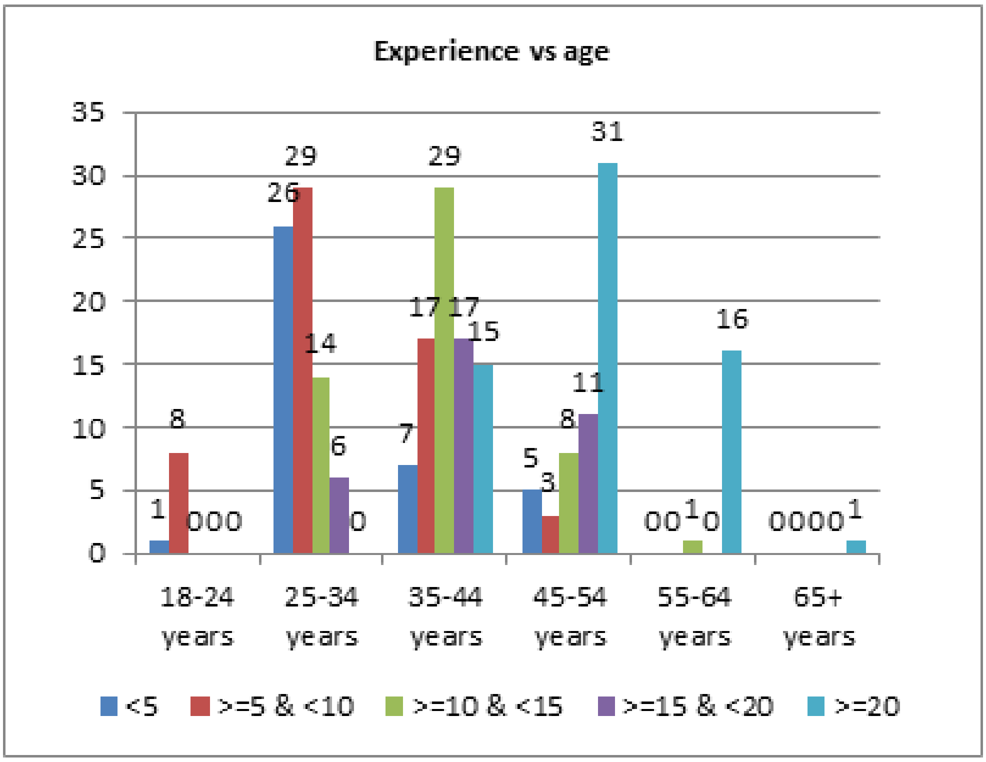


Figure 3. Distribution of age and experience among the respondents

How many times did you professionally use feedback of robots?	>10 times	How many times did you professionally use feedback of wearables?	>10 times	How many times did you professionally use feedback of drones?	>10 times	2
					None	1
			None	How many times did you professionally use feedback of drones?	1-5 times	3
	1-5 times	How many times did you professionally use feedback of wearables?	>10 times	How many times did you professionally use feedback of drones?	>10 times	1
					1-5 times	2
					None	1
			1-5 times	How many times did you professionally use feedback of drones?	1-5 times	3
					None	5
			6-10 times	How many times did you professionally use feedback of drones?	>10 times	2
			None	How many times did you professionally use feedback of drones?	1-5 times	8
					None	7
	6-10 times	How many times did you professionally use feedback of wearables?	1-5 times	How many times did you professionally use feedback of drones?	>10 times	1
					None	1
			None	How many times did you professionally use feedback of drones?	1-5 times	1
	None	How many times did you professionally use feedback of wearables?	>10 times	How many times did you professionally use feedback of drones?	>10 times	2
					1-5 times	2
					6-10 times	2
					None	6
			1-5 times	How many times did you professionally use feedback of drones?	>10 times	1
					1-5 times	20
					6-10 times	3
					None	18
			6-10 times	How many times did you professionally use feedback of drones?	>10 times	1
					1-5 times	3
					6-10 times	1
					None	4
			None	How many times did you professionally use feedback of drones?	>10 times	6
					1-5 times	28
					6-10 times	1
					None	109

Figure 4. Crosstab of respondents and their professional experience with drones, wearables and robots

2.2.2. Preference of learning methods

Regarding the preferred learning methods (learning to use information provided by drones, wearables and robots in general), **training with digital simulations (VR/AR), e-learning and participating in workshops are most preferred**. We also asked the respondents what their approximate preferred amount of time would be that they would like to spend on learning how to handle data provided by drones, wearables, and robots respectively.

Regarding drones, about an equal amount of people would prefer 16 hours (27%) of training or 4 hours (20,5%), whereas the majority (35%) would prefer 8 hours of training.

Regarding wearables, the majority prefers 4 hours of training (35%) or 8 hours of training (34%), with only 15% of the respondents that would prefer 16 hours of training.

Finally, the preferred amount of time on learning about robots does not provide us with a distinct conclusion: about one third responders preferred 8 hours (30%), another part preferred 16 hours (27%) and the same portion preferred 4 hours (27%). One could draw the conclusion that the FRs preference remains unclear due to their own unfamiliarity with learning with drones, wearables and robots.

2.2.3. Needs

An inventory was also made of what is needed to effectively use technological tools during a real incident, according to FRs. Multiple answers were possible here, and each answer option was picked an approximately equal amount of times, see table 1.

What is needed, in your opinion, to successfully apply technological tools (drones, wearables, robots) during a real incident?	#answers
Insights about the conditions needed for using the tools	146
Knowledge on how to read feedback of the tools	149
Knowledge on how to make decisions using feedback of the tools	149

Table 1. Number of respondents' statements about what is needed to effectively use the information from drones, wearables and robots

Ideally, FRs stated that they would like practical training. However, this is not always possible due to the availability of practical training locations, travel time and other factors that negatively affect the costs of providing the training.

VR is a very good alternative for practical training, since it can simulate the real world in an advanced manner. VR training also offers many advantages from a training point of view. One of the main benefits of VR is that the FR could follow training independent of time and location.

3. Objectives

3.1. Main objective

The aim of T6.1 is to define the training methodology for better practice and knowledge acquisition of each skill proposed by the end users. First a concise literature review regarding training methodology and evaluation criteria is performed. The methodology to be defined will concentrate on learning with virtual, augmented and mixed reality for training different FRs' organizations.

For more information on T6.1 and the successor task 6.2, see Annex 1 of the Grant Agreement 832576, page 33.

3.2. Learning objectives / training goals

To accomplish the main WP6 objective, the FRs need to be properly trained and educated. To that end, the following learning objectives and training goals should be covered at the end of the project:

- The FRs' skills and capabilities will be improved through tailored training based on new learning approaches adapted to each type of FR organizations' needs, through an European advanced training network for FRs.
- The FRs' capability for using relevant data in an efficient way will be increased by the use of sensors, drones and robots via a situational awareness platform (SAP) as an active FR tool.

The training methodology and evaluation criteria will be tested through different workshops and online training material. This will take place prior to the pilot demonstrations.

4. Methodology

The training methodology lays the foundation for the training curriculum, which in turn increases the FRs’ skills and capabilities.

The target group is adult learners in emergency response situations. Following this, the methodology focusses on what the ideal settings are for adults to learn, and which components of emergency response situations that influence situational awareness need to be considered.

4.1. Adult learning

According to Hermans, Jansen, Vogten & Koper (2015) and Lee, Choi & Cho (2019), in general adults are a heterogeneous group with a large variety of learning preferences, learning ambitions, prior knowledge and personal circumstances. Cerone (2008) adds that most adult learners are highly motivated and task-oriented, with Lee et al. (2019) expanding on this stating that adults are more independent and self-regulated in their learning.

Tretsiakova-McNally, Maranne, Verbecke & Molkov (2017) pose that experience, including making mistakes, provides the basis for learning activities. They also state that adult learning is problem-centered rather than content-oriented, and that adults are most interested in learning subjects that have immediate relevance to their job or personal life.

Adults have certain limitations, such as multiple responsibilities (e.g. families and jobs), biological conditions and difficulty in dealing with technology as Lee et al. (2019) suggests. Younger learners have to deal with such limitations to a lesser extend or not at all. Especially since most adults enter educational programs voluntarily and manage their classes around work and family responsibilities, all these characteristics, responsibilities and situations can interfere with the learning process, as Cerone (2008) warns.

To overcome this, adults need to be involved in the planning and evaluation of their instruction and their learning process, as Tretsiakova-McNally et al. (2017) and Lee et al. (2019) suggest. This would mean that the end users need to be highly involved and that ideally separate workshops should be given to small group of end users.

Cerone (2008) also states that primarily due to their busy schedules and the online format’s convenience, many adults want to take advantage of online learning environments. However, they use technology with different sets of expectations that are based on their personal experience and most adults of today were taught in a traditional and passive classroom.

Online learning environments are relatively new to adult learners as well as instructors, who must learn new methods for teaching in this kind of setting. According to Cerone (2008), learners and instructors both need to adapt and change as they learn how to use this new medium.

4.2. Emergency response situations

FRs need to perform in emergency response situations, making the best decisions quickly based on information about the disaster at hand and its immediate surrounding. To better understand this, the following key components are briefly addressed here: the level of situational awareness, and the influence of time pressure and workload in those situations.

4.2.1. Situational awareness

According to Endsley (2000), situational awareness “consists of the ability to describe the situation, understand the situation, and accurately predict the future situation". Fundamental to this is the way in which a person deploys his or her attention in acquiring and processing information. As Endsley (2000) notes, this is particularly true for complex environments where multiple sources of information compete for attention, as which information people attend to has a substantial influence on their situation awareness. Influencing attention distribution therefore can have a significant impact on situation awareness (also see Figure 5).

Graafland et al. (2014) put forward that situational awareness can be measured only by structured rating scales and by trained assessors. Furthermore, correct situational assessment and subsequent handling are key components to successfully manage complex procedures. These requirements are important to consider when developing the training curriculum in task 6.2.

4.2.2. Time pressure

During disasters, time is of the essence when making decisions. One needs to find the right balance between speed and thoroughness. Gok & Atsan (2016) pose three major ways in which people respond to decision problems under time pressure.

First, people accelerate their processing. Second, processing tends to be more selective under time stress focusing on more important and/or negative information about alternatives. Third, decision strategies may shift as a function of increased time pressure. This implies that under higher levels of time pressure, the decision maker is more focused on probabilities and the most important attribute of an alternative. That focus will help them reach the right – or best – decision faster.

However, several researchers point out that time pressure can also have a negative influence on decision making and the quality of the decision. For instance, Maule, Hockey & Bdzola (2000) point out that long periods of continuous time-pressured decision making may lead to increased fatigue. They cite Holding (1983) when stating that increases in fatigue are known to affect underlying cognitive strategies and risk-taking behavior. Thus, there is only a certain amount of time pressure one can handle before it negatively impacts the decision making.

Maule et al. (2000) note that this may explain why decision makers tend to give priority to developing a broad understanding of the decision problem, as opposed to developing a detailed evaluation of alternatives and their outcomes. The authors state that this is consistent with previous suggestions by Payne, Bettman & Johnson (1993) amongst others, that "under time-pressure people prefer to have a relatively small amount of knowledge about all alternatives than detailed information about just some of them".

4.2.3. Workload

Roldán et al. (2017) define workload as the sum of the amount of work, the working time and the subjective experience of the operator. When broadening the definition, workload consists of mental demand, physical demand, temporal demand, work performance, effort and frustration. Longer working hours lead to a higher workload, for instance. Although the research by Roldán et al. (2017) focuses on a slightly different target group (operators rather than FRs), their findings that the inability to extract the most relevant parts when processing large amounts of data holds true for FRs as well.

The risk of providing unfiltered, large amounts of data is that the workload is so high that the decision maker might remain oblivious to crucial information such as which task is more critical, which situation requires more attention or which decision is riskier. Roldán et al. (2017) propose to solve this by assigning information discovery (rather: extracting information from the received data) to the interface instead of the operator (FR), by means of a predicting neural network.

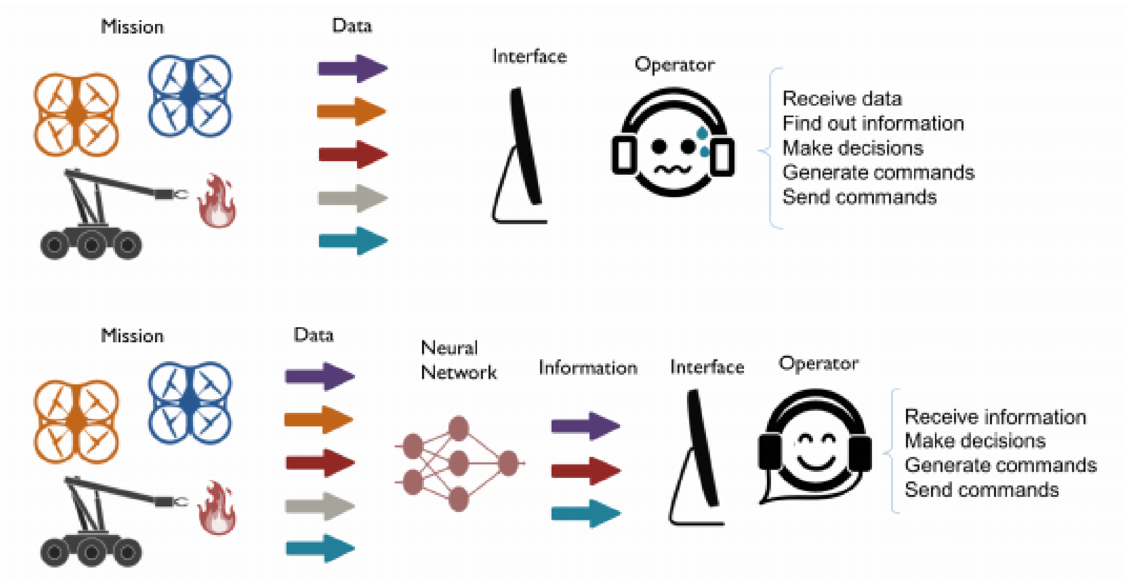


Figure 5. Contribution of prediction to interfaces.

Operators of non-predictive interfaces have to receive data, find information, make decisions, generate commands and send them. Predictive interfaces can help operators perform functions by reducing the workload to an acceptable level. From: Roldán et al. (2017).

As noted in the Grant Agreement, the logic interfaces developed in Task 3.2 will send the data gathered from sensors, drones and robots to the SAP. Selecting the SAP function mode will then present each type of FRs organizations the information they have considered as more useful/important. Ideally, the SAP Human Machine Interface (HMI) would filter and transform data into information that can be interpreted and used by the FRs. As such, the SAP HMI would fulfill the role of the neural network mentioned above. However, developing or adding neural or predictive functionality to these systems does not fall within the project scope. This makes balancing the workload for FRs even more a key factor in designing the training materials and preparing the FRs for their tasks. See WP5 for more information on SAP functionalities.

According to Endsley (2000), research shows that there is no *direct* link between workload and situational awareness. She states that "only when workload demands exceed maximum human capacity" situational awareness is necessarily at risk, as problems with situational awareness may also occur under low workload (because of low vigilance) or moderate workload. Endsley (2000) further notes that although situation awareness and workload are inter-related in certain circumstances, the two are essentially independent constructs.

The author therefore stresses the importance of measuring both situation awareness and workload during design testing, to get a complete understanding of the effects of that design.

4.2.4. Virtual reality & workload

Results of the workload and situational awareness tests conducted by Roldán et al. (2017) show that VR improves the situational awareness without increasing the workload of operators. This suggests that VR is suitable as a training method, after adapting the workload to the limits of the human capacity is a key factor in improving FRs' situational awareness.

Figure 6. Screenshot of one of the available VR platforms within the European training network.

Research in the medical domain by Graafland et al. (2014) indicates that the increase in electronic systems, displays and operating room technology has drastically enlarged the mental workload of the modern surgeon. It is difficult to filter out relevant signals from the data clutter while focusing on performing surgery. One could argue that this applies well to the target group of the ASSISTANCE project, since the FRs also must handle multiple systems and streams of data when mitigating disasters.

Furthermore, Graafland et al. (2014) advocate to integrate information into one system with a single visual display, as this will improve situational awareness by distributing and focusing the FRs' attention. The authors expand on this by stating that technological innovations that integrate data from different sources could be used to declutter information and give timely warnings, further helping the FRs in their decision making. This information can be useful when working during WP5, in which the SAP will be developed and designed.

4.2.5. Learning outcomes

When designing the training methodology, we need to strive to create long-lasting situational awareness training effects.

To achieve this, according to Polikarpus, Bøhm & Ley (2019) three elements must come together: significant learning outcomes, situational assessment procedures and learning activities. Significant learning, as defined by Fink (2003), means that a learning experience resulted in something that is truly significant in terms of the learners' lives. This connects well with adult learner characteristics posed by Cerone (2008), Lee et al. (2019) and Tretsiakova-McNally et al. (2017): engaged learners that want to learn something meaningful and relevant to their lives.

Expanding on the significant learning outcomes by Fink (2003), Polikarpus et al. (2019) claim that the following learning outcomes for situational awareness training help FRs becoming more effective decision makers in critical moments:

- Collecting: the learner collects information about the incident consulting various sources such as radio communication, key figures and relevant incident documentation.
- Understanding: the learner understands the type, size, scope and complexity of the incident and the rate of incident change, and adequately upscales responses to the incident.
- Predicting: the learner understands the circumstances of the incident and predicts its possible course.

When these outcomes are reached, the learner has significantly improved his or her situational awareness. Polikarpus et al. (2019) note that reflective dialogs and frequent and immediate feedback based on clear criteria and standards is important for learners. They also stress that the training should support the FR's decision making, planning, actions and review during the whole incident.

Lastly, the authors point out that trainers should consider information and ideas as well as experiences and reflection when it comes to developing engaging activities; a holistic view of active learning. Camachon & Barbaroux (2019) expand on this by stating that training must "integrate the new capabilities on an ongoing basis, and not only after the ad hoc acquisition of certain (…) capabilities". This calls for a thorough, engaging, full training experience.

As for training situational awareness and decision making, other research shows that using simulation software and VR are very capable tools. Polikarpus et al. (2019) suggest computer-based training to train and assess FR situational awareness levels. Graafland et al. (2014) show that "simulation-based surgical team crisis training has construct validity for assessing situational awareness in surgical trainees".

Although VR shows very high potential in education by making learning more motivating and engaging, Kollöffel (2019) cautions that although VR can be a training solution it should be the means, not the goal.

4.3. Design principles

With the broad spectrum of characteristics of adult learning in mind, we suggest designing the training methodology based on the following principles:

- Actively involve the learners in the learning process. This can be achieved by providing small groups within workshops or classes.
- Inform the learners what they are going to learn, how the learning will be conducted, and why it is important.
- Clarify the link between what is learned and how it can be applied to their daily (professional) lives; focus on issues that directly concern them by increasing their situational awareness and thereby the FRs' safety and their countries' safety in general.
- Acknowledge the learners' prior experience; let them connect new knowledge to past events.
- Acknowledge the learners' learning history; support them to work in the new learner-centered paradigm.
- As an instructor, act as a facilitator and provide 'scaffolding'; allow learners to perform activities they were unable to perform without this support.
- Let the learners reflect on their learning process.
- Provide a climate that is collaborative, respectful, mutual, and informal.
- Facilitate dialogue and social interaction; let learners collaborate with each other.

With the above directives from scientific literature concerning emergency response situations in mind, we suggest also designing the training methodology based on the following principles:

- Balance workload in order to optimize situational awareness.
- Create engaging activities for learners, based on a holistic view.
- Provide frequent and immediate feedback based on clear criteria and standards.
- Use simulation software to support FRs' active learning and to assess their situational awareness.
- Integrate newly acquired capabilities on an ongoing basis in the FRs' activities.
- Support the FR's mitigating activities during the whole incident.

The following training methodology can be relevant when implementing products from WP5, like the SAP. The FRs will receive the information on this device from various sources and how this data is filtered and presented.

- Provide small amounts of knowledge about all alternatives instead of detailed information about just some of them.

- Limit workload for the FR by filtering data prior to presenting it.
- Use one system with a single visual display.

4.4. Training methods

Following the design principles, a proper training method needs to be selected. The training method will be the foundation for the task 6.2 curriculum development.

Website teach.com provides a clear overview of modern-day teaching / training methods:

Figure 7. Training methods - tech vs. centeredness. From: teach.com (2019)

Each category holds specific teaching roles, instructor behavior and mix of learning and assessment practices. According to teach.com, educators can gain a better understanding of how best to implement instruction and connect with their students using these methods. The methods from teach.com can be described shortly as follows:

- Direct instruction: explicit teaching through lectures and teacher-led demonstrations.

- Flipped classroom: students watching pre-recorded lessons at home and completing in-class assignments.
- Kinesthetic learning: students performing physical, hands-on activities rather than listening to lectures or watching demonstrations (maker movement).
- Differentiated instruction: tailoring instruction to meet individual student needs.
- Inquiry-based learning: providing guidance and support for students throughout their learning process (supportive teacher role).
- Expeditionary learning: project-based learning in which students go on expeditions and engage in in-depth study of topics that impact their schools and communities.
- Personalized learning: students following personalized learning plans that are specific to their interests and skills.
- Game-based learning: students working on quests to accomplish a specific goal (learning objective) by choosing actions and experimenting along the way.

Due to the nature of the ASSISTANCE project and the VR, AR and MR requirements, we automatically need to select training methods from the upper part of the spectrum. High tech means technology plays a substantial role in these methods (e.g. use of laptops, gamification, online learning environments).

As stated by Pappas (2018), adult learners weren't raised with mobile devices, so they may not be as *tech-savvy* as their younger peers. The author suggests that adult learners who are resistant to change may need some extra encouragement, for instance by providing them with all the online training resources they need, such as online training tutorials and guides, so that they feel comfortable and reassured. Polikarpus et al. (2019) expand on this by proposing using the VR software to create short videos for self-checking tests in e-learning courses, as this will engage and trigger the interest of learners.

When taking the design principles into account, none of these methods cover the spectrum of learning characteristics on their own. Some methods are not suited for training FRs' situational awareness due to their practical nature, such as kinesthetic learning and expeditionary learning.

A method like personalized learning seems less suited for designing this training since the target group is so broad and designing such a training will be too elaborate for the purpose and tempo of this project. Active learning, problem solving, scaffolding, feedback, reflection and being able to make your own learning choices are best represented in game-based learning and inquiry-based learning. Scaffolding is a teaching method that enables a student to solve a problem, carry out a task or achieve a goal through gradual shedding of outside assistance.

Game-based learning will appeal to the target group, as it requires solving problems disguised as puzzles to advance or achieve a certain goal. This method encourages trial and error, and a mastery mindset rather than a focus on grades.

Although the VR environments used in the ASSISTANCE project are not games, they have a lot of game elements in them. Inquiry-based learning has the teacher or trainer take on any of three roles: facilitator, delegator or personal model. A facilitator loosely guides the learner and fosters independent learning and exploration, while undergoing the learning process together with the learner. The personal model is less interconnected, as such a trainer demonstrates what needs to be learned or done, with the learner observing and copying those actions.

Delegators are the most passive: they act as a resource that learners can consult. Of course, trainers can switch roles during the learning process based on learning phase or learner needs. As mentioned earlier, actively facilitating the learners and providing scaffolding is preferred here.

Finally, flipped classroom has added value in that it facilitates efficient training sessions: the FRs will read up and learn prior to the training, so more time can be spent on learning new skills or improving existing ones during the training.

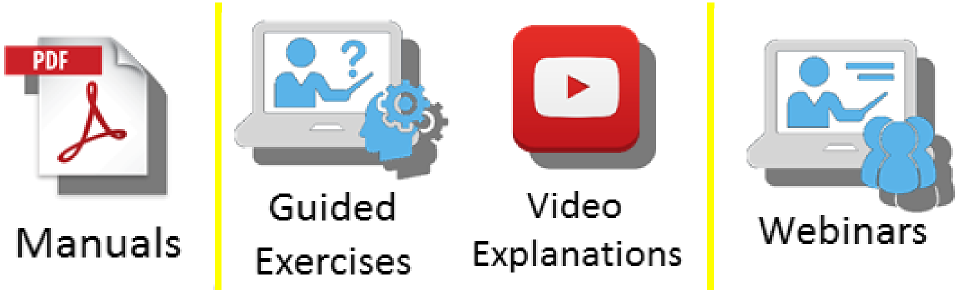
4.5. Conclusion

Considering the knowledge gained from the previous section, we recommend using a variety of activities to train the FRs, and make sure to do that in a diverse manner.

Unfortunately, the scope of this project does not give enough room to implement all mentioned activities. Based on results of the questionnaire and the availability of methods within the European training network D6.4, the following methods have been chosen.

E-learning: through an Advanced Distance Learning platform (e.g. Moodle) several contents will be made available to the learners (FRs) in order to give them knowledge on VR training (e.g. pdfs, videos, etc) and knowledge on the use of the VR platforms that compose the ASSISTANCE training network (e.g. Manuals, explicative videos, etc).

Webinar (online seminar): through online webinars some directed workshops will be performed with reduced number of FRs for deeper explanations on the VR tools and problems solving.



And of course, the progressive use of the available VR/AR/MR training platforms that form part of the ASSISTANCE training network.

At the end of the training process described in this methodology, the FRs will be able to use the available VR platforms for performing several scenarios (from simplest to more complicated ones) in order to proof the concept stated in the DoA. This consist on providing a set of online VR platforms to FRs for increasing their training capabilities and exchanges scenarios, procedures, etc for improving their skills through the use of these platforms.

5. Topics of evaluation criteria

The topics of criteria in this section are important when evaluating our training methodology. This list is constructed, based upon scientific research, but also upon common sense and our educated guess and will consist of a recommendation of subjects that should be considered when evaluating the training program. From an evaluation point of view, it is advised that the training methodology is evaluated. The topics of evaluation would be: adult learning, time pressure, workload and training. In addition, the proposed KPI's will be used for measuring the performance of the FR training methodology. In the next section these topics will be explained.

5.1. Adult learning

The trainees are adults and thus should be trained as such. When evaluating this topic, it is advised to measure if the training method considers the design principles for adult learning. For example, are the trainees actively involved in the learning process? Is a climate provided that is collaborative, respectful, mutual and informal? As been stated in chapter 4 of this deliverable, the training should be designed based on the design principle regarding adult learning.

5.2. Time pressure

As stated before, time pressure can have a negative influence on performance. Therefore, the training should not contain too much time pressure, but should also not interfere with its representative goal (i.e. the training must be representative for 'the real world').

The aim should be to find a balance between the time pressure being too low or too high regarding the scenario. It is advised to measure if this principle is considered.

5.3. Workload

A reduced workload is better for the first responder's performance (Graafland et al., 2014). Same applied here as for the criterium time pressure, so not too much workload and certainly not too little. It is advised to measure if the design principles are considered.

5.4. Training feedback

The described training methodology results in newly formed evaluation criterium: the training method should provide frequent and immediate feedback. This can be measured by checking if the frequency of feedback meets the expectation of the adult learner.

5.5. KPI's

Several KPI's are established during the proposal phase of the ASSISTANCE project that support the third project objective, which is stated in the Grant Agreement[2]:

"**O3.** To establish the core of an advanced training network based on VR and/or AR, which includes recognized FRs training institutions that form part of ASSISTANCE consortium along with a set of training curricula tailored to the needs of the different types of first responders (e.g. firefighters, sanitary staff, police, etc.) in order to improve their current capabilities."

The supporting KPI's for this third objective are:

- 5 Training network core members
- 9 FRs organizations that will test the network
- 3 Different virtual, mixed and augmented reality platforms available in the network
- 3 Training workshops/exercises performed during the project demonstration phase.

The above KPIs address the organization and structure of the project but they do not address the performance of the training activities. For this reason, additional KPIs that deal with training performance are needed.

[2] See page 5 of the Grant Agreement 832576 (in section 1.1) for objective descriptions and supporting KPI's.

For example, how well have the FRs learned how to use the human machine interface (HMI)? Do they know what to do with the situational awareness information provided by the platform? More generally, how well do the FRs learn when they use AR/MR/VR to train for large disasters? Do they learn better in comparison to traditional methods of training, for example lectures and handbooks?

Also, the training methodology should be perceived as useful, a match between education and the real world, comprehensive and pleasant to interact with. The specific objective of D6.1 is development of the training methodology and evaluation criteria. The topics of the evaluation criteria are 'adult learning', 'workload', 'time pressure' and 'training feedback'.

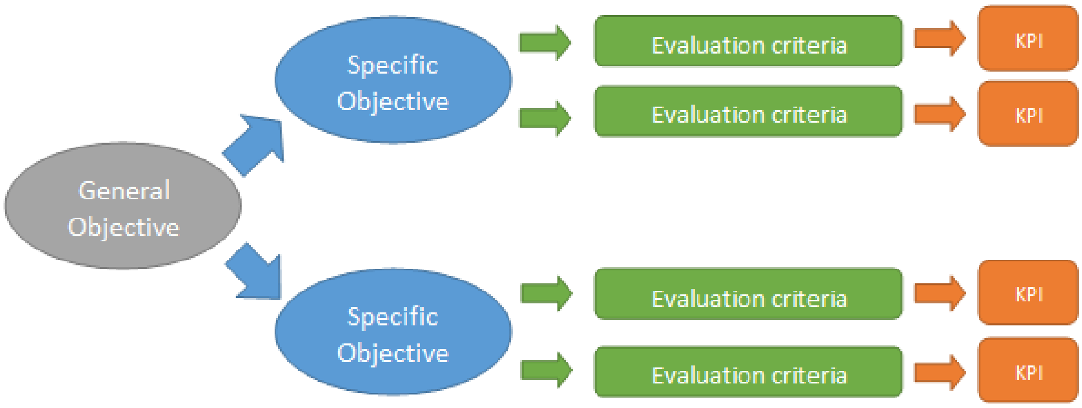


Figure 8: Relationship between general objective, specific objective, evaluation criteria and KPI

The proposed KPI's for measuring the performance of the FR training methodology and the evaluation criteria are:

- The FRs and observers shall assign a rating higher than 5 (on a 10-point scale) regarding the level of collaboration within the training.
- The FRs and observers shall assign a rating higher than 5 (on a 10-point scale) regarding the level of respectfulness within the training.
- The FRs and observers shall assign a rating higher than 5 (on a 10-point scale) regarding the level of involvement within the training.
- The FRs and observers shall assign a rating higher than 5 (on a 10-point scale) regarding the level of informality within the training.
- The FRs shall be able to perform VR scenarios through the different VR platforms available, without time or workload stress, prior to using the system for the pilot scenarios and rated by the observers as 'sufficient'.
- The FRs and observers shall rate the provided feedback in terms of frequent and immediate as 'sufficient'.

5.6. Method of measurement

All the above stated KPI's can be measured by a questionnaire for the FRs and observers. In order to test if the values of the KPI's are achieved, a questionnaire consisting of 6 questions will be filled out.

- How would you rate the level of collaboration within the training? (scale 1-10, where 10 is the best level of collaboration)

- How would you rate the level of respectfulness within the training? (scale 1-10, where 10 is the best level of respectfulness)

- How would you rate the level of involvement within the training? (scale 1-10, where 10 is the best level of involvement)

- How would you rate the level of informality within the training? (scale 1-10, where 10 is the best level of informality)

- Were you/Was the FR able to perform all VR scenarios provided by the available VR platforms, without time or workload stress? (Single answer question. Choices are: 'Yes, sufficiently.' or 'No, insufficiently.')

- Was the provided feedback within the training immediate and frequent? (Single answer question. Choices are: 'Yes, sufficiently.' or 'No, insufficiently.')

The assigned KPI's will be based on subjective and objective factors, namely the opinion of the FRs and the observations of the observers.

6. From methodology to curriculum

6.1. Conclusion

This deliverable has presented the training methodology of the project ASSISTANCE and its evaluations methods and criteria.

A questionnaire has been requested to be filled by FRs to gather information on three main goals. First, we wanted to know about their prior knowledge and experience with drones, wearables and robots. The second goal was to make an inventory of their preferred learning methods. The third goal was to gain insight in their needs regarding learning. By achieving these three goals, more clarification is gained on how to teach them about using the information extracted from drones, wearables and robots.

As a results of this questionnaire, an ad hoc training methodology has been defined. After a concise literature review regarding training methods and combining with the previously mentioned questionnaire, the following training methods have been chosen. They include webinars, e-learning, guided exercises, videos and the use of VR/AR/MR training platforms.

The evaluation method and criteria were defined, based on what researchers in scientific literature state as effective ways to evaluate a training method. These criteria resulted in KPI's, that can be measured by means of a questionnaire (or evaluation form).

6.2. Curriculum

Based on the training methodology, a tailored step-by-step training curriculum will be composed, consisting of training objectives per step as well as the methods for their evaluation. Specific requirements in terms of training materials, facilities, teachers/mentors, facilitators and so forth will also be addressed. The curriculum will be developed in task 6.2.

6.3. Suggestions

With the outcomes of the questionnaire mentioned in par. 1.2.1 and the proposed methodology in mind, suggestions for task 6.2 are to focus on providing information and disclosing knowledge via e-learning and workshops.

Furthermore, the use of VR seems to be better suited for the training purposes of the ASSISTANCE context than AR, since AR is less immersive, has higher development costs and it will be difficult to develop generic AR scenarios that all partners can use at their respective locations. The same counts for MR, that might be difficult to implement due to its costs and its novelty. These assumptions are to be further analyzed in task 6.2.

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7.1. Further reading

Below are other sources that deserve attention when exploring these subjects further. They have not been included in the literature section, as they are not referenced in this document.

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Appendix 1: Questionnaire used for T6.1

Questionnaire training experience and training methodology

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 learning methods with regard to the use of three types of technology.

It is important to know that this project is not about teaching the first responders (FR) how to operate/control the technological tools (drones, wearables and robots). The focus of this project and thus the questionnaire is to gather information on how to teach first responders about using the information extracted from the tools. Therefore, in this questionnaire, we ask about your experience with the technological tools, your preferred learning method(s) and some demographic features. However, we will not ask any personal questions that can be linked to you.

Please be kind to share with us your practitioner's knowledge that is of the best value for good understanding of your operational reality. We can build upon this to provide you with improved tools and systems supporting you in your specialized tasks.

Thank you very much for your contribution!

ASSISTANCE project team

About ASSISTANCE

Nowadays different FR 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 situational awareness (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 organization's 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.

The Dutch Institute for Safety (IFV) is a partner of the project ASSISTANCE, and responsible for conducting this questionnaire. If you would like to contact us, please send an e-mail to our project leader Eric Didderen: eric.didderen@ifv.nl

General questions

1) What is your age?

- 18-24 years
- 25-34 years
- 35-44 years
- 45-54 years
- 55-64 years
- 65+ years
- I do not want to answer this question

2) What is your gender?

- Female
- Male
- Prefer not to say
- Other ...

3) In which country do you work?

- France
- Italy
- The Netherlands
- Poland
- Spain
- Sweden
- Switzerland
- Turkey

4) How many years of experience do you have as a first responder within your department?

[Open question]

5) What is your current mission type? (Multiple answers are possible)

- Command/Dispatch
- Field work
- Managerial (office)
- Technical support
- Training
- Other …

Professional use of drones (1)

The next question is about your experience with using drones

6) How many times did you professionally use feedback of drones?

- None (→ continue to question 12)
- 1-5 times
- 6-10 times
- >10 times

Professional use of drones (2)

7) When using drones professionally, do you operate them yourself or do you use subcontracting by a third party? (Multiple answers are possible)

- I operate them myself
- Someone else within my organisation operates the drone(s)
- I use subcontracting by a third party
- Other …

8) Did you have any training on the use of drones?

- No (→ continue to question 12)
- Yes

Training on use of drones

9) Approximately, how many hours did you receive training on using drones?

[Open question]

10) What type of training did you receive on using drones? (Multiple answers are possible)

- E-learning (i.e. gather online information independent of location and time)
- Handbook (paper manual)
- Informative films
- Lectures/seminars
- Training with digital simulations (Augmented Reality / Virtual Reality / Mixed Reality)
- Webinars (online seminar)
- Workshops
- I don’t know
- Other …

11) What is your opinion on the training methods you received?

[Open question]

Use of drones as a free time activity

12) How many times did you use feedback of drones as a free time activity?

- None
- 1-5 times
- 6-10 times
- >10 times

Professional use of wearables (1)

13) How many times did you professionally use feedback of wearables?

- None (→ continue to question 19)
- 1-5 times
- 6-10 times
- >10 times

Professional use of wearables (2)

14) When using wearables professionally, do you operate them yourself or do you use subcontracting by a third party? (Multiple answers are possible)

- I operate them myself
- Someone else within my organization operates the drone(s)
- I use subcontracting by a third party

15) Did you have any training on the use of wearables?

- No (→ continue to question 19)
- Yes

Training on use of wearables

16) Approximately, how many hours did you receive training on using wearables?

[Open question]

17) What type of training did you receive on using wearables? (Multiple answers are possible)

- E-learning (i.e. gather online information independent of location and time)
- Handbook (paper manual)
- Informative films
- Lectures/seminars
- Training with digital simulations (Augmented Reality / Virtual Reality / Mixed Reality)
- Webinars (online seminar)
- Workshops
- I don't know
- Other …

18) What is your opinion on the training methods you received?

[Open question]

Use of wearables as a free time activity

19) How many times did you use feedback of wearables as a free time activity?

- None
- 1-5 times
- 6-10 times
- >10 times

Professional use of robots (1)

The next question is about your experience with using robots.

20) How many times did you professionally use feedback of robots?

- None (→ continue to question 26)
- 1-5 times
- 6-10 times
- >10 times

Professional use of robots (2)

21) When using robots professionally, do you operate them yourself or do you use subcontracting by a third party? (Multiple answers are possible)

- I operate them myself
- Someone else within my organisation operates the drone(s)
- I use subcontracting by a third party

22) Did you have any training on the use of robots?

- No (→ continue to question 26)
- Yes

Training on use of robots

23) Approximately, how many hours did you receive training on using robots?
[Open question]

24) What type of training did you receive on using robots? (Multiple answers are possible)

- E-learning (i.e. gather online information independent of location and time)
- Handbook (paper manual)
- Informative films
- Lectures/seminars
- Training with digital simulations (Augmented Reality / Virtual Reality / Mixed Reality)
- Webinars (online seminar)
- Workshops
- I don't know
- Other …

25) What is your opinion on the training methods you received? [Open question]

Use of robots as a free time activity

26) How many times did you use feedback of robots as a free time activity?

- None
- 1-5 times
- 6-10 times
- >10 times

Gaining knowledge and skills

27) What would be your preferred way of gaining knowledge and skills with regard to using technological tools (drones, wearables, robots)? (Multiple answers are possible)

- E-learning (i.e. gather online information independent of location and time)
- Handbook (paper manual)
- Informative films
- Lectures/seminars
- Training with digital simulations (Augmented Reality / Virtual Reality / Mixed Reality)
- Webinars (online seminar)
- Workshops
- I don't know
- Other …

28) What is needed, in your opinion, to successfully apply technological tools (drones, wearables, robots) during a real incident? (Multiple answers are possible)

- Insights about the conditions needed for using the tools
- Knowledge on how to read feedback of the tools
- Knowledge on how to make decisions using feedback of the tools

29) What is your approximate preferred amount of time you would like to spend on learning about drones?

- 4 hours
- 8 hours
- 16 hours

30) What is your approximate preferred amount of time you would like to spend on learning about wearables?

- 4 hours
- 8 hours
- 16 hours

31) What is your approximate preferred amount of time you would like to spend on learning about robots?

- 4 hours
- 8 hours
- 16 hours

General remarks

32) If you have any general remarks, additions or comments, please write them down below.

[Open question]

Thank you

Thank you for answering this questionnaire.

If you have any questions, please e-mail eric.didderen@ifv.nl