

# FASTER: First Responder Advanced Technologies for Safe and Efficient Emergency Response

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**Abstract.** FASTER is an H2020 RIA project that develops a set of tools for enhancing the operational capacity of first responders while increasing their safety in the field. It will introduce Augmented Reality technologies for improved situational awareness and early risk identification, and Mobile and Wearable technologies for better mission management and information delivery to First Responders. Body and Gesture-based User Interfaces will be employed to enable new capabilities while reducing equipment clutter, offering unprecedented ergonomics. Moreover, FASTER will provide a platform of Autonomous Vehicles aiming to collect valuable information from the disaster scene prior to operations, extend situational awareness and offer physical response capabilities to First Responders. Furthermore, First Responders will improve their situational awareness receiving information gathered and analyzed by a Portable Common Operational Picture (PCOP). PCOP will gather multi-modal data from the field, utilizing an IoT network, and Social Media content to extract meaningful information and to orchestrate an intelligent response to the disaster. The whole system will be facilitated by tools for Resilient Communications Support featuring opportunistic relay services, emergency communication devices, and 5G-enabled communication capabilities.

**Keywords:** first responders · augmented reality · unmanned vehicles · common operational picture · wearables · communication.

## 1 Introduction

The European Environment Agency (EAA) reports that Europe is experiencing an increasing number of disasters, derived either from natural phenomena, technological accidents or human actions [1]. These disasters affect EU citizens, the EU economy and environment every year [2]. Over the period 1980-2016, the total reported losses caused by weather and climate-related extremes in the EEA member countries amounted to 436 billion EUR. The economic and societal impact will continue to escalate, as weather-related disasters alone could affect about two-thirds of the EU population annually by the year 2100, according to a recent data-driven forecast study [3]. First responders (FRs) are the people who are among the first to arrive and provide assistance at the disaster scene. First responders are typically professionals with specialized training, including LEAs, firefighters, emergency medical personnel, rescuers, K9 units, civil protection authorities and other related organisations.

Due to the nature of their work, first responders are often operating in risky and hazardous conditions disaster sites, like demolished, burnt or flooded districts, being exposed to non-visible threats such as very high temperatures and dangerous gases. Furthermore, first responders may experience incidents (e.g. sudden illness, dizziness or exhaustion strokes) during operations, which can prevent them from completing their mission, but, more importantly, put their own health at risk. Overzealous first responders may often not notice early signs or choose to ignore them in favour of accomplishing their mission, which can lead to become additional casualties of the disaster [4].

Despite their willingness and proper training, first responders' capabilities may be limited by chaotic environments, making it extremely difficult for them to estimate the exact position of the victims, dangerous areas, other first responder teams or valuable resources. The overwhelming amount of information available to them may reduce rather than increase their situational awareness. Multiple displays and gadgets are adding clutter to their equipment. Autonomous vehicles are useful in disaster scenes, according to a member of the Reykjavik Search and Rescue (SAR) Team, who claims that using drones has enabled them to respond faster and more accurately [5], but they lack in operational autonomy. Communication between first responders and the Command and Control centre is often obstructed by broken, overloaded or non-existent network infrastructure [6]. In addition to communication, cooperation and interoperability amongst first responders with LEAs and community members needing help or willing to help is often ad-hoc and lacks coordination. Often the problem lies not so much in the lack of resources and willingness to provide help, but in the logistics to efficiently direct and deliver assistance to the right places where and when it is most needed. These problems raise the need to exploit rapidly evolving technological advances towards protecting first responders from multiple and unexpected dangers, and provide solutions enabling them to operate in a seamless and efficient way in any environment and in cooperation with the community.

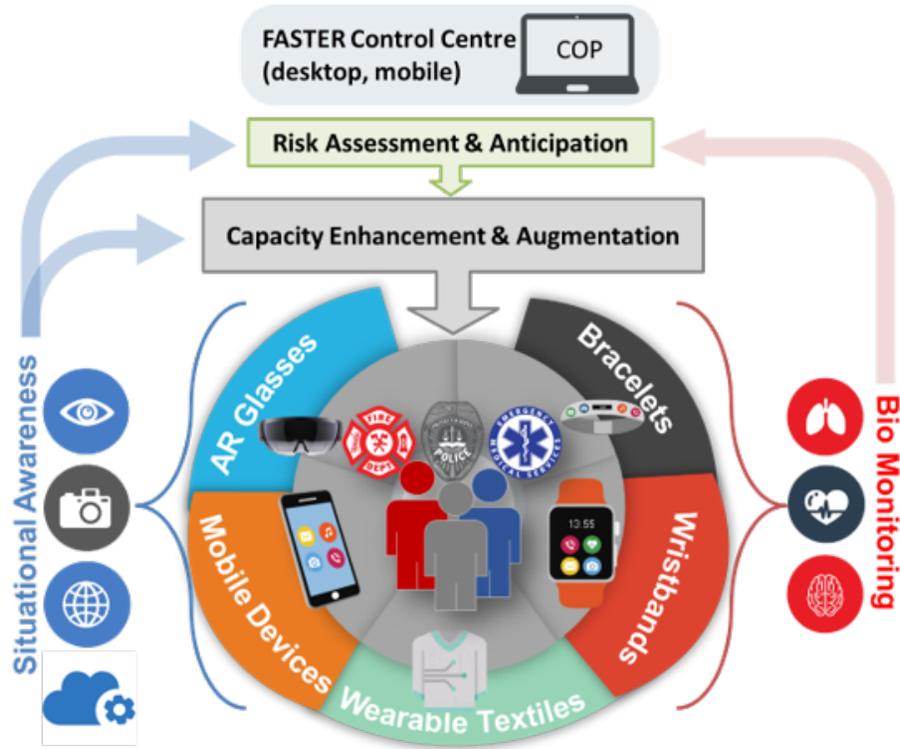
FASTER<sup>7</sup> aims to address the challenges associated with the protection of first responders in hazardous environments, while at the same time enhancing their capabilities in terms of situational awareness and communication. FASTER will provide innovative, accepted and efficient tools covering 1) Data collection providing a secure IoT platform for distributed, real-time gathering and processing of heterogeneous physiological and critical environmental data from smart textiles, wearables, sensors and Social Media, 2) Operational capabilities providing flexible, multi-functional autonomous vehicles, including swarms of them, for ex-tended inspection capabilities and physical mitigation, 3) Risk assessment providing tools for individual health assessment and disaster scene analysis for early warning and risk mitigation, 4) Improved ergonomics providing augmented reality tools for enhanced information streaming, as well as body and gesture-based interfaces for vehicle navigation and communication, 5) Resilient communication at the field level providing haptic communication capabilities, emergency communication devices, communication with K9s; and at the infrastructure level through 5G technologies and UAVs, 6) Tactical situational awareness providing innovative visualisation services for a portable Common Operational Picture for both indoor and outdoor scenarios representation. 7) Efficient Cooperation and Interoperability amongst first responders, LEA, community members and other resource providers to request and deliver assistance where and when it is most needed using blockchain technology to give everyone involved the ability to write and read data (including sensor data) on an open source platform to speed up disaster relief to a whole new level.

## 2 Overall Concept

FASTER aims to establish a new approach for disaster response in order to improve disaster resilience. This will be accomplished by the targeted employment and synergetic deployment of a set of appropriate and complementary technologies. Immediate response is a crucial part of the disaster management cycle for dealing effectively with disasters. Consequently, FASTER aims to improve the disaster response and monitoring capabilities by providing first responders with a suite of tools to augment their situational awareness and, as a result, enhance their safety and their operational capacity. The focus of disaster response is mitigating the impact of the disaster and ensuring the safety of those in immediate risk. However, as this takes place during the emergency, it also includes the safety of first responders who provide the means and resources for effective disaster mitigation and protection of life. Their in-field effectiveness is critical to mitigation and ensuring a short and smooth recovery phase.

FASTER's overall concept is illustrated in Fig. 1, where it shows that at the heart of FASTER's concept lie the first responders that will be supported by a set of ergonomic and non-intrusive wearable devices that comprise sensors, actuators and displays, as well as artificial intelligence capacity. These will be responsible for assessing the situation, be it either individualized bio-monitoring

<sup>7</sup> <https://www.faster-project.eu/>



**Fig. 1.** FASTER core first responder capacity enhancement and augmentation tools.

of the first responders or local environmental sensing. Their purpose will be to deliver information either in a peer-to-peer manner among first responders or centralized points of presence. The distinction made between these two schemes is necessary as disasters can manifest in various – typically uncontrollable – ways, necessitating the employment of centralised, decentralised and distributed (P2P) management schemes. To that end, FASTER will consider both edge-based and cloud-based processing and analysis technologies to realize a risk assessment and anticipation system that will reach decisions and analyse the overall situation to provide targeted information and instructions to first responders. These will be delivered by the same wearable devices to augment and enhance their operational capacities.

### 3 Technical Approach

FASTER will develop a set of tools towards enhancing the operational capacity of first responders while increasing their safety in the field. It will introduce Augmented Reality technologies for improved situational awareness and early risk

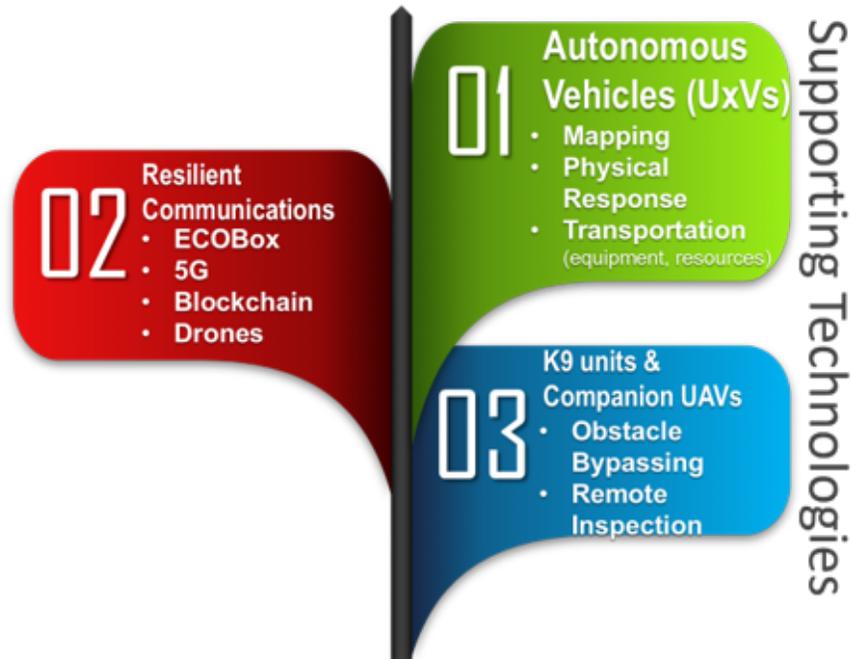


Fig. 2. Illustration of FASTER supporting technologies.

identification, and Mobile and Wearable technologies for better mission management and information delivery to first responders. Body and Gesture based User Interfaces will be employed to enable new capabilities while reducing equipment clutter, offering unprecedented ergonomics. Moreover, FASTER will provide a platform of Autonomous Vehicles, namely drones and robots, aiming to collect valuable information from the disaster scene prior to operations, extend situational awareness and offer physical response capabilities to first responders. FASTER will gather multi-modal data from the field, utilizing an IoT network, and Social Media content to extract, either locally or in the cloud, meaningful information and to provide an enhanced Common Operational Picture to the responder teams in a decentralised way using Portable Control Centres. It will, additionally, use ledger technology to enable trusted communication. The whole system will be facilitated by tools for Resilient Communications Support featuring opportunistic relay services, emergency communication devices and 5G-enabled communication capabilities.

### 3.1 Augmented Reality for operational awareness

Mobile Augmented Reality (AR) can offer more efficient situational awareness and decision making to practitioners in critical conditions that require full at-

tention and focus from involved first responders. FASTER aims to provide Augmented Reality (AR) technology delivering in real time information gathered from the other FASTER components (e.g. alerts, team status and location, sensor values), filtering the information and providing targeted content to the AR user. AR will be supplied both through mobile phones and AR glasses (e.g. HoloLens) by superimposing the data to the real world. Many different factors may prevent first responders from reaching and visually inspecting unreachable and/or dangerous areas in disaster sites, such as ruins, obstacles, harmful or unknown environmental conditions. FASTER aims to extend first responders' visual perception by deploying lightweight and camera-equipped UAVs to explore otherwise inaccessible or potentially dangerous areas. These small-factor UAVs will comprise part of the first responders' gear and will be deployed on demand when and where necessary. FASTER will offer first responders an exocentric X-ray like visualization of occluded areas from their physical viewpoint, rendering the UAVs' video stream on AR devices. This will widen their field of view and offer the ability to make obstacles between the UAV and the responder partially transparent.

### 3.2 Mobile and Wearable technologies

During emergencies there is a strong need of effective coordination between the control centre and in-field units. FASTER will design and implement a novel mobile application for first responders able to: support inter-agency communication, manage mission tasking and progress monitoring, allow real-time reporting of incidents and of geo-located multimedia content to improve situational awareness. The mobile application will rely on a cloud-based back-end and front-end to provide data services and the user interface for decision makers at control room, respectively. The mobile application will interact with other components to provide responders the latest available data, including the location of K9 units.

FASTER will design and develop a prototype regarding the use of sensors in wearable textiles that will be able to collect biometric data. Other sensors will be deployed on the First responder's uniform. All this data will be analysed locally using edge computing capabilities to enhance the information gained at almost real-time. On top of this, the design of the solution for FASTER will have to follow the existing security standards for the first responder's uniforms, keeping in mind the protection of electronic parts of wearables, under extreme conditions that first responders may face.

### 3.3 Body and Gesture based User Interfaces

In order to improve the ergonomics of the tools, wearable devices will capture and identify arm/body movements exploiting Artificial Intelligence. FASTER will provide non-visual/non-audible communication capabilities, translating movements or critical readings from paired wearable devices to coded messages, able to

be communicated to the team members on the field through vibrations on wearable devices. Given that often during operations communication infrastructure has collapsed, messages will be transmitted using IoT communication protocols (e.g., Bluetooth Low Energy; BLE). FASTER will also enable UAV navigation through gestures.

In the context of FASTER, a novel wearable device for K9s will be developed, featuring sensors such as 3-axis accelerometer and gyroscope, to extract valuable information about K9 behaviour and translate it to specific messages that can be transmitted wirelessly through IoT communication protocols to first responders. At the same time, the definition of a communication protocol will be studied that will translate the K9's behaviour (e.g., movement or bark) into a message addressed at the person in need in order to inform him/ her about the K9's role and provide some useful tips that should be followed to facilitate the first responder's work.

### 3.4 Autonomous Vehicles

FASTER will also present a robotic platform, integrating different sensors (optical and thermal cameras, environmental, nuclear, biological, chemical, radiological and explosives) and, if required by the use cases, a robotic arm with several end-effector options (grippers or tools). Wireless communication capabilities will support data exchange of large amounts of data (including video) and enabling multi-robot cooperation. It will also feature advanced features such as operation control, with enhanced user interface and visualisation capabilities, localization services and 3D map generation.

FASTER will employ an array of heavyweight drones of different sizes and payload capabilities that will be able to provide different services to first responders, such as mapping of the disaster area, physical operations like carrying heavy equipment, and acting as communication nodes in an ad-hoc network to provide resilient communication. The capability to operating in swarms in a coordinated manner following simple operational rules will also be provided.

### 3.5 Resilient Communications Support

FASTER will offer, a novel, low cost device, capable of delivering through broadcasting, critical information to first responders or instructions to civilians. The device will be able to send encrypted and signed messages in a massive way, able to cover large number of recipients. By deploying multiple devices, a mesh communication network could be provided, increasing the coverage area. Triggering message broadcasting will be feasible even from great distances, using the appropriate technology (LoRa or Short-wave to devices).

FASTER will also work on 5G network infrastructure to offer the means to manage and orchestrate resources of an edge cloud in the proximity to the geographic area under investigation and in accordance to the requirements of the rescue team. This will be achieved by leveraging the advantages provided by 5G technologies, including 1) high speed, zero latency network, 2) capability to

extend allocated resources in real time, 3) steering traffic efficiently to cover the changing operational needs of the responders' teams in real-time.

It has been shown that UAVs can be integrated into a cellular network to compensate cell overload or site outage, to enhance public safety in the failure of the base stations, and to boost the capacity of the network. FASTER will provide a resilient communication service based on devices from the FASTER eco-system and an augmented communication support through opportunistic relay services e.g. swarm of drones' usage, ensuring the minimal acceptable network performance to provide the basic services in a crisis scenario.

FASTER will also develop distributed ledger technology that allows central systems of first responders and other relief mission participants, including social networks and IoT control systems, to connect via a distributed network. For the involved parties, this means: 1) distributed power, 2) trusted interoperability, 3) ad-hoc capabilities and 4) privacy, yet can respond to needs they are capable of fulfilling.

### 3.6 Common Operational Picture

FASTER will develop a decentralised solution for Common Operational Picture that will be supported by services and tools to deal with an adaptive environment, considering contextual information and according to a shared situational picture. FASTER advanced visualization tools will provide different types of information regarding the position of first responders, possible victims, evacuation and rescue routes, managing countermeasures, resources required and, at the same time, highlight dangerous areas, dangerous environmental conditions through an advanced geo-location information system visualisation layer for both 3D indoor and outdoor scenarios. FASTER Portable Control Centre will allow teams of FRs on the field to make efficient and effective decisions organizing a proper response.

FASTER will harness information available in Social Media content, implementing smart filtering techniques that will exclude erroneous or misleading data, retaining only informative content related to emergency situations and enhance real-time situational assessment. Text mining and deep learning techniques will be used to classify social media posts according to the event type and map it into relevant categories. Deep learning models will be used to recognize scenes depicting emergency situations, such as floods, fires, and extreme weather events, and also damaged infrastructures, from social media multimedia content.

## 4 Target scenarios of the FASTER system

FASTER will be validated in 3 carefully selected scenarios that cover diverse disaster types and involve the tools deployed, namely a collapsed building, urban flooding and an indoor disaster. The pilots will take place in Spain, Italy and Finland respectively.

## Campo de Prácticas



**Fig. 3.** Practice area for First Responders in Madrid area, where the technologies of FASTER will be evaluated during the Spanish pilot.

FASTER will be demonstrated in a multi-storey building collapse case Fig. 3. The scenario revolves around a structural failure that triggers the complete collapse of a building in an urban environment. Possible escalation factors in terms of the risks such a situation poses to first responders include: building materials, building contents (e.g. storage of chemicals), presence of fire and weather conditions. These conditions may bring about physical hazards (e.g. unstable rubble pile, electrical equipment or sharp objects) or chemical hazards.

The second use case of FASTER consists of a major flood in a city with a high building density, which poses challenging hazards to first responders. Escalation factors may include: Disruption of services, Dangerous debris carried by water, Live victims trapped under water, looting and people stranded on evacuation routes.

The third application of the FASTER solution will be demonstrated in an indoor disaster scenario. An explosion in a populated building can include many hazards ranging from fires and their implications (e.g. heat or smoke), dangerous debris, hazardous materials, to the possibility of secondary attacks. Escalation

factors may include: secondary explosion, hostages, shooting, toxic chemical release, etc.

## 5 Exploitation planning

FASTER is building a community that will consist of the aggregation of the relevant first responders and stakeholders in a systematic interactive approach. The project will use experience from the activities of the formation which operate in Member States of the European Union and carry out tasks for first responders, including in the field of fire protection as well as in the protection of persons and property. The firefighters, policemen, members of rescue teams, security engineers will share their experiences, and the final effect of their cooperation will be new technical, technological and organizational solutions in the field of response to crisis situations, transport (communication), construction, industrial and also natural disasters.

FASTER is expected to release technologies at an average TRL level 7. It is, however, important to have a forecast of future market need for FASTER outcomes. According to Gartner (Fig. 4), it is evident that most of relevant technologies proposed by FASTER to first responders, are part of their hype cycle in 2018. As innovation proceeds, the array of mission-critical tools that can aid emergency services providers will continue to proliferate. By harnessing technology, FASTER will help provide first responders with crucial tools and information they need to operate. The project itself is planning to monitor existing players to better focus the research throughout the project duration.

## 6 Conclusion

FASTER is an ambitious project that aims to provide state of the art tools to First Responders to improve their capabilities and safety. The envisioned toolset is covering a wide range of technological aspects, including communication, augmented situational awareness, remote operations, team monitoring and improved operational planning capabilities. All developed technologies will be evaluated by First Responders within the project, as well as external ones, in 3 pilots addressing diverse scenarios in 3 different countries.

FASTER encompasses all the elements required to research and develop new technologies for First Responders, actively involving them in the design and validation of the tools. The FASTER consortium is an interdisciplinary, while focused, team consisting of 8 experienced academic / research partners, 3 industrial partners, 4 SMEs and 8 First Responder organizations including law enforcement agencies, firefighters, medical emergency services, K9 units, disaster response teams and civil protection organizations. Moreover, in order to ensure the exploitation of the project results beyond the lifetime of the project, a community of stakeholders is built to support their uptake to the market.

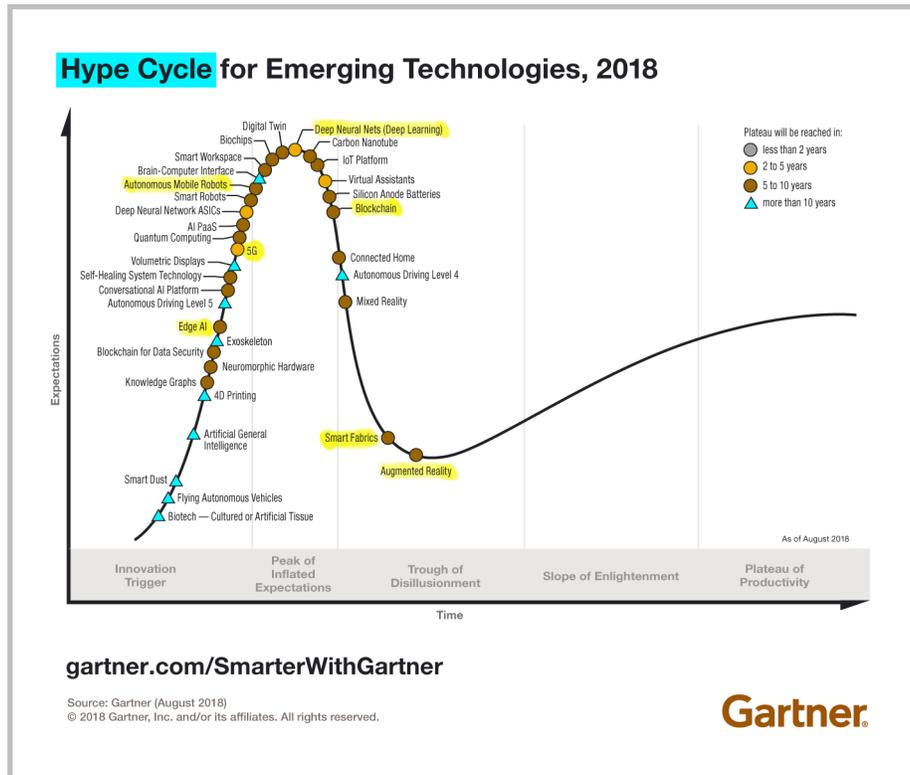


Fig. 4. Hype cycle for emerging technologies, Gartner.

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